Chemistry - 0620

■ 50 Questions

Topics Covered :

✓ 4.1 - Electrolysis
✓ 3.1 - Formulae
✓ 6.4 - Redox
✓ 12.5 - Identification of ions and gases
✓ 6.1 - Physical and chemical changes
✓ 5.1 - Exothermic and endothermic reactions
✓ 6.2 - Rate of reaction
✓ 6.3 - Reversible reactions and equilibrium
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Question No 1 - (0620_w21_41_4)

Topics: 12.5 - Identification of ions and gases, 3.1 - Formulae, 4.1 - Electrolysis, 5.1 - Exothermic and endothermic reactions, 6.1 - Physical and chemical changes, 6.2 - Rate of reaction, 6.3 - Reversible reactions and equilibrium, 6.4 - Redox

Subsection Topics: a: 4.1 - Electrolysis | b: 3.1 - Formulae, 6.4 - Redox | c: 4.1 - Electrolysis | d: 12.5 - Identification of ions and gases | e: 3.1 - Formulae, 6.1 - Physical and chemical changes

Chalcopyrite, $FeCuS_2$, is used in the manufacture of sulfuric acid in the Contact process.

(a) In the first stage of the process, chalcopyrite reacts with oxygen in the air to produce sulfur dioxide, SO_2, iron(III) oxide and copper(II) oxide.

Complete the chemical equation for the reaction of $FeCuS_2$ with oxygen.

$4FeCuS_2 + 13O_2 \rightarrow$ ..... + ... + ... [2]

(b) Sulfur dioxide is then converted to sulfur trioxide.

$$2SO_2 + O_2 \rightleftharpoons 2SO_3$$

The reaction is exothermic. It is also an equilibrium.

(i) State **two** features of an equilibrium.

1 .....

2 .....
[2]

(ii) State the temperature and pressure used in this reaction.
Include units.

- temperature .....
- pressure .....
[2]

(iii) Name the catalyst used.

..... [1]

(iv) Explain why a catalyst is used.

..... [1]

(v) Describe and explain, in terms of equilibrium, what happens when the temperature is increased.

.....

..... [2]

(c) Concentrated sulfuric acid is a dehydrating agent.

When glucose is dehydrated, carbon and one other product are formed.

Complete the equation to show the dehydration of glucose, $C_6H_{12}O_6$.

$C_6H_{12}O_6 \rightarrow$ .....C + ... [2]

[Total: 12]

Question No 2 - (0620_s23_41_6)

Topics: 11.3 - Fuels, 11.4 - Alkanes, 11.5 - Alkenes, 11.7 - Carboxylic acids, 11.8 - Polymers, 12.4 - Separation and purification, 6.3 - Reversible reactions and equilibrium, 7.3 - Preparation of salts
Subsection Topics: a: 11.3 - Fuels | b: 11.4 - Alkanes | c: 11.4 - Alkanes | d: 11.5 - Alkenes | e: 11.5 - Alkenes | f: 11.8 - Polymers | g: 11.8 - Polymers | h: 11.7 - Carboxylic acids

This question is about sulfur and compounds of sulfur.

Sulfur is converted into sulfuric acid, H_2SO_4, by the Contact process.

The process involves four stages.

stage 1 Molten sulfur is converted into sulfur dioxide.

stage 2 Sulfur dioxide reacts with oxygen to form sulfur trioxide.

stage 3 Sulfur trioxide combines with concentrated sulfuric acid to form oleum, $H_2S_2O_7$.

stage 4 Oleum reacts to form concentrated sulfuric acid.

(a) (i) In **stage 1**, iron pyrites, FeS_2, can be used instead of molten sulfur.
The iron pyrites is heated strongly in air.

Balance the equation for the reaction occurring when iron pyrites reacts with oxygen in the air.

$$.....FeS_2 + ...O_2 \rightarrow .....Fe_2O_3 + ...SO_2$$ [1]

(ii) Name Fe_2O_3. Include the oxidation number of iron.

..... [1]

(b) The equation for **stage 2** is shown.

$$2SO_2(g) + O_2(g) \rightleftharpoons 2SO_3(g)$$

The forward reaction is exothermic.
The reaction is carried out at a temperature of 450 °C and a pressure of 2 atm.

Using explanations that do **not** involve cost:

(i) explain why a temperature greater than 450 °C is **not** used

.....

..... [1]

(ii) explain why a pressure lower than 2 atm is **not** used.

.....

..... [1]

(c) When sulfuric acid reacts with ammonia the salt produced is ammonium sulfate.

Write the symbol equation for this reaction.

..... [2]

(d) Lead(II) sulfate is an insoluble salt.

Lead(II) sulfate can be made from aqueous ammonium sulfate using a precipitation reaction.

(i) Name a solution that can be added to aqueous ammonium sulfate to produce a precipitate of lead(II) sulfate.

..... [1]

(ii) Write an ionic equation for this precipitation reaction. Include state symbols.

..... [3]

(iii) The precipitate of lead(II) sulfate forms in an aqueous solution.

Describe how pure lead(II) sulfate can be obtained from the mixture.

.....

.....

..... [3]

[Total: 13]

Question No 3 - (0620_s21_41_7)

Topics: 10.3 - Air quality and climate, 11.1 - Formulae, functional groups and terminology, 11.3 - Fuels, 11.5 - Alkenes, 11.8 - Polymers, 12.5 - Identification of ions and gases, 3.1 - Formulae

Subsection Topics: a: 12.5 - Identification of ions and gases | b: 12.5 - Identification of ions and gases | c: 12.5 - Identification of ions and gases | d: 12.5 - Identification of ions and gases

Many organic compounds contain carbon, hydrogen and oxygen only.

(a) An organic compound **V** has the following composition by mass.

C, 48.65%; H, 8.11%; O, 43.24%

Calculate the empirical formula of compound **V**.

empirical formula = ... [3]

(b) Compound **W** has the empirical formula CH_4O and a relative molecular mass of 32.

Calculate the molecular formula of compound **W**.

molecular formula = ... [1]

(c) Compounds **X** and **Y** have the same general formula.

X and **Y** are both carboxylic acids.

Compound **X** has the molecular formula $C_2H_4O_2$.

Compound **Y** has the molecular formula $C_4H_8O_2$.

(i) Deduce the general formula of compounds **X** and **Y**.

..... [1]

(ii) Draw the structure of compound **Y**. Show all of the atoms and all of the bonds.

Name compound **Y**.

name .....
[3]

(iii) Give the name used to describe a 'family' of similar compounds with the same general formula, similar chemical properties and the same functional group.

..... [1]

(d) Propene is an unsaturated hydrocarbon. The formula of propene is shown.

$$CH_3CH{=}CH_2$$

(i) State the colour change observed when propene is added to aqueous bromine.

from ..... to ..... [1]

(ii) Propene can be produced by cracking long chain alkanes.

Pentadecane, $C_{15}H_{32}$, is cracked to produce an alkane and propene in a 1 : 2 molar ratio.

Complete the chemical equation for this reaction.

$C_{15}H_{32} \rightarrow$ ..... + ... [2]

(iii) Propene can be converted into poly(propene).

Name the type of polymerisation that occurs when propene is converted into poly(propene).

..... [1]

(iv) Complete the diagram to show a section of poly(propene).

Question No 4 - (0620_s19_43_1)

Topics: 12.4 - Separation and purification, 2.2 - Atomic structure and the Periodic Table, 8.1 - Arrangement of elements

Subsection Topics: a: 2.2 - Atomic structure and the Periodic Table | b: 2.2 - Atomic structure and the Periodic Table

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]

Question No 5 - (0620_s20_42_6)

Topics: 11.1 - Formulae, functional groups and terminology, 11.2 - Naming organic compounds, 11.4 - Alkanes, 11.5 - Alkenes, 11.7 - Carboxylic acids, 11.8 - Polymers, 5.1 - Exothermic and endothermic reactions
Subsection Topics: a: 11.4 - Alkanes, 11.2 - Naming organic compounds | b: 11.5 - Alkenes, 5.1 - Exothermic and endothermic reactions | c: 11.1 - Formulae, functional groups and terminology | d: 11.8 - Polymers

(a) Propane reacts with chlorine in a photochemical reaction as shown.

$$C_3H_8 + Cl_2 \rightarrow C_3H_7Cl + HCl$$

(i) What type of reaction is this?

..... [1]

(ii) What condition is needed for this photochemical reaction to occur?

..... [1]

(iii) Draw **two** structural isomers of compounds with the formula C_3H_7Cl.
Show all of the atoms and all of the bonds.

[2]

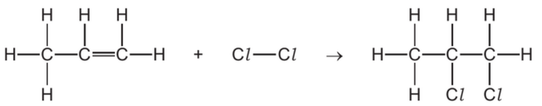
(b) Propene reacts with chlorine in an addition reaction as shown.

$$C_3H_6 + Cl_2 \rightarrow C_3H_6Cl_2$$

(i) State why this is an addition reaction.

..... [1]

(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–Cl	339
Cl–Cl	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.

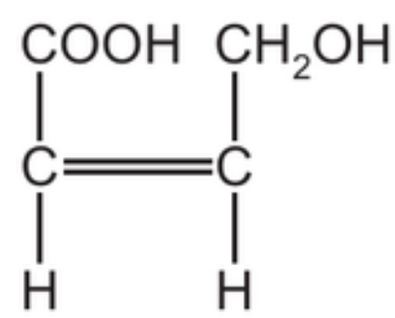
..... kJ

- Calculate the energy change for the reaction between propene and chlorine.

..... kJ / mol
[3]

(c) There are three functional groups in compound **A**.

compound **A**



(i) Name the homologous series of compounds that contains the following structures.

C=C .....

–OH .....

–COOH .....

[3]

(ii) What would you observe when compound **A** is added to:

aqueous bromine .....

aqueous sodium carbonate? .....

[2]

(d) Compound **A** can be used as a single monomer to produce two different polymers.

(i) Draw **one** repeat unit of the addition polymer formed from compound **A**.

[2]

(ii) What type of condensation polymer is formed from compound **A**?

Question No 6 - (0620_w19_41_4)

Topics: 12.4 - Separation and purification, 5.1 - Exothermic and endothermic reactions, 6.2 - Rate of reaction, 7.3 - Preparation of salts

Subsection Topics: a: 12.4 - Separation and purification | b: 7.3 - Preparation of salts

Insoluble salts can be made by precipitation reactions.

A student mixed solutions of some soluble salts.

The results the student obtained are shown in the table.

		second salt solution		
		$Co(NO_3)_2(aq)$	$AgNO_3(aq)$	$Pb(NO_3)_2(aq)$
first salt solution	NaI(aq)	no change	yellow precipitate	yellow precipitate
	$Na_2CO_3(aq)$	purple precipitate	yellow precipitate	white precipitate
	$Na_2SO_4(aq)$	no change	white precipitate	white precipitate

All sodium salts are soluble in water.
Use only results from the table to answer the following questions.

(a) Name:

(i) an insoluble cobalt salt ..... [1]

(ii) an insoluble yellow lead salt. ..... [1]

(b) Write the chemical equation for the reaction in which silver carbonate is formed.

..... [2]

(c) Write the ionic equation for the reaction in which lead(II) iodide is formed.

..... [2]

(d) Aqueous silver nitrate produces a yellow precipitate with both iodide ions and carbonate ions. When testing an unknown solution for iodide ions, the aqueous silver nitrate is acidified.

Explain why the aqueous silver nitrate is acidified.

.....

..... [1]

[Total: 7]

Question No 7 - (0620_m22_42_6)

Topics: 10.2 - Fertilisers, 11.1 - Formulae, functional groups and terminology, 11.4 - Alkanes, 11.5 - Alkenes, 11.6 - Alcohols, 11.7 - Carboxylic acids, 11.8 - Polymers, 12.1 - Experimental design, 12.4 - Separation and purification, 3.1 - Formulae, 6.3 - Reversible reactions and equilibrium, 6.4 - Redox
Subsection Topics: a: 11.1 - Formulae, functional groups and terminology, 3.1 - Formulae | b: 12.4 - Separation and purification | c: 11.7 - Carboxylic acids, 11.6 - Alcohols | d: 11.1 - Formulae, functional groups and terminology, 11.7 - Carboxylic acids | e: 11.8 - Polymers

The names of four esters are listed.

methyl propanoate

ethyl propanoate

propyl propanoate

butyl propanoate

(a) Esters are a family of organic compounds with similar chemical properties. They can be represented by the formula $C_nH_{2n}O_2$.

(i) State the name given to a family of organic compounds with similar chemical properties.

..... [1]

(ii) Explain why members of a family of organic compounds have similar chemical properties.

..... [1]

(iii) State the name given to a formula such as $C_nH_{2n}O_2$.

..... [1]

(iv) Determine the value of '*n*' in butyl propanoate.

..... [1]

(b) All four of the esters in the list are liquids at room temperature.

Name the technique used to separate ethyl propanoate from a mixture of the four esters.

..... [2]

(c) All four esters can be made by reacting different alcohols with the same substance.

(i) Name this substance and draw its structure. Show all of the atoms and all of the bonds.

name .....

structure

[2]

(ii) Name the alcohol used to make methyl propanoate.

..... [1]

(d) Other esters, not in the list, have the same molecular formula as propyl propanoate, but different structures.

(i) State the term used to describe substances with the same molecular formula but different structures.

..... [1]

(ii) Name **two** esters with the same molecular formula as propyl propanoate.

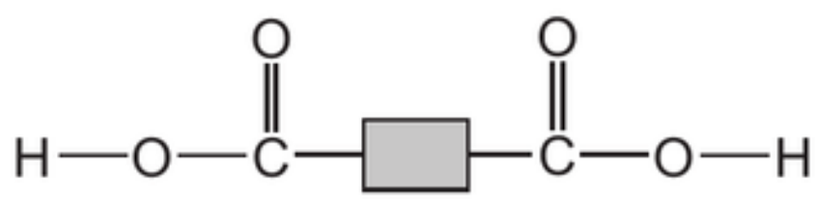
1 .....

2

∠ .....

[2]

(e) Polyesters can be made from the two different molecules shown.



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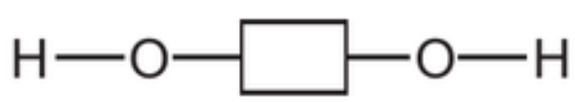


(i) Complete the diagram to show a section of the polyester made from these two molecules. Include all of the atoms and all of the bonds in the linkages.

[3]

(ii) Name the type of polymerisation that takes place when this polymer forms.

..... [1]

(iii) Name a polyester.

Question No 8 - (0620_s24_41_7)

Topics: 11.1 - Formulae, functional groups and terminology, 11.2 - Naming organic compounds, 11.3 - Fuels, 11.5 - Alkenes, 11.6 - Alcohols, 11.7 - Carboxylic acids, 11.8 - Polymers, 3.1 - Formulae

Subsection Topics: a: 3.1 - Formulae | b: 11.8 - Polymers | c: 11.3 - Fuels | d: 11.2 - Naming organic compounds, 11.6 - Alcohols, 11.7 - Carboxylic acids

Many organic compounds contain carbon and hydrogen only.

(a) **(i)** Organic compound **A** has the following composition by mass.

C, 82.76%; H, 17.24%

Calculate the empirical formula of compound **A**.

empirical formula = ... [3]

(ii) Compound **B** has the empirical formula CH_2 and a relative molecular mass of 70.

Determine the molecular formula of compound **B**.

molecular formula = ... [1]

(b) Fig. 7.1 shows a section of polymer **Q**.

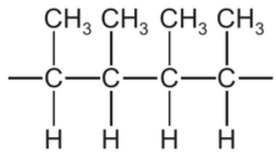


Fig. 7.1

- Draw the displayed formula of the monomer that forms polymer **Q**.

- Name the monomer used to form polymer **Q**.

.....
[3]

(c) Propene, C_3H_6, can be produced by heating $C_{11}H_{24}$. The products of the reaction are propene, hydrogen and one other product in a 1 : 1 : 1 mole ratio.

Complete the symbol equation for this reaction.

$C_{11}H_{24} \rightarrow C_3H_6 + H_2 +$ ..... [1]

(d) Carboxylic acids and esters contain carbon, hydrogen and oxygen only.

An ester **X** and a carboxylic acid **Y** both contain 3 carbon atoms.

X and **Y** have the same molecular formula.

(i) State the name given to compounds with the same molecular formula but different structural formulae.

..... [1]

(ii) Esters are made by the reaction between carboxylic acids and alcohols.

Ester **X** is methyl ethanoate.

Name the carboxylic acid and the alcohol used to make methyl ethanoate.

carboxylic acid .....

alcohol .....
[2]

(iii) Draw the displayed formula of carboxylic acid **Y**. Name the carboxylic acid.

name .....
[2]

[Total: 13]

Question No 9 - (0620_s22_41_4)

Topics: 10.3 - Air quality and climate, 2.5 - Simple molecules and covalent bonds, 3.1 - Formulae, 4.1 - Electrolysis, 6.3 - Reversible reactions and equilibrium, 7.1 - Characteristics of Acids & Bases
Subsection Topics: a: 3.1 - Formulae, 10.3 - Air quality and climate, 7.1 - Characteristics of Acids & Bases | b: 2.5 - Simple molecules and covalent bonds, 3.1 - Formulae

This question is about compounds of sulfur.

(a) Sulfuric acid, H_2SO_4, is manufactured using the Contact process. This manufacture involves four stages.

stage 1 Molten sulfur burns in air to produce sulfur dioxide.

stage 2 Sulfur dioxide reacts with oxygen to form sulfur trioxide.

stage 3 Sulfur trioxide combines with concentrated sulfuric acid to form oleum, $H_2S_2O_7$.

stage 4 Oleum reacts to form concentrated sulfuric acid.

(i) Write a chemical equation for the reaction occurring in **stage 1**.

..... [1]

(ii) State the essential conditions that are necessary for **stage 2**. Write an equation for the chemical reaction that occurs.

.....

.....

.....

..... [4]

(iii) Write a chemical equation for the reaction occurring in **stage 3**.

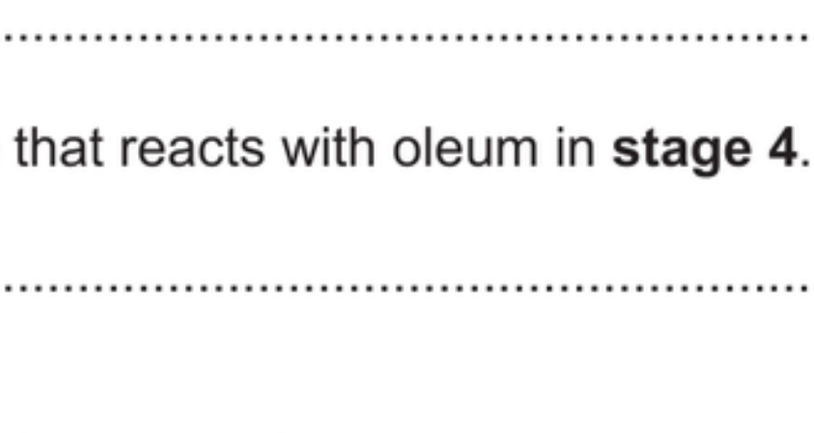
..... [1]

(iv) Name the substance that reacts with oleum in **stage 4**.

..... [1]

(b) Hydrogen sulfide has the formula H_2S.

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



[2]

(ii) Balance the chemical equation for the reaction of hydrogen sulfide with sulfur dioxide shown.

$$.....H_2S + SO_2 \rightarrow .....S + ...H_2O$$ [1]

[Total: 10]

Question No 10 - (0620_w23_42_4)

Topics: 12.4 - Separation and purification, 12.5 - Identification of ions and gases, 4.1 - Electrolysis, 7.3 - Preparation of salts

Subsection Topics: a: 7.3 - Preparation of salts, 12.4 - Separation and purification | b: 4.1 - Electrolysis, 12.5 - Identification of ions and gases

This question is about lead(II) chloride, $PbCl_2$.

(a) A student prepares a sample of insoluble lead(II) chloride, $PbCl_2$, by mixing aqueous solutions of **two** salts in a beaker.

(i) Identify **two** soluble salts suitable for making lead(II) chloride when mixed together.

.....

..... [2]

(ii) Write the ionic equation for the formation of lead(II) chloride by mixing aqueous solutions.

Include state symbols.

..... [3]

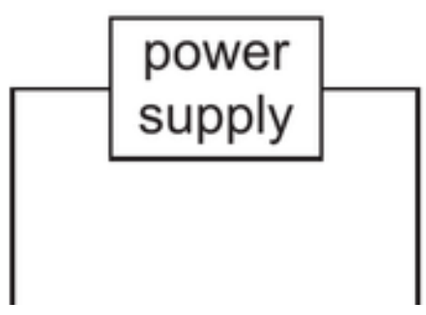
(iii) List the steps the student should take in preparing a pure sample of lead(II) chloride from the mixture in the beaker.

.....

.....

..... [3]

(b) The student carries out an electrolysis experiment on molten lead(II) chloride using the apparatus shown in Fig. 4.1. Chlorine gas forms at the anode and escapes from the apparatus.



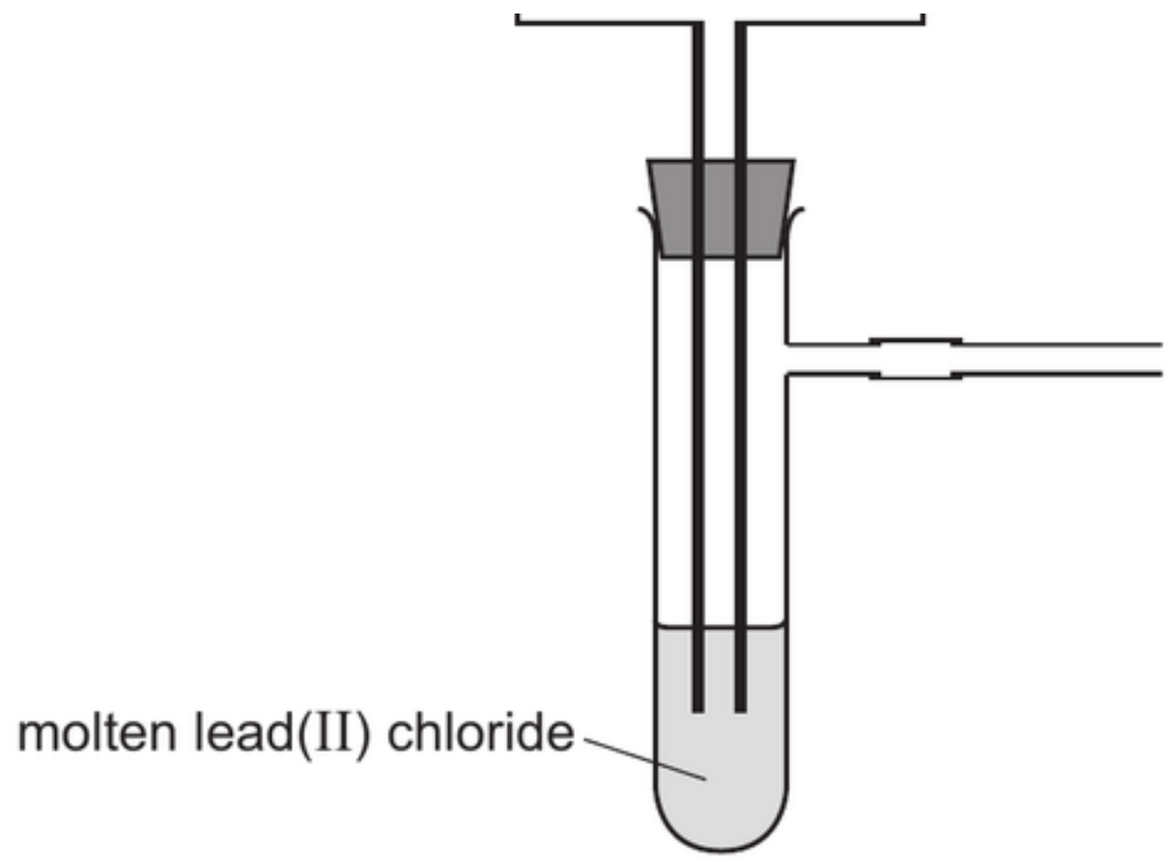


Fig. 4.1

(i) Explain why lead(II) chloride needs to be molten before it will conduct electricity.

.....

..... [1]

(ii) Write the ionic half-equation for the reaction occurring at the anode.

..... [2]

(iii) State the test for chlorine gas.

test .....

observations .....
[2]

(iv) Describe what is observed at the cathode.

..... [1]

[Total: 14]

Question No 11 - (0620_s22_42_6)

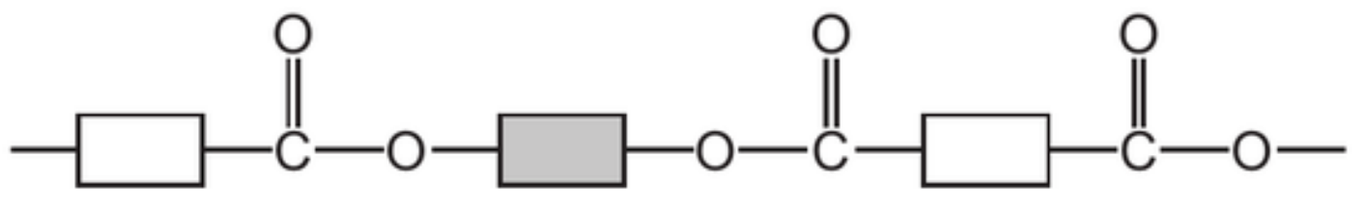
Topics: 11.5 - Alkenes, 11.8 - Polymers

Subsection Topics: a: 11.8 - Polymers | b: 11.8 - Polymers | c: 11.8 - Polymers, 11.5 - Alkenes

This question is about polymers.

(a) Polymer **X** is a condensation polymer.

Part of the structure of polymer **X** is shown.



(i) How many molecules of water are produced when this part of polymer **X** is formed from its monomers?

..... [1]

(ii) Complete the structures of the **two** monomers used to make polymer **X**.

Show all of the atoms and all of the bonds in the functional groups.

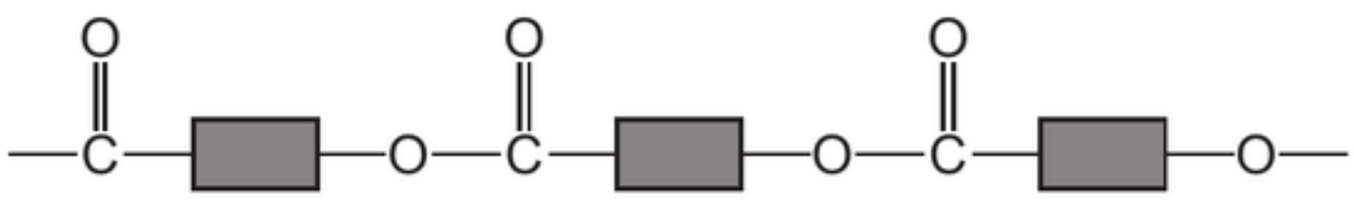
and

[2]

(iii) What type of condensation polymer is **X**?

..... [1]

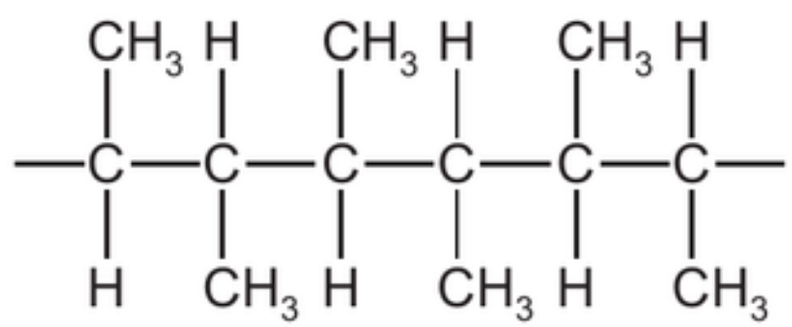
(b) Part of polymer **Y** has the structure shown.



State the number of different types of monomer needed to make polymer **Y**.

..... [1]

(c) Part of polymer **Z** has the structure shown.



(i) Draw and name the structure of the monomer which forms polymer **Z**.

Show all of the atoms and all of the bonds.

name .....

[3]

(ii) Name the chemical process used to make the monomer that forms polymer **Z**.

..... [1]

[Total: 9]

Question No 12 - (0620_w23_43_4)

Topics: 12.1 - Experimental design, 12.5 - Identification of ions and gases, 3.3 - The mole and the Avogadro constant, 4.1 - Electrolysis, 5.1 - Exothermic and endothermic reactions, 6.2 - Rate of reaction, 7.3 - Preparation of salts

Subsection Topics: c: 5.1 - Exothermic and endothermic reactions | a: 7.3 - Preparation of salts, 4.1 - Electrolysis | b: 4.1 - Electrolysis, 12.5 - Identification of ions and gases

This question is about sulfuric acid and salts that are made from sulfuric acid.

(a) Zinc reacts with dilute sulfuric acid. Aqueous zinc sulfate is one of the products.

Powdered zinc is added to dilute sulfuric acid. The mixture is stirred. More zinc is added, with stirring, until the zinc is in excess.

$$Zn(s) + H_2SO_4(aq) \rightarrow ZnSO_4(aq) + H_2(g)$$

The mixture is then filtered.

(i) Name the limiting reactant.

..... [1]

(ii) State two **observations** that indicate the zinc is in excess.

1 .....

2 .....
[2]

(iii) Name the filtrate.

..... [1]

(iv) Name **two** compounds which both react with dilute sulfuric acid to produce aqueous zinc sulfate.

1 .....

2 .....
[2]

(b) Zinc sulfate crystals are produced by heating aqueous zinc sulfate until a saturated solution is formed. When the saturated solution cools down, crystals of zinc sulfate start to form.

(i) State what is meant by the term saturated solution.

.....

..... [2]

(ii) Explain why crystals form when the saturated solution cools down.

..... [1]

(c) Nickel(II) sulfate crystals contain water of crystallisation.

When nickel(II) sulfate crystals, $NiSO_4 \bullet \mathbf{x}H_2O$, are heated, they give off water.

$$NiSO_4 \bullet \mathbf{x}H_2O(s) \rightarrow NiSO_4(s) + \mathbf{x}H_2O(g)$$

A student carries out an experiment to determine the value of **x** in $NiSO_4 \bullet \mathbf{x}H_2O$.

step 1 Nickel(II) sulfate crystals are weighed.

step 2 Nickel(II) sulfate crystals are heated.

step 3 The remaining solid is allowed to cool and is then weighed.

step 4 The remaining solid is heated again, allowed to cool and is then weighed.

step 5 Step 4 is repeated until there is no change in mass.

(i) State the term used to describe crystals that contain water of crystallisation.

..... [1]

(ii) State why **step 4** is repeated until there is no change in mass.

..... [1]

(iii) In an experiment, 0.454 g of nickel(II) sulfate crystals, $NiSO_4 \bullet \mathbf{x}H_2O$, is used. The mass of anhydrous nickel(II) sulfate, $NiSO_4$, remaining is 0.310 g.

[M_r: $NiSO_4$, 155; H_2O, 18]

Determine the value of **x** in $NiSO_4 \bullet \mathbf{x}H_2O$.

Use the following steps.

- Calculate the number of moles of $NiSO_4$ remaining.

moles of $NiSO_4$ = ...

- Calculate the mass of H_2O given off.

mass of H_2O = ... g

- Calculate the number of moles of H_2O given off.

moles of H_2O = ...

- Calculate the value of **x**.

x = ...
[4]

[Total: 15]

Question No 13 - (0620_m19_42_2)

Topics: 2.1 - Elements, compounds and mixtures, 2.2 - Atomic structure and the Periodic Table, 2.3 - Isotopes
Subsection Topics: b: 2.1 - Elements, compounds and mixtures, 2.3 - Isotopes | a: 2.2 - Atomic structure and the Periodic Table

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

Complete the table.

	number of protons	number of electrons	electronic structure	charge
A	11	10	2,8	
B		18		0
C		10	2,8	–1

[4]

(b) (i) Carbon is an element.

Define the term *element*.

.....

..... [1]

(ii) $^{12}_{6}C$, $^{13}_{6}C$ and $^{14}_{6}C$ are isotopes of carbon.

Complete the table.

	number of protons	number of neutrons
$^{12}_{6}C$		
$^{13}_{6}C$		
$^{14}_{6}C$		

[2]

[Total: 7]

Question No 14 - (0620_w22_42_4)

Topics: 1.1 - Solids, liquids and gases, 12.1 - Experimental design, 12.4 - Separation and purification, 3.1 - Formulae, 3.3 - The mole and the Avogadro constant, 5.1 - Exothermic and endothermic reactions, 6.2 - Rate of reaction, 7.3 - Preparation of salts

Subsection Topics: d: 1.1 - Solids, liquids and gases, 12.4 - Separation and purification | e: 3.1 - Formulae, 3.3 - The mole and the Avogadro constant | f: 5.1 - Exothermic and endothermic reactions | a: 3.1 - Formulae | b: 12.1 - Experimental design | c: 12.4 - Separation and purification

A student prepares magnesium sulfate crystals, $MgSO_4$, by adding excess magnesium to dilute sulfuric acid.

(a) Write the chemical equation for this reaction.

..... [1]

(b) Describe **two** observations which show the reaction has finished.

1 .....

2 .....
[2]

(c) The excess magnesium is removed by filtration.

State the general name given to a solid separated from a solution by filtration.

..... [1]

(d) The aqueous magnesium sulfate is heated until crystals begin to appear.

(i) Suggest the name for a solution in which no more solute can dissolve.

..... [1]

(ii) Suggest why more crystals of magnesium sulfate appear on cooling.

..... [1]

(e) Magnesium sulfate crystals have the formula, $MgSO_4 \bullet xH_2O$, where x is a whole number of molecules of water.

The student heats the crystals to remove the molecules of water.

$$MgSO_4 \bullet xH_2O(s) \rightarrow MgSO_4(s) + xH_2O(g)$$

(i) Name the term given to crystals containing molecules of water.

..... [1]

(ii) The student heats a sample of $MgSO_4 \bullet xH_2O$ and finds it has lost 0.140 moles of H_2O and has 2.40 g of $MgSO_4$ remaining.

Determine the value of x. Use the following steps.

- Calculate the M_r of $MgSO_4$.

M_r = ...

- Determine the number of moles of $MgSO_4$ formed.

moles of $MgSO_4$ formed = ...

- Determine the value of x in $MgSO_4 \bullet xH_2O$.

x = ...
[3]

(f) If the student uses dilute nitric acid instead of dilute sulfuric acid, the salt formed is magnesium nitrate, $Mg(NO_3)_2$.

Write the chemical equation for the reaction when solid magnesium nitrate is heated.

..... [2]

[Total: 12]

Question No 15 - (0620_w22_43_3)

Topics: 2.4 - Ions and ionic bonds, 2.5 - Simple molecules and covalent bonds, 3.1 - Formulae, 4.1 - Electrolysis, 6.2 - Rate of reaction, 7.1 - Characteristics of Acids & Bases, 7.2 - Oxides, 9.4 - Reactivity series, 9.6 - Extraction of metals

Subsection Topics: a: 9.6 - Extraction of metals | b: 4.1 - Electrolysis | c: 4.1 - Electrolysis | d: 6.2 - Rate of reaction | e: 7.1 - Characteristics of Acids & Bases | f: 3.1 - Formulae

Aluminium is extracted from its ore by electrolysis.

(a) Name the ore of aluminium which consists mainly of aluminium oxide.

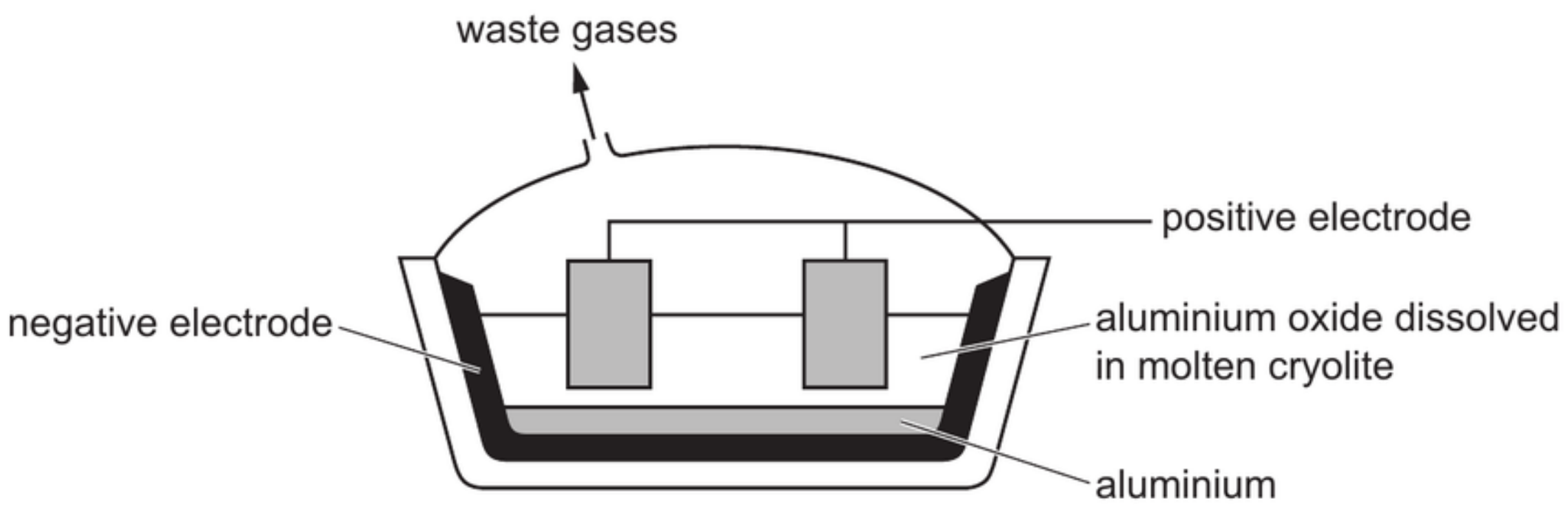
..... [1]

(b) State what is meant by the term *electrolysis*.

.....

..... [2]

(c) Electrolysis is carried out on aluminium oxide dissolved in molten cryolite.



(i) Give **two** reasons why the electrolysis is carried out on aluminium oxide dissolved in molten cryolite instead of electrolysing molten aluminium oxide only.

1 .....

2 .....
[2]

(ii) Write the ionic half-equation for the reaction occurring at the negative electrode.

..... [2]

(iii) The positive electrodes are made of carbon.

Explain why the positive carbon electrodes are replaced regularly.

.....

..... [2]

(d) Aluminium is more reactive than copper.

When aluminium is added to aqueous copper(II) sulfate, no immediate reaction is seen.

Explain why.

..... [1]

(e) Aluminium reacts with oxygen to form an amphoteric oxide.

(i) State what is meant by the term *amphoteric*.

.....

..... [1]

(ii) The reaction between aluminium oxide and aqueous sodium hydroxide forms a salt containing the negative ion AlO_2^-. The only other product is water.

Write a chemical equation for the reaction between aluminium oxide and aqueous sodium hydroxide.

..... [2]

(f) Gallium is in the same group as aluminium and forms similar compounds.

Predict the formulae of:

gallium(III) chloride .....

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

[Total: 15]

Question No 16 - (0620_m20_42_3)

Topics: 2.2 - Atomic structure and the Periodic Table, 2.4 - Ions and ionic bonds, 2.5 - Simple molecules and covalent bonds, 3.3 - The mole and the Avogadro constant, 6.2 - Rate of reaction, 6.3 - Reversible reactions and equilibrium, 8.1 - Arrangement of elements

Subsection Topics: a: 2.2 - Atomic structure and the Periodic Table | b: 2.4 - Ions and ionic bonds | c: 2.5 - Simple molecules and covalent bonds | d: 6.3 - Reversible reactions and equilibrium, 6.2 - Rate of reaction | e: 3.3 - The mole and the Avogadro constant | f: 2.4 - Ions and ionic bonds

The Periodic Table is a method of classifying elements.

(a) Identify the element which is in Group VI and Period 4.

..... [1]

(b) Calcium is in Group II and chlorine is in Group VII of the Periodic Table.

Explain, in terms of number of outer shell electrons and electron transfer, how calcium atoms and chlorine atoms form ions. Give the formulae of the ions formed.

.....

.....

.....

.....

.....

.....

..... [5]

(c) Group V chlorides are covalent molecules. The boiling points of some Group V chlorides are shown.

chloride	boiling point / °C
NCl_3	71
PCl_3	
$AsCl_3$	130
$SbCl_3$	283

(i) Suggest the approximate boiling point of PCl_3.

..... [1]

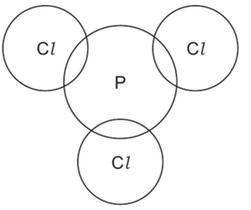
(ii) Explain the trend in boiling points in terms of attractive forces between particles.

.....

..... [2]

(iii) Complete the dot-and-cross diagram to show the electron arrangement in a molecule of PCl_3.

Show outer electrons only.



[3]

(d) PCl_3 reacts with chlorine, Cl_2, to form PCl_5. This reaction is exothermic and reaches an equilibrium.

$$PCl_3(g) + Cl_2(g) \rightleftharpoons PCl_5(g)$$

(i) Describe **two** features of an equilibrium.

.....

.....

..... [2]

(ii) State the effect, if any, on the position of this equilibrium when the following changes are made.
Explain your answers.

temperature is increased .....

.....

pressure is increased .....

.....

[4]

(iii) Explain, in terms of particles, what happens to the rate of the forward reaction when the reaction mixture is heated.

.....

.....

.....

.....

..... [3]

(e) PCl_5 reacts with lithium fluoride, LiF, to form $LiPF_6$.

$$PCl_5 + 6LiF \rightarrow LiPF_6 + 5LiCl$$

Calculate the mass of LiF needed to form 3.04 g of $LiPF_6$ using the following steps.

- Calculate the number of moles of $LiPF_6$ formed.
  [M_r: $LiPF_6$, 152]

number of moles = ...

- Deduce the number of moles of LiF needed.

number of moles = ...

- Calculate the mass of LiF needed.

mass = ... g
[3]

(f) Lithium fluoride has ionic bonding.

(i) What is an ionic bond?

.....

..... [2]

(ii) Give **two** physical properties of ionic compounds.

.....

..... [2]

[Total: 28]

Question No 17 - (0620_w22_41_1)

Topics: 10.2 - Fertilisers, 10.3 - Air quality and climate, 12.5 - Identification of ions and gases, 1.2 - Diffusion, 2.2 - Atomic structure and the Periodic Table, 7.1 - The characteristic properties of acids and bases, 8.1 - Arrangement of elements, 8.2 - Group I properties

Subsection Topics: a: 10.3 - Air quality and climate | b: 10.3 - Air quality and climate | c: 8.2 - Group I properties | d: 10.2 - Fertilisers | e: 1.2 - Diffusion | f: 12.5 - Identification of ions and gases | g: 2.2 - Atomic structure and the Periodic Table | h: 10.3 - Air quality and climate

The names of the elements of Period 2 of the Periodic Table are shown.

lithium beryllium boron carbon nitrogen oxygen fluorine neon

Answer the following questions about these elements.
Each element may be used once, more than once or not at all.

Identify the element which:

(a) is a product of photosynthesis

..... [1]

(b) has an oxide found in clean, dry air

..... [1]

(c) forms a basic oxide with the formula X_2O

..... [1]

(d) is a main component of fertilisers used to improve crop growth

..... [1]

(e) has the highest rate of diffusion at room temperature

..... [1]

(f) produces a red flame in a flame test

..... [1]

(g) has only 5 electrons in each of its atoms

..... [1]

(h) has an oxide responsible for acid rain.

..... [1]

[Total: 8]

Question No 18 - (0620_w23_42_3)

Topics: 3.1 - Formulae, 6.4 - Redox, 7.2 - Oxides, 9.2 - Uses of metals, 9.3 - Alloys and their properties, 9.5 - Corrosion of metals, 9.6 - Extraction of metals

Subsection Topics: a: 9.6 - Extraction of metals | b: 9.6 - Extraction of metals, 3.1 - Formulae, 6.4 - Redox | c: 7.2 - Oxides | d: 9.3 - Alloys and their properties, 9.2 - Uses of metals | e: 9.5 - Corrosion of metals | f: 9.5 - Corrosion of metals

Iron is manufactured in a blast furnace.

(a) Three of the starting materials added to the blast furnace are coke, iron ore and limestone.

Name the **other** starting material added to the blast furnace.

..... [1]

(b) The source of iron in the blast furnace is Fe_2O_3. Fe_2O_3 is found in iron ore.

(i) Name the main ore of iron which contains Fe_2O_3.

..... [1]

(ii) The iron in Fe_2O_3 is reduced by reaction with carbon monoxide. The unbalanced symbol equation is shown.

Complete the equation.

$$Fe_2O_3 + ...CO \rightarrow .....CO_2 + ...Fe$$ [1]

(iii) State the change in oxidation number of iron in the reaction in **(ii)**.

from ..... to ..... [2]

(iv) Explain how the change of oxidation number shows that iron has been reduced.

..... [1]

(c) The major impurity in iron ore is silicon(IV) oxide. Limestone is added to the blast furnace to remove this impurity.

Write two symbol equations to show how silicon(IV) oxide is removed. For each equation, state the type of chemical reaction that takes place.

equation 1 .....

type of chemical reaction .....

equation 2 .....

type of chemical reaction .....

[4]

(d) Iron is converted to steel by mixing it with carbon and other elements.

(i) State the term given to a substance which is a mixture of a metal and other elements.

..... [1]

(ii) Name **one** element, other than carbon, mixed with iron in the making of stainless steel.

..... [1]

(e) Preventing the rusting of steel is important.

State the chemical name of rust.

..... [1]

(f) Steel can be coated with zinc to prevent rusting. This provides both a barrier method and sacrificial protection.

(i) State the term used for coating steel with zinc.

..... [1]

(ii) Describe another barrier method for preventing rusting.

..... [1]

(iii) Explain how zinc provides sacrificial protection.

.....

..... [2]

[Total: 17]

Question No 19 - (0620_s23_43_7)

Topics: 11.1 - Formulae, functional groups and terminology, 11.2 - Naming organic compounds, 11.4 - Alkanes, 11.8 - Polymers

Subsection Topics: a: 11.4 - Alkanes, 11.2 - Naming organic compounds | b: 11.1 - Formulae, functional groups and terminology, 11.8 - Polymers | c: 11.8 - Polymers

This question is about organic compounds.

(a) Propane and chlorine react at room temperature. An equation for the reaction is shown.

$$C_3H_8 + Cl_2 \rightarrow C_3H_7Cl + HCl$$

(i) State the condition required for this reaction.

..... [1]

(ii) Draw the displayed formulae of **two** structural isomers with the formula C_3H_7Cl.

[2]

(b) Alkenes are a homologous series of hydrocarbons.

(i) State **two** characteristics that all members of the same homologous series have in common.

1 .....

2 .....

[2]

(ii) Addition polymers are made from alkenes.

Complete Fig. 7.1 to show one repeat unit of the addition polymer formed from but-2-ene.

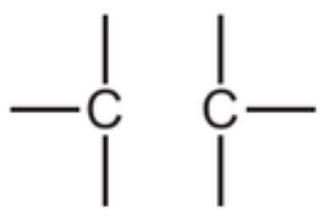


Fig. 7.1

[2]

(c) A repeat unit of a condensation polymer is shown in Fig. 7.2.
The polymer is made from two monomers.

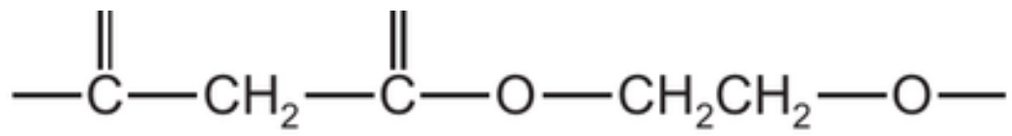


Fig. 7.2

(i) Draw the structures of the monomers used to produce the polymer in Fig. 7.2.

[2]

(ii) Name the **type** of condensation polymer in Fig. 7.2.

..... [1]

(iii) Name the **two** homologous series to which the monomers in **(i)** belong.

1 .....

2 .....

[2]

[Total: 12]

Question No 20 - (0620_s22_42_4)

Topics: 2.4 - Ions and ionic bonds, 2.5 - Simple molecules and covalent bonds, 3.1 - Formulae, 8.3 - Group VII properties

Subsection Topics: c: 2.5 - Simple molecules and covalent bonds | d: 2.4 - Ions and ionic bonds | a: 8.3 - Group VII properties | b: 3.1 - Formulae | e: 2.4 - Ions and ionic bonds

Fluorine and chlorine are halogens.

(a) Suggest the appearance of fluorine.

..... [1]

(b) Fluorine reacts with sulfur to form a compound which has 25.2% sulfur by mass and a relative molecular mass of 254.

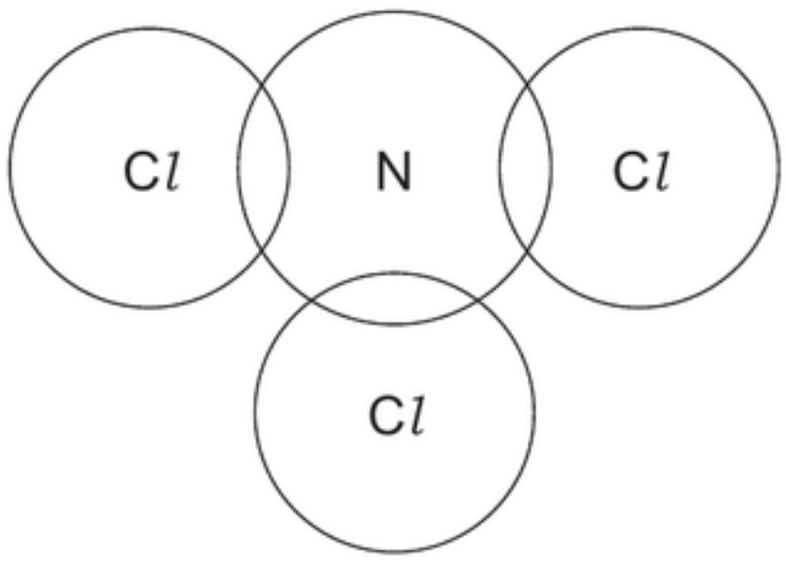
Determine the molecular formula of this compound.

molecular formula = ... [3]

(c) Nitrogen trichloride, NCl_3, is a covalent compound.

Complete the dot-and-cross diagram to show the electron arrangement in a molecule of NCl_3.

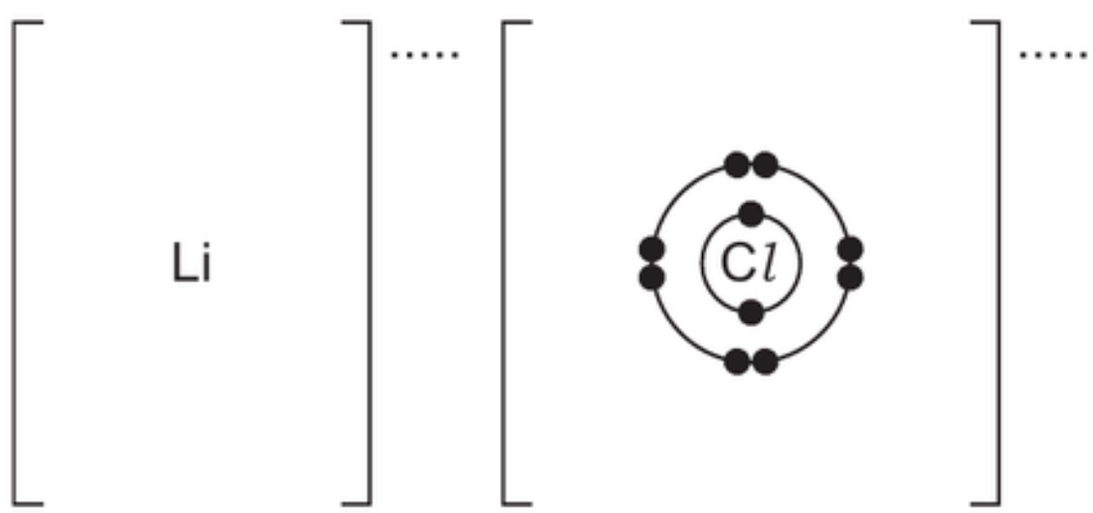
Show outer electrons only.



[3]

(d) Lithium chloride, LiC*l*, is an ionic compound.

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



[3]

(e) Explain, in terms of attractive forces between particles, why LiC*l* is a solid at room temperature but NCl_3 is a liquid with a relatively low boiling point.

.....

.....

..... [3]

[Total: 13]

Question No 21 - (0620_m21_42_6)

Topics: 10.3 - Air quality and climate, 11.3 - Fuels, 11.8 - Polymers, 3.3 - The mole and the Avogadro constant, 5.1 - Exothermic and endothermic reactions, 6.2 - Rate of reaction

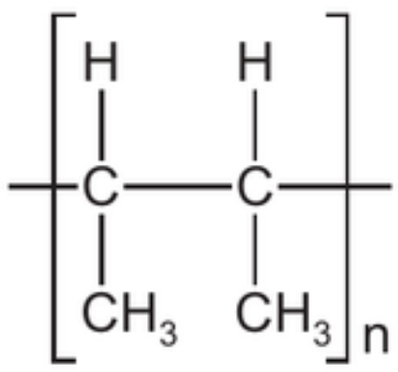
Subsection Topics: a: 11.3 - Fuels | b: 3.3 - The mole and the Avogadro constant | c: 10.3 - Air quality and climate

Polymers are large molecules built up from small molecules.

(a) State the name given to the small molecules from which polymers are made.

..... [1]

(b) The formula of a polymer is shown.



(i) Draw the structure of the small molecule from which this polymer is made. Show all of the atoms and all of the bonds.

[2]

(ii) State the type of polymerisation used to make this polymer.

..... [1]

(c) Three amino acids are shown. They combine to form part of a natural polymer.

(i) Name the type of natural polymer formed when amino acids combine.

..... [1]

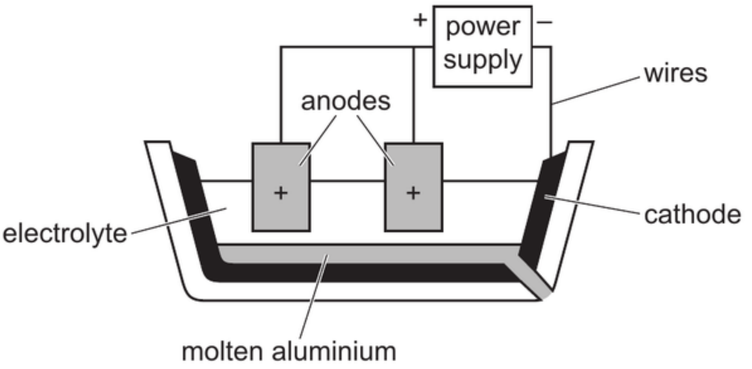
(ii) Complete the diagram to show part of the structure of the natural polymer that forms when these three amino acids combine. Show all of the bonds in the linkages.

Question No 22 - (0620_m20_42_2)

Topics: 2.2 - Atomic structure and the Periodic Table, 2.3 - Isotopes, 3.1 - Formulae, 4.1 - Electrolysis, 7.1 - Characteristics of Acids & Bases, 7.2 - Oxides, 9.6 - Extraction of metals

Subsection Topics: a: 9.6 - Extraction of metals, 4.1 - Electrolysis | b: 9.6 - Extraction of metals, 4.1 - Electrolysis | c: 7.1 - Characteristics of Acids & Bases, 3.1 - Formulae, 9.6 - Extraction of metals

Aluminium is extracted from its ore. The ore is converted into pure aluminium oxide, which then undergoes electrolysis as shown.



(a) **(i)** Name an ore of aluminium.

..... [1]

(ii) What is meant by the term *electrolysis*?

.....

..... [2]

(b) Aluminium oxide has a melting point of about 2000 °C, but the electrolysis process operates at about 900 °C.

(i) Name the compound added to aluminium oxide to reduce the operating temperature.

..... [1]

(ii) Suggest **one** benefit to the environment of reducing the operating temperature.

.....

..... [1]

(iii) Write the ionic half-equation for the reaction taking place at:

the negative electrode (cathode) .....

the positive electrode (anode) .....

[4]

(iv) Explain why the anodes need frequent replacement.

.....

..... [2]

(c) Aluminium oxide reacts with acids and with alkalis.

(i) What term is used to describe an oxide that reacts with acids and with alkalis?

..... [1]

(ii) Aluminium oxide reacts with dilute sulfuric acid to form a salt.

State the name and write the formula of the salt formed.

name .....

formula .....
[2]

(iii) Aluminium oxide reacts with dilute sodium hydroxide to form a salt and one other product.

Name the other product.

..... [1]

(iv) Aluminium hydroxide, $Al(OH)_3$, decomposes when heated to form aluminium oxide and water.

Write the chemical equation for this reaction.

..... [2]

(v) Suggest the names of **two** other aluminium compounds that decompose when heated to form aluminium oxide.

.....

..... [2]

[Total: 19]

Question No 23 - (0620_w23_42_5)

Topics: 11.3 - Fuels, 11.6 - Alcohols, 11.7 - Carboxylic acids, 11.8 - Polymers, 5.1 - Exothermic and endothermic reactions, 6.2 - Rate of reaction, 6.3 - Reversible reactions and equilibrium

Subsection Topics: a: 11.7 - Carboxylic acids, 11.6 - Alcohols | b: 11.3 - Fuels, 11.7 - Carboxylic acids | c: 11.7 - Carboxylic acids | d: 11.8 - Polymers

Chemical reactions can involve transfer of thermal energy.

(a) State the term used for the transfer of thermal energy during a reaction.

..... [1]

(b) Tetrachloromethane gas, $CCl_4(g)$, reacts with steam as shown.

$$CCl_4(g) + 2H_2O(g) \rightleftharpoons CO_2(g) + 4HCl(g)$$

The reaction is reversible. The forward reaction is exothermic.

(i) State what happens, if anything, to the rate of the forward reaction if the concentration of CCl_4 is increased.
Explain your answer in terms of collision theory.

.....

.....

.....

..... [3]

(ii) State what happens to the position of equilibrium, if anything, when the pressure is increased.
Explain your answer.

.....

..... [2]

(iii) Fig. 5.1 shows an incomplete reaction pathway diagram for the forward reaction.

$$CCl_4(g) + 2H_2O(g) \rightleftharpoons CO_2(g) + 4HCl(g)$$

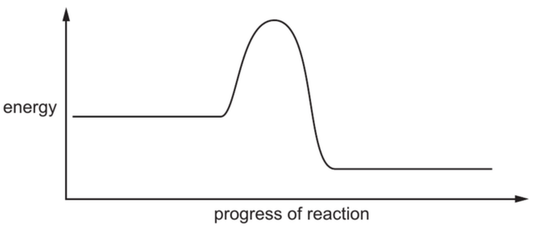


Fig. 5.1

On Fig. 5.1:

- insert the formulae of the reactants and products
- draw an arrow, labelled E_a, to show the activation energy
- draw an arrow, labelled ΔH, to show the transfer of energy in the reaction.

[3]

(iv) Define the term activation energy.

.....

..... [2]

(v) State **one** way in which the activation energy of a reaction can be changed.

..... [1]

(c) The equation for the reaction between tetrachloromethane gas and steam can be represented as shown in Fig. 5.2.

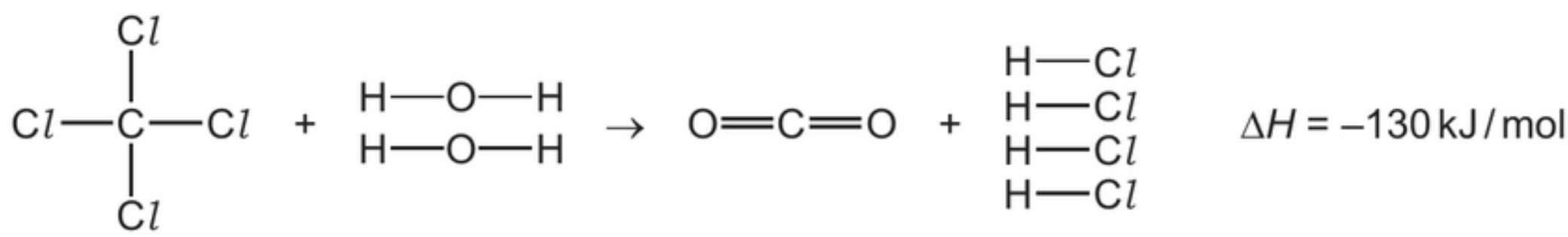


Fig. 5.2

Table 5.1 shows some bond energies.

Table 5.1

bond	C–C*l*	H–O	C=O
bond energy in kJ / mol	340	460	805

Use the bond energies in Table 5.1 and the ΔH value for the reaction to calculate the H–C*l* bond energy using the following steps.

- Calculate the energy needed to break the bonds in the reactants.

..... kJ

- Calculate the energy released when the bonds in carbon dioxide form.

..... kJ

- Calculate the H–C*l* bond energy.

..... kJ / mol
[4]

[Total: 16]

Question No 24 - (0620_s19_41_1)

Topics: 10.3 - Air quality and climate, 12.5 - Identification of ions and gases, 2.2 - Atomic structure and the Periodic Table, 2.3 - Isotopes, 8.5 - Noble gases

Subsection Topics: a: 2.2 - Atomic structure and the Periodic Table | b: 2.3 - Isotopes | c: 2.2 - Atomic structure and the Periodic Table | d: 2.2 - Atomic structure and the Periodic Table

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]

Question No 25 - (0620_w22_43_4)

Topics: 2.5 - Simple molecules and covalent bonds, 3.1 - Formulae, 3.2 - Relative masses of atoms and molecules, 5.1 - Exothermic and endothermic reactions, 6.2 - Rate of reaction, 6.3 - Reversible reactions and equilibrium

Subsection Topics: a: 6.3 - Reversible reactions and equilibrium | b: 2.5 - Simple molecules and covalent bonds | c: 3.1 - Formulae | d: 3.2 - Relative masses of atoms and molecules | e: 3.2 - Relative masses of atoms and molecules

This question is about compounds of phosphorus.

(a) Gaseous phosphorus(V) chloride decomposes into gaseous phosphorus(III) chloride and gaseous chlorine.

When the three gases are present in a closed container the system reaches equilibrium.

$$PCl_5(g) \rightleftharpoons PCl_3(g) + Cl_2(g)$$

(i) Complete the table using only the words *increases*, *decreases* or *no change*.

	effect on the rate of the forward reaction	effect on the equilibrium yield ($PCl_3(g)$ and $Cl_2(g)$)
increasing the temperature		increases
decreasing the pressure		
adding a catalyst		no change

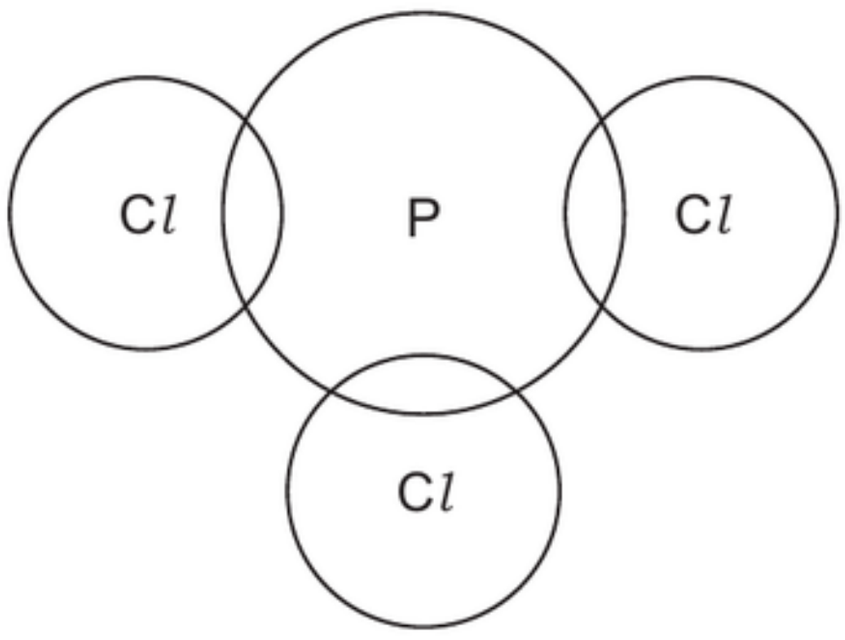
[4]

(ii) The table shows that when the temperature increases, the equilibrium yields of $PCl_3(g)$ and $Cl_2(g)$ increase.

State what conclusion can be made from this.

..... [1]

(b) 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]

(c) Phosphorus oxychloride has the formula $POCl_3$.

Phosphorus oxychloride is the only product of the reaction between phosphorus(V) chloride, PCl_5, and phosphorus(V) oxide, P_4O_{10}.

Write a chemical equation for the reaction between phosphorus(V) chloride and phosphorus(V) oxide.

..... [2]

(d) Compound **X** has the following composition by mass.

H, 3.66%; P, 37.80%; O, 58.54%

Calculate the empirical formula of compound **X**.

empirical formula = ... [2]

(e) Compound **Y** has the empirical formula H_3PO_4 and a relative molecular mass of 98.

Deduce the molecular formula of compound **Y**.

molecular formula = ... [1]

[Total: 12]

Question No 26 - (0620_w23_41_3)

Topics: 12.1 - Experimental design, 3.1 - Formulae, 8.3 - Group VII properties, 9.1 - Properties of metals, 9.4 - Reactivity series

Subsection Topics: a: 9.4 - Reactivity series, 12.1 - Experimental design, 3.1 - Formulae | b: 8.3 - Group VII properties

Order of reactivity can be determined by displacement reactions.

(a) A student investigates the reactivities of four metals by carrying out a series of experiments.

Each of the metals lead, manganese, silver and zinc are added separately to aqueous metal nitrates of the other metals.

(i) Table 3.1 shows some of the results.

Table 3.1

aqueous solution	lead Pb	manganese Mn	silver Ag	zinc Zn
lead(II) nitrate		✓		
manganese(II) nitrate				
silver nitrate	✓	✓		✓
zinc nitrate	✗	✗		

key

✓ = displacement reaction occurs

✗ = displacement reaction does not occur

Complete Table 3.1 and place the four metals in their order of reactivity with the most reactive first.

1 ..... most reactive

2 .....

3 .....

4 .....

[3]

(ii) Suggest why the metal nitrates and not the metal sulfates of these four metals are used as the aqueous solutions.

..... [1]

(iii) Write the symbol equation for the reaction between zinc and silver nitrate.

..... [2]

(b) The reactivity of Group VII elements can be investigated experimentally.

A student bubbles 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.

..... + ...Br^-(aq) → ..... + ... [3]

(iii) The reactivity trend seen in C*l*, Br and I applies to all the elements in Group VII.

Use the Periodic Table to identify the Group VII element which **cannot** displace any other Group VII elements.

..... [1]

[Total: 12]

Question No 27 - (0620_m19_42_6)

Topics: 10.2 - Fertilisers, 11.4 - Alkanes, 11.6 - Alcohols, 11.7 - Carboxylic acids, 12.2 - Acid–base titrations, 3.3 - The mole and the Avogadro constant, 6.3 - Reversible reactions and equilibrium, 7.1 - The characteristic properties of acids and bases, 8.2 - Group I properties, 8.4 - Transition elements, 9.2 - Uses of metals, 9.4 - Reactivity series, 9.5 - Corrosion of metals

Subsection Topics: a: 11.4 - Alkanes | b: 11.4 - Alkanes, 11.6 - Alcohols | c: 11.6 - Alcohols | d: 11.7 - Carboxylic acids

This question is about transition elements.

(a) Transition elements are harder and stronger than Group I elements.

Describe **two** other differences in **physical** properties between transition elements and Group I elements.

1 .....

2 .....
[2]

(b) State **one** physical property of transition elements that is similar to Group I elements.

..... [1]

(c) State **two** chemical properties of transition elements.

1 .....

2 .....
[2]

(d) Cobalt is a transition element. Anhydrous cobalt(II) chloride is used to test for water.

State the colour change that occurs when water is added to anhydrous cobalt(II) chloride.

from ..... to .....
[2]

(e) Iron is a transition element.

(i) Which **two** substances react with iron to form rust?

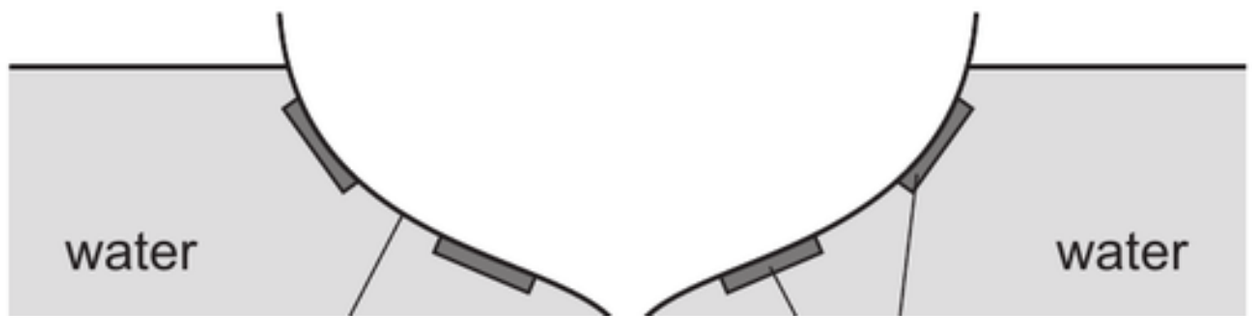
1 .....

2 .....
[2]

(ii) Which metal is used to galvanise iron?

..... [1]

(f) The hull of a ship is made from steel (mainly iron). Metal blocks are placed on the ship's hull to prevent rusting.



Use your knowledge of the reactivity series to explain why:

- magnesium is suitable to use as the metal blocks
- copper is **not** suitable to use as the metal blocks.

.....

.....

..... [2]

(g) Rust contains iron(III) oxide.

Phosphoric acid, H_3PO_4, can be used to remove rust from an iron object and prevent further rusting.

(i) Write a chemical equation for the reaction between iron(III) oxide and phosphoric acid to form iron(III) phosphate and water.

..... [2]

(ii) Iron(III) phosphate is an insoluble salt.

Suggest how the formation of iron(III) phosphate prevents further rusting.

.....

..... [1]

[Total: 15]

Question No 28 - (0620_w19_43_2)

Topics: 10.3 - Air quality and climate, 1.1 - Solids, liquids and gases, 12.1 - Experimental design, 2.4 - Ions and ionic bonds, 2.5 - Simple molecules and covalent bonds, 2.6 - Giant covalent structures, 9.1 - Properties of metals

Subsection Topics: a: 1.1 - Solids, liquids and gases | b: 1.1 - Solids, liquids and gases | c: 2.5 - Simple molecules and covalent bonds | d: 9.1 - Properties of metals | e: 2.6 - Giant covalent structures | f: 2.4 - Ions and ionic bonds

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]

Question No 29 - (0620_w21_42_6)

Topics: 10.2 - Fertilisers, 11.1 - Formulae, functional groups and terminology, 11.3 - Fuels, 11.4 - Alkanes, 11.6 - Alcohols, 11.7 - Carboxylic acids, 12.2 - Acid–base titrations, 3.3 - The mole and the Avogadro constant, 6.3 - Reversible reactions and equilibrium, 7.1 - The characteristic properties of acids and bases
Subsection Topics: a: 11.6 - Alcohols | b: 11.6 - Alcohols | c: 11.4 - Alkanes, 11.3 - Fuels | d: 11.3 - Fuels | e: 11.7 - Carboxylic acids | f: 11.7 - Carboxylic acids

Ethanol, C_2H_5OH, belongs to the homologous series called alcohols.

(a) Write the general formula of alcohols.

..... [1]

(b) Explain why ethanol **cannot** be described as a hydrocarbon.

..... [1]

(c) Ethanol can be manufactured from different substances by reaction with steam or by fermentation.

(i) Give the formula of the substance which reacts with steam to form ethanol.

..... [1]

(ii) Name a substance which will undergo fermentation to form ethanol.

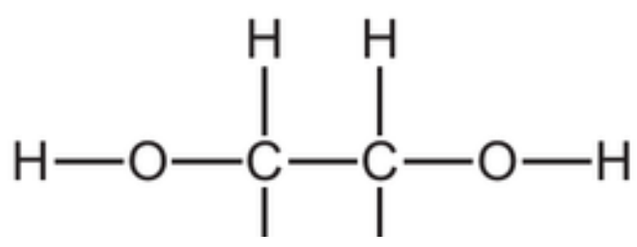
..... [1]

(d) Ethanol is a fuel.

Write the chemical equation for the complete combustion of ethanol.

..... [2]

(e) Ethane-1,2-diol has two alcohol functional groups.



H H

One molecule of ethane-1,2-diol will react with two molecules of ethanoic acid to form molecule **X**.

X has two ester functional groups and a molecular formula of $C_6H_{10}O_4$.

(i) State the empirical formula of **X**.

..... [1]

(ii) Draw the structure of **X**.

Show all of the atoms and all of the bonds.

[2]

(iii) Name the **other** substance formed in this reaction.

..... [1]

(f) Each alcohol functional group in ethane-1,2-diol reacts with acidified potassium manganate(VII) to form a different organic compound, **Y**.

(i) Name the functional groups formed in **Y**.

..... [1]

(ii) Draw the structure of **Y**.

Question No 30 - (0620_s19_42_5)

Topics: 10.1 - Water, 12.1 - Experimental design, 12.5 - Identification of ions and gases, 3.3 - The mole and the Avogadro constant, 4.1 - Electrolysis, 6.2 - Rate of reaction, 7.3 - Preparation of salts

Subsection Topics: a: 10.1 - Water | b: 12.5 - Identification of ions and gases

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]

(b) **Steps 1–5** were done correctly but the mass of crystals obtained was less than the maximum mass.

Explain why.

..... [1]

(c) State **two** observations that would indicate that the copper(II) carbonate is in excess in **step 1**.

1 .....

2 .....
[2]

(d) When the reaction in **step 1** is done using lumps of copper(II) carbonate instead of powder, the rate of reaction decreases. All other conditions are kept the same.

Give a reason for this. Explain your answer in terms of particles.

.....

.....

..... [2]

(e) Name a different substance, other than copper(II) carbonate, that could be added to dilute sulfuric acid to produce copper(II) sulfate in **step 1**.

..... [1]

(f) Name the process used to separate the aqueous copper(II) sulfate from the excess of copper(II) carbonate in **step 2**.

..... [1]

(g) The solution of aqueous copper(II) sulfate was heated until it was saturated in **step 3**.

(i) Suggest what is meant by the term *saturated solution*.

.....

.....

..... [2]

(ii) What evidence would show that the solution was saturated in **step 3**?

..... [1]

(iii) Why should the aqueous copper(II) sulfate **not** be heated to dryness in **step 3**?

..... [1]

[Total: 14]

Question No 31 - (0620_s19_42_2)

Topics: 10.3 - Air quality and climate, 2.2 - Atomic structure and the Periodic Table, 2.3 - Isotopes, 2.4 - Ions and ionic bonds, 2.6 - Giant covalent structures

Subsection Topics: a: 2.3 - Isotopes, 2.2 - Atomic structure and the Periodic Table, 2.4 - Ions and ionic bonds | b: 2.6 - Giant covalent structures, 10.3 - Air quality and climate

(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]

Question No 32 - (0620_w21_41_2)

Topics: 12.1 - Experimental design, 12.5 - Identification of ions and gases, 2.2 - Atomic structure and the Periodic Table, 2.3 - Isotopes, 3.1 - Formulae, 3.2 - Relative masses of atoms and molecules, 3.3 - The mole and the Avogadro constant, 6.1 - Physical and chemical changes, 9.1 - Properties of metals
Subsection Topics: b: 12.5 - Identification of ions and gases, 3.1 - Formulae, 12.1 - Experimental design | a: 2.3 - Isotopes, 2.2 - Atomic structure and the Periodic Table, 3.2 - Relative masses of atoms and molecules | c: 12.5 - Identification of ions and gases, 3.1 - Formulae | d: 3.3 - The mole and the Avogadro constant | e: 6.1 - Physical and chemical changes

This question is about copper and its compounds.

(a) Copper has two different naturally occurring atoms, ^{63}Cu and ^{65}Cu.

(i) State the term used for atoms of the same element with different nucleon numbers.

..... [1]

(ii) The atomic number of copper is 29.

Complete the table to show the number of protons, neutrons and electrons in the particles of copper shown.

	^{63}Cu	$^{65}Cu^{2+}$
protons		
neutrons		
electrons		

[3]

(iii) Relative atomic mass is the average mass of naturally occurring atoms of an element.

The percentage of the naturally occurring atoms in a sample of copper is shown.

^{63}Cu	^{65}Cu
70%	30%

Deduce the relative atomic mass of copper in this sample.

Give your answer to **one** decimal place.

relative atomic mass = ... [2]

(b) Anhydrous copper(II) sulfate is used to test for the presence of water. When this test is positive, hydrated copper(II) sulfate is formed.

(i) State the colour change seen during this test.

from ..... to ..... [2]

(ii) Complete the chemical equation to show the reaction that takes place.

$$CuSO_4 + \text{.....} \rightleftharpoons CuSO_4{\bullet}5H_2O$$ [1]

(iii) State how hydrated copper(II) sulfate can be turned back into anhydrous copper(II) sulfate.

..... [1]

(iv) Describe a test for pure water.

.....

..... [2]

(c) Aqueous copper(II) sulfate contains $Cu^{2+}(aq)$ ions.

(i) Describe what is seen when aqueous copper(II) sulfate is added to aqueous sodium hydroxide, NaOH(aq).

..... [1]

(ii) Write the ionic equation for the reaction between aqueous copper(II) sulfate and aqueous sodium hydroxide.

Include state symbols.

..... [3]

(d) When solid copper(II) nitrate is heated copper(II) oxide, nitrogen dioxide and oxygen are formed.

$$2Cu(NO_3)_2 \rightarrow 2CuO + 4NO_2 + O_2$$

Calculate the volume of nitrogen dioxide formed at room temperature and pressure when 4.7 g of $Cu(NO_3)_2$ is heated.

Use the following steps:

- calculate the mass of one mole of $Cu(NO_3)_2$

..... g

- calculate the number of moles of $Cu(NO_3)_2$ used

..... moles

- determine the number of moles of nitrogen dioxide formed

..... moles

- calculate the volume of nitrogen dioxide formed at room temperature and pressure.

..... dm^3
[4]

(e) Write the chemical equation to show the action of heat on sodium nitrate, $NaNO_3$.

..... [2]

[Total: 22]

Question No 33 - (0620_w21_43_4)

Topics: 2.3 - Isotopes, 2.6 - Giant covalent structures, 3.3 - The mole and the Avogadro constant, 5.1 - Exothermic and endothermic reactions, 6.2 - Rate of reaction

Subsection Topics: a: 2.3 - Isotopes | b: 2.6 - Giant covalent structures | c: 3.3 - The mole and the Avogadro constant

Carbon is an important element.

(a) Carbon exists as the isotopes $^{12}_{6}C$ and $^{13}_{6}C$.

Complete the table.

isotope	number of protons in one atom	number of electrons in one atom	number of neutrons in one atom
$^{12}_{6}C$			
$^{13}_{6}C$			

[2]

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

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

(c) The Avogadro constant is the number of particles in 1 mole.

The numerical value of the Avogadro constant is 6.02×10^{23}.

(i) Calculate the number of molecules in 22.0 g of carbon dioxide, CO_2.

..... molecules [2]

(ii) Calculate the number of molecules in 6.00 dm^3 of carbon dioxide gas at room temperature and pressure.

..... molecules [1]

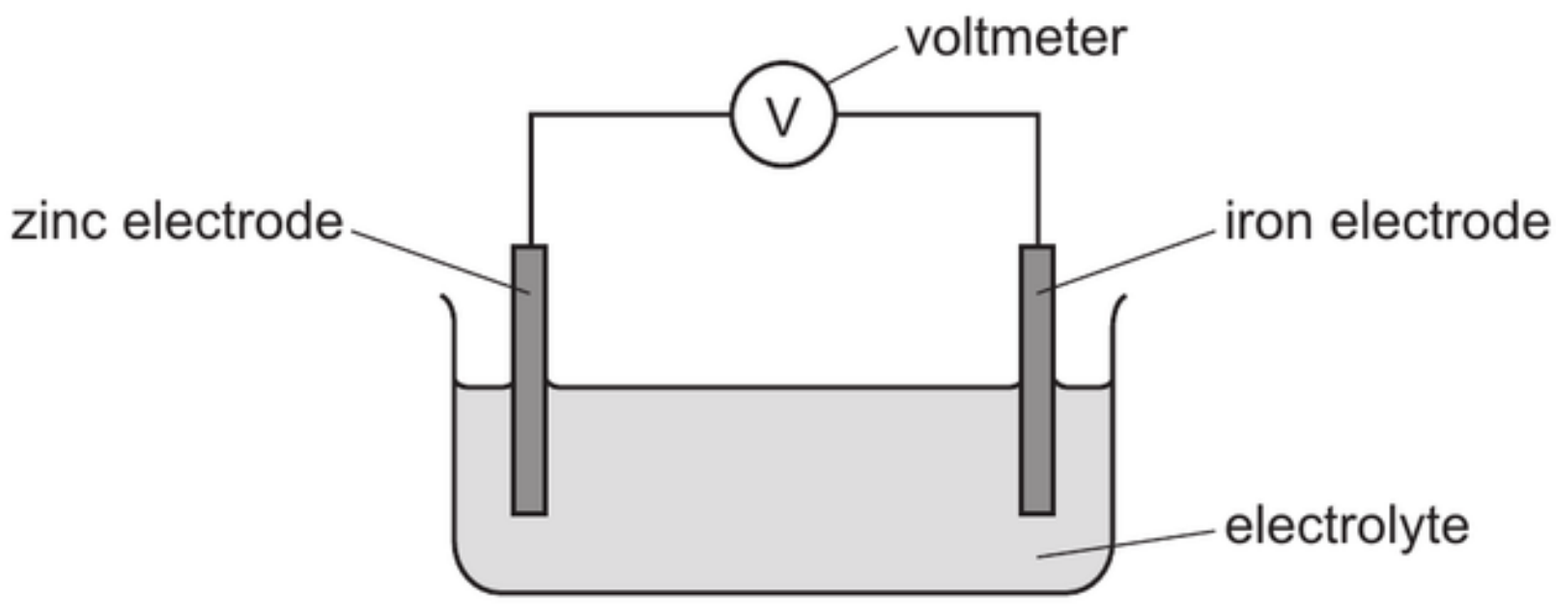
[Total: 6]

Question No 34 - (0620_m22_42_4)

Topics: 3.1 - Formulae, 3.3 - The mole and the Avogadro constant, 4.1 - Electrolysis, 4.2 - Hydrogen–oxygen fuel cells, 5.1 - Exothermic and endothermic reactions, 6.2 - Rate of reaction, 9.4 - Reactivity series
Subsection Topics: a: 4.2 - Hydrogen–oxygen fuel cells | b: 9.4 - Reactivity series | c: 4.2 - Hydrogen–oxygen fuel cells | d: 4.1 - Electrolysis | e: 4.1 - Electrolysis

This question is about chemical reactions and electricity.

(a) The diagram shows the apparatus used in the production of electrical energy in a simple cell.



The zinc electrode dissolves in the electrolyte forming $Zn^{2+}(aq)$ ions.

(i) Draw an arrow on the diagram to show the direction of electron flow. [1]

(ii) Write the ionic half-equation for the reaction that occurs when the zinc electrode dissolves.

..... [2]

(b) The reading on the voltmeter can be increased if either zinc or iron is replaced by another metal.

(i) Name a metal that can replace zinc and increase the reading on the voltmeter.

..... [1]

(ii) Name a metal that can replace iron and increase the reading on the voltmeter.

..... [1]

(c) Fuel cells are used to generate electricity.

(i) Name the reactants in a fuel cell.

..... [1]

(ii) Name the waste product of a fuel cell.

..... [1]

(d) Electricity can be used to break down aqueous or molten ionic compounds.

(i) Name the process which uses electricity to break down aqueous or molten ionic compounds.

..... [1]

(ii) Explain why the ionic compound needs to be aqueous or molten.

..... [1]

(e) Brine is concentrated aqueous sodium chloride.

(i) Name **three** substances which are manufactured by passing electricity through brine.

1 .....

2 .....

3 .....

[3]

(ii) Name a different substance formed when molten sodium chloride is used instead of concentrated aqueous sodium chloride.

..... [1]

[Total: 13]

Question No 35 - (0620_s23_43_6)

Topics: 10.2 - Fertilisers, 12.5 - Identification of ions and gases, 3.1 - Formulae, 6.2 - Rate of reaction, 6.3 - Reversible reactions and equilibrium, 6.4 - Redox, 7.3 - Preparation of salts

Subsection Topics: a: 10.2 - Fertilisers, 6.2 - Rate of reaction | b: 10.2 - Fertilisers, 3.1 - Formulae | c: 3.1 - Formulae, 12.5 - Identification of ions and gases, 7.3 - Preparation of salts

This question is about nitrogen and compounds of nitrogen.

(a) Ammonia is manufactured by the reaction between nitrogen and hydrogen in the Haber process.
The equation is shown.

$$N_2(g) + 3H_2(g) \rightleftharpoons 2NH_3(g)$$

(i) State the source of nitrogen for the Haber process.

..... [1]

(ii) State the source of hydrogen for the Haber process.

..... [1]

(iii) State the typical conditions used in the Haber process.

temperature ..... °C

pressure ..... atm

[2]

(iv) Name the catalyst used in the Haber process.

..... [1]

(v) State what is meant by the term catalyst.

.....

..... [2]

(b) Ammonia is converted into nitric acid.

(i) The first stage is the conversion of ammonia into nitrogen monoxide, NO.
The equation is shown.

$$4NH_3(g) + 5O_2(g) \rightleftharpoons 4NO(g) + 6H_2O(g)$$

The reaction is carried out at a temperature of 900 °C and a pressure of 7 atm.
The forward reaction is exothermic.

Using explanations that do **not** involve cost:

- explain why a temperature less than 900 °C is **not** used

.....

- explain why a pressure greater than 7 atm is **not** used.

.....

[2]

(ii) In the second stage, nitrogen monoxide reacts with water and oxygen to produce nitric acid.

Balance the symbol equation for the reaction.

$$.....NO + ...O_2 + ...H_2O \rightarrow .....HNO_3$$ [1]

(c) A student makes aqueous copper(II) nitrate by adding an excess of solid copper(II) carbonate to dilute nitric acid.

(i) Write the symbol equation for this reaction.

..... [2]

(ii) State **two** observations that indicate the copper(II) carbonate is in excess.

1 .....

2 .....
[2]

(iii) Name **one** compound, other than copper(II) carbonate, that can be added to dilute nitric acid to produce aqueous copper(II) nitrate.

..... [1]

[Total: 15]

Question No 36 - (0620_s24_42_1)

Topics: 10.3 - Air quality and climate, 11.3 - Fuels, 11.5 - Alkenes, 6.4 - Redox, 8.5 - Noble gases, 9.6 - Extraction of metals

Subsection Topics: a: 11.3 - Fuels, 10.3 - Air quality and climate, 11.5 - Alkenes, 8.5 - Noble gases, 9.6 - Extraction of metals | b: 6.4 - Redox

A list of gases is shown.

ammonia
helium
hydrogen
carbon dioxide
carbon monoxide
chlorine
methane
nitrogen dioxide
propene
sulfur dioxide

Answer the following questions about these gases.

Each gas may be used once, more than once or not at all.

(a) State **one** gas which:

(i) is the main constituent of natural gas

..... [1]

(ii) is responsible for both photochemical smog **and** acid rain

..... [1]

(iii) is unsaturated

..... [1]

(iv) has monatomic particles

..... [1]

(v) reduces iron(III) oxide in a blast furnace.

..... [1]

(b) Nitrogen dioxide, NO_2, and carbon monoxide are removed from a car exhaust by a catalytic converter.

Write the symbol equation for this reaction.

..... [2]

[Total: 7]

DO NOT WRITE IN THIS MARGIN

Question No 37 - (0620_w19_42_3)

Topics: 2.4 - Ions and ionic bonds, 2.5 - Simple molecules and covalent bonds, 3.3 - The mole and the Avogadro constant, 5.1 - Exothermic and endothermic reactions, 6.3 - Reversible reactions and equilibrium, 6.4 - Redox, 7.1 - Characteristics of Acids & Bases, 7.1 - The characteristic properties of acids and bases, 7.3 - Preparation of salts

Subsection Topics: a: 2.5 - Simple molecules and covalent bonds | d: 7.1 - Characteristics of Acids & Bases | e: 7.1 - Characteristics of Acids & Bases | b: 5.1 - Exothermic and endothermic reactions | c: 6.4 - Redox

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]

(c) When aqueous ammonia is added to aqueous iron(II) sulfate a green precipitate is seen. This green precipitate turns red-brown at the surface.

(i) Name the green precipitate.

..... [1]

(ii) Suggest why the green precipitate turns red-brown at the surface.

.....

..... [2]

(iii) State what happens when an excess of aqueous ammonia is added to the green precipitate.

..... [1]

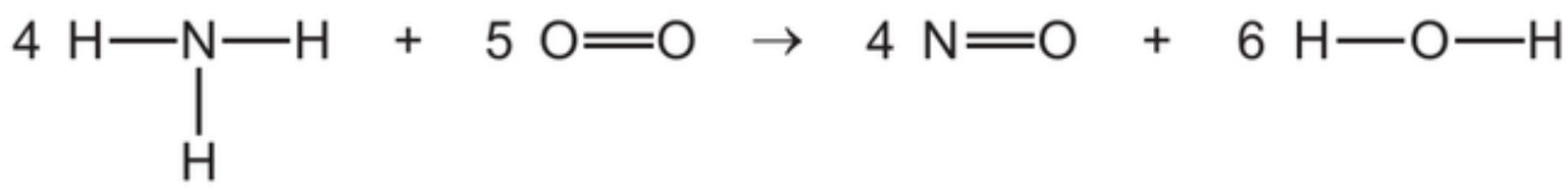
(d) Ammonia reacts with oxygen as shown.

$$4NH_3(g) + 5O_2(g) \rightarrow 4NO(g) + 6H_2O(g)$$

(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]

(ii) The chemical equation for the reaction can be represented as shown.



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]

[Total: 22]

BESTGRADEZ

Question No 38 - (0620_w24_43_3)

Topics: 11.8 - Polymers, 1.1 - Solids, liquids and gases
Subsection Topics: a: 11.8 - Polymers | e: 11.8 - Polymers | b: 11.8 - Polymers | c: 11.8 - Polymers | d: 11.8 - Polymers

This question is about compounds of tin.

(a) Tin(IV) oxide has the formula SnO_2.

The relative formula mass, M_r, of SnO_2 is 151.

Calculate the percentage by mass of tin in SnO_2.

percentage by mass of tin in SnO_2 = ...% [1]

(b) SnO_2 is an amphoteric oxide.

SnO_2 reacts with aqueous sodium hydroxide, NaOH, to form a sodium salt and water only. The sodium salt contains a negative ion with the formula SnO_3^{2-}.

(i) State the meaning of the term amphoteric.

.....

..... [1]

(ii) Write the symbol equation for the reaction between SnO_2 and NaOH.

..... [2]

(c) Tin is a metal that forms both covalent and ionic compounds.

Suggest why this is unusual for a metal.

..... [1]

(d) **(i)** Tin(IV) chloride, $SnCl_4$, is covalently bonded.

A tin atom has four electrons in its outer shell.

Complete the dot-and-cross diagram in Fig. 3.1 for a molecule of $SnCl_4$.
Show the outer shell electrons only.

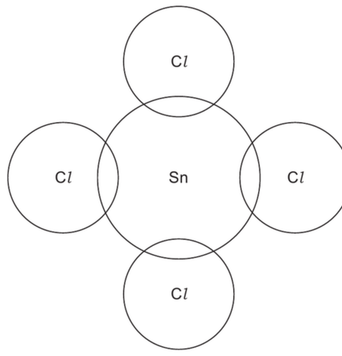


Fig. 3.1

[2]

(ii) Tin(II) oxide, SnO, is ionically bonded.

The melting points of $SnCl_4$ and SnO are shown in Table 3.1.

Table 3.1

	melting point / °C
$SnCl_4$	–33
SnO	1080

Explain, in terms of structure and bonding, why $SnCl_4$ has a much lower melting point than SnO.

.....

.....

.....

.....

..... [3]

(e) Part of the reactivity series is shown.

magnesium	most reactive
aluminium	↑
tin	
copper	least reactive

DO NOT WRITE IN THIS MARGIN

(i) When aluminium foil is added to aqueous tin(II) sulfate, a reaction does **not** occur even though aluminium is above tin in the reactivity series.

Explain why a reaction does **not** occur.

.....

..... [1]

(ii) An aqueous solution of tin(II) sulfate contains Sn^{2+} ions.

Two experiments are carried out.

Experiment 1 Copper is added to aqueous tin(II) sulfate.

Experiment 2 Magnesium is added to aqueous tin(II) sulfate.

Write an ionic equation for any reaction that occurs in each experiment.
If no reaction occurs, write 'no reaction'.

Experiment 1 .....

Experiment 2 .....
[2]

(f) Hydrated tin(II) nitrate, $Sn(NO_3)_2 \bullet 20H_2O$, decomposes when it is heated.

(i) State what is meant by the term hydrated.

.....

..... [1]

(ii) Complete the equation for the decomposition of $Sn(NO_3)_2 \bullet 20H_2O$.

$$2Sn(NO_3)_2 \bullet 20H_2O \rightarrow \text{.....}SnO + \text{.....}NO_2 + O_2 + \text{.....}H_2O$$

[2]

[Total: 16]

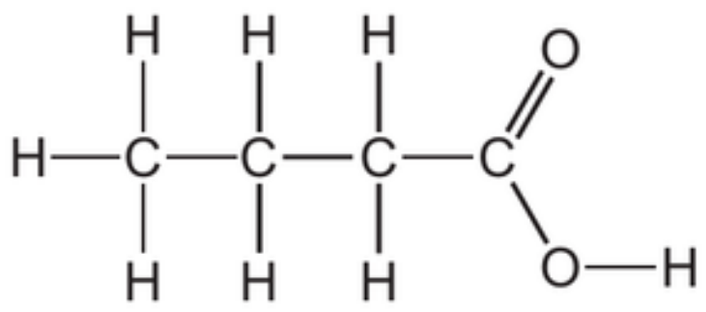
Question No 39 - (0620_s20_43_1)

Topics: 11.1 - Formulae, functional groups and terminology, 11.2 - Naming organic compounds, 11.4 - Alkanes, 11.5 - Alkenes, 11.6 - Alcohols, 11.7 - Carboxylic acids, 12.4 - Separation and purification, 2.2 - Atomic structure and the Periodic Table, 3.1 - Formulae, 7.1 - Characteristics of Acids & Bases, 7.1 - The characteristic properties of acids and bases, 8.1 - Arrangement of elements
Subsection Topics: a: 11.6 - Alcohols, 3.1 - Formulae, 11.5 - Alkenes, 11.4 - Alkanes, 11.7 - Carboxylic acids, 11.2 - Naming organic compounds | b: 7.1 - Characteristics of Acids & Bases

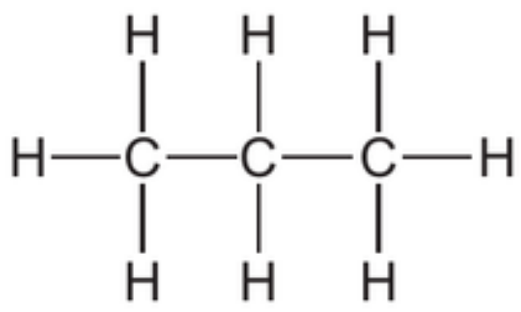
(a) The structures of five organic compounds, **A**, **B**, **C**, **D** and **E**, are shown.

Answer the questions that follow.
Each letter may be used once, more than once or not at all.

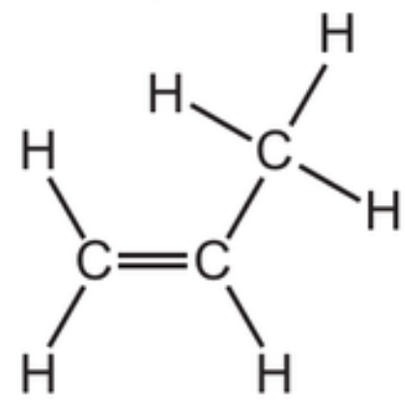
A



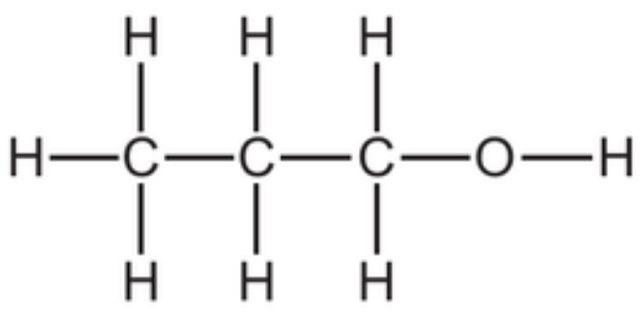
B



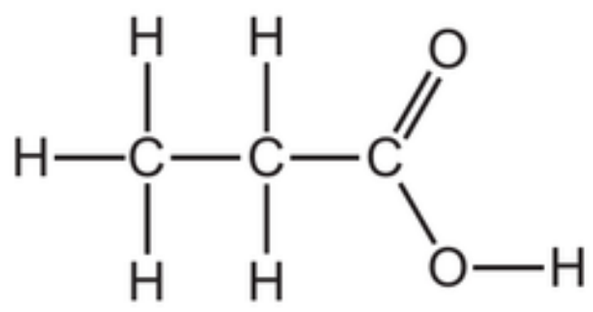
C



D



E



(i) Give the letter of the compound that is propan-1-ol.

..... [1]

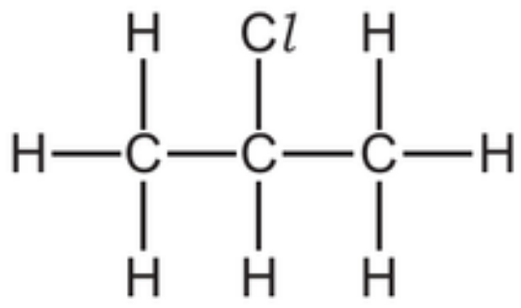
(ii) Give the letter of the compound that has the empirical formula CH_2.

..... [1]

(iii) Give the letter of **one** compound that reacts with bromine in an addition reaction.

..... [1]

(iv) Give the letter of **one** compound that reacts with chlorine to form the compound shown.



..... [1]

(v) Give the letters of **two** compounds that can react with each other to form an ester.

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

(vi) Give the letter of the compound that is in the same homologous series as hex-1-ene.

..... [1]

(vii) Give the letter of **one** compound that is an acid.

..... [1]

(viii) Draw a structural isomer of compound **D**.

Show all of the atoms and all of the bonds.

[1]

(b) Some acids are described as weak acids.

State the meaning of the term *weak acid*.

weak .....

acid .....
[2]

[Total: 10]

Question No 40 - (0620_w19_43_7)

Topics: 11.8 - Polymers

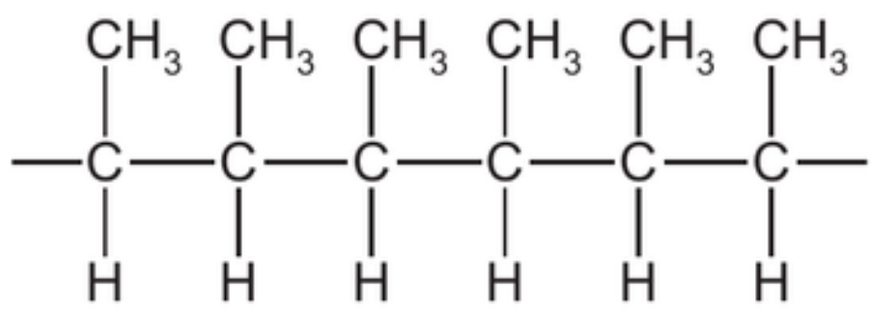
Subsection Topics: a: 11.8 - Polymers | b: 11.8 - Polymers

Addition polymerisation and condensation polymerisation are two types of polymerisation.

(a) Which functional group is present in all the monomers which are used to make addition polymers?

..... [1]

(b) Part of an addition polymer is shown.



(i) How many monomer units are needed to make the part of the addition polymer shown?

..... [1]

(ii) Draw the structure of the monomer that is used to make this addition polymer. Show all of the atoms and all of the bonds.

Name the monomer.

name ..... [2]

(iii) State the empirical formula of:

the monomer .....

the polymer. ..... [2]

(c) Complex carbohydrates are natural condensation polymers. They can be broken down into colourless monomers which can then be separated and identified.

X is a complex carbohydrate.

Starting with a sample of **X**, describe how to produce, separate, detect and identify the

Starting with a sample of **X**, describe how to produce, separate, detect and identify the monomers which make it up.

Your answer should include:

- the name of the process used to break down **X** into its monomers
- **two** types of substance that can be used to break down **X**
- the name of the process used to **separate** the monomers
- the method used to **detect** the monomers after they have been separated
- the method used to **identify** the monomers after they have been separated and detected.

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

..... [6]

(d) Synthetic polyamides are condensation polymers.

(i) Name a synthetic polyamide.

Question No 41 - (0620_w24_42_5)

Topics: 11.3 - Fuels, 11.5 - Alkenes, 11.8 - Polymers, 3.1 - Formulae, 6.1 - Physical and chemical changes
Subsection Topics: d: 11.8 - Polymers | a: 11.3 - Fuels | b: 11.3 - Fuels | c: 3.1 - Formulae, 6.1 - Physical and chemical changes

Alkenes are manufactured by cracking larger alkane molecules.

(a) State the source of the large alkane molecules used in cracking.

..... [1]

(b) State **two** conditions needed for cracking large alkane molecules.

1 .....

2 .....

[2]

(c) When one molecule of dodecane, $C_{12}H_{26}$, is cracked, three molecules of but-1-ene and one other product are formed.

(i) Use molecular formulae to complete the symbol equation for this reaction.

$C_{12}H_{26} \rightarrow$ ..... + ...

[2]

(ii) Suggest the type of chemical reaction which happens during cracking.

..... [1]

(d) Propene will undergo polymerisation.

(i) Suggest the name of the polymer formed from propene.

..... [1]

(ii) Draw part of this polymer molecule to show **three** repeat units.

[3]

(iii) State the type of polymerisation propene undergoes.

..... [1]

[Total: 11]

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Question No 42 - (0620_m22_42_5)

Topics: 11.3 - Fuels, 11.4 - Alkanes, 11.5 - Alkenes, 4.1 - Electrolysis, 5.1 - Exothermic and endothermic reactions

Subsection Topics: a: 11.3 - Fuels | b: 11.4 - Alkanes | c: 11.5 - Alkenes, 5.1 - Exothermic and endothermic reactions

This question is about alkanes and alkenes.

(a) Short-chain alkanes and alkenes can be formed from long-chain alkanes in a chemical reaction.

(i) Name the type of chemical reaction which forms short-chain alkanes and alkenes from long-chain alkanes.

..... [1]

(ii) Decane has 10 carbon atoms. It forms ethane and ethene as the only products in this type of chemical reaction.

Write the chemical equation for this reaction.

..... [3]

(b) Ethane reacts with chlorine at room temperature to form chloroethane, C_2H_5Cl, and one other product.

(i) Name the other product formed.

..... [1]

(ii) State the condition needed for this reaction to take place.

..... [1]

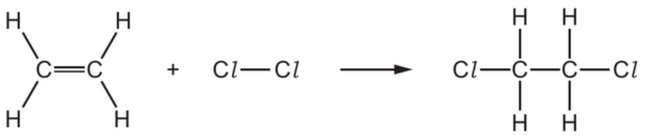
(c) Ethene reacts with chlorine at room temperature to form dichloroethane, $C_2H_4Cl_2$.

$$C_2H_4 + Cl_2 \rightarrow C_2H_4Cl_2$$

(i) State why this is an addition reaction.

..... [1]

(ii) The chemical equation for this reaction can be represented as shown.



The energy change for the reaction is –180 kJ / mol.

Use the bond energies in the table to calculate the bond energy of a C–Cl bond, in kJ / mol.

bond	C–H	C=C	Cl–Cl	C–C
bond energy in kJ / mol	410	610	240	350

Use the following steps.

step 1 Calculate the energy needed to break bonds.

energy needed to break bonds = ... kJ

step 2 Use your answer in **step 1** and the energy change for the reaction to determine the energy released when bonds are formed.

energy released when bonds form = ... kJ

step 3 Use your answer in **step 2** and bond energy values to determine the energy of a C–C*l* bond.

bond energy of a C–C*l* bond = ... kJ / mol
[4]

[Total: 11]

Question No 43 - (0620_s22_41_1)

Topics: 10.3 - Air quality and climate, 11.3 - Fuels, 11.6 - Alcohols, 12.5 - Identification of ions and gases, 1.2 - Diffusion, 2.6 - Giant covalent structures, 6.4 - Redox, 9.6 - Extraction of metals
Subsection Topics: a: 10.3 - Air quality and climate | b: 9.6 - Extraction of metals | c: 11.3 - Fuels | d: 11.3 - Fuels | e: 9.6 - Extraction of metals | f: 10.3 - Air quality and climate | g: 10.3 - Air quality and climate | h: 2.6 - Giant covalent structures

A list of substances is shown.

aluminium oxide	**carbon dioxide**	**chlorine**	**diamond**	**ethanol**
glucose	**iron(III) oxide**	**limestone**	**nitrogen**	**oxygen**

Answer the questions using the list of substances.

Each substance may be used once, more than once or not at all.

State which of the substances:

(a) is a reactant in photosynthesis

..... [1]

(b) is the main constituent of bauxite

..... [1]

(c) are **two** products of fermentation

..... and ..... [2]

(d) is used as a fuel

..... [1]

(e) is a gas used to convert iron into steel

..... [1]

(f) is a greenhouse gas

..... [1]

(g) is a gas that is approximately 78% of clean, dry air

..... [1]

(h) is a form of carbon.

..... [1]

[Total: 9]

Question No 44 - (0620_s24_42_2)

Topics: 2.2 - Atomic structure and the Periodic Table, 2.4 - Ions and ionic bonds, 3.1 - Formulae, 6.1 - Physical and chemical changes, 6.4 - Redox, 7.1 - Characteristics of Acids & Bases, 7.2 - Oxides, 8.1 - Arrangement of elements, 8.4 - Transition elements, 9.1 - Properties of metals, 9.2 - Uses of metals, 9.4 - Reactivity series, 9.6 - Extraction of metals

Subsection Topics: a: 2.2 - Atomic structure and the Periodic Table, 9.4 - Reactivity series, 8.4 - Transition elements, 9.2 - Uses of metals | b: 6.1 - Physical and chemical changes | c: 7.1 - Characteristics of Acids & Bases, 9.6 - Extraction of metals | d: 6.4 - Redox

A list of five metals is shown.

copper
iron
magnesium
potassium
silver

(a) All metals form positive ions.

(i) Describe how atoms form positive ions.

..... [1]

(ii) State which of the five metals in the list has the greatest tendency to form positive ions.

..... [1]

(iii) Suggest **one** of the five metals in the list which is **not** likely to show catalytic properties.

..... [1]

(iv) State which of the five metals in the list is a major component of stainless steel.

..... [1]

(b) A student adds a sample of a metal to an aqueous metal salt in a beaker to see if a displacement reaction takes place.

Complete Table 2.1 to show the colour of the solution in the beaker at the start and at the end of the experiment.

Table 2.1

metal	aqueous solution	colour at the start	colour at the end
magnesium	iron(II) sulfate	green	
silver	copper(II) sulfate		

[3]

(c) Most Group II metals form a gas when placed into cold water. An alkaline solution is also formed.

(i) Name the gas formed when strontium is added to cold water.

..... [1]

(ii) Name the alkaline solution formed when strontium is added to cold water.

..... [1]

(iii) One Group II metal reacts very slowly when placed in cold water. When heated, the metal reacts with steam to form a white solid.

Identify this metal and name the white solid formed.

metal .....

white solid .....

[2]

(d) Under certain conditions, iron will react with steam to form an oxide of iron with the formula Fe_3O_4.

DO NOT WRITE IN THIS MARGIN
DO NOT WRITE IN THIS MARGIN
DO NOT WRITE IN THIS MARGIN

Fe_3O_4 reacts with dilute hydrochloric acid to form a mixture of iron(II) and iron(III) salts and water.

Deduce the symbol equation for the reaction between Fe_3O_4 and dilute hydrochloric acid.

..... [3]

[Total: 14]

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Question No 45 - (0620_w21_41_1)

Topics: 10.3 - Air quality and climate, 12.5 - Identification of ions and gases, 2.2 - Atomic structure and the Periodic Table, 3.1 - Formulae, 6.2 - Rate of reaction, 6.4 - Redox, 8.2 - Group I properties, 8.3 - Group VII properties, 8.4 - Transition elements, 8.5 - Noble gases, 9.1 - Properties of metals, 9.2 - Uses of metals, 9.3 - Alloys and their properties, 9.4 - Reactivity series, 9.6 - Extraction of metals
Subsection Topics: a: 8.3 - Group VII properties, 8.2 - Group I properties, 9.2 - Uses of metals, 2.2 - Atomic structure and the Periodic Table, 9.3 - Alloys and their properties, 8.4 - Transition elements | b: 9.6 - Extraction of metals | c: 9.4 - Reactivity series | d: 9.6 - Extraction of metals | e: 6.4 - Redox, 3.1 - Formulae, 6.2 - Rate of reaction

Some elements are shown in the order they appear in the reactivity series. The most reactive element is at the top.

sodium
calcium
magnesium
aluminium
zinc
iron
hydrogen
copper

(a) Answer the questions using the list of elements. Each element may be used once, more than once or not at all.

Identify:

(i) a non-metal

..... [1]

(ii) a metal which is stored under oil

..... [1]

(iii) the main component of steel

..... [1]

(iv) a metal with three electrons in the outer shell of its atoms

..... [1]

(v) a metal found in brass

..... [1]

(vi) a metal that forms chlorides of the type XCl_2 and XCl_3.

..... [1]

(b) Name the main ores of:

(i) zinc ..... [1]

(ii) aluminium. ..... [1]

(c) In an experiment, a sample of aluminium appeared less reactive than expected.

Explain why.

.....

..... [1]

(d) Name **two** metals from the list which are extracted by reduction of their ores using carbon.

1 .....

2 .....
[2]

(e) When zinc granules are added to aqueous copper(II) sulfate, a reaction occurs. During the reaction, a red-pink solid is formed and the solution becomes colourless.

(i) Name the red-pink solid.

..... [1]

(ii) Name the colourless solution.

..... [1]

(iii) Explain, in terms of particles, why the rate of this reaction increases when the temperature is increased.

.....

.....

.....

.....

.....

..... [3]

(iv) Suggest two **other** ways of increasing the rate of this reaction.

1 .....

2 .....
[2]

[Total: 18]

Question No 46 - (0620_s22_41_6)

Topics: 10.2 - Fertilisers, 1.1 - Solids, liquids and gases, 12.2 - Acid–base titrations, 12.4 - Separation and purification, 3.1 - Formulae, 3.3 - The mole and the Avogadro constant, 6.2 - Rate of reaction, 6.3 - Reversible reactions and equilibrium, 6.4 - Redox, 7.1 - The characteristic properties of acids and bases, 7.3 - Preparation of salts, 9.6 - Extraction of metals

Subsection Topics: c: 6.4 - Redox | a: 9.6 - Extraction of metals, 1.1 - Solids, liquids and gases | b: 7.3 - Preparation of salts, 6.2 - Rate of reaction, 12.4 - Separation and purification, 3.1 - Formulae | d: 12.2 - Acid–base titrations, 3.3 - The mole and the Avogadro constant

This question is about zinc and its compounds.

(a) Zinc is extracted from its ore which is mainly zinc sulfide, ZnS.

The steps for this extraction are shown.

step 1 Zinc sulfide is converted into zinc oxide.

step 2 The zinc oxide is then reduced to zinc in a furnace. The zinc formed becomes a gas.

step 3 The zinc gas is cooled to form molten zinc.

(i) Name the ore of zinc, which is mainly zinc sulfide.

..... [1]

(ii) Describe how zinc sulfide is converted into zinc oxide in **step 1**.

.....

..... [1]

(iii) Name the reducing agent used in **step 2**.

..... [1]

(iv) Explain why the zinc forms a gas in **step 2** inside the furnace.

..... [1]

(v) State the name of the physical change occurring when zinc gas is converted into molten zinc.

..... [1]

(b) Zinc sulfate crystals, $ZnSO_4 \bullet 7H_2O$, are hydrated.

Zinc sulfate crystals are made by reacting zinc carbonate with dilute sulfuric acid.

The equation for the overall process is shown.

$$ZnCO_3 + H_2SO_4 + 6H_2O \rightarrow ZnSO_4 \bullet 7H_2O + CO_2$$

step 1 Large pieces of solid zinc carbonate are added to dilute sulfuric acid until the zinc carbonate is in excess. This forms aqueous zinc sulfate.

step 2 The excess zinc carbonate is separated from the aqueous zinc sulfate.

step 3 The aqueous zinc sulfate is heated until a saturated solution is formed.

step 4 The saturated solution is allowed to cool and crystallise.

step 5 The crystals are removed and dried.

(i) In **step 1**, zinc carbonate is in excess when no more zinc carbonate dissolves.

State one **other** observation that indicates the zinc carbonate is in excess in **step 1**.

..... [1]

(ii) Name a different substance, other than zinc carbonate, that can be added to dilute sulfuric acid to produce aqueous zinc sulfate in **step 1**.

..... [1]

(iii) **Step 1** is repeated using powdered zinc carbonate instead of large pieces.

All other conditions are kept the same.

The rate of reaction increases.

Give a reason why the rate of reaction increases. Explain your answer in terms of particles.

.....

.....

..... [2]

(iv) Suggest what is observed when the solution is saturated in **step 3**.

.....

.....

..... [1]

(v) The formula of zinc sulfate crystals is $ZnSO_4 \bullet 7H_2O$.

Give the formula of the solid formed if the crystals are heated to dryness in **step 3**.

..... [1]

[Total: 11]

Question No 47 - (0620_s22_43_1)

Topics: 10.1 - Water, 10.3 - Air quality and climate, 11.3 - Fuels, 11.6 - Alcohols, 12.5 - Identification of ions and gases, 6.3 - Reversible reactions and equilibrium, 8.5 - Noble gases, 9.1 - Properties of metals, 9.4 - Reactivity series, 9.6 - Extraction of metals

Subsection Topics: a: 11.3 - Fuels | b: 9.4 - Reactivity series | c: 12.5 - Identification of ions and gases | d: 10.3 - Air quality and climate | e: 11.3 - Fuels | f: 9.6 - Extraction of metals | g: 9.1 - Properties of metals | h: 10.3 - Air quality and climate

A list of substances is shown.

aluminium oxide	**carbon dioxide**	**carbon monoxide**	**chlorine**	**copper**
glucose	**iron(III) oxide**	**limestone**	**nitrogen**	**oxygen**

Answer the questions using the substances in the list.

Each substance may be used once, more than once or not at all.

State which substance is:

(a) a product of respiration

..... [1]

(b) the main constituent of hematite

..... [1]

(c) an element which has a sulfate that is used to test for water

..... [1]

(d) a colourless toxic gas

..... [1]

(e) a reactant in fermentation

..... [1]

(f) a reducing agent in the extraction of iron

..... [1]

(g) a conductor of electricity when solid

..... [1]

(h) a gas that is approximately 21% of clean, dry air.

..... [1]

[Total: 8]

Question No 48 - (0620_s24_41_5)

Topics: 12.1 - Experimental design, 12.4 - Separation and purification, 12.5 - Identification of ions and gases, 3.1 - Formulae, 3.3 - The mole and the Avogadro constant, 4.1 - Electrolysis, 6.1 - Physical and chemical changes, 7.3 - Preparation of salts

Subsection Topics: a: 7.3 - Preparation of salts, 12.4 - Separation and purification, 4.1 - Electrolysis | b: 12.5 - Identification of ions and gases | c: 6.1 - Physical and chemical changes | d: 12.1 - Experimental design, 3.3 - The mole and the Avogadro constant

(a) Lead(II) bromide, $PbBr_2$, is an insoluble salt and is made by precipitation.

(i) Name **two** aqueous solutions that produce a precipitate of lead(II) bromide when they are mixed.

1 .....

2 .....
[2]

(ii) Describe how to produce a pure sample of lead(II) bromide from the mixture of aqueous solutions in **(a)(i)**.

.....

..... [2]

(iii) Write an ionic equation for the precipitation reaction which produces lead(II) bromide. Include state symbols.

..... [3]

(b) When iron(II) sulfate crystals are heated strongly, sulfur dioxide gas is given off.

Describe a test for sulfur dioxide gas.

test .....

observations .....
[2]

(c) Complete the equation for the thermal decomposition of hydrated cobalt(II) nitrate.

$$2Co(NO_3)_2{\bullet}4H_2O \rightarrow \ldots.CoO + \ldots.NO_2 + O_2 + \ldots.H_2O$$ [2]

(d) Hydrated cobalt(II) sulfate, $CoSO_4{\bullet}\mathbf{x}H_2O$, produces water when it is heated.

$$CoSO_4{\bullet}\mathbf{x}H_2O(s) \rightarrow CoSO_4(s) + \mathbf{x}H_2O(g)$$

A student does an experiment to determine the value of **x** in $CoSO_4{\bullet}\mathbf{x}H_2O$.

step 1 The student weighs a sample of hydrated cobalt(II) sulfate.

step 2 The student heats the sample of hydrated cobalt(II) sulfate.

step 3 The student weighs the remaining solid after heating.

(i) Describe what else the student should do to ensure that **all** the water has been given off. No other substances are required.

.....

.....

..... [2]

(ii) In an experiment, 1.405 g of $CoSO_4{\bullet}\mathbf{x}H_2O$ is heated until all the water is given off.

The mass of $CoSO_4$ that remains is 0.775 g.

[*M*r: $CoSO_4$, 155; H_2O, 18]

Determine the value of **x** using the following steps.

- Calculate the number of moles of $CoSO_4$ that remains.

..... mol

- Calculate the mass of H_2O given off.

..... g

- Calculate the number of moles of H_2O given off.

..... mol

- Determine the value of **x**.

x = ...
[4]

[Total: 17]

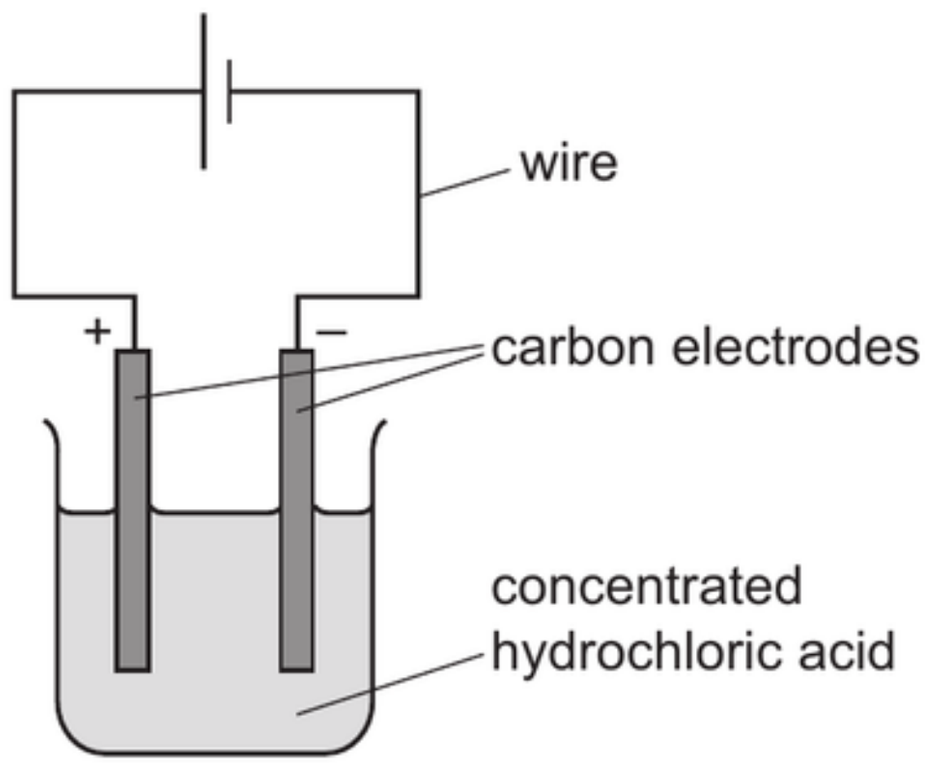
Question No 49 - (0620_w21_41_3)

Topics: 2.4 - Ions and ionic bonds, 2.5 - Simple molecules and covalent bonds, 3.1 - Formulae, 4.1 - Electrolysis, 6.4 - Redox, 7.1 - Characteristics of Acids & Bases, 7.3 - Preparation of salts, 9.4 - Reactivity series

Subsection Topics: a: 6.4 - Redox, 3.1 - Formulae | b: 9.4 - Reactivity series, 7.1 - Characteristics of Acids & Bases | c: 7.3 - Preparation of salts, 3.1 - Formulae | d: 9.4 - Reactivity series, 3.1 - Formulae

This question is about electrolysis.

Concentrated hydrochloric acid is electrolysed using the apparatus shown.



(a) Chloride ions are discharged at the anode.

(i) Complete the ionic half-equation for this reaction.

.....Cl^-(aq) → .....(g) + ...e^- [2]

(ii) State whether oxidation or reduction takes place. Explain your answer.

.....

..... [1]

(b) Describe what is seen at the cathode.

..... [1]

(c) Write the ionic half-equation for the reaction at the cathode.

..... [2]

(d) The pH of the electrolyte is measured throughout the experiment.

(i) Suggest the pH of the electrolyte at the beginning of the experiment.

..... [1]

(ii) State how the pH changes, if at all, during the experiment.

Explain your answer.

.....

..... [2]

(e) The electrolysis is repeated using molten lead(II) bromide.

Describe what is seen at the:

- cathode .....
- anode. .....

[2]

(f) State **two** properties of graphite (carbon) which make it suitable for use as an electrode.

1 .....

2 .....

[2]

[Total: 13]

Question No 50 - (0620_w24_41_6)

Topics: 11.8 - Polymers, 12.3 - Chromatography
Subsection Topics: a: 11.8 - Polymers | b: 11.8 - Polymers | c: 11.8 - Polymers | d: 11.8 - Polymers | e: 12.3 - Chromatography | f: 12.3 - Chromatography

Natural polyamides are polymers made from amino acid monomers.

(a) State the type of polymerisation reaction that occurs when natural polyamides form.

..... [1]

(b) State the term given to natural polyamides.

..... [1]

(c) An amino acid is represented as shown in Fig. 6.1.

Fig. 6.1

Complete Fig. 6.2 to show the general structure of an amino acid.

Show all of the atoms and all of the bonds in the functional groups.

Fig. 6.2

[3]

(d) Three different amino acids are represented as shown in Fig. 6.3.

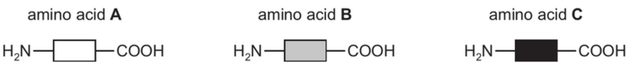


Fig. 6.3

Complete the diagram in Fig. 6.4 to show the part of the structure of the natural polyamide that forms when the three amino acids, **A**, **B** and **C**, combine.
Show all of the atoms and all of the bonds in the linkages.

Fig. 6.4

[3]

(e) A mixture of the three amino acids, **A**, **B** and **C**, can be separated and the amino acids identified using paper chromatography.

Complete the equation for R_f.

R_f =

[2]

(f) A sample of the mixture of the three amino acids, **A**, **B** and **C**, is placed onto the baseline and a chromatogram is allowed to develop as shown in Fig. 6.5.

The finished chromatogram is shown in Fig. 6.6.

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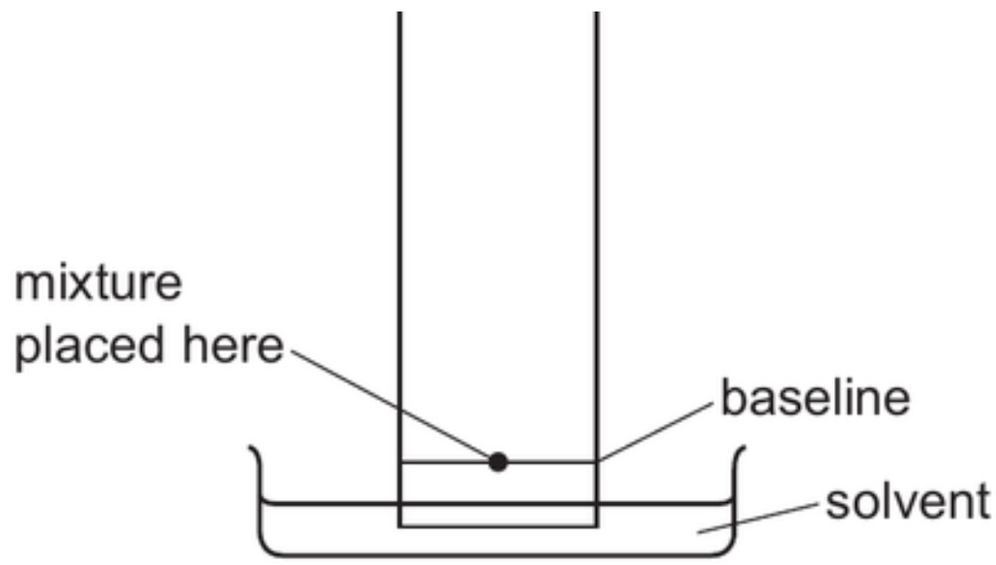

Fig. 6.5

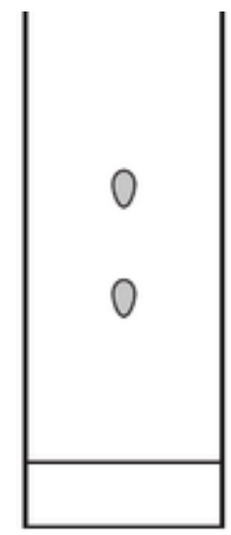

Fig. 6.6

The amino acids, **A**, **B** and **C**, are colourless. Water is used as the solvent.

(i) Explain why the baseline is drawn in pencil.

..... [1]

(ii) State the type of substance used to make the colourless amino acids visible on the chromatogram in Fig. 6.6.

..... [1]

(iii) Explain why in Fig. 6.6 only **two** spots are seen from the mixture of three amino acids.

.....

..... [1]

(iv) Suggest how the experiment can be changed to separate all three amino acids.

..... [1]

[Total: 14]

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Answer for Question 1 (0620_w21_41_4)

Question	Answer	Marks
4(a)	$(4FeCuS\ 13O_2) \rightarrow 2Fe_2O_3 + 4CuO + 8SO_2$ Fe_2O_3 and CuO as a product (1) Equation fully correct (1)	**2**
4(b)(i)	**M1** rate of forward reaction = rate of reverse reaction (1) **M2** concentration of reactants and products are constant (1)	**2**
4(b)(ii)	**M1** 450 °C (1) **M2** 1-2 atm (1)	**2**
4(b)(iii)	vanadium(V) oxide	**1**
4(b)(iv)	increase rate of reaction	**1**
4(b)(v)	**M1** equilibrium shifts to left hand side (1) **M2** forward reaction is exothermic (1)	**2**
4(c)	$C_6H_{12}O_6 \rightarrow 6C + 6H_2O$ H_2O (1) balance (1)	**2**

Answer for Question 2 (0620_s23_41_6)

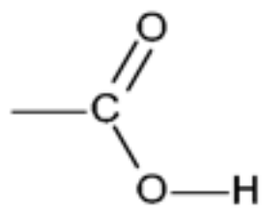
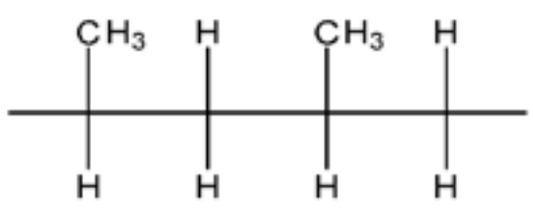
Question	Answer	Marks
6(a)(i)	$4FeS_2 + 11O_2 \rightarrow 2Fe_2O_3 + 8SO_2$	1
6(a)(ii)	iron(III) oxide	1
6(b)(i)	yield of SO_3 is less	1
6(b)(ii)	yield of SO_3 is less **OR** rate is less	1
6(c)	$2NH_3 + H_2SO_4 \rightarrow (NH_4)_2SO_4$ **M1** $(NH_4)_2SO_4$ on the right (1) **M2** equation correct(1)	2
6(d)(i)	lead(II) nitrate	1

Question	Answer	Marks
6(d)(ii)	$Pb^{2+}(aq) + SO_4^{2-}(aq) \rightarrow PbSO_4(s)$ **M1** $PbSO_4$ on the right(1) **M2 only** Pb^{2+} and SO_4^{2-} on the left(1) **M3**(aq) + (aq) → (s)(1)	3
6(d)(iii)	**M1** filter(1) **M2** wash (the residue or lead sulfate) with distilled or deionised **water**(1) **M3 description** of drying(1)	3

Answer for Question 3 (0620_s21_41_7)

Question	Answer	Marks
7(a)	48.65 / 12 8.11 / 1 43.24 / 16 (1) **OR evaluation** 4.05 8.11 2.7(0) divide all by smallest **OR** 1.5 : 3 : 1 **OR** 6 : 3 : 2 (1) $C_3H_6O_2$ (1) **ALLOW** symbols in any order	**3**
7(b)	(M_r of CH_4O = 32) CH_4O (1)	**1**
7(c)(i)	$C_nH_{2n}O_2$ **OR** C_nH_{2n+1} COOH	**1**

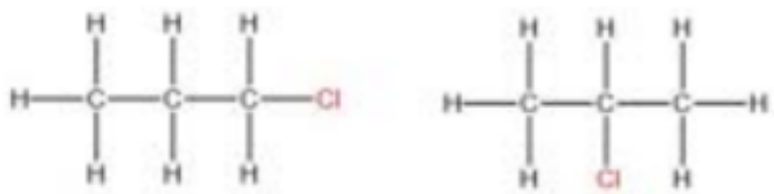
Answer for Question 3 (0620_s21_41_7)

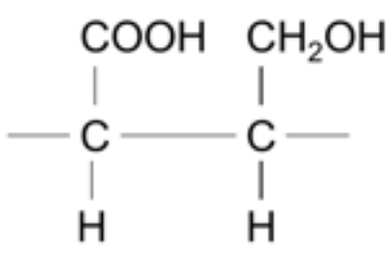
Question	Answer	Marks
7(c)(ii)	butanoic acid (1) fully displayed carboxylic acid group (1)  correct structure of butanoic acid showing all atoms and bonds (1)	3
7(c)(iii)	homologous series	1
7(d)(i)	brown to colourless	1
7(d)(ii)	C_9H_{20} (1) $2C_3H_6$ (1)	2
7(d)(iii)	addition	1
7(d)(iv)	 any one repeat unit (1) both repeat units fully correct (1)	2

Answer for Question 4 (0620_s19_43_1)

<table>
<tr><th>Question</th><th>Answer</th><th>Marks</th></tr>
<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>

Answer for Question 5 (0620_s20_42_6)

Question	Answer	Marks
6(a)(i)	substitution	1
6(a)(ii)	ultraviolet light / ultraviolet radiation	1
6(a)(iii)		2
6(b)(i)	only one product / double bond becomes single bond / two molecules join (to make one molecule)	1
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)	3

Question	Answer	Marks
6(c)(i)	alkene (1) alcohols / alkanols (1) carboxylic acids/alkanoic acids (1)	3
6(c)(ii)	turns colourless / decolourised (1) bubbles / fizzing / effervescence (1)	2
6(d)(i)	 C–C (1) each C bonded to $–CH_2OH$ / –COOH and H with no other atoms + extension bonds (1)	2
6(d)(ii)	polyester	1

Answer for Question 6 (0620_w19_41_4)

Question	Answer	Marks
4(a)(i)	cobalt carbonate	1
4(a)(ii)	lead iodide	1
4(b)	$2\ AgNO_3 + Na_2CO_3 \rightarrow Ag_2CO_3 + 2\ NaNO_3$ formula of silver carbonate correct (1) fully correct equation (1)	2
4(c)	$Pb^{2+} + 2\ I^- \rightarrow PbI_2$ Pb^{2+} **and** I^- on left of equation (1) fully correct equation (1)	2
4(d)	(nitric) acid reacts with / removes carbonate ions	1

Answer for Question 7 (0620_m22_42_6)

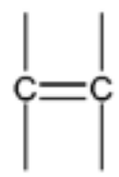
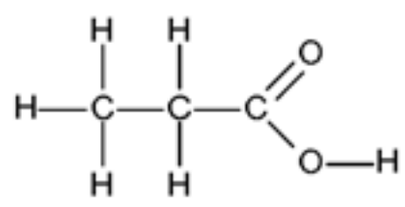
Question	Answer	Marks
6(a)(i)	homologous series	1
6(a)(ii)	Same functional group	1
6(a)(iii)	general (formula)	1
6(a)(iv)	7	1

Question	Answer	Marks
6(b)	fractional distillation	2
6(c)(i)	propanoic acid structure of propanoic acid	2
6(c)(ii)	methanol	1
6(d)(i)	structural isomers	1
6(d)(ii)	ethyl butanoate butyl ethanoate	2
6(e)(i)	any correct displayed ester link between any two blocks showing all atoms and all bonds correct orientation of three displayed inter-block ester links with correct orientation continuation bonds on polyester	3
6(e)(ii)	condensation	1
6(e)(iii)	terylene	1

Answer for Question 8 (0620_s24_41_7)

Question	Answer	Marks
7(a)(i)	**M1** C 82.76 / 12: H 17.24/1 (1) **OR** evaluation i.e. 6.90:17.24 **M2** fractions showing division of both by smaller ie 6.9 / 6.9 and 17.24 / 6.9 **OR** evaluation ie 1:2.5 **OR** 4:10 **M3** C_2H_5 (1)	3

Answer for Question 8 (0620_s24_41_7)

Question	Answer	Marks
7(a)(ii)	C_5H_{10}	**1**
7(b)	**M1**  any C=C with both carbons having a valency of 4(1) **M2** correct displayed formula of (cis or trans) but–2–ene(1) **M3** but–2–ene	**3**
7(c)	C_8H_{16}	**1**
7(d)(i)	structural isomers	**1**
7(d)(ii)	**M1** ethanoic acid(1) **M2** methanol(1)	**2**
7(d)(iii)	**M1** Displayed formula of propanoic acid showing **ALL** atoms and bonds  (1) **M2** propanoic acid(1)	**2**

Answer for Question 9 (0620_s22_41_4)

Question	Answer	Marks
4(a)(i)	$S + O_2 \rightarrow SO_2$	1
4(a)(ii)	(temperature) 450 °C (1) (pressure) 1–2 atmosphere(s) (1) vanadium(V) oxide catalyst (1) $2SO_2 + O_2 \rightleftharpoons 2SO_3$ (1)	4
4(a)(iii)	$SO_3 + H_2SO_4 \rightarrow H_2S_2O_7$	1
4(a)(iv)	water	1
4(b)(i)	2 bonding pairs as **one dot and cross** each (1) 2 lone pairs on S (and no additional electrons on Hs) to complete the outer shell on S and both Hs (1)	2
4(b)(ii)	$\mathbf{2}H_2S + SO_2 \rightarrow \mathbf{3}S + \mathbf{2}H_2O$	1

Answer for Question 10 (0620_w23_42_4)

Question	Answer	Marks
4(a)(i)	**M1** lead nitrate (1) **M2** soluble chloride e.g. sodium chloride (1)	**2**
4(a)(ii)	$Pb^{2+}(aq) + 2Cl^-(aq) \rightarrow PbCl_2(s)$ **M1** $PbCl_2$ as **only** product (1) **M2** $Pb^{2+} + 2Cl^-$ as **only** reactants (1) **M3** state symbols (1)	**3**

Question	Answer	Marks
4(a)(iii)	**M1** filter (1) **M2** wash (the residue) using water (1) **M3** dry the residue between filter papers / in a warm place (1)	**3**
4(b)(i)	mobile ions	**1**
4(b)(ii)	$2Cl^- \rightarrow Cl_2 + 2e^-$ **M1** any negative Cl species **losing** electron(s) (1) **M2** correct ionic half equation (1)	**2**
4(b)(iii)	**M1** (damp) litmus (paper) (1) **M2** is bleached / goes white (1)	**2**
4biv	(shiny) grey **AND** solid	**1**

Answer for Question 11 (0620_s22_42_6)

Question	Answer	Marks
6(a)(i)	3	1
6(a)(ii)	diagram of dioic acid showing two fully displayed carboxylic acid groups on unshaded block diagram of diol showing two fully displayed hydroxyl groups on shaded block	2
6(a)(iii)	polyester	1
6(b)	one	1
6(c)(i)	any hydrocarbon with one C=C bond (with both C atoms having 4 bonds) (1) structure of but-2-ene (1) but-2-ene	3
6(c)(ii)	cracking	1

Answer for Question 12 (0620_w23_43_4)

Question	Answer	Marks
4(a)(i)	dilute sulfuric acid	1
4(a)(ii)	**M1** solid remains / solid undissolved (1) **M2** bubbling / effervescence / fizzing stops (1)	2
4(a)(iii)	aqueous zinc sulfate	1
4(a)(iv)	any two • zinc oxide • zinc carbonate • zinc hydroxide	2
4(b)(i)	**M1** (a solution containing the) maximum amount of solute dissolved / no more solute can dissolve (1) **M2** at a given temperature (1)	2
4(b)(ii)	solubility decreases as temperature decreases	1
4(c)(i)	hydrated	1
4(c)(ii)	to ensure <u>all</u> the water of crystallisation is removed	1

Question	Answer	Marks
4(c)(iii)	**M1** 2×10^{-3} / 0.002 (1) **M2** 0.144 (g) (1) **M3** (0.144 ÷ 18 =) 8×10^{-3} / 0.008 (1) **M4** (0.008 ÷ 0.002 =) 4 (1)	4

Answer for Question 13 (0620_m19_42_2)

<table>
<tr><th>Question</th><th>Answer</th><th>Marks</th></tr>
<tr><td>2(a)</td><td>
<table>
<tr><th>number of protons</th><th>electrons</th><th>electronic structure</th><th>charge on particle</th></tr>
<tr><td>11</td><td>10</td><td>2,8</td><td>M4 1+ / +1(1)</td></tr>
<tr><td>M1 18(1)</td><td>18</td><td>M3 2,8,8(1)</td><td>0</td></tr>
<tr><td>M2 9(1)</td><td>10</td><td>2,8</td><td>1-</td></tr>
</table>
</td><td>4</td></tr>
<tr><td>2(b)(i)</td><td>element
EITHER (substance) made of atoms with the same atomic number / number of protons / proton number

OR a substance that cannot be split up / broken down into two or more simple(r) substances by chemical means</td><td>1</td></tr>
<tr><td>2(b)(ii)</td><td>M1 6 protons in all three rows(1)
M2 6,7 and 8 neutrons(1)</td><td>2</td></tr>
</table>

Answer for Question 14 (0620_w22_42_4)

Question	Answer	Marks
4(a)	$Mg + H_2SO_4 \rightarrow MgSO_4 + H_2$	**1**
4(b)	**M1** no (more) fizzing (1) **M2** solid stops dissolving or a solid remains / is visible (in the mixture) (1)	**2**
4(c)	residue	**1**
4(d)(i)	saturated	**1**
4(d)(ii)	solubility (of $MgSO_4$ / solid) decreases (as temperature decreases)	**1**
4(e)(i)	hydrated	**1**

Question	Answer	Marks
4(e)(ii)	**M1** Mr $MgSO_4$ = 120 (1) **M2** mol $MgSO_4$ = 2.40 / M1 = 2.40 / 120 = 0.02(00) (1) **M3** 0.02(00) / 0.02(00) = 1 0.140 / 0.02(00) = 7 **and** x = 7 (1)	**3**
4(f)	$2Mg(NO_3)_2 \rightarrow 2MgO + 4NO_2 + O_2$ **M1** $NO_2 + O_2$ (1) **M2** equation completely correct (1)	**2**

Answer for Question 15 (0620_w22_43_3)

Question	Answer	Marks
3(a)	bauxite	**1**
3(b)	**M1 breakdown** by (the passage of) **electricity** (1) **M2** of an **ionic compound** in **molten or aqueous** (state) (1)	**2**
3(c)(i)	**M1** improves conductivity of the electrolyte / makes the electrolyte a better conductor (1) **M2** low**er** operating temperature (1)	**2**
3(c)(ii)	$Al^{3+} + 3e^- \rightarrow Al$ **M1** only Al^{3+} + (3) e^- on the left (1) **M2** equation fully correct (1)	**2**
3(c)(iii)	**M1** anodes **or** carbon react(s) with oxygen (1) **M2** form carbon dioxide (1)	**2**
3(d)	unreactive coating of aluminium oxide (1)	**1**
3(e)(i)	neutralises both acids **AND** alkalis	**1**

Question	Answer	Marks
3(e)(ii)	$2NaOH + Al_2O_3 \rightarrow 2NaAlO_2 + H_2O$ **M1** $NaAlO_2$ on the right hand side (1) **M2** equation fully correct (1)	**2**
3(f)	**M1** $GaCl_3$ (1) **M2** $Ga_2(SO_4)_3$ (1)	**2**

Answer for Question 16 (0620_m20_42_3)

Question	Answer	Marks
3(a)	selenium / Se	1
3(b)	Ca has 2 and C*l* has outer electrons 7 (1) Ca (atoms) lose electrons (1) C*l* (atoms) gain electrons (1) Ca^{2+} (ions) (1) Cl^{-} (ions) (1)	5

Answer for Question 16 (0620_m20_42_3)

Question	Answer	Marks
3(c)(i)	any number in the range 72 – 129°C	1
3(c)(ii)	attraction increase (1) between molecules (1)	2
3(c)(iii)	3 P – C*l* dot cross bonds (1) 2 (only) non-bonding electrons to make an octet on P (1) 6 (only) non-bonding electrons to make an octet on each C*l* (1)	3
3(d)(i)	constant concentrations (1) rate of forward reaction = rate of reverse reaction (1)	2
3(d)(ii)	*increased temperature*: (equilibrium) shifts to LHS (1) (forward) reaction is exothermic (1) *increased pressure*: (equilibrium) shifts to RHS (1) fewer moles (of gas) on RHS (1)	4
3(d)(iii)	rate increases **and** particles have more energy (1) more collisions (between particles) occur per second / per unit time 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	3
3(e)	mol of $LiPF_6$ = 3.04 / 152 = 0.02(00) (1) mol of LiF = 0.02(00) × 6 = 0.12(0) (1) mass of LiF = 3.12 g (1)	3

Answer for Question 16 (0620_m20_42_3)

Question	Answer	Marks
3(f)(i)	oppositely charged ions (ions) are attracted	2
3(f)(ii)	any two from: *physical constants*: high boiling point / melting point *conductivity*: conduct (electricity) when aqueous or conduct (electricity) when molten *solubility*: soluble in water	2

Answer for Question 17 (0620_w22_41_1)

Question	Answer	Marks
1(a)	oxygen	1
1(b)	carbon	1
1(c)	lithium	1
1(d)	nitrogen	1
1(e)	neon	1
1f	lithium	1
1(g)	boron	1
1(h)	nitrogen	1

Answer for Question 18 (0620_w23_42_3)

Question	Answer	Marks
3(a)	(hot) air	1
3(b)(i)	hematite	1
3(b)(ii)	$Fe_2O_3 + 3CO \rightarrow 3CO_2 + 2Fe$	1
3(b)(iii)	**M1** from +3 (1) **M2** to 0 (1)	2
3(b)(iv)	decrease (in oxidation number)	1

Question	Answer	Marks
3(c)	**M1** $CaCO_3 \rightarrow CaO + CO_2$ (1) **M2** thermal decomposition (1) **M3** $SiO_2 + CaO \rightarrow CaSiO_3$ (1) **M4** acid-base reaction (1)	4
3(d)(i)	alloy	1
3(d)(ii)	nickel / chromium	1
3(e)	hydrated iron(III) oxide	1
3(f)(i)	galvanising	1
3(f)(ii)	painting / greasing / coating with plastic	1
3(f)(iii)	**M1** zinc more reactive (than iron) (1) **M2** zinc corrodes / oxidises / reacts in preference to / instead of iron (1)	2

Answer for Question 19 (0620_s23_43_7)

Question	Answer	Marks
7(a)(i)	ultraviolet (light)	1
7(a)(ii)	**M1** displayed formula of 1–chloropropane **M2** displayed formula of 2–chloropropane	2
7(b)(i)	any 2 from: (same) general formula (same / similar) chemical properties or reactions (contain the same) functional group	2

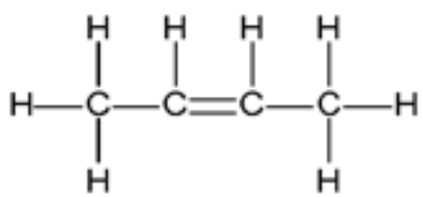
Question	Answer	Marks
7(b)(ii)	**M1** single bond between the two C atoms (and nothing on continuation bonds) **M2** 1 CH_3 group and 1 H on first carbon and 1 CH_3 group and 1 H on second carbon and whole structure correct	2
7(c)(i)	**M1** structural formula of propan-1,3-dioic acid **M2** structural formula of ethan-1,2-diol	2
7(c)(ii)	polyester	1
7(c)(iii)	**M1** carboxylic acids **M2** alcohols	2

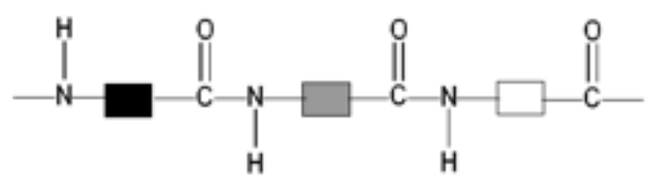
Answer for Question 20 (0620_s22_42_4)

Question	Answer	Marks
4(a)	(pale) yellow **and** gas	**1**
4(b)	**Method 1** M1 S 25.2 / 32 **or** 0.78/0.79 … **and** F 74.8 / 19 **or** 3.93 / 3.94… M2 ÷ both by 0.7875 = 1 : 5 **or** SF_5 M3 (254 ÷ 127 = 2 and) S_2F_{10} **Method 2** M1 254 × 25.2/100 **and** 254 × 74.8 / 100 **OR** '64' **and** '190' M2 64 / 32 **and** 190 / 19 M3 (2 and 10) to give S_2F_{10}	**3**

Question	Answer	Marks
4(c)	N with 1 dot-cross bonding pair with each C*l* 2 non-bonding dots for N 6 non-bonding crosses for C*l*	**3**
4(d)	two crosses in first shell of Li 7 dots and 1 cross in third shell of C*l* '+' charge on Li on correct answer line **and** '–' charge on C*l* ion on correct answer line	**3**
4(e)	ionic bonds in LiC*l* attraction between molecules in NCl_3 weaker attraction (between particles) in NCl_3 ORA	**3**

Answer for Question 21 (0620_m21_42_6)

Question	Answer	Marks
6(a)	monomers	1
6(b)(i)	any **hydrocarbon** with one C=C bond (with both C atoms having 4 bonds) (1) structure of but-2-ene (1) 	2
6(b)(ii)	addition	1

Question	Answer	Marks
6(c)(i)	protein	1
6(c)(ii)	 any correct amide link between any two blocks showing all atoms and all bonds (1) identical orientation of both inter-block amide links including terminal groups with correct orientation (if shown) (1) continuation bonds on polymer (1)	3
6(c)(iii)	hydrolysis (1)	1

Answer for Question 22 (0620_m20_42_2)

Question	Answer	Marks
2(a)(i)	bauxite	1
2(a)(ii)	**breakdown** by (the passage of) **electricity** (1) of an **ionic compound** in **molten / aqueous** (state) (1)	2
2(b)(i)	cryolite	1
2(b)(ii)	less CO_2 emission	1

Question	Answer	Marks
2(b)(iii)	$Al^{3+} + 3e^- \rightarrow Al$ any positive Al species gaining electron(s) (1) correct species and balance (1) $2O^{2-} \rightarrow O_2 + 4e^-$ any negative O species losing electron(s) (1) correct species and balance (1)	4
2(b)(iv)	anodes **or** carbon / graphite react with oxygen / O_2 (1) (form) carbon dioxide (1)	2
2(c)(i)	amphoteric	1
2(c)(ii)	aluminium sulfate (1) $Al_2(SO_4)_3$ (1)	2
2(c)(iii)	water	1
2(c)(iv)	$2Al(OH)_3 \rightarrow Al_2O_3 + 3H_2O$ species (1) balance (1)	2
2(c)(v)	aluminium carbonate (1) aluminium nitrate (1)	2

Answer for Question 23 (0620_w23_42_5)

Question	Answer	Marks
5(a)	enthalpy change (of reaction)	1
5(b)(i)	**M1** rate of reaction increases (1) **M2** more (CCl_4) particles per unit volume (1) **M3** frequency of collisions between (CCl_4 and H_2O) particles increases (1)	3
5(b)(ii)	**M1** (position of) equilibrium moves to left hand side (1) **M2** more (gaseous) moles / molecules on right hand side (1)	2

Answer for Question 23 (0620_w23_42_5)

Question	Answer	Marks
5(b)(iii)	**M1** *Labels mark* $CCl_4(g) + 2H_2O(g)$ on reactant line **AND** $CO_2(g) + 4HCl(g)$ on product line **M2** *Activation E mark* upward arrow labelled E_a from energy level of reactants to top of 'hump' **M3** *Energy change mark* one downward arrow labelled ΔH **AND** energy change starting from E level of reactants and finishing at E level of products	**3**
5(b)(iv)	**M1** minimum energy (1) **M2** that colliding particles must have to react (1)	**2**
5(b)(v)	(decreased by adding) catalyst	**1**
5(c)	*energy needed to break bonds in reactants* **M1** $[(4 \times 340) + (4 \times 460) =$ **3200** (kJ / mol) (1) *energy released when bond in carbon dioxide form* **M2** $2 \times 805 =$ **1610** (kJ / mol) (1) *calculate H–Cl bond energy* **M3** $3200 - (1610 + E(4H–Cl)) = -130$ $E(4H–Cl) = 3330 - 1610 =$ **1720** (kJ / mol) (1) **M4** $1720 / 4 =$ **430** (kJ / mol) (1)	**4**

Answer for Question 24 (0620_s19_41_1)

Question	Answer	Marks
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

Answer for Question 25 (0620_w22_43_4)

Question	Answer	Marks
4(a)(i)	**M1** increases (1) **M2** decreases (1) **M3** increases (1) **M4** increases (1)	**4**
4(a)(ii)	forward reaction is endothermic	**1**
4(b)	**M1** 3 **dot and cross** bonding pairs (1) **M2** All lone pairs correct. All octets should be complete AND dots and crosses should be different on P and all C*l* (1)	**2**
4(c)	P_4O_{10} + $6PCl_5 \rightarrow 10POCl_3$ **M1** all formula correct and on the correct sides of the arrow (1) **M2** equation fully correct (1)	**2**

Question	Answer	Marks
4(d)	**M1** H 3.66 / 1 P 37.80 / 31 O 58.54 / 16 **OR** H = 3.66 P = 1.22 O = 3.66 **OR** H:P:O 3:1:3 (1) **M2** H_3PO_3 (1)	**2**
4(e)	H_3PO_4 (1)	**1**

Answer for Question 26 (0620_w23_41_3)

Question	Answer	Marks
3(a)(i)	**M1** Ag column all ✗ (1) **M2** ✗ in Pb **AND** 2 ✓ in Zn (1) **M3** Zn, Mn, Pb Ag (1)	**3**
3(a)(ii)	(all) nitrates are soluble **OR** lead sulfate is insoluble	**1**

Question	Answer	Marks
3(a)(iii)	$Zn + 2AgNO_3 \rightarrow Zn(NO_3)_2 + 2Ag$ **M1** $Zn(NO_3)_2$ on the right hand side (1) **M2** correct equation (1)	**2**
3(b)(i)	**M1** colourless (1) **M2** orange (1)	**2**
3(b)(ii)	Cl_2**(g)** + $2Br^-$(aq) → Br_2**(aq)** + $2Cl^-$**(aq)** **M1** Br_2 + Cl^- as products (1) **M2** correct equation (1) **M3** state symbols (1)	**3**
3(b)(iii)	tenessine / Ts	**1**

Answer for Question 27 (0620_m19_42_6)

Question	Answer	Marks
6(a)	**M1** Transition element has higher melting point / high boiling point **ORA**(1) **M2** Transition element has higher density **ORA**(1)	**2**
6(b)	good conduction of heat or electricity **OR** malleability **OR** ductility	**1**
6(c)	1 mark each for any two of: • catalyst • more than one or different or variable oxidation state / oxidation number / valency • coloured **compounds** / coloured **ions**	**2**

Question	Answer	Marks
6(d)	from blue(1) to pink(1)	**2**
6(e)(i)	**M1** oxygen(1) **M2** water(1)	**2**
6(e)(ii)	zinc / Zn	**1**
6(f)	**M1** magnesium above iron / steel in the reactivity series **ORA** / magnesium more reactive than iron / steel **ORA**(1) **M2** copper below iron / steel in the reactivity series **ORA /** copper less reactive than iron **ORA**(1)	**2**
6(g)(i)	$Fe_2O_3 + 2H_3PO_4 \rightarrow 2FePO_4 + 3H_2O$ **M1** $FePO_4$ anywhere(1) **M2** The whole equation correct(1)	**2**
6(g)(ii)	iron(III) phosphate acts as a barrier which prevents contact between iron and water or air / oxygen	**1**

Answer for Question 28 (0620_w19_43_2)

Question	Answer	Marks
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

Answer for Question 29 (0620_w21_42_6)

Question	Answer	Marks
6(a)	$C_nH_{2n+1}OH$ (1)	1
6(b)	not all atoms are C or H	1
6(c)(i)	C_2H_4	1
6(c)(ii)	glucose	1
6(d)	$C_2H_5OH + 3O_2 \rightarrow 3H_2O + 2CO_2$ species (1) correct equation (1)	2
6(e)(i)	$C_3H_5O_2$	1
6(e)(ii)	any one ester link (1) rest of molecule (1)	2
6(e)(iii)	water	1
6(f)(i)	carboxylic acid	1

Answer for Question 30 (0620_s19_42_5)

Question	Answer	Marks
5(a)	**M1** 0.0025 / 2.5 × 10^{-3} (moles of H_2SO_4) (1) **M2** 0.0025 / 2.5 × 10^{-3} (moles of $CuSO_4 \bullet 5H_2O$) (1) **M3** 0.625(g) (1)	3
5(b)	some copper(II) sulfate remains in solution / some copper(II) sulfate does not form crystals **OR** some of the crystals decomposed **OR** some crystals lost in transfer	1
5(c)	**M1 no more** bubbling / fizzing / effervescence (1) **M2 solid** or **powder** stops dissolving (1)	2
5(d)	**M1** (lumps have) small**er** surface area **OR powder** has larger surface area (1) **M2** (lumps have) fewer collisions per unit time / less collision frequency **OR powder** has more collisions per unit time / more collision frequency	2
5(e)	copper(II) oxide **or** copper(II) hydroxide	1
5(f)	filtration	1
5(g)(i)	**M1** containing the maximum amount of **dissolved** solute / no more solute can **dissolve** (1) **M2** at any given temperature (1)	2

Question	Answer	Marks
5(g)(ii)	when crystals form on a glass rod withdrawn from solution / on a sample of solution placed on microscope slide etc.	1
5(g)(iii)	(heating to dryness) would remove water **of crystallisation**	1

Answer for Question 31 (0620_s19_42_2)

Question	Answer	Marks
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

Answer for Question 32 (0620_w21_41_2)

<table>
<tr><th>Question</th><th>Answer</th><th>Marks</th></tr>
<tr><td>2(a)(i)</td><td>isotopes</td><td>1</td></tr>
<tr><td>2(a)(ii)</td><td>1 mark for each correct row
<table>
<tr><th></th><th>^{63}Cu</th><th>$^{65}Cu^{2+}$</th></tr>
<tr><td>p</td><td>29</td><td>29</td></tr>
<tr><td>n</td><td>34</td><td>36</td></tr>
<tr><td>e</td><td>29</td><td>27</td></tr>
</table></td><td>3</td></tr>
<tr><td>2(a)(iii)</td><td>M1 = (70 × 63) + (30 × 65) or [(4410) + (1950)] or 6360 (1)

M2 = M1 / 100 = 63.6 (1)

OR

M1= (0.7(0) × 63) + (0.3(0) × 65) or [(44.1(0)) + (19.5(0))] (1)

M2 = 63.6 (1)</td><td>2</td></tr>
</table>

Answer for Question 32 (0620_w21_41_2)

Question	Answer	Marks
2(b)(i)	**M1** white (1) **M2** to (light) blue (1)	**2**
2(b)(ii)	$5H_2O$	**1**
2(b)(iii)	heating	**1**
2(b)(iv)	**M1** boiling point (1) **M2** is 100 °C OR **M1** freezing point (1) **M2** is 0 °C (1)	**2**
2(c)(i)	blue precipitate	**1**
2(c)(ii)	Alternative suggestion: **M1** $Cu(OH)_2$ (as only product) (1) **M2** Cu^{2+} and $2OH^-$ (as reactants) (1) **M3** state symbols (1)	**3**
2(d)	**M1** 188 **M2** 4.7 / 188 = 0.025(0) **M3** 0.025(0) × 2 = 0.05(0) **M4** 0.05(0) × 24.0 = 1.2	**4**
2(e)	$2NaNO_3 \rightarrow 2NaNO_2 + O_2$ $NaNO_2$ (1) rest of equation (1)	**2**

Answer for Question 33 (0620_w21_43_4)

<table>
<tr><th>Question</th><th>Answer</th><th>Marks</th></tr>
<tr><td>4(a)</td><td>1 mark for each row
<table><tr><td>6</td><td>6</td><td>6</td></tr><tr><td>6</td><td>6</td><td>7</td></tr></table></td><td>2</td></tr>
<tr><td>4(b)</td><td>diamond and graphite</td><td>1</td></tr>
<tr><td>4(c)(i)</td><td>M1 (22 ÷ 44 =) 0.5 (moles) (1)

M2 3.01×10^{23}(1)</td><td>2</td></tr>
<tr><td>4(c)(ii)</td><td>1.505×10^{23}</td><td>1</td></tr>
</table>

Answer for Question 34 (0620_m22_42_4)

Question	Answer	Marks
4(a)(i)	arrow going from Zn to Fe	1
4(a)(ii)	$Zn \rightarrow Zn^{2+} + 2e^-$ Zn as only reactant **and** Zn^{2+} as only product correct equation	2
4(b)(i)	any metal above zinc in reactivity series	1
4(b)(ii)	any metal below iron in reactivity series	1
4(c)(i)	hydrogen **and** oxygen	1
4(c)(ii)	water	1
4(d)(i)	electrolysis	1
4(d)(ii)	mobile ions	1
4(e)(i)	hydrogen chlorine sodium hydroxide	3
4(e)(ii)	sodium	1

Answer for Question 35 (0620_s23_43_6)

Question	Answer	Marks
6(a)(i)	air	1
6(a)(ii)	methane	1
6(a)(iii)	**M1** 450 (°C) **M2** 200 (atm)	2
6(a)(iv)	iron	1
6(a)(v)	**M1** (a substance which) increases the rate of a reaction **M2** remains unchanged at the end of the reaction	2

Question	Answer	Marks
6(b)(i)	**temperature change:** **M1** low(er) rate (of reaction) **pressure change:** **M2** (position of) equilibrium shifts to the left hand side/ towards reactants	2
6(b)(ii)	**4**NO + **3**O_2 + **2**H_2O →.**4**HNO_3	1
6(c)(i)	$CuCO_3 + 2HNO_3 \rightarrow Cu(NO_3)_2 + CO_2 + H_2O$ **M1** $Cu(NO_3)_2$ **M2** correct equation	2
6(c)(ii)	**M1** undissolved solid **M2** effervescence stops on addition of more copper(II) carbonate	2
6(d)(iii)	copper(II) oxide **or** copper(II) hydroxide	1

Answer for Question 36 (0620_s24_42_1)

Question	Answer	Marks
1(a)(i)	methane	1
1(a)(ii)	nitrogen dioxide	1
1(a)(iii)	propene	1
1(a)(iv)	helium	1
1(a)(v)	carbon monoxide	1
1(b)	$2NO_2 + 4CO \rightarrow N_2 + 4CO_2$ **M1** $N_2 + CO_2$ as only products **M2** correct equation	2

Answer for Question 37 (0620_w19_42_3)

Question	Answer	Marks
3(a)(i)	⇌	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
3(c)(i)	iron(II) hydroxide	1
3(c)(ii)	any **two** from: • it (iron(II) hydroxide) is oxidised • to form iron(III) (hydroxide) / (oxide) • by (iron(II) hydroxide reacting with) air / oxygen	2
3(c)(iii)	(green ppt) Remains	1
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

Answer for Question 37 (0620_w19_42_3)

Question	Answer	Marks
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**

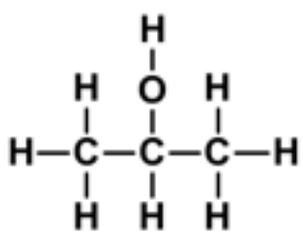
Answer for Question 38 (0620_w24_43_3)

Question	Answer	Marks
3(a)	78.8 (%)	1
3(b)(i)	reacts with acids and with bases to produce a salt and water	1
3(b)(ii)	$SnO_2 + 2NaOH \rightarrow Na_2SnO_3 + H_2O$ (2) **M1** Na_2SnO_3 **M2** correct equation	2
3(c)	metals form ionic compounds or ionic bonds only **OR** covalent compounds contain non-metals only	1
3(d)(i)	**M1** four single bonds using one dot and one cross **M2** three pairs of non-bonding electrons on each chlorine and no non-bonding electrons on tin	2

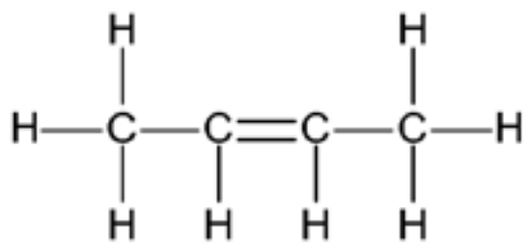
Answer for Question 38 (0620_w24_43_3)

Question	Answer	Marks
3(d)(ii)	**M1** attraction between molecules **or** intermolecular forces in tin(IV) chloride **M2** tin(II) oxide has a giant ionic structure **M3** weaker attraction (between particles) in tin(IV) chloride **ORA**	**3**
3(e)(i)	unreactive coating of aluminium oxide	**1**
3(e)(ii)	**M1** no reaction **M2** $Mg + Sn^{2+} \rightarrow Mg^{2+} + Sn$	**2**
3(f)(i)	substance that is chemically combined with water **OR** containing water of crystallisation	**1**
3(f)(ii)	$2Sn(NO_3)_2{\bullet}20H_2O \rightarrow 2SnO + 4NO_2 + O_2 + 40H_2O$ (2) **M1** $2(SnO) + 4(NO_2)$ **M2** $40H_2O$	**2**

Answer for Question 39 (0620_s20_43_1)

Question	Answer	Marks
1(a)(i)	**D**	**1**
1(a)(ii)	**C**	**1**
1(a)(iii)	**C**	**1**
1(a)(iv)	**B**	**1**
1(a)(v)	**D** AND **E** or **A**	**1**
1(a)(vi)	**C**	**1**
1(a)(vii)	**A** or **E**	**1**
1(a)(viii)		**1**
1(b)	donate or lose protons does not fully ionise / partially ionises / forms an equilibrium mixture	**2**

Answer for Question 40 (0620_w19_43_7)

Question	Answer	Marks
7(a)	carbon-carbon double bond / C = C	1
7(b)(i)	3	1
7(b)(ii)	 (1) but-2-ene (1)	2

Question	Answer	Marks
7(b)(iii)	CH_2 (1) CH_2 (1)	2
7(c)	(broken down by) hydrolysis (1) acid (used to break down) (1) enzymes (used to break down) (1) chromatography (used to separate) (1) locating agent / (view under) UV light (used to detect) (1) measure R_f (values) or retention factor / compare with standards (used to identify) (1)	6
7(d)(i)	Nylon / Kevlar	1
7(d)(ii)	water	1

Answer for Question 41 (0620_w24_42_5)

Question	Answer	Marks
5(a)	petroleum	**1**
5(b)	**M1** high temperature **M2** catalyst	**2**
5(c)(i)	$C_{12}H_{26} \rightarrow 3C_4H_8 + H_2$ **M1** C_4H_8 **M2** correct equation	**2**
5(c)(ii)	thermal decomposition	**1**
5(d)(i)	poly(propene)	**1**
5(d)(ii)	**M1** chain of six C atoms joined by single bonds in a chain **M2** three correctly placed CH_3 groups **M3** correct structure **AND** continuation bonds	**3**
5(d)(iii)	addition	**1**

Answer for Question 42 (0620_m22_42_5)

Question	Answer	Marks
5(a)(i)	cracking	1
5(a)(ii)	$C_{10}H_{22} \rightarrow 4C_2H_4 + C_2H_6$ $C_{10}H_{22}$ as only reactant formulae of ethene **and** ethane as only products correct equation	3
5(b)(i)	hydrogen chloride	1
5(b)(ii)	ultraviolet light	1
5(c)(i)	(only) one product is formed	1
5(c)(ii)	M1 Bond energy in breaking bonds = [(4 × 410) + 610 + 240] = 2490 (kJ / mol) M2 Use of total E change to find bond energy of $C_2H_4Cl_2$ = M1 + 180 = 2490 + 180 = 2670 (kJ / mol) M3 Determination of total C–C*l* bond energy = M2 – [(4 × 410) + 350] = 2670 – 1990 = 680 (kJ / mol) M4 Determination of each C–C*l* bond energy = M3 / 2 = 680 / 2 = 340 (kJ / mol)	4

Answer for Question 43 (0620_s22_41_1)

Question	Answer	Marks
1(a)	carbon dioxide	1
1(b)	aluminium oxide	1
1(c)	ethanol (1) carbon dioxide (1)	2
1(d)	ethanol	1
1(e)	oxygen	1
1(f)	carbon dioxide	1
1(g)	nitrogen	1
1(h)	diamond	1

Answer for Question 44 (0620_s24_42_2)

Question	Answer	Marks
2(a)(i)	electron loss (from outer shell)	1
2(a)(ii)	potassium	1
2(a)(iii)	magnesium or potassium	1
2(a)(iv)	iron	1
2(b)	<table><tr><td></td><td>M1 Colourless</td></tr><tr><td>M2 Blue</td><td>M3 Colour given in M2</td></tr></table>	3
2(c)(i)	hydrogen	1
2(c)(ii)	strontium hydroxide	1

Question	Answer	Marks
2(c)(iii)	**M1** magnesium **or** Mg **M2** magnesium oxide	2
2(d)	$Fe_3O_4 + 8HCl \rightarrow 2FeCl_3 + FeCl_2 + 4H_2O$ M1 $FeCl_2$ **or** $FeCl_3$ as product of equation M2 $FeCl_2$ **and** $FeCl_3$ **and** H_2O as only products of equation M3 Correct equation	3

Answer for Question 45 (0620_w21_41_1)

Question	Answer	Marks
1(a)(i)	hydrogen	1
1(a)(ii)	sodium	1
1(a)(iii)	iron	1
1(a)(iv)	aluminium	1
1(a)(v)	zinc or copper	1
1(a)(vi)	iron	1
1(b)(i)	zinc blende	1
1(b)(ii)	bauxite	1
1(c)	protective oxide layer	1
1(d)	Any 2 from 3 • zinc • iron • copper	2
1(e)(i)	copper	1
1(e)(ii)	zinc sulfate	1
1(e)(iii)	**M1** particles have more energy **M2** More collisions (between particles) occur per second / per unit time **M3** A greater percentage / proportion / fraction of collisions (of particles) are successful / have energy above activation energy / have energy equal to activation energy	3

Answer for Question 45 (0620_w21_41_1)

Question	Answer	Marks
1(e)(iv)	Any 2 from 3: • use a catalyst • use smaller granules • increase concentration	2

Answer for Question 46 (0620_s22_41_6)

Question	Answer	Marks
6(a)(i)	zinc blende	**1**
6(a)(ii)	heat(zinc sulfide) strongly in air / roast in air	**1**
6(a)(iii)	carbon **or** carbon monoxide	**1**
6(a)(iv)	the temperature in the furnace is above **or** higher than the boiling point of zinc **OR** the boiling point of zinc is below **or** less than the temperature of the furnace	**1**
6(a)(v)	condensation / condensing / condense	**1**
6(b)(i)	no bubbles **or** no fizzing **or** no effervescence	**1**

Question	Answer	Marks
6(b)(ii)	zinc / zinc oxide / zinc hydroxide	**1**
6(b)(iii)	(powder has) larg**er** surface area **OR** lumps have small**er** surface area (1) (powder has) more collisions per unit time / more collision frequency **OR** **lumps** have fewer collisions per unit time / less collision frequency (1)	**2**
6(b)(iv)	crystals (form on glass rod or microscope slide)	**1**
6(b)(v)	$ZnSO_4$	**1**

Answer for Question 47 (0620_s22_43_1)

Question	Answer	Marks
1(a)	carbon dioxide	1
1(b)	iron(III) oxide	1
1(c)	copper	1
1(d)	carbon monoxide	1
1(e)	glucose	1
1(f)	carbon monoxide	1
1(g)	copper	1
1(h)	oxygen	1

Answer for Question 48 (0620_s24_41_5)

Question	Answer	Marks
5(a)(i)	**M1** lead(II) nitrate(1) **M2** sodium bromide / potassium bromide / ammonium bromide(1)	**2**
5(a)(ii)	**M1** filter precipitate **or** lead(II) bromide **or** solid **or** residue(1) **M2** wash the residue with distilled water **AND** dry e.g. between filter papers(1)	**2**
5(a)(iii)	$Pb^{2+}(aq) + 2Br^{-}(aq) \rightarrow PbBr_2(s)$ **M1** $PbBr_2$ as the **only** product (1) **M2** $Pb^{2+} + 2Br^{-}$ as the **only** reactants in a balanced equation(1) **M3** state symbols (aq) + (aq) → (s)(1)	**3**
5(b)	**M1** acidified aqueous potassium manganate(VII) (1) **M2** purple to colourless (1)	**2**
5(c)	**M1** $2CoO + 4NO_2$ (1) **M2** $8H_2O$ (1)	**2**

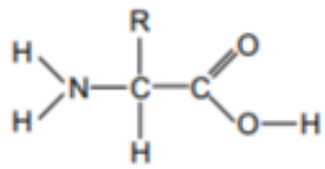
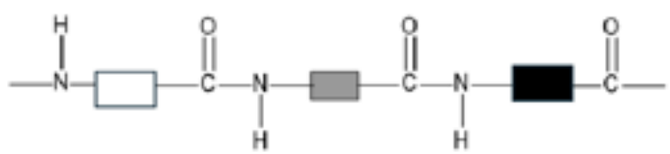
Answer for Question 48 (0620_s24_41_5)

Question	Answer	Marks
5(d)(i)	**M1 heat** again **and weigh** again **OR** repeat steps 2 and 3(1) **M2** until mass is constant (1)	**2**
5(d)(ii)	**M1** 0.005 / 5 $\times 10^{-3}$ (1) **M2** 0.63 (1) **M3** (0.63 / 18 =) 0.035 (1) **M4** (0.035 ÷ 0.005 =) 7 (1)	**4**

Answer for Question 49 (0620_w21_41_3)

Question	Answer	Marks
3(a)(i)	$2Cl^- \rightarrow Cl_2 + 2e^-$ Cl_2 (1) rest of equation (1)	2
3(a)(ii)	Oxidation AND lose electrons	1
3(b)	effervescence (of colourless gas)	1
3(c)	$2H^+ + 2e^- \rightarrow H_2$ $H^+ + e$ as only species on LHS (1) rest of equation fully correct (1)	2
3(d)(i)	1	1
3(d)(ii)	**M1** increase (1) **M2** H+ ions being removed (1)	2
3(e)	**M1** cathode: silver / grey solid (1) **M2** anode: bubbles of orange / brown gas (1)	2
3(f)	**M1** inert (1) **M2** conducts electricity (1)	2

Answer for Question 50 (0620_w24_41_6)

Question	Answer	Marks
6(a)	condensation	1
6(b)	proteins	1
6(c)	 (3) **M1** NH_2 group displayed **M2** COOH group displayed **M3** use of R	3
6(d)	 **M1** correct amide link between any two blocks showing all atoms and all bonds **M2** identical orientation of inter-block amide links including terminal groups with correct orientation **M3** continuation bonds on polymer	3
6(e)	**M1** <u>distance travelled by substance</u> **M2** distance travelled by solvent	2
6(f)(i)	pencil is insoluble (in solvent)	1
6(f)(ii)	locating agent	1
6(f)(iii)	same R_f value	1
6(f)(iv)	use a different solvent	1