CHEMISTRY
UNIT 1
2020

MARKING GUIDE

Section One: Multiple-choice **(25 marks)**

1	a ☐ b ☐ c ☐ d ■
2	a ☐ b ☐ c ☐ d ■
3	a ☐ b ■ c ☐ d ☐
4	a ☐ b ☐ c ■ d ☐
5	a ■ b ☐ c ☐ d ☐

6	a ☐ b ■ c ☐ d ☐
7	a ☐ b ☐ c ■ d ☐
8	a ☐ b ☐ c ☐ d ■
9	a ☐ b ☐ c ☐ d ■
10	a ☐ b ■ c ☐ d ☐

11	a ■ b ☐ c ☐ d ☐
12	a ☐ b ☐ c ☐ d ■
13	a ■ b ☐ c ☐ d ☐
14	a ☐ b ☐ c ■ d ☐
15	a ☐ b ■ c ☐ d ☐

16	a ☐ b ☐ c ☐ d ■
17	a ☐ b ☐ c ■ d ☐
18	a ☐ b ■ c ☐ d ☐
19	a ☐ b ☐ c ☐ d ■
20	a ☐ b ■ c ☐ d ☐

21	a ■ b ☐ c ☐ d ☐
22	a ☐ b ☐ c ☐ d ■
23	a ☐ b ☐ c ☐ d ■
24	a ☐ b ☐ c ■ d ☐
25	a ■ b ☐ c ☐ d ☐

(1 mark per question)

Section Two: Short answer **35% (62 marks)**

This section has **9** questions. Answer **all** questions. Write your answers in the spaces provided.

Supplementary pages for planning/continuing your answers to questions are provided at the end of this Question/Answer booklet. If you use these pages to continue an answer, indicate at the original answer where the answer is continued, i.e. give the page number.

Suggested working time: 60 minutes.

Question 26 **(10 marks)**

Complete the following table by writing either the name or formula for each substance. Then state the type of bonding (i.e. ionic or covalent) present within each substance.

Name	**Formula**	**Type of bonding (ionic / covalent)**
iron(III) oxide	$\mathbf{Fe_2O_3}$	**ionic**
dinitrogen tetrafluoride	N_2F_4	**covalent**
hydrogen peroxide	$\mathbf{H_2O_2}$	**covalent**
strontium nitride	Sr_3N_2	**ionic**
silver chromate	$\mathbf{Ag_2CrO_4}$	**ionic and covalent**

Question 27 **(12 marks)**

A group of students were investigating temperature changes associated with various chemical reactions.

They began by measuring the initial temperature of the reagents with a thermometer. Then the reaction was allowed to proceed for 2 minutes, before the final temperature of the reagents was measured.

In a particular beaker, the students mixed 2 g of barium hydroxide pellets with 2 g of powdered ammonium thiocyanate (NH_4SCN).

(a) In the table below, record as accurately as possible, the data collected by the students for this reaction. Include a measure of the uncertainty or error associated with each of your recorded values. (6 marks)

Initial temperature (°C) (including uncertainty / error)	**Final temperature (°C)** (including uncertainty / error)	**Temperature change (°C)** (including uncertainty / error)
Accept 19.1 – 19.7 $\pm$**0.5**	**Accept 3.2 – 3.8** $\pm$**0.5**	**Accept -15.3 to -16.5** $\pm$**1.0**

(Temperature change must be based on correct subtraction of other values, all values must be stated to 1 dp to get marks, 1m for each temperature reading, 1m for each error)

(b) Classify this reaction as endothermic or exothermic. Justify your answer. (3 marks)

- **Endothermic**
- **Heat was taken from the surroundings into the system**
- **Products therefore have higher enthalpy / H is therefore positive**

As this reaction proceeded, the two solids were observed to form a cloudy white liquid mixture. The reaction also produced a very pungent smelling gas. The students' teacher told them that the reaction had produced ammonia gas, water and the insoluble salt barium thiocyanate.

(c) Write a balanced chemical equation for this reaction, indicating the enthalpy change. (3 marks)

$$\mathbf{Ba(OH)_2(s) + 2\ NH_4SCN(s) + heat \rightarrow 2\ NH_3(g) + 2\ H_2O(l) + Ba(SCN)_2(s)}$$

(1m reactant and product formulas, 1m balancing, 1m indicating H)

Question 28 **(9 marks)**

Lawn and garden fertilisers will often contain the three (3) most important elements for plant growth; nitrogen (N), phosphorus (P) and potassium (K). Fertilisers will therefore often have an ‘N–P–K label’ written on the pack, to identify how much of each element is present in the fertiliser.

For example, if the N–P–K label was written as 16–4–8, the values would refer to the percent by mass of each element present, i.e. the fertiliser would contain 16% nitrogen by mass, 4% phosphorus by mass and 8% potassium by mass. The remaining mass of the fertiliser would consist of ‘fillers’ such as gypsum, lime and sand, which can be assumed to contain no nitrogen, phosphorus or potassium.

A particular sample of fertiliser was known to contain;

- 26.9 grams of ammonium nitrate, NH_4NO_3
- 19.1 g of calcium dihydrogenphosphate, $Ca(H_2PO_4)_2$
- 14.4 g of potassium chloride, KCl
- 22.6 g of additional ‘fillers’

(a) Calculate the percent composition of N, P and K respectively in each of the fertiliser ingredients named above. (3 marks)

% N in NH_4NO_3	**% N = 28.02 / 80.052 x 100 = 35.00 %** **[marks are not lost here for incorrect significant figures, but students should be aware that in some cases there may be a loss of marks]**
% P in $Ca(H_2PO_4)_2$	**% P = 61.94 / 234.052 x 100 = 26.46 %**
% K in KCl	**% K = 39.10 / 74.55 x 100 = 52.45 %**

(b) Using the masses given on the previous page, calculate the mass in grams of N, P and K present in the fertiliser sample. (3 marks)

mass of N in fertiliser sample	**m(N) = 35.0022 / 100 x 26.9 = 9.42 g** **OR** **m(N) = 28.02 / 80.052 x 26.9 = 9.42 g**
mass of P in fertiliser sample	**m(P) = 26.4642 / 100 x 19.1 = 5.05 g** **OR** **m(P) = 61.94 / 234.052 x 19.1 = 5.05 g**
mass of K in fertiliser sample	**m(K) = 52.4480 / 100 x 14.4 = 7.55 g** **OR** **m(K) = 39.10 / 74.55 x 14.4 = 7.55 g**

(c) State the final composition of the fertiliser as it would be written on the fertiliser label, using the typical N–P–K notation (i.e. round your values to whole numbers). (3 marks)

N–P–K label	**11 – 6 – 9** **(3m, below working not required for full marks)**

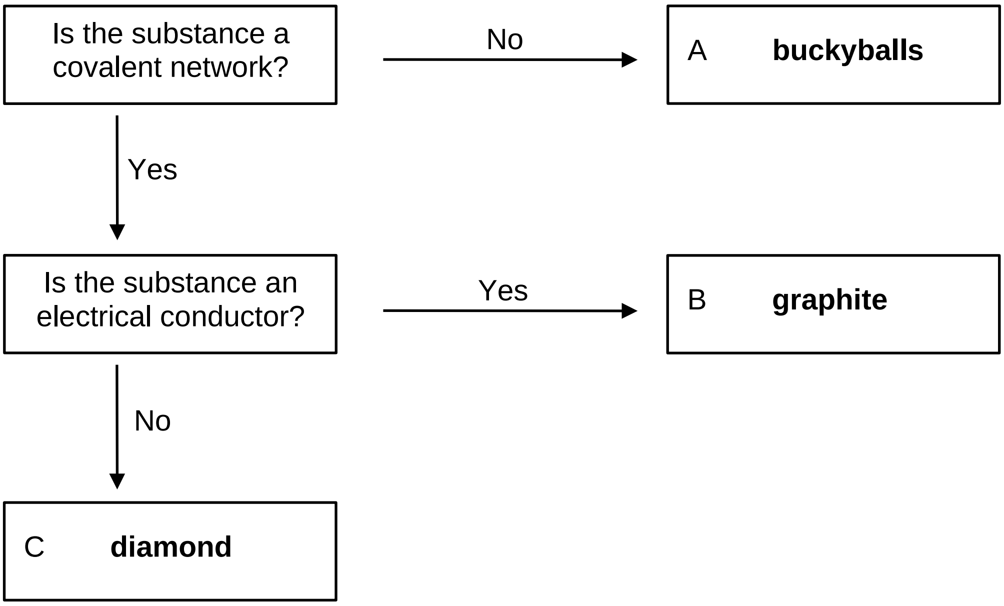
% N in entire sample = 9.42 / 83 x 100 = 11.34

% P in entire sample = 5.05 / 83 x 100 = 6.08

% K in entire sample = 7.55 / 83 x 100 = 9.10

Question 29 **(9 marks)**

Consider the key below, which refers to three (3) common allotropes of carbon; graphite, diamond and buckyballs.



(a) Complete the key above, by writing the labels ‘graphite’, ‘diamond’ and ‘buckyballs’ in the appropriate boxes labelled A, B and C. (3 marks)

(b) Justify the choices you made in part (a), using your knowledge of the differences in structure and bonding of these 3 allotropes. (6 marks)

- **Buckyballs are large molecules (C_{60})**
- **Therefore they do not form a covalent network structure**

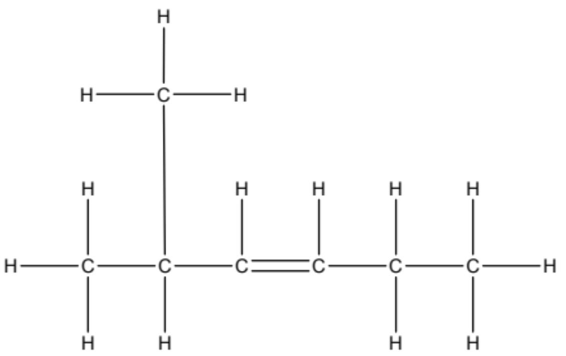
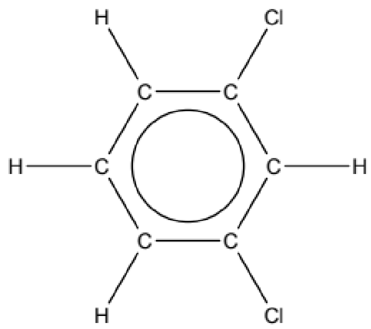
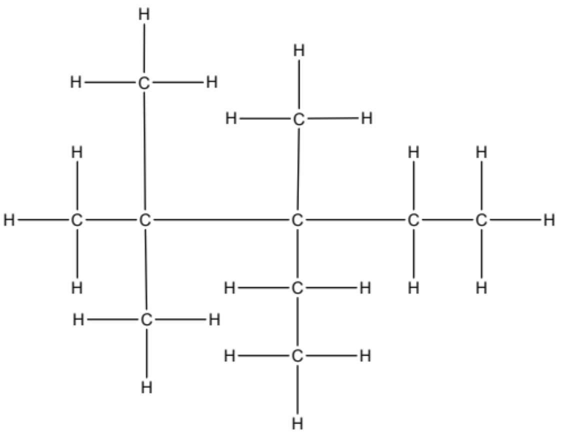
- **Each carbon atom in graphite forms 3 covalent bonds to other carbon atoms**
- **The fourth valence electron is delocalised, constituting mobile charge, therefore it is an electrical conductor**

- **Each carbon atom in diamond forms 4 covalent bonds to other carbon atoms**
- **There is no mobile charge, therefore diamond cannot conduct electricity**

Question 30 **(8 marks)**

Consider the organic compounds named in the table below.

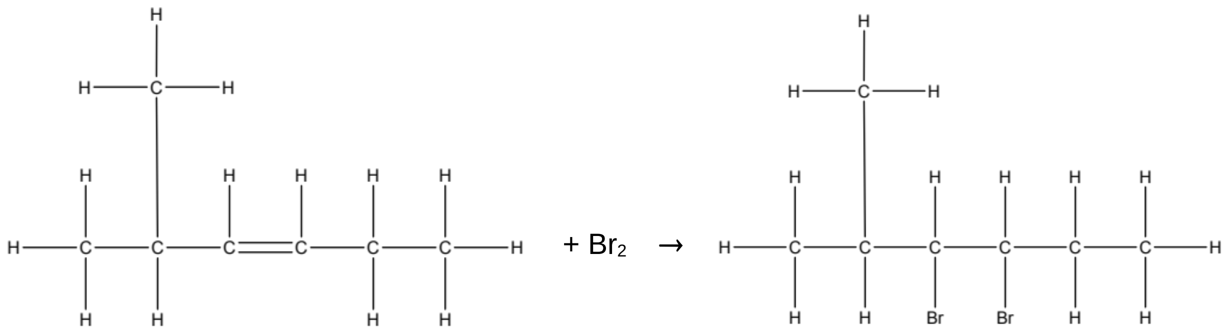
(a) Complete the table below by drawing full structural diagrams, showing **all** atoms and **all** bonds, for each of these compounds. (3 marks)

IUPAC Name	Full structural diagram
2-methylhex-3-ene **cis or trans could be shown, but not required**	
1,3-dichlorobenzene **Although technically contrary to the question, also accept the version not showing C or H (also accept Kekule structures – alternating double and single bonds)**	
3-ethyl-2,2,3-trimethylpentane	

(b) Describe a chemical test that could be used to distinguish 2-methylhex-3-ene from the other two compounds. Your answer should include a brief justification of your chosen test, expected observations, and a relevant chemical equation. (5 marks)

- **Add bromine / iodine water**
- **2-methylhex-3-ene would undergo an addition reaction**
- **Orange / brown would fade to colourless**
- **Other 2 compounds would have no reaction, orange / brown colour would remain**

Chemical equation:



OR

$CH_3CH(CH_3)CH{=}CHCH_2CH_3$ + Br_2 → $CH_3CH(CH_3)CHBrCHBrCH_2CH_3$

(or I_2 instead of Br_2) (molecular fomulas are insufficient as they do not the location of double bond or Br's)

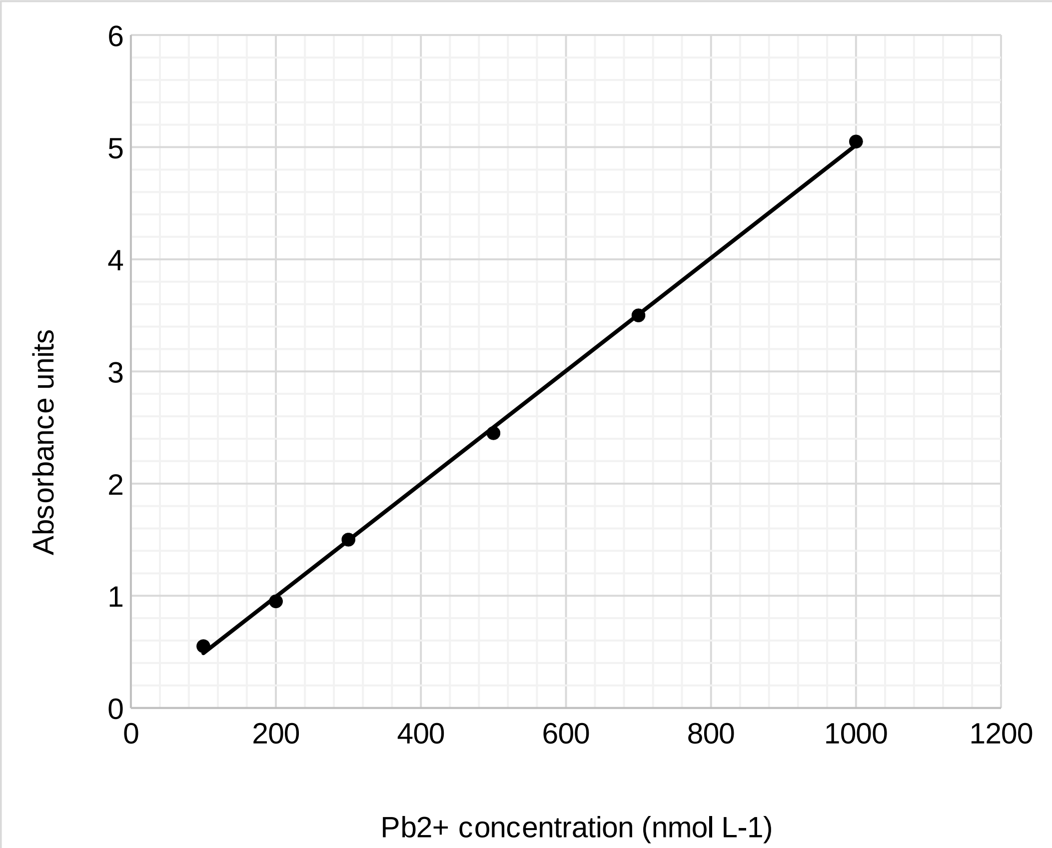
Question 31 **(8 marks)**

Lead poisoning can occur when the lead concentration in the blood exceeds 480 nmol L^{-1}.
(Note: nmol L^{-1} refers to nanomoles per litre; 1 nmol L^{-1} = 1 x 10^{-9} mol L^{-1})

The risk of health effects from lead poisoning is greatest for children under the age of 5.

An unwell child was taken to hospital with suspected lead poisoning. A blood sample was taken from the child and atomic absorption spectroscopy (AAS) was performed to determine if any lead was present in the blood.

The blood sample was compared to the calibration curve for lead below.



The absorbance reading for the child's blood sample was found to be 2.8.

(a) Determine the concentration of lead in the child's blood and comment on whether this concentration is high enough to be classified as lead poisoning. (3 marks)

- **(Allocate 1m for working shown on graph)**
- **560 nmol L^{-1} (accept 550 - 570 nmol L^{-1})**
- **Yes, would be classified as lead poisoning, since concentration is greater than 480 nmol L^{-1}**

(b) Calculate the total mass (in grams) of lead present in the child's bloodstream, if they had a blood volume of 1.0 L. (3 marks)

560 nmol L^{-1}; therefore in 1.0 L of blood there would be 560 nmol present

n(Pb) = 560×10^{-9}
= 5.6×10^{-7} mol

m(Pb) = nM
= $5.6 \times 10^{-7} \times 207.2$
= 0.000116 g
= 1.2×10^{-4} g

Lead can be found in some types of paint. In order to determine how the lead had got into the child's bloodstream, samples of different paints from within the child's bedroom were taken, dissolved in nitric acid, and then analysed by AAS.

The results of the paint analysis are shown in the table below.

Paint sample	**Absorbance**
Paint from the child's cot	4.1
Paint from the bedroom wall	0.8
Paint from a wooden toy train	0.1

(c) Name the most likely source of lead to have caused the child's illness. (1 mark)

- **Cot paint**

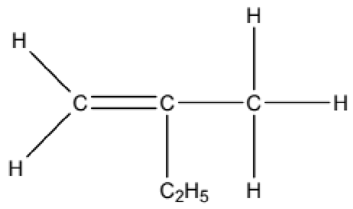
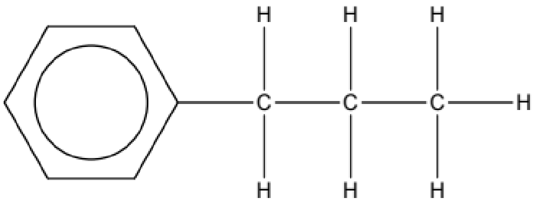
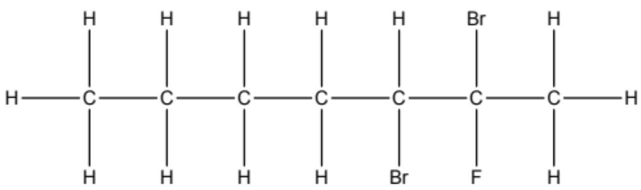
(d) Other than in the field of medicine, state one further use of AAS. (1 mark)

- **Food and drink analysis / heavy metal contamination in water / archaeology (artefact analysis) / agriculture (soil analysis) … (1m for any relevant example)**

Question 32 **(6 marks)**

Consider the organic compounds (A to C) shown in the table below.

(a) Complete the table below by writing the IUPAC name of each compound. (3 marks)

	Structure	IUPAC Name
A		**2-methylbut-1-ene**
B		**propylbenzene**
C		**2,3-dibromo-2-fluoroheptane**

When **compound B** underwent combustion in the presence of limited oxygen, carbon monoxide gas was formed instead of carbon dioxide gas.

(b) Write a balanced chemical equation representing this combustion process. (3 marks)

$$2\ C_9H_{12} + 15\ O_2 \rightarrow 18\ CO + 12\ H_2O$$

(1m for MF of compound B, 1m other reactants and products correct, 1m balancing)

End of Section Two

Section Three: Extended answer 40% (74 marks)

This section contains **five (5)** questions. You must answer **all** questions. Write your answers in the spaces provided below.

Where questions require an explanation and/or description, marks are awarded for the relevant chemical content and also for coherence and clarity of expression. Lists or dot points are unlikely to gain full marks.

Final answers to calculations should be expressed to the appropriate number of significant figures.

Supplementary pages for planning/continuing your answers to questions are provided at the end of this Question/Answer booklet. If you use these pages to continue an answer, indicate at the original answer where the answer is continued, i.e. give the page number.

Suggested working time: 70 minutes.

[maximum of 1 mark lost per question for significant figures, excepting serious inaccuracies)

Question 33 (20 marks)

Neon was discovered in 1898, as one of the previously unknown components of air. Scientists immediately knew it was a new element because it produced a distinctive bright red emission spectrum.

(a) Explain how an element can produce an emission spectrum and what would cause the emission spectrum for neon to be red. (5 marks)

- **Atoms can become excited when electrons absorb energy / photons**
- **The electrons then move to higher energy levels / shells**
- **Electrons then move back down to original levels / shells to return to ground state**
- **This process releases energy / photons**
- **The frequency / wavelength of light released determines the colour observed – red is dominant in the case of neon**

In 1913, J.J. Thompson fired a stream of neon ions through a magnetic and electric field and measured the deflections of the ions on a photographic plate. He observed 2 separate patches of light on the plate.

The instrument he used to perform this experiment was an early and very basic version of a mass spectrometer. This was the first discovery of isotopes of stable atoms, although Thompson did not realise this at the time.

(b) What is meant by the term ‘isotope’? (1 mark)

- **Atoms of the same element with a different number of neutrons / Atoms that have the same number of protons but different number of neutrons**

(c) Briefly describe how mass spectrometry can be used to determine the isotopic composition of an element. (4 marks)

- **Atoms of the element are ionised and accelerated**
- **Ions are deflected by a magnetic field based on their mass to charge ratio**
- **Different isotopes have different masses and are therefore separated / deflected by different amounts**
- **The proportion of each isotope present is detected**

We now know that neon in fact has 3 stable isotopes.

Isotope	Atomic mass	Percentage abundance
neon-20	19.992	90.48%
neon-21	20.994	0.27%
neon-22	21.991	9.25%

(d) Justify which 2 isotopes were most likely discovered by Thompson. (2 marks)

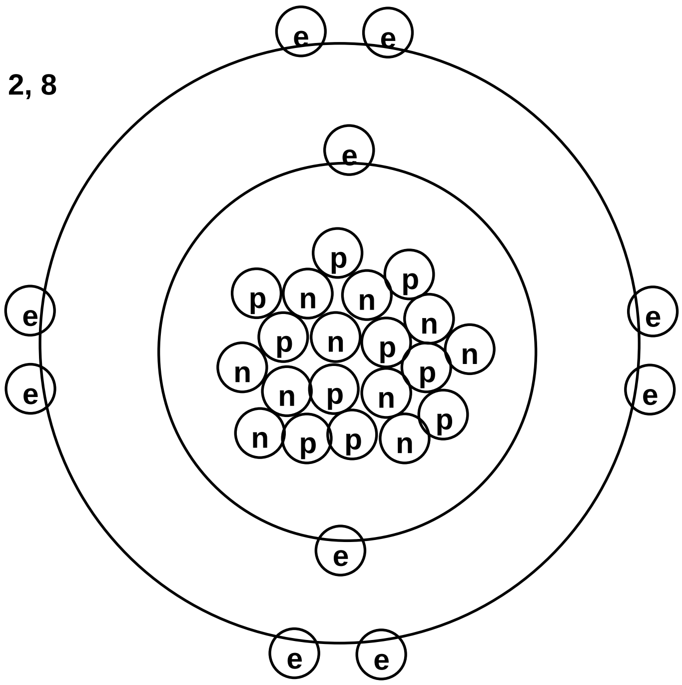
- **Neon 20 and 22**
- **These are the two most abundant isotopes / The early model of the mass spectrometer would not have been sensitive enough to detect the small amount of Ne-21**

Thompson played an important role in our understanding of the nature of atoms. He discovered electrons and developed the ‘plum pudding model’ of atoms. However, we now have a greater understanding of the structure of an atom, and more accurate models have since been developed.

Using the information regarding the existence of a nucleus, gathered by Rutherford in his ‘gold leaf experiment’, as well as Bohr’s theory of electron shells;

(e) Draw a diagram showing the subatomic particle arrangement of the most abundant isotope of neon. Use the symbols provided in the key below. (3 marks)

1m 10 protons
1m 10 neutrons
1m 10 electrons in 2, 8



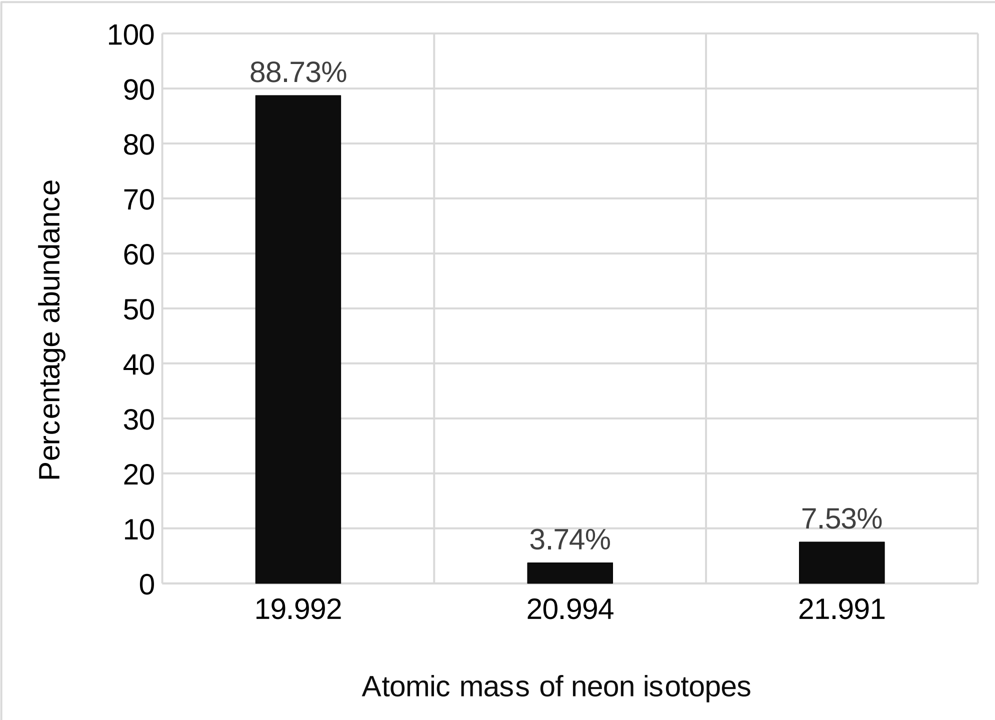
The industrial production of neon involves extracting it from a sample of air. In this process, the air is cooled under a high pressure, until it is in liquid form. When the liquid air is again warmed, the various components can be separated by fractional distillation.

(f) Describe how the process of fractional distillation works, and how this would allow isolation of neon. (3 marks)

- **As the liquid air is warmed, the different components would begin to boil**
- **Each component would have a unique boiling point, this would comprise the different ‘fractions’**
- **Therefore each component, in this case neon, could be separated / isolated from air**

A sample of neon from an asteroid was analysed by mass spectrometry, to determine whether the isotopic composition was the same as that on Earth.

The results are shown in the graph below.



(g) Calculate the relative atomic mass of this sample of neon. (2 marks)

Ar = 0.8873 x 19.992 + 0.0374 x 20.994 + 0.0753 x 21.991

= 17.73 + 0.785 + 1.66

= 20.18 g mol^{-1}

[*relative* atomic mass actually has no units, so accept with or without units]

Includes 1 marks for significant figures / decimal places

Question 34 **(15 marks)**

Copper metal can be extracted from ores containing the mineral chalcopyrite ($CuFeS_2$). The chemical equation representing this process is given below.

$$2\ CuFeS_2(s) + 5\ O_2(g) \rightarrow 2\ FeO(s) + 2\ Cu(s) + 4\ SO_2(g)$$

A 6.38 tonne sample of ore containing 42.7% chalcopyrite was smelted.

(a) Calculate the mass of oxygen required to react with this ore. State your answer to the appropriate number of significant figures. (6 marks)

m($CuFeS_2$)	**=**	**42.7 / 100 x 6.38**				
	=	**2.72426 t**				
	=	**2.72426 x 10^6 g**				
n($CuFeS_2$)	**=**	**m/M**				
	=	**(2.72426 x 10^6) / 183.54**				
	=	**14842.868 mol**				
n(O_2)	**=**	**5/2 x n($CuFeS_2$)**				
	=	**5 / 2 x 14842.868**				
	=	**37107.1701 mol**				
m(O_2)	**=**	**nM**				
	=	**37107.1701 x 32.00**				
	=	**1187429 g**	**OR**	**1187.4 kg**	**OR**	**1.187 t**
	=	**1.19 x 10^6 g**	**OR**	**1.19 x 10^3 kg**	**OR**	**1.19 t (3 SF)**

The oxygen gas used in the smelting process is extracted directly from air. If air is comprised 23.0% oxygen by mass;

(b) Calculate the mass of air required to provide the oxygen for this process. (1 mark)

m(air)	**=**	**100 / 23.0 x 1187429**				
	=	**5162737 g**				
	=	**5.16 x 10^6 g**	**OR**	**5.16 x 10^3 kg**	**OR**	**5.16 t (3 SF)**

One of the main uses of copper metal is for electrical wiring. For this purpose, copper needs to have a **high electrical conductivity** and be **ductile**.

(c) Explain, in terms of structure and bonding, why copper possesses both these properties. (4 marks)

- **Copper displays metallic bonding, which consists of positive metal ions surrounded by a sea of delocalised electrons**
- **The delocalised electrons constitute mobile charge, therefore allowing copper to conduct electricity**

- **The metallic bonding is non-directional**
- **Therefore when a force is applied copper can be shaped without disrupting the bonding, therefore making it ductile**

Read this short extract on copper nanoparticles and answer the following questions.

As early as the 9th century, copper nanoparticles were used as a component of pottery glaze. These copper nanoparticles were able to change the colour of the ceramic or glass on which they were painted, by the way they reflected light off the surface of the object.

In modern times, copper nanoparticles have been found to have antifungal and antibacterial properties that are not observed in commercially sourced copper. They are also finding use as catalysts in various reactions. In one case, the nanoparticle form of the copper catalyst provided an 88% conversion of reactants to products, compared to only a 43% conversion with commercially available copper catalyst.

There are several methods of producing copper nanoparticles. The starting materials, as well as the conditions used, can alter the size and shape of the copper nanoparticle produced.

(d) Define a 'nanomaterial'. (1 mark)

- **Materials that contain particles in the size range 1-100 nm**

(e) Give one example of how the properties of copper nanoparticles differ from those of the bulk form. (1 mark)

- **Different colour / antifungal properties / antibacterial properties / increased catalytic activity (1m for any relevant example)**
-

A particular copper nanoparticle contained 64500 atoms of copper.

(f) Calculate the mass of this nanoparticle. (2 marks)

n(Cu) = $\mathbf{N/N_A}$
= $\mathbf{64500 / (6.022 \times 10^{23})}$
= $\mathbf{1.07107 \times 10^{-19}}$ **mol**

m(Cu) = **nM**
= $\mathbf{1.07143 \times 10^{-19} \times 63.55}$
= $\mathbf{6.807 \times 10^{-18}}$ **g**

Question 35 **(20 marks)**

Two sources of the fuel methane gas (CH_4) are ‘natural gas’ and ‘biogas’. Methane is a widely used fuel in ovens, houses, water heaters, cars, Bunsen burners and turbines.

The natural gas that reaches our homes is approximately 97% methane. Alternately, biogas contains around 68% methane.

The combustion of the methane in both natural gas and biogas can be represented by the following chemical equation.

$$CH_4(g) \quad + \quad 2\ O_2(g) \quad \rightarrow \quad CO_2(g) \quad + \quad 2\ H_2O(g) \quad + \quad 882\ kJ$$

(a) State one advantage and one disadvantage of each source of methane gas. (4 marks)

	Natural gas
Advantage	**Higher purity / well established methods of extraction (or purification) …(any relevant comment)**
Disadvantage	**From non-renewable resource / use of fossil fuels to extract … (any relevant comment)**

	Biogas
Advantage	**Lower overall carbon emissions / smaller carbon footprint / from renewable resource / more sustainable / green or environmentally friendly process …(any relevant comment)**
Disadvantage	**Less pure / slower production process / needs further refining / higher cost of refinement …(any relevant comment)**

A 20.0 kg sample of natural gas was combusted. Assume the natural gas was 97.0% pure.

(b) Calculate the amount of energy released. (4 marks)

$m(CH_4)$ = 97.0 / 100 x 20.0
= 19.4 kg

= 19.4×10^3 g

$n(CH_4)$ = m/M
= 19400 / 16.042
= 1209.3 mol

Energy released = 882 x $n(CH_4)$
= 882 x 1209.3
= 1066625 kJ
= 1.07×10^6 kJ (3 SF)

(c) Calculate the mass of biogas that would be required to produce the same amount of energy. Assume the biogas was 68.0% pure. (2 marks)

$m(CH_4$ required) = 19400 g (from part (b))

m(biogas) = 100 / 68.0 x 19400
= 28529 g
= 2.85×10^4 g OR 28.5 kg (3 SF)

(d) State the energy output of each fuel source in kilojoules per gram of fuel (kJ g^{-1}). (2 marks)

	Energy output (kJ per gram of fuel)
Natural gas	**53.3 kJ / g**
Biogas	**37.4 kJ / g**

(e) State the energy output of each fuel source in kilojoules per litre of fuel (kJ L^{-1}). (2 marks)

	Density	Energy output (kJ per litre of fuel)
Natural gas	0.57 g L^{-1}	**30.4 kJ / L**
Biogas	0.85 g L^{-1}	**31.8 kJ / L**

Consider again, the reaction for the combustion of methane, represented by the chemical equation below.

$$CH_4(g) \;+\; 2\,O_2(g) \;\rightarrow\; CO_2(g) \;+\; 2\,H_2O(g) \;+\; 882\text{ kJ}$$

(f) State whether this reaction is ‘endothermic’ or ‘exothermic’. Describe this process in terms of bonds breaking and bond forming. (3 marks)

- **Exothermic**
- **The energy required to break the C-H and O-O bonds is less**
- **Than the energy released when C-O and H-O bonds are formed**

(g) Describe the energy transformations occurring between the ‘system’ and the ‘surroundings’ in this reaction. Your answer should include a justification of how energy is conserved in this process. (3 marks)

- **Some of the enthalpy in the system is transformed**
- **Into heat energy which is released to the surroundings**
- **The amount of energy lost by the system is equal to the amount of energy gained by the surroundings**

Question 36 **(19 marks)**

The paint used to mark the lanes, parking bays and symbols on our roads is called "thermoplastic road marking paint". The paint mixture has five (5) components;

1. A synthetic resin – this contains the thermoplastic that adheres to the road surface.
2. Additives – these increase the resistance of the paint to pollution and fading.
3. Pigments – to provide the desired colour of paint.
4. Packing materials – these increase the strength and resistance of the paint.
5. Glass beads – allows the paint to reflect light better and provides anti-skid properties.

This paint mixture is heated to around 200 $^{\circ}$C and sprayed onto the road surface where it quickly dries.

The 'synthetic resin' used in the road marking paint is often a hydrocarbon plastic, made from reactants such as pent-1-ene or pent-2-ene. The thermoplastic component should ideally have a softening or melting point around 80-140 $^{\circ}$C.

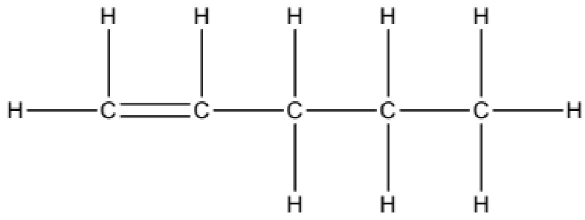
(a) Name the type of bonding present in the 'synthetic resin'. Describe how and why this type of bonding forms. (4 marks)

- **Covalent (molecular)**
- **This type of bonding is the electrostatic attraction between shared electrons and adjacent nuclei**
- **The (two or more) non-metal elements share pair(s) of electrons**
- **In order to achieve a stable electron configuration (often octet)**

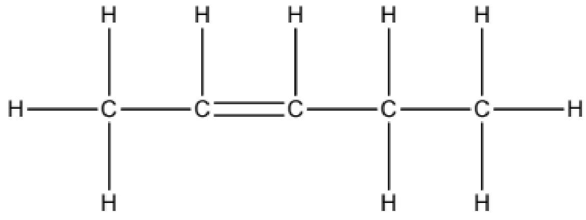
(b) Explain, in terms of structure and bonding, why the 'synthetic resin' has a low melting point. (2 marks)

- **Covalent molecular substances have weak intermolecular forces**
- **Therefore only a small amount of heat energy is required to disrupt the bonding**

The structures of pent-1-ene and pent-2-ene are shown below.



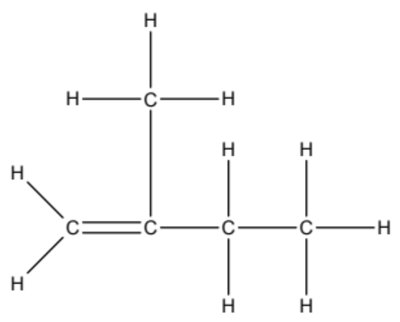
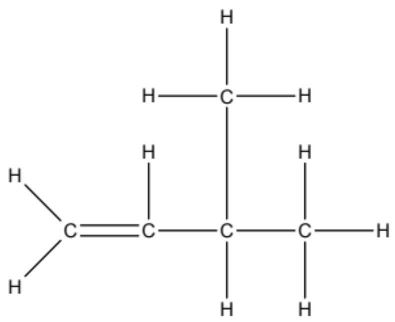
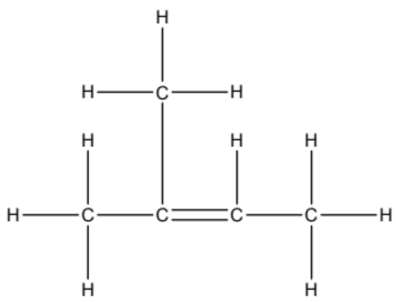
pent-1-ene



pent-2-ene

These compounds are known as 'isomers' because they have the same molecular formula, but a different structure.

(c) Draw full structural formulas for three (3) other organic compounds that would also be classified as 'isomers' of pent-1-ene and pent-2-ene. Include **all** atoms and **all** bonds. (3 marks)

(accept also appropriate cyclics such as cyclopentane, methylcyclobutane etc…also, since 2-pentene has cis and trans isomers, if both of these are listed, that can count as ONE additional structure)

The 'packing materials' used in the road marking paint include compounds such as calcium carbonate, barium sulfate and aluminium hydroxide. If the proportion of these compounds is too high, it results in a brittle paint coating that cracks and does not adhere to the road effectively.

(d) Name the type of bonding present in the 'packing materials'. Describe how and why this type of bonding forms. (4 marks)

- **Ionic (**Elsewhere we allude to the covalent bonding in polyatomic ions, so any student raising this should not be penalised (but no specific credit here either))
- **This type of bonding is the electrostatic attraction between cations and anions**
- **Electrons are transferred (from the metal element to the non-metal element)**
- **In order to achieve a stable electron configuration (often octet)**

(e) Explain, in terms of structure and bonding, why a high concentration of ‘packing materials’ can result in the road paint mix being brittle. (2 marks)

- **Ionic substances have a rigid lattice structure**
- **If a force is applied, like charges align and repel, causing the substance to shatter i.e. it is brittle**

Glass beads (silicon dioxide, SiO_2) provide anti-skid properties to the paint, as well as increase the brightness and reflectivity, which is especially important for night driving. These characteristics are provided by the very durable nature of the glass.

(f) Explain, in terms of structure and bonding, why glass is such a strong and durable material. (4 marks)

- **Glass contains covalent network bonding**
- **Consists of an extensive covalently bonded 3D network**
- **Due to the strong electrostatic attraction between shared electrons and adjacent nuclei throughout the network**
- **A large amount of force or heat is required to disrupt the bonding, this results in glass being strong and durable**

End of questions