2021 Edition

IGCSE

CHEMISTRY

0620

Paper 4

Years

2012-2020

Unsolved Topical

Past Papers with Marking

Schemes All Variants

IGCSE CHEMISTRY TOPICAL PAPER 4

TABLE OF CONTENTS

The Periodic Table of Elements

Key

atomic number atomic symbol name relative atomic mass

Group I	II											III	IV	V	VI	VII	VIII
							1 H hydrogen 1										2 He helium 4
3 Li lithium 7	4 Be beryllium 9											5 B boron 11	6 C carbon 12	7 N nitrogen 14	8 O oxygen 16	9 F fluorine 19	10 Ne neon 20
11 Na sodium 23	12 Mg magnesium 24											13 Al aluminium 27	14 Si silicon 28	15 P phosphorus 31	16 S sulfur 32	17 Cl chlorine 35.5	18 Ar argon 40
19 K potassium 39	20 Ca calcium 40	21 Sc scandium 45	22 Ti titanium 48	23 V vanadium 51	24 Cr chromium 52	25 Mn manganese 55	26 Fe iron 56	27 Co cobalt 59	28 Ni nickel 59	29 Cu copper 64	30 Zn zinc 65	31 Ga gallium 70	32 Ge germanium 73	33 As arsenic 75	34 Se selenium 79	35 Br bromine 80	36 Kr krypton 84
37 Rb rubidium 85	38 Sr strontium 88	39 Y yttrium 89	40 Zr zirconium 91	41 Nb niobium 93	42 Mo molybdenum 96	43 Tc technetium –	44 Ru ruthenium 101	45 Rh rhodium 103	46 Pd palladium 106	47 Ag silver 108	48 Cd cadmium 112	49 In indium 115	50 Sn tin 119	51 Sb antimony 122	52 Te tellurium 128	53 I iodine 127	54 Xe xenon 131
55 Cs caesium 133	56 Ba barium 137	57–71 lanthanoids	72 Hf hafnium 178	73 Ta tantalum 181	74 W tungsten 184	75 Re rhenium 186	76 Os osmium 190	77 Ir iridium 192	78 Pt platinum 195	79 Au gold 197	80 Hg mercury 201	81 Tl thallium 204	82 Pb lead 207	83 Bi bismuth 209	84 Po polonium –	85 At astatine –	86 Rn radon –
87 Fr francium –	88 Ra radium –	89–103 actinoids	104 Rf rutherfordium –	105 Db dubnium –	106 Sg seaborgium –	107 Bh bohrium –	108 Hs hassium –	109 Mt meitnerium –	110 Ds darmstadtium –	111 Rg roentgenium –	112 Cn copernicium –		114 Fl flerovium –		116 Lv livermorium –		

lanthanoids	57 La lanthanum 139	58 Ce cerium 140	59 Pr praseodymium 141	60 Nd neodymium 144	61 Pm promethium –	62 Sm samarium 150	63 Eu europium 152	64 Gd gadolinium 157	65 Tb terbium 159	66 Dy dysprosium 163	67 Ho holmium 165	68 Er erbium 167	69 Tm thulium 169	70 Yb ytterbium 173	71 Lu lutetium 175
actinoids	89 Ac actinium –	90 Th thorium 232	91 Pa protactinium 231	92 U uranium 238	93 Np neptunium –	94 Pu plutonium –	95 Am americium –	96 Cm curium –	97 Bk berkelium –	98 Cf californium –	99 Es einsteinium –	100 Fm fermium –	101 Md mendelevium –	102 No nobelium –	103 Lr lawrencium –

The volume of one mole of any gas is 24 dm^3 at room temperature and pressure (r.t.p.).

[0620/33/O/N/10/Q6-B]

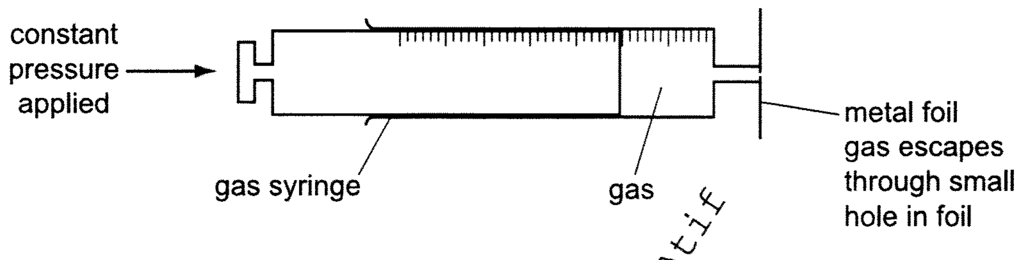
Q1. (b) Use the ideas of the Kinetic Theory to explain the following.

(i) A sealed container contains nitrogen gas. The pressure of a gas is due to the molecules of the gas hitting the walls of the container.
Explain why the pressure inside the container increases when the temperature is increased.

....

.... [2]

(ii) The following apparatus can be used to measure the rate of diffusion of a gas.



The following results were obtained.

gas	temperature /°C	rate of diffusion in cm^3/min
nitrogen	25	1.00
chlorine	25	0.63
nitrogen	50	1.05

Explain why nitrogen diffuses faster than chlorine.

....

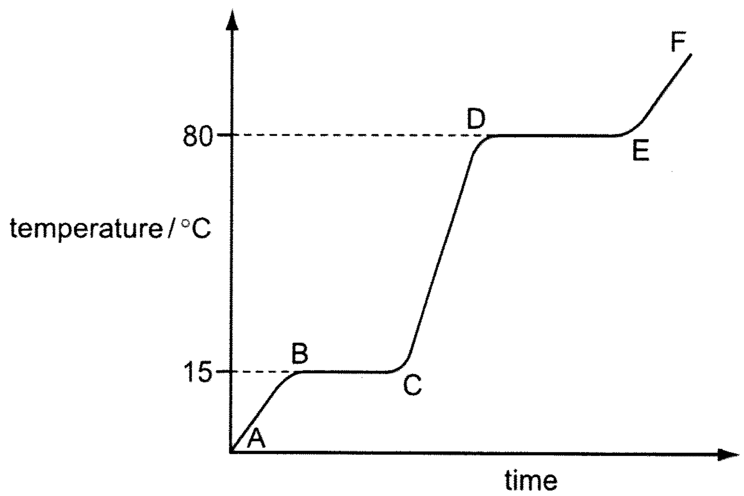
.... [2]

Explain why the nitrogen diffuses faster at the higher temperature.

.... [1]

[0620/32/O/N/12/Q2]

Q2. The diagram shows a heating curve for a sample of compound X.



(a) Is X a solid, a liquid or a gas at room temperature, 20 °C?

.... [1]

(b) Write an equation for the equilibrium which exists in region BC.

.... [2]

(c) Name the change of state which occurs in region DE.

.... [1]

(d) Explain how the curve shows that a pure sample of compound X was used.

....

.... [2]

[Total: 6]

Q3. [0620/31/M/J/14/Q3-A-B]

(a) Different gases diffuse at different speeds.

(i) What is meant by the term *diffusion*?

....

.... [1]

(ii) What property of a gas molecule affects the speed at which it diffuses?

.... [1]

(b) Helium is a gas used to fill balloons. It is present in the air in very small quantities. Diffusion can be used to separate it from the air.

Air at 1000 °C is on one side of a porous barrier. The air which passes through the barrier has a larger amount of helium in it.

(i) Why does the air on the other side of the barrier contain more helium?

.... [1]

(ii) Why is it an advantage to have the air at a high temperature?

....

.... [1]

3

Q4. [0620/33/M/J/14/Q2]

Explain each of the following in terms of the kinetic particle theory.

(a) The rate of most reactions increases at higher temperatures.

....

....

....

.... [3]

(b) A liquid has a fixed volume but takes up the shape of the container. A gas takes up the shape of the container but it does not have a fixed volume.

....

....

....

....

.... [3]

[Total: 6]

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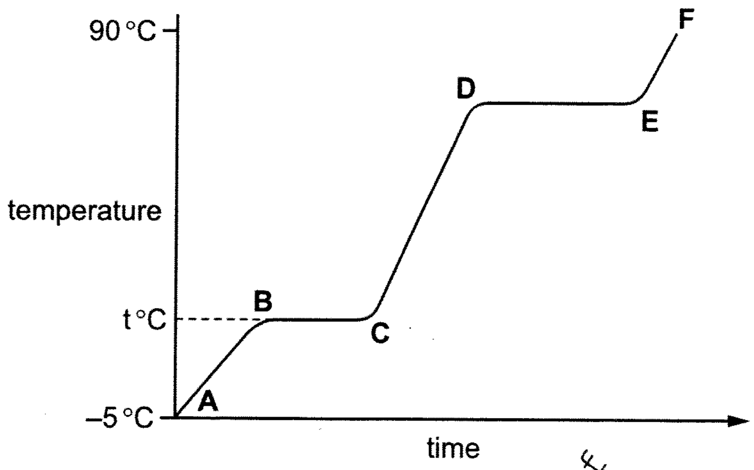
Q5. [0620/33/O/N/14/Q2-A]

Compound X is a colourless liquid at room temperature.

(a) A sample of pure X was slowly heated from –5.0 °C, which is below its melting point, to 90 °C, which is above its boiling point. Its temperature is measured every minute and the results are represented on the graph.



(i) Complete the equation for the equilibrium present in the region **BC**.

X(s) $\rightleftharpoons$ .... [1]

(ii) What is the significance of temperature t °C?

.... [1]

(iii) What is the physical state of compound X in the region **EF**?

.... [1]

(iv) What would be the difference in the region **BC** if an impure sample of X had been used?

.... [1]

[0620/31/M/J/15/Q6-C]

Q6.

(c) Gases diffuse, which means that they move to occupy the total available volume.

(i) Explain, using kinetic particle theory, why gases diffuse.

....

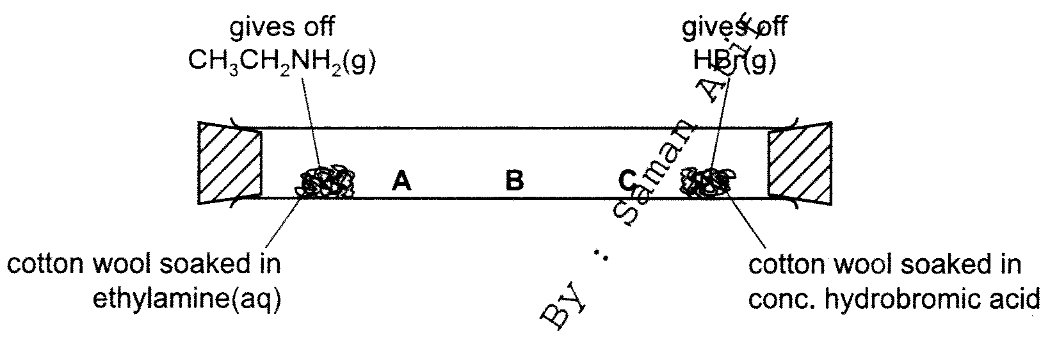
....

.... [2]

(ii) When the colourless gases hydrogen bromide and ethylamine come into contact, a white solid is formed.

$$CH_3CH_2NH_2(g) + HBr(g) \rightarrow \underset{\text{white solid}}{CH_3CH_2NH_3Br(s)}$$

The following apparatus can be used to compare the rates of diffusion of the two gases ethylamine and hydrogen bromide.



Predict at which position, **A**, **B** or **C**, the white solid will form. Explain your choice.

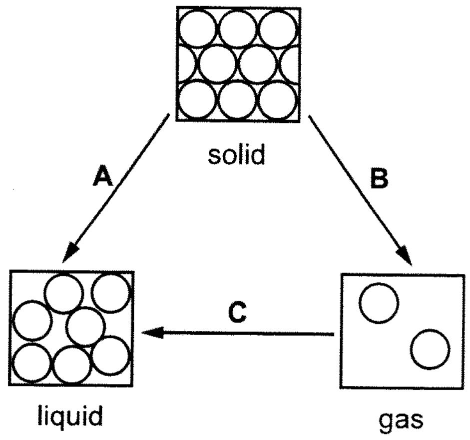
....

....

.... [3]

[0620/41/O/N/16/Q2]

Q7. Matter can exist as solid, liquid or gas. The arrows show some changes of state.



(a) Name the changes of state represented on the diagram.

(i) A .... [1]

(ii) B .... [1]

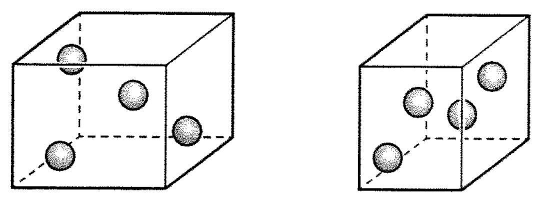
(iii) C .... [1]

(b) Explain why energy has to be supplied to turn a liquid into a gas.

....

.... [1]

(c) The diagrams represent the same number of particles of a gas in two containers, **D** and **E**, which have different volumes. The two containers are at the same temperature.



In which container will the pressure be higher? Explain your answer.

....

....

.... [1]

[Total: 5]

7

[0620/42/O/N/16/Q1]

Q8. Particles behave differently when in different physical states.

(a) Solids have a fixed volume and a definite shape.
Gases have no fixed volume and take the shape of the container.

Describe the volume and shape of liquids.

....

.... [1]

(b) Complete the table to show the separation, arrangement and movement of particles in each physical state.

state	separation of particles	arrangement of particles	movement of particles
solid			
liquid	touching one another	randomly arranged	move over one another
gas			

[6]

(c) Name the following changes of state.

(i) Ice turning into water.

.... [1]

(ii) Solid carbon dioxide turning directly into gaseous carbon dioxide at room temperature.

.... [1]

[Total: 9]

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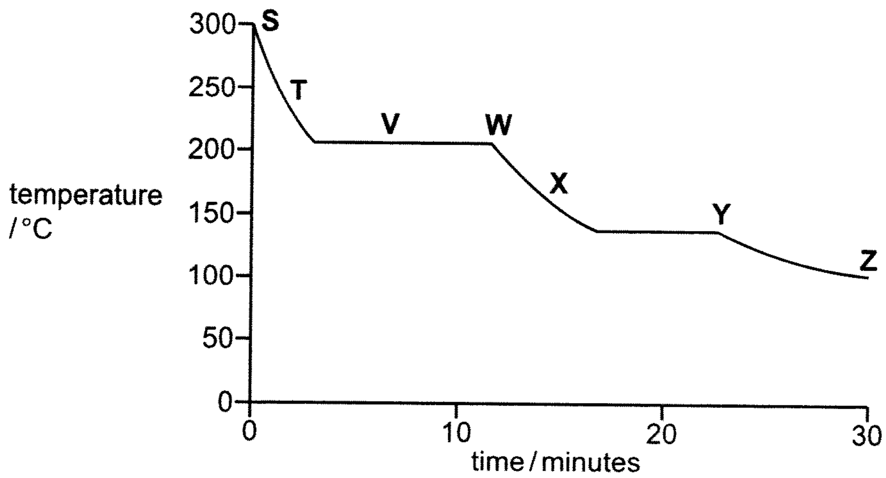
Q9. [0620/41/O/N/17/Q2]

The graph shows how the temperature of a substance changes as it is cooled over a period of 30 minutes. The substance is a gas at the start.



Each letter on the graph may be used once, more than once or not at all.

(a) Which letter, **S**, **T**, **V**, **W**, **X**, **Y** or **Z**, shows when

(i) the particles in the substance have the most kinetic energy,

.... [1]

(ii) the particles in the substance are furthest apart,

.... [1]

(iii) the substance exists as both a gas and a liquid?

.... [1]

(b) Use the graph to estimate the freezing point of the substance.

.... °C [1]

(c) Name the change of state directly from a solid to a gas.

.... [1]

(d) When smoke is viewed through a microscope, the smoke particles in the air appear to jump around.

(i) What term describes this movement of the smoke particles?

.... [1]

(ii) Explain why the smoke particles move in this way.

....

....

.... [2]

[Total: 8]

[0620/42/O/N/17/Q1]

Q10.

(a) Dust particles in the air move around in a random way.

(i) What term describes the random movement of the dust particles?

.... [1]

(ii) Identify the particles in the air which cause the random movement of the dust particles.

.... [2]

(iii) Explain why the dust particles move in this way.

....

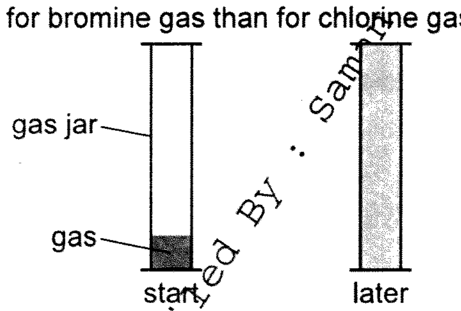
....

.... [2]

(b) When chlorine gas, Cl_2, is put into a gas jar, it spreads out to fill the gas jar.

When bromine gas, Br_2, is put into a gas jar, it also spreads out to fill the gas jar.

The process takes longer for bromine gas than for chlorine gas.



(i) What term describes the way that the gas particles spread out?

.... [1]

(ii) Use **data** from the Periodic Table to explain why bromine gas takes longer to fill a gas jar than chlorine gas.

....

....

.... [2]

(iii) Explain why increasing the temperature increases the rate at which the gas particles spread out.

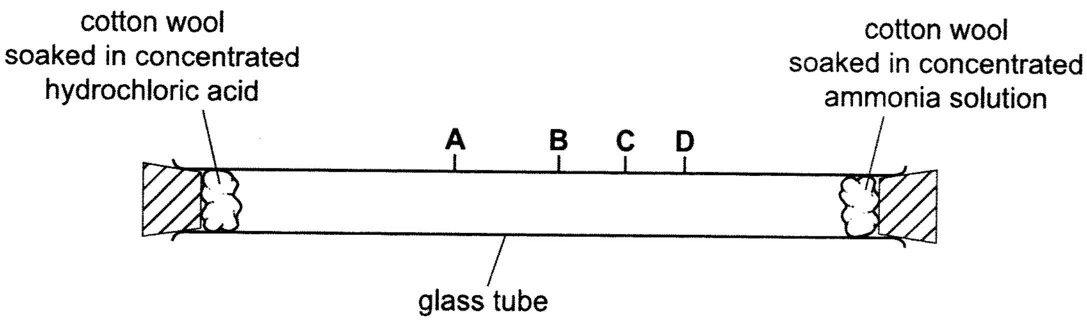
....

.... [1]

Q11. [0620/43/M/J/16/Q6-A]

Concentrated ammonia solution gives off ammonia gas. Concentrated hydrochloric acid gives off hydrogen chloride gas. Ammonia, NH_3, and hydrogen chloride, HCl, are both colourless gases. Ammonia reacts with hydrogen chloride to make the white solid ammonium chloride.

Apparatus is set up as shown.



After ten minutes a white solid forms in the tube where the gases meet.

(a) **(i)** Write the chemical equation for the reaction of ammonia with hydrogen chloride.

.... [1]

(ii) Name the process by which the ammonia and hydrogen chloride gases move in the tube.

.... [1]

(iii) At which point, **A**, **B**, **C** or **D**, does the white solid form? Explain why the white solid forms at that point.

the solid forms at ....

explanation ....

....

[3]

(iv) The experiment was repeated at a higher temperature.

Predict how the results of the experiment would be different. Explain your answer.

....

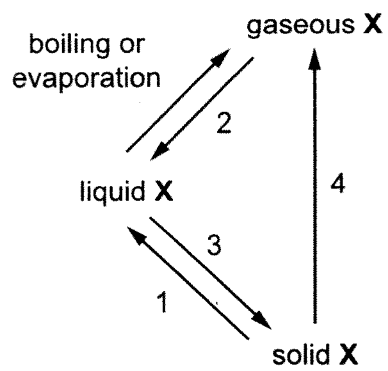
....

.... [3]

[0620/42/O/N/18/Q1-A-B]

Q12.

Element **X** can undergo the following physical changes.



(a) **(i)** Give the scientific name for each of the numbered physical changes.

1 ....

2 ....

3 ....

4 .... [4]

(ii) Explain why the changes shown are physical changes.

....

.... [1]

(iii) One difference between boiling and evaporation is the rate at which the processes occur.

State **one** other difference between boiling and evaporation.

....

.... [1]

(b) Describe the separation, arrangement and motion of particles of element **X** in the solid state.

separation ....

arrangement ....

motion .... [3]

[0620/42/M/J/20/Q4-d]

Q13.

(d) In terms of particles, explain what happens to the rate of this reaction when the temperature is increased.

....

....

....

....

.... [3]

[0620/43/M/J/20/Q5]

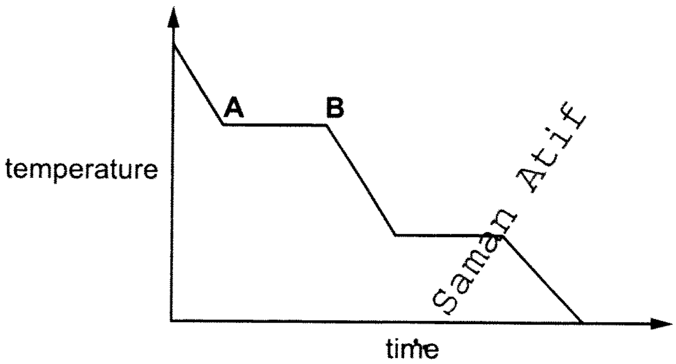
Q14.

(a) Complete the table about solids, liquids and gases.

	particle separation	particle arrangement	type of motion
solid		regular	vibrate only
liquid	touching		random
gas	apart	random	

[3]

(b) The graph shows the change in temperature as a sample of a gas is cooled.



Name the change of state taking place between **A** and **B**.

.... [1]

(c) A bottle of liquid perfume is left open at the front of a room.

After some time, the perfume is smelt at the back of the room.

Name the **two** physical processes taking place.

1 ....

2 ....

[2]

[Total: 6]

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Page 4	Mark Scheme: Teachers' version	Syllabus	Paper
	IGCSE – October/November 2010	0620	33

Q1.

(b) (i) **particles/molecules** have more energy / move faster [1]
collide harder / collide more frequently / more collisions / collide with more force (with the walls) [1]

(ii) (1) nitrogen has smaller M_r / lighter molecules / lower density [1]
nitrogen **molecules** / **particles** **move** faster (than chlorine molecules) [1]

(2) at higher temperature nitrogen **molecules or particles** (not atoms) move faster / have more energy [1]

Page 2	Mark Scheme	Syllabus	Paper
	IGCSE – October/November 2012	0620	32

Q2.

(a) liquid; [1]

(b) (l) and (s); [1]
reversible sign; [1]
accept: X in equation
ignore: any compounds just look for state symbols
must be the same compound on both sides of equation

(c) boiling / condensation; [1]
accept: evaporation or vaporisation

(d) (in region BC) solid melts / liquid boils (in region DE); [1]
at one / fixed / sharp / single / specific temperature; [1]

[Total: 6]

Page 2	Mark Scheme	Syllabus	Paper
	IGCSE – May/June 2014	0620	31

Q3.

(a) (i) (particles) spread to fill total available volume / move from high concentration to low concentration / moves down a concentration gradient (1) [1]

(ii) mass or M_r (1) [1]

(b) (i) helium atoms / molecules are lighter than molecules in air or N_2 **and** O_2
or helium is less dense than air or N_2 **and** O_2.
or helium diffuses (through the porous barrier) faster than air or N_2 **and** O_2. (1) [1]

(ii) faster rate of diffusion / molecules move faster (at high temperatures). (1) [1]

Page 2	Mark Scheme	Syllabus	Paper
	IGCSE – May/June 2014	0620	33

Q4.

(a) any **three** from:
particles have more energy (1)
move faster (1)
collide more frequently (1)
more particles have energy greater than E_a [3]
guidance: more colliding molecules have enough energy to react is worth (2)

(b) particles move in all directions / randomly in both liquids and gases (1)

no bonds / very weak forces between particles in gases (1)
molecules can move apart / separate (to fill entire volume) (1)
OR
bonds / forces / IMF between particles in liquids (1)
molecules cannot move apart / separate (so fixed volume in liquids) (1) [3]

[Total: 6]

Page 2	Mark Scheme	Syllabus	Paper
	Cambridge IGCSE – October/November 2014	0620	33

Q5.

(a) (i) (X(s) ↔) X(l) [1]

(ii) melting point/freezing point (of X) [1]

(iii) gas/gaseous or vapour [1]

(iv) not horizontal **or** line slopes **or** line is lower [1]

Q6.

Page 13	Mark Scheme	Syllabus	Paper
	Cambridge IGCSE – May/June 2015	0620	31

			oxide
6(c)(i)	*Any **two** from:* (particles move in) random motion; (particles) collide; (particles) move from a region of high concentration to low concentration;	2	**A** alternative phrases for collide **A** down a concentration gradient
6(c)(ii)	C; M2 it has a lower (relative) molecular mass (than HBr); M3 ethylamine diffuses faster (than HBr);	3	**A** ethylamine is less dense **A** ethylamine is a lighter molecule but **I** 'ethylamine is lighter' **I** ethylamine is a smaller molecule **A** ethylamine **molecules** or **particles** move faster **A** ECF for M2 and M3 if A is given e.g. HBr diffuses faster for M3 because it is a lighter molecule for M2 **A** ECF for M2 if B is given e.g. they diffuse at same rate for M3 because molecules weigh the same for M2

Q7.

Page 2	Mark Scheme	Syllabus	Paper
	Cambridge IGCSE – October/November 2016	0620	41

2(a)(i)	melt(ing)	1
2(a)(ii)	sublimation / sublime	1
2(a)(iii)	condensing / condensation	1
2(b)	overcome / break the attractive forces	1
2(c)	**E AND** particles hit the walls (of the container) more often	1

Q8.

Page 2	Mark Scheme	Syllabus	Paper
	Cambridge IGCSE – October/November 2016	0620	42

1(a)	fixed volume **AND** take the shape of the container	1
1(b)	(table below)	6
1(c)(i)	melting	1
1(c)(ii)	sublimation	1

1(b):

solid	touching	regular	vibrate
liquid			
gas	not touching	random	random

0620/41 Cambridge IGCSE – Mark Scheme PUBLISHED October/Novembe 2017

Q9.

2(a)(i)	S	1
2(a)(ii)	S	1
2(a)(iii)	V	1
2(b)	any value in the range 130–145 °C	1
2(c)	sublimation	1
2(d)(i)	Brownian motion	1
2(d)(ii)	nitrogen / oxygen / carbon dioxide / air molecules hit / bombard the smoke particles	1
	(the bombarding particles) move randomly	1

0620/42 Cambridge IGCSE – Mark Scheme PUBLISHED October/Novembe 2017

Q10.

1(a)(i)	Brownian (motion)	1
1(a)(ii)	molecules	1
	nitrogen / N_2 / N **OR** oxygen / O_2 / O	1
1(a)(iii)	nitrogen **OR** oxygen (particles) collide with / bombard / hit the dust (particles)	1
	(the bombarding particles) move **randomly**	1
1(b)(i)	diffusion	1
1(b)(ii)	Br_2 has an M_r of 160 **AND** Cl_2 has an M_r of 71 / bromine has an A_r of 80 **AND** chlorine has an A_r of 35.5	1
	(heavier) bromine (molecules / particles) diffuses more slowly	1
1(b)(iii)	particles have more energy / move faster	1

Page 9	Mark Scheme	Syllabus	Paper
	Cambridge IGCSE – May/June 2016	0620	43

Q11.

6(a)(i)	$NH_3 + HCl \rightarrow NH_4Cl$;		1
6(a)(ii)	diffusion;		1
6(a)(iii)	solid forms at: A; explanation: ammonia molecules / particles have a smaller mass; (and so) move / diffuse faster;	1 2	3
6(a)(iv)	**M1** solid forms in less time / faster / quicker; **M2** particles / molecules have more energy; **M3** (and so) move faster / diffuse faster;	1 1 1	3

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Q12.

Question	Answer	Marks
1(a)(i)	M1 Melting M2 Condensing M3 Freezing M4 Sublimation	4
1(a)(ii)	No new substances are made **or** The change can be reversed (by a physical process)	1
1(a)(iii)	Boiling happens at a specific temperature **or** Evaporation happens over a range of temperatures	1
1(b)	M1 Separation: Touching M2 Arrangement: Regular M3 Movement: Vibrate	3

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Q13.

Question	Answer	Marks
4(d)	particles gain kinetic energy / particles move faster (1) greater number of collisions with activation energy (or more) / greater number of particles with activation energy (or more) / greater number of particles with energy required for reaction (1) more collisions are successful / more collisions are fruitful / more collisions lead to reaction (1)	3

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Q14.

Question	Answer	Marks
5(a)	see table below	3
5(b)	condensing	1
5(c)	evaporation diffusion	2

5(a):

	particle separation	particle arrangement	type of motion
solid	touching		
liquid		random	
gas			random

[0620/33/O/N/12/Q3]

Q1. (a) A small amount of liquid bromine is added to a container which is then sealed.

$$Br_2(l) \rightarrow Br_2(g)$$

Use the ideas of the Kinetic Theory to explain why, after about an hour, the bromine molecules have spread uniformly to occupy the whole container.

....

....

.... [3]

(b) The diagrams below show simple experiments on the speed of diffusion of gases.

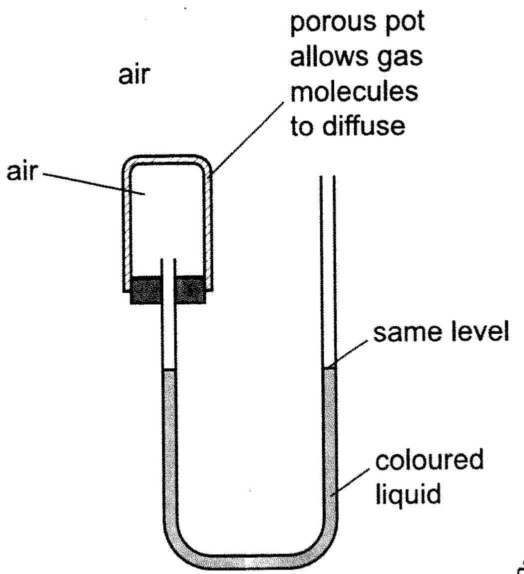

diagram 1

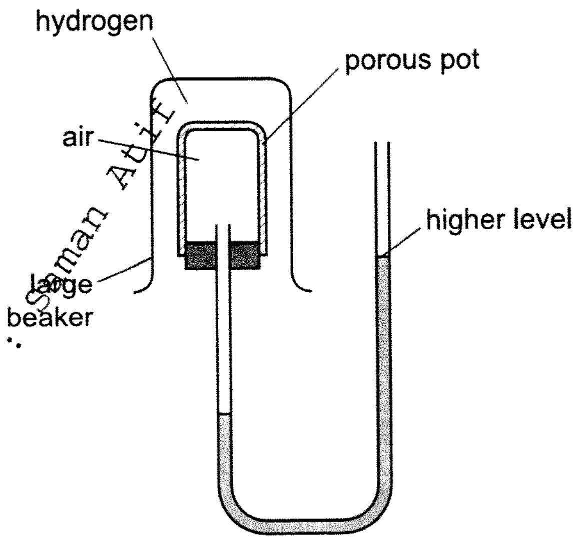

diagram 2

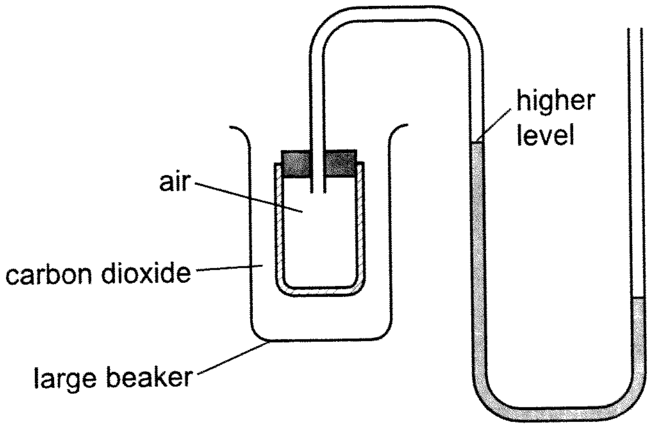

diagram 3

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Complete the following explanations. Diagram 1 has been done for you.

Diagram 1

There is air inside and outside the porous pot so the rate of diffusion of air into the pot is the same as the rate of diffusion of air out of the pot. The pressure inside and outside the pot is the same so the coloured liquid is at the same level on each side of the tube.

Diagram 2

....

....

....

.... [3]

Diagram 3

....

....

....

.... [3]

[Total: 9]

[0620/33/M/J/14/Q5-D]

Q2.

(d) The equilibrium mixture leaving the reaction chamber contains 15% ammonia. Suggest how the ammonia could be separated from the mixture.

	boiling point / °C
hydrogen	−253
nitrogen	−196
ammonia	−33

....

.... [2]

[0620/42/M/J/17/Q1]

Q3.

(a) State the name of the process that is used to

(i) separate oxygen from liquid air,

.... [1]

(ii) separate the individual dyes in ink,

.... [1]

(iii) produce ethanol from simple sugars,

.... [1]

(iv) obtain water from aqueous sodium chloride,

.... [1]

(v) separate the precipitate formed when aqueous silver nitrate is added to aqueous sodium chloride.

.... [1]

(b) State what is meant by the terms

(i) *element*,

....

.... [1]

(ii) *compound*,

....

.... [1]

(iii) *ion*.

....

.... [1]

[Total: 8]

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Q4. [0620/42/M/J/18/Q1]

Give the name of the process that is used:

(a) to obtain water from aqueous sodium chloride

.... [1]

(b) to produce lead from molten lead(II) bromide

.... [1]

(c) to separate an insoluble solid from a liquid

.... [1]

(d) to separate the components of petroleum

.... [1]

(e) to separate a mixture of coloured dyes.

.... [1]

[Total: 5]

[0620/31/O/N/12/Q1]

Q5. A list of techniques used to separate mixtures is given below.

filtration

diffusion

fractional distillation

simple distillation

crystallisation

chromatography

From this list, choose the most suitable technique to separate the following mixtures.
A technique may be used once, more than once or not at all.

(a) butane from a mixture of propane and butane .... [1]

(b) oxygen from liquid air .... [1]

(c) water from aqueous magnesium sulfate .... [1]

(d) potassium chloride from aqueous potassium chloride .... [1]

(e) silver chloride from a mixture of silver chloride and water .... [1]

(f) glucose from a mixture of glucose and maltose .... [1]

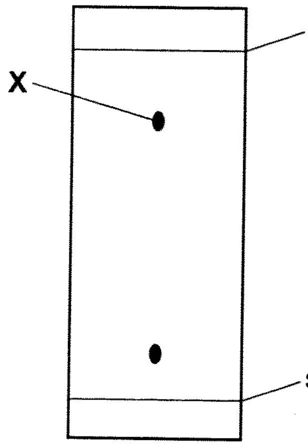
[Total: 6]

25

Q8. [0620/43/M/J/20/Q4-C]

(c) Chromatography can be used to test the purity of substances.

The diagram shows the chromatogram of a coloured substance.



(i) How does this chromatogram show that this substance is **not** pure?

.... [1]

(ii) Draw a circle round the correct R_f value for the spot labelled **X**.

0.2 0.4 0.8 1.2 [1]

(iii) State how a colourless substance can be made visible on a chromatogram.

.... [1]

Page 3	Mark Scheme	Syllabus	Paper
	IGCSE – October/November 2012	0620	33

Q1.

(a) explanation of evaporation e.g. particles (or molecules) with a lot of energy leave the liquid / bromine particles break free from each other / forces or bonds between bromine molecules broken / molecules (in liquid) have weak forces holding them together / weak intermolecular forces / Van der Waals forces between molecules (don't have to be stated as weak) / (weak intermolecular forces alone scores this mark);
allow: particles (or molecules) of bromine escape from liquid [1]

diffusion / diffuse / movement of particles; [1]

explanation of diffusion involving qualified movement of molecules / particles
i.e. random movement of molecules / particles move in all directions; [1]

(b) air more dense / heavier / high<u>er</u> M_r <u>than hydrogen</u>; [1]
hydrogen diffuses fast<u>er</u> (than air diffuses out); [1]
accept: diffusion in is faster than out (without naming gases)
pressure inside pot is great<u>er</u> (than outside); [1]
air less dense / light<u>er</u> / low<u>er</u> M_r <u>than carbon dioxide</u>; [1]

air diffuses / moves fast<u>er</u> (than carbon dioxide); [1]
accept: diffusion out is faster than in (without naming gases)

pressure inside pot less (than outside); [1]

ORA in both parts

[Total: 9]

Page 4	Mark Scheme	Syllabus	Paper
	IGCSE – May/June 2014	0620	33

Q2.

(d) lower the temperature (1)
only ammonia will liquefy (1)
OR
add water (1)
only ammonia will dissolve (1)
OR
increase pressure (1)
only ammonia will liquefy (1) [2]

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Q3.

Question	Answer	Marks
1(a)(i)	fractional distillation	1
1(a)(ii)	chromatography	1
1(a)(iii)	fermentation / ferment	1
1(a)(iv)	(simple) distillation / distil	1
1(a)(v)	filtration / decantation / centrifugation	1
1(b)(i)	(substance that) cannot be split up / broken down into (two or more) simpler substances by chemical means **OR** (substance) made of **atoms** with the same atomic number / number of protons / proton number	1
1(b)(ii)	(two or more) **elements** joined or combined or bonded (together)	1
1(b)(iii)	(particle) containing different numbers of protons and electrons **OR** atom or group of atoms that has gained or lost an electron / electrons	1

0620/42 Cambridge IGCSE – Mark Scheme PUBLISHED May/June 2018

Q4.

Question	Answer	Marks
1(a)	distillation	1
1(b)	electrolysis	1
1(c)	filtration	1
1(d)	fractional distillation / fractionation	1
1(e)	chromatography	1

Page 2	Mark Scheme	Syllabus	Paper
	IGCSE – October/November 2012	0620	31

Q5.

(a) diffusion or fractional distillation;

(b) fractional distillation;

(c) simple distillation;

(d) crystallisation;

(e) filtration;

(f) chromatography;

[Total: 6]

Page 5	Mark Scheme	Syllabus	Paper
	IGCSE – May/June 2013	0620	32

Q6.

(c) (i) to make colourless / invisible (spots) [1]
visible / coloured / seen / position made clear / indicate [1]

(ii) $\dfrac{\text{distance travelled by sample}}{\text{distance travelled by solvent (front)}} = R_f$ [1]

(iii) sample 1 R_f = 0.20 to 0.24 tartaric (acid) [1]
sample 2 R_f = 0.44 to 0.48 malic (acid) [1]

0620/41 Cambridge IGCSE – Mark Scheme PUBLISHED October/November 2019

Q7.

Question	Answer	Marks
1(b)	(compound / salt) on wooden splint **or** (nichrome / platinum) wire (1) into (roaring) Bunsen flame (1)	2

Q8.

Question	Answer	Marks
4(c)(i)	more than one spot	1
4(c)(ii)	0.8 (circled)	1
4(c)(iii)	use a locating agent	1

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[0620/32/M/J/12/Q1]

Q1. The table below includes information about some of the elements in Period 2.

element	carbon	nitrogen	fluorine	neon
symbol	C	N	F	Ne
structure	macromolecular	simple molecules N_2	simple molecules F_2	single atoms Ne
boiling point / °C	4200	–196	–188	–246

(a) Why does neon exist as single atoms but fluorine exists as molecules?

....

.... [2]

(b) What determines the order of the elements in a period?

.... [1]

(c) When liquid nitrogen boils the following change occurs.

$$N_2(l) \rightarrow N_2(g)$$

The boiling point of nitrogen is very low even though the bond between the atoms in a nitrogen molecule is very strong. Suggest an explanation.

....

.... [2]

(d) Draw a diagram showing the arrangement of the outer shell (valency) electrons in a molecule of nitrogen.

[2]

[Total: 7]

[0620/32/M/J/12/Q2]

Q2. Diamond and graphite are different forms of the same element, carbon.
Explain the following in terms of their structure.

(a) Graphite is a soft material which is used as a lubricant.

....

.... [2]

(b) Diamond is a very hard material which is used for drilling and cutting.

....

.... [2]

(c) Graphite is a good conductor of electricity and diamond is a poor conductor.

....

....

.... [2]

[Total: 6]

[0620/32/M/J/12/Q3]

Q3. The uses of a substance are determined by its properties.

(a) Plastics are poor conductors of electricity. They are used as insulation for electric cables.
Which other **two** properties of plastics make them suitable for this purpose?

....

.... [2]

(b) Chromium is a hard, shiny metal. Suggest **two** reasons why chromium is used to electroplate steel.

....

.... [2]

(c) Why is aluminium used extensively in the manufacture of aeroplanes?

....

.... [2]

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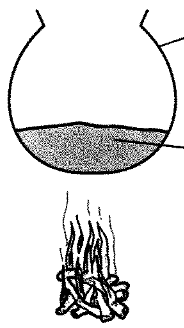
(d) Why is copper a suitable material from which to make cooking utensils?



....

.... [2]

(e) Describe the bonding in a typical metal.

....

....

.... [2]

[Total: 10]

[0620/31/O/N/12/Q2-A-B]

Q4. Three of the halogens in Group VII are listed below.

chlorine
bromine
iodine

(a) **(i)** How does their colour change down the Group?

.... [1]

(ii) How do their melting points and boiling points change down the Group?

.... [1]

(iii) Predict the colour and physical state (solid, liquid or gas) of astatine, At.

colour ....

physical state .... [2]

(b) A radioactive isotope of iodine, $^{131}_{53}I$, is used to treat cancer.

(i) Define the term *isotope*.

....

.... [2]

(ii) How many protons, electrons and neutrons are there in one atom of $^{131}_{53}I$?

number of protons ....

number of electrons ....

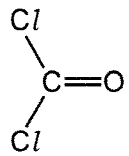
number of neutrons .... [2]

(iii) When this isotope, $^{131}_{53}I$, emits radiation, a different element with a proton number of 54 is formed.
What is the name of this element?

.... [1]

[0620/31/O/N/12/Q5-C]

Q5. **(c)** The structural formula of carbonyl chloride is given below.



Draw a diagram showing the arrangement of the outer (valency) electrons in one molecule of this covalent compound.

Use o to represent an electron from a carbon atom.
Use x to represent an electron from a chlorine atom.
Use • to represent an electron from an oxygen atom.

[3]

[0620/31/O/N/12/Q7-A]

Q6. Both strontium and sulfur have chlorides of the type XCl_2. The table below compares some of their properties.

	strontium chloride	sulfur chloride
appearance	white crystals	red liquid
formula	$SrCl_2$	SCl_2
melting point / °C	874	−120
boiling point / °C	1250	59
conductivity of liquid	good	poor
solubility in water	dissolves to form a neutral solution	reacts to form a solution of pH 1

(a) (i) Use the data in the table to explain why sulfur chloride is a liquid at room temperature, 25 °C.

....

.... [2]

(ii) Strontium is a metal and sulfur is a non-metal. Explain why both have chlorides of the type XCl_2.
The electron distribution of a strontium atom is 2 + 8 + 18 + 8 + 2.

....

....

.... [2]

(iii) Deduce the name of the acidic compound formed when sulfur chloride reacts with water.

.... [1]

(iv) Explain the difference in the electrical conductivity of liquid strontium chloride and liquid sulfur chloride.

....

....

.... [3]

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[0620/32/O/N/12/Q7-A-iii]

Q7. (iii) Draw a diagram showing the arrangement of the outer (valency) electrons in one molecule of methanol.

Use x to represent an electron from a carbon atom.
Use o to represent an electron from a hydrogen atom.
Use • to represent an electron from an oxygen atom.

[3]

[0620/32/O/N/12/Q7-C]

Q8. (c) Methanol is oxidised by atmospheric oxygen. This reaction is catalysed by platinum.

(i) The products of this reaction include a carboxylic acid. Give its name and structural formula.

name ....

structural formula showing all bonds

[2]

(ii) Deduce the name of the ester formed by the reaction of methanol with the carboxylic acid named in **(i)**.

.... [1]

[0620/33/O/N/12/Q4-A]

Q9. Zinc alloys have been used for over 2500 years.

(a) (i) Explain the phrase *zinc alloy*.

....

.... [1]

(ii) Making alloys is still a major use of zinc. State **one** other large scale use of zinc.

.... [1]

(iii) Describe the bonding in a typical metal, such as zinc, and then explain why it is malleable. You may use a diagram to illustrate your answer.

....

....

.... [3]

(iv) Suggest why the introduction of a different atom into the structure makes the alloy less malleable than the pure metal.

....

.... [2]

Q10. structural formula showing all bonds

[3]

(c) An organic compound has a molecular formula $C_6H_8O_4$. It is an unsaturated carboxylic acid. One mole of the compound reacts with two moles of sodium hydroxide.

(i) Explain the phrase *molecular formula*.

....

.... [2]

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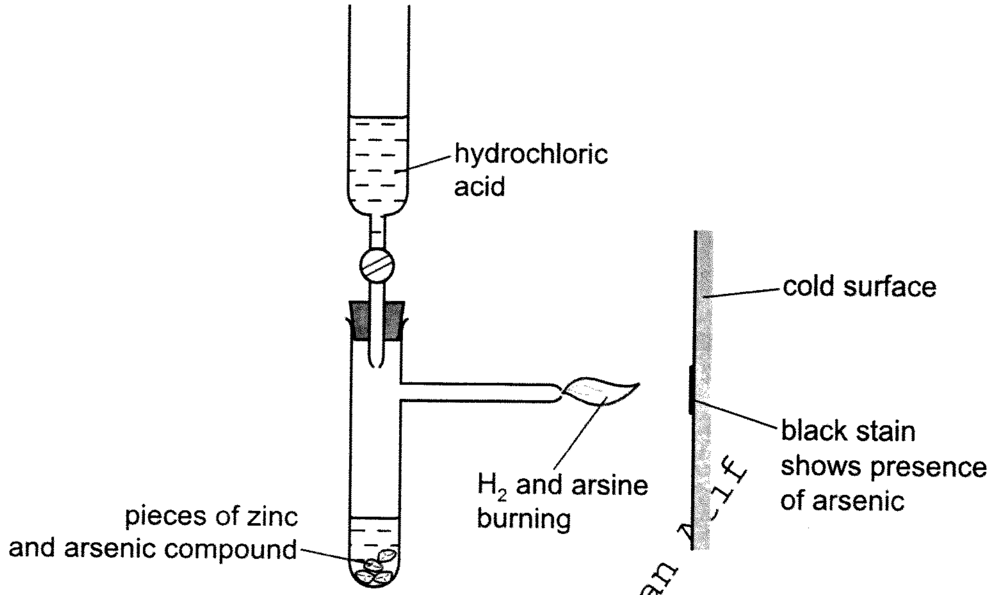
Q11. [0620/33/O/N/12/Q6-A]

Until recently, arsenic poisoning, either deliberate or accidental, has been a frequent cause of death. The symptoms of arsenic poisoning are identical with those of a common illness, cholera. A reliable test was needed to prove the presence of arsenic in a body.

(a) In 1840, Marsh devised a reliable test for arsenic.



Hydrogen is formed in this reaction. Any arsenic compound reacts with this hydrogen to form arsine which is arsenic hydride, AsH_3.
The mixture of hydrogen and arsine is burnt at the jet and arsenic forms as a black stain on the glass.

(i) Write an equation for the reaction which forms hydrogen.

.... [2]

(ii) Draw a diagram which shows the arrangement of the outer (valency) electrons in one molecule of the covalent compound arsine.
The electron distribution of arsenic is 2 + 8 + 18 + 5.

Use x to represent an electron from an arsenic atom.
Use o to represent an electron from a hydrogen atom.

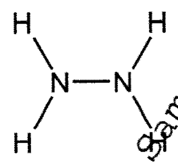
[2]

(iii) Deduce the structural formula of this hydride.

[1]

[0620/31/M/J/13/Q6-D]

Q12. (d) The structural formula of hydrazine is given below.



Draw a diagram showing the arrangement of the valency electrons in one molecule of the covalent compound hydrazine.
Use x to represent an electron from a nitrogen atom.
Use o to represent an electron from a hydrogen atom.

[3]

43

Q13. [0620/31/M/J/13/Q8]

There are three types of giant structure - ionic, metallic and giant covalent.

(a) In an ionic compound, the ions are held in a lattice by strong forces.

(i) Explain the term *lattice*.

....

.... [2]

(ii) Explain how the ions are held together by strong forces.

....

.... [1]

(b) Describe the bonding in a typical metal.

....

....

.... [3]

(c) The electrical conductivities of the three types of giant structure are given in the following table.

type of structure	conductivity of solid	conductivity of liquid
ionic	poor	good
metallic	good	good
giant covalent	poor	poor

Explain the differences in electrical conductivity between the three types of giant structure and the difference, if any, between the solid and liquid states of the same structure.

....

....

....

....

.... [5]

[Total: 11]

44

[0620/32/M/J/13/Q2]

Q14.(a) The table below gives the number of protons, neutrons and electrons in atoms or ions. Complete the table. The first line is given as an example.
You will need to use the Periodic Table.

particle	number of protons	number of electrons	number of neutrons	symbol or formula
A	4	4	5	$^{9}_{4}Be$
B	19	18	20	....
C	30	30	35	....
D	8	10	8	....
E	31	31	39	....

[6]

(b) Using the data in the table, explain how you can determine whether a particle is an atom, a negative ion or a positive ion.

....

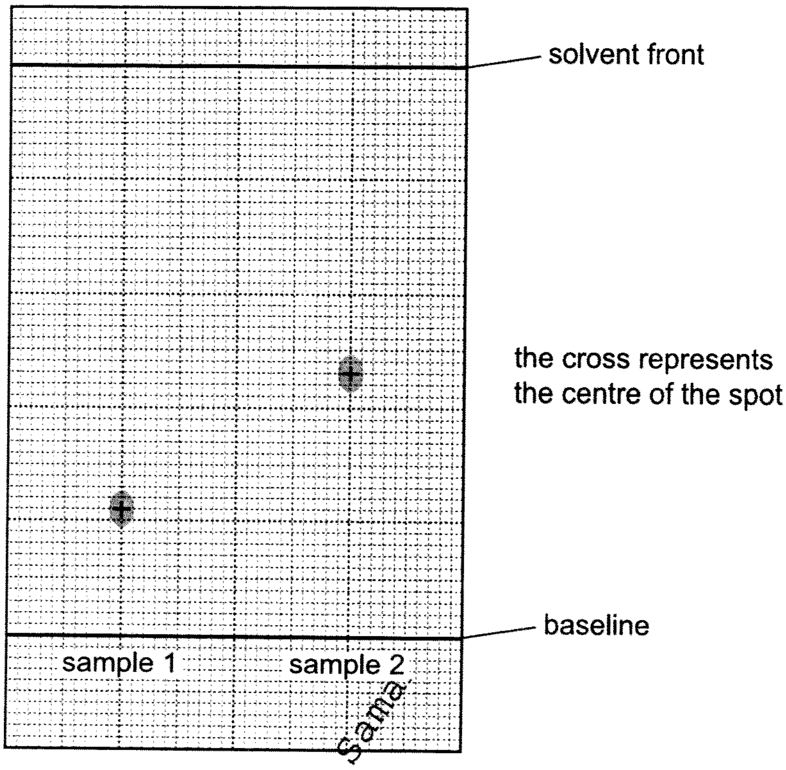
....

.... [3]

[Total: 9]

Q15. [0620/32/M/J/13/Q7-C]

(c) Esters can be used as solvents in chromatography. The following shows a chromatogram of plant acids.



An ester was used as the solvent and the chromatogram was sprayed with bromothymol blue.

(i) Suggest why it was necessary to spray the chromatogram.

....

.... [2]

(ii) Explain what is meant by the R_f value of a sample.

....

.... [1]

(iii) Calculate the R_f values of the two samples and use the data in the table to identify the plant acids.

plant acid	R_f value
tartaric acid	0.22
citric acid	0.30
oxalic acid	0.36
malic acid	0.46
succinic acid	0.60

sample 1 R_f = ... It is .... acid.

sample 2 R_f = ... It is .... acid. [2]

Q16. [0620/33/M/J/13/Q1]

Substances can be classified as:

elements mixtures compounds

Elements can be divided into:

metals non-metals

(a) Define each of the following terms.

(i) *element*

....

.... [2]

(ii) *compound*

....

.... [2]

(iii) *mixture*

....

.... [1]

(b) Classify each of the following as either an element, compound or mixture.

(i) brass .... [1]

(ii) carbon dioxide .... [1]

(iii) copper .... [1]

(c) Which physical property is used to distinguish between metals and non-metals? It is possessed by all metals but by only one non-metal.

.... [1]

[Total: 9]

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[0620/33/M/J/13/Q4-C]

Q17.(c) Describe the structure of the giant covalent compound germanium(IV) oxide, GeO_2. It has a similar structure to that of silicon(IV) oxide.

....

....

.... [3]

[0620/33/M/J/13/Q6-A]

Q18. Sulfuric acid and malonic acid are both dibasic acids. One mole of a dibasic acid can form two moles of hydrogen ions.

$$H_2SO_4 \rightarrow 2H^+ + SO_4^{2-}$$

Dibasic acids can form salts of the type Na_2X and CaX.

(a) Malonic acid is a white crystalline solid which is soluble in water. It melts at 135 °C. The structural formula of malonic acid is given below. It forms salts called malonates.

$$CH_2(COOH)_2 \text{ or } HOOC-CH_2-COOH$$

(i) How could you determine if a sample of malonic acid is pure?

technique used ....

result if pure .... [2]

(ii) What is the molecular formula of malonic acid?

.... [1]

(iii) When malonic acid is heated there are two products, carbon dioxide and a simpler carboxylic acid. Deduce the name and molecular formula of this acid.

....

.... [2]

49

Q19. [0620/31/O/N/13/Q1]

For each of the following, name an element which matches the description.

(a) It is used as a fuel in nuclear reactors.

.... [1]

(b) It is the only non-metal which is a good conductor of electricity.

.... [1]

(c) Inert electrodes are made from this metal.

.... [1]

(d) This gaseous element is used to fill balloons in preference to hydrogen.

.... [1]

(e) An element which can form an ion of the type X^{3-}.

.... [1]

(f) It has the same electron distribution as the calcium ion, Ca^{2+}.

.... [1]

(g) The element is in Period 5 and Group VI.

.... [1]

[Total: 7]

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[0620/33/O/N/13/Q1-A-B]

Q20. Zirconium (Zr) is a metal in Period 5. Its main oxidation state is +4.

(a) The following are all zirconium atoms: $^{90}_{40}Zr$, $^{91}_{40}Zr$ and $^{92}_{40}Zr$.

In terms of numbers of electrons, neutrons and protons, how are these three atoms the same and how are they different?

They are the same because ....

....

They are different because ....

.... [3]

(b) Containers for fuel rods in nuclear reactors are made of zirconium.
Nuclear reactors are used to produce energy and to make radioactive isotopes.

(i) Which isotope of a different element is used as a fuel in nuclear reactors?

.... [1]

(ii) State one medical and one industrial use of radioactive isotopes.

....

.... [2]

(iii) Above 900 °C, zirconium reacts with water to form zirconium(IV) oxide, ZrO_2, and hydrogen. Write an equation for this reaction.

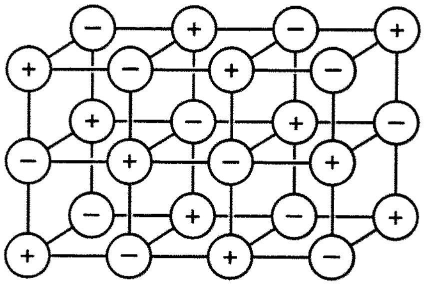
.... [2]

(iv) In a nuclear accident, water may come in contact with very hot zirconium.
Explain why the presence of hydrogen inside the reactor greatly increases the danger of the accident.

.... [1]

Q21. [0620/33/O/N/13/Q2]

(a) The diagram shows the lattice of a typical ionic compound.



(i) Explain the term *ionic lattice*.

....

.... [2]

(ii) In this lattice, the ratio of positive ions to negative ions is 1:1.
In the lattice of a different ionic compound, the ratio of positive ions to negative ions is 1:2.
Suggest why this ratio varies in different ionic compounds.

.... [1]

(iii) Give **three** physical properties of ionic compounds.

....

....

.... [3]

(b) Strontium oxide is an ionic compound. Draw a diagram which shows its formula, the charges on the ions and the arrangement of the **valency** electrons around the negative ion.
The electron distribution of a strontium atom is 2 + 8 + 18 + 8 + 2.

Use o to represent an electron from a strontium atom.
Use x to represent an electron from an oxygen atom.

[3]

[Total: 9]

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Q22. [0620/31/M/J/14/Q1]

The table below gives the composition of six particles which are either atoms or ions.

particle	number of protons	number of neutrons	number of electrons
A	33	40	33
B	19	20	18
C	34	45	36
D	33	42	33
E	13	14	13
F	24	28	21

(a) Which particles are atoms? Explain your choice.

....

.... [2]

(b) Which particle is a negative ion and why has this particle got a negative charge?

....

.... [2]

(c) Which particles are positive ions?

.... [1]

(d) Explain why particle **A** and particle **D** are isotopes.

....

.... [2]

[Total: 7]

[0620/31/M/J/14/Q3-C]

Q23.

(c) Most helium is obtained from natural gas found in the USA. Natural gas contains methane and 7% helium. One possible way to obtain the helium would be to burn the methane.

(i) Write an equation for the complete combustion of methane.

.... [1]

(ii) Suggest why this would **not** be a suitable method to obtain the helium.

....

.... [1]

(iii) Suggest another method, other than diffusion, by which helium could be separated from the mixture of gases in natural gas.

.... [1]

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Q24. [0620/31/M/J/14/Q4]

In the Periodic Table, the elements are arranged in columns called Groups and in rows called Periods.

(a) (i) Complete the table for some of the elements in Period 3.

group number	I	II	III	IV	V	VI	VII
symbol	Na	Mg	A*l*	Si	P	S	C*l*
number of valency electrons							
valency							

[2]

(ii) What is the relationship between the group number and the number of valency electrons?

....

.... [1]

(iii) Explain the relationship between the number of valency electrons and the valency

for the elements Na to A*l*,

....

....

....

for the elements P to C*l*.

....

....

....

[4]

(b) Across a period, the elements change from metallic to non-metallic.

(i) Describe how the type of oxide changes across this period.

....

.... [2]

(ii) Describe how the type of bonding in the chlorides formed by these elements changes across this period.

....

.... [2]

[Total: 11]

Q25. [0620/32/M/J/14/Q1]

The table below gives the electron distributions of atoms of different elements.

element	electron distribution
A	2 + 7
B	2 + 8 + 4
C	2 + 8 + 8 + 1
D	2 + 8 + 18 + 5
E	2 + 8 + 18 + 7
F	2 + 8 + 18 + 18 + 8

For each of the following, select an element or elements from the table that matches the description. Each element may be selected once, more than once or not at all.

(a) These **two** elements are in the same group.

.... [1]

(b) This element forms a fluoride with a formula of the type XF_3.

.... [1]

(c) This element reacts violently with cold water.

.... [1]

(d) This element has a macromolecular structure similar to that of diamond.

.... [1]

(e) The only oxidation state of this element is 0.

.... [1]

(f) This element is bromine.

.... [1]

(g) This element is a good conductor of electricity.

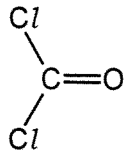
.... [1]

[Total: 7]

[0620/32/M/J/14/Q5-C]

Q26.

(c) The structural formula of carbonyl chloride is given below.



Draw a diagram showing the arrangement of the valency electrons around the atoms in one molecule of this covalent compound.

Use o to represent an electron from an oxygen atom.
Use × to represent an electron from a chlorine atom.
Use ● to represent an electron from a carbon atom.

[3]

[0620/32/M/J/14/Q6-B]

Q27.

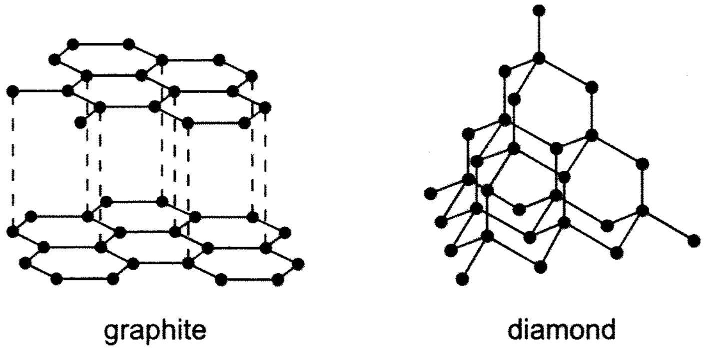
(b) Scandium fluoride is an ionic compound. The valency of scandium in scandium fluoride is three.
Draw a diagram which shows the formula of this compound, the charges on the ions and the arrangement of the valency electrons around the negative ions.

Use × to represent an electron from a fluorine atom.
Use o to represent an electron from a scandium atom.

[3]

Q28. [0620/31/O/N/14/Q2]

Two macromolecular forms of carbon are graphite and diamond. The structures of graphite and diamond are given below.



(a) Explain in terms of its structure why graphite is soft and is a good conductor of electricity.

....

....

....

....

.... [3]

(b) State **two** uses of graphite which depend on the above properties.

It is soft ....

....

It is a good conductor of electricity ....

.... [2]

(c) Silicon(IV) oxide also has a macromolecular structure.

(i) Describe the macromolecular structure of silicon(IV) oxide.

....

.... [1]

(ii) Predict **two** physical properties which diamond and silicon(IV) oxide have in common.

....

.... [2]

[Total: 8]

58

Q29. [0620/31/O/N/14/Q7]

Nitrogen can form ionic compounds with reactive metals and covalent compounds with non-metals.

(a) Nitrogen reacts with lithium to form the ionic compound lithium nitride, Li_3N.

(i) Write the equation for the reaction between lithium and nitrogen.

.... [2]

(ii) Lithium nitride is an ionic compound. Draw a diagram which shows its formula, the charges on the ions and the arrangement of the valency electrons around the negative ion.

Use x for an electron from a lithium atom.
Use o for an electron from a nitrogen atom.

[2]

(b) Nitrogen fluoride is a covalent compound.

(i) Draw a diagram showing the arrangement of the valency electrons in one molecule of the covalent compound nitrogen trifluoride, NF_3.

Use x for an electron from a nitrogen atom.
Use o for an electron from a fluorine atom.

[2]

(ii) Lithium nitride has a high melting point, 813 °C. Nitrogen trifluoride has a low melting point, –207 °C.
Explain why the melting points are different.

....

....

.... [2]

[Total: 8]

[0620/32/O/N/14/Q1]

Q30.

An important aspect of chemistry is purity and methods of purification.

(a) Give an example of substances used in everyday life which must be pure.

.... [1]

(b) A list of techniques used to separate mixtures is given below.

chromatography **crystallisation** **diffusion** **dissolving**

evaporation **filtration** **fractional distillation** **simple distillation**

(i) From the list, choose the most suitable technique to separate the following.

water from sea-water ....

helium from a mixture of helium and methane ....

ethanol from a mixture of ethanol and propanol ....

iron filings from a mixture of iron filings and water ....

a mixture of two amino acids, glycine and alanine ....

[5]

(ii) Describe how you would obtain a pure sample of copper(II) sulfate-5-water crystals from a mixture of copper(II) sulfate-5-water with copper(II) oxide using some of the techniques listed above.

....

....

....

....

.... [4]

[Total: 10]

60

Q31. [0620/33/O/N/14/Q1]

For each of the following elements give **one** physical property and **one** chemical property.

(a) bromine (Br_2)

physical property ....

chemical property ....

[2]

(b) carbon$_{graphite}$(C)

physical property ....

chemical property ....

[2]

(c) manganese (Mn)

physical property ....

chemical property ....

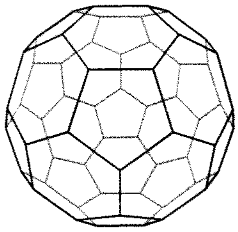
[2]

[Total: 6]

[0620/33/O/N/14/Q3-A-B]

Q32.

In 1985 the fullerenes were discovered. They are solid forms of the element carbon. The structure of the C_{60} fullerene is given below.



(a) **(i)** In the C_{60} fullerene, how many other carbon atoms is each carbon atom bonded to?

.... [1]

(ii) Another fullerene has a relative molecular mass of 840.
How many carbon atoms are there in one molecule of this fullerene?

.... [1]

(b) Fullerenes are soluble in liquid hydrocarbons such as octane. The other solid forms of carbon are insoluble.
Describe how you could obtain crystals of fullerenes from soot which is a mixture of fullerenes and other solid forms of carbon.

....

....

....

.... [3]

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62

Q33. [0620/32/M/J/15/Q1]

Complete the following table which gives the number of protons, electrons and neutrons in each of the five particles.

particle	number of protons	number of electrons	number of neutrons
....	19	19	20
$^{56}_{26}Fe$	....	....	....
....	3	2	4
$^{70}_{31}Ga^{3+}$	....	....	....
....	34	36	45

[Total: 8]

Q34. [0620/32/M/J/15/Q2]

The table shows the melting points, boiling points and electrical properties of five substances, **A** to **E**.

substance	melting point /°C	boiling point /°C	electrical conductivity of solid	electrical conductivity of liquid
A	−7	59	poor	poor
B	1083	2567	good	good
C	755	1387	poor	good
D	43	181	poor	poor
E	1607	2227	poor	poor

Choose a substance from the table above to match each of the following descriptions. A substance may be used once, more than once or not at all. Justify each choice with evidence from the table.

One has been completed as an example.

This substance is covalent and is a solid at room temperature (25 °C). ....**D**........

evidence *Its melting point is above room temperature. It has a low melting point and it does not conduct as a liquid, so it is covalent.*

(a) This substance has a giant covalent structure. ....

evidence ....

.... [3]

(b) This substance is a metal. ....

evidence ....

.... [2]

(c) This substance is a liquid at room temperature (25 °C). ....

evidence ....

.... [3]

(d) This substance is an ionic solid. ....

evidence ....

.... [3]

[Total: 11]

64

Q35. [0620/32/M/J/15/Q3-A-B]

Calcium reacts with nitrogen to form the ionic compound calcium nitride, Ca_3N_2.

(a) Draw a diagram, based on the correct formula, which shows the charges on the ions and the arrangement of the electrons around the negative ion.

Use o to represent an electron from a calcium atom.
Use x to represent an electron from a nitrogen atom.

[3]

(b) In the lattice of calcium nitride, the ratio of calcium ions to nitride ions is 3 : 2.

(i) What is meant by the term *lattice*?

....

.... [2]

(ii) In terms of ionic charges, explain why the ratio of ions is 3 : 2.

....

.... [2]

65

[0620/33/M/J/15/Q1]

Q36. Use your copy of the Periodic Table to help you answer these questions.

(a) Predict the formula of each of the following compounds.

(i) aluminium fluoride .... [1]

(ii) arsenic oxide .... [1]

(iii) silicon bromide .... [1]

(b) Deduce the formula of each of the following ions.

(i) phosphide .... [1]

(ii) barium .... [1]

(iii) francium .... [1]

(c) Draw a diagram showing the arrangement of the valency electrons in one molecule of the covalent compound carbon dioxide.

Use x to represent an electron from a carbon atom.
Use o to represent an electron from an oxygen atom.

[Total: 9]

66

Q37. [0620/31/O/N/15/Q1]

(a) The symbols of six particles are shown below.

Na^+ Ca^{2+} Kr P Si O^{2-}

Select from the list of particles to answer the following questions. A particle may be selected once, more than once or not at all.

(i) Which **two** ions have the same electronic structure? .... [1]

(ii) Which ion has the same electronic structure as an atom of argon? .... [1]

(iii) Which atom can form an ion of the type X^{3-}? .... [1]

(iv) Which atom can form a hydride which has a formula of the type XH_4? .... [1]

(b) (i) How many protons, neutrons and electrons are there in one copper(II) ion $^{64}_{29}Cu^{2+}$?

number of protons ....

number of neutrons ....

number of electrons ....

[2]

(ii) $^{45}_{21}Sc$ represents an atom of scandium.

How many nucleons and how many charged particles are there in one atom of scandium?

number of nucleons ....

number of charged particles ....

[2]

(c) Two different atoms of sodium are $^{23}_{11}Na$ and $^{24}_{11}Na$.

(i) Explain why these two atoms are isotopes.

....

.... [2]

(ii) $^{24}_{11}Na$ is radioactive. It changes into an atom of a different element which has one more proton.

Identify this element.

.... [1]

(iii) State **two** uses of radioactive isotopes.

....

.... [2]

[Total: 13]

Q38. [0620/31/O/N/15/Q2]

Describe how to separate the following. In each example, give a description of the procedure used and explain why this method works.

(a) Copper powder from a mixture containing copper and zinc powders.

procedure ....

....

explanation ....

.... [3]

(b) Nitrogen from a mixture of nitrogen and oxygen.

procedure ....

....

explanation ....

.... [3]

(c) Glycine from a mixture of the two amino acids glycine and alanine. Glycine has the lower R_f value.

procedure ....

....

explanation ....

.... [2]

(d) Magnesium hydroxide from a mixture of magnesium hydroxide and zinc hydroxide.

procedure ....

....

explanation ....

.... [3]

[Total: 11]

68

[0620/31/O/N/15/Q6]

Q39.

Carbon and silicon are elements in Group IV. They both form oxides of the type XO_2.

(a) Silicon(IV) oxide, SiO_2, has a macromolecular structure.

(i) Describe the structure of silicon(IV) oxide.

....

....

....

....

.... [3]

(ii) State **three** properties which silicon(IV) oxide and diamond have in common.

....

....

.... [3]

(iii) How could you show that silicon(IV) oxide is acidic and not basic or amphoteric?

....

....

.... [2]

(b) Explain why the physical properties of carbon dioxide are different from those of diamond and silicon(IV) oxide.

....

.... [1]

[Total: 9]

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Q40. [0620/41/M/J/16/Q1]

Protons, neutrons and electrons are subatomic particles.

(a) Complete the table to show the relative mass and relative charge of a proton, a neutron and an electron.

particle	relative mass	relative charge
proton		
neutron		
electron	$\frac{1}{1840}$	

[3]

(b) Bromine has two isotopes.

(i) Define the term *isotope*.

....

.... [2]

(ii) Explain why the two isotopes of bromine have the same chemical properties.

....

.... [2]

(c) The table shows the number of protons, neutrons and electrons in some atoms and ions.

Complete the table.

particle	number of protons	number of neutrons	number of electrons
$^{7}_{3}Li$			
$^{34}_{16}S^{2-}$			
	19	22	18

[5]

[Total: 12]

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70

[0620/41/M/J/16/Q2-E]

Q41.

(e) Calcium phosphate is used in fertilisers. The bonding in calcium phosphate is ionic. Calcium phosphate contains the phosphate ion, PO_4^{3-}.

(i) What is ionic bonding?

....

.... [2]

(ii) Deduce the formula of calcium phosphate.

.... [1]

[0620/42/M/J/16/Q2]

Q42.

(a) (i) Define the term *atomic number*.

.... [1]

(ii) Define the term *nucleon number*.

....

.... [2]

(b) The table shows the number of protons, neutrons and electrons in some atoms or ions.

Complete the table. The first line is given as an example.

particle	number of protons	number of electrons	number of neutrons	symbol or formula
A	6	6	6	$^{12}_{6}C$
B	12	12	12	
C	8			$^{16}_{8}O^{2-}$
D	11	10	13	

[6]

[Total: 9]

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Q43. [0620/42/M/J/16/Q3]

Gallium is a metallic element in Group III. It has similar properties to aluminium.

(a) **(i)** Describe the structure and bonding in a metallic element.
You should include a labelled diagram in your answer.

....

.... [3]

(ii) Explain why metallic elements such as gallium are good conductors of electricity.

.... [1]

(b) Give the formula of

gallium(III) chloride, ...

gallium(III) sulfate. .... [2]

(c) Gallium(III) oxide, Ga_2O_3, is amphoteric.

(i) Write the chemical equation for the reaction between gallium(III) oxide and dilute nitric acid to form a salt and water only.

.... [2]

(ii) The reaction between gallium(III) oxide and sodium hydroxide solution forms only water and a salt containing the negative ion $Ga_2O_4^{2-}$.

Write the chemical equation for this reaction.

.... [2]

(d) Alloys of gallium and other elements are often more useful than the metallic element itself.

Suggest **two** reasons why alloys of gallium are more useful than the metallic element.

....

.... [2]

[Total: 12]

Q44. [0620/43/M/J/16/Q4-A]

(a) Potassium iodide is an ionic compound.

(i) Describe what happens, in terms of electron loss and gain, when a potassium atom reacts with an iodine atom.

....

....

....

.... [2]

(ii) Describe the structure of solid potassium iodide. You may draw a diagram.

....

....

.... [2]

(iii) Explain why potassium iodide has a high melting point.

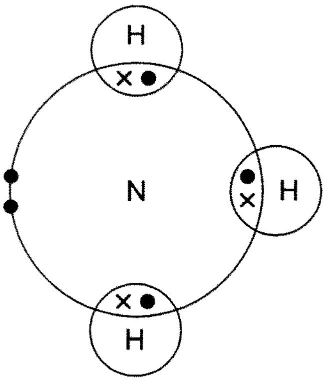
....

....

.... [2]

Q45. [0620/43/M/J/16/Q6-C-D]

(c) The diagram shows the electron arrangement in a molecule of ammonia, showing only outer shell electrons.

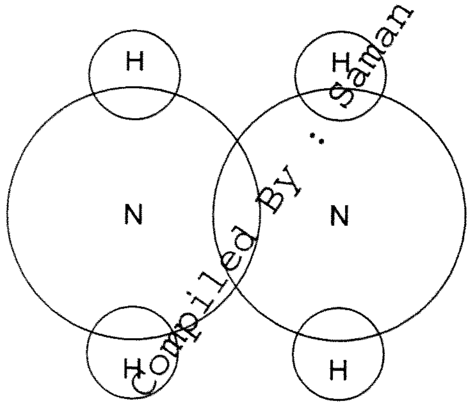


(i) State the type of bonding in ammonia.

.... [1]

(ii) Hydrazine, N_2H_4, is another compound of nitrogen and hydrogen.

Complete the diagram to show the electron arrangement in a molecule of hydrazine, showing only outer shell electrons.



[3]

(d) Nylon and proteins are both polymers containing nitrogen.

(i) Name the linkages found in the polymers of nylon and protein.

.... [1]

(ii) Describe **one** difference in the structures of nylon and protein.

.... [1]

(iii) What is the general name given to the products of hydrolysis of proteins?

.... [1]

Q46. [0620/41/O/N/16/Q1]

The table gives some information about five substances.

substance	melting point /°C	boiling point /°C	solubility in water	electrical conductivity when molten	electrical conductivity when solid
F	–97	65	very soluble	does not conduct	does not conduct
G	1600	2230	insoluble	does not conduct	does not conduct
H	801	1413	soluble	conducts	does not conduct
I	–57	126	insoluble	does not conduct	does not conduct
J	1085	2562	insoluble	conducts	conducts

(a) Which substance in the table has ionic bonding?

.... [1]

(b) Which substance in the table has a giant covalent structure?

.... [1]

(c) Name a method you could use to separate a mixture of substance **J** and water.

.... [1]

(d) Name a method you could use to obtain substance **F** from a mixture of substance **F** and water.

.... [2]

(e) Describe how you could obtain a solid sample of substance **H** from a mixture of substance **H** and substance **G**.

....

....

....

....

....

.... [3]

(f) Substance **J** is a metal.

Describe how substance **J** is able to conduct electricity when it is a solid.

....

....

.... [2]

[Total: 10]

Q47. [0620/42/O/N/16/Q2]

This question is about atoms, ions and isotopes.

(a) Define the term *nucleon number*.

....

.... [2]

(b) Give the electronic structure of the following atom and ion.

Na ....

P^{3-} ....

[2]

(c) State **one** medical use of radioactive isotopes.

.... [1]

(d) What is meant by the term *relative atomic mass*?

....

....

.... [2]

(e) Suggest why the relative atomic mass of chlorine is **not** a whole number.

....

....

.... [2]

(f) Aluminium is a metal in Group III.

Describe the bonding in aluminium.
Include a labelled diagram and any appropriate charges in your answer.

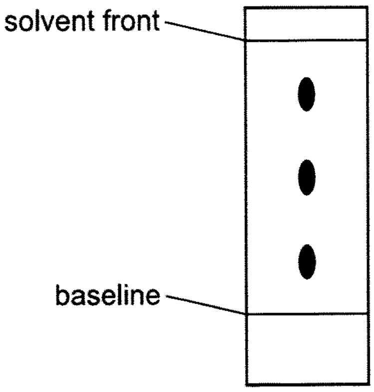
[3]

[Total: 12]

76

Q48. [0620/42/O/N/16/Q7-C]

(c) A colourless mixture of amino acids was separated by chromatography.
Amino acid **X** has an R_f value of 0.8.
The chromatogram of the mixture after treatment with a locating agent is shown.



(i) How is an R_f value calculated?

R_f =

[1]

(ii) On the diagram put a ring around the spot caused by amino acid **X**. [1]

(iii) Describe how you would perform a chromatography experiment to produce the chromatogram shown in **(c)**. Assume you have been given the mixture of amino acids and a suitable locating agent. You are provided with common laboratory apparatus.

....

....

....

....

....

.... [3]

Q49. [0620/43/O/N/16/Q1]

(a) Complete the table.

particle	charge	relative mass
proton	+1	
neutron		1
electron		

[2]

(b) The following are isotopes of carbon.

$^{12}_{6}C$ $^{13}_{6}C$ $^{14}_{6}C$

(i) In terms of numbers of protons, neutrons and electrons, how are these **three** isotopes the same and how are they different?

They are the same because ....

....

They are different because ....

.... [3]

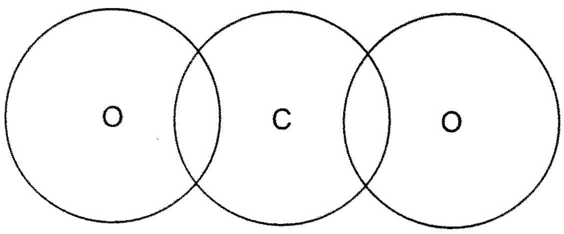
(ii) Why do all isotopes of carbon have the same chemical properties?

.... [1]

(c) Name **two** forms of the element carbon which have giant covalent structures.

.... and .... [1]

(d) Complete the diagram to show the electron arrangement in a carbon dioxide molecule.
Show the outer shell electrons only.



[2]

[Total: 9]

[0620/43/O/N/16/Q2-A]

Q50.

Beryllium is a metallic element in Group II.

(a) Give the electronic structure of a beryllium atom.

.... [1]

(b) Give the formula of beryllium oxide.

.... [1]

(c) **(i)** Describe the bonding in a metallic element such as beryllium.
Include a labelled diagram and any appropriate charges in your answer.

....

....

.... [3]

(ii) Explain why metallic elements, such as beryllium, are good conductors of electricity.

....

.... [1]

Q51. [0620/43/O/N/16/Q4-A-B-C-D]

Silicon(IV) oxide and sodium chloride have different types of bonding and structure.

(a) Name the type of bonding present in

silicon(IV) oxide, ...

sodium chloride. ....
[2]

(b) Name the type of structure present in silicon(IV) oxide.

.... [1]

(c) **(i)** Silicon(IV) oxide has a high melting point. Explain why.

....

.... [2]

(ii) Silicon(IV) oxide is a poor conductor of electricity. Explain why.

.... [1]

(d) Solid sodium chloride does not conduct electricity. However, it conducts electricity when molten.

Explain why solid sodium chloride does **not** conduct electricity, whereas molten sodium chloride does conduct electricity.

....

....

....

.... [3]

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80

Q52. [0620/41/M/J/17/Q1]

This question is about subatomic particles.

(a) Define the terms

proton number, ...

....

nucleon number. ....

.... [3]

(b) Why is the ^1_1H hydrogen atom the **only** atom to have an identical proton number and nucleon number?

....

.... [1]

(c) Complete the table to show the number of protons, neutrons and electrons in the atoms and ions given.

	number of protons	number of neutrons	number of electrons
^{19}F			9
^{26}Mg	12		
$^{31}P^{3-}$			
$^{87}Sr^{2+}$			

[6]

(d) (i) Write the formula of the compound formed from fluorine and magnesium.

.... [1]

(ii) Write the formula of the compound formed from Sr^{2+} and P^{3-}.

.... [1]

[Total: 12]

Q53. [0620/42/M/J/17/Q2-A-B-C]

Carbon and silicon are elements in Group IV of the Periodic Table. Both carbon and silicon exist as more than one isotope.

(a) Define the term *isotopes*.

....

.... [2]

(b) Complete the following table which gives information about carbon atoms and silicon atoms.

	carbon	silicon
proton number		
electronic structure		
nucleon number	12	28
number of neutrons in one atom		

[3]

(c) Silicon has a giant structure which is similar to the structure of diamond.

(i) Name the type of bond which is present between silicon atoms in silicon.

.... [1]

(ii) Suggest **two** physical properties of silicon.
Use your knowledge of structure and bonding to explain why silicon has these physical properties.

property 1 ....

reason 1 ....

property 2 ....

reason 2 .... [4]

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Q54. [0620/43/M/J/17/Q1]

Six different atoms can be represented as follows.

$^{3}_{1}A$ $^{3}_{2}D$ $^{12}_{6}E$ $^{13}_{6}G$ $^{14}_{7}J$ $^{19}_{9}L$

(a) Answer the following questions using atoms from the list. Each atom may be used once, more than once or not at all.

Select **one** atom from the six shown which

(i) has exactly seven protons,

.... [1]

(ii) has exactly six neutrons,

.... [1]

(iii) has more protons than neutrons,

.... [1]

(iv) has the electronic structure [2,5],

.... [1]

(v) is an atom of an element from Group VII of the Periodic Table,

.... [1]

(vi) is an atom of a noble gas.

.... [1]

(b) Two of the six atoms shown are isotopes of each other.

(i) What is meant by the term *isotopes*?

....

.... [2]

(ii) Which **two** of the six atoms shown are isotopes of each other?

.... [1]

(iii) Why do isotopes have identical chemical properties?

....

.... [1]

[Total: 10]

83

Q55. [0620/43/M/J/17/Q2-C]

(c) The boiling point of bromine is 59 °C and the boiling point of iodine is 184 °C.
Explain why iodine has a higher boiling point than bromine.

....

....

....

....

.... [2]

Q56. [0620/43/M/J/17/Q3]

Magnesium is a metal.

(a) Describe the structure and bonding in magnesium.

....

....

....

.... [3]

(b) Why can magnesium conduct electricity when solid?

....

....

....

.... [2]

(c) Why is magnesium malleable?

....

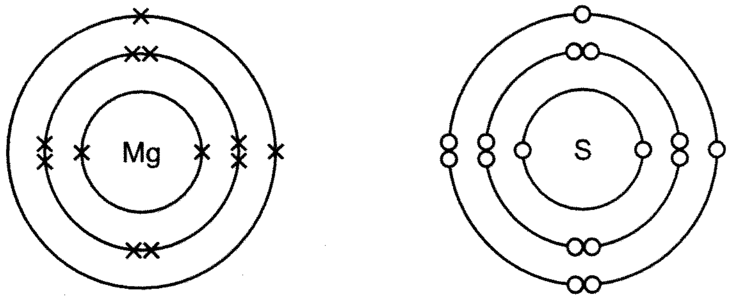
....

....

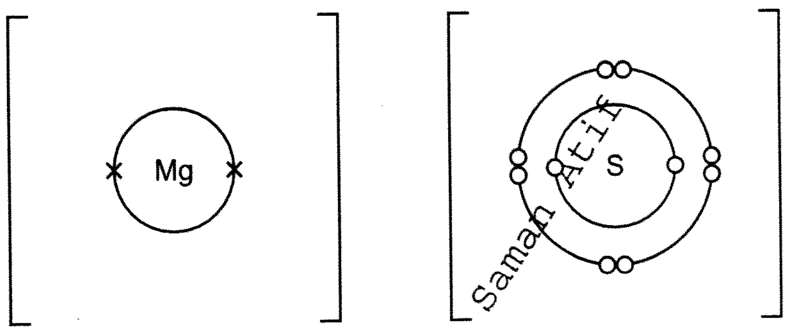
.... [2]

(d) Magnesium reacts with sulfur to form the ionic compound magnesium sulfide, MgS.

The diagrams show the electronic structures of atoms of magnesium and sulfur.



(i) Complete the diagrams to show the electronic structures of the ions in magnesium sulfide. Show the charges on the ions.



[3]

(ii) Ionic compounds, such as magnesium sulfide, do **not** conduct electricity when solid. Magnesium sulfide does **not** dissolve in water. Magnesium sulfide **does** conduct electricity under certain conditions.

State the conditions needed for magnesium sulfide to conduct electricity. Explain why magnesium sulfide conducts electricity under these conditions.

....

....

....

.... [2]

[Total: 12]

85

Q57. [0620/41/O/N/17/Q1]

The table gives information about five particles. The particles are all atoms or ions.

particle	number of protons	number of neutrons	number of electrons
A	6	8	6
B	12	12	12
C	13	14	10
D	8	8	10
E	11	12	11

Answer the following questions using the information in the table.
Each particle may be used once, more than once or not at all.

(a) Which particle, **A**, **B**, **C**, **D** or **E**,

(i) is an atom with atomic number 12,

.... [1]

(ii) is an atom with nucleon number 14,

.... [1]

(iii) is an ion with a positive charge,

.... [1]

(iv) has only **one** electron in its outer shell?

.... [1]

(b) **D** is an ion of an element.

Identify the element and write the formula of **D**.

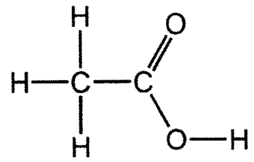
.... [2]

[Total: 6]

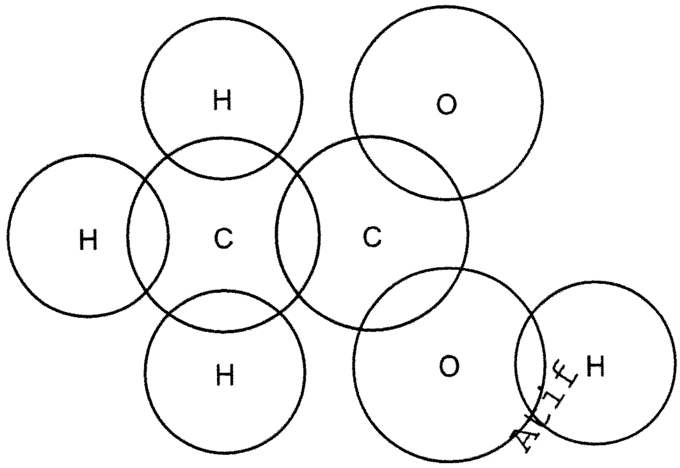
86

[0620/41/O/N/17/Q4-C-ii]

Q58. (ii) A molecule of ethanoic acid has the structure shown.



Complete the dot-and-cross diagram to show the electron arrangement in ethanoic acid. Show outer shell electrons only.



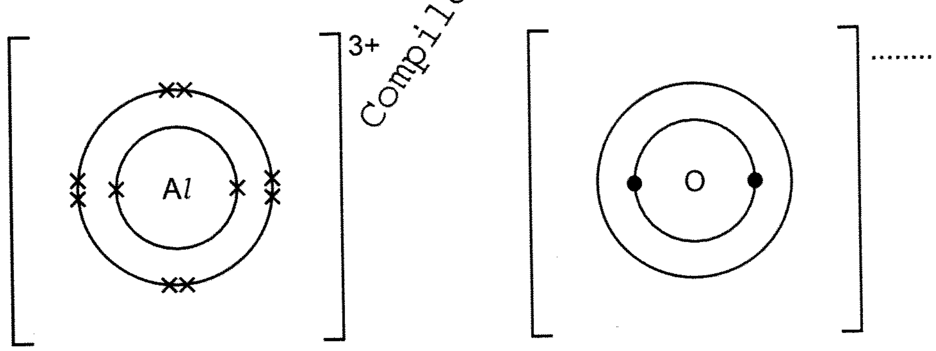
[3]

[0620/41/O/N/17/Q6-b]

Q59.

(b) Aluminium oxide is an ionic compound with a high melting point.

(i) Complete the dot-and-cross diagram to show the electron arrangement in **one** of the oxide ions present in aluminium oxide. Include the charge on the oxide ion. One of the aluminium ions is shown.



[2]

(ii) The melting point of aluminium oxide is above 2000 °C.

Explain why aluminium oxide has a high melting point.

....

....

.... [2]

Q60. [0620/42/O/N/17/Q2]

(a) Complete the table to show the electronic structure of the atoms and ions.

	electronic structure
F	2,7
Si	
Ca^{2+}	
N^{3-}	

[3]

(b) Predict the formula of the compound formed between Ca^{2+} and N^{3-}.

.... [1]

(c) Draw a dot-and-cross diagram to show the electron arrangements in the **two** ions present in lithium chloride, LiC*l*.
Show outer shell electrons only. Include the charges on the ions.

[3]

(d) Sulfur dichloride, SCl_2, is a covalent compound. It has the structure C*l*–S–C*l*.

Draw a dot-and-cross diagram to show the electron arrangement in a molecule of sulfur dichloride.
Show outer shell electrons only.

[3]

(e) In terms of attractive forces, explain why $LiCl$ has a higher melting point than SCl_2.

....

....

....

....

.... [3]

(f) Suggest the identity of a **covalent compound** with a higher melting point than $LiCl$.

.... [1]

[Total: 14]

Q61. [0620/43/O/N/17/Q2]

(a) (i) Define the term *molecule*.

....

.... [2]

(ii) Define the term *element*.

....

.... [1]

(b) The table shows the composition of four atoms or ions, **A**, **B**, **C** and **D**.

	number of protons	number of neutrons	number of electrons
A	10	10	10
B	10	12	10
C	12	10	10
D	13	14	10

(i) What is the atomic number of **A**?

.... [1]

(ii)

.... [1]

(iii) Which of **A**, **B**, **C** and **D** are isotopes of each other?

.... [1]

(iv) Which of **A**, **B**, **C** and **D** are atoms?

.... [1]

(v) Which of **A**, **B**, **C** and **D** are positive ions?

.... [1]

(c) Complete the table.

	number of protons	number of electrons
Na		
S^{2-}		
Cl_2		

[3]

[Total: 11]

Q62. [0620/41/M/J/18/Q1]

Substances can be classified as elements, compounds or mixtures.

(a) What is meant by the term *compound*?

....

....

.... [2]

(b) Mixtures can be separated by physical processes.

A sequence of physical processes can be used to separate common salt (sodium chloride) from a mixture containing sand and common salt only.

Give the order and the correct scientific term for the physical processes used to separate the common salt from the mixture.

1 ....

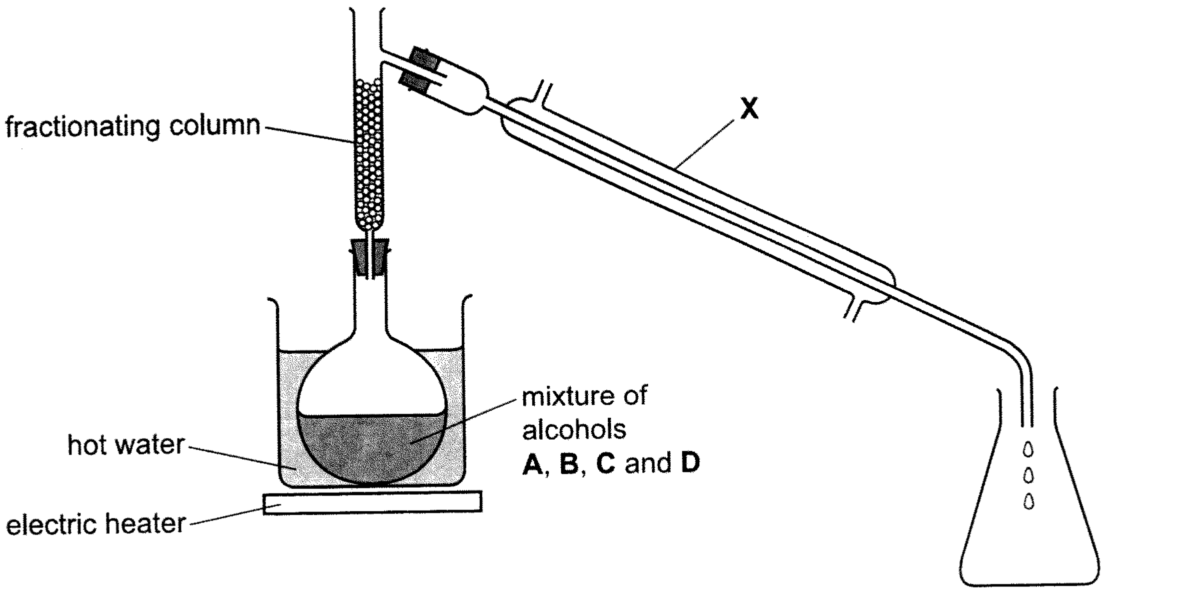
2 ....

3 ....
[4]

The boiling points of four different alcohols, **A**, **B**, **C** and **D**, are shown.

alcohol	A	B	C	D
boiling point/°C	56	78	122	160

(c) A student suggested that the apparatus shown could be used to separate the mixture of alcohols.



(i) Apparatus **X** needs to have cold water flowing through it.

- Draw an arrow on the diagram to show where the cold water enters apparatus **X**.
- Name apparatus **X**.

....

[2]

(ii) Part of the fractionating column is missing. This means that the experiment will not work.

- Draw on the diagram the part of the fractionating column which is missing.
- Explain why the experiment will **not** work with this part of the fractionating column missing.

....

....

[2]

(iii) Suggest why a Bunsen burner is **not** used to heat the flask.

.... [1]

(iv) A hot water bath cannot be used to separate alcohols **C** and **D**.

Explain why.

....

....

.... [2]

[Total: 13]

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Q63. [0620/42/M/J/18/Q3]

Complete the following table.

particle	number of protons	number of electrons	number of neutrons	number of nucleons
$^{23}_{11}Na$	11	11	....	23
$^{37}_{17}Cl^{-}$	....	....	20	....
$^{56}_{26}$............	26	24	30	56

[6]

[Total: 6]

Q64. [0620/42/M/J/18/Q4-A-B-D-E]

Potassium reacts with bromine at room temperature to form potassium bromide.

(a) Write a chemical equation for this reaction. Include state symbols.

.... [3]

(b) Potassium bromide exists as an ionic lattice.
Potassium bromide does **not** conduct electricity when solid but does conduct electricity when molten.

(i) What is meant by the term *ionic lattice*?

....

.... [2]

(ii) Explain why potassium bromide does **not** conduct electricity when solid but does conduct electricity when molten.

....

....

.... [2]

(d) Iodine reacts with chlorine to form iodine monochloride, ICl, as the only product.

(i) Write a chemical equation for this reaction.

.... [2]

(ii) Draw a dot-and-cross diagram to show the electron arrangement in a molecule of iodine monochloride. Show outer shell electrons only.

[2]

(e) Potassium bromide has a melting point of 734 °C.
Iodine monochloride has a melting point of 27 °C.

In terms of attractive forces, explain why there is a large difference between these melting points.

....

....

....

....

.... [3]

[0620/32/O/N/13/Q1]

Q65. The table gives the melting points, the boiling points and the electrical properties of six substances A to F.

substance	melting point / °C	boiling point / °C	electrical conductivity as a solid	electrical conductivity as a liquid
A	–210	–196	does not conduct	does not conduct
B	777	1627	does not conduct	good conductor
C	962	2212	good conductor	good conductor
D	–94	63	does not conduct	does not conduct
E	1410	2355	does not conduct	does not conduct
F	1064	2807	good conductor	good conductor

(a) Which **two** substances could be metals? .... [1]

(b) Which substance could be nitrogen? .... [1]

(c) Which substance is an ionic solid? .... [1]

(d) Which substance is a liquid at room temperature? .... [1]

(e) Which substance has a giant covalent structure similar to that of diamond? .... [1]

(f) Which **two** substances could exist as simple covalent molecules? .... [1]

[Total: 6]

95

Q66. [0620/43/O/N/17/Q1]

Substances can be classified as elements, compounds or mixtures.

State whether each of the following is an element, a compound or a mixture.

(a) brass .... [1]

(b) gold .... [1]

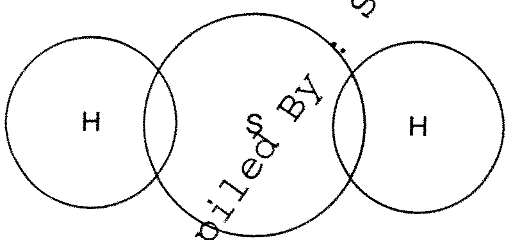
(c) butane .... [1]

(d) air .... [1]

[Total: 4]

Q67. [0620/41/O/N/18/Q4-C-ii_iii]

(ii) Complete the dot-and-cross diagram to show the electron arrangement in a molecule of hydrogen sulfide. Show outer shell electrons only.



[2]

(iii) Hydrogen sulfide has a simple molecular structure.

Explain why hydrogen sulfide has a low boiling point.

....

....

.... [2]

[0620/41/O/N/18/Q2]

Q68.

The table gives some information about four different particles, **A**, **B**, **C** and **D**.

particle	number of electrons	number of neutrons	number of protons	electronic structure	charge on particle
A	11	12	11	2,8,1	0
B		14	11	2,8,1	0
C	18	20		2,8,8	0
D	18	20	17		

(a) Complete the table. The first row has been done for you. [4]

(b) Give **two** particles from the table which are isotopes of each other.

.... [1]

(c) Element **Z** is in the same group of the Periodic Table as **A** and is less reactive than **A**.

State the identity of element **Z**.

.... [1]

(d) **C** is unreactive.

Use information from the table to explain why.

.... [1]

[Total: 7]

97

Q69. [0620/42/O/N/18/Q2-A-B-D]

Magnesium, calcium and strontium are Group II elements.

(a) Complete the table to show the arrangement of electrons in a calcium atom.

shell number	1	2	3	4
number of electrons				

[1]

(b) Describe how the arrangement of electrons in a strontium atom is:

(i) similar to the arrangement of electrons in a calcium atom

....

....

(ii) different from the arrangement of electrons in a calcium atom.

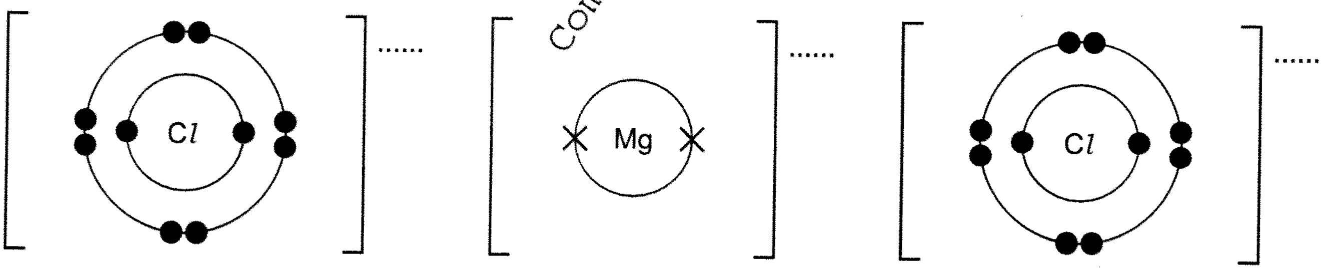
....

....

[2]

(d) Magnesium reacts with chlorine to form magnesium chloride, $MgCl_2$. Magnesium chloride is an ionic compound.

(i) Complete the diagrams to show the electronic structures of the ions in magnesium chloride. Show the charges on the ions.



[3]

(ii) Give **three** physical properties that are typical of ionic compounds such as $MgCl_2$.

1 ....

2 ....

3 ....

[3]

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Q70. [0620/41/M/J/19/Q1]

This question is about the structures of atoms and ions.

(a) Define the term *proton number*.

....

.... [2]

(b) **(i)** Complete the table to show the number of protons, neutrons and electrons present in atoms of $^{24}_{12}Mg$ and $^{26}_{12}Mg$.

	number of protons	number of neutrons	number of electrons
$^{24}_{12}Mg$			
$^{26}_{12}Mg$			

[2]

(ii) What term is used to describe atoms of the same element, such as $^{24}_{12}Mg$ and $^{26}_{12}Mg$?

.... [1]

(iii) Explain why the chemical properties of $^{24}_{12}Mg$ and $^{26}_{12}Mg$ are the same.

....

.... [2]

(c) Complete the table to identify the atoms and ions which have the following numbers of protons, neutrons and electrons.

	number of protons	number of neutrons	number of electrons
$^{23}_{11}Na^{+}$	11	12	10
	4	5	4
	17	20	18

[4]

(d) State the electronic structure of the following atom and ion.

A*l* ....

S^{2-} ....

[2]

[Total: 13]

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Q71. [0620/42/M/J/19/Q2]

(a) $^{22}_{11}Na$, $^{23}_{11}Na$ and $^{24}_{11}Na$ are isotopes of sodium.

(i) Describe how these sodium isotopes are the same and how they are different in terms of the total number of protons, neutrons and electrons in each.

same ....

....

different ....

....
[3]

(ii) Why do all **three** isotopes have an overall charge of zero?

....

.... [1]

(iii) Why do all **three** isotopes have the same chemical properties?

....

.... [2]

(iv) Why do sodium ions have a charge of +1?

....

.... [1]

(b) Carbon is an element which exists in different forms.

(i) Name **two** forms of the element carbon that have giant covalent structures.

.... and .... [1]

(ii) Name the oxide of carbon that is a toxic gas.

.... [1]

[Total: 9]

100

[0620/42/M/J/19/Q3-A]

Q72.

This question is about phosphorus and compounds of phosphorus.

(a) Phosphorus has the formula P_4. Some properties of P_4 are shown.

melting point / °C	45
boiling point / °C	280
electrical conductivity	non-conductor
solubility in water	insoluble

(i) Name the type of bonding that exists between the atoms in a P_4 molecule.

.... [1]

(ii) Explain, in terms of attractive forces between particles, why P_4 has a low melting point.

....

.... [1]

(iii) Explain why phosphorus is a non-conductor of electricity.

....

.... [1]

[0620/41/O/N/19/Q1-C]

Q73.

(c) Magnesium phosphate contains magnesium ions, Mg^{2+}, and phosphate ions, PO_4^{3-}.

Deduce the formula of magnesium phosphate.

.... [1]

101

Q74. [0620/43/M/J/19/Q1]

Atoms contain particles called electrons, neutrons and protons.

(a) Complete the table.

particle	where the particle is found in an atom	relative mass	relative charge
	orbiting the nucleus	$\frac{1}{1840}$	
			+1
	in the nucleus		

[3]

(b) How many electrons, neutrons and protons are there in the ion shown?

$$^{44}_{20}Ca^{2+}$$

number of electrons ....

number of neutrons ....

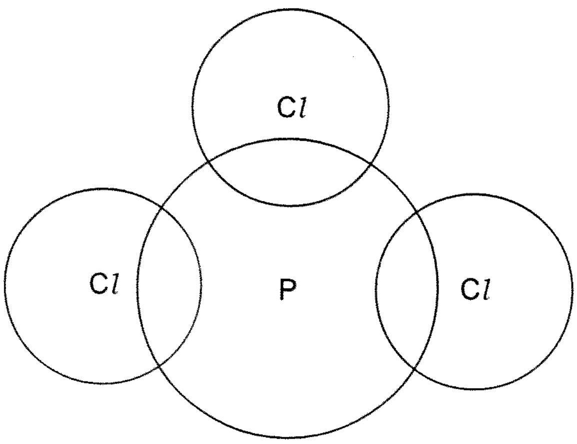
number of protons ....

[3]

[Total: 6]

Q75. [0620/43/O/N/19/Q4-B-ii]

(ii) Complete the dot-and-cross diagram to show the electron arrangement in a molecule of phosphorus(III) chloride, PCl_3. Show outer shell electrons only.



[2]

102

[0620/43/M/J/19/Q2]

Q76.

Magnesium exists as three isotopes, $^{24}_{12}Mg$, $^{25}_{12}Mg$ and $^{26}_{12}Mg$.

(a) State, in terms of the total numbers of electrons, neutrons and protons, **one** difference and **two** similarities between these magnesium isotopes.

difference ....

similarity 1 ....

similarity 2 .... [3]

(b) All isotopes of magnesium react with dilute hydrochloric acid to make hydrogen and a salt.

(i) Why do all isotopes of magnesium react in the same way?

....

....

.... [2]

(ii) Write a chemical equation for the reaction between magnesium and dilute hydrochloric acid.

.... [2]

(iii) Describe a test for hydrogen.

test ....

result .... [2]

(c) Magnesium is a metal.

Describe the structure and bonding of metals. Include a labelled diagram in your answer.

....

....

....

.... [3]

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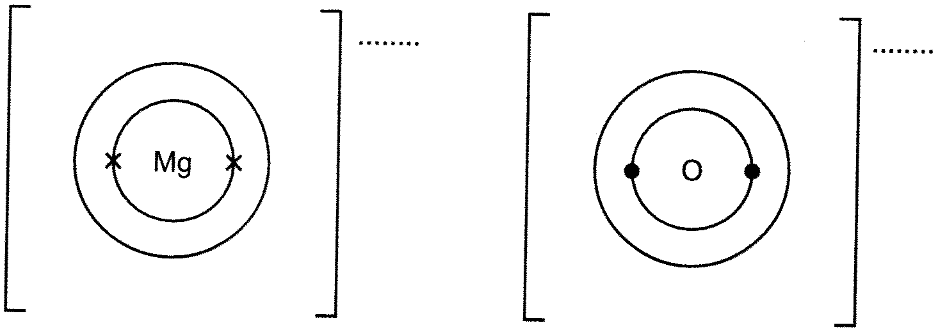
(d) Magnesium reacts with oxygen to form the ionic compound magnesium oxide.

(i) Complete the dot-and-cross diagrams to show the electronic structures of the ions in magnesium oxide. Show the charges on the ions.



[3]

(ii) Magnesium oxide melts at 2853 °C.

Why does magnesium oxide have a high melting point?

....

.... [1]

(iii) Explain why molten magnesium oxide can conduct electricity.

....

....

.... [1]

[Total: 17]

Q77. [0620/41/O/N/19/Q2-A-B]

(a) Sulfur exists as a number of different isotopes.

What is meant by the term *isotopes*?

....

....

.... [2]

(b) A sulfide ion has the symbol shown.

$$^{34}_{16}S^{2-}$$

(i) How many neutrons are contained in this sulfide ion?

.... [1]

(ii) How is a sulfide ion, S^{2-}, formed from a sulfur atom?

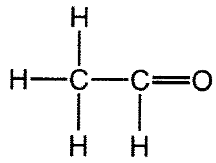
.... [1]

(iii) Which element forms an ion with a 2+ charge that has the same number of electrons as a S^{2-} ion?

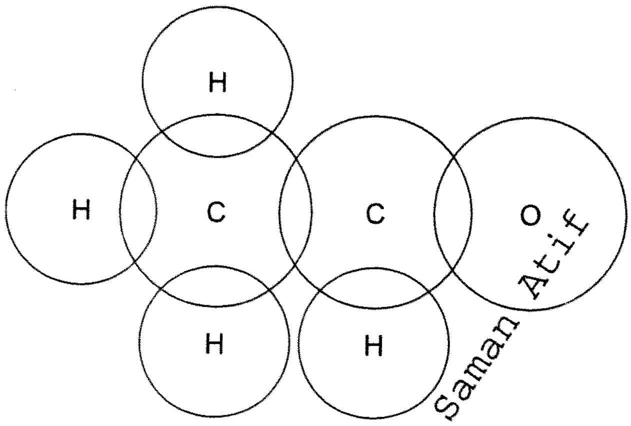
.... [1]

Q78. [0620/41/O/N/19/Q7-C-ii]

(ii) The structure of ethanal is shown.



Complete the dot-and-cross diagram to show the electron arrangement in a molecule of ethanal. Show outer shell electrons only.



[3]

(iii) The table gives the boiling points of ethanal and ethanol.

substance	boiling point/°C
ethanal	20
ethanol	78

In terms of attractive forces between particles, suggest why ethanal has a lower boiling point than ethanol.

....

.... [1]

106

[0620/42/O/N/19/Q1-A]

Q79.

The Periodic Table is very useful to chemists.

Refer only to elements with atomic numbers 1 to 36 in the Periodic Table provided when answering **Question 1**.

(a) Use information from the Periodic Table provided to identify **one** element which:

(i) has atoms with exactly 9 protons .... [1]

(ii) has atoms with 0 neutrons .... [1]

(iii) has atoms with exactly 23 electrons .... [1]

(iv) has atoms with an electronic structure of 2,8,6 .... [1]

(v) forms ions with a charge of 3– containing 18 electrons .... [1]

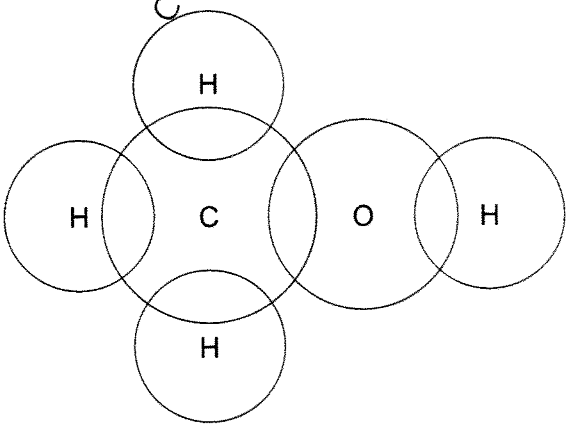
(vi) forms ions with a charge of 2+ containing 10 electrons .... [1]

(vii) has a relative atomic mass that shows it has at least two isotopes. .... [1]

[0620/42/O/N/19/Q5-B]

Q80. Methanol, CH_3OH, is a member of the homologous series of alcohols.

(b) Draw a dot-and-cross diagram to show the electron arrangement in a molecule of methanol. Show outer shell electrons only.



[2]

107

Q81. [0620/43/O/N/19/Q1]

(a) Atoms are made of smaller particles called electrons, neutrons and protons.

Complete the table.

particle	relative charge	relative mass
electron		$\frac{1}{1840}$
neutron		
proton	+1	

[2]

(b) The table gives information about atoms and ions **A**, **B** and **C**.

Complete the table.

	number of electrons	number of neutrons	number of protons	symbol
A		14	13	${}^{27}_{13}Al$
B			12	${}^{25}_{12}Mg^{2+}$
C	10	10	9	

[6]

[Total: 8]

Q82. [0620/43/O/N/19/Q2]

The table shows the melting points, boiling points and electrical conductivities of six substances **D**, **E**, **F**, **G**, **H** and **I**.

substance	melting point /°C	boiling point /°C	electrical conductivity when solid	electrical conductivity when liquid
D	1610	2230	non-conductor	non-conductor
E	801	1413	non-conductor	good conductor
F	–119	43	non-conductor	non-conductor
G	1535	2750	good conductor	good conductor
H	114	184	non-conductor	non-conductor
I	–210	–196	non-conductor	non-conductor

Choose substances from the table which match the following descriptions. Each substance may be used once, more than once or not at all.

(a) Which substance is a liquid at 25 °C? .... [1]

(b) Which substance is a gas at 25 °C? .... [1]

(c) Which **three** substances contain simple molecules?

.... [3]

(d) Which substance could be a metal? Give a reason for your answer.

substance ....

reason ....

.... [2]

(e) Which substance has a macromolecular structure? Give **two** reasons for your answer.

substance ....

reason 1 ....

reason 2 .... [3]

(f) Which substance is an ionic solid? Give **one** reason for your answer.

substance ....

reason ....

.... [2]

[Total: 12]

109

Q83. [0620/41/M/J/20/Q2]

Magnesium is a metal.

(a) Name and describe the bonding in magnesium.

name ....

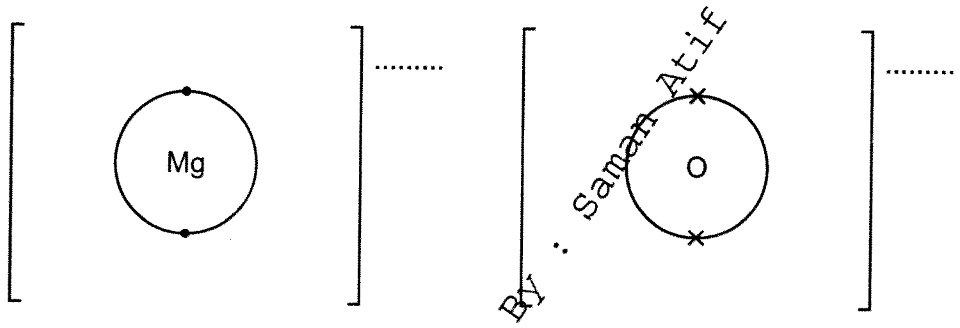
description of bonding ....

....

.... [4]

(b) Magnesium oxide, MgO, is formed when magnesium burns in oxygen.

(i) Complete the dot-and-cross diagram to show the electron arrangement of the ions in magnesium oxide.
The inner shells have been drawn.
Give the charges on the ions.



[3]

(ii) Write the chemical equation for the reaction that occurs when magnesium burns in oxygen.

.... [2]

(c) Magnesium oxide also forms when magnesium nitrate, $Mg(NO_3)_2$, is heated strongly. This is an endothermic reaction.

(i) Write the chemical equation for this reaction.

.... [2]

(ii) What type of reaction is this?

.... [1]

(iii) Name **two** other compounds of magnesium that form magnesium oxide when heated.

....

.... [2]

[Total: 14]

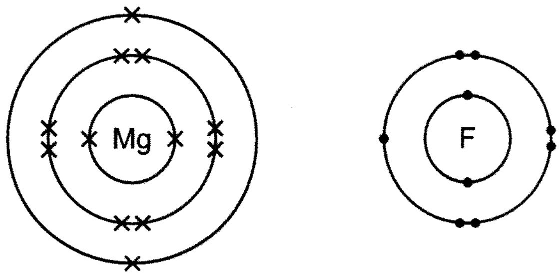
110

Q84. [0620/42/M/J/20/Q2]

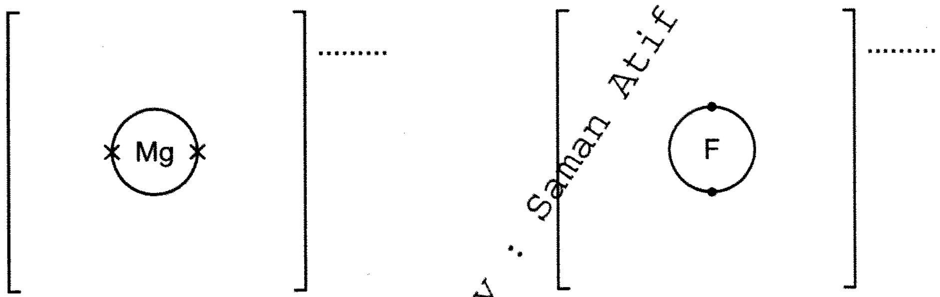
Fluorine forms both ionic and covalent compounds.

(a) Magnesium reacts with fluorine to form the ionic compound magnesium fluoride.

The electronic structures of an atom of magnesium and an atom of fluorine are shown.



(i) Complete the dot-and-cross diagrams to show the electronic structures of one magnesium ion and one fluoride ion. Show the charges on the ions.



[3]

(ii) What is the formula of magnesium fluoride?

.... [1]

(iii) Magnesium fluoride does **not** conduct electricity when it is solid.

What can be done to solid magnesium fluoride to make it conduct electricity?

In your answer explain why magnesium fluoride conducts electricity when this change is made.

....

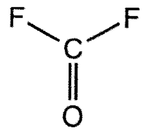
....

....

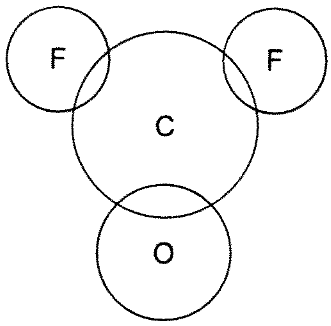
.... [2]

111

(b) Carbonyl fluoride, COF_2, is a covalent compound. The structure of a molecule of COF_2 is shown.



Complete the dot-and-cross diagram to show the electron arrangement in a molecule of carbonyl fluoride. Show outer shell electrons only.



[3]

(c) The melting points of magnesium fluoride and carbonyl fluoride are shown.

	melting point / °C
magnesium fluoride	1263
carbonyl fluoride	−111

(i) Explain, using your knowledge of structure and bonding, why magnesium fluoride has a high melting point.

....

....

....

.... [2]

(ii) Explain, using your knowledge of structure and bonding, why carbonyl fluoride has a low melting point.

....

....

....

.... [2]

[Total: 13]

112

Q85. [0620/43/M/J/20/Q3-A-B-C]

Chlorine is in Group VII of the Periodic Table.

(a) Two isotopes of chlorine are chlorine-35 and chlorine-37.

(i) State why these two isotopes of chlorine have the same chemical properties.

....

....

.... [2]

(ii) Complete the table to show the number of electrons, neutrons and protons in each atom and ion.

	number of electrons	number of neutrons	number of protons
$^{35}_{17}Cl$			
$^{37}_{17}Cl^{-}$			

[3]

(b) (i) Chlorine reacts with aqueous sodium bromide.

The equation for the reaction is shown.

$$Cl_2 + 2NaBr \rightarrow 2NaCl + Br_2$$

State the type of reaction shown.

.... [1]

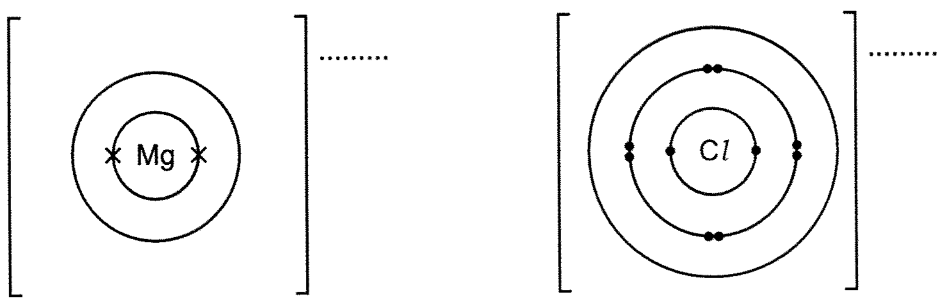
(ii) Why is there **no** reaction between iodine and aqueous sodium bromide?

.... [1]

(c) Magnesium reacts with chlorine to form magnesium chloride.

Complete the dot-and-cross diagram to show the electron arrangement of the ions in magnesium chloride. Give the charges on the ions.

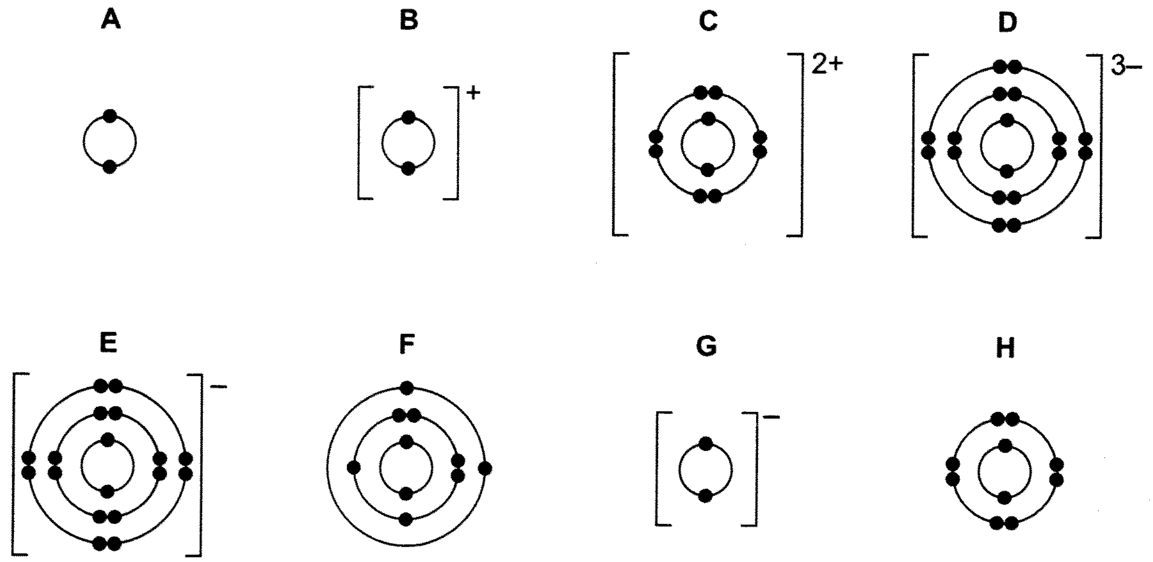
The inner shells have been completed.



[3]

Q86. [0620/42/O/N/2020/Q1]

The electronic structures of some atoms and ions are shown.



(a) Write the letters, **A**, **B**, **C**, **D**, **E**, **F**, **G** or **H**, of the electronic structures which show:

(i) atoms of two different noble gases .... and .... [2]

(ii) an ion of a Group I element .... [1]

(iii) an ion of a Group V element .... [1]

(iv) a pair of ions that could form a compound with the formula XY_2. .... and .... [1]

(b) State which electronic structure, **A**, **B**, **C**, **D**, **E**, **F**, **G** or **H**, is incorrect.

Explain why.

incorrect electronic structure ....

explanation ....

.... [2]

(c) State how many protons are found in the nucleus of ion **C**. .... [1]

(d) Use the Periodic Table to deduce:

(i) the chemical symbol for ion **G** .... [1]

(ii) the element which forms an ion with a 3+ charge and the same electronic structure as **H**.

.... [1]

[Total: 10]

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Q87. [0620/43/O/N/2020/Q2]

The table gives information about five particles, **A**, **B**, **C**, **D** and **E**.

particle	number of electrons	number of neutrons	number of protons
A	10	13	11
B	18	20	18
C	18	18	18
D	10	12	8
E	10	10	10

(a) State the atomic number of **A**.

.... [1]

(b) State the nucleon number of **B**.

.... [1]

(c) Write the electronic structure of **C**.

.... [1]

(d) Give the letters of all the particles which are:

(i) atoms .... [1]

(ii) positive ions .... [1]

(iii) negative ions .... [1]

(iv) isotopes of each other. .... [1]

[Total: 7]

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Q1.

(a) neon has full outer shell / energy level / valency shell / octet / 8 (electrons) in outer shell / neon does not need to lose or gain electrons; [1]
fluorine atoms have 7 electrons / needs 1 to fill / has incomplete shell / forms bonds with other fluorine atoms / fluorine (atoms) form covalent bonds / shares electrons; [1]

(b) atomic number / proton number / number of protons (in one atom); [1]

(c) weak intermolecular (or between molecules) forces / Van der Waals forces between molecules / low amount of energy required to break bonds between molecules; [1]
strong bonds don't break / covalent bonds don't break / (unnamed) bonds within molecules / between atoms don't break; [1]

(d) 1 non-bonding pair on each nitrogen atom; [1]
6 electrons between nitrogen atoms; [1]

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Q2.

(a) weak forces between layers or between (hexagonal) rings / weak bonds between layers or between (hexagonal) rings / Van der Waals forces between layers or between (hexagonal) rings; [1]
(layers/rings) slip/slide (over each other) / move over each other [1]

(b) strong bonds (between atoms) / covalent bonds (between atoms); [1]
all bonds are covalent/strong / each atom covalently bonded / carbon (atoms) is bonded to four others / bonds are directional / (atoms are arranged) tetrahedrally; [1]
accept: carbon has four bonds

(c) graphite has delocalised / mobile / free electrons; [1]
diamond (outer shell) electrons used / fixed / localised in bonding / no delocalised electrons / no mobile electrons / no free electrons; [1]

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Q3.

(a) flexible / easily form different shapes / easily moulded / bends (without cracking); [1]
non-biodegradable / unreactive / don't corrode / prevent corrosion / prevent oxidation (of the conducting metal) / water resistant / waterproof; [1]

(b) improve appearance / decorative / makes appearance shiny; [1]
prevent corrosion / rusting / protect steel / chromium will not corrode / chromium is not oxidised / chromium protected by an oxide layer; [1]

(c) low density / light / protected by oxide layer / no need to paint / resists corrosion / (high) strength / strong;; **any two** [2]
note: high strength to weight ratio = 2

(d) high mpt / withstands high temperature / good conductor (of heat) / heats up quickly / malleable / ductile / resists corrosion / good appearance / unreactive (or example of lack of reactivity e.g. does not react with food or water or acid or air);; **any two** [1]

(e) (lattice) positive ions / cations / metal ions and sea of electrons / delocalised or free or mobile or moving electrons; [1]
attraction between positive ions and electrons; [1]

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Q4.

(a) (i) become darker; [1]

(ii) increase; [1]

(iii) black / dark grey; [1]
not: brown
solid; [1]

(b) (i) same Z / same number of protons; [1]
accept: atoms of the same element
different number of neutrons / different nucleon number / different mass number; [1]

(ii) 53 protons and 53 electrons; [1]

78 neutrons; [1]

(iii) xenon; [1]

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Q5.

(c) each chlorine 1 bp and 3 nbps; [1]
4 e between carbon atom and oxygen atom; [1]
2 nbps on oxygen atom; [1]

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Q6.

(a) (i) melting point is below 25°C; [1]
boiling point above 25°C; [1]
accept: argument based on actual values
note: 25°C is between mp and bp = [2]

(ii) strontium loses 2e; [1]
sulfur gains 2e; [1]

(iii) hydrogen chloride / hydrochloric acid; [1]
accept: sulfurous acid or sulfur dioxide

(iv) molten strontium chloride has ions / ionic compound; [1]
which can move; [1]
sulfur chloride has no ions / only molecules / molecular / covalent; [1]

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Q7.

(iii) 4bps around C; [1]
1 bp on each hydrogen; [1]
2bps and 2nbps on oxygen; [1]

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Q8.

(c) (i) methanoic acid; [1]
correct SF showing all bonds; [1]
accept: -OH

(ii) methyl methanoate; [1]

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Q9.

(a) (i) zinc mixed with an element(s) or metal(s) or non-metal; [1]

(ii) galvanising / baths / coating steel (i.e. description of galvanising) / roofing / sacrificial protection / protection from rusting / electroplating / zinc plating / batteries; [1]

(iii) (lattice) positive ions / cations / metal ions / sea of electrons / delocalised or free or mobile or moving electrons; [1]
attraction between positive ions and electrons; [1]
the layers (of ions) or particles can slide or slip or shift past each other; [1]

(iv) different atom / ion / particle of different size; [1]
prevents (layers / atoms / ions / particles / molecules) moving / slipping / sliding / shifting; [1]

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Q10.

(b) ethyl propenoate; [1]
correct SF all bonds shown;; [2]
allow: [1] for correct displayed ester linkage

(c) (i) number of atoms of each element; [1]
in one molecule; [1]

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Q11.

(a) (i) $Zn + 2HCl \rightarrow ZnCl_2 + H_2$ [2]
not balanced = [1]

(ii) 3 bps and 1 nbp around As; [1]
1 bp each hydrogen atom; [1]

(iii) $H_2As–AsH_2$ / $AsH_2–AsH_2$; [1]

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Q12.

(d) 4 hydrogen atoms 1 bonding pair each [1]
2 nitrogen atoms with 1 bonding pair between them [1]
one non-bonding pair on each N (need not be seen as a pair) [1]

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Q13.

(a) **(i)** regular arrangement / repeating pattern **NOT** structure [1]
cond: ions [1]
not molecules / atoms

(ii) attraction between opposite charges / electrostatic attraction [1]

(b) delocalised / mobile / free / sea of electrons [1]
positive ions / cations
not atoms / protons / nuclei [1]
attraction between these electrons and ions [1]

(c) **giant covalent**
no ions [1]
no delocalised / free / mobile / sea of electrons **or** all electrons [1]

ionic
in ionic solid ions cannot move [1]
liquid ionic compound ions can move [1]

metallic
(both solid and liquid) metals have delocalised (or alternative term) electrons [1]

[Total: 11]

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Q14.

(a) B $^{39}_{19}K$ [1]
positive charge + [1]

C $^{65}_{30}Zn$ [1]

D $^{16}_{8}O$ [1]
charge 2– [1]

E $^{70}_{31}Ga$ [1]

(b) number of p = number of e [1]

number of p > number of e [1]

number of p < number of e [1]

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Q15.

(c) (i) to make colourless / invisible (spots) [1]
visible / coloured / seen / position made clear / indicate [1]

(ii) $\frac{\text{distance travelled by sample}}{\text{distance travelled by solvent (front)}} = R_f$ [1]

(iii) sample 1 R_f = 0.20 to 0.24 tartaric (acid) [1]
sample 2 R_f = 0.44 to 0.48 malic (acid) [1]

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Q16.

(a) (i) *element*
cannot be broken into anything simpler [1]
by chemical means [1]
OR made up of one type of atom only [2]

(ii) *compound*
two **or** more different elements [1]
chemically bonded together [1]

(iii) *mixture*
two **or** more substances not chemically joined together [1]

(b) (i) mixture [1]

(ii) compound [1]

(iii) element [1]

(c) conductivity (of heat or electricity) [1]

[Total: 9]

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Q17.

(c) four oxygen atoms around each germanium atom [1]
two germanium atoms around each oxygen atom [1]
tetrahedral [1]

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Q18.

(a) (i) measure melting point — **NOT** just heating [1]
pure sample would melt at 135 °C [1]
OR impure would melt lower than 135 °C

(ii) $C_3H_4O_4$ [1]

(iii) $C_2H_4O_2$ **OR** CH_3COOH [1]
ethanoic **OR** acetic acid [1]
both marks are independent of each other

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Q19.

(a) uranium / plutonium / thorium [1]

(b) graphite / carbon [1]

(c) platinum / titanium / mercury / gold [1]
NOT: carbon / graphite

(d) helium [1]

(e) nitrogen / phosphorus [1]

(f) argon [1]
ACCEPT: any ion 2 + 8 + 8 e.g. K^+ etc.

(g) tellurium [1]
ACCEPT: correct symbol

[Total: 7]

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Q20.

(a) same number of protons [1]
same number of electrons [1]
different number of neutrons [1]

(b) (i) ^{235}U / ^{239}Pu [1]
NOTE: need symbol or name and nucleon number

(ii) treating cancer / chemotherapy / radiographs / tracer studies / x–ray (scans) / sterilise surgical instruments / diagnose or treat thyroid disorders / radiotherapy [1]

paper thickness / steel thickness / radiographs / welds / tracing / fill levels in packages / food irradiation / smoke detectors [1]
ACCEPT: any other uses

(iii) $Zr + 2H_2O \rightarrow ZrO_2 + 2H_2$ [2]
not balanced = (1) only

(iv) hydrogen explodes / fire (risk) [1]

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Q21.

(a) (i) positive **and** negative ions [1]
regular pattern / opposite charges closer than the same charge [1]

(ii) so that charges cancel / ions may not have the same charge [1]

(iii) Any **three** of:
high melting point or boiling point
hard
brittle
soluble in water / insoluble in organic solvents
conduct (electricity) in liquid state **or** in aqueous solution / non-conductors or poor conductor (when solid) [3]

(b) correct formula [1]
correct charges [1]
6x and 2o around oxygen [1]

[Total: 9]

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Q22.

(a) A, D, E (1)

same number of protons and electrons / electrically neutral (1) [2]

(b) C (1)

more electrons than protons / $36e^-$ and $34p^+$ / it has gained electrons (1) [2]

(c) B, F (1) [1]

(d) they have same number of protons (1)

different number of neutrons / neutron number (1) [2]

[Total: 7]

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Q23.

(c) (i) $CH_4 + 2O_2 \rightarrow CO_2 + 2H_2O$ (1) [1]

(ii) would get a mixture of helium and carbon dioxide
or would get a mixture of gases
or waste of methane / natural gas / fossil fuel (1) [1]

(iii) fractional distillation (1) [1]

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Q24.

(a) (i)

Group number	I	II	III	IV	V	VI	VII
symbol	Na	Mg	Al	Si	P	S	Cl
number of valency electrons	1	2	3	4	5	6	7
valency	1	2	3	4	3	2	1

(1) for each line [2]

(ii) number of valency electrons = the group number (1) [1]

(iii) for Na to Al
the valency is the same as the number of valency (outer) electrons (1)

(because) this is the number of electrons **lost** (for full energy level) (1)

for P to Cl
the valency is 8 – [number of valency (outer) electrons]
or valency + valency electrons = 8 (1)

(because) this is number of electrons **needed** (or to be **gained**) (for full energy level) (1)

(b) (i) Assume change is from L to R unless clearly stated:
basic to amphoteric to acidic (2) [2]

(ii) ionic (metal) chlorides on the left (1)
covalent (non-metal) chlorides on the right (1) [2]

[Total: 11]

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Q25.

(a) A and E **need both** (1) [1]

(b) D (1) [1]

(c) C (1) [1]

(d) B (1) [1]

(e) F (1) [1]

(f) E (1) [1]

(g) C (1) [1]

[Total: 7]

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Q26.

(c) each chlorine 1 bond pair and 3 non-bond pair (1)

oxygen atom 2 non-bond pairs and 2 bond pairs as double bond (1)

carbon atom 4 bond pairs including 2 bond pairs as double bond (1) [3]

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Q27.

(b) ScF_3 (1)

correct charges on **both** ions (1)

8 electrons around (each) fluoride (1) [3]

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Q28.

(a) soft because weak forces between layers/sheets/rows [1]

layers can slip/slide [1]

good conductor because electrons can move/mobile [1]

(b) it is soft: pencils **or** lubricant **or** polish [1]
good conductor: electrodes **or** brushes (in electric motors) [1]

(c) (i) every silicon atom is bonded/attached to 4 oxygen atoms or every oxygen bonded/attached to two silicon atoms [1]

(ii) Any **two** from:
high melting point/boiling point
hard
colourless crystals/shiny
poor/non-conductor of electricity/insulator
insoluble in water [2]

[Total: 8]

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Q29.

(a) (i) $6Li + N_2 = 2Li_3N$
species (1) balancing (1)

(ii) N^{3-} ion drawn correctly [1]

Charges correct (minimum 1 × Li ion and 1 nitride ion) [1]

(b) (i) 3 × shared pairs between N and 3 × F [1]

only 2 non-bonding electrons on N, 6 non-bonding electrons on each F (COND on first point) [1]

(ii) Strong attractive forces/strong ionic bonds in lithium nitride [1]

weak (attractive) forces between molecules in NF_3 [1]

[Total: 8]

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Q30.

(a) foodstuffs or drugs [1]

(b) (i) simple distillation
fractional distillation **or** diffusion
fractional distillation
filtration **or** evaporation
chromatography [5]

(ii) M1 dissolving
M2 filtration
M3 evaporation or heat (to crystallisation point)
M4 crystallisation or allow leave to cool [4]
or
M3 crystallisation
M4 filtration

OR: Adding to H_2SO_4 method

M1 Add excess mixture to acid (or until no more dissolves)
M2 Filtration
or
M1 Add excess acid to mixture
M2 With heat

M3 evaporation or heat (to crystallisation point) Stop marking if heated to dryness.
M4 crystallisation or allow leave to cool
or
M3 crystallisation
M4 filtration

[Total: 10]

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Q31.

(a) **Bromine**

Physical: reddish-brown liquid **or** brown liquid **or** volatile liquid/low boiling point liquid **or** poor/non-conductor (of electricity) **or** soluble in water **or** soluble in organic/non-polar solvents [1]

Chemical: Reacts with water **or** reacts with iodides (in solution) **or** displaces iodine **or** reacts with alkenes/named alkene/unsaturated hydrocarbons **or** reacts with alkane in UV/named alkane in UV **or** valency/oxidation state(–)1 **or** forms Br^- **or** gains or shares 1 electron **or** combines or reacts with metals/named metal **or** combines or reacts with non-metals/named non-metal **or** oxidising agent **or** bleaches litmus paper/indicator paper **or** corrosive **or** forms acidic oxides [1]

(b) **Graphite**

Physical: (good) conductor (of electricity) **or** soft **or** lubricant **or** high melting point/high boiling point **or** grey black **or** black solid **or** slippery or greasy (to touch) **or** brittle/breaks when subjected to stress **or** insoluble in water [1]

Chemical: reducing agent **or** reduces metal oxides/named metal oxide **or** reacts with/burns in air/oxygen **or** forms an acidic oxide (CO_2) **or** valency/oxidation state of 2 or 4 [1]

(c) **Manganese**

Physical: (good) conductor (of heat/electricity) **or** high melting point/high boiling point **or** forms coloured compounds/coloured ions **or** hard **or** strong **or** high density **or** malleable **or** ductile **or** sonorous **or** shiny [1]

Chemical: Variable or different valency/oxidation state/oxidation number **or** catalytic activity **or** forms coloured compounds/coloured ions **or** forms complex ions/complexes **or** reacts with acids **or** reducing agent **or** reacts with non-metals [1]

[Total: 6]

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Q32.

(a) (i) 3 [1]

(ii) 70 [1]

(b) Add octane (or other liquid hydrocarbon) (to soot) [1]

COND(on addition of **any** solvent) filter (to remove insoluble forms of carbon) [1]

(allow to) evaporate **or** heat **or** warm **or** leave in sun(to get crystals of fullerene) [1]

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Q33.

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Question	Answer	Marks	Guidance
1	$^{39}_{19}K$; 26p 26e 30n All three for 1 mark; $^{7}_{3}Li^{+}$ numbers and symbol; charge +; 31p 28e 39n All three for 2 marks, any two for 1 mark; $^{79}_{34}Se^{2-}$ numbers and symbol; charge 2^{-};	8	

Q34.

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Question	Answer	Marks	Guidance
2(a)	E; high melting point / mp / mpt **OR** high boiling point / bp / bpt; poor / non conductor (when liquid and / or solid);	3	**I** mpt/bpt above room temp
2(b)	B; (good) conductor when <u>solid</u> (and liquid);	2	**A** (good) conductor in any state / both states **I** high melting point/boiling point **R** low melting point/boiling point
2(c)	A; melting point / –7 (°C) is below room temperature / 25 (°C) / RTP ora; boiling point / 59 (°C) is above room temperature / 25 (°C) / RTP ora;	3	**I** low melting point / boiling point / conductivity 25 (°C) / room temperature / RTP is in between –7 (°C) and 59 (°C) **OR** 25 (°C) / room temperature / RTP is between mpt and bpt would both score the 2 evidence marks
2(d)	C; high melting point / mp / mpt **OR** high boiling point / bp / bpt; **BOTH** poor / non conductor when solid **and** good conductor when liquid **OR** molten / only conduct when liquid;	3	**A** melting point **and** boiling point both above room temp / 25 °C / RTP **I** conducts when aqueous or in solution **I** conducts in liquid due to free electrons

Q35.

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Question	Answer	Marks	Guidance
3(a)	M1 both correct charges of ions (calcium 2+ and nitrogen 3–); M2 8 electrons around nitrogen (can be 3 dots and 5 crosses **or** 5 crosses and 3 dots **or** all dots **or** all crosses, but reject any other combinations of dots and crosses); M3 Two electrons on the inner shell on any nitride ions/nitrogen atom: allow 2x or 2o once;	3	Charges can be shown anywhere **I** missing symbols for nitrogen **R** wrong symbol of nitrogen **anywhere** **A** if electron configuration of nitride is given as 2,8 or N is given as 2,5 **I** any missing inner shells as long as one is present *General guidance:* **I** electron configuration / symbol of calcium ion **I** formulae / stoichiometry Covalent can score **only** M3
3(b)(i)	regular / repeated / pattern / framework / periodic / ordered / alternating / organised; (of)particles / atoms / molecules / ions / cations / anions;	2	**I** layers **A** ionic / molecular / atomic **I** arrangement / bonding / properties
3(b)(ii)	M1 (so that ionic) charges balance or cancel / charge = 0 / no charge / number of positive = number of negative charges / charge is neutral or neutralised; M2 3(–) × 2 = 2(+) × 3 ;	2	**A** 6(+) = 6(–) **I** statements about electron transfer / valency / ox state unless valency is referring to ionic charges e.g. valencies 3+ and 2– can get credit if used properly Ratio of ions is 3:2 therefore ratio of charges is 2:3 scores 2

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Q36.

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Question	Answer	Marks	Guidance
1(a)(i)	AlF_3;	1	
1(a)(ii)	As_2O_3;	1	**A** As_2O_5
1(a)(iii)	$SiBr_4$;	1	
1(b)(i)	P^3 ;	1	
1(b)(ii)	Ba^{2+};	1	
1(b)(iii)	Fr^+;	1	
1(c)	M1 2 double bonds, one between each O and the C atom; M2 each O has 8 outer electrons; M3 each C has 8 outer electrons;	3	**R** wrong symbols for O for M2 **R** wrong symbols for C for M3 **I** missing symbols **A** any combination of x and o

Q37.

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Question	Answer	Marks
1(a)(i)	Na^+ / sodium **and** O^{2-} / oxide;	1
1(a)(ii)	Ca^{2+} / calcium;	1
1(a)(iii)	P / phosphorus;	1
1(a)(iv)	Si / silicon;	1
1(b)(i)	• *number of protons* = 29; • *number of neutrons* = 35; • *number of electrons* = 27; three correct = [2]; two correct = [1]	2
1(b)(iii)	*number of nucleons* = 45; *number of charged particles* = 42;	1 1
1(c)(i)	have same proton number / same element / same atomic number; different number of neutrons / nucleons / mass number;	1 1
1(c)(ii)	magnesium / Mg;	1
1(c)(iii)	any two from: • treating cancer or radiotherapy; • biological tracer; • thickness (of paper or foil); • (checking for) leaks / cracks (in pipes); • (carbon) dating; • (generating) energy / electricity; • smoke detectors; • fill levels in packages; • sterilising surgical instruments;	2

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Q38.

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Question	Answer	Marks
2(a)	add a (dilute) acid; filter; copper does not react or dissolve / zinc reacts or dissolves or forms a salt;	1 1 1
2(b)	diffusion (through a membrane); nitrogen diffuses faster; because it has the smaller M_r; **or** (turn into) liquid; (fractional) distillation; different boiling points; **or** burn a named substance to make non-gaseous product; oxygen reacts / nitrogen does not react; name of product of combustion;	3
2(c)	chromatography; use a locating agent / the two acids move at different rates / alanine travels faster / alanine higher up paper / travels further;	1 1
2(d)	add sodium hydroxide solution; filter; zinc hydroxide (is amphoteric it) will react or will dissolve / magnesium hydroxide does not react or does not dissolve;	1 1 1

Q39.

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Question	Answer	Marks
6(a)(i)	any three from: • each oxygen is joined to two silicons / atoms; • each silicon is joined to four oxygens / atoms; • tetrahedral (around silicon) / similar to diamond; • linear around oxygen;	3
6(a)(ii)	any three from: • high melting point / boiling point; • hard; • strong; • (colourless) crystalline (solid); • brittle / not malleable; • poor / non-conductor (of electricity) / insulator; • insoluble (in water);	3
6(a)(iii)	SiO_2 reacts with or dissolves in or neutralises an acid or acidic oxide; SiO_2 does not react or dissolve in or neutralise an alkali or base or basic oxide;	1 1
6(b)	carbon dioxide has a simple molecular structure;	1

Q40.

Page 3	Mark Scheme	Syllabus	Paper
	Cambridge IGCSE – May/June 2016	0620	41

Question	Answer	Marks
1(a)	(see table below)	3
1(b)(i)	**M1** atom(s) of the same element; **M2** with different number of neutrons;	2 1 1
1(b)(ii)	**M1** (both have) the same number of electrons; **M2** in the outer shell;	2 1 1
1(c)	(see table below)	5

1(a)

particle	relative mass	relative charge
proton	1	+1
neutron	1	nil
electron	1/1840	−1

1(c)

particle	number of protons	number of neutrons	number of electrons
$^{7}_{3}Li$	3	4	3
$_{16}S^{2-}$	16	18	18
$^{41}_{19}K^{+}$	19	22	18

Q41.

Page 4	Mark Scheme	Syllabus	Paper
	Cambridge IGCSE – May/June 2016	0620	41

Question	Answer	Marks
2(e)(i)	**M1** (electrostatic) attraction; **M2** between oppositely charged ions;	2 1 1
2(e)(ii)	$Ca_3(PO_4)_2$;	1

Q42.

Page 4	Mark Scheme	Syllabus	Paper
	Cambridge IGCSE – May/June 2016	0620	42

Question	Answer	Marks
2(a)(i)	number of protons in one atom of an element;	1
2(a)(ii)	**M1** number of protons and neutrons in one atom of an element; **M2** in one atom of an element;	2 1 1
2(b)	(see table below)	6

2(b)

A	6	6	6	$^{12}_{6}C$
B	12	12	12	$^{24}_{12}Mg$;
C	8	10;	8;	$^{16}_{8}O^{2-}$
D	11	10	13	$^{24}_{11}Na^{+}$ 11, 24; Na;+;

Q43.

Page 4	Mark Scheme	Syllabus	Paper
	Cambridge IGCSE – May/June 2016	0620	42

Question	Answer	Marks
3(a)(i)	**M1** positive ions / cations (labelled or named in text); **M2** electrons (labelled or named in text); **M3** attraction between positive and negative;	3 1 1 1
3(a)(ii)	(conduction due to) movement of electrons / mobile electrons;	1
3(b)	$GaCl_3$; $Ga_2(SO_4)_3$;	2 1 1
3(c)(i)	$Ga_2O_3 + 6HNO_3 \rightarrow 2Ga(NO_3)_3 + 3H_2O$ formula of $Ga(NO_3)_3$; all formulae and balancing correct;	2
3(c)(ii)	$Ga_2O_3 + 2NaOH \rightarrow Na_2Ga_2O_4 + H_2O$; formula of $Na_2Ga_2O_4$; all formulae and balancing correct;	2
3(d)	any 2 from: • (do not) corrode; • strong; • hard; • (improved) appearance;	2

Q44.

Page 7	Mark Scheme	Syllabus	Paper
	Cambridge IGCSE – May/June 2016	0620	43

Question	Answer	Marks
4(a)(i)	**M1** movement of electron(s) from potassium to iodine; **M2** one electron transferred;	2 1 1
4(a)(ii)	**M1** regular arrangement / (giant) lattice of alternating; **M2** positive potassium ions / K^+ **and** negative iodide ions / I^-;	2 1 1
4(a)(iii)	**M1** strong (forces of) attraction (between oppositely charged ions) / ionic bonds are strong; **M2** which require lots of energy to overcome / break;	2 1 1

Q45.

Page 10	Mark Scheme	Syllabus	Paper
	Cambridge IGCSE – May/June 2016	0620	43

Question	Answer	Marks
6(c)(i)	covalent;	1
6(c)(ii)	**M1** one shared pair of electrons between each N and H; **M2** one shared pair of electrons between the N atoms; **M3** one lone pair on each N and no additional electrons anywhere;	3 1 1 1
6(d)(i)	amide;	1
6(d)(ii)	proteins are made from more than two monomers; **OR** nylon is made from 1 or 2 monomers (only);	1
6(d)(iii)	amino acids;	1

Q46.

Page 2	Mark Scheme	Syllabus	Paper
	Cambridge IGCSE – October/November 2016	0620	41

Question	Answer	Marks
1(a)	H	1
1(b)	G	1
1(c)	filtration	1
1(d)	fractional distillation	1 1
1(e)	add / mix / stir / dissolve / shake / heat with water filter / decant heat (filtrate) or (leave filtrate to) evaporate	1 1 1
1(f)	electrons (electrons) move / flow (throughout structure)	1 1

Q47.

Page 2	Mark Scheme	Syllabus	Paper
	Cambridge IGCSE – October/November 2016	0620	42

Question	Answer	Mark
2(a)	(total) number of protons and neutrons in a nucleus (of an atom)	2
2(b)	Na 2 : 8 : 1 P^{3-} 2 : 8 : 8	2
2(c)	radiotherapy **OR** treatment of cancer	1
2(d)	average mass of (naturally occurring) atom(s) (of an element) (compared to an atom of) ^{12}C	2
2(e)	chlorine must have more than one isotope the masses of these isotopes / (any given) mass numbers are averaged	2
2(f)	lattice of labelled Al^{3+} ions electrons seen on the diagram between the ions attraction between (positive) ions and (sea of / delocalised) electrons	3

Q48.

Page 6	Mark Scheme	Syllabus	Paper
	Cambridge IGCSE – October/November 2016	0620	42

Question	Answer	Mark
7(c)(i)	$\frac{\text{distance moved by substance}}{\text{distance moved by solvent (front)}}$	1
7(c)(ii)	circle around top spot	1
7(c)(iii)	mixture of amino acids is placed as a spot onto a (pencil) baseline placed into a (suitable) solvent / water a locating agent is added to the (finished) chromatogram (to reveal spots)	

Q49.

Page 2	Mark Scheme	Syllabus	Paper
	Cambridge IGCSE – October/November 2016	0620	43

Question	Answer	Marks
1(a)	proton / +1 / 1 neutron / 0 / 1 electron / –1 / $^{1}/_{1840}$	2
1(b)(i)	(same) number of protons and electrons / 6 protons and six electrons (different) neutron (number) / 6,7 and 8 neutrons	2 1
1(b)(ii)	same <u>number</u> of electrons / electron configuration	1
1(c)	diamond *and* graphite	1
1(d)	two double bonds with no extra electrons on the carbon atoms both oxygen atoms with four non-bonding electrons	1 1

Q50.

Page 3	Mark Scheme	Syllabus	Paper
	Cambridge IGCSE – October/November 2016	0620	43

Question	Answer	Marks
2(a)	2,2 / 2.2	1
2(b)	BeO	1
2(c)(i)	<u>positive ions / cations</u> labelled or named in text <u>electrons</u> labelled or named in text <u>attraction</u> between positive ions and negative electrons	1 1 1
2(c)(ii)	(conduction due to) moving electrons / mobile electrons	1

Q51.

Page 5	Mark Scheme	Syllabus	Paper
	Cambridge IGCSE – October/November 2016	0620	43

Question	Answer	Marks
4(a)	*silicon(IV) oxide*: covalent *sodium chloride*: ionic / electrovalent	1 1
4(b)	giant molecular / macromolecular / giant covalent / giant atomic	1
4(c)(i)	**M1** (covalent) bonds are strong **M2** a lot of heat or energy is needed to break / weaken / overcome bonds **OR** there are no <u>weak bonds</u> **OR** there are <u>no intermolecular forces</u> **OR** covalent bonds are the <u>only bonds</u> **OR** strong bonds are the <u>only bonds</u>	2
4(c)(ii)	(it has) no moving ions / no moving electrons / all electrons are used in bonding / no moving charged particles	1
4(d)	(sodium chloride contains) ions / is ionic in the solid ions are not moving / they are in fixed positions ions can move when molten	1 1 1

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Q52.

Question	Answer	Marks
1(a)	*proton number*: the number of protons	1
	nucleon number: the total number of protons and neutrons	1
	nucleon number: in the nucleus / nuclei (of an atom)	1
1(b)	(hydrogen is the only atom to have) no neutrons	1
1(c)		

	number of protons	number of neutrons	number of electrons
^{19}F	9	10	9
^{26}Mg	12	14	12
$^{31}P^{3}$	15	16	18
$^{87}Sr^{2+}$	38	49	36

Question	Answer	Marks
1(c)	fluorine protons **AND** neutrons correct	1
	magnesium neutrons **AND** electrons correct	1
	phosphorus protons **AND** neutrons correct	1
	phosphorus electrons correct	1
	strontium protons **AND** neutrons correct	1
	strontium electrons correct	1
1(d)(i)	MgF_2	1
1(d)(ii)	Sr_3P_2	1

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Q53.

Question	Answer	Marks
2(a)	<u>atoms</u> of the same element / <u>atoms</u> with the same proton number / <u>atoms</u> with the same atomic number	1
	different neutron **number** / different nucleon **number** / different mass number	1
2(b)		3

	carbon	silicon	
proton number	6	14	M1
electronic structure	2,4	2,8,4	M2
nucleon number	12	28	
number of neutrons in one atom	6	14	M3

Question	Answer	Marks
2(c)(i)	covalent	1
2(c)(ii)	award 1 mark for each correct property and one mark for each correct matching reason.	4
	property: high melting point / high boiling point reason: bonds between atoms are strong **OR** covalent bonds are strong / **bonds** need large amount of energy to break	
	property: non-conductor / poor conductor(of electricity) / insulator reason: no moving charged particles / no moving ions / no moving electrons / all (outer shell) electrons used in bonding	
	property: hard reason: bonds between atoms are strong **OR** covalent bonds are strong	
	property: brittle reason: bonds between atoms are strong **OR** covalent bonds are strong / bonds are directional	
	property: insoluble reason: does not form hydrogen bonds with water / no ions that can be hydrated	

Q54.

Question	Answer	Marks
1(a)(i)	J	1
1(a)(ii)	E	1
1(a)(iii)	D	1
1(a)(iv)	J	1
1(a)(v)	L	1
1(a)(vi)	D	1
1(b)(i)	(atoms with) same **number** of protons / atomic number / of same element	1
	different **number** of neutrons / different mass number / different nucleon number	1
1(b)(ii)	E AND G	1
1(b)(iii)	they have the same number of electrons in their outer shell	1

Q55.

Question	Answer	Marks
2(c)	(attractive) forces between molecules	1
	(forces of attraction) are stronger in iodine	1

Q56.

Question	Answer	Marks
3(a)	regular arrangement / lattice of positive ions / magnesium ions / Mg^{2+} ions	1
	sea of electrons **OR** delocalised electrons	1
	attraction between (positive) ions and (delocalised / sea of) electrons	1
3(b)	electrons	1
	move / flow (throughout / through the structure)	1
3(c)	layers (of atoms or ions)	1
	layers / atoms / ions can slide / slip / glide (over each other) (without breaking the metallic bonds)	1
3(d)(i)	magnesium shown as (2, 8) using crosses	1
	sulfide shown as (2, 8, 8), with the two gained electrons in the outer shell of sulfur shown as crosses and all other electrons on sulfur shown as dots	1
	magnesium ion charge as 2^+ **AND** sulfide charge as 2	1
3(d)(ii)	melt / fused	1
	ions can move **OR** are mobile	1

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Q57.

Question	Answer	Marks
1(a)(i)	B	1
1(a)(ii)	A	1
1(a)(iii)	C	1
1(a)(iv)	E	1
1(b)	O^{2} **M1** O **M2** $^{2-}$	2

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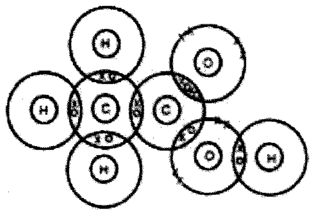
Q58.

Question	Answer	Marks
4(c)(ii)	 **M1** all shared pairs of electrons correct for single bonds **M2** 2 shared pairs of electrons for the C=O bond **M3** total of 8 electrons on each O including 4 non-bonding electrons and no additional non-bonding electrons	3
4(d)(i)	partially ionised / dissociated	1

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Q59.

Question	Answer	Marks
6(b)(i)	oxide ion has an outer shell with six <u>dots</u> and two <u>crosses</u>	1
	oxide ion has a charge of 2	1
6(b)(ii)	(electrostatic) forces of attraction between ions	1
	(are) strong **OR** require lots of energy to overcome	1

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Q60.

Question	Answer	Marks
2(a)	*Si*: 2: 8 : 4	1
	Ca^{2+}: 2 : 8: 8	1
	N^{3-}: 2 : 8	1
2(b)	Ca_3N_2	1
2(c)	Li shown as having one shell with 2 electrons **OR** no electrons **OR** no outer shell	1
	C*l* shown as having an outer shell of 7 electrons of one type, plus one different electron which matches Li electrons	1
	'+' charge on Li **AND** '–' charge on C*l*	1
2(d)	two shared pairs of electrons	1
	both C*l* with complete outer shells	1
	S with complete outer shell	1
2(e)	SCl_2 has intermolecular forces (of attraction)	1
	LiC*l* has (electrostatic) forces (of attraction) between ions	1
	intermolecular forces are weaker / less energy is needed to break intermolecular forces	1
2(f)	silicon(IV) oxide	1

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Q61.

Question	Answer	Marks
2(a)(i)	(two or more) **atoms**	1
	combined / joined / sharing electrons (by a covalent bond) / bonded	1
2(a)(ii)	substance that cannot be split up / broken down / decomposed (into anything simpler) **OR** (substance) made of **atoms** with the same atomic number / number of protons / proton number	1
2(b)(i)	10	1
2(b)(ii)	22	1
2(b)(iii)	A **AND** B	1
2(b)(iv)	A **AND** B	1
2(b)(v)	C **AND** D	1
2(c)	see table below	3

	number of protons	number of electrons
Na	11	11
S^{2-}	16	18
Cl_2	34	34

0620/41 Cambridge IGCSE – Mark Scheme **PUBLISHED** May/June 2018

Q62.

1(a)	a substance made from two (or more) **elements**	1
	chemically combined	1
1(b)	dissolving	1
	filtration	1
	evaporation / crystallisation	1
	three correct stages in the correct order	1
1(c)(i)	condenser	1
	arrow pointing into lower aperture **only**	1
1(c)(ii)	stopper shown in diagram	1
	gases or vapours escape	1
1(c)(iii)	(mixture is) (in)flammable	1
1(c)(iv)	water bath cannot exceed 100 (°C)	1
	C AND D have a boiling point above 100 (°C)	1

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Q63.

3 (6 marks)

particles	number of protons	number of electrons	number of neutrons	number of nucleons
			12 (1)	
	17 (1)	18 (1)		37 (1)
Fe (1) 2+ (1)				

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Q64.

4(a)	$2K(s) + Br_2(l) \rightarrow 2KBr(s)$ 1 mark for formulae all correct 1 mark for balancing 1 mark for state symbols	3
4(b)(i)	(ionic): made of, positive and negative ions / anions and cations / oppositely charged ions / unlike charged ions / different charged ions	1
	(lattice): regular / sequence / pattern / alternating / repeated / framework / ordered / organised / network / uniform	1
4(b)(ii)	(in solid) ions don't move	1
	(when molten) ions move / ions mobile	1
4(d)(i)	$I_2 + Cl_2 \rightarrow 2ICl$ 1 mark for formulae all correct 1 mark for correct balancing	2
4(d)(ii)	one bonding pair	1
	6 non-bonding electrons on each atom	1
4(e)	(potassium bromide): ionic bonds / attraction between ions	1
	(iodine monochloride): intermolecular forces / forces between molecules / named intermolecular forces, e.g. van der Waals / London forces / dispersion forces / dipole- dipole	1
	bonds in KBr are stronger / need more energy to break bonds / ORA	1

Page 2	Mark Scheme	Syllabus	Paper
	IGCSE – October/November 2013	0620	32

Q65.

(a) C and F [1]

(b) A [1]

(c) B [1]

(d) D [1]

(e) E [1]

(f) A and D [1]

[Total: 6]

0620/43 Cambridge IGCSE – Mark Scheme PUBLISHED October/Novembe 2017

Q66.

Question	Answer	Marks
1(a)	mixture	1
1(b)	element	1
1(c)	compound	1
1(d)	mixture	1

0620/41 Cambridge IGCSE – Mark Scheme PUBLISHED October/November 2018

Q67.

Question	Answer	Marks
4(c)(ii)	**M1** one shared pair between each H and S	1
	M2 four unpaired electrons on S giving S a total of 8 outer shell electrons and no other unpaired electrons	1
4(c)(iii)	**M1** weak (attractive) forces **OR** (attractive) forces need little energy to overcome	1
	M2 forces between molecules / intermolecular	1

Q68.

Question	Answer	Marks
2(a)	**M1** 11 **M2** 18 **M3** 2.8.8 **M4** –1	4
2(b)	A **and** B	1
2(c)	Li / Lithium	1
2(d)	it has a complete **or** full **or** 8 electrons in the outer shell	1

[0620/42/O/N/18/Q2-A-B-D]

Q69.

2(a)	2 : 8 : 8 : 2	1
2(b)(i)	M1 Same number of (**or** 2) outer electrons	2
2(b)(ii)	M2 (Sr has) outer electrons are in the 5th shell	
2(d)(i)	M1 Mg shown with new outer shell with 8 crosses; M2 Both C*l* atoms with a new outer shell with 7 dots and 1 cross; M3 '2+' charge on Mg **and** '–' charge on each C*l*;	3
2(d)(ii)	M1 *Physical constants mark* High melting point or high boiling point M2 *Solubility mark* Dissolve in water M3 *Electrical conductivity mark* Conduct (electricity) when molten **or** conduct (electricity) in aqueous solution	3

[0620/41/MJ/2019/Q1]

Q70.

1(a)	number of protons (1) protons in the nucleus (of an atom) (1)	2
1(b)(i)	12p 12n 12e (1) 12p 14n 12e (1)	2
1(b)(ii)	isotope(s)	1
1(b)(iii)	same number of electrons (1) (same number) of electrons in the outer shell (1)	2
1(c)	$^{9}_{4}Be$ any element symbol with a single negative charge (1) use of C*l* (1) use of $^{37}{}_{17}$ (1)	4
1(d)	2 8 3 (1) 2 8 8 (1)	2

[0620/42/MJ/2019/Q2]

Q71.

2(a)(i)	**M1** protons (are the same) / 11 protons (1) **M2** electrons (are the same) / 11 electrons (1) **M3** neutrons (are different) / 11,12,13 neutrons (1)	3
2(a)(ii)	same number of protons and electrons (1)	1
2(a)(iii)	**M1** same **number** of electrons (1) **M2** (same number of) electrons in outer shell (1)	2
2(a)(iv)	(they all have) 1 more proton than electrons / 11 protons and 10 electrons	1
2(b)(i)	diamond / graphite / graphene **ANY TWO**	1
2(b)(ii)	carbon monoxide	1

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Q72.

[0620/42/MJ/2019/Q3-A]

3(a)(i)	covalent	1
3(a)(ii)	forces of attraction between molecules **AND** are weak / need a small amount of energy to break	1
3(a)(iii)	no **moving** or **flowing** or **mobile charged particles** or **ions** or **electrons**	1

Q73.

[0620/41/O/N/2019/Q1-C]

1(c)	$Mg_3(PO_4)_2$	1

Q74.

[0620/43/M/J/2019/Q1]

<table>
<tr><td>1(a)</td><td>
<table>
<tr><th>particle</th><th>where found in an atom</th><th>relative mass</th><th>relative charge</th></tr>
<tr><td>electron</td><td>orbiting nucleus</td><td>1/1840</td><td>–1</td></tr>
<tr><td>proton</td><td>(in the) nucleus</td><td>1</td><td>+1</td></tr>
<tr><td>neutron</td><td>in the nucleus</td><td>1</td><td>0 / nil</td></tr>
</table>
</td><td>3</td></tr>
<tr><td>1(b)</td><td>M1 electrons 18
M2 neutrons 24
M3 protons 20</td><td>3</td></tr>
</table>

Q75.

[0620/43/O/N/2019/Q4-B-ii]

4(b)(ii)	3 bonding pairs and 1 lone pair on P (1) six non-bonding electrons on 3 chlorine atoms (1)	2

Q76.

[0620/43/M/J/2019/Q2]

2(a)	difference: **M1** (number of) neutrons similarities: **M2** (number of) protons **M3** (number of) electrons	3
2(b)(i)	**M1** same number of electrons **M2** (same number of) electrons in outer shell	2
2(b)(ii)	$Mg + 2\ HCl \rightarrow MgCl_2 + H_2$ **M1** $MgCl_2$ as product **M2** fully correct equation	2
2(b)(iii)	**M1** Test: lighted / burning splint **M2** Result: (squeaky) pop	2
2(c)	**M1** (lattice of) positive ions / cations **M2** (delocalised / sea of) electrons **M3** attraction / attract between positive and negative	3
2(d)(i)	**M1** magnesium ion second shell shown containing 8 electrons shown as X **M2** oxide ion second shell shown containing 8 electrons, two as X and six as ● **M3** charges: magnesium ion as 2+ **and** oxide as 2-	3
2(d)(ii)	strong forces of **attraction** (between oppositely charged ions)	1
2(d)(iii)	ions / Mg^{2+} **and** O^{2-} / anions **and** cations can move (throughout the structure)	1

Q77.

[0620/41/O/N/2019/Q2-A-B]

2(a)	atoms with same number of protons **or** atoms of the same element **or** atoms with same atomic number (1) atoms with different number of neutrons **or** atoms with different mass number **or** atoms with different nucleon number (1)	2
2(b)(i)	18	1
2(b)(ii)	gain of two electrons	1
2(b)(iii)	Ca / calcium	1

Q78.

[0620/41/O/N/2019/Q7-C-ii]

7(c)(ii)	4 electrons in double bond between C and O (1) all single bonds correct (1) C and O each have 8 electrons in outer shell, all H have 2 electrons in outer shell (1)	3
7(c)(iii)	(attractive) forces between molecules weak<u>er</u> in ethanal	1

Q79.

[0620/42/O/N/2019/Q1-A]

1(a)	fluorine / F	1
1(a)(ii)	hydrogen / H	1
1(a)(iii)	vanadium / V	1
1(a)(iv)	sulfur / S	1
1(a)(v)	phosphorus / P	1
1(a)(vi)	magnesium / Mg	1
1(a)(vii)	chlorine / C*l*	1

Q80.

[0620/42/O/N/2019/Q5-B]

5(b)	all bonding pairs correct (1) H atoms have 2 electrons and C and O atoms have 8 electrons (1)	2

Q81.

[0620/43/O/N/2019/Q1]

<table>
<tr><td>1(a)</td><td>
<table>
<tr><td>particle</td><td>charge</td><td>relative mass</td></tr>
<tr><td>electron</td><td>M1 –1</td><td></td></tr>
<tr><td>neutron</td><td>M2 0</td><td>M3 1</td></tr>
<tr><td>proton</td><td></td><td>M4 1</td></tr>
<tr><td></td><td>(1)</td><td>(1)</td></tr>
</table>
Mark by column</td><td>2</td></tr>
<tr><td>1(b)</td><td>
<table>
<tr><td>number of electrons</td><td>number of neutrons</td><td>number of protons</td><td>symbol</td></tr>
<tr><td>M1 13 (1)</td><td></td><td></td><td></td></tr>
<tr><td>M2 10 (1)</td><td>M3 13 (1)</td><td></td><td></td></tr>
<tr><td></td><td></td><td></td><td>M4 19
9 (1)
M5 F (1)
M6 – (1)</td></tr>
</table>
</td><td>6</td></tr>
</table>

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Q82.

[0620/43/O/N/2019/Q2]

2(a)	F	1
2(b)	I	1
2(c)	F (1) H (1) I (1)	3
2(d)	G (1) good conductor when solid (1)	2
2(e)	D (1) high melting point (1) non-conductor of electricity when solid or liquid (1)	3
2(f)	E (1) only conducts when liquid / conducts when liquid but not when solid (1)	2

Q83.

[0620/41/M/J/2020/Q2]

2(a)	metallic (bonding)	1
	sea of electrons	1
	positive ions	1
	attraction between	1
2(b)(i)	Mg octet of eight dots	1
	O octet of six crosses and two dots.	1
	correct charges on both ions	1
2(b)(ii)	$2Mg + O_2 \rightarrow 2MgO$ M1 species M2 balancing	2
2(c)(i)	$2Mg(NO_3)_2 \rightarrow 2MgO + 4NO_2 + O_2$ M1 product species M2 balancing	2
2(c)(ii)	(thermal) decomposition	1
2(c)(iii)	magnesium carbonate	1
	magnesium hydroxide	1

Q84.

[0620/42/M/J/2020/Q2]

2(a)(i)	magnesium 2.8 (all crosses) (1) fluorine 2.8 (seven dots and one cross in outer shell) (1) Mg^{2+} **and** F^-(1)	3
2(a)(ii)	MgF_2	1
2(a)(iii)	heat until molten **or** dissolve in water (1) moving ions / mobile ions (1)	2
2(b)	two single bonds (1) one double bond (1) six non-bonding electrons on both F atoms and four non- bonding electrons on O atom to complete the octet in each case (1)	3
2(c)(i)	forces of attraction between oppositely charged ions / ionic bonds (1) strong / need a lot of energy to break / weaken (1)	2
2(c)(ii)	forces of attraction between molecules (1) weak / need a small of energy to break / weaken (1)	2

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[0620/43/M/J/2020/Q3-A-B-C]

Q85.

3(a)(i)	same number of electrons same electronic configuration	2
3(a)(ii)	(see table below)	3
3(b)(i)	displacement / redox	1
3(b)(ii)	iodine is less reactive than bromine	1
3(c)	magnesium ion has an outer shell with eight crosses chloride ion has an outer shell with seven dots **and** one cross chloride has a charge of 1– **and** magnesium has a charge 2+	3

3(a)(ii):

	number o electrons	number o neutrons	number o protons
${}^{35}_{17}Cl$	17	18	17
${}^{37}_{17}Cl^-$	18	20	17

[0620/42/O/N/2020/Q1]

Q86.

1(a)(i)	A (1) H (1)	2
1(a)(ii)	B	1
1(a)(iii)	D	1
1(a)(iv	C **and** G **OR** C **and** E	1
1(b)	F (1) third / outer shell is being filled before second shell is full; second shell has 6 electrons: it should have 8 electrons (1)	2
1(c)	12	1
1(d)(i)	H^-	1
1(d)(ii)	aluminium / Al	1

[0620/43/O/N/2020/Q2]

Q87.

2(a)	11	1
2(b)	38	1
2(c)	2,8,8	1
2(d)(i)	B, C and E	1
2(d)(ii)		1
2(d)(iii)	D	1
2(d)(iv)	B and C	1

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[0620/32/O/N/11/Q6-C]

Q1.(c) Insoluble salts are made by precipitation. An equation for the preparation of barium sulfate is given below.

$$BaCl_2(aq) + MgSO_4(aq) \rightarrow BaSO_4(s) + MgCl_2(aq)$$

This reaction can be used to find x in the formula for hydrated magnesium sulfate $MgSO_4.xH_2O$.

A known mass of hydrated magnesium sulfate, $MgSO_4.xH_2O$, was dissolved in water. Excess aqueous barium chloride was added. The precipitate of barium sulfate was filtered, washed and dried. Finally it was weighed.

Mass of hydrated magnesium sulfate = 1.476 g

Mass of barium sulfate formed = 1.398 g

The mass of one mole of $BaSO_4$ = 233 g

The number of moles of $BaSO_4$ formed = ... [1]

The number of moles of $MgSO_4.xH_2O$ = ... [1]

The mass of one mole of $MgSO_4.xH_2O$ = ... g [1]

The mass of one mole of $MgSO_4$ = 120 g

The mass of xH_2O in one mole of $MgSO_4.xH_2O$ = ... [1]

x = ... [1]

[0620/31/M/J/12/Q8-B]

Q2. (b) A sample of rust had the following composition:

51.85 g of iron 22.22 g of oxygen 16.67 g of water.

Calculate the following and then write the formula for this sample of rust.

number of moles of iron atoms, Fe = ... [1]

number of moles of oxygen atoms, O = ... [1]

number of moles of water molecules, H_2O = ... [1]

simplest mole ratio $Fe:O:H_2O$ is .... : .... : ....

formula for this sample of rust is .... [1]

Q3. [0620/32/M/J/12/Q7-E]

(e) 0.01 moles of an alkene needed 2.4 g of oxygen for complete combustion. 2.2 g of carbon dioxide were formed. Determine the following mole ratio.

moles of alkene : moles of O_2 : moles of CO_2

From this ratio determine the formula of the alkene.

.... [3]

Write an equation for the complete combustion of this alkene.

.... [1]

Q4. [0620/31/O/N/12/Q2-C]

(c) Fluorine, the most reactive halogen, forms compounds with the other halogens. It forms two compounds with bromine.
Deduce their formulae from the following information.

compound 1
The mass of one mole of this compound is 137 g.

Its formula is .... [1]

compound 2
0.02 moles of this compound contain 0.02 moles of bromine atoms and 0.1 moles of fluorine atoms.

Its formula is .... [1]

[0620/31/O/N/12/Q7-B-C]

Q5. **(b)** Strontium chloride-6-water can be made from the insoluble compound, strontium carbonate, by the following reactions.

$SrCO_3(s) + 2HCl(aq) \rightarrow SrCl_2(aq) + CO_2(g) + H_2O(l)$

$SrCl_2(aq) + 6H_2O(l) \rightarrow SrCl_2.6H_2O(s)$

The following method was used to prepare the crystals.

1 Add excess strontium carbonate to hot hydrochloric acid.
2 Filter the resulting mixture.
3 Partially evaporate the filtrate and allow to cool.
4 Filter off the crystals of $SrCl_2.6H_2O$.
5 Dry the crystals between filter papers.

(i) How would you know when excess strontium carbonate had been added in step 1?

....

.... [1]

(ii) Why is it necessary to filter the mixture in step 2?

.... [1]

(iii) In step 3, why partially evaporate the filtrate rather than evaporate to dryness?

.... [1]

(c) In the above experiment, 50.0 cm^3 of hydrochloric acid of concentration 2.0 mol/dm^3 was used. 6.4 g of $SrCl_2.6H_2O$ was made.
Calculate the percentage yield.

number of moles of HCl used = ...

number of moles of $SrCl_2.6H_2O$ which could be formed = ...

mass of one mole of $SrCl_2.6H_2O$ is 267 g

theoretical yield of $SrCl_2.6H_2O$ = ...g

percentage yield = ...% [4]

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[0620/32/O/N/12/Q5-D]

Q6.(d) Sulfur dioxide can also be made by the reaction between a sulfite and an acid.

$$Na_2SO_3 + 2HCl \rightarrow 2NaCl + SO_2 + H_2O$$

Excess hydrochloric acid was added to 3.15 g of sodium sulfite. Calculate the maximum volume, measured at r.t.p., of sulfur dioxide which could be formed.
The mass of one mole of Na_2SO_3 is 126 g.

....

....

.... [3]

[0620/33/O/N/12/Q6-B]

Q7. **(b)** Another hydride of arsenic has the composition below.

arsenic 97.4 % hydrogen 2.6 %

(i) Calculate the empirical formula of this hydride **from the above data**.
Show your working.

....

....[2]

(ii) The mass of one mole of this hydride is 154 g. What is its molecular formula?

.... [1]

[0620/31/M/J/13/Q7-B-C]

Q8. **(b)** The concentration of the hydrochloric acid was 2.20 mol / dm^3. The volume of acid needed to neutralise the 25.0 cm^3 of lithium hydroxide was 20.0 cm^3. Calculate the concentration of the aqueous lithium hydroxide.

$$LiOH + HCl \rightarrow LiCl + H_2O$$

....

....

.... [2]

(c) Lithium chloride forms three hydrates. They are $LiCl.H_2O$, $LiCl.2H_2O$ and $LiCl.3H_2O$. Which **one** of these three hydrates contains 45.9 % of water?
Show how you arrived at your answer.

....

....

.... [3]

[0620/32/M/J/13/Q4-Biii]

Q9. **(iii)** Name the other **two** products of the electrolysis of concentrated aqueous sodium chloride and give a use of each one.

product .... use ....

product .... use .... [4]

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[0620/32/M/J/13/Q8]

Q10. (a) Define the following

(i) the mole

....

.... [1]

(ii) the Avogadro constant

....

.... [1]

(b) Which **two** of the following contain the same number of molecules?
Show how you arrived at your answer.

2.0 g of methane, CH_4
8.0 g of oxygen, O_2
2.0 g of ozone, O_3
8.0 g of sulfur dioxide, SO_2

....

....

.... [2]

(c) 4.8 g of calcium is added to 3.6 g of water. The following reaction occurs.

$$Ca + 2H_2O \rightarrow Ca(OH)_2 + H_2$$

(i) the number of moles of Ca = ...

the number of moles of H_2O = ... [1]

(ii) Which reagent is in excess? Explain your choice.

....

.... [2]

(iii) Calculate the mass of the reagent named in **(ii)** which remained at the end of the experiment.

....

.... [1]

[Total: 8]

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[0620/33/M/J/13/Q7-D]

Q11. **(d)** 20 cm^3 of a hydrocarbon was burnt in 175 cm^3 of oxygen. After cooling, the volume of the remaining gases was 125 cm^3. The addition of aqueous sodium hydroxide removed carbon dioxide leaving 25 cm^3 of unreacted oxygen.

(i) volume of oxygen used = ... cm^3 [1]

(ii) volume of carbon dioxide formed = ... cm^3 [1]

(iii) Deduce the formula of the hydrocarbon and the balanced equation for the reaction.

....

....

....

.... [2]

[0620/31/O/N/13/Q4-D]

Q12. **(d)** Calculate the maximum mass of carbon dioxide given off when 20.0 g of small lumps of calcium carbonate react with 40 cm^3 of hydrochloric acid, concentration 2.0 mol / dm^3.

$$CaCO_3(s) + 2HCl(aq) \rightarrow CaCl_2(aq) + H_2O(l) + CO_2(g)$$

number of moles of HC*l* used =

mass of carbon dioxide = ... g [4]

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[0620/31/O/N/13/Q6-C]

Q13.(c) Basic lead(II) carbonate has a formula of the type $xPbCO_3.yPb(OH)_2$ where x and y are whole numbers.
Determine x and y from the following information.

$$PbCO_3 \rightarrow PbO + CO_2$$

$$Pb(OH)_2 \rightarrow PbO + H_2O$$

When heated, the basic lead(II) carbonate gave 2.112 g of carbon dioxide and 0.432 g of water.

Mass of one mole of CO_2 = 44 g
Mass of one mole of H_2O = 18 g

Number of moles of CO_2 formed = ... [1]

Number of moles of H_2O formed = ... [1]

x = ... and y = ...

Formula of basic lead(II) carbonate is .... [1]

[0620/32/O/N/13/Q4-B]

Q14.(b) Each year, blast furnaces discharge millions of tonnes of carbon dioxide into the atmosphere. This will increase the percentage of atmospheric carbon dioxide.

(i) Explain why this increased percentage of carbon dioxide may cause problems in the future.

....

.... [2]

(ii) Until the early eighteenth century, charcoal, not coke, was used in the blast furnace. Charcoal is made from wood but coke is made from coal. Explain why the use of charcoal would have a smaller effect on the level of atmospheric carbon dioxide.

....

....

.... [2]

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(iii) A method being developed to produce iron with lower emissions of carbon dioxide is by electrolysis. Hematite, Fe_2O_3, is dissolved in molten lithium carbonate and electrolysed. The ore is spilt into its constituent elements.

Write an equation for the reaction at the negative electrode (cathode).

....

Complete the equation for the reaction at the positive electrode (anode).

........O^{2-} → .... + ... [3]

[0620/32/O/N/13/Q5-Cii-iii]

Q15. (ii) What mass of silver(I) nitrate is needed to prepare 100 cm^3 of silver(I) nitrate solution, concentration 0.2 mol/dm^3?
The mass of one mole of $AgNO_3$ is 170 g.

....

.... [2]

(iii) What is the maximum mass of silver(I) chromate(VI) which could be obtained from 20 cm^3 of aqueous silver(I) nitrate, concentration 0.2 mol/dm^3?

number of moles of $AgNO_3$ used = ... [1]

number of moles of Ag_2CrO_4 formed = ... [1]

mass of one mole of Ag_2CrO_4 = 332 g

mass of Ag_2CrO_4 formed = ... g [1]

[0620/33/O/N/13/Q6-Di]

Q16.(d) Alcohols can be made by fermentation and from petroleum.

(i) Ethanol is made from sugars by fermentation.

$$C_6H_{12}O_6 \rightarrow 2C_2H_5OH + 2CO_2$$

The mass of one mole of glucose, $C_6H_{12}O_6$, is 180 g.
Calculate the maximum mass of ethanol which could be obtained from 72 g of glucose.

....

....

....

.... [3]

[0620/31/M/J/14/Q6-D]

Q17.

(d) In the first experiment, the maximum volume of oxygen produced was 96 cm³ measured at r.t.p. Calculate the concentration of the aqueous hydrogen peroxide in mol / dm³.

$$2H_2O_2(aq) \rightarrow 2H_2O(l) + O_2(g)$$

number of moles of O_2 formed = ... [1]

number of moles of H_2O_2 in 40 cm³ of solution = ... [1]

concentration of the aqueous hydrogen peroxide in mol / dm³ = ...

.... [1]

[0620/32/M/J/14/Q7-B]

Q18.

(b) Using 25.0 cm³ of aqueous lithium hydroxide, concentration 2.48 mol / dm³, 2.20 g of hydrated lithium sulfate was obtained.
Calculate the percentage yield, giving your answer to **one** decimal place.

$$2LiOH + H_2SO_4 \rightarrow Li_2SO_4 + 2H_2O$$

$$Li_2SO_4 + H_2O \rightarrow Li_2SO_4.H_2O$$

Number of moles of LiOH used = ...

Number of moles of $Li_2SO_4.H_2O$ which could be formed = ...

Mass of one mole of $Li_2SO_4.H_2O$ = 128 g

Maximum yield of $Li_2SO_4.H_2O$ = ... g

Percentage yield = ...% [4]

Q19. [0620/33/M/J/14/Q6-C-D]

(c) The complete combustion of hydrocarbons produces carbon dioxide and water only.

(i) Write the equation for the complete combustion of nonane, C_9H_{20}.

.... [2]

(ii) 20 cm³ of a gaseous hydrocarbon was mixed with an excess of oxygen, 200 cm³. The mixture was ignited. After cooling, 40 cm³ of oxygen and 100 cm³ of carbon dioxide remained. Deduce the formula of the hydrocarbon and the equation for its combustion. All volumes were measured at r.t.p..

....

....

....

....

.... [3]

(d) Cracking is used to obtain short-chain alkanes, alkenes and hydrogen from long-chain alkanes.

(i) Give a use for each of the three products listed above.

short-chain alkanes ....

alkenes ....

hydrogen .... [3]

(ii) Write an equation for the cracking of decane, $C_{10}H_{22}$, which produces two different alkenes and hydrogen as the only products.

.... [1]

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Q20. [0620/32/O/N/14/Q6-Biii-C]

(iii) A mineral of the type $FeSO_4.xH_2O$ contains 37.2% of water.
Complete the calculation to determine x.

mass of one mole of H_2O = 18 g

mass of water in 100 g of $FeSO_4.xH_2O$ = 37.2 g

number of moles of H_2O in 100 g of $FeSO_4.xH_2O$ = ...

mass of $FeSO_4$ in 100 g of $FeSO_4.xH_2O$ = ... g

mass of one mole of $FeSO_4$ = 152 g

number of moles of $FeSO_4$ in 100 g of $FeSO_4.xH_2O$ = ...

x = ...

[4]

(c) When a mixture of sulfur and potassium nitrate is burned and the products are dissolved in water, sulfuric acid is formed.

(i) The sulfuric acid formed by this method is not pure. It contains another acid.
Deduce the identity of this acid.

.... [1]

(ii) The heat causes some of the potassium nitrate to decompose.
Write the equation for the action of heat on potassium nitrate.

.... [2]

Q21. [0620/33/O/N/14/Q2-B]

(b) Compound X is a hydrocarbon. It contains 85.7% of carbon. The mass of one mole of X is 84 g.

(i) What is the percentage of hydrogen in the compound ?

.... [1]

(ii) Calculate the empirical formula of X. Show your working.

empirical formula = ... [3]

(iii) What is the molecular formula of compound X?

.... [1]

[0620/33/O/N/14/Q8-C]

Q22.

(c) 6.31 g of cobalt(II) chloride-6-water crystals were obtained. Calculate the percentage yield to 1 decimal place.

number of moles of HCl in 50 cm^3 of acid, concentration 2.2 mol/dm^3 = ...

maximum number of moles of $CoCl_2.6H_2O$ which could be formed = ...

mass of 1 mole of $CoCl_2.6H_2O$ = 238 g

maximum yield of $CoCl_2.6H_2O$ = ... g

percentage yield = ...%

[4]

[0620/31/M/J/15/Q3-D]

Q23.

(d) Calculate the maximum mass of zinc which will react with 50 cm^3 of hydrochloric acid, of concentration 2.0 mol/dm^3.

$$Zn + 2HCl \rightarrow ZnCl_2 + H_2$$

Show your working.

[3]

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Q24. [0620/32/M/J/15/Q6-C]

(c) The equation for the decomposition of copper(II) nitrate is given below.

$$2Cu(NO_3)_2 \rightarrow 2CuO + 4NO_2 + O_2$$

(i) Predict what you would observe when copper(II) nitrate is heated.

....

....

.... [3]

(ii) Copper(II) nitrate forms a series of hydrates with the formula $Cu(NO_3)_2.xH_2O$.
All these hydrates decompose to form copper(II) oxide.
1 mole of $Cu(NO_3)_2.xH_2O$ forms 1 mole of CuO.

What is meant by 1 mole of a substance?

....

.... [2]

(iii) 7.26 g of a hydrate, $Cu(NO_3)_2.xH_2O$, formed 2.4 g copper(II) oxide.

number of moles of CuO formed = ...

number of moles of $Cu(NO_3)_2.xH_2O$ in 7.26 g = ...

mass of 1 mole of $Cu(NO_3)_2.xH_2O$ = ... g

mass of 1 mole of $Cu(NO_3)_2$ is 188 g

the value of x in this hydrate = ...

[4]

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Q25. [0620/31/O/N/15/Q5]

(a) A compound, **X**, contains 55.85% carbon, 6.97% hydrogen and 37.18% oxygen.

(i) How does this prove that compound **X** contains only carbon, hydrogen and oxygen?

.... [1]

(ii) Use the above percentages to calculate the empirical formula of compound **X**.

.... [2]

(iii) The M_r of **X** is 86.

What is its molecular formula?

.... [2]

(b) (i) Bromine water changes from brown to colourless when added to **X**.

What does this tell you about the structure of **X**?

.... [1]

(ii) Magnesium powder reacts with an aqueous solution of **X**. Hydrogen is evolved.

What does this tell you about the structure of **X**?

.... [1]

(iii) **X** contains two different functional groups.

Draw a structural formula of **X**.

[1]

[Total: 8]

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Q26. [0620/41/M/J/16/Q2-A]

Period 3 contains the elements sodium to argon. This question asks about the chemistry of each of the Period 3 elements or their compounds.

(a) Sodium nitrate is a white crystalline solid. When heated it melts and the following reaction occurs.

$$2NaNO_3(l) \rightarrow 2NaNO_2(l) + O_2(g)$$

A 3.40 g sample of sodium nitrate is heated.

Calculate the

- number of moles of $NaNO_3$ used,

.... mol

- number of moles of O_2 formed,

.... mol

- volume of O_2 formed, in dm^3 (measured at r.t.p.).

.... dm^3
[3]

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[0620/42/M/J/16/Q5-A-B]

Q27.

(a) Hydrocarbons are compounds which contain hydrogen and carbon only.

- $10\,cm^3$ of a gaseous hydrocarbon, C_xH_y, are burned in $100\,cm^3$ of oxygen, which is an excess of oxygen.
- After cooling to room temperature and pressure, there is $25\,cm^3$ of unreacted oxygen, $50\,cm^3$ of carbon dioxide and some liquid water.

All volumes are measured under the same conditions of temperature and pressure.

(i) What is meant by an *excess* of oxygen?

.... [1]

(ii) What was the volume of oxygen that reacted with the hydrocarbon?

.... [1]

(iii) Complete the table below to express the smallest whole number ratio of

volume of hydrocarbon reacted : volume of oxygen reacted : volume of carbon dioxide produced

	volume of hydrocarbon reacted	volume of oxygen reacted	volume of carbon dioxide produced
smallest whole number ratio of volumes			

[1]

(iv) Use your answer to **(a)(iii)** to find the mole ratio in the equation below. Complete the equation and deduce the formula of the hydrocarbon.

.........$C_xH_y(g)$ + ...$O_2(g)$ → ....$CO_2(g)$ + ...$H_2O(l)$

formula of hydrocarbon = ...

[2]

(b) Cracking is used to convert long chain alkanes into shorter chain alkanes and alkenes. Alkenes are unsaturated compounds.

Decane, $C_{10}H_{22}$, can be cracked to give propene and one other product.

(i) Complete the chemical equation.

$$C_{10}H_{22} \rightarrow C_3H_6 + \ldots\ldots\ldots\ldots\ldots$$

[1]

(ii) What is meant by the term *unsaturated*?

.... [1]

(iii) Describe a test to show that propene is an unsaturated compound.

test ....

result ....

[2]

Q28. [0620/43/M/J/16/Q5]

Dilute hydrochloric acid reacts with sodium carbonate solution.

$$2HCl(aq) + Na_2CO_3(aq) \rightarrow 2NaCl(aq) + H_2O(l) + CO_2(g)$$

(a) Explain why effervescence is seen during the reaction.

....

.... [1]

(b) Dilute hydrochloric acid was titrated with sodium carbonate solution.

- $10.0\,cm^3$ of $0.100\,mol/dm^3$ hydrochloric acid were placed in a conical flask.
- A few drops of methyl orange indicator were added to the dilute hydrochloric acid.
- The mixture was titrated with sodium carbonate solution.
- $16.2\,cm^3$ of sodium carbonate solution were required to react completely with the acid.

(i) What colour would the methyl orange indicator be in the hydrochloric acid?

.... [1]

(ii) Calculate how many moles of hydrochloric acid were used.

.... mol [1]

(iii) Use your answer to **(b)(ii)** and the equation for the reaction to calculate the number of moles of sodium carbonate that reacted.

.... mol [1]

(iv) Use your answer to **(b)(iii)** to calculate the concentration of the sodium carbonate solution in mol/dm^3.

.... mol/dm^3 [2]

(c) In another experiment, 0.020 mol of sodium carbonate were reacted with excess hydrochloric acid.

Calculate the maximum volume (at r.t.p.) of carbon dioxide gas that could be made in this reaction.

.... dm^3 [3]

[Total: 9]

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Q29. [0620/41/O/N/16/Q7]

Calcium chloride can be made by reacting calcium carbonate with hydrochloric acid.

$$CaCO_3(s) + 2HCl(aq) \rightarrow CaCl_2(aq) + H_2O(l) + CO_2(g)$$

An excess of calcium carbonate was added to $50.0\,cm^3$ of $0.500\,mol/dm^3$ hydrochloric acid. The solution was filtered to remove the excess calcium carbonate.

(a) How many moles of HC*l* were used in this reaction?

.... mol [2]

(b) Deduce the number of moles of carbon dioxide gas made in this reaction.

.... mol [1]

(c) Calculate the mass of carbon dioxide made in this reaction.

.... g [2]

(d) Calculate the volume, in dm^3, of carbon dioxide made in this reaction at room temperature and pressure (r.t.p.).

.... dm^3 [1]

[Total: 6]

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Q30. [0620/42/O/N/16/Q5-A&E]

Chlorine, bromine and iodine are halogens.

(a) Chlorine can be made in the laboratory by heating manganese(IV) oxide with concentrated hydrochloric acid.

$$MnO_2(s) + 4HCl(aq) \rightarrow MnCl_2(aq) + 2H_2O(l) + Cl_2(g)$$

Calculate the volume of 8.00 mol / dm³ $HCl(aq)$ needed to react with 3.48 g of MnO_2.

- moles of MnO_2 used

.... mol

- moles of HCl needed

.... mol

- volume of HCl needed

.... cm^3

[4]

(e) Iodine forms an oxide which has the composition by mass: I, 76.0%; O, 24.0%.

(i) Use this information to determine the empirical formula of this oxide of iodine.

empirical formula .... [3]

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Q31. [0620/43/O/N/16/Q3]

When lead(II) nitrate is heated, two gases are given off and solid lead(II) oxide remains. The equation for the reaction is shown.

$$2Pb(NO_3)_2(s) \rightarrow 2PbO(s) + 4NO_2(g) + O_2(g)$$

(a) Calculate the M_r of lead(II) nitrate.

.... [1]

(b) 6.62 g of lead(II) nitrate are heated until there is no further change in mass.

(i) Calculate the mass of lead(II) oxide produced.

.... g [2]

(ii) Calculate the volume of oxygen, O_2, produced at room temperature and pressure (r.t.p.).

.... dm^3 [2]

(c) Describe a test for oxygen.

test ....

result ....

[2]

(d) Lead(II) oxide is insoluble. A student adds solid lead(II) oxide to dilute nitric acid until the lead(II) oxide is in excess. Aqueous lead(II) nitrate and water are produced.

(i) What is meant by the term *excess*?

.... [1]

(ii) How would the student know when the lead(II) oxide is in excess?

.... [1]

(iii) Write a chemical equation for the reaction.

.... [1]

[Total: 10]

[0620/41/M/J/17/Q3-B]

Q32.

(b) Magnesium sulfate crystals are hydrated. Another student heated some hydrated magnesium sulfate crystals in a crucible and obtained the following results.

mass of hydrated magnesium sulfate crystals = 4.92 g

mass of water removed = 2.52 g

(i) Calculate the number of moles of water removed.

moles of water = ... mol [1]

(ii) Calculate the number of moles of anhydrous magnesium sulfate remaining in the crucible. The M_r of anhydrous magnesium sulfate is 120.

moles of anhydrous magnesium sulfate = ... mol [1]

(iii) Calculate the ratio of moles of anhydrous magnesium sulfate : moles of water. Give your answer as whole numbers.

ratio = ... : .... [1]

(iv) Suggest the formula of hydrated magnesium sulfate crystals.

formula of hydrated magnesium sulfate crystals = ... [2]

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Q33. [0620/43/M/J/17/Q6-C]

(c) Barium carbonate reacts with dilute hydrochloric acid.

$$BaCO_3 + 2HCl \rightarrow BaCl_2 + CO_2 + H_2O$$

9.85 g of barium carbonate were added to 250 cm³ of 1.00 mol/dm³ hydrochloric acid. This is an excess of hydrochloric acid.

(i) Calculate how many moles of barium carbonate were used in this experiment.

moles of barium carbonate = ... mol [2]

(ii) Deduce how many moles of carbon dioxide were made when all the barium carbonate had reacted.

moles of carbon dioxide = ... mol [1]

(iii) Calculate the volume of carbon dioxide formed in **(c)(ii)** at room temperature and pressure, in dm³.

volume of carbon dioxide = ... dm³ [1]

(iv) Calculate how many moles of hydrochloric acid there were **in excess**.

excess moles of hydrochloric acid = ... mol [2]

[0620/41/O/N/17/Q7-B-C]

Q34.

(b) (i) Calculate the number of moles of copper(II) oxide added to the hydrochloric acid.

moles of copper(II) oxide = ... mol [2]

(ii) Calculate the number of moles of hydrochloric acid used.

moles of hydrochloric acid = ... mol [1]

(iii) Calculate the mass of copper(II) oxide that did **not** react.

mass of copper(II) oxide that did **not** react = ... g [2]

(c) Crystals of hydrated copper(II) chloride were obtained from the solution at the end of the reaction.

The crystals had the following composition by mass: C*l*, 41.52%; Cu, 37.43%; H, 2.34%; O, 18.71%.

Calculate the empirical formula of the crystals.

empirical formula = ... [2]

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Q35. [0620/43/O/N/17/Q6-B]

(b) 25 cm³ of a gaseous hydrocarbon, C_xH_y, were burnt in 150 cm³ of oxygen. This was an excess of oxygen.

After cooling, the volume of the gases remaining was 100 cm³. This consisted of 75 cm³ of carbon dioxide and 25 cm³ of unreacted oxygen. The water that was produced in the reaction was liquid.

All volumes were measured at the same temperature and pressure.

(i) What is meant by an *excess* of oxygen?

.... [1]

(ii) What was the volume of oxygen that reacted with the hydrocarbon?

.... cm³ [1]

(iii) Complete the table to show the smallest whole number ratio of volumes.

	volume of hydrocarbon reacted	:	volume of oxygen reacted	:	volume of carbon dioxide produced
smallest whole number ratio of volumes		:		:	

[1]

(iv) Use your answer to **(b)(iii)** to balance the chemical equation. Deduce the formula of the hydrocarbon.

$$C_xH_y(g) + ...O_2(g) \rightarrow ......CO_2(g) + ...H_2O(l)$$

formula of the hydrocarbon = ... [2]

[Total: 12]

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Q36. [0620/41/M/J/18/Q4]

This question is about masses, volumes and moles.

(a) Which term is defined by the following statement?

The average mass of naturally occurring atoms of an element on a scale where the ^{12}C atom has a mass of exactly 12 units.

.... [1]

(b) Butane, C_4H_{10}, has a relative **molecular** mass of 58.
Potassium fluoride, KF, has a relative **formula** mass of 58.

Explain why the term relative molecular mass can be used for butane but **cannot** be used for potassium fluoride.

....

.... [2]

(c) A 0.095 g sample of gaseous element **Y** occupies 60.0 cm^3 at room temperature and pressure.

- Determine the number of moles of element **Y** in 60.0 cm^3.

moles of element **Y** = ... mol

- Calculate the relative molecular mass of element **Y** and hence suggest the identity of element **Y**.

relative molecular mass = ...

identity of element **Y** = ...
[3]

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(d) A 1.68 g sample of phosphorus was burned and formed 3.87 g of an oxide of phosphorus.

Calculate the empirical formula of this oxide of phosphorus.

empirical formula = ... [4]

(e) Another oxide of phosphorus has the empirical formula P_2O_3.
One molecule of this oxide of phosphorus contains four atoms of phosphorus.

Calculate the mass of **one** mole of this oxide of phosphorus.

mass = ... g [2]

[Total: 12]

[0620/42/M/J/18/Q7A-B]

Q37.

Many organic compounds, such as alcohols, carboxylic acids and esters, contain the elements carbon, hydrogen and oxygen only.

(a) Compound **R** has the following composition by mass: C, 60.00%; H, 13.33%; O, 26.67%.

Calculate the empirical formula of compound **R**.

empirical formula = ... [2]

(b) Compound **S** has the empirical formula C_2H_4O and a relative molecular mass of 88.

Calculate the molecular formula of compound **S**.

molecular formula = ... [2]

[0620/43/M/J/18/Q5-A]

Q38.

(a) Nickel(II) iodide crystals are hydrated. A sample of hydrated nickel(II) iodide crystals has the following composition by mass: Ni, 14.01%; I, 60.33%; H, 2.85%; O, 22.81%.

Calculate the empirical formula of the hydrated nickel(II) iodide crystals.

empirical formula = ... [2]

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Q39. [0620/43/M/J/18/Q6-A]

Calcium chlorate(V), $Ca(ClO_3)_2$, is made by reacting calcium hydroxide with chlorine gas.

$$6Ca(OH)_2 + 6Cl_2 \rightarrow Ca(ClO_3)_2 + 5CaCl_2 + 6H_2O$$

(a) 8.88 g of calcium hydroxide and 7200 cm^3 of chlorine gas are mixed together.

(i) How many moles is 8.88 g of calcium hydroxide?

.... mol [2]

(ii) How many moles of chlorine gas is 7200 cm^3?

.... mol [1]

(iii) What is the maximum **number of moles** of calcium chlorate(V) that can be made from 8.88 g of calcium hydroxide and 7200 cm^3 of chlorine gas?

.... mol [1]

(iv) What is the maximum **mass** of calcium chlorate(V) that can be made from 8.88 g of calcium hydroxide and 7200 cm^3 of chlorine gas?

.... g [2]

The experiment is repeated using different amounts of calcium hydroxide and chlorine gas. The maximum mass of calcium chlorate(V) that can be made in the experiment is 4.84 g.

(v) The actual mass of calcium chlorate(V) made in the experiment is 3.63 g.

Calculate the percentage yield.

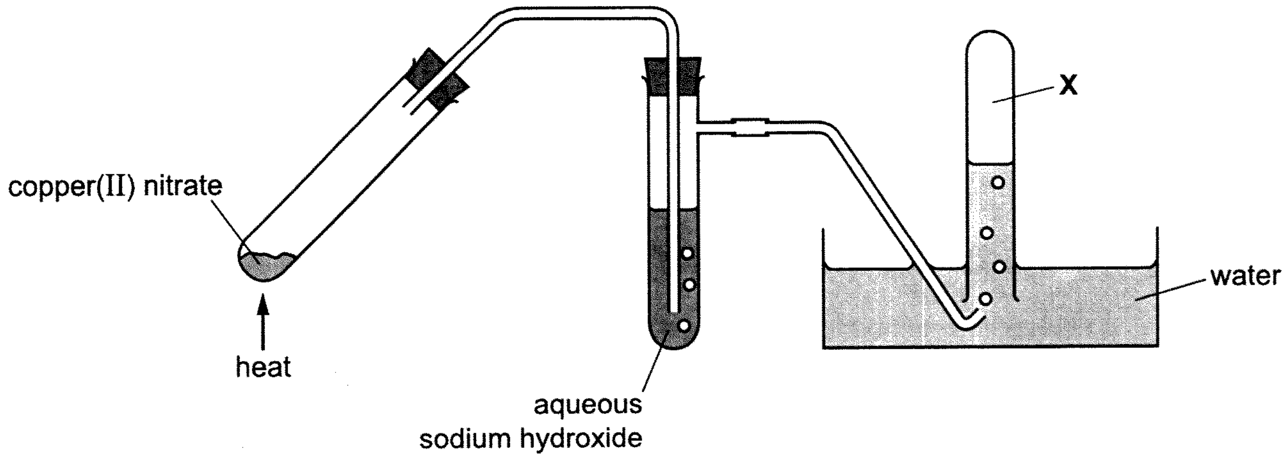
percentage yield = ... % [1]

[0620/41/O/N/18/Q3-C]

Q40.

(a) Copper(II) nitrate decomposes when heated. Two gases, oxygen and nitrogen dioxide, and a solid are made in the reaction.

A sample of copper(II) nitrate was decomposed using the apparatus shown.



(c) A teacher heated 18.8 g of copper(II) nitrate.

(i) Calculate the number of moles of copper(II) nitrate present in the 18.8 g.

.... mol [2]

(ii) Calculate the maximum number of moles of oxygen that can be made by heating 18.8 g of copper(II) nitrate.

.... mol [1]

(iii) Calculate the maximum volume of oxygen at room temperature and pressure, in cm^3, that can be made by heating 18.8 g of copper(II) nitrate.

.... cm^3 [1]

Q41. [0620/42/O/N/18/Q3-D-E]

(d) In a titration, a student added $25.0\,cm^3$ of $0.200\,mol/dm^3$ aqueous sodium hydroxide to a conical flask. The student then added a few drops of methyl orange to the solution in the conical flask.
Dilute sulfuric acid was then added from a burette to the conical flask. The volume of dilute sulfuric acid needed to neutralise the aqueous sodium hydroxide was $20.0\,cm^3$.

$$2NaOH + H_2SO_4 \rightarrow Na_2SO_4 + 2H_2O$$

(i) What was the colour of the methyl orange in the aqueous sodium hydroxide?

.... [1]

(ii) Determine the concentration of the dilute sulfuric acid in g/dm^3.

- Calculate the number of moles of aqueous sodium hydroxide added to the conical flask.

.... mol

- Calculate the number of moles of dilute sulfuric acid added from the burette.

.... mol

- Calculate the concentration of the dilute sulfuric acid in mol/dm^3.

.... mol/dm^3

- Calculate the concentration of the dilute sulfuric acid in g/dm^3.

.... g/dm^3
[4]

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(e) Iron(II) sulfate decomposes when heated strongly.

$$2FeSO_4(s) \rightarrow Fe_2O_3(s) + SO_2(g) + SO_3(g)$$

15.20 g of $FeSO_4(s)$ was heated and formed 4.80 g of $Fe_2O_3(s)$.

[M_r, $FeSO_4$ = 152; M_r, Fe_2O_3 = 160]

Calculate the percentage yield for this reaction.

.... % [3]

Q42. [0620/41/O/N/18/Q4-D]

(d) Dilute sulfuric acid reacts with aqueous sodium hydrogencarbonate in a neutralisation reaction.

$$H_2SO_4(aq) + 2NaHCO_3(aq) \rightarrow Na_2SO_4(aq) + 2H_2O(l) + 2CO_2(g)$$

In a titration, 0.200 mol/dm^3 aqueous sodium hydrogencarbonate was used to neutralise 20.0 cm^3 of dilute sulfuric acid of concentration 0.150 mol/dm^3.

(i) Calculate the number of moles of dilute sulfuric acid used in the titration.

.... mol [1]

(ii) Calculate the number of moles of sodium hydrogencarbonate needed to neutralise the dilute sulfuric acid.

.... mol [1]

(iii) Calculate the volume, in cm^3, of 0.200 mol/dm^3 aqueous sodium hydrogencarbonate needed to neutralise the dilute sulfuric acid.

.... cm^3 [1]

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Q43. [0620/43/O/N/18/Q3-A-B-C-D]

Tin is a metallic element in Group IV. Its main ore is cassiterite which is an impure form of tin(IV) oxide, SnO_2.
Tin also occurs in stannite, Cu_2FeSnS_4.

(a) Calculate the relative formula mass, M_r, of Cu_2FeSnS_4.

M_r of Cu_2FeSnS_4 = ... [1]

(b) The M_r of SnO_2 is 151.

Calculate the percentage of tin by mass in SnO_2.

percentage of tin by mass in SnO_2 = ... [1]

(c) The percentage of tin by mass in Cu_2FeSnS_4 is 27.6%.

Use this information and your answer to **(b)** to suggest whether it would be better to extract tin from SnO_2 or Cu_2FeSnS_4.
Explain your answer.

....

.... [1]

(d) Tin can be extracted by heating tin(IV) oxide with carbon. Carbon monoxide is the other product.

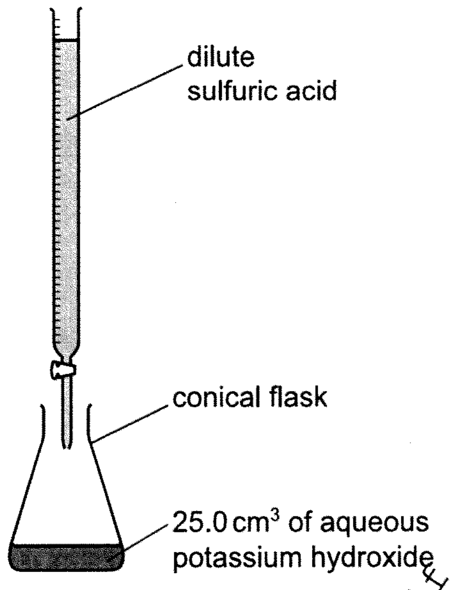
Write a chemical equation for this reaction.

.... [2]

[0620/43/O/N/18/Q4-A]

Q44.

(a) Dilute sulfuric acid and aqueous potassium hydroxide can be used to make potassium sulfate crystals using a method that includes titration.



A student titrated 25.0 cm^3 of 0.0500 mol/dm^3 aqueous potassium hydroxide with dilute sulfuric acid in the presence of an indicator. The volume of dilute sulfuric acid needed to neutralise the aqueous potassium hydroxide was 20.0 cm^3.

The equation for the reaction is shown.

$$H_2SO_4 + 2KOH \rightarrow K_2SO_4 + 2H_2O$$

Determine the concentration of the dilute sulfuric acid.

- Calculate the number of moles of aqueous potassium hydroxide used.

.... mol

- Calculate the number of moles of dilute sulfuric acid needed to neutralise the aqueous potassium hydroxide.

.... mol

- Calculate the concentration of the dilute sulfuric acid.

.... mol/dm^3

[3]

Q45. [0620/41/M/J/19/Q3-D-E]

(d) A compound of copper can be used to test for water.

(i) State the full name of this compound of copper.

.... [1]

(ii) State the colour change that occurs when water is added to this compound of copper.

from .... to .... [2]

(e) Aqueous potassium iodide reacts with aqueous copper(II) sulfate to produce iodine.

(i) Balance the chemical equation for this reaction.

$$KI + CuSO_4 \rightarrow CuI + I_2 + K_2SO_4$$

[2]

(ii) Deduce the charge on the copper ion in CuI.

.... [1]

(iii) In terms of electron transfer, explain why copper is reduced in this reaction.

.... [1]

(iv) Identify the reducing agent.

.... [1]

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[0620/41/M/J/19/Q4-C]

Q46.

(c) Hydrochloric acid produces salts called chlorides.

Magnesium carbonate reacts with hydrochloric acid to produce magnesium chloride.

$$MgCO_3 + 2HCl \rightarrow MgCl_2 + H_2O + CO_2$$

A student used 50.00 cm^3 of 2.00 mol / dm^3 hydrochloric acid in an experiment to produce magnesium chloride.

Calculate the mass, in g, of magnesium carbonate needed to react exactly with 50.00 cm^3 of 2.00 mol / dm^3 hydrochloric acid using the following steps.

- Calculate the number of moles of HCl present in 50.00 cm^3 of 2.00 mol / dm^3 HCl.

.... mol

- Determine the number of moles of $MgCO_3$ which would react with 50.00 cm^3 of 2.00 mol / dm^3 HCl.

.... mol

- Calculate the relative formula mass, M_r, of $MgCO_3$.

M_r of $MgCO_3$ = ...

- Calculate the mass of $MgCO_3$ needed to react exactly with 50.00 cm^3 of 2.00 mol / dm^3 HCl.

mass = ... g
[4]

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Q47. [0620/42/M/J/19/Q5-A]

Copper(II) sulfate crystals, $CuSO_4.5H_2O$, are hydrated.

Copper(II) sulfate crystals are made by reacting copper(II) carbonate with dilute sulfuric acid.

The equation for the overall process is shown.

$$CuCO_3 + H_2SO_4 + 4H_2O \rightarrow CuSO_4.5H_2O + CO_2$$

step 1 Powdered solid copper(II) carbonate is added to 50.0 cm^3 of 0.05 mol/dm^3 sulfuric acid until the copper(II) carbonate is in excess.

step 2 The excess of copper(II) carbonate is separated from the aqueous copper(II) sulfate.

step 3 The aqueous copper(II) sulfate is heated until the solution is saturated.

step 4 The solution is allowed to cool and crystallise.

step 5 The crystals are removed and dried.

(a) Calculate the maximum mass of the copper(II) sulfate crystals, $CuSO_4.5H_2O$, that can form using the following steps.

- Calculate the number of moles of H_2SO_4 in 50.0 cm^3 of 0.05 mol/dm^3 H_2SO_4.

.... mol

- Determine the number of moles of $CuSO_4.5H_2O$ that can form.

.... mol

- The M_r of $CuSO_4.5H_2O$ is 250.

  Calculate the maximum mass of $CuSO_4.5H_2O$ that can form.

.... g
[3]

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[0620/43/M/J/19/Q3-A-B-E]

Q48.

(a) (i) Sodium is in Group I of the Periodic Table.

Describe **two** physical properties of sodium which are different from the physical properties of transition elements such as copper.

1 ....

....

2 ....

....
[2]

(ii) Sodium reacts rapidly with water.

Give **one** observation made when sodium is added to water.

.... [1]

(b) Some car airbags contain sodium azide.
When a car airbag is used the sodium azide, NaN_3, decomposes.
The products are nitrogen and sodium.

The equation for the decomposition of sodium azide is shown.

$$2NaN_3(s) \rightarrow 2Na(l) + 3N_2(g)$$

Calculate the mass, in g, of sodium azide needed to produce 144 dm^3 of nitrogen using the following steps.

- Calculate the number of moles in 144 dm^3 of N_2 measured at room temperature and pressure.

moles of N_2 = ... mol

- Determine the number of moles of NaN_3 needed to produce this number of moles of N_2.

moles of NaN_3 = ... mol

- Calculate the relative formula mass, M_r, of NaN_3.

M_r = ...

- Calculate the mass of NaN_3 needed to produce 144 dm^3 of N_2.

.... g
[4]

(e) An organic compound made from sodium azide has the composition by mass: 49.5% carbon, 7.2% hydrogen and 43.3% nitrogen.

Calculate the empirical formula of the organic compound.

[3]

[0620/41/O/N/19/Q2-E]

Q49.

(e) Sulfur dioxide reacts with aqueous sodium sulfite to produce a compound with the following composition by mass: 29.1% Na, 40.5% S and 30.4% O.

Calculate the empirical formula of this compound.

empirical formula = ... [3]

Q50. [0620/41/O/N/19/Q6-A-B-C-i]

Dilute hydrochloric acid, $HCl(aq)$, reacts with aqueous sodium carbonate, $Na_2CO_3(aq)$.

The chemical equation for the reaction is shown.

$$2HCl + Na_2CO_3 \rightarrow 2NaCl + CO_2 + H_2O$$

(a) A 25.0 cm^3 portion of $Na_2CO_3(aq)$ was placed in a conical flask with a few drops of a suitable indicator. It was titrated against $HCl(aq)$ of concentration 0.180 mol/dm^3.

20.0 cm^3 of $HCl(aq)$ was required to reach the end-point.

Calculate the concentration of the $Na_2CO_3(aq)$, in mol/dm^3, using the following steps.

- Calculate the number of moles of HCl used in the titration.

.... mol

- Calculate the number of moles of Na_2CO_3 contained in the 25.0 cm^3 portion of $Na_2CO_3(aq)$.

.... mol

- Calculate the concentration of the $Na_2CO_3(aq)$ in mol/dm^3.

.... mol/dm^3
[3]

(b) In another experiment, the volume of carbon dioxide, CO_2, produced was 48.0 cm^3, measured at room temperature and pressure.

How many moles of CO_2 is this?

moles of CO_2 = ... mol [1]

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(c) A sample of concentrated hydrobromic acid, HBr(aq), was electrolysed using platinum electrodes.
The concentration of the hydrobromic acid was 8.89 mol / dm^3.

(i) Calculate the concentration of the HBr(aq) in g / dm^3.

concentration of HBr(aq) = ... g / dm^3 [1]

[0620/42/O/N/19/Q3-D-i]

Q51.

(d) Ammonia reacts with oxygen as shown.

$$4NH_3(g) + 5O_2(g) \rightarrow 4NO(g) + 6H_2O(g)$$

(i) Calculate the volume of oxygen at room temperature and pressure, in dm^3, that reacts with 4.80 dm^3 of ammonia.

volume = ... dm^3 [3]

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[0620/43/O/N/19/Q4-H]

Q52.

(h) Phosphorus forms another compound with hydrogen with the following composition by mass: P, 93.94%; H, 6.06%.

(i) Calculate the empirical formula of the compound.

empirical formula = ... [2]

(ii) The compound has a relative molecular mass of 66.

Deduce the molecular formula of the compound.

molecular formula = ... [1]

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[0620/43/O/N/19/Q5]

Q53.

Nitrates such as ammonium nitrate are used as fertilisers.

The final stage in the production of ammonium nitrate is shown in the equation.

$$Ca(NO_3)_2 + 2NH_3 + CO_2 + H_2O \rightarrow 2NH_4NO_3 + CaCO_3$$

Calculate the maximum mass of ammonium nitrate that can be produced from 820 g of calcium nitrate, $Ca(NO_3)_2$, using the following steps.

The relative formula mass, M_r, of calcium nitrate, $Ca(NO_3)_2$, = 164.

- Calculate the number of moles of $Ca(NO_3)_2$ in 820 g.

.... mol

- Deduce the number of moles of NH_4NO_3 produced.

.... mol

- Calculate the M_r of NH_4NO_3.

M_r of NH_4NO_3 = ...

- Calculate the maximum mass of ammonium nitrate produced.

.... g

[4]

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[0620/41/M/J/20/Q4-C-D]

Q54.

(c) Aqueous sodium hydroxide, NaOH(aq), is a strong alkali that reacts with dilute sulfuric acid exothermically.

(i) What type of reaction is this?

.... [1]

(ii) Complete the equation for the reaction between aqueous sodium hydroxide and dilute sulfuric acid.

$2NaOH + H_2SO_4 \rightarrow$ .... + ...

[2]

(d) A student wanted to find the concentration of some dilute sulfuric acid by titration. The student found that 25.0 cm^3 of 0.0400 mol/dm^3 NaOH(aq) reacted exactly with 20.0 cm^3 of H_2SO_4(aq).

(i) Name a suitable indicator to use in this titration.

.... [1]

(ii) Calculate the concentration of the H_2SO_4(aq) in mol/dm^3 using the following steps.

- Calculate the number of moles of NaOH in 25.0 cm^3.

moles = ...

- Deduce the number of moles of H_2SO_4 that reacted with the 25.0 cm^3 of NaOH(aq).

moles = ...

- Calculate the concentration of H_2SO_4(aq) in mol/dm^3.

concentration = ... mol/dm^3
[3]

(iii) Calculate the concentration of the 0.0400 mol/dm^3 NaOH(aq) in g/dm^3.

concentration = ... g/dm^3 [2]

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[0620/42/M/J/20/Q4-E-F]

Q55.

(e) The equation for the decomposition of hydrogen peroxide is shown.

$$2H_2O_2(aq) \rightarrow 2H_2O(l) + O_2(g)$$

$25.0\,cm^3$ of aqueous hydrogen peroxide forms $48.0\,cm^3$ of oxygen at room temperature and pressure (r.t.p.).

Calculate the concentration of aqueous hydrogen peroxide at the start of the experiment using the following steps.

- Calculate the number of moles of oxygen formed.

.... mol

- Deduce the number of moles of hydrogen peroxide that decomposed.

.... mol

- Calculate the concentration of hydrogen peroxide in mol/dm^3.

.... mol/dm^3
[3]

(f) Oxygen can also be produced by the decomposition of potassium chlorate(V), $KClO_3$.

The only products of this decomposition are potassium chloride and oxygen.

Write a chemical equation for this decomposition.

.... [2]

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[0620/43/M/J/20/Q2-D-ii-iii-iv]

$$4NH_3 + 5O_2 \rightarrow 4NO + 6H_2O$$

Q56.

(ii) In this reaction the predicted yield of NO is 512 g. The actual yield is 384 g.

Calculate the percentage yield of NO in this reaction.

percentage yield of NO = ... [1]

(iii) The equation for the reaction in **stage 2** is shown.

$$2NO + O_2 \rightarrow 2NO_2$$

Which major environmental problem does NO_2 cause if it is released into the atmosphere?

....

.... [1]

(iv) The equation for the reaction in **stage 3** is shown.

$$4NO_2 + 2H_2O + O_2 \rightarrow 4HNO_3$$

Calculate the volume of O_2 gas, at room temperature and pressure (r.t.p.), needed to produce 1260 g of HNO_3.
Use the following steps.

- Calculate the number of moles of HNO_3.

moles of HNO_3 = ...

- Deduce the number of moles of O_2 that reacted.

moles of O_2 = ...

- Calculate the volume of O_2 gas that reacts at room temperature and pressure (r.t.p.).

volume of O_2 gas = ... dm^3
[4]

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Q57. [0620/42/O/N/2020/Q2]

Soluble salts can be made by adding a metal carbonate to a dilute acid.

(a) Give the formula of the dilute acid which reacts with a metal carbonate to form a nitrate salt.

.... [1]

(b) A student wanted to make hydrated iron(II) sulfate crystals, $FeSO_4 \cdot xH_2O$, by adding excess iron(II) carbonate to dilute sulfuric acid. The student followed the procedure shown.

step 1 Add dilute sulfuric acid to a beaker.

step 2 Add small amounts of iron(II) carbonate to the dilute sulfuric acid in the beaker until the iron(II) carbonate is in excess.

step 3 Filter the mixture formed in **step 2**.

step 4 Heat the filtrate until it is a saturated solution. Allow to cool.

step 5 Once cold, pour away the remaining solution. Dry the crystals between filter papers.

(i) Why must the iron(II) carbonate be added in excess in **step 2**?

.... [1]

(ii) State **two** observations in **step 2** that would show that iron(II) carbonate was in excess.

1 ....

2 ....

[2]

(iii) Describe what should be done during **step 3** to ensure there is a maximum yield of crystals.

.... [1]

(iv) A saturated solution is formed in **step 4**.

Describe what a saturated solution is.

....

.... [2]

(v) Name a different compound that could be used instead of iron(II) carbonate to produce hydrated iron(II) sulfate crystals from dilute sulfuric acid.

.... [1]

(c) On analysing the crystals, the student found that one mole of the hydrated iron(II) sulfate crystals, $FeSO_4 \cdot xH2O$, had a mass of 278 g.

Determine the value of *x* using the following steps:

- calculate the mass of one mole of $FeSO_4$

mass = ... g

- calculate the mass of H_2O present in one mole of $FeSO_4 \cdot xH_2O$

mass of H_2O = ... g

- determine the value of *x*.

x = ...

[3]

(d) Insoluble salts can be made by mixing solutions of two soluble salts.

A student followed the procedure shown to make silver bromide, an insoluble salt.

step 1 Add aqueous silver nitrate to a beaker. Then add aqueous potassium bromide and stir.

step 2 Filter the mixture formed in **step 1**.

step 3 Dry the residue.

(i) State the term used to describe this method of making salts.

.... [1]

(ii) Give the observation the student would make during **step 1**.

.... [1]

(iii) Write the ionic equation for the reaction between aqueous silver nitrate and aqueous potassium bromide.

Include state symbols.

.... [3]

(e) Sodium chloride is an ionic salt. It can be made by reacting sodium with chlorine gas.

The equation for this reaction is shown.

$$2Na(s) + Cl_2(g) \rightarrow 2NaCl(s)$$

Calculate the volume of chlorine gas, in cm^3, that reacts to form 2.34 g of NaCl.

The reaction takes place at room temperature and pressure.

volume of chlorine gas = ... cm^3 [3]

(f) Sodium chloride does not conduct electricity when solid, but does conduct electricity when molten.

(i) Explain why, in terms of structure and bonding.

....

....

....

.... [3]

(ii) Name the product formed at the positive electrode when electricity is passed through molten sodium chloride.

.... [1]

(iii) State the type of change that occurs at the positive electrode in **(ii)**.

Explain your answer in terms of electron transfer.

type of change ....

explanation ....

[2]

(iv) Describe what else can be done to sodium chloride to allow it to conduct electricity.

.... [1]

[Total: 26]

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Q1.

(c) mass of hydrated magnesium sulfate = 1.476 g
mass of barium sulfate formed = 1.398 g
the mass of one mole of $BaSO_4$ = 233 g
the number of moles of $BaSO_4$ formed = 0.006 [1]
the number of moles of $MgSO_4.xH_2O$ used in experiment = 0.006 [1]
the mass of one mole of $MgSO_4.xH_2O$ = 1.476/0.006 = 246 g [1]
the mass of xH_2O in one mole of $MgSO_4.xH_2O$ = 246 – 120 = 126 g [1]
x = 126/18 = 7 [1]
if x given without method = max 1
note: apply ecf but x must be an integer and less than 10

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Q2.

(b) moles of Fe = 51.85/56 = 0.926 (0.93); [1]
moles of O = 22.22/16 = 1.389 (1.39); [1]
moles of H_2O = 16.67/18 = 0.926 (0.93); [1]

if given as 0.9 1.4 0.9
three of the above correct = [2]
two of the above correct = [1]

simplest whole number mole ratio Fe : O : H_2O is 2: 3: 2 / $Fe_2O_3.2H_2O$; [1]
allow: ecf for a formula based on an incorrect whole number ratio

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Q3.

(e) if C_5H_{10} is given award 3 marks;;; [3]
if $C_{10}H_{20}$ is given award 2 marks;;
if 1:7.5:5 / 2:15:10 is given award 2 marks;;
in all other cases a mark can be awarded for moles of O_2 (= 2.4/32 =) 0.075 **AND** moles of CO_2 (= 2.2/44 =) 0.05;

$2C_5H_{10} + 15O_2 \rightarrow 10CO_2 + 10H_2O$ [1]
accept: multiples including fractions
allow: ecf for correct equation from any incorrect alkene

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Q4.

(c) BrF_3 / F_3Br; [1]
BrF_5 / F_5Br; [1]

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Q5.

(b) (i) strontium carbonate does not dissolve / no effervescence; [1]
note: not just reaction is complete

(ii) to remove excess/unreacted / undissolved strontium carbonate; [1]

(iii) water of crystallisation needed / $6H_2O$ in crystals / would get anhydrous salt / would not get hydrated salt / crystals dehydrate; [1]
not: just to obtain crystals

(c) number of moles of HCl used = 0.05 × 2 = 0.1 [1]
number of moles of $SrCl_2.6\ H_2O$ which could be formed. = 0.05 [1]
mass of one mole of $SrCl_2.6H_2O$ is 267 g
theoretical yield of $SrCl_2.6H_2O$ = 0.05 × 267 = 13.35 g [1]
percentage yield = 6.4 / 13.35 × 100 = 47.9% [1]
accept: 48%
allow: ecf

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Q6.

(d) number of moles of Na_2SO_3 = 3.15/126 = 0.025 [1]
number of moles of SO_2 formed = 0.025 [1]
volume of SO_2 = 0.025 x 24 = 0.6 dm^3/litres **or** 600 cm^3 [1]
allow: ecf
for 1.6 g of SO_2 [1] only
If used 22.4 max [2]
note: need correct units for last m

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Q7.

(b) (i) (97.4 / 75 =) 1.3 **and** (2.6 / 1 =) 2.6; [1]
empirical formula AsH_2; [1]
note: correct formula with no working = [1]

(ii) As_2H_4; [1]

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Q8.

(b) number of moles of HCl = 0.020 x 2.20 = 0.044 [1]
number of moles of LiOH = 0.044
concentration of LiOH = 0.044/0.025 = 1.769 (mol / dm^3) [1]
accept 1.75 to 1.77 need 2 dp
correct answer scores = 2

(c) (for $LiCl.2H_2O$)
mass of one mole = 78.5 [1]
percentage water = 36 / 78.5 x 100 [1]
45.9 so is $LiCl.2H_2O$ [1]
only award the marks if you can follow the reasoning and it gives 45.9% of water

note: if correct option given mark this and ignore the rest of the response

allow: max 2 for applying a correct method to another hydrate, [1] for the method and [1] for the correct value, working essential

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Q9.

(iii) chlorine / Cl_2 / [1]
cond: water treatment / solvents / plastics / PVC / bleach / disinfectants / HCl / kill bacteria / sterilising water / chlorination <u>of water</u> / swimming pools / pesticides / herbicides / insecticides / germicides / pharmaceuticals [1]

sodium hydroxide/NaOH [1]

cond: making soap / degreasing / making paper / detergents / bio-diesel / paint stripper / clearing drains / alumina from bauxite / oven cleaner / bleach [1]

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Q10.

(a) (i) (the number of particles which is equal to the number of atoms in) 12 g of carbon 12
or
the mass in grams which contains the Avogadro's constant number of particles
or
Avogadro's constant **or** 6 to 6.023×10^{23} of atoms / ions / molecules / electrons / particles

(the amount of substance which has a mass equal to) its relative formula mass / relative atomic mass / relative molecular mass in grams
or
(the amount of substance which has a volume equal to) 24 dm^3 of a gas at RTP [1]

(ii) (Avogadro's constant is the) number of particles / atoms / ions / molecules in one mole of a substance
or
the number of carbon atoms in 12 g of C(12).
or
the number of particles / molecules in 24 dm^3 of a gas at RTP
or
6 to 6.023×10^{23} (particles / atoms / ions / molecules / electrons) [1]

(b) CH_4 **and** SO_2 [1]

2/16 = 1/8 or 0.125 moles of CH_4 **AND** 8/64 = 1/8 or 0.125 moles of SO_2 [1]

(c) (i) 4.8/40 = 0.12 moles of Ca
3.6/18 = 0.2 moles of H_2O **both** correct [1]

(ii) Ca is in excess (**no mark**) (because 0.12 moles of Ca need) 0.24 moles / 4.32 g of H_2O to react [1]
there is not enough / there are 0.2 moles / 3.6 g of H_2O [1]

Ca is in excess **(no mark)** (because 0.2 moles / 3.6 g of water will react with) 0.1 moles/4.0 g of Ca [1]
there is more than that / there are 0.12 moles / 4.8 g of Ca [1]
or
Ca is in excess **(no mark)** because the mole ratio Ca:H_2O is 3:5 / mass ratio 4:3 [1]
which is bigger than the required mole ratio of 1:2 / mass ratio 10:9 [1]
or
Ca is in excess **(no mark)** because the mole ratio H_2O:Ca is 5:3 / mass ratio 3:4 [1]
which is smaller than the required mole ratio of 2:1 / mass ratio 9:10 [1]

(iii) $0.02 \times 40 = 0.8$ (g) [1]

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Q11.

(d) volume of oxygen used = 150 cm^3 [1]

volume of carbon dioxide formed = 100 cm^3 [1]
any equation of the combustion of an alkene
e.g. $2C_5H_{10} + 15O_2 \rightarrow 10CO_2 + 10H_2O$
formulae [1]
COND balancing [1]

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Q12.

(d) number of moles of HCl in 40 cm^3 of hydrochloric acid,
concentration 2.0 mol / dm^3 = 0.04 × 2.0 = 0.08 [1]
maximum number of moles of CO_2 formed = 0.04 [1]
mass of one mole of CO_2 = 44 g [1]
maximum mass of CO_2 lost = 0.04 × 44 = 1.76 g [1]

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Q13.

(c) number of moles of CO_2 formed = 2.112 / 44 = 0.048 [1]
number of moles of H_2O formed = 0.432 / 18 = 0.024 [1]

x = 2 and y = 1 **NOT:** ecf from this line

formula is $2PbCO_3.Pb(OH)_2$ / $Pb(OH)_2.\ 2PbCO_3$ [1]

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Q14.

(b) (i) greenhouse effect / CO_2 is a greenhouse gas [1]
global warming / ice caps melting / suitable example [1]

(ii) burning or combustion of charcoal produces carbon dioxide [1]
trees use carbon dioxide (in photosynthesis) [1]

(iii) cathode reaction $Fe^{3+} + 3e \rightarrow Fe$ [1]

anode reaction $2O^{2-} \rightarrow O_2 + 4e$ [2]
not balanced = (1) only

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Q15.

(ii) mass of $AgNO_3$ needed is 170 × 0.2 × 0.1 = 3.4g [2]
NOTE: if answer given is 34 they have omitted 0.1
ALLOW: (1) ecf

(iii) number of moles of $AgNO_3$ used = 0.02 × 0.2 = 0.004 [1]

number of moles of Ag_2CrO_4 formed = 0.002 [1]

mass of one mole of Ag_2CrO_4 = 332g

mass of Ag_2CrO_4 formed = 0.664g [1]
NOTE: use ecf when appropriate

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Q16.

(d) (i) number of moles of glucose = 72/180 = 0.4 [1]
maximum number of moles ethanol = 0.8 [1]
maximum mass of ethanol, M_r = 46 g, 0.8 × 46 = 36.8 g [1]
or
180 (g) produces 2 × 46 = 92 (g) (1)
(72 (g) produces) 72/180 × 92 (1)
=36.8 (g) (1)

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Q17.

(d) number of moles of O_2 formed = 0.096/24 = 0.004 (1)
number of moles of H_2O_2 in 40 cm^3 of solution = 0.004 × 2 = 0.008 (1)

concentration of the hydrogen peroxide in mol/dm^3 = 0.008/0.04 = 0.2 (1) [3]

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Q18.

(b) <u>0.062</u> (1)

0.031 (1)

3.97 g (1)

55.4% (1) [4]

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Q19.

(c) (i) $C_9H_{20} + 14\ O_2 \rightarrow 9CO_2 + 10H_2O$ (2) [2]

(ii) Volume ratio

$C_xH_y(g)$	+ $O_2(g)$	→	$CO_2(g)$	+	$H_2O(l)$	
20	160		100			all in cm^3
1	8		5			mole ratio
C_5H_{12}	+ $8O_2$	→	$5CO_2$	+	$6H_2O$	

For evidence of method (1)
for equation as above (2) [3]

(d) (i) alkanes in petrol / fuel / solvent (1)
alkenes to make alcohols / plastics / polymers / solvents (1)
hydrogen to make ammonia / fuel / fuel cells, etc. (1) [3]

(ii) a correct equation for example:
$C_{10}H_{22} \rightarrow C_8H_{16} + C_2H_4 + H_2$ (1) [1]

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Q20.

(iii) M1 = 2.07 Allow 2.1 or 2.0666…7

M2 = 62.8.g

M3 =(M2/152 =) 0.41(3)

M4 (=M1/M3) rounded to the nearest whole number $\times$ = 5 [4]

(c) (i) nitric acid or nitric(V) acid or HNO_3 [1]

(ii) $2KNO_3 = 2KNO_2 + O_2$ [2]
Species (1)
Balance (1)

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Q21.

(b) (i) 14.3 [1]

(ii) 85.7 ÷ 12 and 14.3 ÷ 1 **or** 7.14 and 14.3 [1]
ratio 1:2 [1]
CH_2 [1]
note: Award all 3 marks for correct answer
allow: alternative working e.g.
85.7 × 84 ÷ 100 and 14.3 × 84 ÷ 100 **or** 71.988/72 and 12/12.012 [1]
6:12 **or** ratio 1:2 [1]
CH_2 [1]

(iii) C_6H_{12} [1]

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Q22.

(c) number of moles of HC*l* in 50 cm^3 of acid, concentration 2.2 mol/dm^3 = 0.11 [1]

maximum number of moles of $CoCl_2.6H_2O$ which could be formed = 0.055 [1]

mass of 1 mole of $CoCl_2.6H_2O$ = 238 g

maximum yield of $CoCl_2.6H_2O$ = 13.09 g [1]

percentage yield = 48.2% **or** ecf mass of $CoCl_2.6H_2O$ above/13.09 × 100% to <u>1 dp</u> [1]

Q23.

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Question	Answer	Marks	Guidance
3(d)	M1 moles of HC*l* = 0.1 (mol); M2 moles of Zn = 0.05 (mol); mass of zinc = 3.25 g;	3	**A** ECF for M1 × ½ **A** ECF for M2 × 65 Unit required for M3

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Q24.

Page 8	Mark Scheme	Syllabus	Paper
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Question	Answer	Marks	Guidance
6(c)(i)	(changes from) blue solid / blue crystals; black solid formed; brown gas / brown vapour / (pungent) smell;	3	**R** precipitate **A** one mark out of the first two for changes from blue to black (without solid or crystals) **I** red / melt **I** water / steam / condensation given off **I** reference to glowing / burning splints / colourless gas / effervescence **I** names / formulae
6(c)(ii)	Avogadro('s) number / constant / 6.02×10^{23}; **COND** particles; **OR** (the number of particles which is equal to the number of atoms in) 12 g of carbon 12; **COND** atoms; **OR** the mass **in grams** which contains Avogadro('s) Number; **COND** particles; **OR** (the amount of substance which has a mass equal to) its <u>relative</u> formula mass / RFM / <u>relative</u> atomic mass / Ar / <u>relative</u> molecular mass / Mr / molar mass; **COND** in grams; **OR** (the amount of substance which has a volume equal to) 24 dm^3; **COND** of a gas **at** RTP;	2	**A** any values from 6 to 6.023×10^{23} **A** atoms / ions / molecules / electrons **A** one mark for reference to C12 **A** equivalent statement for any element **or** compound e.g. 32 grams of oxygen(1) **COND** <u>molecules</u> / O_2 (1) e.g. 16 grams of oxygen (1) **COND** <u>atoms</u> / O(1) **A** different volumes under different conditions e.g. 22.4 dm^3 at STP or volumes in different units e.g. 24 000 cm^3 at RTP
6(c)(iii)	M1 (number of moles of CuO formed =) **0.03**; M2 (number of moles of $Cu(NO_3)_2.xH_2O$ in 7.26 g =) **0.03**; M3 (mass of 1 mole of $Cu(NO_3)_2.xH_2O$ 7.26 ÷ 0.03 =) **242** (g); (mass of 1 mole of $Cu(NO_3)_2$ is 188 g) M4 the value of x = **3**;	4	 ecf same as M1 ecf 7.26 ÷ M2 ecf M3 – 188 ÷ 18

Q25.

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Question	Answer	Marks
5(a)(i)	adds up to 100%;	1
5(a)(ii)	**M1** 55.85/12 **and** 6.97(/1) **and** 37.2/16; **or** evaluation 4.650 6.970 2.325; **M2** C_2H_3O; correct answer with no working = [2]	1 1
5(a)(iii)	**M1** (86/)43; **M2** $C_4H_6O_2$; correct answer with no working = [2]	1 1
5(b)(i)	unsaturated / C=C double bond / alkene;	1
5(b)(ii)	(organic / carboxylic) acid / contains or releases H^+ ions;	1
5(b)(iii)	$CH_3CH{=}CHCOOH$ / $CH_2{=}CHCH_2COOH$ / $CH_2{=}CH(CH_3)COOH$;	1

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Q26.

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Question	Answer	Marks
2(a)	number of moles of $NaNO_3$ used: 3.40/85 = 0.04(00) (mol) **OR** 4.(00) × 10^{-2} (mol); number of moles of O_2 formed: 0.04/2 = 0.02(00) (mol) **OR** 2.(00) × 10^{-2} (mol); volume of O_2 formed: 0.02 × 24 = 0.48 (dm^3);	3

Q27.

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Question	Answer		
5(a)(i)	more than enough to react (with all the hydrocarbon); **OR** (some) oxygen remaining;		1
5(a)(ii)	75 cm^3;		1
5(a)(iii)	2 : 15 : 10;		1
5(a)(iv)	2 : 15 : 10 : 10; C_5H_{10};	1 1	2
5(b)(i)	C_7H_{16};		1
5(b)(ii)	contains a double bond/triple bond/multiple bond; **OR** not all bonds are single bonds;		1
5(b)(iii)	test: aqueous bromine/bromine (water)/Br_2; result: (orange/yellow/brown) to colourless/decolourised/colour disappears;	1 1	2

Q28.

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Question	Answer		Marks
5(a)	carbon dioxide/a gas is made;		1
5(b)(i)	red;		1
5(b)(ii)	0.001;		1
5(b)(iii)	0.0005;		1
5(b)(iv)	0.031 (2 marks) **M1 (iii)**/0.0162;		2
5(c)	0.48 (dm^3) **M1** moles carbon dioxide = 0.02; **M2** volume carbon dioxide = 0.02 × 24; **M3** = 0.48 (dm^3);	1 1 1	3

Q29.

Page 6	Mark Scheme	Syllabus	Paper
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Question	Answer	Marks
7(a)	0.025 **M1** 50 / 1000 (=0.05) **M2** (0.05 × 0.5) = 0.025	 1 1
7(b)	0.0125	1
7(c)	0.55 **M1** 44 **M2** 0.55	 1 1
7(d)	0.3	1

Q30.

Page 4	Mark Scheme	Syllabus	Paper
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Question	Answer	Mark
5(a)	20 cm^3 **M1** M_r of MnO_2: 87 **M2** moles of MnO_2 used: 3.48 / 87 = 0.04 **M3** moles of HCl needed: 0.04 × 4 = 0.16 **M4** volume of HCl needed: (0.16 / 8.0) × 1000 **AND** 20 cm^3	4
5(e)(i)	I_2O_5 **M1** 76.0 / 127 **AND** 24.0 / 16.0 **M2** 0.59 **AND** 1.5 **OR** 1 **AND** 2.5 **M3** I_2O_5	3

Q31.

Page 4	Mark Scheme	Syllabus	Paper
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Question	Answer	Marks
3(a)	331	1
3(b)(i)	**M1** mol = 6.62 / 331 **OR** 0.02 **M2** 0.02 × 223 = 4.46 (g)	1 1
3(b)(ii)	**M1** mol O_2 = 0.02 ÷ 2 **OR** 0.01 **M2** vol = 0.01 × 24 = 0.24 (dm^3)	1 1
3(c)	*test:* glowing splint *result:* relights / rekindles	1 1
3(d)(i)	more than enough to react (with all the acid) **OR** some lead oxide remains after the reaction **OR** (nitric) acid is limiting	1
3(d)(ii)	solid stops dissolving	1
3(d)(iii)	$PbO + 2HNO_3 \rightarrow Pb(NO_3)_2 + H_2O$ **OR** $PbO + 2H^+ \rightarrow Pb^{2+} + H_2O$	1

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Q32.

Question	Answer	Marks
3(b)(i)	moles of water = 2.52 / 18 = 0.14 (mol)	1
3(b)(ii)	moles of anhydrous magnesium sulfate = 0.02 (mol)	1
3(b)(iii)	ratio = 0.02 / 0.02 : 0.14 / 0.02 = 1 : 7	1
3(b)(iv)	$MgSO_4.7H_2O$ **M1** $MgSO_4$ **M2** rest of the formula correct	2

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Q33.

Question	Answer	Marks
6(c)(i)	*M* = 197	1
	(9.85 / 197 =) 0.05 (mol)	1
6(c)(ii)	0.05 (mol)	1
6(c)(iii)	(0.05 □ 24) = 1.2 (dm_3)	1
6(c)(iv)	moles of HC*l* at the start = (250 / 1000 □ 1.00) = 0.25	1
	moles HC*l* in excess = 0.25 – (2 □ 0.05) = 0.15 (mol)	1

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Q34.

Question	Answer	Marks
7(b)(i)	0.075 If full credit is not awarded, allow 1 mark for M_r of CuO = 80	2
7(b)(ii)	0.05	1
7(b)(iii)	4 (g) **M1** moles copper(II) oxide that reacted = (0.05/2) = 0.025 mol **M2** mass copper(II) oxide = ((0.075 – 0.025) □ 80) = 4 g	2
7(c)	$Cl_2CuH_4O_2$ **M1** 41.52 / 35.5; 37.43 / 64; 2.34 / 1; 18.71 / 16 **OR** 1.17 : 0.58 : 2.34 : 1.17 **M2** appropriate scaling to give whole number ratios	2

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Q35.

Question	Answer	Marks
6(b)(i)	**more than** enough oxygen to react with **all** of the hydrocarbon	1
6(b)(ii)	125 (cm^3)	1
6(b)(iii)	1:5:3	1
6(b)(iv)	C_3H_8 If full credit is not awarded, allow 1 mark for C H (g) + **5**O_2(g) → **3**CO_2(g) + **4**H_2O(l)	2

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Q36.

Question	Answer	Marks
4(a)	relative atomic mass	1
4(b)	C_4H_{10} is covalent	1
	KF is ionic	1
4(c)	mol of Y = 0.060 / 24.0 = 2.5 □ 10^{-3} or 0.0025	1
	M_r = 0.095 / 2.5 □ 10^{-3} = 38(.0)	1
	fluorine	1
4(d)	mass of O = 3.87 g – 1.68 g = 2.19 (g)	1
	mol of P and mol of O 1.68 / 31 OR 0.054.. 2.19 / 16 **OR** 0.13…	1
	ratio of P to O P = 0.054… / 0.054 O = 0.13… / 0.054… = 1 = 2.5	1
	whole number ratio and P_2O_5 = 2 = 5	1
4(e)	the formula is P_4O_6 or (one mole of) P_2O_3 = 110 (g)	1
	mass = 220 (g)	1

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Q37.

Question	Answer	Marks
7(a)	60 / 12 :13.33 / 1 : 26.67 / 16 or evaluation 5 : 13.33 : 1.67 or 3:8:1	1
	C_3H_8O	1
7(b)	(C_2H_4O =) 44	1
	$C_4H_8O_2$	1

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Q38.

Question	Answer	Marks
5(a)	14.01/59 : 60.33/127 : 2.85/1 : 22.81/16 **OR** 0.237 : 0.475 : 2.85 : 1.43	1
	$NiI_2H_{12}O_6$	1

Q39.

[0620/43/M/J/2018/Q6-A]

6(a)(i)	74	1
	0.12	1
6(a)(ii)	0.3	1
6(a)(iii)	0.02	1
6(a)(iv)	207	1
	4.14	1
6(a)(v)	75%	1

Q40.

[0620/41/O/N/2018/Q3-C]

3(c)(i)	**M1** 188 **M2** (18.8 / 188) = 0.1(00)	2
3(c)(ii)	0.05	1
3(c)(iii)	1200	1

Q41.

[0620/42/O/N/2018/Q3-D-E]

3(d)(i)	yellow	1
3(d)(ii)	M1 0.2 × 25 / 1000 = 5(.00) × 10^{-3} or 0.005(00) (mol) M2 5(.00) × 10^{-3} / 2 = 2.5(.0) × 10^{-3} or 0.0025(0) (mol) M3 2.5(.0) × 10^{-3} × 1000 / 20 = 0.125 (mol / dm^3) M4 0.125 × 98 = 12.25 (g / dm^3)	4
3(e)	M1 Mol $FeSO_4$ = 15.2 / 152 = 0.1(00) M2 Expected mol of Fe_2O_3 = 0.1 / 2 = 0.05(00)) **or** Actual mol of Fe_2O_3 = 4.80 / 160= 0.03(00) M3 Percentage yield = 100 × 0.03(00) / 0.05(00) = 60%	3

Q42.

[0620/41/O/N/2018/Q4-D]

4(d)(i)	0.003	1
4(d)(ii)	0.006	1
4(d)(iii)	30	1

Q43.

[0620/43/O/N/2018/Q3-A-B-C-D]

3(a)	[(64 × 2) + 56 + 119 + (32 × 4) =] **431**	1
3(b)	[(119 / 151) × 100 =] **78.8 (%)**	1
3(c)	SnO_2 because the percentage of tin is **larger** in SnO_2 **or** answer to **(b)** □ 27.6 %	1
3(d)	$SnO_2 + 2C \rightarrow Sn + 2CO$ **M1 all** formulae correct **M2** equation fully correct	2

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Q44.

[0620/43/O/N/2018/Q4-A]

4(a)	**M1** (Mol KOH =) 0.00125 / 1.25×10^{-3} **M2** (Mol H_2SO_4 =) 0.000625 / 6.25×10^{-4} **M3** (Conc H_2SO_4 =) 0.03125 / 3.125×10^{-2} (mol / dm^3)	3

Q45.

[0620/41/M/J/2019/Q3-D-E]

3(d)(i)	**anhydrous** copper(II) sulfate	1
3(d)(ii)	white (1) blue (1)	2
3(e)(i)	$4KI + 2CuSO_4 \rightarrow 2CuI + I_2 + 2K_2SO_4$ (2)	2
3(e)(ii)	1+	1
3(e)(iii)	gains electron(s)	1
3(e)(iv)	KI / potassium iodide / iodide (ions) / I^-	1

Q46.

[0620/41/M/J/2019/Q4-C]

4(c)	**M1** mol of HC*l* = $2.00 \times \frac{50.0}{1000}$ = 0.1(00) mol (1) **M2** mol of $MgCO_3$ = $\frac{\textbf{M1}}{2}$ = 0.1(00) / 2 = 0.05(00) (1) **M3** M_r of $MgCO_3$ = 84 (1) **M4** mass of $MgCO_3$ = **M3** × **M2** = 84 × 0.05(00) = 4.2(0)g (1)	4

Q47.

[0620/42/M/J/2019/Q5-A]

5(a)	**M1** 0.0025 / 2.5×10^{-3} (moles of H_2SO_4) (1) **M2** 0.0025 / 2.5×10^{-3} (moles of $CuSO_4{\cdot}5H_2O$) (1) **M3** 0.625(g) (1)	3

Q48.

[0620/43/M/J/2019/Q3-A-B-E]

3(a)(i)	any two from: • low melting point **or** low boiling point • soft • low density	max 2
3(a)(ii)	any one from: • fizz / bubbles • moves • floats • melts / forms a ball • gets smaller / disappears	max 1
3(b)	mass sodium azide = 260 (g) • Moles N_2 = (144 / 24 =) 6 • Moles NaN_3 = (6 × 2 / 3 =) 4 • M_r NaN_3 = 65 • (4 × 65 =) 260	4
3(e)	**M1** 49.5 / 12 7.2 / 1 43.3 / 14 OR 4.125 7.2 3.093…. **M2** 1.33 : 2.33 : 1 OR 4 : 7 : 3 **M3** $C_4H_7N_3$	3

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Q49.

[0620/41/O/N/2019/Q2-E]

2(e)	29.1 / 23 40.5 / 32 30.4 / 16 **or** 1.2(65) 1.2(65) 1.9 (1) 1:1:1.5 (1) $Na_2S_2O_3$ (1)	3

Q50.

[0620/41/O/N/2019/Q6-A-B-C-i]

6(a)	correct final answer = 0.072(0) **M1** moles HC*l* = 0.0036(0) **M2** moles Na_2CO_3 = 0.0018(0) (**M1** / 2) **M3** concentration Na_2CO_3 = 0.072 (**M2** / 0.025)	3
6(b)	0.002(00)	1
6(c)(i)	720(.09)	1

Q51.

[0620/42/O/N/2019/Q3-D-i]

3(d)(i)	mol of NH_3 = 4.8(0) / 24 = 0.2(0) (1) mol of O_2 = 0.2 □ 5 / 4 = 0.25 (1) mol of O_2 = 0.25 □ 24 = 6.(0) (1)	3

Q52.

[0620/43/O/N/2019/Q4-H]

4(h)(i)	93.94 / 31 and 6.06 / 1 **OR** 3.03 and 6.06 **OR** 1 : 2 ratio (1) PH_2 (1)	2
4(h)(ii)	P_2H_4	1

Q53.

[0620/43/O/N/2019/Q5]

5	**M1** 5 moles of calcium nitrate (1) **M2** 10 moles ammonium nitrate (1) or ecf **M1** □ 2 **M 3** M_r of ammonium nitrate = 80 **M4** 800 g or ecf **M2** □ **M3**	4

Q54.

[0620/41/M/J/2020/Q4-C-D]

4(c)(i)	neutralisation	1
4(c)(ii)	Na_2SO_4	1
	$2H_2O$	1
4(d)(i)	methyl orange	1
4(d)(ii)	M1 mol of NaOH $= 0.0400 \times \frac{25.0}{1000} = 0.001(00)$ mol M2 mol of H_2SO_4 $= \frac{M1}{2} = \frac{0.001}{2} = 0.0005(00)$ M3 M2 $\times \frac{1000}{20.0} = 0.0005 \times \frac{1000}{20.0} = 0.025$ (mol / dm^3) allow ec	3
4(d)(iii)	M1 use of 40 g/mol M2 $40 \times 0.04 = 1.6$ (g/dm^3)	2

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Q55.

[0620/42/M/J/2020/Q4-E-F]

4(e)	**M1** moles of oxygen $= \frac{48.0}{24000}$ or moles of oxygen = 0.002 (1) **M2** moles of hydrogen peroxide = **M1** × 2 or moles of hydrogen peroxide = 0.004 (1) **M3** concentration = **M2** × 40 = 0.16 mol / dm³ (1) allow ECF	3
4(f)	$2KClO_3 \rightarrow 2KCl + 3O_2$ **ALL** formulae correct (1) balancing (1)	2

Q56.

[0620/43/M/J/2020/Q2-D-ii-iii-iv]

2(d)(ii)	75	1
2(d)(iii)	(it could react with rain water to) form nitric acid / acid rain	1
2(d)(iv)	(M_r of HNO_3 =) 63 (1) 20 (1) 5 (1) 120 (dm³) (1)	4

Q57.

[0620/43/O/N/2020/Q2]

2(a)	HNO_3	1
2(b)(i)	to make sure all the (sulfuric) acid reacts	1
2(b)(ii)	no (more) fizzing (1) ($FeCO_3$) stops dissolving or a solid remains / is visible (in the mixture) (1)	2
2(b)(iii)	inse the residue (with distilled water)	1
2(b)(iv	a solution that can dissolve no more solute (1) at the specified temperature (1)	2
2(b)(v)	iron(II) oxide / iron(II) hydroxide	1
2(c)	mass of $FeSO_4$ = 152 (1) mass of H_2O = 278 – 152 = 126 (1) mol of H_2O = 126 / 18 **and** x = 7 (1)	3
2(d)(i)	precipitation	1
2(d)(ii)	cream precipitate	1
2(d)(iii)	$Ag^+(aq) + Br^-(aq) \rightarrow AgBr(s)$ AgBr (as only product) (1) Ag^+ and Br^- (as reactants)(1) state symbols(1)	3
2(e)	M1 mol of NaCl = 2.34 / 58.5 = 0.04(00) M2 mol of Cl_2 = M1/2 = 0.04(00)/2 = 0.02(00) M3 0.02(00) × 24000 = 480 (cm³)	3
2(f)(i)	ions (1) (ions) are fixed (in a lattice) (1) ions are mobile (1)	3
2(f)(ii)	chlorine	1
2(f)(iii)	oxidation (1) electrons are lost (1)	2
2(f)(iv)	dissolve it (in water)	1

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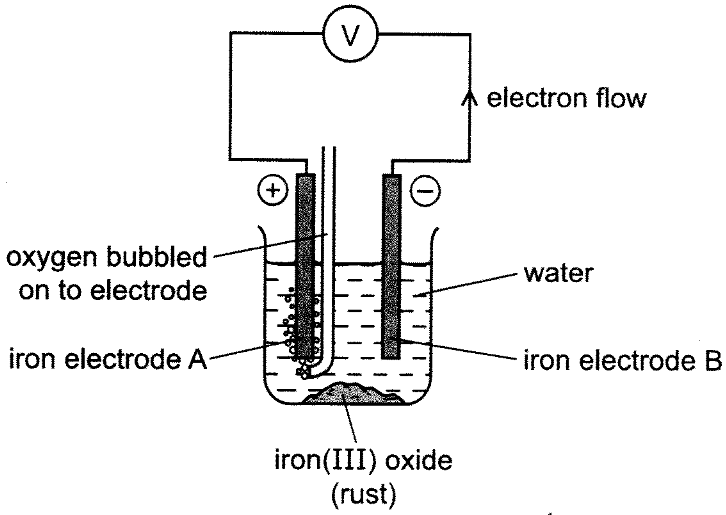
[0620/31/M/J/12/Q8]

Q1. Iron and steel rust when exposed to water and oxygen. Rust is hydrated iron(III) oxide.

(a) The following cell can be used to investigate rusting.



(i) What is a cell?

....

.... [2]

(ii) Which electrode will be oxidised and become smaller? Explain your choice.

....

....

.... [3]

(iii) What measurements would you need make to find the rate of rusting of the electrode you have chosen in **(ii)**?

....

.... [2]

(iv) Suggest an explanation why the addition of salt to the water increases the rate of rusting.

.... [1]

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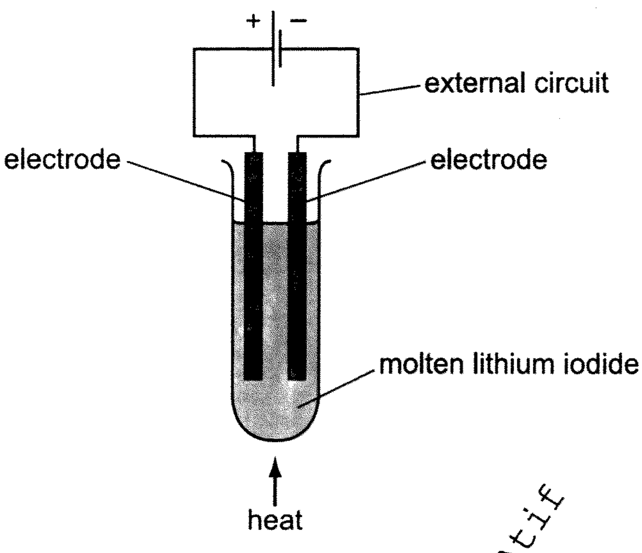
[0620/32/O/N/12/Q6]

Q2. During electrolysis, ions move in the electrolyte and electrons move in the external circuit. Reactions occur at the electrodes.

(a) The diagram shows the electrolysis of molten lithium iodide.



(i) Draw an arrow on the diagram to show the direction of the electron flow in the external circuit. [1]

(ii) Electrons are supplied to the external circuit. How and where is this done?

....

.... [2]

(iii) Explain why solid lithium iodide does not conduct electricity but when molten it is a good conductor.

....

.... [1]

(b) The results of experiments on electrolysis are shown in the following table. Complete the table. The first line has been done as an example.

electrolyte	electrodes	product at cathode	product at anode	change to electrolyte
molten lithium iodide	carbon	lithium	iodine	used up
aqueous copper(II) sulfate	platinum		oxygen	
concentrated aqueous potassium chloride	carbon		chlorine	

[4]

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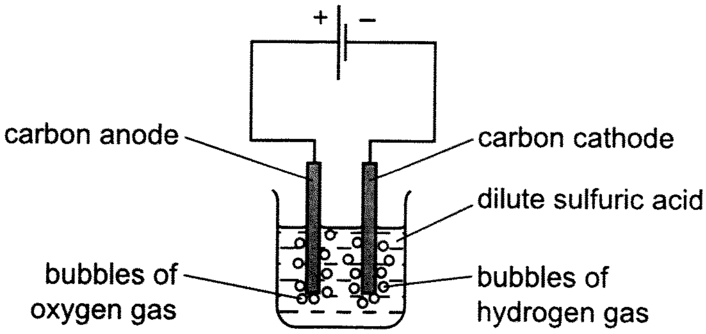
(c) The diagram below shows the electrolysis of dilute sulfuric acid. Hydrogen is formed at the negative electrode (cathode) and oxygen at the positive electrode (anode) and the concentration of sulfuric acid increases.



The ions present in the dilute acid are $H^+(aq)$, $OH^-(aq)$ and $SO_4^{2-}(aq)$.

(i) Write an equation for the reaction at the negative electrode (cathode).

.... [2]

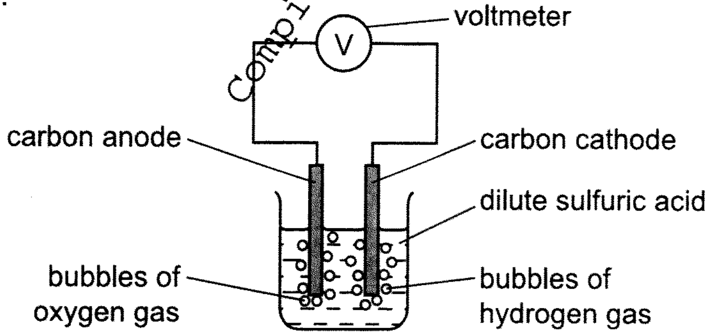
(ii) Complete the equation for the reaction at the positive electrode (anode).

$$4OH^-(aq) \rightarrow O_2(g) + ...H_2O(l) + ...$$ [1]

(iii) Suggest an explanation of why the concentration of the sulfuric acid increases.

.... [1]

(d) In the apparatus used in **(c)**, the power supply is removed and immediately replaced by a voltmeter.



A reading on the voltmeter shows that electrical energy is being produced. Suggest an explanation for how this energy is produced.

....

....

.... [3]

[Total: 15]

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[0620/33/O/N/12/Q4-Biv]

Q3. (iv) Describe how zinc metal can be obtained from zinc sulfate solution by electrolysis. A labelled diagram is acceptable. Include all the products of this electrolysis. The electrolysis is similar to that of copper(II) sulfate solution with inert electrodes.

[4]

[0620/31/M/J/13/Q5]

Q4.

The reactivity series shows the metals in order of reactivity.

(a) The reactivity series can be established using displacement reactions. A piece of zinc is added to aqueous lead nitrate. The zinc becomes coated with a black deposit of lead.

$$Zn + Pb^{2+} \rightarrow Zn^{2+} + Pb$$

Zinc is more reactive than lead.

The reactivity series can be written as a list of ionic equations.

...... $\rightarrow$ ...... + ... most reactive metal : the best reductant (reducing agent)

$Zn \rightarrow Zn^{2+} + 2e^-$

$Fe \rightarrow Fe^{2+} + 2e^-$

$Pb \rightarrow Pb^{2+} + 2e^-$

$Cu \rightarrow Cu^{2+} + 2e^-$

$Ag \rightarrow Ag^+ + e^-$

(i) In the space at the top of the list, write an ionic equation for a metal which is more reactive than zinc. [1]

(ii) Write an ionic equation for the reaction between aqueous silver(I) nitrate and zinc.

.... [2]

(iii) Explain why the positive ions are likely to be oxidants (oxidising agents).

.... [1]

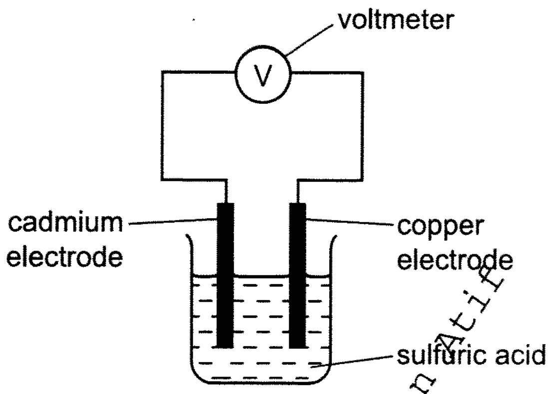
(iv) Deduce which ion is the best oxidant (oxidising agent).

.... [1]

(v) Which ion(s) in the list can oxidise lead metal?

.... [1]

(b) A reactivity series can also be established by measuring the voltage of simple cells. The diagram shows a simple cell.



Results from cells using the metals tin, cadmium, zinc and copper are given in the table below.

cell	electrode 1 positive electrode	electrode 2 negative electrode	voltage / volts
1	copper	cadmium	0.74
2	copper	tin	0.48
3	copper	zinc	1.10

Write the four metals in order of increasing reactivity and explain how you used the data in the table to determine this order.

....

....

.... [3]

[Total: 9]

[0620/32/M/J/13/Q4-Bii-iii]

Q5. **(ii)** There are three products of the electrolysis of concentrated aqueous sodium chloride. Hydrogen is one of them.
Write an equation for the electrode reaction which forms hydrogen.

.... [2]

(iii) Name the other **two** products of the electrolysis of concentrated aqueous sodium chloride and give a use of each one.

product .... use ....

product .... use .... [4]

[0620/32/O/N/13/Q6]

Q6. The following reactivity series shows both familiar and unfamiliar elements in order of decreasing reactivity. Each element is represented by a redox equation.

$$Rb \rightleftharpoons Rb^{+} + e^{-}$$
$$Mg \rightleftharpoons Mg^{2+} + 2e^{-}$$
$$Mn \rightleftharpoons Mn^{2+} + 2e^{-}$$
$$Zn \rightleftharpoons Zn^{2+} + 2e^{-}$$
$$H_2 \rightleftharpoons 2H^{+} + 2e^{-}$$
$$Cu \rightleftharpoons Cu^{2+} + 2e^{-}$$
$$Hg \rightleftharpoons Hg^{2+} + 2e^{-}$$

Two of the uses of the series are to predict the thermal stability of compounds of the metals and to explain their redox reactions.

(a) Most metal hydroxides decompose when heated.

(i) Complete the equation for the thermal decomposition of copper(II) hydroxide.

$Cu(OH)_2 \rightarrow$ .... + ... [1]

(ii) Choose a metal from the above series whose hydroxide does not decompose when heated.

.... [1]

(b) **(i)** Define in terms of electron transfer the term *oxidation*.

.... [1]

(ii) Explain why the positive ions in the above equations are oxidising agents.

....

.... [1]

(c) **(i)** Which metals in the series above do not react with dilute acids to form hydrogen?

.... [1]

(ii) Describe an experiment which would confirm the prediction made in **(c)(i)**.

....

.... [1]

(d) **(i)** Which metal in the series above can form a negative ion which gives a pink/purple solution in water?

.... [1]

(ii) Describe what you would observe when zinc, a reducing agent, is added to this pink/purple solution. .... [1]

[Total: 8]

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[0620/33/O/N/13/Q3-C]

Q7.

(c) The solution of zinc sulfate is electrolysed using inert electrodes.
This electrolysis is similar to that of copper(II) sulfate with inert electrodes.

(i) Write the equation for the reaction at the negative electrode (cathode).

.... [1]

(ii) Complete the equation for the reaction at the positive electrode (anode).

$$\ldots\ldots OH^- \rightarrow 2H_2O + \ldots\ldots + \ldots\ldots e^-$$ [2]

(iii) The electrolyte changes from zinc sulfate to

.... [1]

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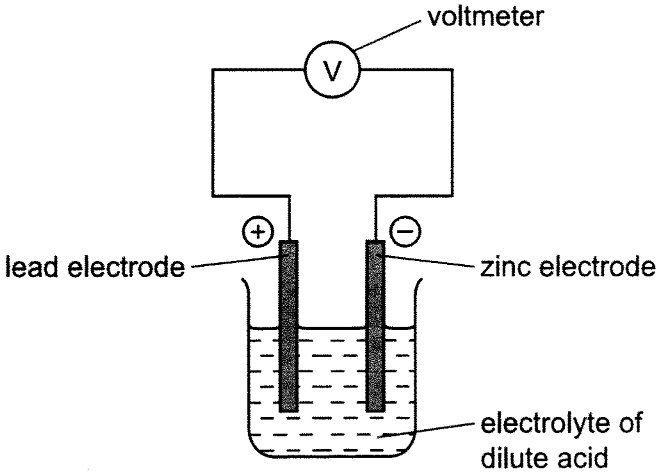
[0620/31/M/J/14/Q7-B]

Q8.

(b) Another way of determining the order of reactivity of metals is by measuring the voltage and polarity of simple cells. The polarity of a cell is shown by which metal is the positive electrode and which metal is the negative electrode. An example of a simple cell is shown below.



(i) Mark on the above diagram the direction of the electron flow. [1]

(ii) Explain, in terms of electron transfer, why the more reactive metal is always the negative electrode.

....

....

.... [2]

(iii) The following table gives the polarity of cells using the metals zinc, lead, copper and manganese.

cell	electrode 1	polarity	electrode 2	polarity
A	zinc	–	lead	+
B	manganese	–	lead	+
C	copper	+	lead	–

What information about the order of reactivity of these four metals can be deduced from the table?

....

....

.... [2]

(iv) What additional information is needed to establish the order of reactivity of these four metals using cells?

.... [1]

Q9. [0620/32/M/J/14/Q5-B]

(b) Chlorine is made by the electrolysis of concentrated aqueous sodium chloride.
Describe this electrolysis. Write ionic equations for the reactions at the electrodes and name the sodium compound formed.

....

....

....

....

.... [5]

Q10. [0620/33/M/J/14/Q7]

Aluminium is obtained from purified alumina, Al_2O_3, by electrolysis.

(a) Alumina is obtained from the main ore of aluminium.
State the name of this ore.

.... [1]

(b) Describe the extraction of aluminium from alumina. Include the electrolyte, the electrodes and the reactions at the electrodes.

....

....

....

....

....

....

.... [6]

(c) Aluminium is resistant to corrosion. It is protected by an oxide layer on its surface.
The thickness of this oxide layer can be increased by anodising.

(i) State a use of aluminium due to its resistance to corrosion.

.... [1]

(ii) Anodising is an electrolytic process. Dilute sulfuric acid is electrolysed with an aluminium object as the anode. The thickness of the oxide layer is increased. Complete the equations for the reactions at the aluminium anode.

.......$OH^- \rightarrow O_2 + 2H_2O +$ ......e^-

....$Al +$ .... $\rightarrow$ ....Al_2O_3 [4]

[Total: 12]

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Q11. [0620/32/O/N/14/Q2-A-B-C]

Aluminium is obtained by the reduction of aluminium ions to aluminium atoms.

(a) Write an ionic equation for the reduction of an aluminium ion to an aluminium atom.

.... [2]

(b) The original method of extracting aluminium involved the reduction of aluminium chloride using the reactive metal sodium. Aluminium obtained by this method was very expensive due to the high cost of extracting sodium from sodium chloride.

(i) Complete the equation for this reduction.

$$AlCl_3 + \text{.......}Na \rightarrow \text{..........} + \text{..........}$$

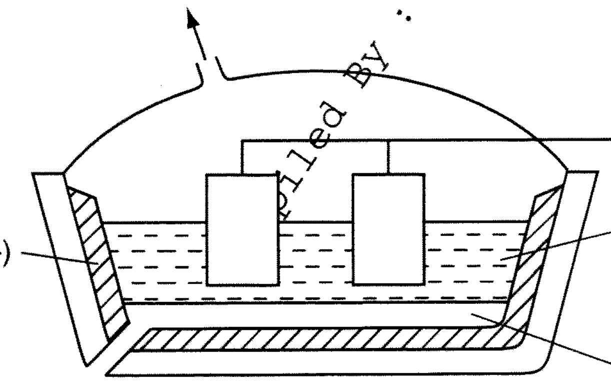
[2]

(ii) How can sodium metal be obtained from sodium chloride?

....

.... [2]

(c) In the modern method, aluminium is obtained by the electrolysis of aluminium oxide (alumina) dissolved in molten cryolite, Na_3AlF_6.



(i) The major ore of aluminium is impure aluminium oxide.
What is the name of this ore?

.... [1]

(ii) This ore is a mixture of aluminium oxide, which is amphoteric, and iron(III) oxide which is basic.
Explain how these two oxides can be separated by the addition of aqueous sodium hydroxide.

....

....

.... [2]

(iii) Give **two** reasons why the electrolyte contains cryolite.

....

....

.... [2]

(iv) The mixture of gases evolved at the positive electrode includes:

carbon dioxide
carbon monoxide
fluorine
oxygen

Explain the presence of these gases in the gaseous mixture formed at the positive electrode. Include at least **one** equation in your explanation.

....

....

....

....

.... [5]

[0620/32/O/N/14/Q4-C-D]

Q12.

(c) Zinc can be obtained from zinc oxide in a two step process. Aqueous zinc sulfate is made from zinc oxide and then this solution is electrolysed with inert electrodes. The electrolysis is similar to that of copper(II) sulfate with inert electrodes.

(i) Name the reagent which will react with zinc oxide to form zinc sulfate.

.... [1]

(ii) Complete the following for the electrolysis of aqueous zinc sulfate.

Write the equation for the reaction at the negative electrode.

....

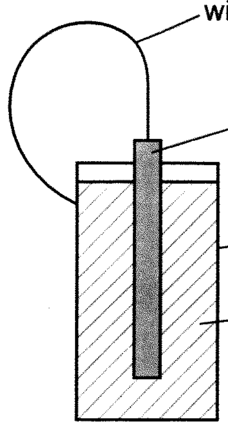
Name the product at the positive electrode.

....

The electrolyte changes from zinc sulfate to ....

[3]

(d) A dry cell (battery) has a central rod, usually made of graphite. This is the positive electrode which is surrounded by the electrolyte, typically a paste of ammonium chloride and manganese(IV) oxide, all of which are in a zinc container which is the negative electrode.



(i) Draw an arrow on the diagram to indicate the direction of electron flow. [1]

(ii) Suggest why the electrolyte is a paste.

.... [1]

(iii) The following changes occur in a dry cell.
For each change, decide if it is oxidation or reduction and give a reason for your choice.

Zn to Zn^{2+}

....

manganese(IV) oxide to manganese(III) oxide

....

[2]

[0620/33/O/N/14/Q3-C]

Q13.

(c) A mixture of a fullerene and potassium is an excellent conductor of electricity.

(i) Which other form of solid carbon is a good conductor of electricity?

.... [1]

(ii) Explain why metals, such as potassium, are good conductors of electricity.

....

.... [2]

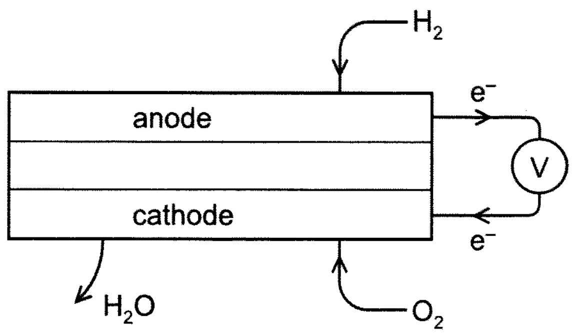
(iii) The mixture of fullerene and potassium has to be stored out of contact with air. There are substances in unpolluted air which will react with potassium.
Name **two** potassium compounds which could be formed when potassium is exposed to air.

.... [2]

[0620/33/O/N/14/Q4]

Q14.

A fuel cell produces electrical energy by the oxidation of a fuel by oxygen.
The fuel is usually hydrogen but methane and methanol are two other fuels which may be used.
A diagram of a hydrogen fuel cell is given below.



(a) When the fuel is hydrogen, the only product is water.
What additional product would be formed if methane was used?

.... [1]

(b) Write the equation for the chemical reaction that takes place in a hydrogen fuel cell.

.... [1]

(c) (i) At which electrode does oxidation occur? Explain your choice.

.... [1]

(ii) Write an ionic equation for the reaction at this electrode.

.... [2]

(d) Fuel cells are used to propel cars.
Give **two** advantages of a fuel cell over a gasoline-fuelled engine.

....

.... [2]

[Total: 7]

Q15. [0620/41/M/J/16/Q4-A-B]

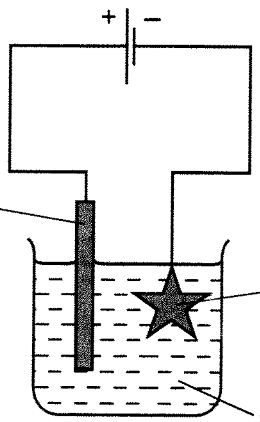
Electroplating steel objects with silver involves a three-step process.

step 1 A coating of copper is applied to the object.

step 2 A coating of nickel is applied to the object.

step 3 The coating of silver is applied to the object.

(a) A diagram of the apparatus used for **step 1** is shown.



(i) The chemical process taking place on the surface of the object is

$$Cu^{2+}(aq) + 2e^- \rightarrow Cu(s)$$

Explain whether this process is oxidation or reduction.

....

.... [1]

(ii) Explain why the concentration of copper ions in the electrolyte remains constant throughout **step 1**.

....

....

.... [2]

(b) Give **two** changes which would be needed in order to coat nickel onto the object in **step 2**.

....

....

....

.... [2]

[0620/42/M/J/16/Q4-E-F-G]

Q16.

(e) Hydrogen can also be manufactured by electrolysis. The electrolyte is concentrated aqueous sodium chloride. The electrodes are inert.

The products of electrolysis are hydrogen, chlorine and sodium hydroxide.

(i) Define the term *electrolysis*.

....

.... [2]

(ii) Name a substance that can be used as the inert electrodes.

.... [1]

(iii) Write an ionic half-equation for the reaction in which hydrogen is produced.

.... [1]

(iv) Where is hydrogen produced in the electrolytic cell?

.... [1]

(v) Describe a test for chlorine.

test ....

result ....

[2]

(f) The electrolysis of concentrated aqueous sodium chloride can be represented by the following word equation.

sodium chloride + water → sodium hydroxide + hydrogen + chlorine

Construct a chemical equation to represent this reaction. Do not include state symbols.

.... [2]

(g) State one use of

chlorine, ...

sodium hydroxide, ...

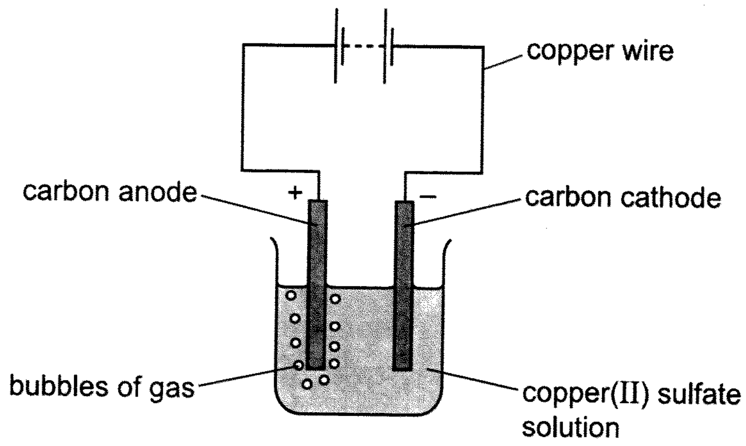
hydrogen. ....

[3]

235

Q17. [0620/41/O/N/16/Q5]

Copper(II) sulfate solution was electrolysed using the apparatus shown.



(a) A gas was formed at the anode.

Identify this gas and give the test for this gas.

gas ....

test ....

result of test .... [3]

(b) During electrolysis, electricity passes through the copper(II) sulfate solution.

Solid copper(II) sulfate does not conduct electricity.

Explain **both** of these statements.

....

....

....

....

.... [3]

(c) The electrolysis was repeated using copper electrodes in place of carbon electrodes. The ionic half-equations for the reactions at the two electrodes are shown.

anode $Cu(s) \rightarrow Cu^{2+}(aq) + 2e^-$

cathode $Cu^{2+}(aq) + 2e^- \rightarrow Cu(s)$

(i) Which species is reduced during the electrolysis? Explain your answer.

....

....

.... [2]

(ii) The masses of the copper electrodes changed during the electrolysis.

State how **and** explain why the masses of the **two** copper electrodes changed.
Use the ionic half-equations to help you.

....

....

....

....

....

....

.... [3]

(iii) Explain why, during the electrolysis, the colour of the copper(II) sulfate solution does **not** change.

....

....

.... [1]

[Total: 12]

237

Q18. [0620/43/O/N/16/Q4-E-F-G]

(e) A **concentrated** aqueous solution of sodium chloride is electrolysed using carbon electrodes.

(i) Name the products formed at the electrodes.

product at the positive electrode (anode) ....

product at the negative electrode (cathode) ....
[2]

(ii) Write an ionic half-equation for the reaction occurring at the negative electrode.

.... [1]

(f) A **dilute** aqueous solution of sodium chloride is electrolysed using carbon electrodes.

Name the main product formed at the positive electrode.

.... [1]

(g) Molten sodium chloride is electrolysed using carbon electrodes.

(i) Name the product formed at the negative electrode.

.... [1]

(ii) Write an ionic half-equation for the reaction occurring at the negative electrode.

.... [1]

(iii) Chlorine is produced at the positive electrode.

Give the test for chlorine.

test ....

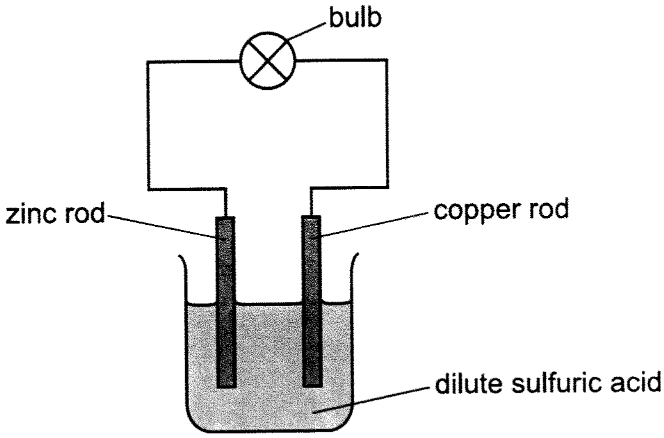
result ....
[2]

238

[0620/41/M/J/17/Q4-C]

Q19.

(c) When rods of zinc and copper are placed into dilute sulfuric acid as shown, electricity is generated.



(i) Write the ionic half-equation for the reaction occurring at the zinc rod.

.... [2]

(ii) Write the ionic half-equation for the reaction occurring at the copper rod.

.... [2]

(iii) The copper rod was replaced by an iron rod.

Suggest the change, if any, in the intensity of the light emitted from the bulb and give a reason for your answer.

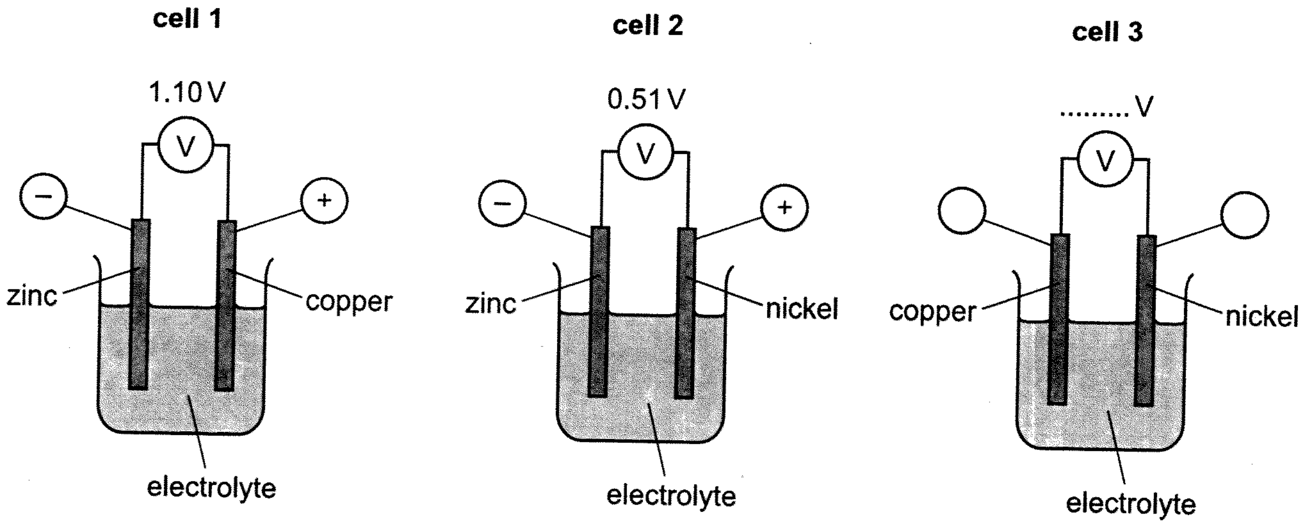
change ....

reason ....

....
[2]

Q20. [0620/42/M/J/17/Q4-C]

(c) Three cells are set up each using two metals.



(i) Write the ionic half-equation for the reaction occurring at the zinc electrode in **cell 1**.

.... [2]

(ii) Put the **three** metals, copper, nickel and zinc, in order of reactivity.

most reactive ....

↓ ....

least reactive ....

[1]

(iii) Complete the labelling in **cell 3** by writing the polarity (+/–) of each electrode in the circles and calculating the reading on the voltmeter. [2]

[0620/42/M/J/17/Q5-B-C]

Q21.

(b) A sample of vanadium chloride was weighed and dissolved in water. An excess of aqueous silver nitrate, acidified with dilute nitric acid, was added. A precipitate of silver chloride was formed. The ionic equation for this reaction is shown.

$$Ag^+(aq) + Cl^-(aq) \rightarrow AgCl(s)$$

The mass of silver chloride formed was 2.87 g.

(i) State the colour of the precipitate of silver chloride.

.... [1]

(ii) The relative formula mass of silver chloride, $AgCl$, is 143.5.

Calculate the number of moles in 2.87 g of $AgCl$.

moles of $AgCl$ = ... mol [1]

(iii) Use your answer to **(b)(ii)** and the ionic equation to deduce the number of moles of chloride ions, Cl^-, that produced 2.87 g of $AgCl$.

moles of Cl^- = ... mol [1]

(iv) The amount of vanadium chloride in the sample was 0.01 moles.

Use this and your answer to **(b)(iii)** to deduce the **whole number** ratio of moles of vanadium chloride : moles of chloride ions.
Deduce the formula of vanadium chloride.

moles of vanadium chloride : moles of chloride ions .... : ....

formula of vanadium chloride ....

[2]

(c) Astatine is at the bottom of Group VII. Use your knowledge of the properties of the halogens to

(i) predict the physical state of astatine at room temperature and pressure,

.... [1]

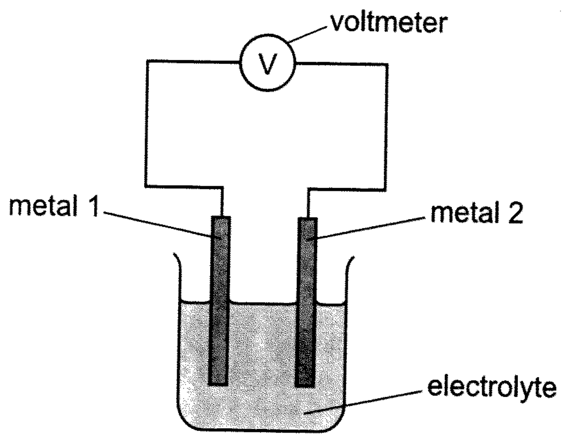
(ii) write a chemical equation for the reaction between sodium and astatine.

.... [2]

241

Q22. [0620/43/M/J/17/Q5]

The diagram shows a simple cell.



The simple cell was used with different metals as electrodes. The voltages were recorded in the table.

- If the voltage measured is positive then metal 2 is more reactive than metal 1.
- If the voltage measured is negative then metal 1 is more reactive than metal 2.

		metal 2				
		beryllium	cobalt	nickel	silver	vanadium
metal 1	beryllium	0.0 V	−1.6 V	−1.6 V	not measured	−0.7 V
	cobalt		0.0 V	0.0 V	−1.1 V	0.9 V
	nickel			0.0 V	−1.1 V	0.9 V
	silver				0.0 V	2.0 V
	vanadium					0.0 V

- The more reactive metal is oxidised.
- The bigger the difference in reactivity of the metals, the larger the reading on the voltmeter.

(a) In a simple cell using nickel and silver, the nickel is oxidised.

(i) Define *oxidation* in terms of electrons.

.... [1]

(ii) Nickel forms ions with a charge of +2.

Write an ionic half-equation to show the oxidation of nickel.

.... [1]

(iii) What will happen to the mass of the nickel electrode when the nickel is oxidised?

....

.... [1]

(b) Use the data in the table to answer the following questions.

(i) Which of the metals in the table is the most reactive?
Explain your answer.

....

.... [2]

(ii) State which **two** different metals have the same reactivity.

.... [1]

(iii) Predict the voltage produced by a simple cell with beryllium as metal 1 and silver as metal 2.

....

.... [2]

(c) Describe how the simple cell in the diagram can be used to show that magnesium is more reactive than beryllium. Explain your answer.

....

....

....

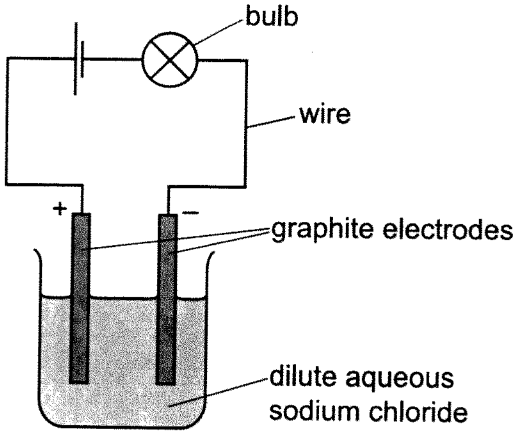
.... [2]

[Total: 10]

243

Q23. [0620/42/O/N/17/Q4]

A student sets up the following electrolysis experiment.



(a) Define the term *electrolysis*.

....

.... [2]

(b) The student observes bubbles of colourless gas forming at each electrode.

(i) Name the main gas produced at the positive electrode (anode).

.... [1]

(ii) Describe a test for the gas produced in **(b)(i)**.

test ....

result ....

[2]

(iii) Write the ionic half-equation for the reaction taking place at the negative electrode (cathode).

.... [2]

(c) Charge is transferred during electrolysis.

Name the type of particle responsible for the transfer of charge in

the wires, ...

the electrolyte. ....

[2]

(d) The student replaces the dilute aqueous sodium chloride with **concentrated** aqueous sodium chloride.

Suggest **two** differences that the student observes.

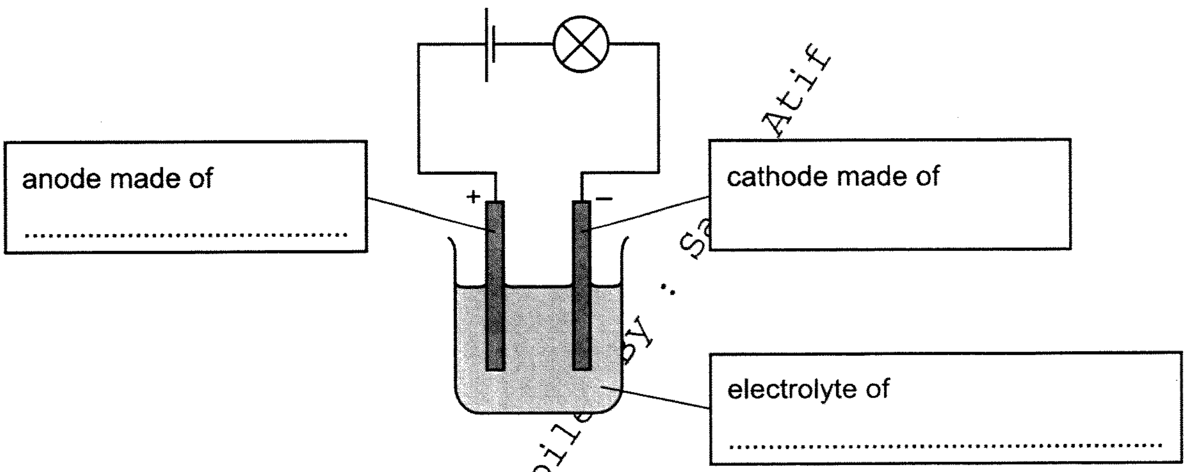
1 ....

2 .... [2]

(e) The student has a small piece of impure copper. The main impurities in the copper are small quantities of silver and zinc.

The student uses electrolysis to extract pure copper from the small piece of impure copper.

(i) Complete the labels on the diagram of the student's electrolysis experiment.



[3]

(ii) Use your knowledge of the reactivity series to suggest what happens to the silver and zinc impurities. Explain your answers.

silver impurities ....

....

....

zinc impurities ....

....

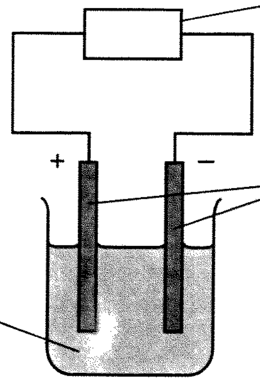
.... [3]

[Total: 17]

245

Q24. [0620/41/M/J/18/Q5-E]

(e) A student electrolyses aqueous copper(II) sulfate using the apparatus shown.



Oxygen gas forms at the positive electrode (anode).

(i) Write an ionic half-equation for the reaction at the negative electrode (cathode). Include state symbols.

.... [3]

(ii) Describe what the student observes at the negative electrode.

.... [1]

(iii) Give **two other** observations which the student makes during the electrolysis.

1 ....

2 ....

[2]

(iv) What difference would the student observe at the positive electrode if the aqueous copper(II) sulfate were replaced by concentrated aqueous copper(II) chloride?

.... [1]

[0620/42/M/J/18/Q4-C]

Q25.

(c) Concentrated aqueous potassium bromide is an electrolyte.

(i) What is meant by the term *electrolyte*?

....

.... [2]

(ii) Describe the electrolysis of concentrated aqueous potassium bromide.

Include:
- an ionic half-equation for the reaction at the cathode
- the name of the product at the anode
- the name of the potassium compound formed.

....

....

....

.... [4]

(iii) When molten potassium bromide is electrolysed, the product at the cathode is different.

Name the product at the cathode when molten potassium bromide is electrolysed.

.... [1]

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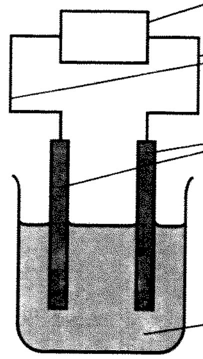
Q26. [0620/43/M/J/18/Q5-B-C]

(b) Molten nickel(II) iodide can be electrolysed using the apparatus shown.



During electrolysis, charge is transferred through the copper wires and through the molten nickel(II) iodide.

(i) Name the type of particles which transfer charge through the copper wires.

.... [1]

(ii) Name the type of particles which transfer charge through the molten nickel(II) iodide.

.... [1]

(iii) Predict the products of the electrolysis of molten nickel(II) iodide. Write an ionic half-equation for the formation of **one** of these products.

products ....

ionic half-equation ....

[3]

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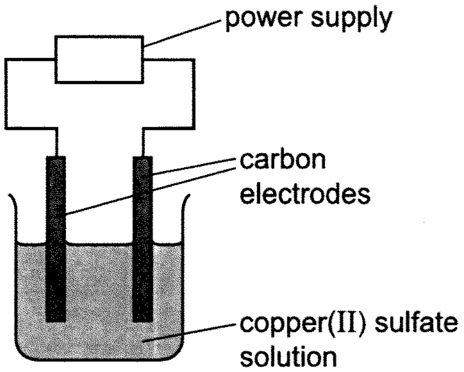
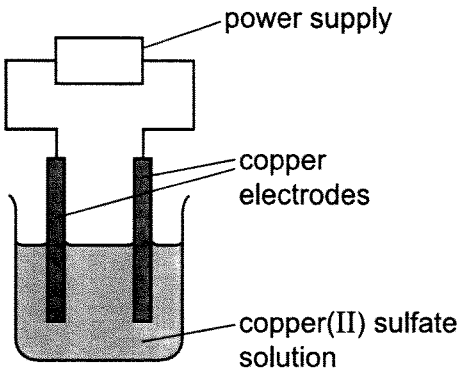
(c) A student electrolysed copper(II) sulfate solution using the two sets of apparatus shown.



apparatus **A**



apparatus **B**

In apparatus **A** the student used carbon electrodes.
In apparatus **B** the student used copper electrodes.

The student made the following observations.

apparatus **A**	apparatus **B**
The mass of the negative electrode increased.	The mass of the negative electrode increased.
The mass of the positive electrode stayed the same.	The mass of the positive electrode decreased.
Bubbles were seen at the positive electrode.	No bubbles were seen at the positive electrode.

(i) Explain why the mass of the negative electrode increased in **both** sets of apparatus.

....

.... [1]

(ii) Name the gas that formed the bubbles seen in apparatus **A**.

.... [1]

(iii) Explain why the mass of the positive electrode decreased in apparatus **B**.

....

.... [1]

(iv) Suggest what happens to the colour of the solution in apparatus **A** and apparatus **B** as the electrolysis progresses.
Explain your answer.

colour of the solution in apparatus **A** ....

colour of the solution in apparatus **B** ....

explanation ....

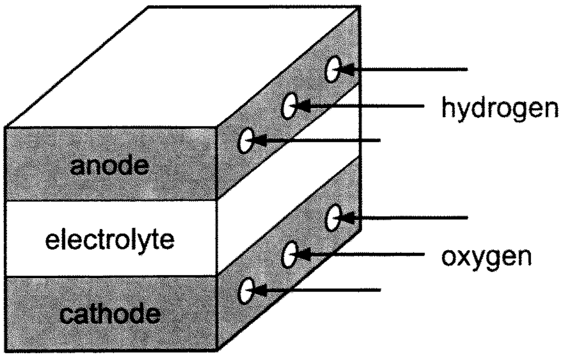
....

....

[3]

[0620/32/M/J/10/Q5]

Q27. Fuel cells are used in spacecraft to produce electrical energy.



(a) How is oxygen obtained from liquid air?

....

.... [2]

(b) Hydrogen and oxygen react to form water.

$$2H_2 + O_2 \rightarrow 2H_2O$$

(i) Give an example of bond breaking in the above reaction.

.... [1]

(ii) Give an example of bond forming in the above reaction.

.... [1]

(iii) Is the change given in **(i)** exothermic or endothermic?

.... [1]

(c) (i) Give **two** reasons why hydrogen may be considered to be the ideal fuel for the future.

....

....

.... [2]

(ii) Suggest a reason why hydrogen is not widely used at the moment.

....

.... [1]

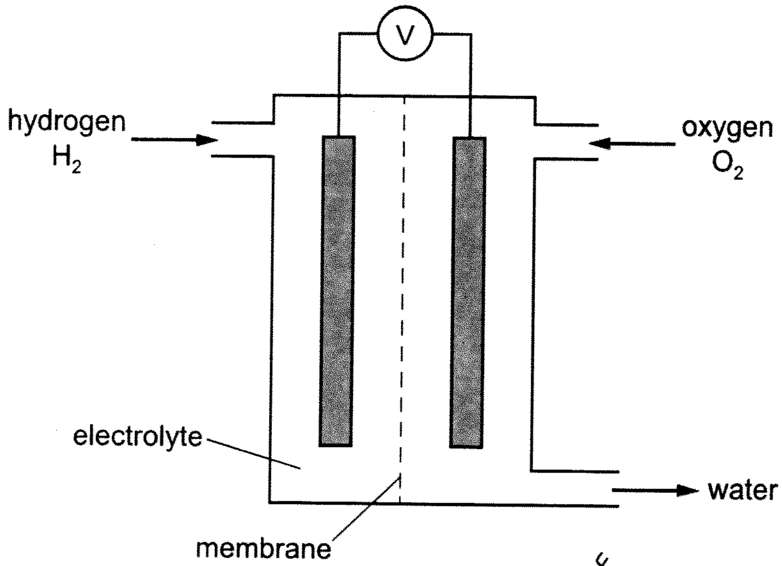
[Total: 8]

251

[0620/43/O/N/17/Q4]

Q28.

Hydrogen and oxygen react together in a hydrogen fuel cell. A hydrogen fuel cell is shown in the diagram.



(a) Name the process by which oxygen is obtained from air.

.... [1]

(b) (i) In a hydrogen fuel cell, the hydrogen molecules are converted into hydrogen ions, H^+, according to the ionic half-equation shown.

$$H_2 \rightarrow 2H^+ + 2e^-$$

What type of reaction does this ionic half-equation represent?

.... [1]

(ii) What **type** of substance reacts by donating hydrogen ions, H^+?

.... [1]

(c) Write a chemical equation for the overall reaction that occurs in a hydrogen fuel cell.

.... [1]

(d) Hydrogen fuel cells are being developed as alternatives to petrol engines in cars.

(i) Give **one** advantage of hydrogen fuel cells compared to petrol engines.

.... [1]

(ii) Give **one** disadvantage of hydrogen fuel cells compared to petrol engines.

.... [1]

(e) Some fuel cells use ethanol, C_2H_5OH, instead of hydrogen. Carbon dioxide and water are products of the reaction in an ethanol fuel cell.

(i) Write a chemical equation for the overall reaction occurring in an ethanol fuel cell.

.... [2]

(ii) State an environmental problem caused by the release of carbon dioxide into the atmosphere.

.... [1]

(iii) Name the process by which ethanol can be manufactured from a renewable resource.

.... [1]

(f) Name the process occurring when electrical energy is used to break down an ionic compound.

.... [1]

[Total: 11]

[0620/32/M/J/10/Q3]

Q29. The following are examples of redox reactions.

(a) Bromine water was added to aqueous sodium sulfide.

$$Br_2(aq) + S^{2-}(aq) \rightarrow 2Br^-(aq) + S(s)$$

(i) Describe what you would observe when this reaction occurs.

....

.... [2]

(ii) Write a symbol equation for this reaction.

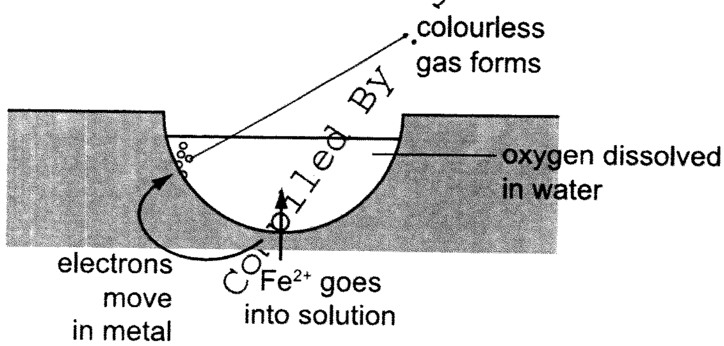
.... [1]

(iii) Explain, in terms of electron transfer, why bromine is the oxidant (oxidising agent) in this reaction.

....

.... [2]

(b) Iron and steel in the presence of water and oxygen form rust.



The reactions involved are:

reaction 1

$Fe \rightarrow Fe^{2+} + 2e^-$

The electrons move through the iron on to the surface where a colourless gas forms.

reaction 2

$Fe^{2+} + \underset{\text{from water}}{2OH^-} \rightarrow Fe(OH)_2$

reaction 3

$.........Fe(OH)_2 + O_2 + ...H_2O \rightarrow ....Fe(OH)_3$

The water evaporates to leave rust.

(i) What type of reaction is **reaction 1**? .... [1]

(ii) Deduce the name of the colourless gas mentioned in **reaction 1**.

.... [1]

(iii) What is the name of the iron compound formed in **reaction 2**?

.... [1]

(iv) Balance the equation for **reaction 3**.

..........$Fe(OH)_2$ + O_2 + ...H_2O → ....$Fe(OH)_3$

[1]

(v) Explain why the change $Fe(OH)_2$ to $Fe(OH)_3$ is oxidation.

....

.... [1]

(vi) Explain why iron in electrical contact with a piece of zinc does not rust.

....

....

.... [3]

[Total: 13]

[0620/41/O/N/18/Q4-C-i]

Q30.

(c) The gas hydrogen sulfide, H_2S, is produced when concentrated sulfuric acid is added to solid potassium iodide.

The reaction involves oxidation.

(i) Define the term *oxidation* in terms of electron transfer.

.... [1]

Q31. [0620/43/O/N/18/Q2]

This question is about electrolysis.

(a) (i) What is meant by the term *electrolysis*?

....

.... [2]

(ii) Name the type of particle responsible for the conduction of electricity during electrolysis in:

the metal wires ....

the electrolyte .... [2]

(b) The table gives information about the products of the electrolysis of two electrolytes. Platinum electrodes are used in each case.

(i) Give **two** reasons why platinum is suitable to use as an electrode.

1 ....

2 .... [2]

(ii) Complete the table.

electrolyte	observation at the anode (+)	name of product at the anode (+)	observation at the cathode (–)	name of product at the cathode (–)
concentrated aqueous potassium chloride			bubbles of colourless gas	
aqueous copper(II) sulfate	bubbles of colourless gas			

[6]

[Total: 12]

256

[0620/43/O/N/18/Q3-E]

Q32.

(e) The position of tin in the reactivity series is shown.

iron	most reactive
tin	↑
copper	least reactive

A student added iron to a solution containing Sn^{2+} ions.

The student then separately added tin to a solution containing Cu^{2+} ions.

Complete the ionic equations. If there is no reaction write 'no reaction'.

$Fe + Sn^{2+} \rightarrow$ ....

$Sn + Cu^{2+} \rightarrow$ ....

[2]

Q33. [0620/42/M/J/19/Q7-D-E-F]

(d) Nickel is a transition element. Nickel is stronger than sodium.

Describe **two** other differences in the physical properties of nickel and sodium.

1 ....

2 ....

[2]

(e) Predict **one** difference in the appearance of aqueous solutions of nickel compounds compared to aqueous solutions of sodium compounds.

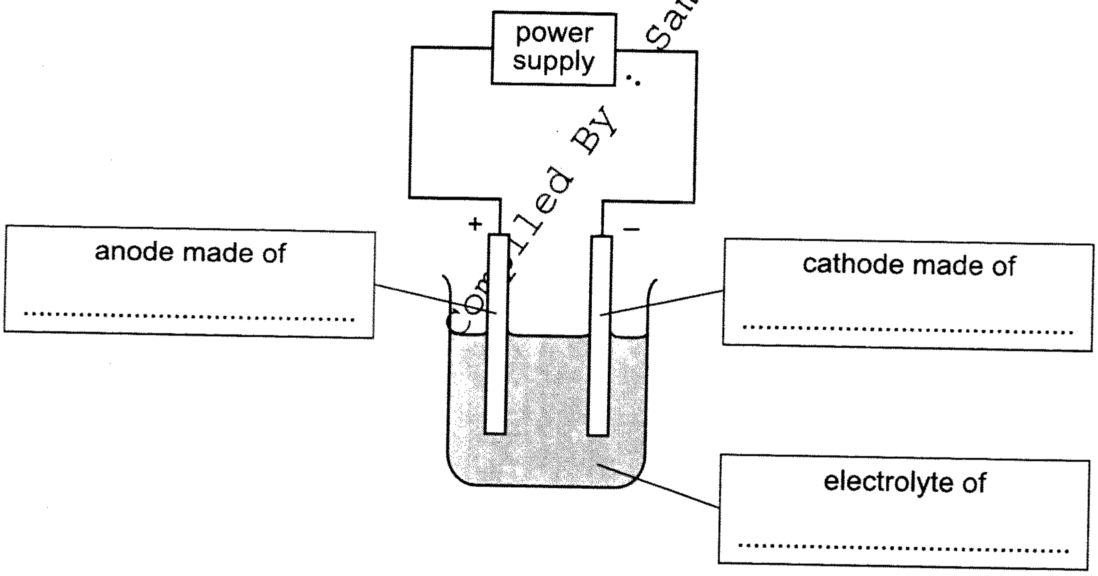
....

.... [1]

(f) Copper is refined (purified) by electrolysis. Nickel can be refined using a similar method.

(i) The diagram shows the refining of nickel by electrolysis.

Complete the labels in the boxes.



[3]

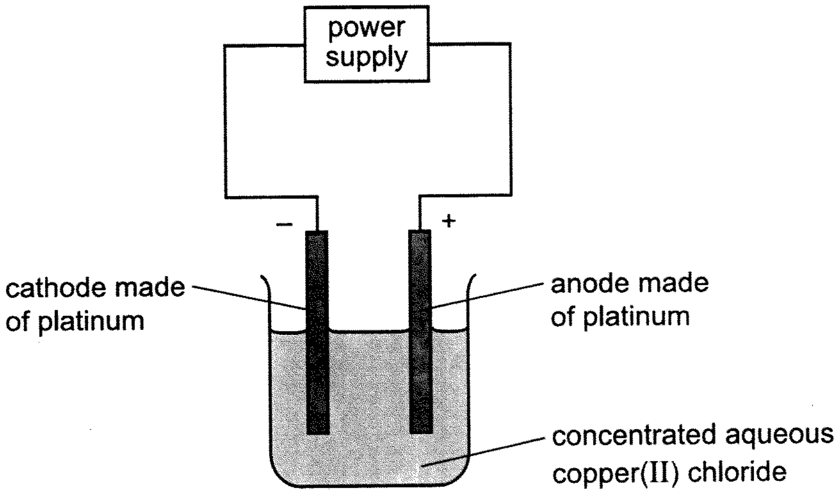
(ii) Indicate, by writing **N** on the diagram, where nickel is produced. [1]

[0620/43/M/J/19/Q4]

Q34.

Solutions of ionic compounds can be broken down by electrolysis.

(a) Concentrated aqueous copper(II) chloride was electrolysed using the apparatus shown.



The ionic half-equations for the reactions at the electrodes are shown.

negative electrode: $Cu^{2+}(aq) + 2e^- \rightarrow Cu(s)$

positive electrode: $2Cl^-(aq) \rightarrow Cl_2(g) + 2e^-$

(i) Platinum is a solid which is a good conductor of electricity.

State **one** other property of platinum which makes it suitable for use as electrodes.

....

.... [1]

(ii) State what would be **seen** at the positive electrode during this electrolysis.

....

.... [1]

(iii) State and explain what would happen to the mass of the negative electrode during this electrolysis.

....

....

.... [2]

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(iv) The concentrated aqueous copper(II) chloride electrolyte is green.

Suggest what would happen to the colour of the electrolyte during this electrolysis.
Explain your answer.

....

....

.... [2]

(v) Identify the species that is oxidised during this electrolysis.
Explain your answer.

species that is oxidised ....

explanation ....

.... [2]

(b) Metal objects can be electroplated with silver.

(i) Describe how a metal spoon can be electroplated with silver.
Include:

- what to use as the positive electrode and as the negative electrode
- what to use as the electrolyte
- an ionic half-equation to show the formation of silver.

You may include a diagram in your answer.

....

....

....

ionic half-equation .... [4]

(ii) Give **one** reason why metal spoons are electroplated with silver.

....

.... [1]

[Total: 13]

260

[0620/41/O/N/19/Q6-C-ii-iii-iv-v]

Q35. **(ii)** Explain why concentrated HBr(aq) can conduct electricity.

....

....

.... [2]

(iii) Magnesium is **not** a suitable material from which to make the electrodes.

Explain why.

....

.... [1]

(iv) Predict the product formed at the anode when concentrated HBr(aq) is electrolysed.

.... [1]

(v) Write the ionic half-equation for the reaction occurring at the cathode.

.... [2]

[0620/42/O/N/19/Q1-C]

Q36.

The Periodic Table is very useful to chemists.

Refer only to elements with atomic numbers 1 to 36 in the Periodic Table provided when answering **Question 1**.

(c) One element in the first 36 elements is used as the fuel in a fuel cell.

(i) Name this element.

.... [1]

(ii) Write the overall chemical equation for the reaction which occurs when the element in **(c)(i)** reacts in a fuel cell.

.... [2]

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Q37. [0620/42/O/N/19/Q4]

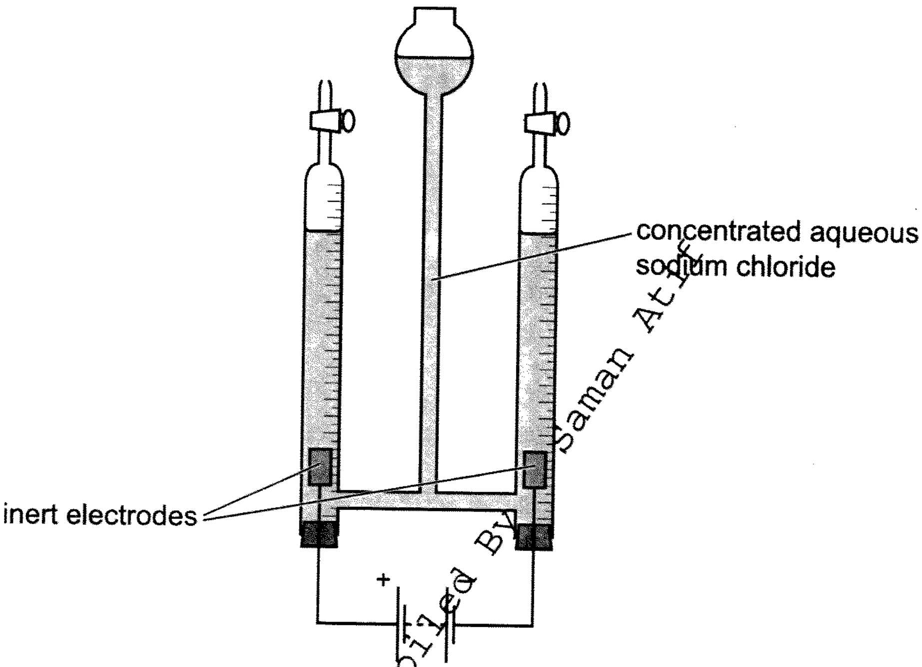
Many substances conduct electricity.

(a) Identify all the particles responsible for the passage of electricity in:

- graphite ....
- magnesium ribbon ....
- molten copper(II) bromide. ....

[4]

(b) A student used the following apparatus to electrolyse concentrated aqueous sodium chloride using inert electrodes.



(i) Suggest the name of a metal which could be used as the inert electrodes.

.... [1]

(ii) Name the gas formed at the positive electrode.

.... [1]

(iii) Write an ionic half-equation for the reaction occurring at the negative electrode. Include state symbols.

.... [3]

(iv) How, if at all, does the pH of the solution change during the electrolysis? Explain your answer.

....

....

.... [3]

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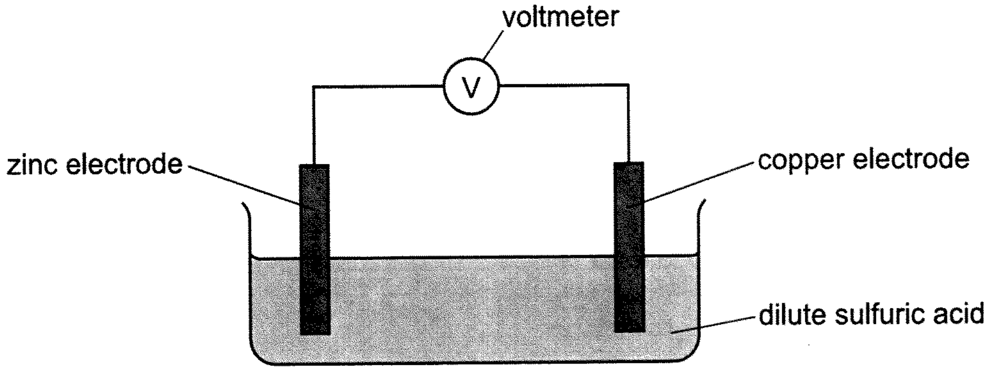
(c) A student used the following electrochemical cell.

The reading on the voltmeter was +1.10 V.



(i) Draw an arrow on the diagram to show the direction of electron flow. [1]

(ii) Suggest the change, if any, in the voltmeter reading if the zinc electrode was replaced with an iron electrode. Explain your answer.

....

.... [2]

(iii) The zinc electrode was replaced with a silver electrode. The reading on the voltmeter was –0.46 V.

Suggest why the sign of the voltmeter reading became negative.

....

.... [1]

[Total: 16]

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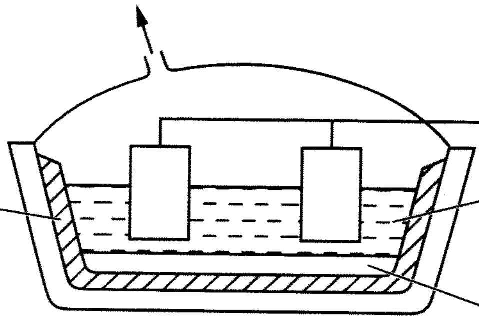
Q38. [0620/43/O/N/19/Q3-A-B]

(a) Name the ore of aluminium which mainly consists of aluminium oxide.

.... [1]

(b) Aluminium is produced by the electrolysis of aluminium oxide dissolved in molten cryolite.



(i) Give **two** reasons why the electrolysis is done using a molten mixture of aluminium oxide and cryolite instead of molten aluminium oxide only.

1 ....

2 ....
[2]

(ii) Write ionic half-equations for the reactions occurring at the electrodes.

positive electrode ....

negative electrode ....
[2]

(iii) The anodes are made of carbon and have to be replaced regularly.

Explain why the carbon anodes have to be replaced regularly.

....

.... [2]

[0620/42/M/J/20/Q5]

Q39.

Electrolysis of concentrated aqueous sodium chloride using inert electrodes forms chlorine, hydrogen and sodium hydroxide.

(a) What is meant by the term *electrolysis*?

....

....

.... [2]

(b) Name a substance that can be used as the inert electrodes.

.... [1]

(c) Write an ionic half-equation for the formation of hydrogen during this electrolysis.

.... [1]

(d) Give the formulae of the **four** ions present in concentrated aqueous sodium chloride.

.... [2]

(e) Explain how sodium hydroxide is formed during this electrolysis.

....

....

.... [2]

[Total: 8]

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Q40. [0620/43/M/J/20/Q2-D-i]

(d) Ammonia, NH_3, is used to produce nitric acid, HNO_3. This happens in a three-stage process.

Stage 1 is a redox reaction.

$$4NH_3 + 5O_2 \rightarrow 4NO + 6H_2O$$

(i) Identify what is oxidised in **stage 1**.

Give a reason for your answer.

substance oxidised ....

reason ....

....

[2]

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[0620/43/M/J/20/Q7-A-B-C-D]

Q41.

Aluminium is extracted by electrolysis. Iron is extracted from its ore by reduction with carbon.

(a) What is meant by the term *electrolysis*?

....

.... [2]

(b) Name the main ore of aluminium.

.... [1]

(c) **(i)** Explain why aluminium **cannot** be extracted by reduction with carbon.

.... [1]

(ii) Describe the role of cryolite in the extraction of aluminium by electrolysis.

.... [1]

(iii) Name the product formed at the positive electrode.

.... [1]

(iv) Write the ionic half-equation for the reaction at the negative electrode.

.... [2]

(d) Aluminium is used in overhead electricity cables.

Give **two** properties of aluminium that make it suitable for use in overhead electricity cables.

1 ....

2 ....
[2]

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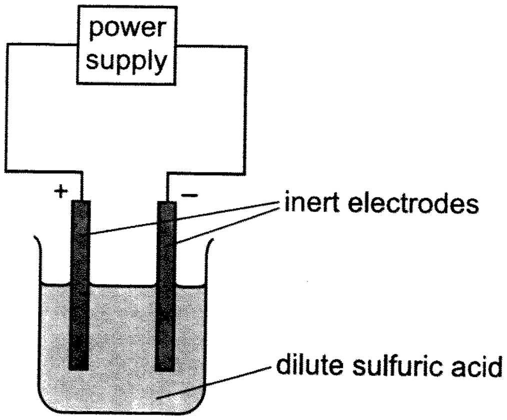
Q42. [0620/41/O/N/2020/Q5-A]

(a) Dilute sulfuric acid is electrolysed using the apparatus shown in the diagram.



(i) State what is meant by the term *electrolysis*.

....

....

.... [2]

(ii) Explain why inert electrodes are used.

....

.... [1]

(iii) Name the products formed at each electrode.

negative electrode ....

positive electrode ....

[2]

(iv) Write an ionic half-equation for the reaction at the negative electrode.

.... [2]

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Q1.

(a) (i) device which changes chemical energy; [1]
into electrical energy; [1]
OR
produces a voltage / potential difference / electricity; [1]
due to difference in reactivity of two metals; [1]
OR
produces a voltage / potential difference / electricity; [1]
by redox reactions; [1]

(ii) negative / electrode B / right electrode; [1]
accept: anode because it is the electrode which supplies electrons to external circuit
loses ions / iron ions / Fe^{2+} or Fe^{3+}; [1]
electrons move from this electrode; [1]

(iii) change of mass of electrode / mass of rust formed; [1]
time / mention of stop watch / regular intervals; [1]

(iv) to make it a better conductor; [1]

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Q2.

(a) (i) correct arrow from negative terminal of battery or from anode; [1]

(ii) from battery / power supply / cell; [1]
from negative electrode of battery to external circuit; [1]
or from anode;
from iodide ion losing electron **or** oxidation of anion;

(iii) ions cannot move in solid / ions can move in liquid; [1]

(b) copper; [1]
(changes to) sulfuric acid; [1]

hydrogen; [1]
(changes to) potassium hydroxide; [1]

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(c) (i) $2H^+ + 2e \rightarrow H_2$ [2]
not balanced = [1]

(ii) $4OH^- \rightarrow O_2 + 2H_2O + 4e$ [1]

(iii) water used up; [1]

(d) it is a cell; [1]
hydrogen reacts with oxygen; [1]
this reaction produces energy / is exothermic / produces flow of electrons / changes chemical energy to electrical energy; [1]

[Total: 15]

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Q3.

(iv) cathode labelled carbon / zinc / platinum; [1]
zinc deposited at cathode; [1]
oxygen formed (at anode); [1]
(electrolyte becomes) sulfuric acid / remaining solution contains H^+ and SO_4^{2-}; [1]

Page 4	Mark Scheme	Syllabus	Paper
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Q4.

(a) (i) any metal above zinc
$Mg \rightarrow Mg^{2+} + 2e^-$ [1]

(ii) $Zn + 2Ag^+ \rightarrow Zn^{2+} + 2Ag$ [2]
Note: not balanced only [1]

(iii) because they can accept or gain electrons / change into atoms or can be reduced [1]

(iv) Ag^+ or silver [1]
charge not essential but if given must be correct

(v) Ag^+ and Cu^{2+} **or** silver and copper [1]
charge not essential but if given must be correct

(b) Cu Sn Cd Zn *(i.e. all **4** in correct order)* [1]
relates order to voltage [1]

one relevant comment from: [1]

higher reactivity metals are the negative electrode / copper is least reactive because it is the positive electrode because copper would have the lowest voltage / copper cell V = 0 / the bigger the difference in reactivity, the bigger the voltage / zinc has highest voltage because it is most reactive / more reactive metals have higher voltage

[Total: 9]

Page 3	Mark Scheme	Syllabus	Paper
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Q5.

(ii) $2H^+ + 2e \rightarrow H_2$ [2]

or $2H_3O^+ + 2e \rightarrow H_2 + 2H_2O$
accept: –2e on right hand side accept: e^-
note: not balanced = 1

(iii) chlorine / Cl_2 / [1]
cond: water treatment / solvents / plastics / PVC / bleach / disinfectants / HC*l* / kill bacteria / sterilising water / chlorination of water / swimming pools / pesticides / herbicides / insecticides / germicides / pharmaceuticals [1]

sodium hydroxide/NaOH [1]

cond: making soap / degreasing / making paper / detergents / bio-diesel / paint stripper / clearing drains / alumina from bauxite / oven cleaner / bleach [1]

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Q6.

(a) (i) $Cu(OH)_2 \rightarrow CuO + H_2O$ [1]

(ii) Rb [1]

(b) (i) electron loss [1]

(ii) because they can accept electrons [1]

(c) (i) copper and mercury [1]

(ii) add copper / mercury / metal to (named) acid **and** no reaction / no bubbles / no hydrogen [1]

(d) (i) Mn [1]

(ii) (solution) becomes colourless / decolourises
NOT: clear [1]

[Total: 8]

Page 3	Mark Scheme	Syllabus	Paper
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Q7.

(c) (i) $Zn^{2+} + 2e \rightarrow Zn$ [1]

(ii) $OH^- \rightarrow 2H_2O + O_2 + ...e$ (1) only
$4OH^- \rightarrow 2H_2O + O_2 + 4e$ [2]

(iii) sulfuric acid / hydrogen sulfate
ACCEPT: sulfuric acid [1]

Page 5	Mark Scheme	Syllabus	Paper
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Q8.

(b) (i) correct direction from zinc to lead (1) [1]

(ii) metals react by **losing electrons** (1)

the more reactive metal/zinc will lose electrons more readily (making the electrode negatively charged). (1) [2]

(iii) manganese **and** zinc are more reactive than lead (and/or copper) (1)

lead is more reactive than copper (1) [2]

(iv) the **polarity** of a Mn/Zn (cell)
or the **voltages** of Zn/Pb **and** Mn/Pb (cells) (1) [1]

Page 5	Mark Scheme	Syllabus	Paper
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Q9.

(b) hydrogen **and** chlorine / H_2 **and** Cl_2 (1)

sodium hydroxide / NaOH / Na^+OH^- (1)

$2H^+ + 2e \rightarrow H_2 / 2H^+ \rightarrow H_2 - 2e$ (1)

$2Cl^- \rightarrow Cl_2 + 2e / 2Cl^- - 2e \rightarrow Cl_2$ (1)

Hydrogen / H_2 / H / H^+ at cathode **and** chlorine / chloride / Cl_2 / Cl / Cl^- at anode (1) [5]

Page 5	Mark Scheme	Syllabus	Paper
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Q10.

(a) bauxite (1) [1]

(b) electrolyte alumina / aluminium oxide dissolved in molten cryolite (1)
use cryolite to reduce mp / comparable idea / temperature of electrolyte 900 to 1000 °C (1)
electrodes carbon (1)
aluminium formed at cathode / $Al^{3+} + 3e \rightarrow Al$ (1)
oxygen formed at anode / $2O^{2-} \rightarrow O_2 + 4e$ (1)
anode burns / reacts to carbon dioxide / $C + O_2 \rightarrow CO_2$ (1) [6]

(c) (i) food containers / window frames / cooking foil / cars / bikes / drink cans (1) [1]

(ii) $4OH^- \rightarrow O_2 + 2H_2O + 4e$ (2) [2]

$4Al + 3O_2 \rightarrow 2Al_2O_3$ (2) [2]

[Total: 12]

Page 2	Mark Scheme	Syllabus	Paper
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Q11.

(a) $Al^{3+} + 3e^- \rightarrow Al$ [2]
species (1) balancing (1)

(b) (i) $AlCl_3 + 3Na \rightarrow 3NaCl + Al$ [2]
species (1) balancing (1)

(ii) M1 electrolysis [1]

M2 molten sodium chloride [1]
or
M1 Add named more reactive metal (e.g. K)
M2 Molten sodium chloride

(c) (i) bauxite [1]

(ii) M1 aluminium oxide / amphoteric oxide dissolves OR iron(III) oxide / basic oxide does not [1]

M2 Filter **COND** on M1 [1]

(iii) Any **two** from:
Lowers (working) temperature or lowers mpt (of mixture)
increases conductivity
reduces cost OR energy need [2]

(iv) M1 = Any one correct equation.

M2 Oxygen mark
Oxygen comes from oxide ions
or $2O^{2-} \rightarrow O_2 + 4e$

M3 Carbon dioxide mark
Anode reacts with oxygen / burns to form CO_2
or $C + O_2 \rightarrow CO_2$

M4 Carbon monoxide mark
Anode reacts with limited oxygen / incompletely burns to form carbon monoxide
or $2C + O_2 \rightarrow 2CO$
or CO_2 reacts with the anode to form carbon monoxide
or $CO_2 + C \rightarrow 2CO$

M5 Fluorine mark
Fluorine comes from cryolite or fluoride ions
or $2F^- \rightarrow F_2 + 2e^-$ [5]

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Q12.

(c) (i) sulfuric acid [1]

(c) (ii) $Zn^{2+} + 2e \rightarrow Zn$ [1]

oxygen or water Allow O_2 and H_2O if no name seen [1]

sulfuric acid [1]
Allow: H_2SO_4 if no name seen

(d) (i) from zinc to carbon
(clockwise direction on or near the wire) [1]

(ii) to allow <u>ions</u> to flow [1]

(iii) oxidation
and loss of electron(s) or increase in oxidation number/state [1]

reduction
and decrease in oxidation number/state or gain of electron(s) [1]

Page 3	Mark Scheme	Syllabus	Paper
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Q13.

(c) (i) graphite [1]

(ii) delocalised electrons/free electrons/sea of electrons [1]

COND (on electrons) move/mobile/electrons flow [1]

(iii) Any **two** from: [2]
potassium oxide
potassium hydroxide
potassium carbonate
potassium hydrogencarbonate (bicarbonate)

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Page 3	Mark Scheme	Syllabus	Paper
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Q14.

(a) carbon dioxide/CO_2 [1]

(b) $2H_2 + O_2 \rightarrow 2H_2O$ [1]

(c) **(i)** anode/negative electrode **and** electrons lost(by hydrogen/H/H_2)/electrons move from this electrode [1]

(ii) $H_2 \rightarrow 2H^+ + 2e(^-)$ / $H_2 - 2e(^-) \rightarrow 2H^+$ / $H_2 + 2OH^- \rightarrow 2H_2O + 2e(^-)$ / $H_2 + 2OH^- - 2e(^-) \rightarrow 2H_2O$
Species (1) Balancing (1) [2]

(d) Any **two** from:

CELL:
lightweight
quieter
fewer working parts/less maintenance
more efficient **or** less energy wasted **or** more energy produced

SUSTAINABILITY:
conserves a limited resource/petroleum/fossil fuels
unlimited supplies of renewable resource(of hydrogen from water)

POLLUTION:
No or less greenhouse effect
No or less acid rain
No or less toxic gases
No or less smog

POLLUTANTS:
No or less C/soot
No or less CO_2
No or less CO
No or less SO_2
No or less oxides of nitrogen/NO/NO_2/N_2O_4/NO_x
No or less (unburnt) hydrocarbons
No or less low level ozone
H_2O is the **only** product [2]

[Total: 7]

Q15.

Page 7	Mark Scheme	Syllabus	Paper
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Question	Answer	Marks
4(a)(i)	reduction **and** (the Cu^{2+} ion/copper ions) is gaining electrons/is decreasing in oxidation number;	1
4(a)(ii)	formation of Cu^{2+}/copper ions at the anode happens at the same rate as; removal of Cu^{2+}/copper ions at the cathode ora;	2 1 1
4(b)	replace (anode of) copper with nickel; replace electrolyte with nickel(II) sulfate/$NiSO_4$;	2 1 1

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Q16.

Page 5	Mark Scheme	Syllabus	Paper
	Cambridge IGCSE – May/June 2016	0620	42

Question	Answer	Marks
4(e)(i)	**M1** breakdown of an ionic compound when molten or in aqueous solution; **M2** (using) electricity / electric current / electrical energy;	2 1 1
4(e)(ii)	carbon / graphite / platinum;	1
4(e)(iii)	$2H^+ + 2e(^-)$ H_2 $2H_3O^+ + 2e(^-)$ $H_2 + 2H_2O$	1
4(e)(iv)	cathode / negative electrode	1
4(e)(v)	**M1** damp blue litmus paper **M2** bleaches / loses colour / turns white / turns colourless	2 1 1
4(f)	$2NaCl + 2H_2O$ $2NaOH + H_2 + Cl_2$ all formulae correct balancing	2
4(g)	**M1** *chlorine*: treating (drinking) water / treating water in swimming pools / kill bacteria in water / chlorination of water / (manufacture of) paper products / plastics / C/ dyes / textiles / medicines / antiseptics / insecticides/ herbicides / fungicides / solvents/ paints / disinfectant / bleach / hydrochloric acid **M2** *sodium hydroxide*: drain cleaner / oven cleaner / extraction of aluminium / purification of bauxite / (manufacture of) biodiesel /paper / soap / detergents / washing powder / textiles / dyes **M3** *hydrogen*: fuel / rocket fuel / fuel cells / in welding/ (manufacture of) ammonia / NH_3 / margarine / methanol / hydrochloric acid / refrigerants	3 1 1 1

Q17.

Page 5	Mark Scheme	Syllabus	Paper
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Question	Answer	Marks
5(a)	(gas) oxygen (test) glowing splint (result of test) relights	1 1 1
5(b)	reference to ions / ionic ions cannot move in solid **OR** are in fixed positions in solid ions can move when in solution	1 1 1
5(c)(i)	copper ions / Cu^{2+} gain of electrons / oxidation number decreases	1 1
5(c)(ii)	any 3 from: anode decreases (in mass) copper removed (from anode) / solid (copper from anode) becomes aqueous cathode increases (in mass) copper deposited / added / Cu^{2+} deposited as Cu (on cathode)	3
5(c)(iii)	copper is both added and removed (at same rate) **OR** the concentration (of copper ions) does not change	1

Q18.

Page 5	Mark Scheme	Syllabus	Paper
	Cambridge IGCSE – October/November 2016	0620	43

Question	Answer	Marks
4(e)(i)	*product at the positive electrode:* chlorine *product at the negative electrode:* hydrogen	1 1
4(e)(ii)	$2H^+ + 2e(\ ) \rightarrow H_2$ **OR** $2H_3O^+ + 2e(^-) \rightarrow H_2 + 2H_2O$	1
4(f)	oxygen	1
4(g)(i)	sodium	1
4(g)(ii)	$Na^+ + e(^-) \rightarrow Na$	1
4(g)(iii)	*test:* (damp blue) litmus *result:* bleached / removes colour / (turns) white	1 1

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Q19.

Question	Answer	Marks
4(c)(i)	$Zn \rightarrow Zn^{2+} + 2e$ **M1** correct species **M2** correct balancing	2
4(c)(ii)	$2H^+ + 2e \rightarrow H_2$ **M1** correct species **M2** correct balancing	2
4(c)(iii)	change: (the intensity would) decrease	1
	reason: the difference in reactivity between zinc and iron is less than the difference in reactivity between zinc and copper	1

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Q20.

uestion	nser	ars
4(c)(i)	$Zn \rightarrow Zn^{2+} + 2e/2e$ □ formula of Zn^{2+} on the right-hand side □ equation fully correct	□
4(c)(ii)	zinc / Zn nickel / Ni copper / Cu	□
4(c)(iii)	copper (+) and nickel (–)	□
	0.59 V	□

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Q21.

Question	Answer	Marks
5(b)(i)	white	1
5(b)(ii)	0.02 (mol)	1
5(b)(iii)	0.02 (mol)	1
5(b)(iv)	1:2	1
	VCl_2	1
5(c)(i)	solid	1
5(c)(ii)	$2Na + At_2 \rightarrow 2NaAt$ **M1** formula of NaAt **M2** equation fully correct	2

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Q22.

Question	Answer	Marks
5(a)(i)	loss (of electrons)	1
5(a)(ii)	Ni → Ni^{2+} + 2e	1
5(a)(iii)	goes down / gets less / decreases / lower / smaller	1
5(b)(i)	beryllium	1
	most negative voltage with any (named) metal **OR** biggest voltage with cobalt / nickel	1
5(b)(ii)	cobalt **AND** nickel	1
5(b)(iii)	– sign	1
	2.7	1
5(c)	(set up cell) using magnesium and beryllium (electrodes)	1
	voltage positive if magnesium is metal 2	1
	OR	
	(set up cells) using both magnesium and beryllium with the same metal as the other electrode	1
	larger (magnitude) voltages with magnesium	1
	OR	
	use magnesium with a different metal and compare to a reference value in a table	1
	value is more negative than with beryllium, if magnesium is metal 1	1

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Q23.

Question	Answer	Marks
4(a)	the breakdown (into elements)	1
	of an (ionic) compound by (the passage of) electricity	1
4(b)(i)	oxygen	1
4(b)(ii)	**glowing** splint	1
	relights	1
4(b)(iii)	$2H^+ + 2e \rightarrow H_2$ **M1** gain of electrons by H^+ **M2** rest of equation	2
4(c)	*the wires:* electrons	1
	the electrolyte: ions	1
4(d)	any 2 from: • green gas at positive electrode • bulb is brighter • rate of bubbles increases	2
4(e)(i)	*anode made of:* impure copper	1
	cathode made of: (pure) copper	1
	electrolyte of: (aqueous) copper sulfate	1
4(e)(ii)	silver (impurities) fall to the bottom of the cell	1
	zinc (impurities) (dissolve) into solution (as ions)	1
	because zinc is more reactive than copper **AND** silver is less reactive than copper	1

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Q24.

Question	Answer	Marks
5(e)(i)	$Cu^{2+}(aq) + 2e^- \rightarrow Cu(s)$ 1 mark for any equation which has Cu as the product or Cu^{2+} ions on left 1 mark for correct species 1 mark for correct state symbols	3
5(e)(ii)	(a pink / brown) solid / deposit forms	1
5(e)(iii)	bubbles / fizzing (at the anode)	1
	solution becomes paler / less blue / colourless	1
5(e)(iv)	a green gas would be seen (on the anode)	1

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Q25.

Question	Answer	Marks
4(c)(i)	substance that conducts electricity / (undergoes) electrolysis	1
	decomposed / chemically changed **OR** molten or liquid or solution or aqueous **AND** containing ions/or ionic	1
4(c)(ii)	$2H^+ + 2e(\ ) \rightarrow H_2$ 1 mark for H^+ + e(⁻) as the only species on the left 1 mark for equation fully correct 1 mark for bromine at the anode 1 mark for potassium hydroxide	4
4(c)(iii)	potassium	1

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Q26.

Question	Answer	Marks
5(b)(i)	electrons	1
5(b)(ii)	(positive and negative) ions	1
5(b)(iii)	nickel	1
	iodine	1
	$Ni^{2+} + 2e^- \rightarrow Ni$ **OR** $2I^- \rightarrow I_2 + 2e^-$	1
5(c)(i)	copper formed/copper deposited	1
5(c)(ii)	oxygen	1
5(c)(iii)	copper removed or copper lost **or** copper forms ions	1
5(c)(iv)	any **three** from: (apparatus **A**): solution becomes paler/fades in **A** (apparatus **B**): solution stays the same colour in **B** (explanation): copper ions removed (but not added) copper ions not replaced in **A** **OR** copper ions both removed and added (at the same rate) copper ions are being replaced (continually)	3

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Q27.

(a) fractional [1]
distillation [1]

(b) (i) O=O / oxygen(–)oxygen / H–H / hydrogen(–)hydrogen [1]

(ii) O-H / oxygen(–)hydrogen / OH / bond between hydrogen and oxygen [1]
not H-O-H

(iii) endothermic. [1]

(c) (i) no pollution / no CO / no CO_2 / no oxides of nitrogen / only produces steam or water / no greenhouse gases / no global warming [1]
does not use up fossil fuels / water is not a finite resource / water is a renewable source of energy / hydrogen is renewable / available from electrolysis of water [1]

(ii) obtaining hydrogen from water requires fossil fuels / storage problems / transport problems / limited range of vehicles available / gaseous nature means only produces small amount of energy per unit volume / methane as a source of steam reforming is finite / lack of distribution network [1]
not expensive / anything regarding safety / flammability / explosiveness

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Q28.

Question	Answer	Marks
4(a)	fractional distillation	1
4(b)(i)	oxidation	1
4(b)(ii)	acid(ic)	1
4(c)	$2H_2 + O_2 \rightarrow 2H_2O$	1
4(d)(i)	no carbon dioxide produced / more efficient	1
4(d)(ii)	storage of hydrogen is difficult / takes more space to store (hydrogen) / high likelihood of (hydrogen) leaks / lack of availability of hydrogen	1
4(e)(i)	$C_2H_5OH + 3O_2 \rightarrow 2CO_2 + 3H_2O$ **M1** species correct **M2** balanced	2
4(e)(ii)	climate change / greenhouse effect / consequence of climate change	1
4(e)(iii)	fermentation	1
4(f)	electrolysis	1

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Q29.

(a) (i) red brown or orange to colourless [1]
not just bromine decolourised
yellow (**not** dark) / white solid / precipitate / goes cloudy [1]
brown to yellow with no mention of solid/precipitate scores = [1]

(ii) $Br_2 + Na_2S \rightarrow 2NaBr + S$ [1]

(iii) look for two comments
sulfide (ion) / sulfur (ion) loses electrons [1]
not sodium sulfide
bromine accepts them [1]

(b) (i) oxidation [1]
not redox

(ii) hydrogen / H_2
not H [1]

(iii) iron(II) hydroxide / ferrous hydroxide [1]

(iv) $4Fe(OH)_2 + O_2 + 2H_2O \rightarrow 4Fe(OH)_3$ [1]

(v) oxidation number or state or valency increases / electron loss / Fe^{2+} to Fe^{3+} [1]
not gains oxygen

(vi) sacrificial protection **or** zinc is sacrificed /
zinc corrodes not iron **or** zinc corrodes therefore iron doesn't /
not just zinc rusts
zinc is oxidised in preference to iron /
zinc reacts with oxygen and water in preference to iron /
zinc more reactive or electropositive than iron /
zinc forms ions more readily than iron **or** zinc loses electrons more readily than iron /
electrons move on to iron /
iron is cathode **or** zinc is anode /
any

Q30. [0620/41/O/N/18/Q4-C-i]

4(c)(i)	(oxidation is) loss of electrons	1

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[0620/43/O/N/2018/Q2]

Q31.

2(a)(i)	**M1** breakdown of an ionic **compound** when molten or in aqueous solution **M2** (using) electricity / electric current	2
2(a)(ii)	**M1** electron(s) **M2** ion(s)	2
2(b)(i)	**M1** inert / unreactive **M2** conducts **electricity**	2
2(b)(ii)	see table below	6

observation at anode(+)	name of product at anode(+)	observation at cathode(–)	name of product at cathode(–)
M1 green / yellow bubbles	**M2** chlorine		**M3** hydrogen
	M4 oxygen	**M5** pink / brown solid	**M6** copper

[0620/43/O/N/2018/Q3-E]

Q32.

3(e)	**M1** (→) Fe^{2+} + Sn **OR** 2Fe + $3Sn^{2+}$ → $2Fe^{3+}$ + 3Sn **M2** (→) Sn^{2+} + Cu **OR** Sn + $2Cu^{2+}$ → Sn^{4+} + 2Cu	2

[0620/42/M/J/2019/Q7-D-F]

Q33.

7(d)	**nickel has** **M1** higher density (1) **ORA** **nickel has** **M2** higher melting point / boiling point (1) **ORA**	2
7(e)	solutions of nickel compounds are coloured **ORA**	1
7(f)(i)	**M1** electrolyte aqueous or solution of named nickel salt (1) **M2 anode** impure nickel (1) **M3 cathode** pure nickel (1)	3
7(f)(ii)	nickel produced at cathode under the liquid surface (1)	1

[0620/43/M/J/2019/Q4]

Q34.

4(a)(i)	inert / unreactive / does not react with chlorine	1
4(a)(ii)	bubbles / fizzing / effervescence	1
4(a)(iii)	**M1** increases **M2** (solid) copper deposited	2
4a(iv)	**M1** colour fades / becomes pale(r) / becomes colourless / becomes lighter **M2** copper (ions) removed (from solution)	2
4(a)(v)	**M1** species oxidised: chlor<u>ide</u> (ions) / Cl^- **M2** explanation: loss of electrons / increase in oxidation state	2
4(b)(i)	**M1** spoon as cathode **M2** (pure)silver as anode **M3** aqueous silver nitrate as electrolyte **M4** Ag^+ + e^- → Ag	4
4(b)(ii)	any one from: • Improves appearance • prevent / resist corrosion / oxidation • antibacterial	max 1

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Q35.

[0620/41/O/N/2019/Q6-C]

6(c)(ii)	(it contains) ions (1) (ions) are able to move (1)	2
6(c)(iii)	magnesium is not inert	1
6(b)(iv)	bromine / Br_2	1
6(b)(v)	H^+ and $e^{(-)}$ on LHS (1) fully correct, i.e.: $2H^+ + 2e^- \rightarrow H_2$ (1)	2

Q36.

[0620/42/O/N/2019/Q1-C]

1(c)(i)	gydrogen / H	1
1(c)(ii)	$2H_2 + O_2 \rightarrow 2H_2O$ water as product from reaction of hydrogen and oxygen (1) balanced (1)	2

Q37.

[0620/42/O/N/2019/Q4]

4(a)	electrons (1) electrons (1) Cu^{2+} (ions) (1) Br^- (ions) (1)	4
4(b)(i)	platinum	1
4(b)(ii)	chlorine	1
4(b)(iii)	$2H^+(aq) + 2e^- \rightarrow H_2(g)$ $H^+ + e^-$ on left hand side (1) rest of equation (1) state symbols of (aq) $\rightarrow$ (g) (1)	3
4(b)(iv)	increases (sodium) hydroxide is formed (sodium) hydroxide is an alkali	3
4(c)(i)	arrow (anywhere) going from Zn $\rightarrow$ Cu	1
4(c)(ii)	reading would decrease (1) Fe less reactive than Zn (1) **OR** difference in reactivity (between Fe and Cu) is smaller	2
4(c)(iii)	Ag less reactive than Cu	1

Q38.

[0620/43/O/N/2019/Q3-A-B]

3(a)	bauxite	1
3(b)(i)	improves conductivity / better conductor (1) lower (operating) temperature (1)	2
3(b)(ii)	positive: $2O^{2-} \rightarrow O_2 + 4e^-$ (1) negative: $Al^{3+} + 3e^- \rightarrow Al$ (1)	2
3(b)(iii)	anodes **or** carbon react with oxygen (1) (form) carbon dioxide (1)	1

[0620/42/M/J/2020/Q5]

Q39.

5(a)	**breakdown** of an ionic **compound** when molten or in aqueous solution (1) (using) electricity / electric current / electrical energy (1)	2
5(b)	platinum / graphite	1
5(c)	$2H^+ + 2e \rightarrow H_2$	1
5(d)	Na^+ H^+ Cl^- OH^- all fou (2) 3 or 2 (1)	2
5(e)	H^+ and Cl^- are discharged / removed (1) Na^+ and OH^- remain (1)	2

[0620/43/M/J/2020/Q2-D-i]

Q40.

2(d)(i)	N / NH_3 change in oxidation state of N from –3 to +2 / increase in oxidation number / gain in oxygen / loss of electrons	2

[0620/43/M/J/2020/Q7-A-B-C-D]

Q41.

7(a)	breakdown of a molten / or aqueous ionic compound by the passage of electricity	2
7(b)	bauxite	1
7(c)(i)	it is above carbon in the reactivity series / more reactive than carbon	1
7(c)(ii)	any **one** from: • aluminium oxide has high melting point / cryolite has lower melting point than aluminium oxide • using cryolite reduces costs / expensive to melt aluminium	1
7(c)(iii)	oxygen	1
7(c)(iv)	$Al^{3+} + 3e^- \rightarrow Al$	2
7(d)	any **two** related to use as electricity cables: • ductile / malleable • conducts (electricity) • low density • protective oxide layer	2

[0620/41/O/N/2020/Q5-A]

Q42.

5(a)(i)	breakdown by (the passage of) electricity (1) of an ionic compound in molten/aqueous (state) (1)	2
5(a)(ii)	they do not react	1
5(a)(iii)	negative electrode: hydrogen (gas) (1) positive electrode: oxygen (gas) (1)	2
5(a)(iv)	H^+ + $e^{(-)}$ as the only species on the left (1) equation fully correct (1) $2H^+ + 2e^{(-)} \rightarrow H_2$ (scores 2)	2

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[0620/33/O/N/12/Q7-Dii]

Q1. (ii) Bond breaking is an endothermic process. Bond energy is the amount of energy needed to break or form one mole of the bond. Complete the table and explain why the forward reaction is exothermic.

$$N{\equiv}N + 3\,H{-}H \rightleftharpoons 2\,H{-}\underset{\displaystyle H}{\underset{|}{N}}{-}H$$

bond	bond energy kJ/mol	energy change kJ	exothermic or endothermic
N≡N	944	+944	endothermic
H—H	436	3 × 436 = +1308	
N—H	388		

....

.... [3]

[0620/33/M/J/13/Q5-Biii-iv]

Q2. (iii) A sealed tube containing an equilibrium mixture of nitrogen dioxide and dinitrogen tetroxide was placed in a beaker of ice cold water.
The colour of the mixture changed from brown to pale yellow.

Is the forward reaction exothermic or endothermic? Give an explanation for your choice.

....

.... [2]

(iv) What other piece of information given in the equation supports your answer to **(iii)**?

$$NO_2 + NO_2 \rightarrow O_2N{-}NO_2$$

.... [1]

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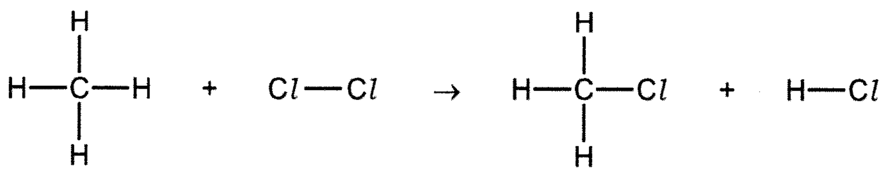
[0620/31/O/N/13/Q7-B-C]

Q3.(b) Bond forming is exothermic, bond breaking is endothermic. Explain the difference between an exothermic reaction and an endothermic reaction.

....

.... [2]

(c) Use the bond energies to show that the following reaction is exothermic.
Bond energy is the amount of energy (kJ / mol) which must be supplied to break one mole of the bond.



Bond energies in kJ / mol

Cl–Cl	+242
C–Cl	+338
C–H	+412
H–Cl	+431

bonds broken energy in kJ / mol

....

....

total energy = ...

bonds formed energy in kJ / mol

....

....

total energy = ...

....

.... [4]

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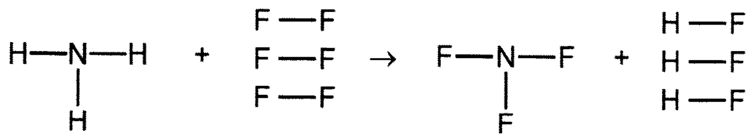
Q4. [0620/33/M/J/14/Q5-E]

(e) Ammonia is used to make nitrogen trifluoride, NF_3.
Nitrogen trifluoride is essential to the electronics industry. It is made by the following reaction.



Determine if the above reaction is exothermic or endothermic using the following bond energies and by completing the following table. The first line has been done as an example.
Bond energy is the amount of energy, in kJ / mole, needed to break or make one mole of the bond.

bond	bond energy in kJ / mole
N–H	390
F–F	155
N–F	280
H–F	565

bond	energy change / kJ
N–H	(3 × 390) = 1170
F–F	
N–F	
H–F	

....

.... [4]

Q5. [0620/31/O/N/15/Q3-D]

(d) The forward reaction is exothermic. The reaction is usually carried out at a temperature between 400 and 450 °C.

(i) What is the effect on the position of equilibrium of using a temperature above 450 °C? Explain your answer.

....

....

.... [2]

(ii) What is the effect on the rate of using a temperature below 400 °C? Explain your answer.

....

....

.... [3]

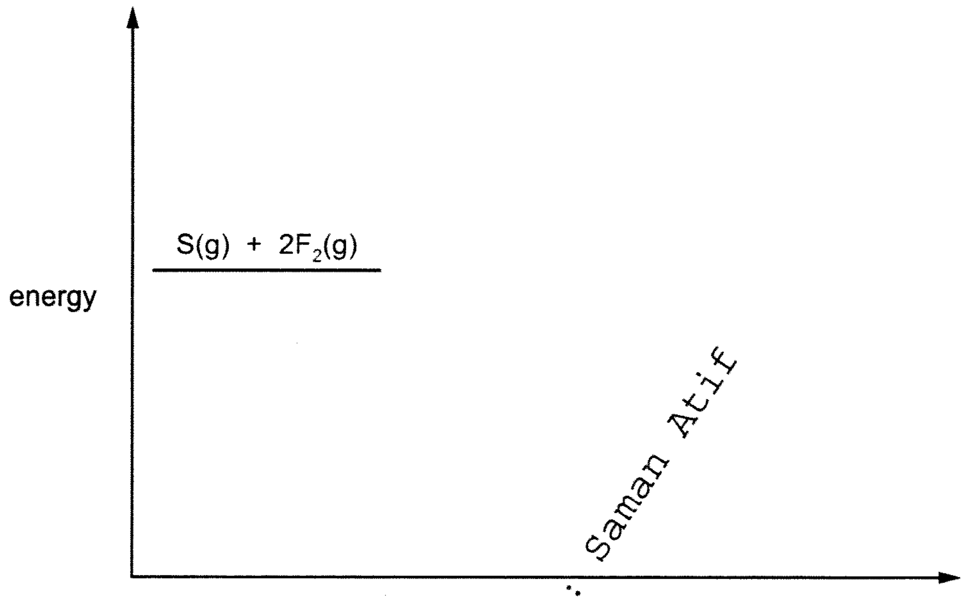
Q6. [0620/41/M/J/16/Q2-F]

(f) Sulfur tetrafluoride, SF_4, can be made by combining gaseous sulfur with fluorine.

$$S(g) + 2F_2(g) \rightarrow SF_4(g)$$

The reaction is exothermic.

(i) Complete the energy level diagram for this reaction. Include an arrow which clearly shows the energy change during the reaction.

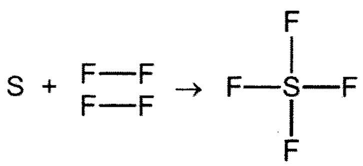


[3]

(ii) During the reaction the amount of energy given out is 780 kJ/mol.

The F–F bond energy is 160 kJ/mol.

Use this information to determine the bond energy, in kJ/mol, of one S–F bond in SF_4.



.... kJ/mol [3]

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Q7. [0620/42/M/J/17/Q5-D]

(d) Iodine reacts with chlorine. The chemical equation is shown.

$$I_2 + Cl_2 \rightarrow 2ICl$$

Use the bond energies to answer the questions.

bond	bond energy in kJ/mol
I–I	151
Cl–Cl	242
I–Cl	208

(i) Calculate the total amount of energy required to break the bonds in 1 mole of I_2 and 1 mole of Cl_2.

.... kJ [1]

(ii) Calculate the total amount of energy given out when the bonds in 2 moles of ICl are formed.

.... kJ [1]

(iii) Use your answers to **(d)(i)** and **(d)(ii)** to calculate the overall energy change for the reaction.

$$I_2 + Cl_2 \rightarrow 2ICl$$

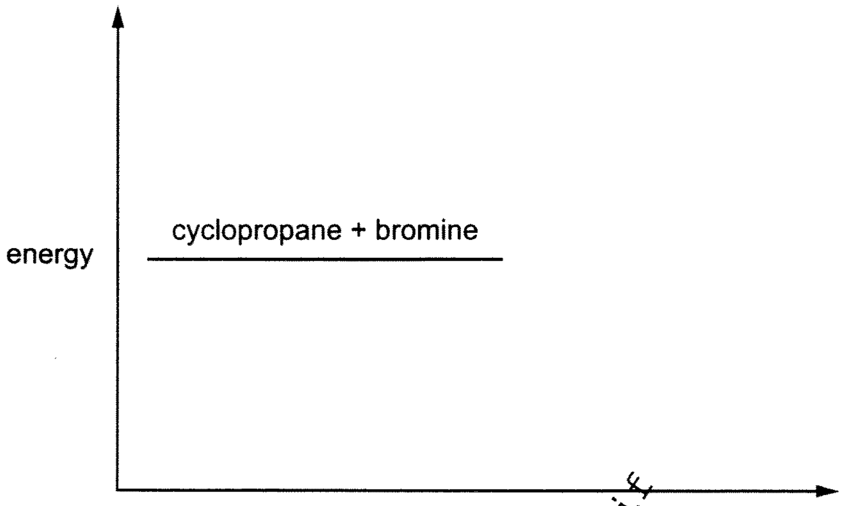
.... kJ/mol [1]

Q8. [0620/43/M/J/17/Q2-B]

(b) The reaction of cyclopropane with bromine is exothermic.

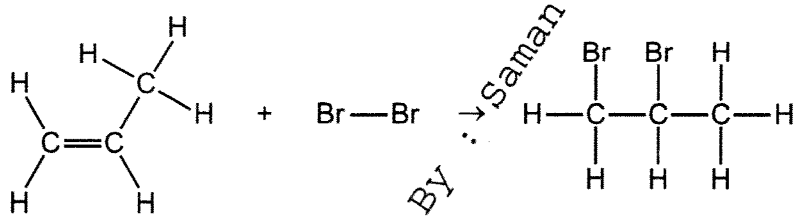
(i) Complete the energy level diagram for this reaction by

- adding the product of the reaction,
- labelling the energy change, ΔH.



[2]

(ii) Propene also reacts with bromine.



Use the bond energies in the table to calculate the energy change, ΔH, for the reaction.

	C–H	C–C	Br–Br	C–Br	C=C
bond energy in kJ/mol	412	348	193	285	611

energy change = ... kJ/mol [3]

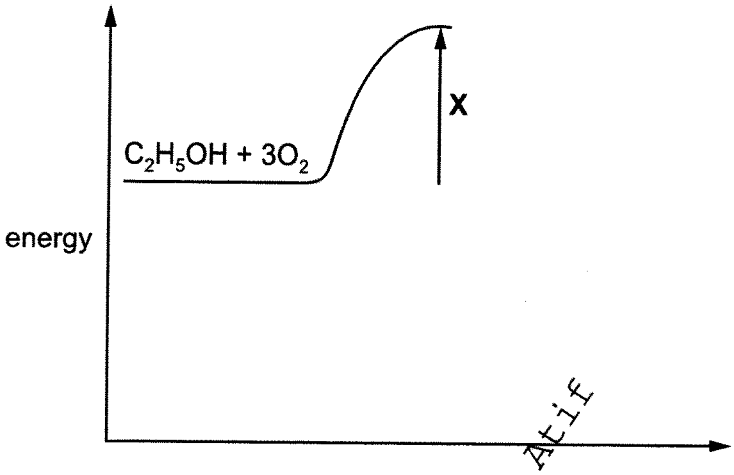
Q9. [0620/42/O/N/17/Q3-A-B-C]

The chemical equation for the complete combustion of ethanol, C_2H_5OH, is shown.

$$C_2H_5OH + 3O_2 \rightarrow 2CO_2 + 3H_2O$$

The energy released when one mole of ethanol undergoes complete combustion is 1280 kJ.

Part of the energy level diagram for this reaction is shown.



(a) Complete the energy level diagram to show
- the products of the reaction,
- the overall energy change of the reaction.

[3]

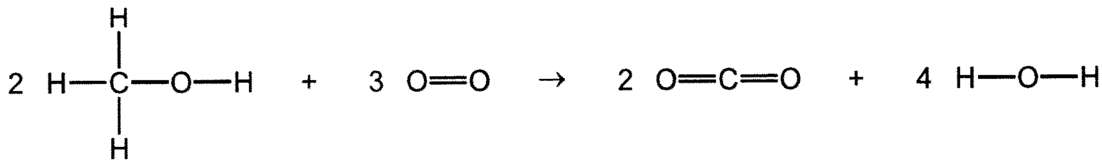
(b) What does **X** represent?

.... [1]

(c) The chemical equation for the complete combustion of methanol, CH_3OH, is shown.

$$2CH_3OH + 3O_2 \rightarrow 2CO_2 + 4H_2O$$

The equation can be represented as shown.



Use the bond energies in the table to determine the energy change, ΔH, for the complete combustion of **one** mole of methanol.

bond	bond energy in kJ/mol
C–H	410
C–O	360
O–H	460
O=O	500
C=O	805

- energy needed to break bonds

.... kJ

- energy released when bonds are formed

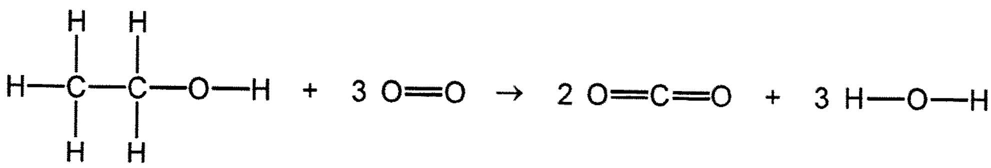
.... kJ

- energy change, ΔH, for the complete combustion of **one** mole of methanol

.... kJ/mol
[4]

Q10. [0620/41/O/N/19/Q7-B]

(b) The equation for the complete combustion of ethanol is shown.



Use the bond energies in the table to calculate the energy change, in kJ/mol, for the complete combustion of ethanol.

bond	bond energy in kJ/mol
C–C	347
C–H	413
C–O	358
C=O	805
O–H	464
O=O	498

- Energy needed to break bonds.

.... kJ

- Energy released when bonds are formed.

.... kJ

- Energy change for the complete combustion of ethanol.

energy change = ... kJ/mol
[3]

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[0620/42/O/N/19/Q3-D-ii]

Q11.

(ii) The chemical equation for the reaction can be represented as shown.

$$4\ \begin{array}{c}\mathrm{H{-}N{-}H}\\ |\\ \mathrm{H}\end{array}\ +\ 5\ \mathrm{O{=}O}\ \rightarrow\ 4\ \mathrm{N{=}O}\ +\ 6\ \mathrm{H{-}O{-}H}$$

Use the bond energies in the table to calculate the energy change, in kJ/mol, which occurs when **one** mole of NH_3 reacts.

bond	N–H	O=O	N=O	O–H
bond energy in kJ/mol	391	498	587	464

- Energy needed to break bonds.

.... kJ

- Energy released when bonds are formed.

.... kJ

- Energy change when **one** mole of NH_3 reacts.

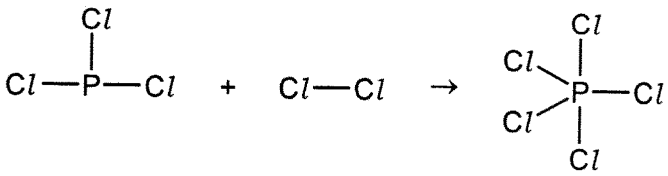
energy change = ... kJ/mol
[4]

Q12. [0620/43/O/N/19/Q4-C]

(c) Gaseous phosphorus(III) chloride, PCl_3, reacts with gaseous chlorine to form gaseous phosphorus(V) chloride, PCl_5.

$$PCl_3(g) + Cl_2(g) \rightarrow PCl_5(g)$$

The chemical equation for this reaction can be represented as shown.



(i) Use the bond energies in the table to calculate the energy change, in kJ/mol, of the reaction.

bond	bond energy in kJ/mol
P–C*l*	326
C*l*–C*l*	243

- Energy needed to break bonds.

.... kJ

- Energy released when bonds are formed.

.... kJ

- Energy change of reaction.

energy change = ... kJ/mol [3]

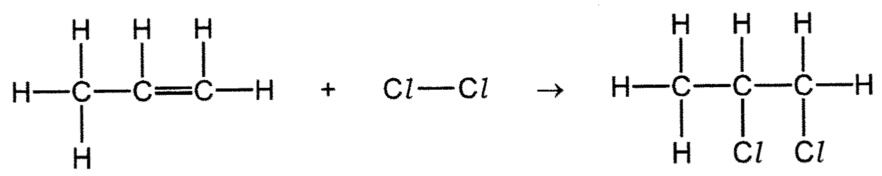
(ii) Deduce whether the energy change for this reaction is exothermic or endothermic. Explain your answer.

....

.... [1]

Q13. [0620/42/M/J/20/Q6-B-ii]

(ii) The structures of the reactants and products of this reaction are shown.



Some bond energies are shown in the table.

bond	bond energy in kJ/mol
C–C	347
C=C	612
C–H	413
C–C*l*	339
C*l*–C*l*	242

Calculate the energy change for the reaction between propene and chlorine using the following steps.

- Calculate the energy needed to break the bonds.

.... kJ

- Calculate the energy released when bonds are formed.

.... kJ

- Calculate the energy change for the reaction between propene and chlorine.

.... kJ/mol
[3]

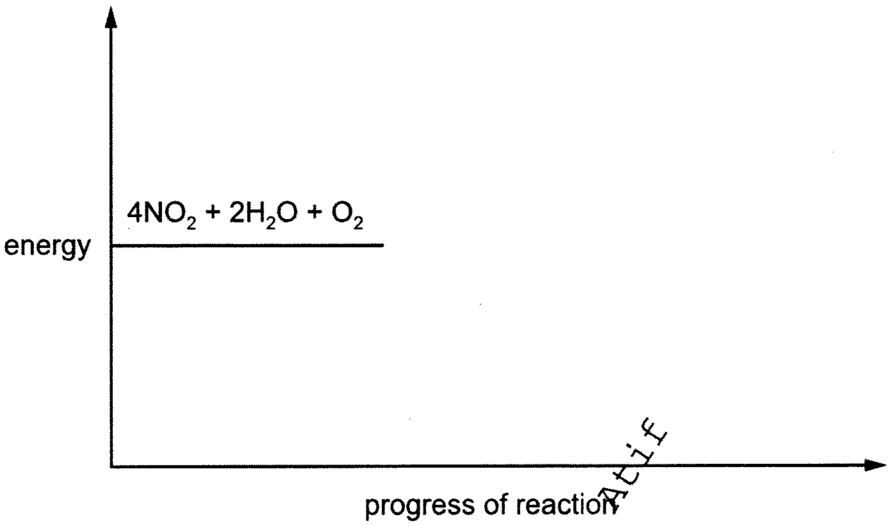
[0620/43/M/J/20/Q2-E]

Q14.

(e) The reaction in **stage 3** is exothermic.

$$4NO_2 + 2H_2O + O_2 \rightarrow 4HNO_3$$

Complete the energy level diagram for this reaction. Include an arrow that clearly shows the energy change during the reaction.



[3]

[0620/43/M/J/20/Q3-D]

Q15.

(d) Hydrogen and chlorine react to form hydrogen chloride gas, as shown in the equation.

$$H_2 + Cl_2 \rightarrow 2HCl$$

This equation can be represented as shown.

$$H–H + Cl–Cl \rightarrow 2H–Cl$$

Some bond energies are shown in the table.

bond	bond energy in kJ/mol
H–H	436
Cl–Cl	243
H–Cl	432

Calculate the energy change for the reaction between hydrogen and chlorine, using the following steps.

- Calculate the energy needed to break the bonds.

.... kJ

- Calculate the energy released when bonds are formed.

.... kJ

- Calculate the energy change for the reaction.

.... kJ/mol
[3]

Page 6	Mark Scheme	Syllabus	Paper
	IGCSE – October/November 2012	0620	33

Q1. (ii) 2328 (ignore + or –) / 6 × 388 (not evaluated); [1]

944 + 1308 / 2252 **and** endothermic and exothermic in table; [1]

2328>2252 or (–) 76 kJ; [1]

or energy of products / RHS > reactants / LHS
or energy needed to break bonds < energy given out on formation of bonds.

Page 4	Mark Scheme	Syllabus	Paper
	IGCSE – May/June 2013	0620	33

Q2. (iii) exothermic [1]

low temperatures favour the exothermic reaction **or**
low temperatures moves equilibrium to right / product side / towards N_2O_4 [1]

(iv) forward reaction is bond forming [1]

Page 5	Mark Scheme	Syllabus	Paper
	IGCSE – October/November 2013	0620	31

Q3.

(b) exothermic reaction gives out energy [1]
endothermic reaction absorbs
takes in energy [1]

(c)

bonds broken	energy	
C-H	+412	
C*l*-C*l*	+242	
total energy	+654	[1]
bonds formed	energy	
C-C*l*	–338	
H-C*l*	–431	
total energy	–769	[1]
energy change	–115	[1]
negative sign indicates exothermic		[1]

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Page 4	Mark Scheme	Syllabus	Paper
	IGCSE – May/June 2014	0620	33

Q4.

(e) second line +3 × 155 = + 465
third line –3 × 280 = (–)840
fourth line –3 × 565 = (–)1695
all **three** correct (2)
two correct (1)

1170 + 465 = 1635
840 + 1695 = 2535
both numerically correct (1)
exothermic reaction with some reasoning (1) [4]

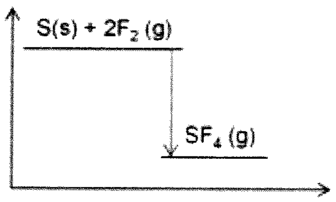
Q5.

Page 5	Mark Scheme	Syllabus	Paper
	Cambridge IGCSE – October/November 2015	0620	31

Question	Answer	Marks
3(d)(i)	moves equilibrium to left; (forward reaction) exothermic;	1 1
3(d)(ii)	decrease rate; molecules have less energy / move slower; fewer collisions (per second) / fewer particles have the activation energy / fewer collisions have the activation energy;	1 1 1

Q6.

Page 5	Mark Scheme	Syllabus	Paper
	Cambridge IGCSE – May/June 2016	0620	41

Question	Answer	Marks
2(f)(i)	 **M1** *exothermic mark*: horizontal product energy line at lower energy than that of reactant energy line **M2** *label of product mark*: SF_4 **M3** *correct direction of vertical heat of reaction arrow*: arrow must start level with reactant energy and finish level with product energy **and** must have only **one** (correct) arrow-head	3 1 1 1
2(f)(ii)	**M1** *bond energy of 2F$_2$*: 2 × F–F = 2 × 160 = 320 (k /mol) **M2** *bond energy of all bonds in SF$_4$*: 780 + 320 = 1100 (k /mol) **M3** *calculated bond energy of SF$_4$ divided by 4*: 1100 / 4 = 275 (k /mol)	3 1 1 1

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Q7.

Question	Answer	Marks
5(d)(i)	393 (kJ)	1
5(d)(ii)	416 (kJ)	1
5(d)(iii)	–23 (kJ / mol)	1

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Q8.

Question	Answer	Marks
2(b)(i)	approximately horizontal line draw to right of and below the reagent line	1
	energy change shown starting level with the reactant energy **AND** finishing level with the product energy **AND** having only one (correct) arrow head **AND** labelled ΔH / energy change	1
2(b)(ii)	(energy required to break bonds =) 3624	1
	(energy given out when bonds made =) 3738	1
	–114 (kJ / mol)	1

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Q9.

Question	Answer	Marks
3(a)	*exothermic mark*: horizontal line representing the energy of the products below the energy of the reactants	1
	label of products mark: product line labelled with $2CO_2$ + $3H_2O$	1
	correct direction of vertical heat of reaction arrow: arrow starts level with reactant energy and finishes level with product energy **AND** has (only) **one** arrow head	1
3(b)	activation energy / E_a	1
3(c)	–650 kJ / mol **M1** bonds broken 2 □ ((3 □ 410) + 360 + 460) + (3 □ 500) 2 □ (1230 + 360 + 460) + 1500 2 □ 2050 + 1500 4100 + 1500 = 5600 **M2** bonds formed (2 □ (2 □ 805)) + (4 □ (2 □ 460)) 2 □ 1610 + 4 □ 920 3220 + 3680 = 6900 **M3 = M1 – M2** energy change of reaction = 5600 – 6900 = –1300 **M4 = M3 / 2**	4

Q10.

[0620/41/O/N/19/Q7-B]

7(b)	(energy to break bonds) = 4728 (1) (energy released by making bonds) = 6004 (1) –1276 (1)	3

Q11.

[0620/42/O/N/2019/Q3-D-ii]

3(d)(ii)	**M1** Bonds broken [4 □ 3 □ 391] + [5 □ 498] = 4692 + 2490 = 7182 **M2** Bonds formed [4 □ 587] + [12 □ 464] = 2348 + 5568 = 7916 **M3** Energy change = 7182 – 7916 = –734 **M4** = **M3** / 4 = –734 / 4 = –183.5	4

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[0620/43/O/N/2019/Q4-C]

Q12.

4(c)(i)	**method 1** □ (bond breaking) = 1221 or (326 □ 3) + 243 (1) □ (bond forming) = 1630 or (326 □ 5) (1) □ energy change = –409 kJ (1) negative sign essential **OR** **method 2** (ignoring 3 P–Cl bonds on both sides) □ bond breaking = 243 .(1) □ bond forming = 652 or 326 □ 2 (1) □ energy change = –409 kJ (1) negative sign essential	3
4(c)(ii)	exothermic **AND** energy released when bonds form is greater than energy absorbed to break bonds **OR** exothermic **AND** overall energy change has a negative sign	1

[0620/42/M/J/2020/Q6-B-ii]

Q13.

6(b)(ii)	(energy required to break bonds =) 854 (1) (energy given out when bonds form =) 1025 (1) overall energy change 854 – 1025 = –171 (1)	

[0620/43/M/J/2020/Q2-E]

Q14.

2(e)	• horizontal product energy line at lower energy level than reactant • label of product • correct direction of vertical arrow – arrow must start level with reactant energy and finish level with product level and one arrow head ONLY	3

[0620/43/M/J/2020/Q3-D]

Q15.

3(d)	energy needed to break bonds = 436 + 243 = 679 energy released when bonds formed = 2 × 432 = 864 energy change = 679 – 864 = – **AND** 185	3

[0620/31/M/J/12/Q4-C-D]

Q1.(c) Vanadium(V) oxide is used to catalyse the exothermic reaction between sulfur dioxide and oxygen in the Contact Process.

$$2SO_2 + O_2 \rightleftharpoons 2SO_3$$

The rate of this reaction can be increased either by using a catalyst or by increasing the temperature. Explain why a catalyst is used and not a higher temperature.

....

....

.... [2]

(d) The oxidation states of vanadium in its compounds are V(+5), V(+4), V(+3) and V(+2). The vanadium(III) ion can behave as a reductant or an oxidant.

(i) Indicate on the following equation which reactant is the oxidant.

$$2V^{3+} + Zn \rightarrow 2V^{2+} + Zn^{2+}$$

[1]

(ii) Which change in the following equation is oxidation? Explain your choice.

$$V^{3+} + Fe^{3+} \rightarrow V^{4+} + Fe^{2+}$$

....

.... [2]

[0620/32/M/J/12/Q6]

Q2. A length of magnesium ribbon was added to 50 cm^3 of sulfuric acid, concentration 1.0 mol/dm^3. The time taken for the magnesium to react was measured. The experiment was repeated with the same volume of different acids. In all these experiments, the acid was in excess and the same length of magnesium ribbon was used.

(a)

experiment	acid	concentration in mol/dm^3	time/s
A	sulfuric acid	1.0	20
B	propanoic acid	0.5	230
C	hydrochloric acid	1.0	40
D	hydrochloric acid	0.5	80

(i) Write these experiments in order of reaction speed. Give the experiment with the fastest speed first.

.... [1]

(ii) Give reasons for the order you have given in (i).

....

....

....

....

....

.... [5]

(b) Suggest **two** changes to experiment C which would increase the speed of the reaction and explain why the speed would increase. The volume of the acid, the concentration of the acid and the mass of magnesium used were kept the same.

change 1 ....

explanation ....

....

change 2 ....

explanation ....

.... [5]

[Total: 11]

306

[0620/31/O/N/12/Q3-A-B]

Q3. The speed (rate) of a chemical reaction depends on a number of factors which include temperature and the presence of a catalyst.

(a) Reaction speed increases as the temperature increases.

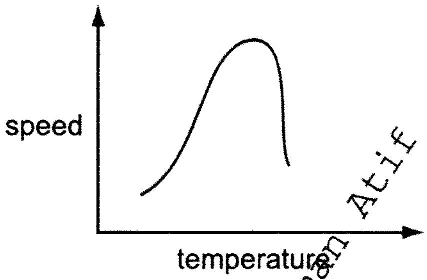
(i) Explain why reaction speed increases with temperature.

....

....

.... [3]

(ii) Reactions involving enzymes do not follow the above pattern.
The following graph shows how the speed of such a reaction varies with temperature.



Suggest an explanation why initially the reaction speed increases then above a certain temperature the speed decreases.

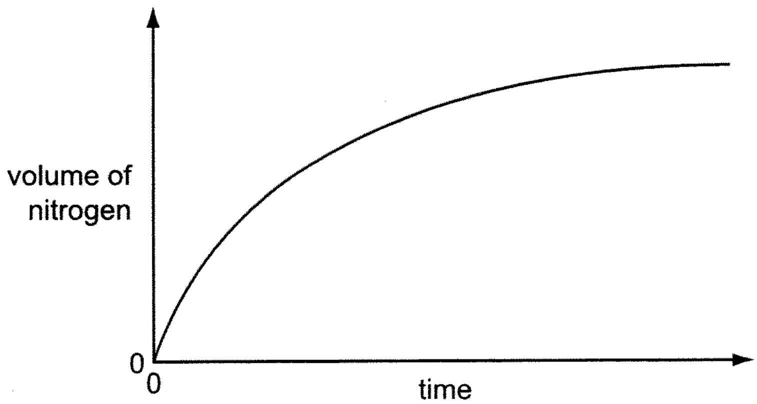
....

.... [2]

(b) An organic compound decomposes to give off nitrogen.

$$C_6H_5N_2Cl(aq) \rightarrow C_6H_5Cl(l) + N_2(g)$$

The speed of this reaction can be determined by measuring the volume of nitrogen formed at regular intervals. Typical results are shown in the graph below.



(i) The reaction is catalysed by copper.

Sketch the graph for the catalysed reaction on the diagram above. [2]

(ii) How does the speed of this reaction vary with time?

.... [1]

(iii) Why does the speed of reaction vary with time?

....

.... [2]

308

[0620/31/O/N/12/Q5-A-B]

Q4. Carbonyl chloride, $COCl_2$, is widely used in industry to make polymers, dyes and pharmaceuticals.

(a) Carbonyl chloride was first made in 1812 by exposing a mixture of carbon monoxide and chlorine to bright sunlight. This is a photochemical reaction.

$$CO(g) + Cl_2(g) \rightarrow COCl_2(g)$$

(i) Explain the phrase *photochemical reaction*.

....

.... [2]

(ii) Give another example of a photochemical reaction and explain why it is important either to the environment or in industry.

....

....

.... [3]

(b) Carbonyl chloride is now made by the reversible reaction given below.

$$CO(g) + Cl_2(g) \rightleftharpoons COCl_2(g)$$

The forward reaction is exothermic.
The reaction is catalysed by carbon within a temperature range of 50 to 150 °C.

(i) Predict the effect on the yield of carbonyl chloride of increasing the pressure. Explain your answer.

....

.... [2]

(ii) If the temperature is allowed to increase to above 200 °C, very little carbonyl chloride is formed. Explain why.

....

.... [2]

(iii) Explain why a catalyst is used.

.... [1]

[0620/32/O/N/12/Q3-C]

Q5. (c) The speed (rate) of reaction between an organic halide and water can be measured by the following method.

A mixture of 10 cm^3 of aqueous silver nitrate and 10 cm^3 of ethanol is warmed to 60 °C. Drops of the organic halide are added and the time taken for a precipitate to form is measured.

Silver ions react with the halide ions to form a precipitate of the silver halide.

$$Ag^+(aq) + X^-(aq) \rightarrow AgX(s)$$

Typical results for four experiments, **A**, **B**, **C** and **D**, are given in the table.

experiment	organic halide	number of drops	time / min
A	bromobutane	4	6
B	bromobutane	8	3
C	chlorobutane	4	80
D	iodobutane	4	0.1

(i) Explain why it takes longer to produce a precipitate in experiment **A** than in **B**.

....

.... [2]

(ii) How does the order of reactivity of the organic halides compare with the order of reactivity of the halogens?

....

.... [2]

(iii) Explain why the time taken to produce a precipitate would increase if the experiments were repeated at 50 °C.

....

....

.... [3]

[0620/32/O/N/12/Q5-A-B-C]

Q6. The food additive E220 is sulfur dioxide. It is a preservative for a variety of foods and drinks.

(a) State **two** other uses of sulfur dioxide.

....

.... [2]

(b) How is sulfur dioxide manufactured?

....

.... [2]

(c) Sulfur dioxide is a reductant (reducing agent). Describe what you would see when aqueous sulfur dioxide is added to acidified potassium manganate(VII).

....

.... [2]

[0620/32/O/N/12/Q7-B]

Q7. (b) Methanol is manufactured using the following method.

$$CH_4(g) + H_2O(g) \rightarrow CO(g) + 3H_2(g) \qquad \text{reaction 1}$$

$$CO(g) + 2H_2(g) \rightleftharpoons CH_3OH(g) \qquad \text{reaction 2}$$

The conditions for reaction 2 are:

pressure	100 atmospheres
catalyst	a mixture of copper, zinc oxide and aluminium oxide
temperature	250 °C

The forward reaction is exothermic.

(i) Why is high pressure used in reaction 2?

....

.... [2]

(ii) Explain why using a catalyst at 250 °C is preferred to using a higher temperature of 350 °C and no catalyst.

....

....

.... [3]

311

[0620/33/O/N/12/Q4-B]

Q8.(b) Zinc metal is made by the reduction of zinc oxide. The major ore of zinc is zinc blende, ZnS. Zinc blende contains silver and lead compounds as well as zinc sulfide.
Zinc blende is converted into impure zinc oxide by heating it in air.

$$2ZnS + 3O_2 \rightarrow 2ZnO + 2SO_2$$

(i) Describe how zinc oxide is reduced to zinc.

.... [1]

[0620/33/O/N/12/Q6-D]

Q9.(d) In the 19th Century, a bright green pigment, copper(II) arsenate(V) was used to kill rats and insects. In damp conditions, micro-organisms can act on this compound to produce the very poisonous gas, arsine.

(i) Suggest a reason why it is necessary to include the oxidation states in the name of the compound.

....

.... [1]

(ii) The formula for the arsenate(V) ion is AsO_4^{3-}. Complete the ionic equation for the formation of copper(II) arsenate(V).

......Cu^{2+} + ...AsO_4^{3-} $\rightarrow$ ....

[2]

[0620/33/O/N/12/Q7-AtoD]

Q10. Ammonia is made by the Haber process.

$$N_2(g) + 3H_2(g) \rightleftharpoons 2NH_3(g)$$

(a) State **one** major use of ammonia.

.... [1]

(b) Describe how hydrogen is obtained for the Haber process.

....

....

.... [3]

(c) This reaction is carried out at a high pressure, 200 atmospheres.
State, with an explanation for each, **two** advantages of using a high pressure.

....

....

....

....

.... [5]

(d) (i) What is the difference between an endothermic and an exothermic reaction?

....

.... [1]

313

[0620/31/M/J/13/Q3-A&C]

Q11.

A small piece of marble, $CaCO_3$, was added to 5.0 cm^3 of hydrochloric acid, concentration 1.0 mol / dm^3, at 25 °C. The time taken for the reaction to stop was measured. The experiment was repeated using 5.0 cm^3 of different solutions of acids. The acid was in excess in all of the experiments.

Typical results are given in the table.

experiment	temperature / °C	acid solution	time / min
1	25	hydrochloric acid 1.0 mol / dm^3	3
2	25	hydrochloric acid 0.5 mol / dm^3	7
3	25	ethanoic acid 1.0 mol / dm^3	10
4	15	hydrochloric acid 1.0 mol / dm^3	8

(a) (i) Explain why it is important that the pieces of marble are the same size and the same shape.

....

....

.... [2]

(ii) How would you know when the reaction had stopped?

.... [1]

(c) (i) Explain why the reaction in experiment 1 is faster than the reaction in experiment 2.

....

.... [1]

(ii) The acids used for experiment 1 and experiment 3 have the same concentration. Explain why experiment 3 is slower than experiment 1.

....

....

.... [2]

(iii) Explain in terms of collisions between reacting particles why experiment 4 is slower than experiment 1.

....

....

.... [3]

[0620/31/M/J/13/Q6-B-C]

Q12. **(b)** Ammonia is manufactured by the Haber Process. The economics of this process require that as much ammonia as possible is made as quickly as possible.
Explain how this can be done using the following information.

The conditions for the following reversible reaction are:

- 450 °C
- 200 atmospheres pressure
- iron catalyst

$$N_2(g) + 3H_2(g) \rightleftharpoons 2NH_3(g) \quad \text{the reaction is exothermic}$$

....

....

....

....

....

.... [5]

(c) Another compound which contains only nitrogen and hydrogen is hydrazine, N_2H_4.

Complete the equation for the preparation of hydrazine from ammonia.

$$.....NH_3 + NaClO \rightarrow N_2H_4 + ... + H_2O$$ [2]

[0620/32/M/J/13/Q4-A]

Q13. At present the most important method of manufacturing hydrogen is steam reforming of methane.

(a) In the first stage of the process, methane reacts with steam at 800 °C.

$$CH_4(g) + H_2O(g) \rightleftharpoons 3H_2(g) + CO(g)$$

In the second stage of the process, carbon monoxide reacts with steam at 200 °C.

$$CO(g) + H_2O(g) \rightleftharpoons CO_2(g) + H_2(g)$$

(i) Explain why the position of equilibrium in the first reaction is affected by pressure but the position of equilibrium in the second reaction is not.

....

....

.... [2]

(ii) Suggest why a high temperature is needed in the first reaction to get a high yield of products but in the second reaction a high yield is obtained at a low temperature.

....

.... [2]

[0620/33/M/J/13/Q2]

Q14.

One of the factors which determine the reaction rate of solids is particle size.

(a) A mixture of finely powdered aluminium and air may explode when ignited.
An explosion is a very fast exothermic reaction. This causes a large and sudden increase in temperature.

Explain each of the following in terms of collisions between reacting particles.

(i) Why is the reaction between finely powdered aluminium and air very fast?

....

.... [2]

(ii) Explain why for most reactions the rate of reaction decreases with time.

....

.... [2]

(iii) Suggest an explanation why the rate of reaction in an explosion could increase rather than decrease with time.

....

....

.... [3]

(b) (i) Give another example of a substance other than a metal which, when finely powdered, might explode when ignited in air.

.... [1]

(ii) Describe a simple test-tube reaction which shows the effect of particle size on the rate at which a solid reacts with a solution.

....

....

.... [3]

[Total: 11]

316

[0620/33/M/J/13/Q4-D]

Q15. (d) Is the change $GeCl_2$ to $GeCl_4$ reduction, oxidation or neither? Give a reason for your choice.

....

.... [2]

[0620/33/M/J/13/Q5-B]

Q16. (b) Almost all samples of nitrogen dioxide are an equilibrium mixture of nitrogen dioxide, NO_2, and dinitrogen tetroxide, N_2O_4.

$$\underset{\text{dark brown}}{2NO_2(g)} \underset{\text{reverse reaction}}{\overset{\text{forward reaction}}{\rightleftharpoons}} \underset{\text{colourless}}{N_2O_4(g)}$$

In the forward reaction, a bond forms between the two nitrogen dioxide molecules.

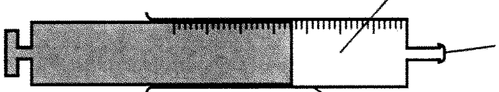
$$NO_2 + NO_2 \rightarrow O_2N-NO_2$$

(i) Explain the term *equilibrium mixture.*

....

.... [1]

(ii) The syringe contains a sample of the equilibrium mixture. The plunger was pulled back reducing the pressure.
How would the colour of the gas inside the syringe change? Give an explanation for your answer.



....

....

.... [3]

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[0620/31/O/N/13/Q3]

Q17.

Ammonia is manufactured by the Haber process.

$$N_2(g) + 3H_2(g) \rightleftharpoons 2NH_3(g)$$

The forward reaction is exothermic.

(a) Describe how the reactants are obtained.

(i) Nitrogen

....

.... [2]

(ii) Hydrogen

....

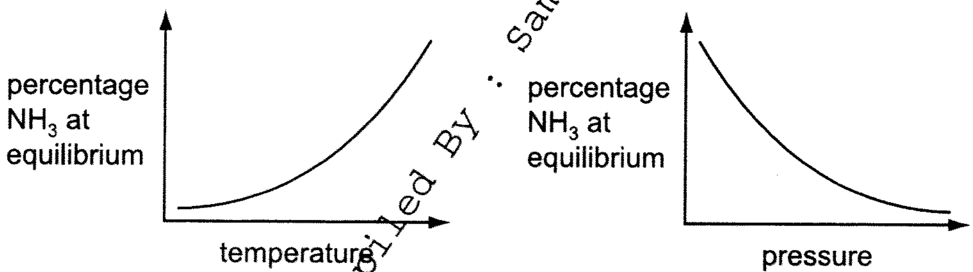
....

.... [3]

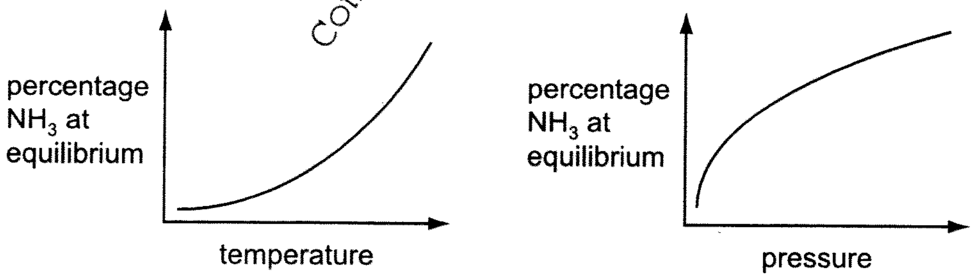
(b) The percentage of ammonia in the equilibrium mixture varies with temperature and pressure.

(i) Which pair of graphs, **A**, **B** or **C**, shows correctly how the percentage of ammonia at equilibrium varies with temperature and pressure?

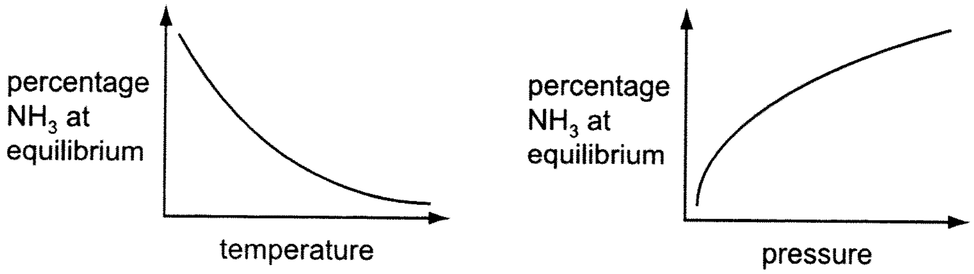
pair **A**



pair **B**



pair **C**



The pair with **both graphs correct** is .... [1]

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(ii) Give a full explanation of why the pair of graphs you have chosen in **(i)** is correct.

....

....

....

....

....

....

.... [6]

(iii) Catalysts do not alter the position of equilibrium. Explain why a catalyst is used in this process.

....

....

....

.... [2]

[Total: 14]

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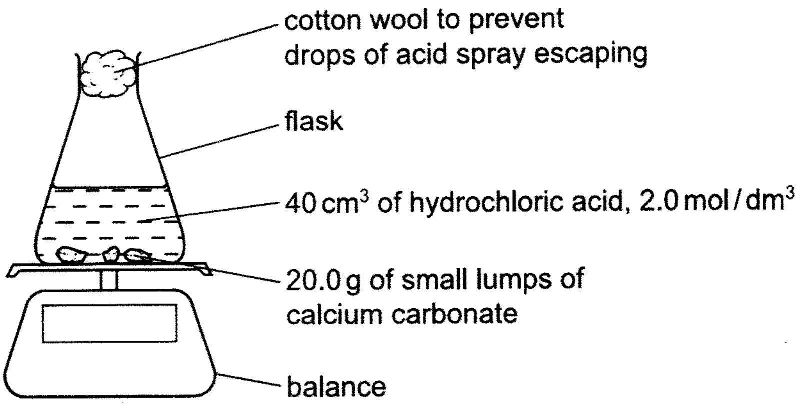
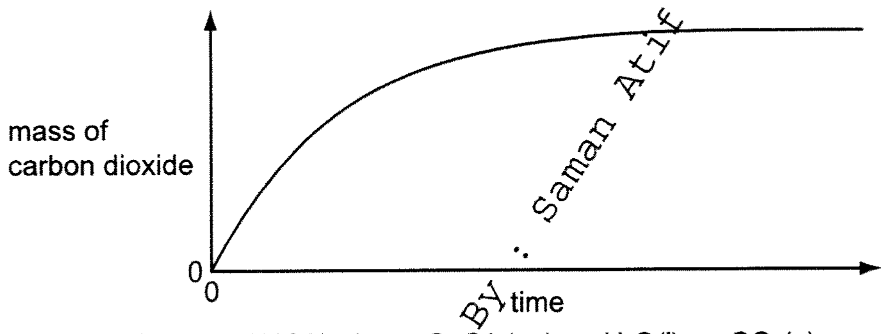
[0620/31/O/N/13/Q4-A-B-C]

Q18.

20.0 g of small lumps of calcium carbonate and 40 cm³ of hydrochloric acid, concentration 2.0 mol / dm³, were placed in a flask on a top pan balance. The mass of the flask and contents was recorded every minute.



The mass of carbon dioxide given off was plotted against time.



$$CaCO_3(s) + 2HCl(aq) \rightarrow CaCl_2(aq) + H_2O(l) + CO_2(g)$$

In all the experiments mentioned in this question, the calcium carbonate was in excess.

(a) (i) Explain how you could determine the mass of carbon dioxide given off in the first five minutes.

.... [1]

(ii) Label the graph **F** where the reaction rate is the fastest, **S** where it is slowing down and **0** where the rate is zero. [2]

(iii) Explain how the shape of the graph shows where the rate is fastest, where it is slowing down and where the rate is zero.

....

....

.... [2]

(b) Sketch on the same graph, the line which would have been obtained if 20.0 g of small lumps of calcium carbonate and 80 cm³ of hydrochloric acid, concentration 1.0 mol / dm³, had been used. [2]

(c) Explain in terms of collisions between reacting particles each of the following.

(i) The reaction rate would be slower if 20.0 g of larger lumps of calcium carbonate and 40 cm^3 of hydrochloric acid, concentration 2.0 mol / dm^3, were used.

....

....

.... [2]

(ii) The reaction rate would be faster if the experiment was carried out at a higher temperature.

....

....

.... [2]

[0620/32/O/N/13/Q2-C]

Q19.(c) Photochromic glass is used in sunglasses. In bright light, the glass darkens reducing the amount of light reaching the eye. When the light is less bright, the glass becomes colourless increasing the amount of light reaching the eye.

Photochromic glass contains very small amounts of the halides silver(I) chloride and copper(I) chloride.
The reaction between these two chlorides is photochemical.

$$\underset{\text{colourless}}{AgCl} + \underset{\text{colourless}}{CuCl} \rightleftharpoons \underset{\text{black}}{Ag} + \underset{\text{colourless}}{CuCl_2}$$

How does photochromic glass work?

....

....

.... [3]

321

Q20. [0620/32/O/N/13/Q3-A]

(a) Nitric acid is now made by the oxidation of ammonia. It used to be made from air and water. This process used very large amounts of electricity.

Air was blown through an electric arc and heated to 3000 °C.

$$N_2(g) + O_2(g) \rightleftharpoons \underset{\text{nitric oxide}}{2NO(g)} \qquad \textbf{equilibrium 1}$$

The equilibrium mixture leaving the arc contained 5 % of nitric oxide. This mixture was cooled rapidly. At lower temperatures, nitric oxide will react with oxygen to form nitrogen dioxide.

$$2NO(g) + O_2(g) \rightleftharpoons 2NO_2 \qquad \textbf{equilibrium 2}$$

Nitrogen dioxide reacts with oxygen and water to form nitric acid.

(i) Suggest a reason why the yield of nitric oxide in **equilibrium 1** increases with temperature.

.... [1]

(ii) What effect, if any, would increasing the pressure have on the percentage of nitric oxide in **equilibrium 1**? Explain your answer.

....

.... [2]

(iii) Deduce why **equilibrium 2** is only carried out at lower temperatures.

....

.... [2]

(iv) Complete the equation for the reaction between nitrogen dioxide, water and oxygen to form nitric acid.

........NO_2 + O_2 + ... → ....HNO_3 [2]

(v) Ammonia is more expensive than water and air. Suggest a reason why the ammonia-based process is preferred to the electric arc process.

.... [1]

322

[0620/32/O/N/13/Q7-A]

Q21. Plants can make complex molecules from simple starting materials, such as water, carbon dioxide and nitrates. Substances produced by plants include sugars, more complex carbohydrates, esters, proteins, vegetable oils and fats.

(a) **(i)** Describe how you could decide from its molecular formula whether a compound is a carbohydrate.

....

.... [2]

(ii) Plants can change the sugar, glucose, into starch which is a more complex carbohydrate. What type of reaction is this?

.... [2]

[0620/33/O/N/13/Q4-A-B]

Q22. Sulfuric acid is a strong acid. Hexanesulfonic acid is also a strong acid. It has similar properties to sulfuric acid.

(a) Sulfonic acids are made from alkanes and oleum, $H_2S_2O_7$.

$$C_6H_{14} + H_2S_2O_7 \rightarrow C_6H_{13}SO_3H + H_2SO_4$$

(i) Describe how oleum is made from sulfur by the Contact process. Give equations and reaction conditions.

....

....

....

....

....

....

.... [6]

(ii) How is concentrated sulfuric acid made from oleum?

.... [1]

(b) The formula of the hexanesulfonate ion is $C_6H_{13}SO_3^-$.

The formula of the barium ion is Ba^{2+}. What is the formula of barium hexanesulfonate?

.... [1]

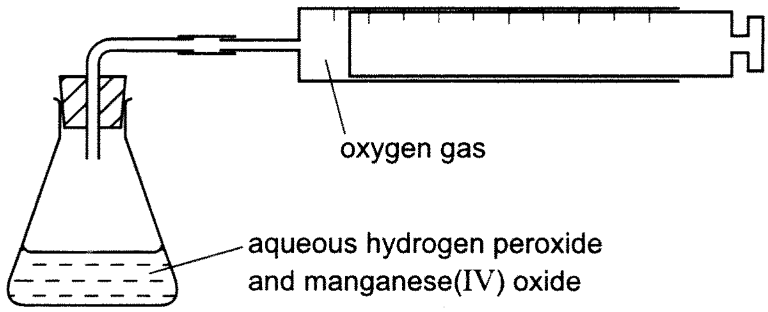
323

Q23. [0620/31/M/J/14/Q6-A-B-C]

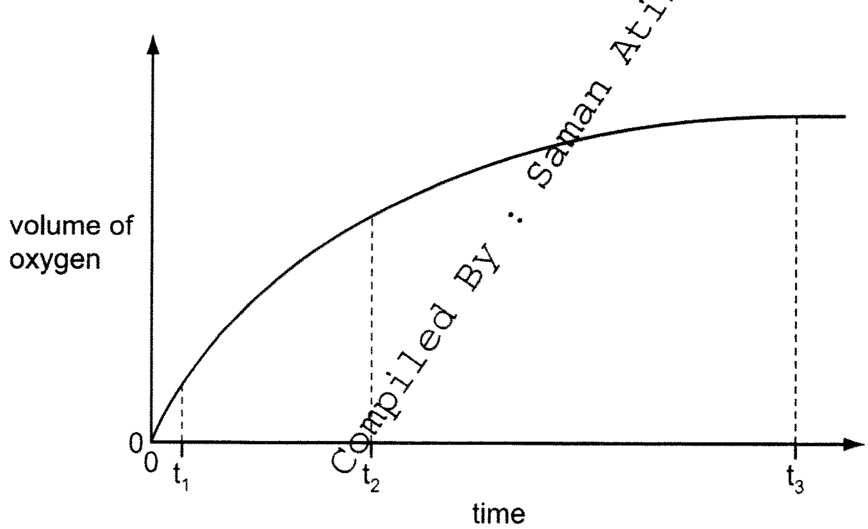
Hydrogen peroxide decomposes to form water and oxygen. This reaction is catalysed by manganese(IV) oxide.

$$2H_2O_2(aq) \rightarrow 2H_2O(l) + O_2(g)$$

The rate of this reaction can be investigated using the following apparatus.



40 cm^3 of aqueous hydrogen peroxide was put in the flask and 0.1 g of small lumps of manganese(IV) oxide was added. The volume of oxygen collected was measured every 30 seconds. The results were plotted to give the graph shown below.



(a) (i) How do the rates at times t_1, t_2 and t_3 differ?

....

.... [2]

(ii) Explain the trend in reaction rate that you described in **(a)(i)**.

....

....

.... [2]

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(b) The experiment was repeated using 0.1 g of finely powdered manganese(IV) oxide. All the other variables were kept the same.

(i) On the axes opposite, sketch the graph that would be expected. [2]

(ii) Explain the shape of this graph. ....

....

....

.... [2]

(c) Describe how you could show that the catalyst, manganese(IV) oxide, was not used up in the reaction. Manganese(IV) oxide is insoluble in water.

....

....

....

....

.... [4]

Q24. [0620/32/M/J/14/Q3-A]

Plant growth is improved by the availability of essential elements, such as nitrogen, and by the soil having a suitable pH.

(a) Nitrogen-based fertilisers are made from ammonia. Ammonia is manufactured by the Haber process.

(i) Describe the Haber process giving reaction conditions and a balanced equation.
(Do not discuss reaction rate and yield.)

....

....

....

....

.... [5]

(ii) Fertilisers contain nitrogen.
Name the other **two** elements essential for plant growth commonly found in fertilisers.

.... [2]

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Q25. [0620/32/M/J/14/Q4-D]

(d) A piece of magnesium was added to 100 cm^3 of an aqueous acid. The time taken for the metal to react completely was measured. This experiment was repeated using different aqueous acids. The same volume of acid was used in each experiment and the pieces of magnesium used were identical. In one experiment the reaction was carried out at a different temperature.

experiment	acid	concentration in mol/dm^3	temperature /°C	time /minutes
A	propanoic	1.0	20	5
B	propanoic	1.0	30	3
C	propanoic	0.5	20	8
D	hydrochloric	1.0	20	1

Explain the following in terms of collision rate between reacting particles.

(i) Why is the rate in experiment **C** slower than the rate in experiment **A**?

....

....

.... [2]

(ii) Why is the rate in experiment **B** faster than the rate in experiment **A**?

....

....

.... [2]

(iii) Why is the rate in experiment **D** faster than the rate in experiment **A**?

....

....

.... [3]

[0620/32/M/J/14/Q5-A]

Q26.

Carbonyl chloride is made from carbon monoxide and chlorine.

$$CO(g) + Cl_2(g) \rightleftharpoons COCl_2(g)$$

(a) Two methods of preparing carbon monoxide are from methane and oxygen, and from methane and steam.

(i) The reaction between methane and oxygen can also form carbon dioxide. How can carbon monoxide be made instead of carbon dioxide?

.... [1]

(ii) The following reaction is used to make carbon monoxide and hydrogen.
The reaction is carried out at 1100 °C and normal pressure.

$$CH_4(g) + H_2O(g) \rightleftharpoons CO(g) + 3H_2(g)$$

The reaction is reversible and comes to equilibrium. Suggest why a high temperature is used.

....

....

.... [2]

(iii) What is the disadvantage of using a high pressure for the reaction given in **(a)(ii)**?

....

.... [2]

[0620/32/M/J/14/Q7-C]

Q27.

(c) An experiment was carried out to show that the formula of the hydrated salt is $Li_2SO_4.H_2O$. A sample of the hydrated salt was weighed and its mass recorded. It was then heated and the anhydrous salt was weighed. This procedure was repeated until two consecutive masses were the same. This procedure is called 'heating to constant mass'.

(i) What is the reason for heating to constant mass?

.... [1]

(ii) The mass of the hydrated salt is m_1 and the mass of the anhydrous salt is m_2. Explain how you could show that the hydrated salt has **one** mole of water of crystallisation per mole of the anhydrous salt.

....

....

.... [3]

Q28. [0620/33/M/J/14/Q5-A-B-C]

Ammonia is made by the Haber process.

$$N_2(g) + 3H_2(g) \rightleftharpoons 2NH_3(g)$$

The forward reaction is exothermic.
The conditions in the reaction chamber are:

- a pressure of 200 atmospheres,
- a catalyst of finely divided iron,
- a temperature of 400 to 450 °C.

(a) What are the **two** advantages of using a high pressure? Give a reason for both.

advantage 1 ....

reason ....

....

advantage 2 ....

reason ....

.... [4]

(b) A higher temperature would give a faster reaction rate.
Why is a higher temperature **not** used?

....

....

.... [3]

(c) **(i)** Why is the iron catalyst used as a fine powder?

....

.... [1]

(ii) Give **two** reasons why a catalyst is used.

....

....

....

.... [2]

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Q29. [0620/31/O/N/14/Q3]

The main use of sulfur dioxide is the manufacture of sulfuric acid.

(a) State **two** other uses of sulfur dioxide.

....

.... [2]

(b) One source of sulfur dioxide is burning sulfur in air.
Describe how sulfur dioxide can be made from the ore zinc sulfide.

....

.... [2]

(c) The Contact process changes sulfur dioxide into sulfur trioxide.

$2SO_2(g) + O_2(g) \rightleftharpoons 2SO_3(g)$

the forward reaction is exothermic

temperature 400 to 450 °C

low pressure 1 to 10 atmospheres

catalyst vanadium(V) oxide

(i) What is the formula of vanadium(V) oxide?

.... [1]

(ii) Vanadium(V) oxide is an efficient catalyst at any temperature in the range 400 to 450 °C.
Scientists are looking for an alternative catalyst which is efficient at 300 °C.
What would be the advantage of using a lower temperature?

....

....

.... [2]

(iii) The process does not use a high pressure because of the extra expense.
Suggest **two** advantages of using a high pressure?
Explain your suggestions.

....

....

....

....

.... [4]

330

(d) Sulfuric acid is made by dissolving sulfur trioxide in concentrated sulfuric acid to form oleum. Water is reacted with oleum to form more sulfuric acid.
Why is sulfur trioxide not reacted directly with water?

.... [1]

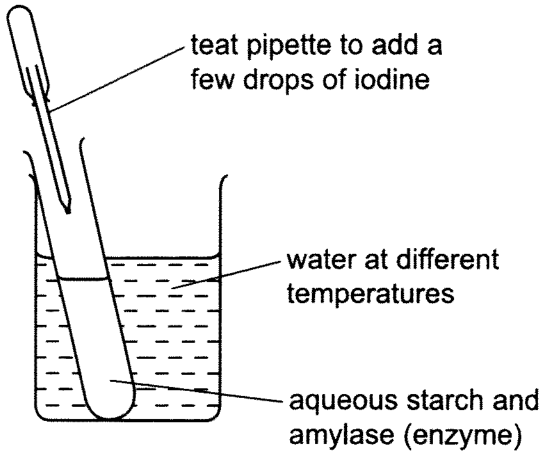
[Total: 12]

331

[0620/32/O/N/14/Q5-C]

Q30.

(c) The effect of temperature on this reaction can be studied by the experiment shown below.
Starch and iodine form a blue-black colour.
Glucose and iodine do not form a blue-black colour.



The experiment is set up as in the diagram and the time measured for the mixture to change from blue-black to colourless. The experiment is repeated at different temperatures.
Typical results of this experiment are given in the table below.

experiment	temperature /°C	time for blue-black colour to disappear /min
A	20	30
B	40	15
C	70	remained blue-black

(i) Put the experiments in order of reaction rate – slowest first and fastest last.

.... [2]

(ii) Explain why the reaction rates in experiments A and B are different.

....

....

....

.... [3]

(iii) Suggest why the colour remains blue-black in experiment C.

.... [1]

Q31. [0620/32/O/N/14/Q6-A-B]

Sulfuric acid is an important acid, both in the laboratory and in industry.
Sulfuric acid is manufactured in the Contact Process. Originally, it was made by heating metal sulfates and by burning a mixture of sulfur and potassium nitrate.

(a) Give a major use of sulfuric acid.

.... [1]

(b) A group of naturally occurring minerals have the formula of the type $FeSO_4.xH_2O$ where x is 1, 4, 5, 6 or 7. The most common of these minerals is iron(II) sulfate-7-water.

(i) When this mineral is heated gently it dehydrates.

$$\underset{\text{green}}{FeSO_4.7H_2O} \rightleftharpoons \underset{\text{pale yellow}}{FeSO_4} + 7H_2O$$

Describe how you could show that this reaction is reversible.

....

....

.... [2]

(ii) When the iron(II) sulfate is heated strongly, further decomposition occurs.

$$2FeSO_4(s) \rightarrow Fe_2O_3(s) + SO_2(g) + SO_3(g)$$

The gases formed in this reaction react with water and oxygen to form sulfuric acid.
Explain how the sulfuric acid is formed.

....

.... [2]

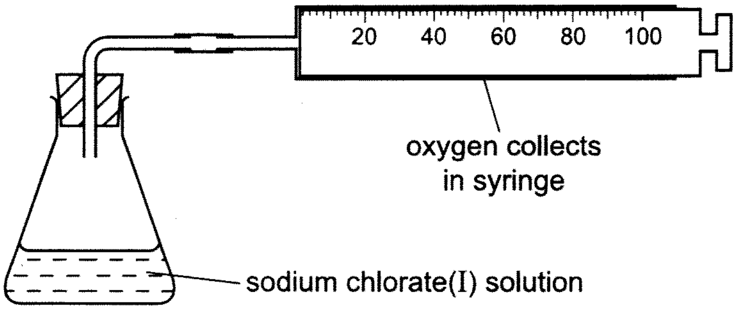
[0620/33/O/N/14/Q5-A]

Q32.

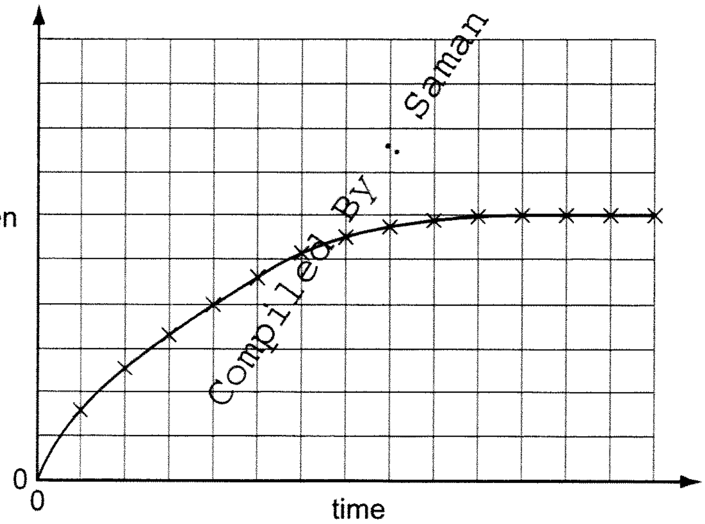
(a) Sodium chlorate(I) decomposes to form sodium chloride and oxygen. The rate of this reaction is very slow at room temperature provided the sodium chlorate(I) is stored in a dark bottle to prevent exposure to light.

$$2NaClO \rightarrow 2NaCl + O_2$$

The rate of this decomposition can be studied using the following experiment.



Sodium chlorate(I) is placed in the flask and 0.2 g of copper(II) oxide is added. This catalyses the decomposition of the sodium chlorate(I) and the volume of oxygen collected is measured every minute. The results are plotted to give a graph of the type shown below.



(i) Explain why the gradient (slope) of this graph decreases with time.

....

.... [2]

(ii) Cobalt(II) oxide is a more efficient catalyst for this reaction than copper(II) oxide. Sketch, on the grid, the graph for the reaction catalysed by cobalt(II) oxide. All other conditions were kept constant. [2]

(iii) What can you deduce from the comment that sodium chlorate(I) has to be shielded from light?

....

.... [1]

(iv) Explain, in terms of collisions between particles, why the initial gradient would be steeper if the experiment was repeated at a higher temperature.

....

....

....

.... [3]

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Q33. [0620/31/M/J/15/Q3-A-B-C]

(a) The reactions between metals and acids are redox reactions.

$$Zn + 2H^+ \rightarrow Zn^{2+} + H_2$$

(i) Which change in the above reaction is oxidation, Zn to Zn^{2+} or $2H^+$ to H_2? Give a reason for your choice.

....

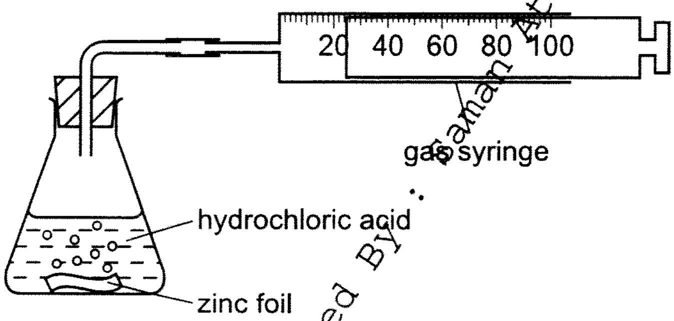
.... [2]

(ii) Which reactant in the above reaction is the oxidising agent? Give a reason for your choice.

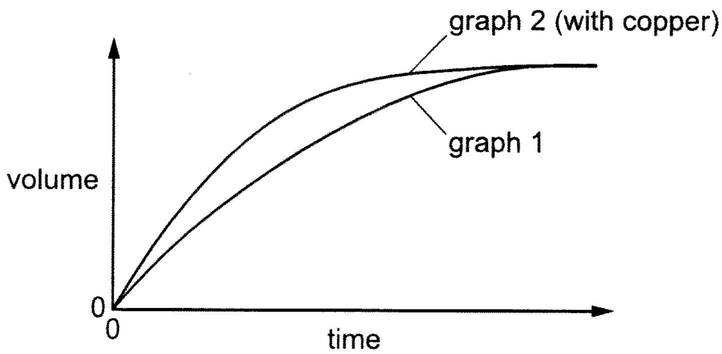
....

.... [2]

(b) The rate of reaction between a metal and an acid can be investigated using the apparatus shown below.



A piece of zinc foil was added to 50 cm^3 of hydrochloric acid, of concentration 2.0 mol / dm^3. The acid was in excess. The hydrogen evolved was collected in the gas syringe and its volume measured every minute. The results were plotted and labelled as graph 1.



The experiment was repeated to show that the reaction between zinc metal and hydrochloric acid is catalysed by copper. A small volume of aqueous copper(II) chloride was added to the acid before the zinc was added. The results of this experiment were plotted on the same grid and labelled as graph 2.

(i) Explain why the reaction mixture in the second experiment contains copper metal. Include an equation in your explanation.

....

.... [2]

(ii) Explain how graph 2 shows that copper catalyses the reaction.

....

....

.... [3]

(c) If the first experiment was repeated using ethanoic acid, CH_3COOH, instead of hydrochloric acid, how and why would the graph be different from graph 1?

....

....

....

.... [4]

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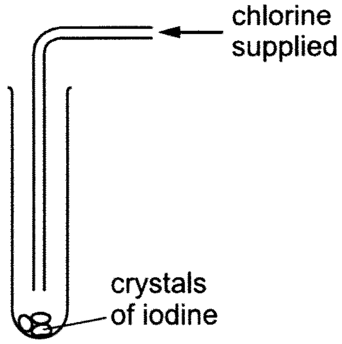
[0620/31/M/J/15/Q5-C-D-E]

Q34.

(c) Iodine reacts with chlorine to form a dark brown liquid, iodine monochloride.



$$I_2(s) + Cl_2(g) \rightarrow \underset{\text{dark brown}}{2ICl(l)}$$

When more chlorine is added and the tube is sealed, a reversible reaction occurs and the reaction comes to equilibrium.

$$\underset{\text{dark brown}}{ICl(l)} + Cl_2(g) \rightleftharpoons \underset{\text{yellow}}{ICl_3(s)}$$

(i) Give another example of a reversible reaction.

.... [1]

(ii) Explain the term *equilibrium*.

....

.... [2]

(d) Chlorine is removed from the tube and a new equilibrium is formed.

Explain why there is less of the yellow solid and more dark brown liquid in the new equilibrium mixture.

....

....

.... [2]

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(e) A sealed tube containing the equilibrium mixture is placed in ice-cold water. There is an increase in the amount of yellow solid in the equilibrium mixture.

What can you deduce about the forward reaction in this equilibrium?

$$ICl(l) + Cl_2(g) \rightleftharpoons ICl_3(s)$$

Explain your deduction.

....

....

....

.... [3]

Q35. [0620/32/M/J/15/Q3-C]

(c) The reaction between calcium and nitrogen to form calcium nitride is a redox reaction.

In terms of electron transfer, explain why calcium is the reducing agent.

....

....

....

.... [3]

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[0620/32/M/J/15/Q4]

Q36.

Ammonia is made by the Haber process.

$$N_2(g) + 3H_2(g) \rightleftharpoons 2NH_3(g)$$

The forward reaction is exothermic.

Typical reaction conditions are:

- finely divided iron catalyst,
- temperature 450 °C,
- pressure 200 atmospheres.

(a) Explain why the catalyst is used as a very fine powder and larger pieces of iron are not used.

....

....

.... [2]

(b) Using the above conditions, the equilibrium mixture contains about 15% ammonia.

State two changes to the reaction conditions which would increase the percentage of ammonia at equilibrium.

....

....

.... [2]

(c) Suggest why the changes you have described in **(b)** are **not** used in practice.

....

....

.... [2]

[Total: 6]

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Q37. [0620/32/M/J/15/Q6-A-B]

The Atacama desert in Chile has deposits of the salt sodium nitrate. Very large amounts of this salt were exported to Europe for use as a fertiliser. After the introduction of the Haber process in 1913, this trade rapidly diminished.

(a) (i) Explain why the introduction of the Haber process reduced the demand for sodium nitrate.

....

.... [2]

(ii) Suggest why surface deposits of sodium nitrate only occur in areas with very low rainfall such as desert areas.

.... [1]

(iii) The desert has smaller surface deposits of potassium nitrate.

Suggest why potassium nitrate is a better fertiliser than the sodium salt.

.... [1]

(b) All nitrates decompose when heated. The extent to which a nitrate decomposes is determined by the metal in the salt.

(i) Sodium nitrate decomposes to form sodium nitrite, $NaNO_2$.

Write the equation for decomposition of sodium nitrate.

.... [2]

(ii) Sodium nitrite is a reducing agent.

What would be observed if an excess of sodium nitrite solution was added to a solution of acidified potassium manganate(VII)?

.... [2]

(iii) Copper(II) nitrate decomposes to form copper(II) oxide, nitrogen dioxide and oxygen.

What is the relationship between the extent of decomposition and the reactivity of the metal in the nitrate?

....

.... [1]

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Q38. [0620/31/O/N/15/Q3-A-B-C-E-F-G]

Sulfuric acid is made by the Contact process.

(a) Sulfur is burned by spraying droplets of molten sulfur into air.

Suggest and explain an advantage of using this method.

....

.... [2]

(b) The following equation represents the equilibrium in the Contact process.

$$2SO_2(g) + O_2(g) \rightleftharpoons 2SO_3(g)$$

Oxygen is supplied from the air.
The composition of the reaction mixture is 1 volume of sulfur dioxide to 1 volume of oxygen.

What volume of air contains 1 dm^3 of oxygen?

.... dm^3 [1]

(c) Sulfur dioxide is more expensive than air.

What is the advantage of using an excess of air?

....

.... [2]

(e) A low pressure, 2 atmospheres, is used. At equilibrium, about 98% SO_3 is present.

(i) What is the effect on the position of equilibrium of using a higher pressure?

.... [1]

(ii) Explain why a higher pressure is **not** used.

.... [1]

(f) Name the catalyst used in the Contact process.

.... [1]

(g) Describe how concentrated sulfuric acid is made from sulfur trioxide.

....

....

....

.... [2]

Q39. [0620/31/O/N/15/Q7-A-B]

The rate of a photochemical reaction is affected by light.

(a) The decomposition of silver bromide is the basis of film photography. This is a redox reaction.

$$2AgBr \rightarrow 2Ag + Br_2$$
cream black

step 1 $2Br^- \rightarrow Br_2 + 2e^-$

step 2 $Ag^+ + e^- \rightarrow Ag$

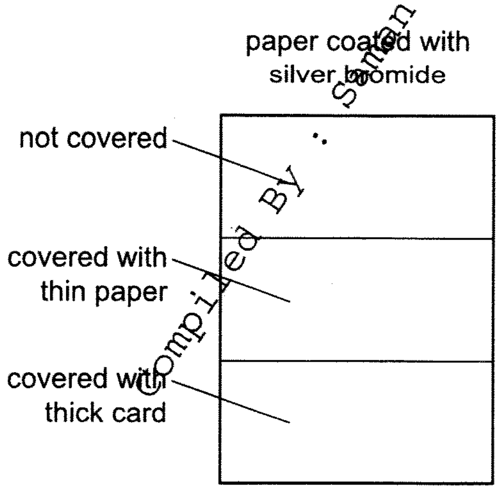
(i) Which step is reduction? Explain your answer.

.... [1]

(ii) Which ion is the oxidising agent? Explain your answer.

.... [1]

(b) A piece of white paper was coated with silver bromide and exposed to the light. Sections of the paper were covered as shown in the diagram.



Predict the appearance of the different sections of the paper after exposure to the light and the removal of the card. Explain your predictions.

....

....

....

....

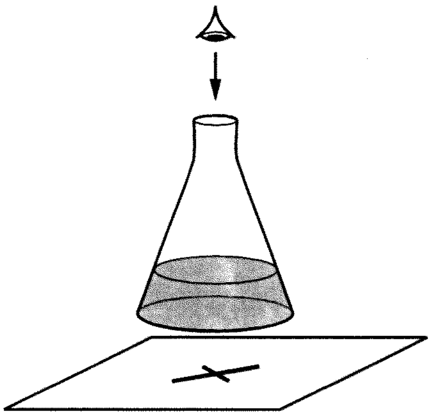
.... [4]

Q40. [0620/41/M/J/16/Q3]

When aqueous sodium thiosulfate and dilute hydrochloric acid are mixed, a precipitate of insoluble sulfur is produced. This makes the mixture difficult to see through.

$$Na_2S_2O_3(aq) + 2HCl(aq) \rightarrow S(s) + 2NaCl(aq) + H_2O(l) + SO_2(g)$$

The time taken for the cross to disappear from view is measured.



A student adds the following volumes of aqueous sodium thiosulfate, dilute hydrochloric acid and distilled water to the conical flask.

The time taken for the formation of the precipitate of sulfur to make the cross disappear from view is recorded.

experiment number	volume of sodium thiosulfate / cm^3	volume of hydrochloric acid / cm^3	volume of distilled water / cm^3	time taken for cross to disappear from view / s
1	10	10	40	56
2	20	10	30	28
3				

(a) State the order in which the aqueous sodium thiosulfate, hydrochloric acid and distilled water should be added to the flask.

....

.... [1]

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(b) In experiment 3 the student wanted the sodium thiosulfate to be double the concentration used in experiment 2.

(i) Complete the table to show the **volumes** which should be used and the **expected** time taken for the cross to disappear from view in experiment 3. [2]

(ii) Use collision theory to explain why increasing the concentration of sodium thiosulfate would change the rate of reaction.

....

....

....

.... [2]

(c) The student repeated experiment 1 at a higher temperature.

Use collision theory to explain why the rate of reaction would increase.

....

....

....

.... [3]

[Total: 8]

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Q41.
[0620/42/M/J/16/Q4-A-B-C-D]

Hydrogen can be manufactured from methane by steam reforming.

$$CH_4(g) + H_2O(g) \rightleftharpoons CO(g) + 3H_2(g)$$

The reaction is carried out using a nickel catalyst at temperatures between 700 °C and 1100 °C and using a pressure of one atmosphere.

The forward reaction is endothermic.

(a) What is meant by the term *catalyst*?

....

.... [2]

(b) Suggest **two** reasons why a temperature lower than 700 °C is not used.

....

.... [2]

(c) Suggest **one** advantage of using a pressure greater than one atmosphere.

.... [1]

(d) Suggest **one** disadvantage of using a pressure greater than one atmosphere.

.... [1]

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[0620/42/M/J/16/Q-Dii-iii-iv-v]

Q42. Solutions of iron(II) chloride and iron(III) chloride were added to solutions of potassium iodide and acidified potassium manganate(VII). The results are shown in the table.

	iron(II) chloride solution	iron(III) chloride solution
potassium iodide solution	no change	solution turns from colourless to brown
acidified potassium manganate(VII) solution	solution turns from purple to colourless	no change

(ii) What **types** of substance cause potassium iodide solution to turn from colourless to brown?

.... [1]

(iii) What **types** of substance cause acidified potassium manganate(VII) solution to turn from purple to colourless?

.... [1]

(iv) Which **ion** in iron(III) chloride solution causes potassium iodide solution to turn from colourless to brown?

.... [1]

(v) Which **ion** in iron(II) chloride solution causes acidified potassium manganate(VII) solution to turn from purple to colourless?

.... [1]

[0620/43/M/J/16/Q4-C]

Q43.

(c) When chlorine gas is bubbled through an aqueous solution of potassium iodide, a redox reaction takes place.

$$2I^- + Cl_2 \rightarrow I_2 + 2Cl^-$$

(i) State the colour change expected in this reaction.

start colour ....

end colour ....
[2]

(ii) Identify the reducing agent in this reaction. Explain your answer.

....

....

.... [2]

[0620/41/O/N/16/Q4]

Q44.

(a) Ammonia, NH_3, is made by reacting nitrogen with hydrogen in the Haber process.

(i) Write a chemical equation for the formation of ammonia in the Haber process.

.... [2]

(ii) Name the raw materials from which nitrogen and hydrogen are obtained.

nitrogen ....

hydrogen ....
[2]

(iii) State the temperature and pressure used in the Haber process. Include the units.

temperature ....

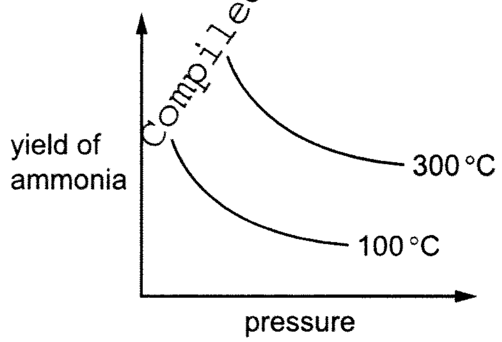
pressure ....
[2]

(b) Ammonia is also made when ammonium carbonate decomposes.

$$(NH_4)_2CO_3(s) \rightleftharpoons 2NH_3(g) + H_2O(g) + CO_2(g)$$

The reaction is reversible and can reach a position of equilibrium.

The graph shows how the yield of ammonia at equilibrium changes with temperature and pressure.



(i) What is meant by the term *equilibrium* for a reversible reaction?

....

....

.... [2]

(ii) Using information from the graph, explain whether the reaction is endothermic or exothermic.

....

.... [1]

(iii) State and explain the effect of increasing the pressure on the yield of ammonia in this reaction.

....

....

....

....

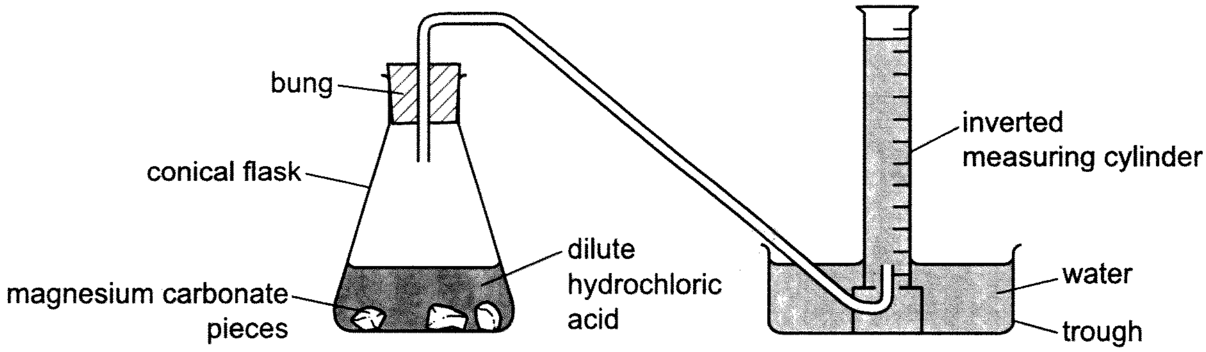
.... [3]

Q45. [0620/41/O/N/16/Q8]

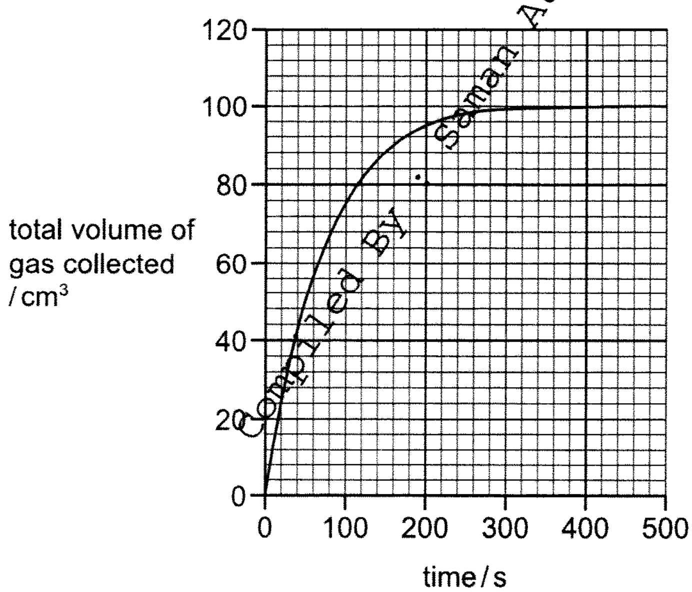
Magnesium carbonate reacts with dilute hydrochloric acid.

$$MgCO_3(s) + 2HCl(aq) \rightarrow MgCl_2(aq) + H_2O(l) + CO_2(g)$$

An excess of magnesium carbonate pieces was added to dilute hydrochloric acid. The apparatus in the diagram was used to measure the volume of gas produced. The total volume of gas collected was recorded every 20 seconds.



(a) The results obtained are shown on the graph.



(i) Describe how the rate of this reaction changed during the reaction. Explain why the rate changed in this way.

....

....

....

....

.... [4]

(ii) The experiment was repeated using the same mass of **powdered** magnesium carbonate with the same volume and concentration of dilute hydrochloric acid.

Explain how the initial rate of reaction and total volume of gas collected would compare to the first experiment.

initial rate of reaction ....

....

....

total volume of gas ....

....

.... [4]

(b) A piece of magnesium ribbon was cleaned. The experiment was repeated using this clean magnesium ribbon instead of magnesium carbonate.

$$Mg(s) + 2HCl(aq) \rightarrow MgCl_2(aq) + H_2(g)$$

This reaction is exothermic.
The rate of the reaction gradually increased over the first 2 minutes.

Explain why the rate of the reaction increased.

....

....

....

....

....

....

.... [5]

[Total: 13]

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[0620/42/O/N/16/Q5-B]

Q46.

(b) A student bubbled chlorine gas into a test-tube containing aqueous potassium bromide.

(i) Describe the colour change seen in the test-tube.

from .... to ....

[2]

(ii) Complete the **ionic** equation for this reaction.

Include state symbols.

$Cl_2(g)$ + ...$Br^-(aq)$ → .... + ...

[3]

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Q47. [0620/43/O/N/16/Q5-AtoE]

Sulfuric acid can be manufactured from the raw materials sulfur, air and water. The process can be divided into four stages.

stage 1 converting sulfur into sulfur dioxide

stage 2 converting sulfur dioxide into sulfur trioxide

stage 3 converting sulfur trioxide into oleum, $H_2S_2O_7$

stage 4 converting oleum into sulfuric acid

stage 1

(a) (i) Describe how sulfur is converted into sulfur dioxide.

.... [1]

(ii) Write a chemical equation for the conversion of sulfur into sulfur dioxide.

.... [1]

stage 2

(b) Sulfur dioxide is converted into sulfur trioxide according to the following equation.

$$2SO_2 + O_2 \rightleftharpoons 2SO_3$$

The reaction is carried out at a temperature of 450 °C and a pressure of 1–2 atmospheres using a catalyst. The energy change, ΔH, for the reaction is –196 kJ/mol.

(i) What is the meaning of the symbol $\rightleftharpoons$?

.... [1]

(ii) Name the catalyst used in this reaction.

.... [1]

(iii) Why is a catalyst used?

.... [1]

(iv) If a temperature higher than 450 °C were used, what would happen to the amount of sulfur trioxide produced? Give a reason for your answer.

....

.... [2]

(v) Suggest a reason why a temperature lower than 450 °C is **not** used.

....

.... [1]

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(vi) If a pressure higher than 1–2 atmospheres were used, what would happen to the amount of sulfur trioxide produced? Give a reason for your answer.

....

.... [2]

stage 3

(c) (i) What is added to sulfur trioxide to convert it into oleum?

.... [1]

(ii) Write a chemical equation for the conversion of sulfur trioxide into oleum.

.... [1]

stage 4

(d) (i) What is added to oleum to convert it into sulfuric acid?

.... [1]

(ii) Write a chemical equation for the conversion of oleum into sulfuric acid.

.... [1]

(e) Give **one** use of sulfuric acid.

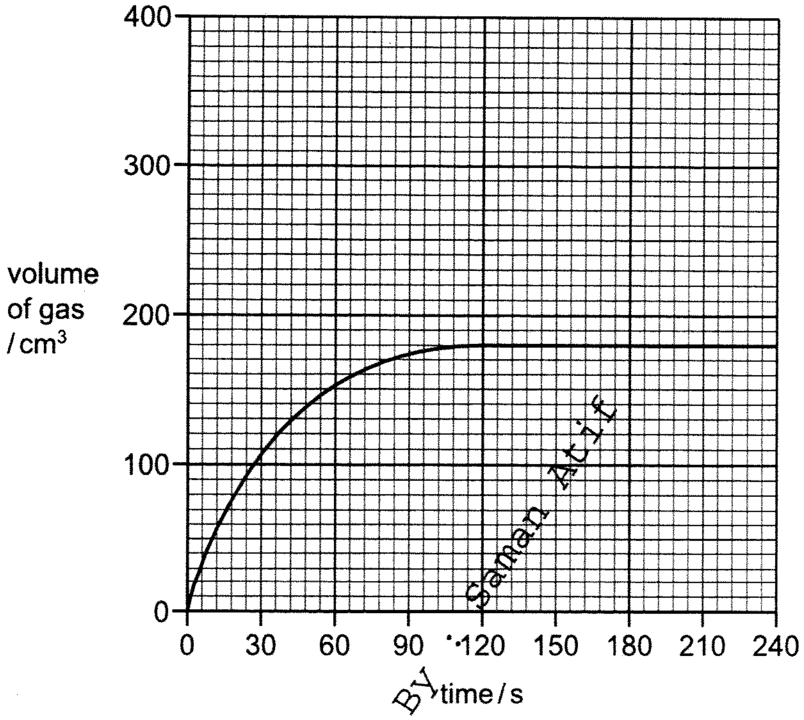
.... [1]

Q48. [0620/41/M/J/17/Q5]

When barium carbonate is added to dilute hydrochloric acid, carbon dioxide gas is formed.

A student carried out an experiment to measure the volume of gas formed as a reaction proceeds. The student added a small mass of powdered barium carbonate to an excess of 0.1 mol/dm^3 hydrochloric acid. A graph of the results was drawn.

The graph is shown.



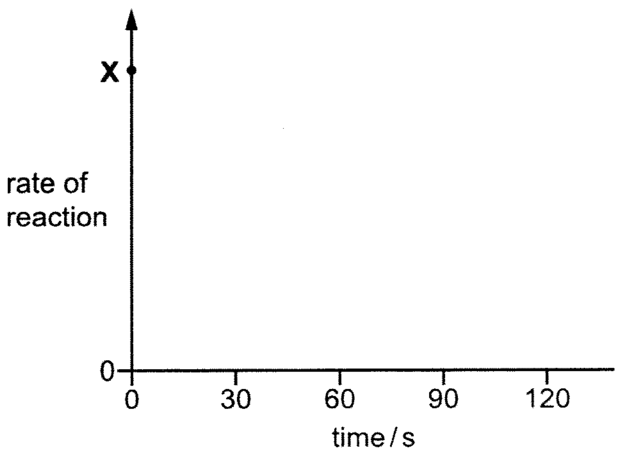
(a) Name the **two** pieces of apparatus needed to take the measurements shown on the graph.

1 ....

2 .... [1]

(b) On the axes below, sketch a graph to show how the rate of reaction changes as the reaction proceeds.

Assume the initial rate of reaction is represented by the point at **X**.



[2]

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(c) The total volume of gas collected was 180 cm³ at room temperature and pressure.

Calculate the mass, in grams, of barium carbonate used.

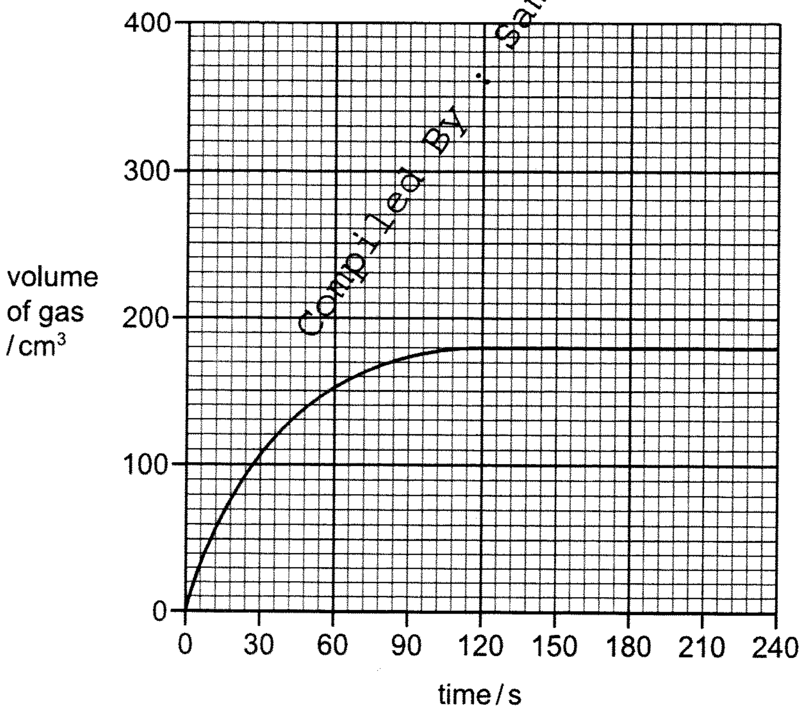
$$BaCO_3 + 2HCl \rightarrow BaCl_2 + H_2O + CO_2$$

mass of barium carbonate = ... g [3]

(d) The original graph has been drawn again.

On the grid, draw the graph expected if the same mass of barium carbonate is added as large lumps instead of as a powder. All other conditions are the same as in the original experiment.

Explain why your graph is different from the original graph.



....

....

.... [2]

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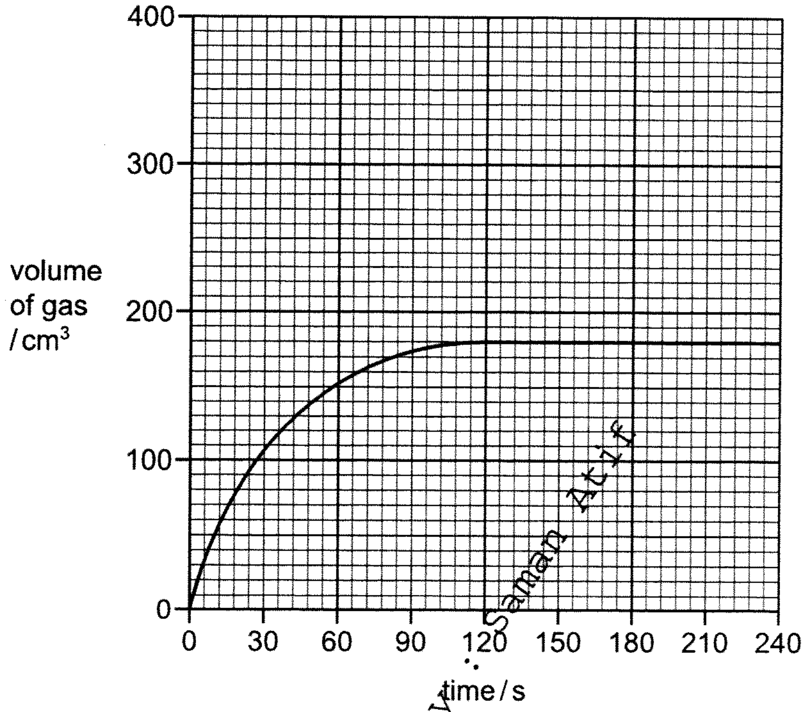
(e) The original graph has been drawn again.

On the grid, draw the graph expected if the concentration of dilute hydrochloric acid is changed from 0.1 mol / dm^3 to 0.2 mol / dm^3. All other conditions are the same as in the original experiment.

Explain, in terms of particles, why your graph is different from the original graph.



....

....

....

.... [4]

(f) The experiment is changed and the mass of powdered barium carbonate is doubled. All other conditions are the same as in the original experiment. The acid is still in excess.

Deduce the volume of gas formed at room temperature and pressure, in cm^3, in this experiment.

volume of gas = ... cm^3 [1]

[Total: 13]

Q49. [0620/42/M/J/17/Q3-A-B-C]

This question is about nitrogen and some of its compounds.

(a) Nitrogen in the air can be converted into ammonia by the Haber process. The chemical equation for the reaction is shown.

$$N_2 + 3H_2 \rightleftharpoons 2NH_3$$

(i) State the temperature and pressure used in the Haber process.

temperature ....

pressure ....

[2]

(ii) Name the catalyst used in the Haber process.

.... [1]

(b) The ammonia produced in the Haber process can be oxidised to nitrogen(II) oxide at 900 °C. The reaction is exothermic.

(i) Balance the chemical equation for this reaction.

$$4NH_3 + ...O_2 \rightleftharpoons .....NO + ...H_2O$$

[2]

(ii) Suggest a reason, other than cost, why a temperature greater than 900 °C is **not** used.

.... [1]

(iii) Suggest a reason why a temperature less than 900 °C is **not** used.

.... [1]

(c) Nitrogen(II) oxide can be reacted with oxygen and water to produce nitric acid as the only product.

Write a chemical equation for this reaction.

.... [2]

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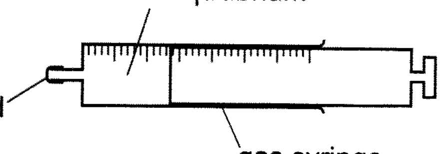
Q50. [0620/41/O/N/17/Q5-C]

(c) Nitrogen dioxide, NO_2, exists in equilibrium with dinitrogen tetroxide, N_2O_4.
Nitrogen dioxide is brown and dinitrogen tetroxide is colourless.

$$\underset{\text{brown}}{2NO_2(g)} \rightleftharpoons \underset{\text{colourless}}{N_2O_4(g)}$$

(i) A sample of nitrogen dioxide and dinitrogen tetroxide at equilibrium was placed in a closed gas syringe.
The syringe plunger was pushed in. This increased the pressure in the gas syringe. The temperature was kept constant.



State how the colour of the gas in the syringe changed. Explain your answer in terms of the position of the equilibrium.

....

....

....

.... [3]

(ii) A sealed tube containing nitrogen dioxide and dinitrogen tetroxide at equilibrium was cooled in an ice bath at constant pressure. The contents of the tube became paler.

Suggest an explanation for this observation in terms of the position of the equilibrium.

....

....

.... [2]

[0620/41/O/N/17/Q7-A]

Q51.

Copper(II) oxide reacts with dilute hydrochloric acid.

$$CuO(s) + 2HCl(aq) \rightarrow CuCl_2(aq) + H_2O(l)$$

6.00 g of copper(II) oxide were added to 50.0 cm^3 of 1.00 mol/dm^3 hydrochloric acid. This was an excess of copper(II) oxide.

(a) The rate of the reaction can be increased by increasing the concentration of the hydrochloric acid or by heating it.

(i) In terms of collisions, explain why increasing the concentration of the hydrochloric acid increases the rate of the reaction.

....

....

....

.... [2]

(ii) In terms of collisions, explain why heating the hydrochloric acid increases the rate of the reaction.

....

....

....

.... [2]

Q52. [0620/42/O/N/17/Q5]

Some chemical reactions are reversible.

(a) Aqueous potassium chromate(VI), K_2CrO_4, is a yellow solution.

Aqueous potassium dichromate(VI), $K_2Cr_2O_7$, is an orange solution.

The two compounds interconvert when the pH of the solution changes.

$$\underset{\text{yellow}}{2K_2CrO_4} + H_2SO_4 \rightleftharpoons \underset{\text{orange}}{K_2Cr_2O_7} + K_2SO_4 + H_2O$$

Solution **Y** is a mixture of aqueous potassium chromate(VI) and aqueous potassium dichromate(VI) at equilibrium.

- Explain, in terms of the position of the equilibrium, what you would **see** if sulfuric acid were added to solution **Y**.

....

....

....

- Explain, in terms of the position of the equilibrium, what you would **see** if sodium hydroxide were added to solution **Y**.

....

....

....

....

[5]

(b) Hydrogen can be manufactured using a reversible reaction between methane and steam.

$$CH_4(g) + H_2O(g) \rightleftharpoons CO(g) + 3H_2(g)$$

At 900 °C, in the presence of a nickel catalyst, the yield of hydrogen is 70%.

(i) What volume of hydrogen is produced from 100 cm³ of methane under these conditions?

.... cm^3 [2]

Under different conditions, different yields of hydrogen are obtained.

(ii) If the pressure is increased, the yield of hydrogen becomes less than 70%.

Explain why, in terms of the position of the equilibrium.

....

.... [1]

(iii) If the temperature is decreased, the yield of hydrogen decreases.

What does this information indicate about the reaction between methane and steam?

.... [1]

(iv) Why is a catalyst used in this reaction?

.... [1]

[Total: 10]

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Q53. [0620/43/O/N/17/Q5-B]

(b) The chemical equation shows the equilibrium between dinitrogen tetroxide (N_2O_4, a colourless gas) and nitrogen dioxide (NO_2, a brown gas).

$$N_2O_4(g) \rightleftharpoons 2NO_2(g)$$

colourless brown

A mixture of dinitrogen tetroxide and nitrogen dioxide is allowed to reach equilibrium in a closed gas syringe.

(i) In chemistry, what is meant by the term *equilibrium*?

....

....

.... [2]

(ii) If the equilibrium mixture is heated at constant pressure, a darker brown colour is seen inside the gas syringe.

What does this information indicate about the decomposition of dinitrogen tetroxide? Explain your answer in terms of the position of the equilibrium.

....

....

.... [2]

(iii) Suggest what you would see if the pressure on the equilibrium mixture were increased at constant temperature.
Explain your answer in terms of the position of the equilibrium.

....

....

.... [2]

[0620/41/M/J/18/Q5-A-B-C-D]

Q54.

(a) The table gives some chemical properties of transition elements and their compounds, and of Group I elements and their compounds.

chemical property	transition elements	Group I elements
ability to act as catalysts	yes	no
exist as coloured compounds	yes	no

(i) What is meant by the term *catalyst*?

....

....

.... [2]

(ii) Give **one** other chemical property shown by transition elements which is **not** shown by Group I elements.

.... [1]

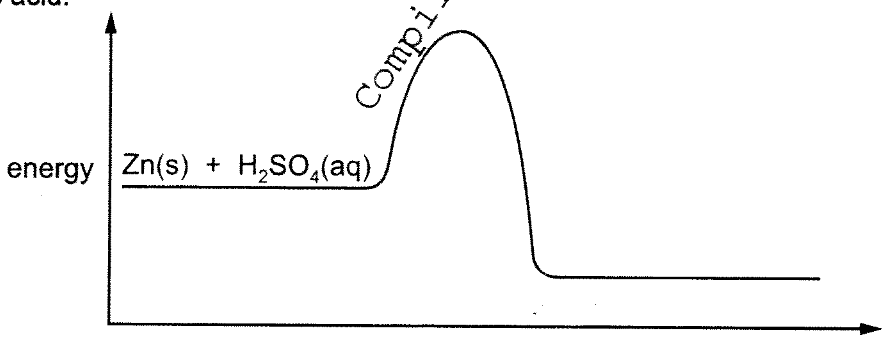
(b) Give **two** physical properties shown by transition elements which are **not** shown by Group I elements.

1 ....

2 ....

[2]

(c) The energy level diagram shows the energy profile for the reaction between zinc and dilute sulfuric acid.



(i) Complete the diagram by adding the formulae of the products. Include state symbols. [3]

(ii) Draw an arrow on the diagram to represent the activation energy. [1]

(iii) Is the reaction endothermic or exothermic? Explain your answer.

....

.... [1]

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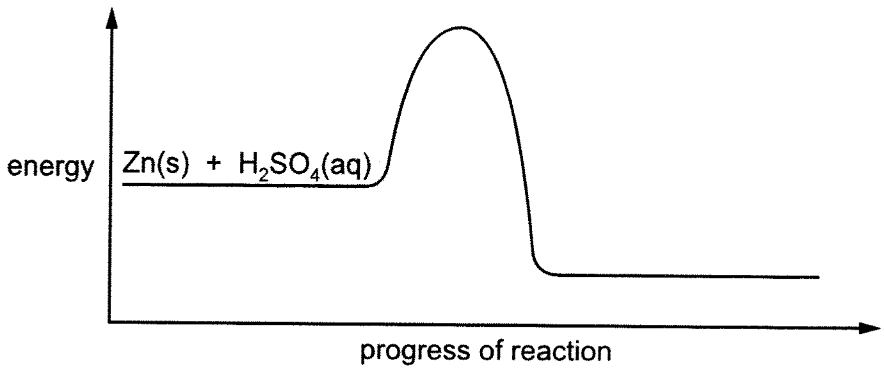
(d) The reaction between zinc and dilute sulfuric acid can be catalysed by the addition of aqueous copper(II) sulfate.

On the diagram, add the energy profile for the catalysed reaction.



[1]

Q55. [0620/42/M/J/18/Q4-F]

(f) When chlorine gas is passed through aqueous potassium bromide, a redox reaction occurs. The ionic equation is shown.

$$Cl_2 + 2Br^- \rightarrow 2Cl^- + Br_2$$

(i) Write an ionic half-equation showing what happens to the chlorine molecules, Cl_2, in this reaction.

.... [1]

(ii) Explain why the bromide ions, Br^-, act as reducing agents in this reaction.

.... [1]

[0620/42/M/J/18/Q5]

Q56.

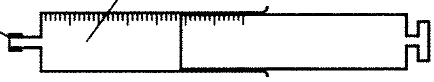
Hydrogen and iodine react together in a reversible reaction. Hydrogen iodide is formed.

$$H_2(g) + I_2(g) \rightleftharpoons 2HI(g)$$

colourless gas	purple gas	colourless gas

The forward reaction is exothermic.

A gas syringe containing an equilibrium mixture of hydrogen, iodine and hydrogen iodide gases was sealed and heated to 250 °C. The equilibrium mixture was a pale purple colour.



(a) What is meant by the term *equilibrium*?

....

....

.... [2]

(b) The plunger of the gas syringe was pressed in while the end of the gas syringe was blocked. This increased the pressure. The position of the equilibrium did **not** change. The colour of the gaseous mixture turned darker purple.

(i) Give a reason why the position of the equilibrium did **not** change.

.... [1]

(ii) Suggest why the gaseous mixture turned darker purple, even though the position of the equilibrium did **not** change.

.... [1]

(c) The temperature of the gas syringe was increased to 300 °C.

(i) What happened to the **position** of the equilibrium when the temperature of the gas syringe was increased from 250 °C to 300 °C?

.... [1]

(ii) What happened to the **rate** of the forward reaction and the **rate** of the backward reaction when the temperature of the gas syringe was increased from 250 °C to 300 °C?

rate of the forward reaction ....

rate of the backward reaction ....

[2]

[Total: 7]

[0620/43/M/J/18/Q3-D-E-F]

Q57.

(d) Cobalt reacts with dilute hydrochloric acid to make the salt cobalt(II) chloride. Bubbles of hydrogen gas are produced.

(i) Describe a test for hydrogen.

test ....

result .... [2]

(ii) The rate of reaction of cobalt with dilute hydrochloric acid can be made faster by heating the acid or by increasing its concentration.

State **one** other way to make the rate of reaction faster.

.... [1]

(iii) Use collision theory to explain how heating the dilute hydrochloric acid makes the rate of reaction faster.

....

....

....

....

.... [3]

(e) When cobalt(II) chloride is added to water an equilibrium is established.

$$\underset{\text{blue}}{[CoCl_4]^{2-}} + 6H_2O \rightleftharpoons \underset{\text{pink}}{[Co(H_2O)_6]^{2+}} + 4Cl^-$$

(i) A student adds water to a blue solution containing $[CoCl_4]^{2-}$ ions.

Describe what the student observes. Give a reason for your answer in terms of the position of the equilibrium.

....

....

.... [2]

(ii) Another student cools a blue solution containing $[CoCl_4]^{2-}$. The blue solution turns pink.

What does this information indicate about the forward reaction?

....

.... [1]

(f) Another compound of cobalt is $Co(OH)_3$.

Deduce the charge on the cobalt ion in $Co(OH)_3$.

.... [1]

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Q58. [0620/41/O/N/18/Q5]

Hydrogen gas reacts with iodine gas. The equation is shown.

$$H_2(g) + I_2(g) \rightleftharpoons 2HI(g)$$

The reaction is reversible and can reach equilibrium.

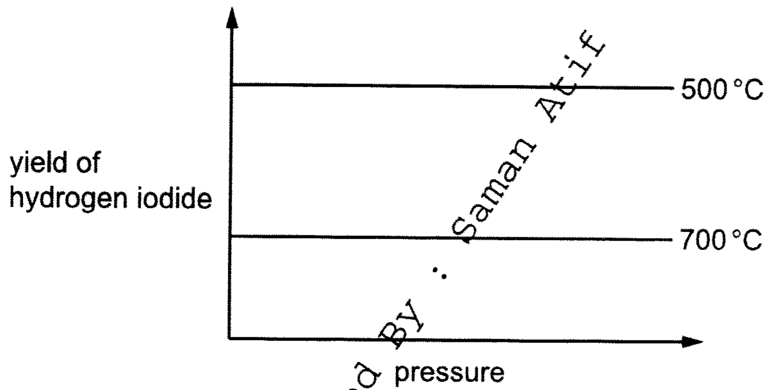
(a) What is meant by the term *equilibrium*?

....

....

.... [2]

(b) The graphs show how pressure affects the yield of hydrogen iodide, HI, at two different temperatures.



(i) Explain why the yield at 500 °C does **not** change as the pressure is increased.

....

.... [1]

(ii) What can you conclude from the difference in the yield of hydrogen iodide at the **two** temperatures shown? Explain your answer.

....

....

.... [2]

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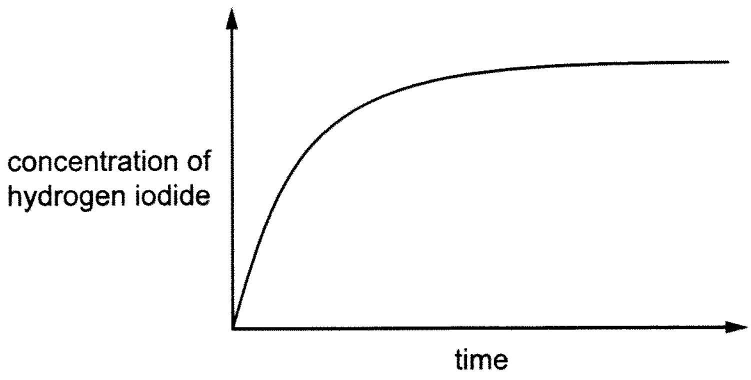
(c) The graph shows how the concentration of hydrogen iodide, HI, changes after hydrogen gas and iodine gas are mixed together in a sealed container.



(i) When is the rate of reaction fastest?

.... [1]

(ii) The reaction was repeated at the same temperature and pressure but in the presence of a catalyst.

Draw a graph on the same axes to show how the concentration of hydrogen iodide changes with time in the presence of a catalyst. [2]

(d) A mixture of hydrogen gas and iodine gas is allowed to reach equilibrium.

(i) Increasing the pressure of a gas increases its concentration.

State and explain the effect of increasing the pressure on the **rate** of the forward reaction.

....

....

.... [2]

(ii) State and explain the effect of increasing the temperature on the **rate** of the reverse reaction.

....

....

....

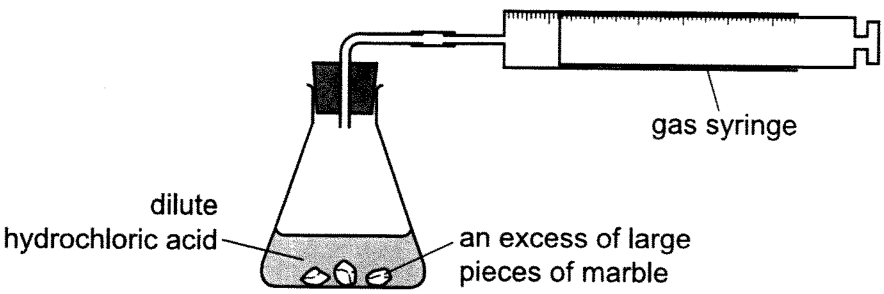
....

.... [3]

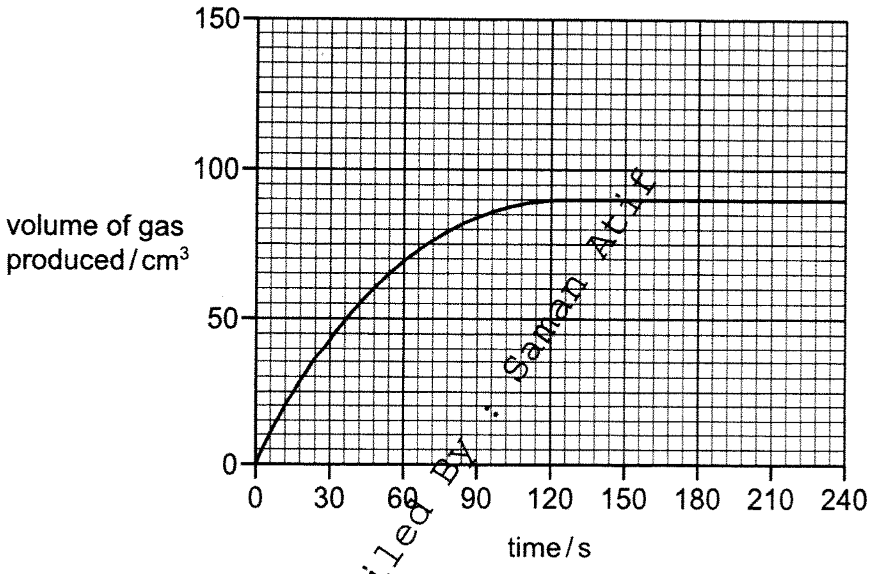
[Total: 13]

Q59. [0620/42/O/N/18/Q4]

A student investigated the progress of the reaction between dilute hydrochloric acid, HCl, and an excess of large pieces of marble, $CaCO_3$, using the apparatus shown.



(a) A graph of the volume of gas produced against time is shown.



(i) How does the shape of the graph show that the rate of reaction decreased as the reaction progressed?

....

.... [1]

(ii) Why did the rate of reaction decrease as the reaction progressed?

.... [1]

(iii) After how many seconds did the reaction finish?

.... s [1]

(b) The experiment was repeated using the same mass of smaller pieces of marble. All other conditions were kept the same.

Draw a graph **on the grid** to show the progress of the reaction using the smaller pieces of marble. [2]

(c) The original experiment was repeated at a higher temperature. All other conditions were kept the same.

Describe and explain, in terms of collisions between particles, the effect of using a higher temperature on the time taken for the reaction to finish.

....

....

....

....

....

....

....

....

.... [5]

[Total: 10]

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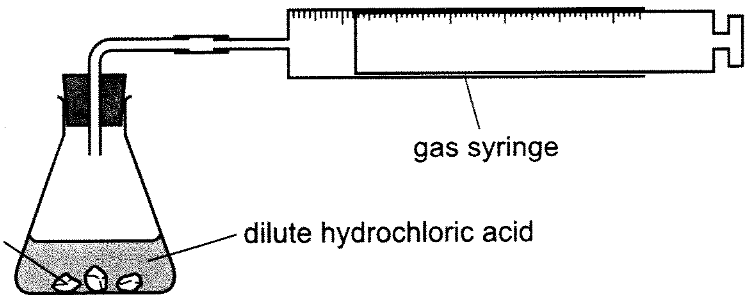
[0620/43/O/N/18/Q5]

Q60.

A student investigates the rate of reaction between lumps of calcium carbonate and dilute hydrochloric acid using the apparatus shown.

$$CaCO_3(s) + 2HCl(aq) \rightarrow CaCl_2(aq) + CO_2(g) + H_2O(l)$$

The calcium carbonate was in excess.



(a) Which measurements should the student make during the reaction to determine the rate of reaction?

....

.... [2]

(b) What happens to the rate of reaction as the reaction proceeds? Explain your answer.

....

....

....

.... [3]

(c) The student repeated the experiment at a higher temperature. All other conditions were kept the same. The student found that the rate of reaction increased.

Explain, in terms of collisions, why the rate of reaction increased.

....

....

....

....

.... [4]

(d) Apart from using a higher temperature, suggest **two** other methods of increasing the rate of this reaction.

1 ....

2 ....

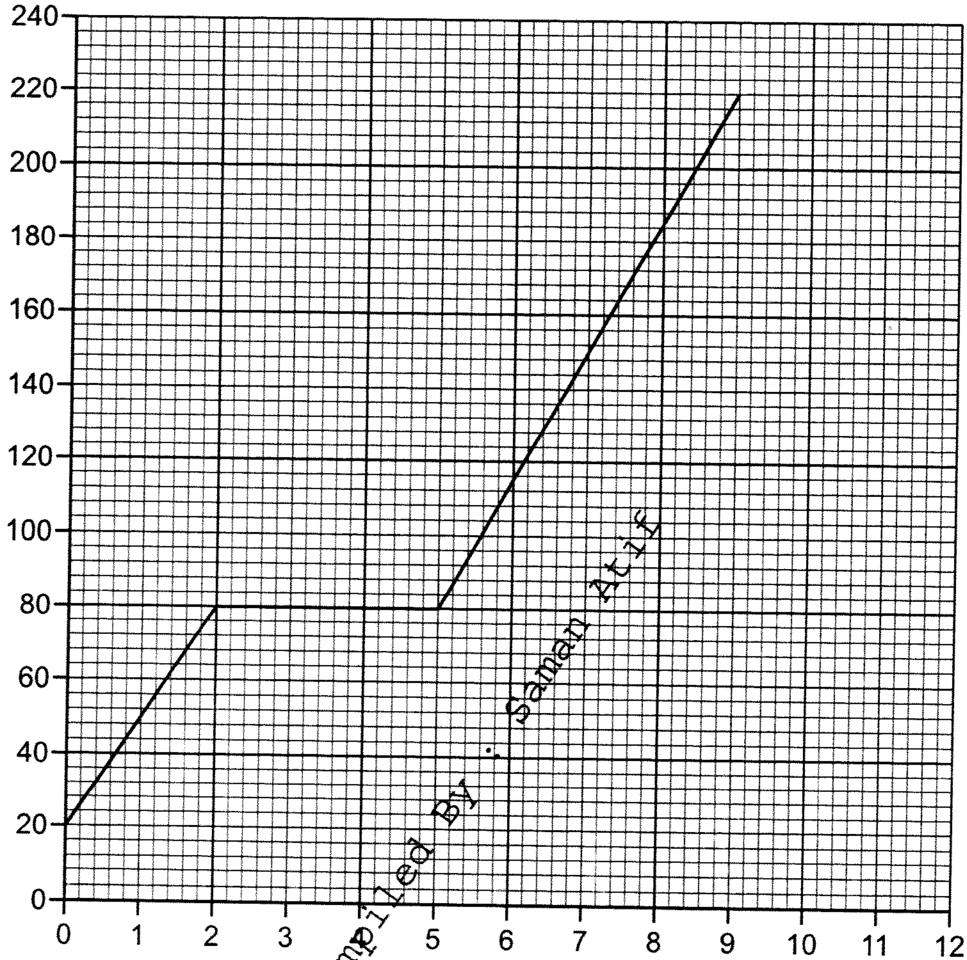
[2]

[Total: 11]

Q61. [0620/41/M/J/19/Q2]

Z is a covalent substance. In an experiment, a sample of pure solid **Z** was continually heated for 11 minutes.

The graph shows how the temperature of the sample of pure **Z** changed during the first 9 minutes.



(a) What is the melting point of pure **Z**?

.... °C [1]

(b) The sample of pure **Z** began to boil at 9 minutes. It was boiled for 2 minutes.

Use this information to sketch on the grid how the temperature of the sample of pure **Z** changed between 9 minutes and 11 minutes. [1]

(c) The sample of pure **Z** was continually heated between 2 minutes and 5 minutes.

Explain, in terms of attractive forces, why there was no increase in the temperature of the sample of pure **Z** between 2 minutes and 5 minutes.

....

....

.... [2]

(d) Describe how the motion of particles of pure **Z** changed from 0 minutes to 2 minutes.

....

.... [2]

(e) The experiment was repeated using a solid sample of **impure Z**.

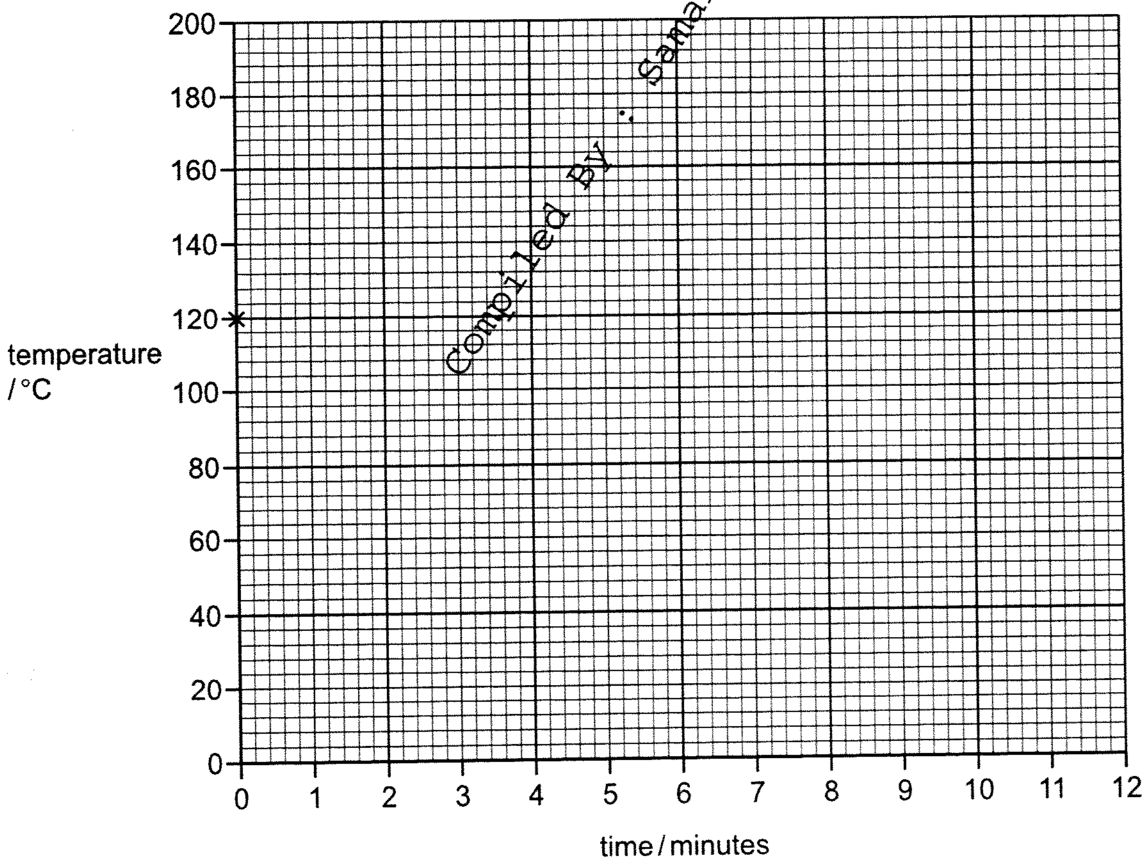
Suggest the differences, if any, in the melting point and boiling point of the sample of impure **Z** compared to the sample of pure **Z**.

melting point ....

boiling point ....
[2]

(f) A sample of pure **Z** was allowed to cool from 120 °C to 20 °C. The total time taken was 8 minutes.

Starting from point **×**, sketch on the grid how the temperature of the sample of pure **Z** changed between 0 minutes and 8 minutes.



[2]

[Total: 10]

375

Q62. [0620/41/M/J/19/Q4-A-B]

Ethanoic acid is a weak acid and hydrochloric acid is a strong acid.
Both ethanoic acid and hydrochloric acid dissociate in aqueous solution.

(a) (i) Define the term *acid*.

.... [1]

(ii) The chemical equation shows the changes which occur when the **strong** acid, hydrochloric acid, is added to water.

$$HCl(aq) \rightarrow H^+(aq) + Cl^-(aq)$$

Complete the chemical equation to show the changes which occur when the **weak** acid, ethanoic acid, is added to water.

$CH_3COOH(aq)$ .... [2]

(b) A student does experiments to show that hydrochloric acid is a strong acid and ethanoic acid is a weak acid. The student adds an excess of hydrochloric acid and an excess of ethanoic acid to separate samples of lumps of calcium carbonate.

Only the identity of the acid is changed between the experiments. All other conditions are kept the same.

(i) State **two** observations which would show that hydrochloric acid is a stronger acid than ethanoic acid.

1 ....

2 ....

[2]

(ii) The student uses the same size container and checks that the pressure is the same for each experiment.

State **three** other conditions which must be kept the same to ensure fair testing.

1 ....

2 ....

3 ....

[3]

[0620/42/M/J/19/Q4-A-B]

Q63.

Methanol is made industrially by reacting carbon monoxide with hydrogen. The gases react at a temperature of 250 °C and a pressure of 75 atmospheres.

$$CO(g) + 2H_2(g) \rightleftharpoons CH_3OH(g)$$

The forward reaction is exothermic.

(a) Suggest a source of hydrogen for this industrial process.

.... [1]

(b) Complete the table using only the words *increases*, *decreases* or *no change*.

	effect on the rate of the reverse reaction	effect on the equilibrium yield of $CH_3OH(g)$
adding a catalyst		no change
increasing the temperature	increases	
decreasing the pressure		

[4]

[0620/41/O/N/19/Q3-C]

Q64.

(c) Iron can be obtained by heating iron(III) oxide with zinc powder.

$$Fe_2O_3 + 3Zn \rightarrow 2Fe + 3ZnO$$

(i) What can be deduced about the reactivity of zinc from this reaction?

.... [1]

(ii) The ionic equation for this reaction is shown.

$$2Fe^{3+} + 3Zn \rightarrow 2Fe + 3Zn^{2+}$$

Identify the oxidising agent in this reaction. Explain your answer in terms of electron transfer.

oxidising agent ....

explanation ....

.... [2]

Q65. [0620/43/M/J/19/Q5]

Carboxylic acids react with alcohols to form esters. The reaction is reversible.
The equation for the reaction between ethanoic acid and ethanol is shown.

$$CH_3COOH + CH_3CH_2OH \rightleftharpoons CH_3COOCH_2CH_3 + H_2O$$

(a) **(i)** What is the name of the ester formed in this reaction?

.... [1]

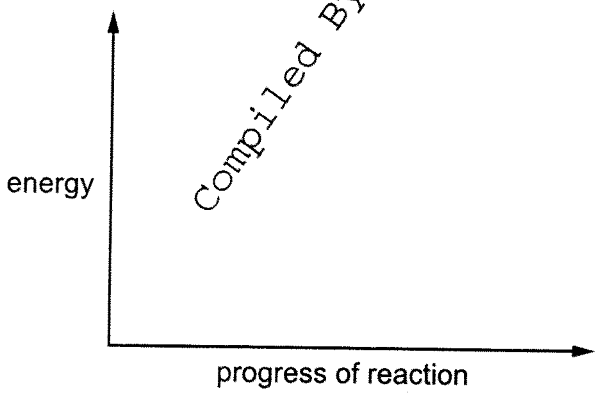
(ii) Draw the structure of the ester formed. Show all of the atoms and all of the bonds.

[1]

(b) The reaction between ethanoic acid and ethanol is exothermic.

Draw an energy level diagram for this reaction.

On your diagram label:
- the reactants and products
- the energy change of the reaction, ΔH.



[3]

(c) Concentrated sulfuric acid is a catalyst for this reaction.

What is meant by the term *catalyst*?

....

.... [2]

(d) The rate of reaction can be increased by increasing the temperature.

Explain why increasing the temperature increases the rate of reaction.

....

....

....

....

....

.... [4]

(e) The reaction between ethanoic acid and ethanol reaches equilibrium.

(i) The reaction between ethanoic acid and ethanol is exothermic.

State and explain the effect, if any, of increasing the temperature on the amount of ester at equilibrium.

....

....

.... [2]

(ii) State and explain the effect, if any, of removing water from the mixture on the amount of ester at equilibrium.

....

....

.... [2]

[Total: 15]

379

Q66. [0620/41/O/N/19/Q7-C-i-D]

(c) Ethanol can be oxidised by hydrogen peroxide to form ethanal, CH_3CHO. A catalyst for this reaction is Fe^{3+}.

(i) What is meant by the term *catalyst*?

....

....

.... [2]

(d) Ethene gas reacts with steam to form gaseous ethanol.

$$C_2H_4(g) + H_2O(g) \rightleftharpoons CH_3CH_2OH(g)$$

The reaction can reach a position of equilibrium. The forward reaction is exothermic.

(i) State and explain the effect of increasing the pressure on the **position of equilibrium**. All other conditions are unchanged.

....

....

.... [2]

(ii) Increasing the pressure of a gas increases its concentration.

State and explain the effect of increasing the pressure on the **rate** of the reaction. All other conditions are unchanged.

....

....

.... [2]

(iii) State and explain the effect of increasing the temperature on the **position of equilibrium**. All other conditions are unchanged.

....

....

.... [2]

Q67. [0620/42/O/N/19/Q3-A-B]

Ammonia is an important chemical.

(a) Ammonia is manufactured by the Haber process. The reaction is reversible.

(i) What is the sign for a reversible reaction?

.... [1]

(ii) State the essential conditions for the manufacture of ammonia by the Haber process starting from hydrogen and nitrogen. Include a chemical equation to show the reaction which occurs.

....

....

....

....

....

.... [5]

(iii) Name **one** raw material which is a source of the hydrogen used in the Haber process.

.... [1]

(b) Ammonia is a base and reacts with sulfuric acid to form the salt, ammonium sulfate.

(i) What is meant by the term *base*?

.... [1]

(ii) Name the industrial process used to manufacture sulfuric acid.

.... [1]

(iii) Write a chemical equation for the reaction between ammonia and sulfuric acid.

.... [2]

[0620/43/O/N/19/Q4-D]

Q68.

(d) Under certain conditions the reaction reaches equilibrium.

$$PCl_3(g) + Cl_2(g) \rightleftharpoons PCl_5(g)$$

State and explain the effect, if any, on the **position of equilibrium** if the pressure is increased. All other conditions are unchanged.

....

....

.... [2]

[0620/41/M/J/20/Q3-A-B]

Q69.

Sulfur dioxide, SO_2, is used in the manufacture of sulfuric acid.

(a) In the first stage of the process, sulfur dioxide is obtained from sulfur-containing ores.

Name **one** of these ores.

.... [1]

(b) The next stage of the process is a reaction which can reach equilibrium.

The equation for this stage is shown.

$$2SO_2(g) + O_2(g) \rightleftharpoons 2SO_3(g)$$

(i) Describe **two** features of an equilibrium.

....

.... [2]

(ii) Name the catalyst used in this stage.

.... [1]

(iii) Why is a catalyst used?

.... [1]

(iv) Explain, in terms of particles, why a high temperature increases the rate of this reaction.

....

....

....

....

.... [3]

(v) In this stage, only a moderate temperature of 450 °C is used.

What does this suggest about the forward reaction?

.... [1]

(vi) Calculate the percentage by mass of sulfur in sulfur trioxide, SO_3.

percentage = ... [2]

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(c) Concentrated sulfuric acid is a dehydrating agent which can chemically remove water from substances.

Both hydrated copper(II) sulfate crystals and sucrose (a sugar), $C_{12}H_{22}O_{11}$, can be completely dehydrated by concentrated sulfuric acid.

Name the solid product formed in each case.

hydrated copper(II) sulfate crystals ....

sucrose ....
[2]

Q70. [0620/41/M/J/20/Q4-A-B]

This question is about reactions of bases and acids.

(a) Ammonia is a gas at room temperature.

What is the test for ammonia gas? Describe the positive result of this test.

test ....

result ....
[2]

(b) Ammonia reacts with water to form ions.

$$NH_3 + H_2O \rightleftharpoons NH_4^+ + OH^-$$

(i) How does this equation show that ammonia, NH_3, behaves as a base?

.... [1]

(ii) Aqueous ammonia is described as a weak base.

Suggest the pH of aqueous ammonia.

pH = ... [1]

(iii) Describe what is seen when aqueous ammonia is added to aqueous copper(II) sulfate, until no further change is seen.

....

....

.... [3]

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Q71. [0620/42/M/J/20/Q3-A-B-C]

(a) Sulfuric acid is made from sulfur in a four-stage process.

stage 1 Sulfur is converted into sulfur dioxide.

stage 2 Sulfur dioxide is converted into sulfur trioxide.

stage 3 Sulfur trioxide is converted into oleum.

stage 4 Oleum is converted into sulfuric acid.

(i) How is sulfur converted into sulfur dioxide in **stage 1**?

.... [1]

(ii) Describe how sulfur dioxide is converted into sulfur trioxide in **stage 2**.

Your answer should include:

- an equation for the reaction
- the temperature used
- the name of the catalyst used.

....

....

....

.... [3]

(iii) The reaction in **stage 2** can reach equilibrium.

What is meant by the term *equilibrium*?

....

....

.... [2]

(b) Sulfur trioxide is converted into oleum, $H_2S_2O_7$, in **stage 3**.

What is sulfur trioxide reacted with to convert it into oleum?

.... [1]

(c) Oleum is converted into sulfuric acid in **stage 4**.

Write a chemical equation for the conversion of oleum, $H_2S_2O_7$, into sulfuric acid.

.... [2]

Q72. [0620/42/M/J/20/Q4-A-B-C]

Oxygen is produced by the decomposition of hydrogen peroxide. Manganese(IV) oxide is the catalyst for this reaction.

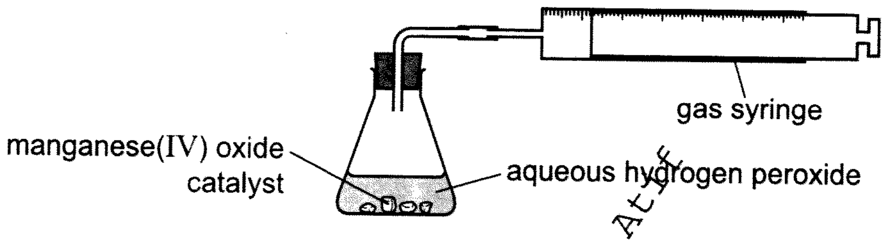
(a) What is meant by the term *catalyst*?

....

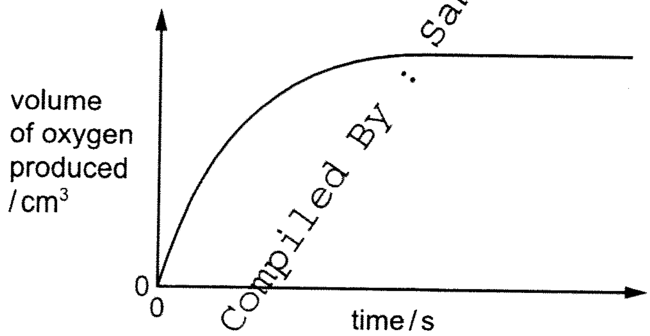
....

.... [2]

(b) A student measures the volume of oxygen produced at regular time intervals using the apparatus shown. Large lumps of manganese(IV) oxide are used.



A graph of the results is shown.



What happens to the **rate** of this reaction as time increases?

In your answer, explain why the rate changes in this way.

....

....

....

.... [4]

(c) The experiment is repeated using the same mass of manganese(IV) oxide. Powdered manganese(IV) oxide is used instead of large lumps. All other conditions stay the same.

Sketch a graph on the axes in **(b)** to show how the volume of oxygen changes with time. [2]

[0620/43/M/J/20/Q2-A-B-C]

Q73.

Ammonia is manufactured by the Haber process.

(a) The equation for the reaction is shown.

$$N_2(g) + 3H_2(g) \rightleftharpoons 2NH_3(g)$$

(i) State what is meant by the symbol $\rightleftharpoons$.

.... [1]

(ii) State **one** source of hydrogen used in the manufacture of ammonia.

.... [1]

(b) The table shows some data for the production of ammonia.

pressure / atm	temperature / °C	percentage yield of ammonia
250	350	58
100	450	28
400	450	42
250	550	20

Deduce the effect on the percentage yield of ammonia of:

- increasing the pressure of the reaction

....

- increasing the temperature of the reaction.

....

[2]

(c) Explain, in terms of particles, what happens to the rate of this reaction when the temperature is increased.

....

....

....

....

....

.... [3]

Q74. [0620/41/O/N/2020/Q3]

(a) Aqueous ammonium sulfate, $(NH_4)_2SO_4$, is warmed with aqueous sodium hydroxide.

The pungent-smelling gas ammonia, NH_3, is produced.

Balance the equation for this reaction.

$(NH_4)_2SO_4$ + ...NaOH → ......NH_3 + ...H_2O + Na_2SO_4 [1]

(b) A 2.8 g sample of impure ammonium sulfate is found to contain 0.7 g of impurities.

Calculate the percentage of ammonium sulfate in this sample.

percentage of ammonium sulfate = ... % [1]

(c) Describe a test for ammonia gas.

test ....

result .... [2]

(d) Ammonia gas is prepared at the front of a laboratory.

The pungent smell of ammonia spreads throughout the laboratory slowly.

(i) Name the process that occurs when ammonia gas spreads throughout the laboratory.

.... [1]

(ii) Explain, using ideas about particles, why ammonia gas spreads throughout the laboratory.

....

....

....

.... [2]

(iii) Explain why carbon dioxide gas, CO_2, will spread throughout the laboratory at a slower rate than ammonia gas, NH_3.

....

.... [1]

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(e) Ammonia is produced in the Haber process.

The equation for the reaction is shown.

$$N_2(g) + 3H_2(g) \rightarrow 2NH_3(g)$$

(i) In the Haber process, a temperature of 450 °C and a pressure of 200 atmospheres are used in the presence of finely-divided iron.

A larger equilibrium yield of ammonia would be produced if a lower temperature and a higher pressure are used.

Explain why a lower temperature and a higher pressure are **not** used.

lower temperature ....

....

higher pressure ....

.... [2]

(ii) State the role of iron in the Haber process.

.... [1]

(f) Ammonia is a weak base.

(i) Explain the meaning of the term *base*.

....

.... [1]

(ii) Suggest the pH of aqueous ammonia.

.... [1]

[Total: 13]

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Q75. [0620/41/O/N/2020/Q5-B-C-D]

(b) Sulfuric acid is manufactured using the Contact process. This manufacture involves four stages.

(i) **Stage 1** involves the combustion of sulfur to form sulfur dioxide.

Write the chemical equation for **stage 1**.

.... [1]

(ii) The equation for **stage 2** is shown.

$$2SO_2(g) + O_2(g) \rightleftharpoons 2SO_3(g)$$

The reaction can reach equilibrium.

Explain what is meant by the term *equilibrium*.

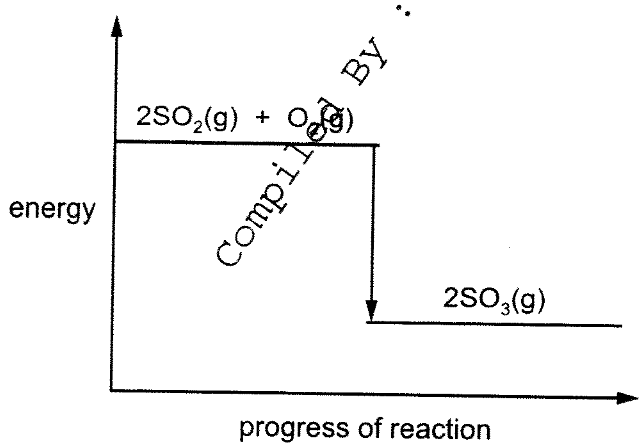
....

....

....

.... [2]

(iii) The energy level diagram for the forward reaction in **stage 2** is shown.



Explain what the diagram shows about the energy changes in the forward reaction.

....

....

....

.... [2]

(c) In **stage 3** sulfur trioxide, SO_3, is converted to oleum, $H_2S_2O_7$.

In **stage 4** oleum reacts to form sulfuric acid, H_2SO_4.

State what oleum reacts with in **stage 4**.

.... [1]

(d) A sample of sulfuric acid, H_2SO_4, has a concentration of 0.75 mol/dm^3.

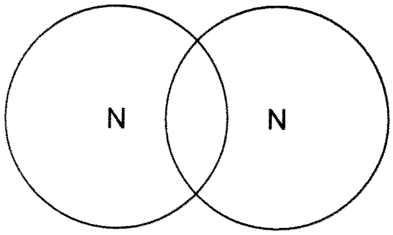
Calculate the concentration of sulfuric acid in g/dm^3.

.... g/dm^3 [2]

Q76. [0620/43/O/N/2020/Q3]

This question is about nitrogen and some of its compounds.

(a) Complete the dot-and-cross diagram to show the electron arrangement in a molecule of nitrogen, N_2.
Show the outer shell electrons only.



[2]

(b) Nitrogen can be converted into ammonia by the Haber process.

(i) Describe how nitrogen is obtained for the Haber process.

....

.... [2]

(ii) Give the essential reaction conditions and write a chemical equation for the reaction occurring in the Haber process.

chemical equation: ....

....

reaction conditions: ....

....

....

....

....

[5]

(c) Some of the ammonia made by the Haber process is converted into nitric acid.

The first stage of this process is the oxidation of ammonia to make nitrogen monoxide.

$$4NH_3(g) + 5O_2(g) \rightleftharpoons 4NO(g) + 6H_2O(g)$$

The process is carried out at 900 °C and a pressure of 5 atmospheres using an alloy of platinum and rhodium as a catalyst.

The forward reaction is exothermic.

(i) State the meaning of the term *catalyst*.

....

.... [2]

(ii) State the meaning of the term *oxidation*.

.... [1]

(iii) Complete the table using the words **increase**, **decrease** or **no change**.

	effect on the rate of the forward reaction	effect on the equilibrium yield of NO(g)
increasing the temperature		
increasing the pressure		

[4]

(d) Nitrogen monoxide, NO, is converted into nitrogen dioxide, NO_2.

$$2NO(g) + O_2(g) \rightarrow 2NO_2(g)$$

The nitrogen dioxide reacts with oxygen and water to produce nitric acid as the only product.

Write a chemical equation for this reaction.

.... [2]

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(e) Ammonium nitrate, NH_4NO_3, is a fertiliser.

Calculate the percentage by mass of nitrogen in ammonium nitrate.

.... % [2]

[Total: 20]

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Q1.

(c) catalyst would not affect yield / change position of equilibrium / affects both sides equally; [1]
(higher) temperature would reduce yield / increase in temperature would favour back reaction; [1]

(d) (i) V^{3+} is oxidant; [1]

(ii) V^{3+} to V^{4+}; [1]
increase in oxidation number / electron loss; [1]

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Q2.

(a) (i) A C D B [1]

(ii) speed (or rate) increases as concentration increases / time decreases as concentration increases; [1]
rate or speed or time depends on (concentration) of H^+ or hydrogen ions; [1]
B is slow because propanoic acid is weak or doesn't dissociate or weakly ionises;
or
B is slow because HC*l* **and** H_2SO_4 are stronger or ionise or dissociate more than propanoic; [1]
D slower than C because C is more concentrated than D / ORA; [1]
A is fast because H^+ concentration high (**note:** this would also score second mark if not already awarded) / H_2SO_4 is diprotic or dibasic or $2H^+$; [1]
time is inversely proportional to rate / owtte / ORA; [1]
max [5]

(b) change 1:
increase temperature / heat (the mixture); [1]
particles/molecules/ions have more energy or move faster; [1]
more (successful) collisions / more particles with E_a; [1]
change 2:
increase surface area / decrease particle size / use powdered (magnesium) / use smaller pieces / crush the magnesium; [1]
more collisions / more particles exposed to reaction; [1]
or
catalyst; [1]
more (successful) collisions; [1]
lowers E_a; [1]
max [5]

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Q3.

(a) (i) any three from:
particles have more energy;
move faster;
collide more frequently;
more successful collisions; [3]
accept: atoms or molecules for particles
not: electrons
not: vibrate more

(ii) reaction faster with temperature increase; [1]
enzymes denatured / destroyed;
not: killed [1]

(b) (i) bigger initial gradient; [1]
same final volume of nitrogen; [1]

(ii) decrease / slows down; [1]

(iii) <u>concentration</u> of organic compound decreases; [2]
compound used up = [1]
or: fewer particles;
collision rate decreases;

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Q4.

(a) (i) rate of reaction; [1]
influenced by light / only happens in light; [1]
or:
turns light into chemical energy = [2]
accept: light is catalyst = [1]

(ii) reduction of silver halides; [1]
they are reduced to silver / $2AgCl \rightarrow 2Ag + Cl_2$; [1]
appropriate importance given; [1]
or:
photosynthesis;
correct comment about chemistry carbon dioxide to carbohydrates / carbon dioxide to oxygen;
anything sensible e.g. its role in the food chain or decrease greenhouse effect or oxygen for respiration;
or:
chlorination;
making chloroalkanes;
appropriate importance given;

(b) (i) pressure would move position of equilibrium to right / increase yield of $COCl_2$; [1]
increase pressure favours side with less (gas) molecules / smaller volume; [1]

(ii) increase temperature favours endothermic reaction; [1]
so less products/reduce yield; [1]

(iii) keeps rate high / increase rate at lower temperatures; [1]

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Q5.

(c) (i) for A;
reaction slower;
decreased collision rate;
less bromobutane present / concentration of bromobutane less / less reacting particles; [2]
any two
accept: reverse arguments for B

(ii) halogens $Cl > Br > I$ reactivity / reactivity decreases down group; [1]
organic halides $I > Br > Cl$ / reactivity increases down group; [1]
opposite without explanation = [1]

(iii) any three from:
less energy;
particles move slower;
less collisions / fewer particles have energy to react / fewer successful collisions;
slower rate; [3]

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Q6.

(a) any two from:
bleaching (wood pulp / silk / straw);
manufacture of sulfuric acid / SO_3 / in Contact process;
fumigating / sterilising; refrigerant; making dyes; making wine; insecticide;
fungicide; [2]

(b) burn / heat / react sulfur; [1]
in air / oxygen; [1]
or
burn / heat / roast zinc sulfide or lead sulfide;
in air / oxygen;

(c) from purple / pink; **not:** red [1]
to colourless;

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Q7.

(b) **(i)** increases yield / moves equilibrium to RHS / favours forward reaction; [1]
high pressure favours side with smaller number of (gas) molecules; [1]

(ii) any two from:
higher temperature / catalyst causes faster reaction;
comment about compromise conditions to give best rate and yield;
at 250°C (lower temp) higher yield / forward reaction favoured;
at 350°C (higher temp) lower yield / back reaction favoured; [3]

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Q8.

(b) **(i)** heat with carbon or coke or carbon monoxide; [1]

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Q9.

(d) **(i)** Cu and As have more than one oxidation state / valency; [1]

(ii) $3Cu^{2+} + 2AsO_4^{3-} \rightarrow Cu_3(AsO_4)_2$ [2]
either side correct = [1]

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Q10.

(a) (making) fertilisers / nitric acid / nylon / refrigeration / explosives / cleaning products; [1]

(b) alkane / named alkane; [1]
water / steam; [1]
heat / catalyst; [1]

or electrolysis; [1]
suggest suitable electrolyte; (**allow:** water) [1]
hydrogen at cathode; [1]

or cracking; [1]
alkane / named alkane; [1]
heat or catalyst [1]

(c) any five from:
faster; (rate) [1]

more collisions / molecules closer together / more particles per unit volume; [1]

(collisions) more frequent / more often / more chance / more effective or successful collisions / more collisions with Ea / increase rate of collisions; [1]

higher yield / moves (equilibrium) to RHS / more ammonia / to side of products / [1]

less moles / molecules / volume on RHS ORA (can be implied in previous comments) [1]

high pressure means lower temperature can be used to achieve comparable rate (thus saving energy); [1]

(d) **(i)** endothermic takes in / absorbs / uses / needs / gains energy / heat <u>and</u> exothermic gives out / loses energy / heat; [1]

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Q11.

(a) **(i)** pieces have (same) surface area [1]
same amount / mass / quantity / volume / number of moles of carbonate [1]

(ii) no more bubbles / carbon dioxide **or** piece disappears / dissolves [1]

(c) **(i)** more concentrated **or** higher concentration (of acid) (in experiment 1) [1]
accept: arguments based on collision theory

(ii) ethanoic acid is a weak acid **or** hydrochloric acid is a strong acid [1]
accept: stronger or weaker

ethanoic acid less ionised / dissociated / lower / smaller concentration of hydrogen ions [1]
accept: less hydrogen ions and vice versa argument but not dissociation of ions

(iii) lower temperature (particles) have less energy [1]
moving more slowly [1]
fewer collisions / lower collision rate [1]
or
lower temperature (particles) have less energy [1]
fewer particles collide [1]
with the necessary energy to react [1]
note: less energy fewer successful collisions gains all 3 marks

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Q12.

(b) any five from:

- high pressure favours lower volume side / movement to right / ammonia side, **or** high pressure increases the yield
- high pressure increases rate
- low temperature favours exothermic reaction / increases yield / favours the forward reaction
- low temperature gives low rate or vice versa
- catalyst increases rate or lowers activation energy
- 450 °C low enough to give an economic yield but with catalyst gives a fast enough rate
note need whole concept to get this compromise temperature point [5]

(c) $2NH_3 + NaClO \rightarrow N_2H_4 + NaCl + H_2O$ [2]
not balanced only 1

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Q13.

(a) (i) first reaction
volume / moles / molecules of reactants and products are different [1]

second reaction
volume / moles / molecules of reactants and products are the same [1]

(ii) first reaction (forward) reaction is endothermic [1]
second reaction (forward) reaction is exothermic [1]

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Q14.

(a) (i) large / high surface area [1]

high collision rate / collide more / many collisions [1]
(between oxygen molecules and aluminium atoms)
NOT faster collisions

(ii) concentration [1]
of reactants decreases [1]

allow one mark **ONLY** *for:*
for reactants used up **or** amount of reactant decreases

(iii) *any three of four from one strand:*

M1	increase in temperature	
M2	molecules move faster **or**	particles have more energy
M3	higher collision rate	
M4	more successful collisions **or**	more particles have enough energy to react/E_a

[3]

(b) (i) flour **or** wood dust **or** coal dust or carbon or sugar [1]

(ii) any three from:
powder and larger pieces / different sized particles use
suitable named solid, e.g. magnesium
suitable named solution, e.g. named acid **or** copper sulfate(aq)
result – powder reacts faster than larger pieces [3]
NOT Cu (with acid); K / Na with anything

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Q15.

(d) oxidation [1]
COND increase in oxidation number [1]
ACCEPT: electron loss

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Q16.

(b) (i) speed / rate of forward reaction = speed / rate of back reaction [1]
OR macroscopic properties do not change / constant (with time)

(ii) goes darker **OR** goes brown [1]
COND lower pressure favours side with more moles [1]
COND this is NO_2 side **OR** reactant side **OR** goes left [1]

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Q17.

(a) (i) fractional distillation [1]
(liquid) air [1]

(ii) cracking / heat in presence of catalyst [1]
of alkane / petroleum [1]
to give an alkene and hydrogen [1]
OR: electrolysis (1)
named electrolyte (1)
hydrogen at cathode (1)
OR: from methane (1)
react water / steam (1)
heat catalyst (1)
only **ACCEPT:** water with methane **or** electrolysis

(b) (i) the pair with both graphs correct is C [1]
NOTE: mark **(b)(ii)** independent of **(b)(i)**

(ii) high pressure favours side with lower volume / fewer moles [1]
this is RHS / product / ammonia [1]
%NH_3 / yield increases as pressure increases [1]

the forward reaction is exothermic [1]
exothermic reactions favoured by low temperatures [1]
%NH_3 / yield decreases as temperature increases [1]
ACCEPT: reverse arguments

(iii) increases reaction rate [1]
ACCEPT: reduces activation energy [1]
OR: decreases the amount of energy particles need to react
OR: economic rate at lower temperature so higher yield

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Q18.

(a) **(i)** (mass at t =0) – (mass at t = 5) [1]
NOTE: must have mass at t = 5 not final mass

(ii) fastest at origin
slowing down between origin and flat section gradient = 0
where gradrient = 0
three of above in approximately the correct positions [2]

(iii) 3 correct comments about gradient = [2]
2 correct comments about gradient = [1]
1 correct comment about gradient = [0] [2]

(b) start at origin and smaller gradient [1]
same final mass just approximate rather than exact [1]

(c) **(i)** smaller surface area [1]
lower collision rate [1]

(ii) molecules have more energy [1]
collide more frequently / more molecules have enough energy to react [1]

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Q19.

(c) (increased) light increases / causes forward reaction / light causes
$AgCl$ reacts with $CuCl$ [1]
(increased) light increases the amount of silver (and so darkens glass) [1]
decrease in light reverses reaction / uses up silver / silver reacts (and so reduces darkness)[1]

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Q20.

(a) (i) the (forward) reaction is endothermic [1]

(ii) none [1]
volume of reactants and products the same [1]
ACCEPT: number of moles or molecules

(iii) the reaction (between oxygen and nitric oxide) is <u>exothermic</u> [1]
high temperatures push equilibrium to left / high temperatures decrease yield of products / low temperatures favour forward reaction [1]

(iv) $4NO_2 + O_2 + 2H_2O \rightarrow 4HNO_3$ [2]
not balanced = (1) only

(v) (cost of) high amount of electricity / energy [1]

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Q21.

(a) (i) contains <u>only</u> carbon, hydrogen and oxygen [1]
hydrogen (atom) to oxygen (atom) ratio is 2:1 [1]
ALLOW: C:H:O as 1:2:1 or $C_n(H_2O)_n$

(ii) condensation [1]
polymerisation [1]

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Q22.

(a) (i) $S + O_2 \rightarrow SO_2$
or sulfur burnt / roasted / heated in air to form sulfur dioxide [1]

$2SO_2 + O_2 \rightleftharpoons 2SO_3$ [2]
unbalanced = (1) only

(catalyst) vanadium(V) oxide / vanadium pentoxide [1]
(temperature) 440 to 460 °C [1]
(dissolve) sulfur trioxide in sulfuric acid (to form oleum) [1]
ignore comments about pressure

(ii) add oleum to water [1]

(b) $Ba(C_6H_{13}SO_3)_2$ / $(C_6H_{13}SO_3)_2Ba$ [1]

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Q23.

(a) (i) rate at t_2 less than at t_1 **or** the rate decreases (1)

rate at t_3 zero / reaction stopped (1) [2]

(ii) rate at t_2 less than at t_1 because **concentration** of hydrogen peroxide is less at t_2 **or concentration** of hydrogen peroxide is decreasing. (1)

(rate at t_3 zero / reaction stopped because) hydrogen peroxide is used up (1) [2]

(b) (i) steeper and must come from the origin (1)
final volumes the same (1) [2]

(ii) Any **two** from: [2]
steeper curve because of a faster rate
faster rate because of increased surface area
same amount / volume / mass / no of mol of hydrogen peroxide
ecf for M1 for a shallower curve because of slower rate.

(c) filter (and rinse / wash) (1)

dry manganese (IV) oxide (1)

weigh / measure mass manganese(IV) oxide after reaction (1)

the mass should be 0.1 g **or** unchanged. (1) [4]

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Q24.

(a) (i) pressure 150–300 atmospheres / atm (1)

temperature **accept** in range 370 to 470 °C (1)

iron (catalyst) (1)

balanced equation $N_2 + 3H_2 \rightleftharpoons 2NH_3$ (1)

equilibrium / reversible (1) [5]

(ii) potassium / K (1)

phosphorus / P (1) [2]

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Q25.

(d) (i) concentration (of acid in C) is less/halved **or** concentration of A is more/doubled. (1)

less collisions **or** more collisions in A (than in C) (1) [2]

(ii) (higher temperature in B particles/molecules/atoms) move faster/have more energy/more have E_a **or** (particles/molecules/atoms) in A move slower/have less energy/less have E_a (1)

more collisions **or** less collisions in A (than in B) (1) [2]

(iii) It (D) has strong (acid) **and** A has weak acid/(D) stronger/(D) ionises more/(D) dissociates more **or** A is weaker/A ionises less/A dissociates less (1)

It (D) has higher concentration of hydrogen ions **or** A has a lower concentration of hydrogen ions (1)

more collisions (in D) **or** fewer collisions in A (1) [3]

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Q26.

(a) (i) incomplete combustion **or** limited oxygen/less oxygen/not enough oxygen (1) [1]

(ii) any **two** from:

(forward) reaction is endothermic (1)

high temperature increases yield/favours forward reaction/shifts equilibrium to right (1)

faster reaction (rate) (1) [2]

(iii) any **two** from:

high pressure reduces yield **or** favours LHS (1)

because LHS has smaller volume **or** number of moles/number of molecules (of gas) ORA (1)

(high pressure plant is) expensive/dangerous/explosion/leaks [2]

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Q27.

(c) **(i)** (to prove) **all** water driven off or evaporated or boiled/no water remains/to make salt anhydrous (1)

(ii) $m_1 - m_2$ = mass of water (1)

(calculate) moles of water **AND** moles of hydrated or anhydrous salt (1)

1:1 ratio/should be equal (1) [3]

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Q28.

(a) faster reaction rate (1)
higher collision rate (1)
greater
yield **or** favour RHS (1)
pressure favours products because it has lower volume/fewer product molecules (1) [4]

(b) higher temperature favour endothermic reaction (1)
this is the back reaction/left hand side/reactants (1)
reduce yield (1) [3]

(c) **(i)** greater surface area (1) [1]

(ii) increase reaction rate (1)
can use a lower temperature to have an economic rate (1)
and not decrease yield (by increasing temperature). [2]

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Q29.

(a) Any **two** from:
bleach/making wood pulp/making paper
food/fruit juice/wine preservative
fumigant/sterilising/insecticide [2]

(b) heating/roasting/burning (zinc sulfides) [1]
in air/oxygen COND on M1 [1]

(c) **(i)** V_2O_5 [1]

(ii) position of equilibrium shifts right/yield increases [1]
to save energy [1]

(iii) faster reaction/rate [1]

more collisions per second/higher collision frequency [1]

fewer moles/molecules (of gas) on right [1]

(so) position of equilibrium shifts right/yield increases [1]

(d) (the reaction is) too violent/too exothermic **or** produces mist/fumes (of acid) [1]

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Q30.

(c) **(i)** C A B [2]

ABC = 1 ACB = 1 BCA = 1 CBA = 1 BAC = 0
Allow 70 for C, 40 for B and 20 for A

(ii) M1 Energy mark: at higher temperature particles/molecules more have more energy or move faster [1]

M2 Collision frequency mark: collide more frequently/often **or** more collisions per unit time **or** higher rate of collisions.
Ignore: 'more collisions' [1]

M3 Collision energy mark: more molecules have enough energy to react or more collisions are above activation energy or successful [1]

(iii) C rate zero or enzymes denatured [1]

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Q31.

(a) making fertilisers or pickling metals or making fibres or making phosphoric acid/phosphates making dyes or making paints/pigments/dyes or making paper making plastics or making detergents or tanning leather or battery acid. [1]

(b) (i) add water (to yellow solid or to (anhydrous) iron(II) sulfate or to $FeSO_4$ or to products [1]

goes green [1]

(ii) M1 Sulfur trioxide reacts with water to make sulfuric acid or equation [1]

M2 sulfur dioxide reacts with oxygen to form sulfur trioxide or equation [1]

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Q32.

(a) (i) rate decreases [1]
<u>concentration</u> of sodium chlorate ((I))/reactant decreases [1]

(ii) (initial) gradient greater/steeper (must start at origin) [1]
same final volume of oxygen [1]

(iii) (to prevent)photochemical reaction/(to prevent)reaction catalysed by light/light breaks down or decomposes sodium chlorate((I)) [1]

(iv) particles have more energy/particles move faster/ [1]
more collisions [1]
collisions more frequent or more often/greater chance of collision/<u>collision</u> rate increases/more particles have energy to react/more collisions are successful or effective [1]

Q33.

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Question	Answer	Marks	Guidance
3(a)(ii)	(2)H^+ or 'hydrogen ion(s)'; it accepts electrons or takes electrons (from zinc atoms);	2	**R** H_2 or 'hydrogen' **A** because it is reduced or because it decreases in oxidation number **A** it causes zinc to lose electrons
3(b)(i)	zinc displaces copper or zinc more reactive than copper; $Zn + CuCl_2 \rightarrow ZnCl_2 + Cu$ **OR** $Zn + Cu^{2+} \rightarrow Cu + Zn^{2+}$;	2	**A** copper less reactive than zinc **I** zinc reacts with copper ions or with Cu^{2+} or with copper chloride **I** zinc reacts with copper **I** Cu^{2+} ions are reduced **A** multiples **I** state symbols
3(b)(ii)	steeper (line) or higher gradient; (means an) increased rate; but the same (final) volume;	3	**A** less time to complete the reaction / same amount of gas in less time / faster reaction / more gas in the same time period **A** same volume of hydrogen produced **A** 'amount' for volume **A** no extra gas is made
3(c)	M1 less steep (line) or lower gradient; M2 (because of) decreased rate; M3 ethanoic is a weak(er) acid; M4 only partially ionised or dissociated **OR** lower concentration of hydrogen ions;	4	**A** alternative phrases e.g. 'shallower' **A** more time to complete the reaction **A** same amount of gas in more time **A** slower rate or slower reaction ORA **A** not fully dissociated or ionised **A** ionises less (than HC*l*) **I** less hydrogen ions

Q34.

Page 10	Mark Scheme	Syllabus	Paper
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Question	Answer	Marks	Guidance
5(c)(i)	example of a reversible reaction including attempts at removing / adding waters of crystallisation **OR** example of a reaction which under closed conditions would be reversible;	1	**A** written description of the reaction e.g. 'Haber process' unless equation is attempted in which case ignore written description **A** word equations / unbalanced equations **A** equations without equilibrium arrows **I** descriptions of physical changes
5(c)(ii)	*Any **two** from:* (a reaction) M1 which can take place in both directions **OR** which can be approached from both directions; M2 in which concentrations / macroscopic properties do not change (with time); M3 the two reaction rates are equal;	2	**I** reference to 'closed system' **A** 'a reaction which can go forwards and backwards' for M1 **I** 'a reaction with an equilibrium arrow' or with '⇌' for M1 **R** concentrations (of reactants and products) are the same
5(d)	M1 equilibrium goes to LHS **OR** equilibrium goes to reactants side; M2 because the concentration of chlorine decreases;	2	**A** reaction goes to LHS but **R** 'equilibrium goes to LHS and to products side' **A** backward reaction is favoured **I** less yield or less products **A** 'reactant' for 'chlorine' but not reactants **A** to replace missing chlorine

5(e)	M1 equilibrium goes to RHS **OR** equilibrium goes to products side; M2 exothermic reactions are favoured by low temperatures; M3 the forward reaction is exothermic;	3	**A** reaction goes to RHS but **R** 'equilibrium goes to RHS and to reactants side' **A** forward reaction is favoured **I** more yield or more products **A** for M1 and M2 'decreasing temperature makes the equilibrium go to RHS' **A** backward reaction is endothermic

Q35.

Page 5	Mark Scheme	Syllabus	Paper
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Question	Answer	Marks	Guidance
3(c)	it (refers to Ca) / Calcium / Ca (atom) loses / gives / donates electrons / e / e^- ; (these are) gained by nitrogen / N / N_2 ; nitrogen / N / N_2 is reduced so calcium / Ca is the reducing agent (these two statements could be split i.e. not in same sentence) **OR** reducing agents are electron donors / give / lose electrons **OR** calcium / Ca is oxidised (by electron loss) therefore calcium is the reducing agent (these two statements could be split i.e. not in same sentence);	3	**A** half-equation with electrons on right-hand side **R** calcium ion / Ca^{2+} **A** half-equation with electrons on left-hand side **R** nitride ion / N^{3-} **I** numbers of electrons / charges on ions / oxidation state / valency if mentioned **R** reference to oxygen / hydrogen if there is a suggestion that oxygen / hydrogen are involved in the reaction **I** reference to oxygen / hydrogen if in general statement e.g. oxidation is gain of oxygen Electrons / e / e^- move from calcium to nitrogen get marks 1 and 2 **A** calcium / Ca / it is a reductant or calcium / Ca / it reduces

Q36.

Page 5	Mark Scheme	Syllabus	Paper
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Question	Answer	Marks	Guidance
4(a)	large surface area / large area of contact / large surface; more (successful) collisions (between catalyst and gases or between reacting gases) **OR** more active sites **OR** faster reaction / increase rate / increase speed;	2	**I** activation energy Second mark must be comparative
4(b)	decrease temperature / temperature below 450 °C / quoted temperature below 450 °C; increase pressure / pressure above 200 atm / quoted pressure above 200 atm;	2	**I** comments about concentration **I** low temperature and high pressure. Both answers must be comparative **I** explanations
4(c)	decreased <u>temperature</u> would reduce rate/reaction slow<u>er</u>/too slow; increased <u>pressure</u> expensive / uneconomic / safety risks / leaks / explosions / yield **or** rate good enough at lower pressure / strong pipes needed / thick pipes needed / sturdy pipes needed / requires a lot of energy;	2	**A** takes long<u>er</u> **I** slow (unqualified) **I** answers that do not refer to decreased temperature and increased pressure e.g. it is too expensive unless this is linked with pressure

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Q37.

Page 7	Mark Scheme	Syllabus	Paper
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Question	Answer	Marks	Guidance
6(a)(i)	(Haber process makes) ammonia / NH_3 ; (ammonia converted into) fertilisers / nitrates / ammonium salts or names or formulae of examples e.g. ammonium nitrate / NH_4NO_3 / ammonium sulfate / $(NH_4)_2SO_4$ / calcium nitrate / $Ca(NO_3)_2$ / urea / $CO(NH_2)_2$;	2	**A** 2 marks for 'ammonia is a fertiliser' **A** ammonia is used to make sodium nitrate Haber process used to make fertilisers gets second mark only
6(a)(ii)	it (refers to sodium nitrate) / sodium nitrate would dissolve (in rain) / soluble (in water) / wash away / leach / drain off;	1	**A** reacts with water **I** reference to fertiliser **R** sodium reacts / dissolves **A** because they are not dissolved by rainfall (implication is in desert)
6(a)(iii)	potassium (is required by plants as well as nitrogen) / NPK;	1	**R** comments about pH / better for soil / %N higher / reactivity of potassium **I** comments about what K does for plants e.g. combat disease
6(b)(i)	$2NaNO_3 \rightarrow 2NaNO_2 + O_2$ species; balancing;	2	**A** multiples **I** state symbols / word equation
6(b)(ii)	(colour changes) from pink / purple; to colourless / decolourised;	2	**I** clear / discoloured / effervescence **I** brown fumes / brown gas **NOTE:** stays pink or purple gets first mark but turns purple or pink is 0
6(b)(iii)	the more reactive the metal the lower rate of decomposition / more difficult the decomposition / more stable the nitrate / more energy needed to decompose / decomposes at higher temperature ora;	1	**A** less (extent the) decomposition **A** reactive metals produce nitrates difficult to decompose ora i.e. comparatives not essential **A** the more reactive the metal the less it decomposes is acceptable because we can assume that *it* refers to the nitrate BOD **A** inverse relationship with further qualification **A** group 1 / reactive metals produce nitrite (and oxygen) **and** less reactive metals produce oxide (+ NO_2 + O_2) (both required for mark) **I** less products (unqualified) **R** less products / metals decompose

Q38.

Page 5	Mark Scheme	Syllabus	Paper
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Question	Answer	Marks
3(a)	fast(er) reaction; large(r) surface area;	1 1
3(b)	4.76 (dm^3);	1
3(c)	moves equilibrium to right; increases yield (of sulfur trioxide) / uses up more sulfur dioxide;	1 1
3(e)(i)	moves to right;	1
3(e)(ii)	high yield at 2 atm;	1
3(f)	vanadium(V) oxide / vanadium pentoxide;	1
3(g)	**M1** dissolve / react sulfur trioxide in (concentrated) sulfuric acid; add water to product of **M1**;	1 1

Q39.

Page 8	Mark Scheme	Syllabus	Paper
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Question	Answer	Marks
7(a)(i)	**step 2 and** it is electron gain / oxidation state decreases;	1
7(a)(ii)	silver (ion) **and** it accepts electrons / gets reduced / oxidation state decreases;	1
7(b)	*prediction:* the '*not covered*' section will be black; the '*covered in thick card*' section will be white / cream; the '*covered in thin card*' section will be grey; *explanation:* the more light, the more silver ions are reduced;	 1 1 1 1

Q40.

Page 6	Mark Scheme	Syllabus	Paper
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Question	Answer	Marks
3(a)	1 $Na_2S_2O_3$ 2 H_2O 3 HCl **OR** 1 HCl 2 H_2O 3 $Na_2S_2O_3$ **OR** 1 H_2O 2 $Na_2S_2O_3$ 3 HCl **OR** 1 H_2O 2 HCl 3 $Na_2S_2O_3$;	1
3(b)(i)	 **M1** volumes 40 : 10 : 10; **M2** time = 14;	2 1 1
3(b)(ii)	 **M1** more particles per unit volume / particles are closer together; **M2** increases the rate of collisions / there are more collisions per unit time;	2 1 1
3(c)	 **M1** particles gain more energy **and** move faster; **M2** increasing rate of collisions / more collisions per unit time; **M3** higher proportion of particles have sufficient energy to react / collisions have sufficient energy to react / are above the activation energy;	3 1 1 1

Q41.

Page 5	Mark Scheme	Syllabus	Paper
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Question	Answer	Marks
4(a)	 **M1** substance that speeds up a reaction / increases rate; **M2** unchanged (chemically) at the end / not used up / lowers activation energy / provides alternative pathway;	2 1 1
4(b)	 **M1** too slow / slower; **M2** lower yield / less product(s) / equilibrium shifts to left / equilibrium shifts in direction of reactants / backward reaction favoured / reverse reaction favoured;	2 1 1
4(c)	faster / increase rate;	1
4(d)	lower yield / less product(s) / equilibrium shifts to left / equilibrium shifts in direction of reactants / backward reaction favoured / reverse reaction favoured; **OR** higher cost / expensive; **OR** safety risks;	1

Q42.

Page 9	Mark Scheme	Syllabus	Paper
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Question	Answer	Marks
6(d)(ii)	oxidising agent / oxidant;	1
6(d)(iii)	reducing agent / reductant;	1
6(d)(iv)	iron(III) / Fe^{3+};	1
6(d)(v)	iron(II) / Fe^{2+};	1

Q43.

Page 7	Mark Scheme	Syllabus	Paper
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Question	Answer	Marks
4(c)(i)	start colour: colourless; end colour: brown;	2 1 1
4(c)(ii)	**M1** iodide / I^-; **M2** it is oxidised **OR** it loses electrons / it increases oxidation number / it reduces the chlorine;	2 1 1

Q44.

Page 4	Mark Scheme	Syllabus	Paper
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Question	Answer	Marks
4(a)(i)	$N_2 + 3H_2 \rightleftharpoons 2NH_3$ **M1** formulae **M2** balancing	2
4(a)(ii)	(nitrogen) air / atmosphere (hydrogen) steam / water / hydrocarbons / natural gas	1 1
4(a)(iii)	(temperature) answer in range 370–470 °C (pressure) answer in range 150–300 atm	1 1
4(b)(i)	**M1** forward and reverse reactions (occur) **M2** amounts / moles / concentrations (of reagents and products) constant **OR** **M2** rate of forward and reverse reactions equal	1 1
4(b)(ii)	endothermic **AND** yield increases as temperature increases	1
4(b)(iii)	**M1** yield decreases (as pressure increases) **M2** because more moles / molecules (of gas) on the right **M3** so position of equilibrium moves left	1 1 1

Q45.

Page 7	Mark Scheme	Syllabus	Paper
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Question	Answer	Marks
8(a)(i)	any 4 from: slowed down acid became less concentrated **OR** fewer particles per unit volume fewer collisions per second **OR** lower collision rate (then the reaction) stopped all the hydrochloric acid reacted	4
8(a)(ii)	any 4 from: faster (reaction) (powder has) larger surface area more collisions per second **OR** higher collision rate same volume of gas amount / moles hydrochloric acid is not changed	4
8(b)	any 5 from: temperature increased particles have more energy (particles) move faster more collisions per second **OR** higher collision rate more particles have sufficient energy to react / activation energy more of the collisions are successful	5

Q46.

Page 4	Mark Scheme	Syllabus	Paper
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Question	Answer	Mark
5(b)(i)	from colourless to yellow / orange / brown	2
5(b)(ii)	$Cl_2(g) + 2Br^-(aq) \rightarrow Br_2(aq) + 2Cl^-(aq)$ **M1** (aq) as state symbols for the two products given **M2** correct products **M3** balancing	3

Q47.

Page 6	Mark Scheme	Syllabus	Paper
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Question	Answer	Marks
5(a)(i)	burned / heated in air	1
5(a)(ii)	$S + O_2 \rightarrow SO_2$	1
5(b)(i)	equilibrium / reversible	1
5(b)(ii)	vanadium(V) oxide / vanadium pentoxide	1
5(b)(iii)	increase rate (of reaction) / allow lower temperature to be used / allow lower pressure to be used	1
5(b)(iv)	less SO_3 forward reaction is exothermic / it is exothermic / reverse reaction is endothermic	1 1
5(b)(v)	rate too low / reaction too slow / slower	1
5(b)(vi)	more SO_3 fewer moles or molecules (of gas) on right-hand side / more moles or molecules(of gas) on left-hand side	1 1
5(c)(i)	concentrated sulfuric acid / concentrated H_2SO_4	1
5(c)(ii)	$SO_3 + H_2SO_4 \rightarrow H_2S_2O_7$	1
5(d)(i)	water	1
5(d)(ii)	$H_2S_2O_7 + H_2O \rightarrow 2H_2SO_4$	1
5(e)	detergents / car batteries / dyes / paints / synthetic resins / printing inks / metal extraction / cleaning metals /	1

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Q48.

Question	Answer	Marks
5(a)	(stop-) watch **AND** syringe	1
5(b)	graph starts at **X** and is a curve with a decreasing gradient	1
	graph hits zero rate at 114□6 seconds	1
5(c)	**M1** moles of carbon dioxide = 180 / 24 000 = 0.0075	1
	M2 molar mass of barium carbonate = 197	1
	M3 mass of barium carbonate = **M1** □ **M2** = 1.48 (g)	1
5(d)	curve starts from (0,0) and has a lower gradient than the original curve	1
	because lumps have a lower surface area	1
5(e)	curve starts from (0,0) and has a steeper gradient than the original curve	1
	finishes at the same volume of gas	1
	because there are more particles per unit volume / dm^3 / cm^3	1
	because there are more collisions per second / unit time **OR** a greater collision rate	1
5(f)	360 (cm^3)	1

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Q49.

Question	Answer	Marks
3(a)(i)	450 °C	1
	200 atmospheres	1
3(a)(ii)	iron	1
3(b)(i)	4(NO)	1
	5(O_2) **AND** 6(H_2O)	1
3(b)(ii)	lower yield of NO / lower yield of nitric acid / lower yield of product / equilibrium shifts to left (at higher temperatures) / backward reaction favoured (at higher temperatures) **ORA**	1
3(b)(iii)	too slow / rate decreases **ORA**	1
3(c)	$4NO + 3O_2 + 2H_2O \rightarrow 4HNO_3$ **M1** all formulae correct **M2** balancing	2

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Q50.

Question	Answer	Marks
5(c)(i)	becomes paler	1
	equilibrium moves right	1
	(because) fewer moles (of gas) on right	1
5(c)(ii)	equilibrium moved right / more N_2O_4 / less NO_2	1
	(forward) reaction exothermic	1

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Q51.

Question	Answer	Marks
7(a)(i)	more particles (of acid) in a given volume / dm^3 / cm^3	1
	more collisions per second / unit time **OR** greater collision rate	1
7(a)(ii)	particles have more energy / particles move faster / more collisions per second / more collisions per unit time / greater collision rate	1
	more (of the) particles / collisions have energy greater than the activation energy / more particles have sufficient energy to react / more collisions have sufficient energy to react / a greater percentage of collisions are successful	1

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Q52.

Question		
5(a)	both colours referred to correctly as observations in both parts of the answer	1
	(if sulfuric acid is added to solution **Y**,) equilibrium moves to the right-hand side	1
	because the concentration of acid has increased	1
	(if sodium hydroxide is added to solution **Y**,) equilibrium moves to the left-hand side	1
	because sodium hydroxide reacts with / neutralises sulfuric acid	1
5(b)(i)	210 cm^3 **M1** expected volume of hydrogen = 300 cm^3 **M2** 70% of **M1**	2
5(b)(ii)	fewer moles / molecules / particles (of gas) on the left-hand side	1
5(b)(iii)	endothermic	1
5(b)(iv)	increases rate (of reaction)	1

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Q53.

Question	Answer	Marks
5(b)(i)	reversible reaction in which the **rate** of the forward reaction **equals** the **rate** of the backward reaction	1
	concentration of all reactants and products becomes constant / does not change	1
5(b)(ii)	forward reaction is endothermic	1
	(increased temperature) causes equilibrium to shift to the right / to shift in the endothermic direction / to form more nitrogen dioxide / to form more product(s)	1
5(b)(iii)	less brown / lighter / paler / colour fades	1
	more molecules / moles / volume on the right **ORA** **OR** equilibrium shifts in the direction of **fewer** molecules / moles / lower volume	1

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Q54.

Question	Answer	Marks
5(a)(i)	(a substance which) increases the rate of a reaction	1
	without being used up (at the end) / remains unchanged or unaffected or without changing mass	1
5(a)(ii)	variable oxidation states	1
5(b)	any **two** from: high(er) melting point / boiling point (very) hard(er) (very) strong(er) dense(r)	2
5(c)(i)	$ZnSO_4$	1
	H_2 written on product line	1
	states (aq) **AND** (g)	1
5(c)(ii)	(labelled) arrow pointing upwards starting level with reactants and finishing level with top of the hump.	1
5(c)(iii)	exothermic **AND** products are at lower energy (than reactants)	1
5(d)	lower hump starting from reactants line	1

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Q55.

Question	Answer	Marks
4(f)(i)	$Cl_2 + 2e( ) \rightarrow 2Cl^-$	1
4(f)(ii)	(bromide ions) lose electrons / donate electrons / are oxidised	1

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Q56.

Question	Answer	Marks
5(a)	the rate of forward reaction equals (the rate of the) reverse reaction	1
	concentrations of reactants and products are constant	1
5(b)(i)	same number of gas moles on both sides of the equilibrium / same number of gas molecules on both sides of the equilibrium	1
5(b)(ii)	(increased pressure) particles or molecules (forced) closer together / same number of particles or molecules in a smaller volume	1
5(c)(i)	to left / towards reactants / in reverse direction	1
5(c)(ii)	increase / faster	1
	increase / faster	1

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Q57.

Question	Answer	Marks
3(d)(i)	test: lighted splint / flame result: (squeaky) pop	2
3(d)(ii)	any **one** from: increase surface area (of cobalt) powder the metal add a catalyst	1
3(d)(iii)	(particles) have more energy / (particles) move faster	1
	more collisions per second / greater collision rate	1
	more of the colliding molecules have sufficient energy (activation energy) to react	1
3(e)(i)	becomes pink / becomes purple	1
	equilibrium moves right	1
3(e)(ii)	(forward reaction is) exothermic	1
3(f)	3+	1

[0620/41/O/N/2018/Q5]

Q58.

5(a)	**M1** forward and back reactions occur at equal rates	1
	M2 concentration (of substances) remains constant	1
5(b)(i)	equal / same number of moles on each side **or** amount / molecules (of gas) on each side is the same	1
5(b)(ii)	**M1** (forward) reaction exothermic **or** reverse reaction endothermic **M2** yield lower at higher temperature **or** (position of) equilibrium moves left at higher temperature ORA	2
5(c)(i)	at the start / beginning	1
5(c)(ii)	**M1** new line is steeper than printed line and starts at origin	1
	M2 new line reaches same final volume as printed line	1
5(d)(i)	**M1** Faster **and** More particles per unit volume / dm^3 / cm^3 **M2** More collisions per second / unit time or greater collision rate	2
5(d)(ii)	Reaction faster **and** (particles) have more energy **or** (particles) move faster	1
	more collisions per second **or** greater collision rate	1
	more (of the) particles / collisions have energy greater than the activation energy **or** more particles / collisions have sufficient energy to react **or** a greater percentage / proportion / fraction of collisions are successful	1

[0620/42/O/N/2018/Q4]

Q59.

4(a)(i)	Gradient gets less	1
4(a)(ii)	Concentration of HC*l* is decreasing	1
4(a)(iii)	120 seconds	1
4(b)	M1 New line steeper than printed line and starts at origin M2 New line reaches same final volume as printed line	2
4(c)	M1 **Time** taken is less M2 (particles) have more energy M3 (particles) move faster M4 More collisions (of particles) occur per second / per unit time M5 More (of the) particles / collisions have energy greater than activation energy **or** More (of the) particles / collisions have sufficient energy to react **or** A greater percentage / proportion / fraction of collisions (of particles) are successful	5

[0620/43/O/N/2018/Q5]

Q60.

5(a)	**M1** volume of gas **M2** time	2
5(b)	**M1** rate decreases / reaction gets slower **M2** concentration of acid decreases **M3** fewer collisions per unit time	3
5(c)	**M1** particles have **more** kinetic energy **M2** particles move faster **M3 more** collisions **per unit time** **M4 more** of the particles have energy greater than or equal to activation energy / **more** of the collisions have energy greater than or equal to activation energy **OR** **more** of the particles have sufficient energy to react / **more** of the collisions have sufficient energy to react **OR** A greater percentage or greater proportion or greater fraction of collisions are successful	4
5(d)	**ANY TWO FROM:** • increase concentration of hydrochloric acid • decrease particle size of calcium carbonate / increase surface area of calcium carbonate • (add)catalyst	2

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Q61.

[0620/41/M/J/2019/Q2]

2(a)	80(°C) (1)	1
2(b)	horizontal line from end of graph at minute 9 to minute 11 (1)	1
2(c)	energy is used to break bonds / overcome attraction (1) between molecules (1)	2
2(d)	vibrations (1) increase (1)	2
2(e)	melting point decreases (1) boiling point increases (1)	2
2(f)	decrease from 120 °C to 80 °C and horizontal line at 80 °C (1) decrease from horizontal line to finish at 20 °C at 8 mins (1)	2

Q62.

[0620/41/M/J/2019/Q4-A-B]

4(a)(i)	proton donor	1
4(a)(ii)	$(CH_3COOH) \rightleftharpoons CH_3COO^-$ (1) + H^+ (1)	2
4(b)(i)	any **two** from: ☐ faster rate of fizzing ☐ solid dissolves quicker / disappears quicker / gets smaller quicker ☐ fizzing stops quicker ☐ dissolving stops quicker	2
4(b)(ii)	any **three** from: ☐ temperature ☐ volume (of acid) ☐ concentration (of acid) ☐ mass / amount (of $CaCO_3$) ☐ particle size / surface area (of $CaCO_3$)	3

Q63.

[0620/42/M/J/2019/Q4-A-B]

4(a)	water / natural gas / hydrocarbons	1
4(b)	see table below	4

effect on the rate of the reverse reaction	effect on the percentage of methanol in the equilibrium mixture
M1 increases(1)	no change
increases	**M3 decreases(1)**
M2 decreases(1)	**M4 decreases(1)**

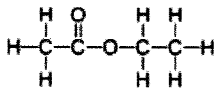
Q64.

[0620/41/O/N/2019/Q3-C]

3(c)(i)	(zinc is) more reactive than iron	1
3(c)(ii)	Fe^{3+} (1) accept / take / gain electrons (1)	2

Q65.

[0620/43/M/J/2019/Q5]

5(a)(i)	ethyl ethanoate	1
5(a)(ii)	correct structure of ethyl ethanoate showing all bonds 	1
5(b)	**M1** right hand energy level lower than left hand side energy level **M2** reactants and product positions identified **M3** energy change shown as approximately vertical line indicating gap between reactants and products with arrow head pointing from reactant to products. Arrow needs to be labelled	3
5(c)	**M1** (a substance which) increases the rate of a reaction **M2** without being used up (at the end) OR unchanged (chemically) at the end OR without changing mass	2
5(d)	**M1** particles / molecules in explanation **M2** (particles) move faster / more energy **M3** more collisions per second or greater collision rate **M4** more of the (colliding) molecules / particles have sufficient energy (activation energy) to react / more of the collisions have sufficient energy (activation energy) to react	4
5(e)(i)	**M1** less ester **M2** equilibrium moves left **and** because forward reaction is exothermic	2
5(e)(ii)	**M1** more ester **M2** (equilibrium moves right) to replace water	2

Q66.

[0620/41/O/N/2019/Q7-C-i-D]

7(c)(i)	speeds up a (chemical) reaction (1) not used up **or** unchanged (at end) (1)	2
7(d)(i)	moves right (1) fewer moles / molecules (of gas) on right (1)	2
7(d)(ii)	(reaction is faster) because more collisions per second (1) particles / molecules closer together **or** more particles / molecules per unit volume (1)	2
7(d)(iii)	moves left (1) (forward) reaction is exothermic **or** backward reaction is endothermic (1)	2

Q67.

[0620/42/O/N/2019/Q3-A-B]

3(a)(i)	$\rightleftharpoons$	1
3(a)(ii)	pressure 100–300 atmospheres / atm (1) temperature in range 330 to 500 °C (1) iron (catalyst) (1) species: $N_2 + 3H_2 \rightleftharpoons 2NH_3$ (1) fully correctly equation (1)	5
3(a)(iii)	water / steam or methane / natural gas	1
3(b)(i)	proton acceptor	1
3(b)(ii)	Contact (process)	1
3(b)(iii)	$2NH_3 + H_2SO_4 \rightarrow (NH_4)_2SO_4$ $(NH_4)_2SO_4$ (1) rest of the equation (1)	2

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Q68.

[0620/43/O/N/2019/Q4-D]

4(d)	fewer **OR** less molecules **OR** moles + on right **OR** in product (1) ORA equilibrium shifts to the right (1)	2

Q69.

[0620/41/M/J/2020/Q3-A-B-C]

3(a)	zinc blende	1
3(b)(i)	reaction is reversible rate of forward reaction = rate of reverse reaction	2
3(b)(ii)	vanadium(V) oxide	1
3(b)(iii)	increases the rate of reaction	1
3(b)(iv)	particles have more energy (E)	1
	rate of collisions increase	1
	a higher proportion of particles have energy greater than activation energy (E > E)	1
3(b)(v)	exothermic	1
3(b)(vi)	*M* of SO_3 = 80	1
	$100 \times \frac{32}{80} = 40\%$	1
3(c)	anhydrous copper(II) sulfate carbon	2

Q70.

[0620/41/M/J/2020/Q4-A-B]

4(a)	(damp) litmus	1
	(turns) blue	1
4(b)(i)	proton accepto	1
4(b)(ii)	bove pH 7 up to 11	1
4(b)(iii)	blue precipitate	1
	precipitate dissolves	1
	deep blue solution remains	1

Q71.

[0620/42/M/J/2020/Q3-A-B-C]

3(a)(i)	heat in ai	1
3(a)(ii)	$2SO_2 + O_2 \rightarrow 2SO_3$ (1) 450°C (1) vanadium(V) oxide (1)	3
3(a)(iii)	rate of forward reaction and rate of backward reaction are equal (1) concentrations of reactants and products are constant (1)	3
3(b)	concentrated sulfuric acid	1
3(c)	$H_2S_2O_7 + H_2O \rightarrow 2H_2SO_4$	2

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Q72.

[0620/42/M/J/2020/Q4-A-B-C]

4(a)	substance that speeds up a reaction / increases rate (1) unchanged (chemically) at the end **OR** not used up **OR** lowers activation energy **OR** provides alternative pathway (1)	2
4(b)	rate decreases (1) particles further apart / less particles per unit volume (1) fewer collisions per unit time / lower collision frequency (1) reaction stops because all hydrogen peroxide is used up	4
4(c)	steeper gradient (1) reaches same volume of oxygen (1)	2

Q73.

[0620/43/M/J/2020/Q2-A-B-C]

2(a)(i)	reversible reaction	1
2(a)(ii)	hydrocarbons (reacting with steam)	1
2(b)	[increasing pressure] increases yield [increasing temperature] decreases yield	2
2(c)	(particles) have more energy OR (particles) move faster more collisions per second OR greater collision rate more (of the) particles OR collisions have sufficient energy / activation energy to react OR a greater percentage / proportion / fraction of collisions are successful	3

Q74.

[0620/41/O/N/2020/Q3]

3(a)(i)	2 → 2 + 2	1
3(b)	75(%)	1
3(c)	test: (damp red) litmus paper (1) result: (litmus goes) blue (1)	2
3(d)(i)	diffusion	1
3(d)(ii)	particles move from an area of high to low concentration particles move randomly	2
3(d)(iii)	CO_2 **molecules** are heavier (than NH_3)	1
3(e)(i)	lower temperature: (rate of reaction) slower (1) higher pressure: expensive/specialist equipment	2
3(e)(ii)	catalyst	1
3(f)(i)	proton accepto	1
3(f)(ii)	any value greater than 7 up to 12	1

Q75.

[0620/41/O/N/2020/Q5-B-C-D]

5(b)(i)	$S + O_2 \rightarrow SO_2$	1
5(b)(ii)	rate of forward reaction is equal to rate of reverse reaction (1) constant concentration (of reactants and products) (1)	2
5(b)(iii)	exothermic / heat / energy is released / surroundings warm up products have lower energy than reactants / OR	2
5(c)	wate / H_2O	1
5(d)	(M_r =) 98 (0.75 × 98 =) 73.5	2

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Q76.

[0620/43/O/N/2020/Q3]

3(a)	triple bond (1) diagram completely correct (1)	2
3(b)(i)	**METHOD 1** **liquid** air (1) **fractional** distillation (1) **METHOD 2** hydrogen burns in **air** (to remove the oxygen and then scrub out the carbon dioxide)	2
3(b)(ii)	(pressure) 200 atmospheres (1) (temperature) 450 °C (1) iron **catalyst** (1) $N_2 + 3H_2 \rightarrow 2NH_3$ (1) equilibrium / reversible (1)	5
3(c)(i)	substance that speeds up a reaction / increases rate (1) unchanged (chemically) at the end **OR** not used **up** **OR** lowers activation energy (1)	2
3(c)(ii)	gain of oxygen / loss of hydrogen / electron loss / increase in oxidation state (oxidation number)	1
3(c)(iii)	*(see table below)*	4
3(d)	$4NO_2 + O_2 + 2H_2O \rightarrow 4HNO_3$ all formulae (1) equation fully correct(1)	2
3(e)	(M_r of NH_4NO_3 =) 80 (1) 35% (1)	2

3(c)(iii):

effect on the rate of the forward reaction	effect on the equilibrium yield of NO(g)
increase (1)	decrease (1)
increase (1)	decrease (1)

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