Insert School Logo

CHEMISTRY

UNIT 1

2020

Name: _____

Teacher: _____

TIME ALLOWED FOR THIS PAPER
Reading time before commencing work: ten minutes
Working time for the paper: three hours

MATERIALS REQUIRED/RECOMMENDED FOR THIS PAPER

To be provided by the supervisor:
This Question/Answer Booklet
Multiple-choice Answer Sheet
Chemistry Data Book

To be provided by the candidate:
Standard items: pens (blue/black preferred), pencils (including coloured), sharpener, eraser, correction tape/fluid, ruler, highlighters

Special items: up to three non-programmable calculators approved for use in the WACE examinations

IMPORTANT NOTE TO CANDIDATES
No other items may be taken into the examination room. It is **your** responsibility to ensure that you do not have any unauthorised notes or other items of a non-personal nature in the examination room. If you have any unauthorised material with you, hand it to the supervisor **before** reading any further.

Structure of this paper

Section	Number of questions available	Number of questions to be answered	Suggested working time (minutes)	Marks available	Percentage of examination
Section One Multiple-choice	25	25	50	/ 25	/ 25
Section Two Short answer	9	9	60	/ 79	/ 35
Section Three Extended answer	5	5	70	/ 92	/ 40
					/ 100

Instructions to candidates

1. Write your answers in this Question/Answer booklet preferably using a blue/black pen. Do not use erasable or gel pens.

2. Answer the questions according to the following instructions.

   Section One: Answer all questions on the separate Multiple-choice answer sheet provided. For each question, shade the box to indicate your answer. Use only a blue or black pen to shade the boxes. Do not use erasable or gel pens. If you make a mistake, place a cross through that square then shade your new answer. Do not erase or use correction fluid/tape. Marks will not be deducted for incorrect answers. No marks will be given if more than one answer is completed for any question.

   Sections Two and Three: Write your answers in this Question/Answer Booklet.

3. When calculating numerical answers, show your working or reasoning clearly. Your working should be in sufficient detail to allow your answer to be checked readily and for marks to be awarded for reasoning. Express numerical answers to the appropriate number of significant figures and include appropriate units where applicable.

4. You must be careful to confine your answers to the specific questions asked and to follow any instructions that are specific to a particular question.

5. 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.

6. The Chemistry Data booklet is not to be handed in with your Question/Answer booklet.

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

This section has **25** questions. Answer **all** questions on the separate Multiple-choice Answer Sheet provided. For each question, shade the box to indicate your answer. Use only a blue or black pen to shade the boxes. If you make a mistake, place a cross through that square then shade your new answer. Do not erase or use correction fluid/tape. Marks will not be deducted for incorrect answers. No marks will be given if more than one answer is completed for any question.

Suggested working time: 50 minutes.

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1. Which of the following statements regarding subatomic particles is **not** correct?

   (a) The mass of a proton and neutron are equal.
   (b) The mass of a proton is greater than that of an electron.
   (c) The charge of a proton and electron are equal in magnitude.
   (d) The charge of a neutron is greater than that of a proton.

2. Which of the following species has the most stable electron configuration?

   (a) Na^{2+}
   (b) P^{2-}
   (c) Al^{+}
   (d) N^{3-}

3. Which of the following is **not** a mixture?

   (a) Brass
   (b) Ammonia
   (c) Air
   (d) Vinegar

4. Cobalt metal is placed into a solution of sulfuric acid, producing cobalt sulfate solution, sulfur dioxide gas and water.

   The correctly balanced chemical equation representing this reaction is

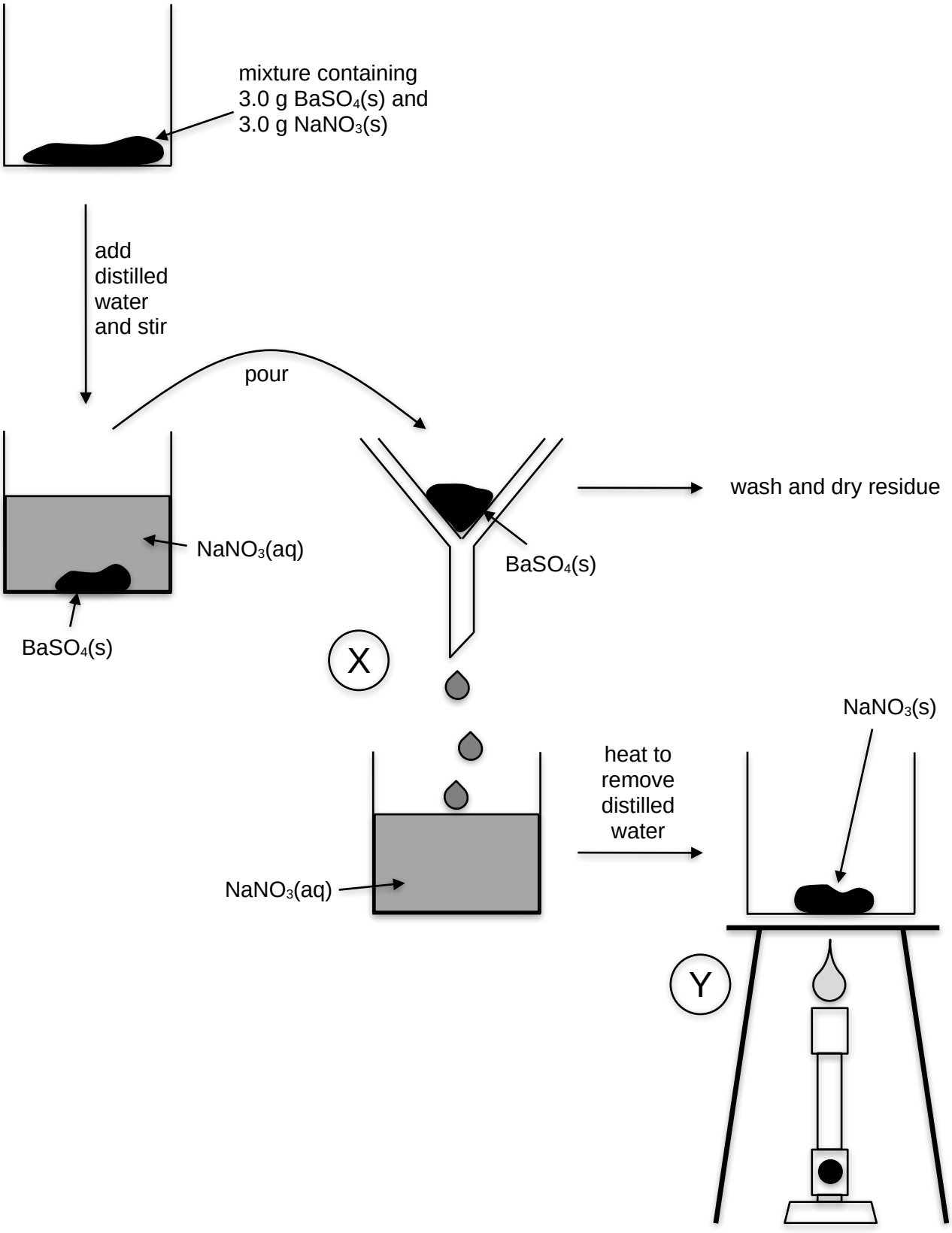
   (a) $Co(s) + H_2SO_4(aq) \rightarrow CoSO_4(aq) + SO_2(g) + H_2O(l)$
   (b) $Co(s) + 2\ H_2SO_4(aq) \rightarrow Co(SO_4)_2(aq) + SO_2(g) + 2\ H_2O(l)$
   (c) $Co(s) + 2\ H_2SO_4(aq) \rightarrow CoSO_4(aq) + SO_2(g) + 2\ H_2O(l)$
   (d) $Co(s) + H_2SO_3(aq) \rightarrow CoSO_3(aq) + SO_2(g) + H_2O(l)$

5. Which of the following statements does **not** contribute to an explanation of why sodium (Na) and magnesium (Mg) display different emission and absorption spectra?

   (a) The number of electron shells present in each element differs.
   (b) The number of electrons in each element differs.
   (c) The energy of the electron shells in each element differs.
   (d) The distance between the electron shells of each element differs.

Questions 6, 7 and 8 refer to the procedure illustrated below.

The following flow chart shows the procedure carried out by several groups of students, in order to separate a mixture of powdered barium sulfate ($BaSO_4$) and powdered sodium nitrate ($NaNO_3$). There was 3.0 grams of each powder present in the initial mixture.



6. Name the separation techniques being used at X and Y.

	X	Y
(a)	decantation	filtration
(b)	filtration	evaporation
(c)	sieving	evaporation
(d)	filtration	decantation

7. Which of the following errors, when introduced into this procedure, would result in a **decreased** mass of $BaSO_4(s)$ being recorded?

(a) Not washing the $BaSO_4$ residue with distilled water before weighing.
(b) Not subtracting the mass of the filter paper when determining the mass of $BaSO_4$.
(c) Not transferring all of the $BaSO_4(s)$ and $NaNO_3(aq)$ mixture into the funnel.
(d) Not allowing the $BaSO_4$ residue to dry before weighing.

8. The table below shows the results of four different student groups (A to D). Each group carried out this separation procedure four (4) times and recorded the final masses of $BaSO_4(s)$ and $NaNO_3(s)$ obtained in each trial. This table shows only the mass, in grams, of $NaNO_3(s)$ obtained by each group, across each of their four trials.

	Trial 1	Trial 2	Trial 3	Trial 4
Group A	3.1	3.2	3.1	3.2
Group B	2.9	3.0	2.9	3.2
Group C	2.3	2.4	2.5	2.4
Group D	3.3	3.3	3.3	3.3

Which of the following statements is **correct**?

(a) Group A was the most accurate.
(b) Group B was the most precise.
(c) Group C suggests only sources of random error were present.
(d) Group D suggests a source of systematic error.

9. Chromium has four (4) naturally occurring isotopes;

(i) chromium-50
(ii) chromium-52
(iii) chromium-53
(iv) chromium-54.

Which of these isotopes would have the same electron configuration, at room temperature?

(a) (i) and (ii) only.
(b) (ii) and (iii) only.
(c) (i) and (iv) only.
(d) All of (i), (ii), (iii) and (iv).

Questions 10, 11 and 12 refer to the four organic compounds in the table below, shown as condensed formulas.

A $(CH_3)_3CCH_2CH_2CH_3$	**B** $CH_3CH(CH_3)CHCHCH_3$
C $CH_3CH_2CH(C_2H_5)CH(CH_3)CH_3$	**D** $CH_3(CH_2)_5CH_3$

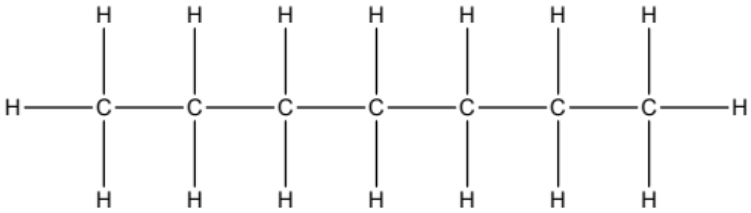
10. Which compound is unsaturated?

(a) A
(b) B
(c) C
(d) D

11. Which compound has the IUPAC name 2,2-dimethylpentane?

(a) A
(b) B
(c) C
(d) D

12. The full structural formula of which compound is shown below?



(a) A
(b) B
(c) C
(d) D

13. Choose the reaction below that represents an endothermic process.

(a) $K(g) \rightarrow K^+(g) + e^-$
(b) $2\ H_2(g) + O_2(g) \rightarrow 2\ H_2O(g)$
(c) $Ag^+(aq) + Cl^-(aq) \rightarrow AgCl(s)$
(d) $2\ N(g) \rightarrow N_2(g)$

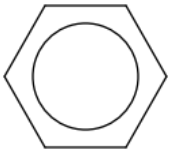
14. Silicon (Si) is placed to the immediate right of aluminium (Al) on the periodic table because

(a) it is a semi-metal.
(b) it is a less reactive element.
(c) it contains one more proton.
(d) it is slightly larger in diameter.

15. An ion will always have

(a) a different number of protons and neutrons.
(b) a different number of protons and electrons.
(c) a different number of neutrons and electrons.
(d) the electron configuration of a Noble Gas.

Questions 16 and 17 relate to the compound shown below.

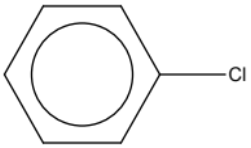


16. Which of the following statements is **not** correct regarding this compound?

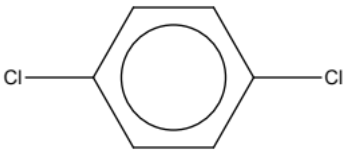
(a) The compound is called benzene.
(b) The compound has the molecular formula C_6H_6.
(c) The compound contains delocalised electrons.
(d) The compound conducts electricity.

17. This compound was mixed with chlorine gas in the presence of an appropriate catalyst. Choose the species below that **cannot** be present in the final reaction mixture.

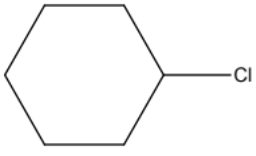
(a)



(b)

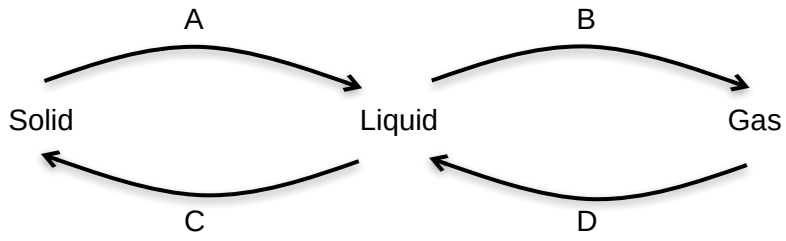


(c)



(d) HCl

Questions 18 and 19 refer to the diagram below regarding changes of state / phase.



18. Give the names for the processes occurring at B and C.

	B	**C**
(a)	boiling	melting
(b)	vaporisation	solidification
(c)	condensation	freezing
(d)	solidification	boiling

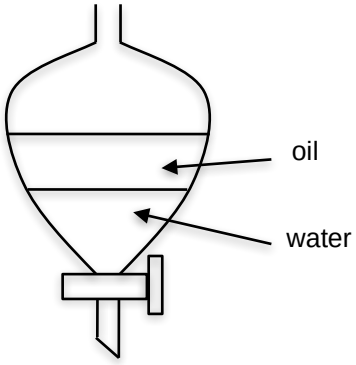
19. Which two processes are exothermic?

(a) A and B
(b) A and C
(c) B and D
(d) C and D

20. Which of the following statements is **not generally** correct?

(a) Elements in group 15 have the capacity to form single covalent bonds with three other atoms.
(b) Elements in group 16 have the capacity to form triple covalent bonds.
(c) Elements in group 17 do not have the capacity to form double covalent bonds.
(d) Elements in group 18 do not tend to form covalent bonds.

21. A separating funnel can be used to separate oil and water, as shown in the diagram below.



Which of the following statements is **least** relevant in justifying the use of this separating technique in this situation?

(a) The oil and water have different boiling points.
(b) The oil and water are both liquid.
(c) The oil and water have different densities.
(d) The oil is not soluble in the water.

Questions 22 and 23 refer to the production of ethanol and bioethanol.

Ethanol and bioethanol are both very useful fuels and chemical reagents. The chemical equations for the manufacture of ethanol and bioethanol are given below.

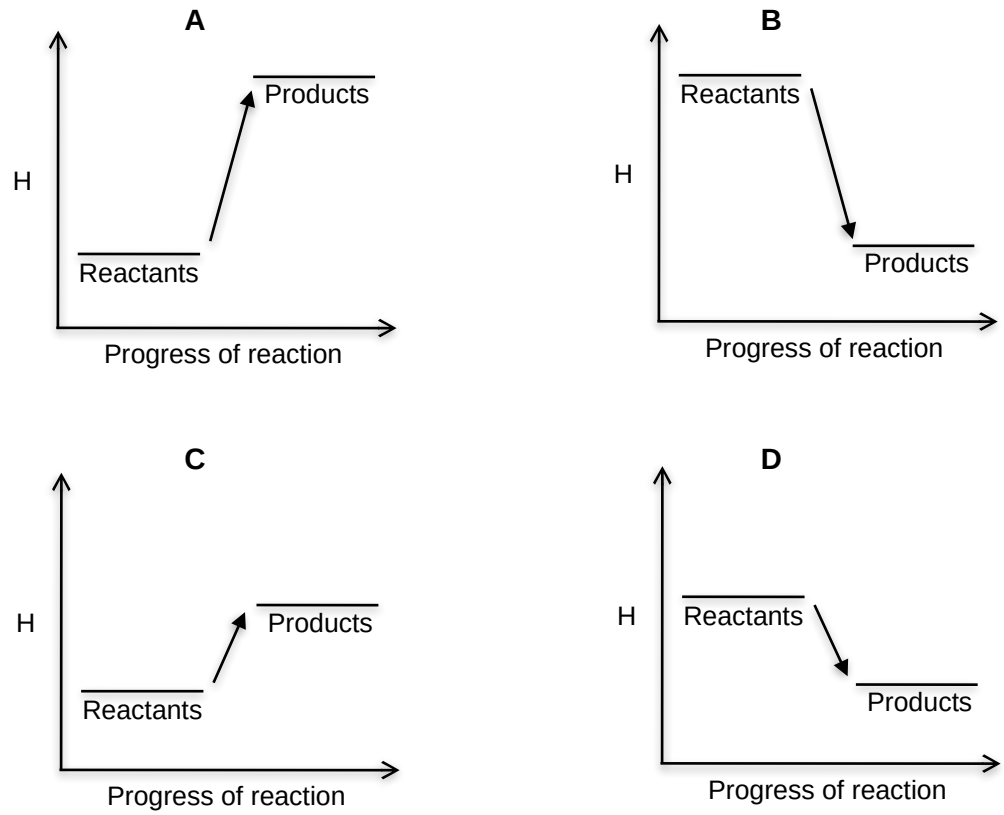
Ethanol: $C_2H_4(g) + H_2O(g) \rightarrow C_2H_5OH(g) + 45\ kJ$

Bioethanol: $C_6H_{12}O_6(s) \rightarrow 2\ C_2H_5OH(l) + 2\ CO_2(g) + 68\ kJ$

22. What is a key difference between the ethanol and bioethanol?

(a) Bioethanol is structurally different to ethanol.
(b) Bioethanol has a different molecular formula to ethanol.
(c) Bioethanol contains a lower percent composition of carbon than ethanol.
(d) Bioethanol is produced from a renewable resource.

23. Consider the enthalpy change diagrams below, which all have the same scale on their vertical axis.



Which diagrams are most representative of the chemical reactions used to produce ethanol and bioethanol?

	Ethanol	**Bioethanol**
(a)	A	C
(b)	C	A
(c)	B	D
(d)	D	B

24. Which of the following lists contains ions that all have the same valency charge?

(a) fluoride, hydrogencarbonate, phosphide
(b) carbonate, nitrate, sulfate
(c) sulfite, dichromate, hydrogenphosphate
(d) hydrogensulfate, phosphate, bromide

25. A sample of pure water boils at 100 ˚C. Under the same conditions of pressure, a sample of pure water containing dissolved sodium chloride would

(a) have a boiling point of 102 ˚C.
(b) have a boiling point of 98 ˚C.
(c) have a boiling point above 100 ˚C.
(d) have a boiling point below 100 ˚C.

End of Section One

Section Two: Short answer **35% (79 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		
	N_2F_4	
hydrogen peroxide		
	Sr_3N_2	
silver chromate		

Question 27 **(12 marks)**

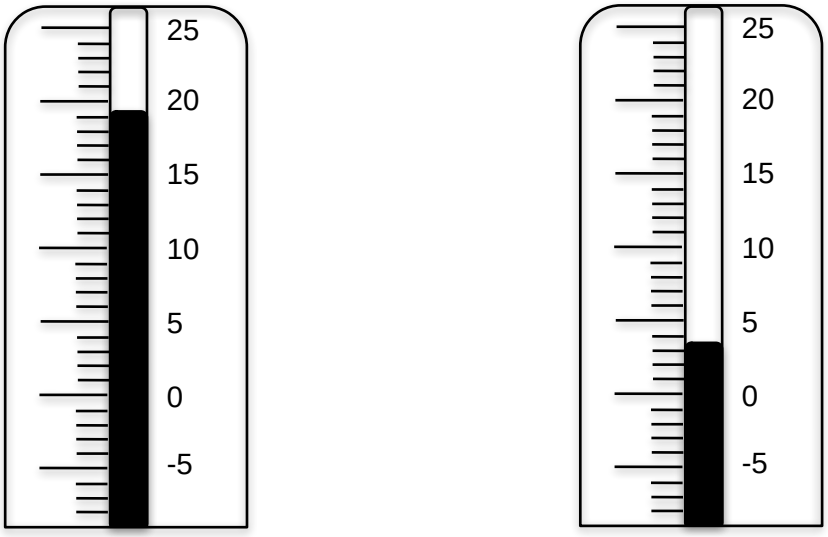
A group of students were investigating temperature changes associated with various chemical reactions.

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).

The measurements taken by the students are illustrated in the diagrams below.

Initial **Final**



(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)

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

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)

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 g 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	
% P in $Ca(H_2PO_4)_2$	
% K in KCl	

(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	
mass of P in fertiliser sample	
mass of K in fertiliser sample	

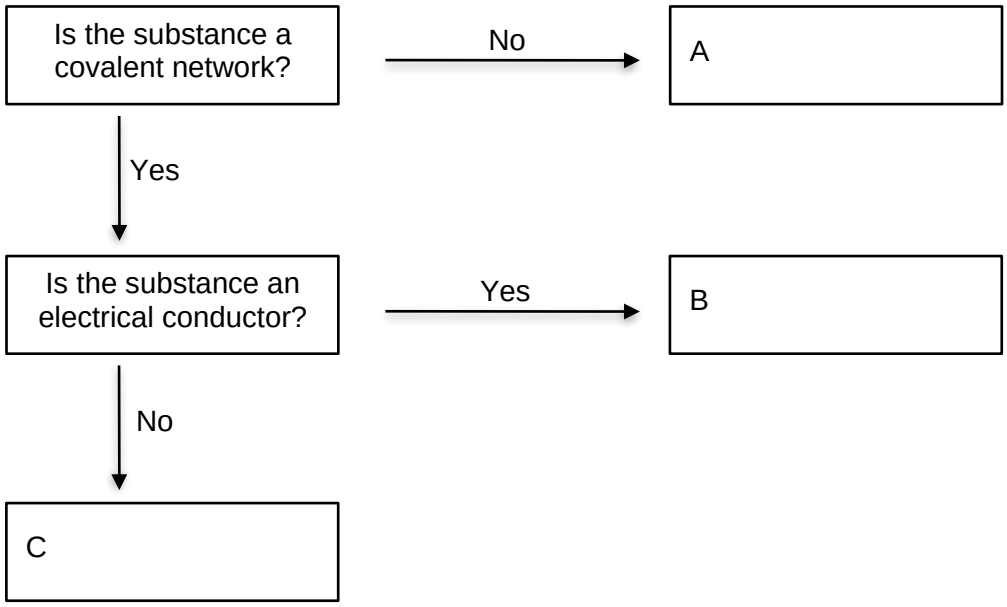
(c) State the final composition of the fertiliser as it would be written on the fertiliser label, using the typical N–P–K notation (i.e. round your values to whole numbers). (3 marks)

N–P–K label	

(This space has been left blank for any working out, if required.)

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)

Question 30 **(11 marks)**

Consider the data provided regarding species V, W, X, Y and Z in the table below.

Species	Symbol	Number of protons	Number of neutrons	Electron configuration
V	$^{24}_{12}Mg^{2+}$	12	12	
W			0	1
X		16	17	2, 8, 8
Y	$^{40}_{18}Ar$	18		
Z	$^{31}_{15}P$		16	

(a) Complete the table above. (8 marks)

(b) Which two (2) species would be electrostatically attracted to one another? (1 mark)

_____

(c) Which two (2) species have the same number of electrons? (1 mark)

_____

(d) Which two (2) species could form covalent bonds with each other? (1 mark)

_____

See Next Page

Question 31 **(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	
1,3-dichlorobenzene	
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)

Chemical equation:

Question 32 **(6 marks)**

Complete the table below by classifying each as a pure substance or a mixture, and then stating if the substance would conduct electricity.

Description of substance	Classification of substance (Pure / Mixture)	Conductor of electricity (Yes / No)
Aqueous potassium nitrate		
Distilled water		
Molten sodium chloride		

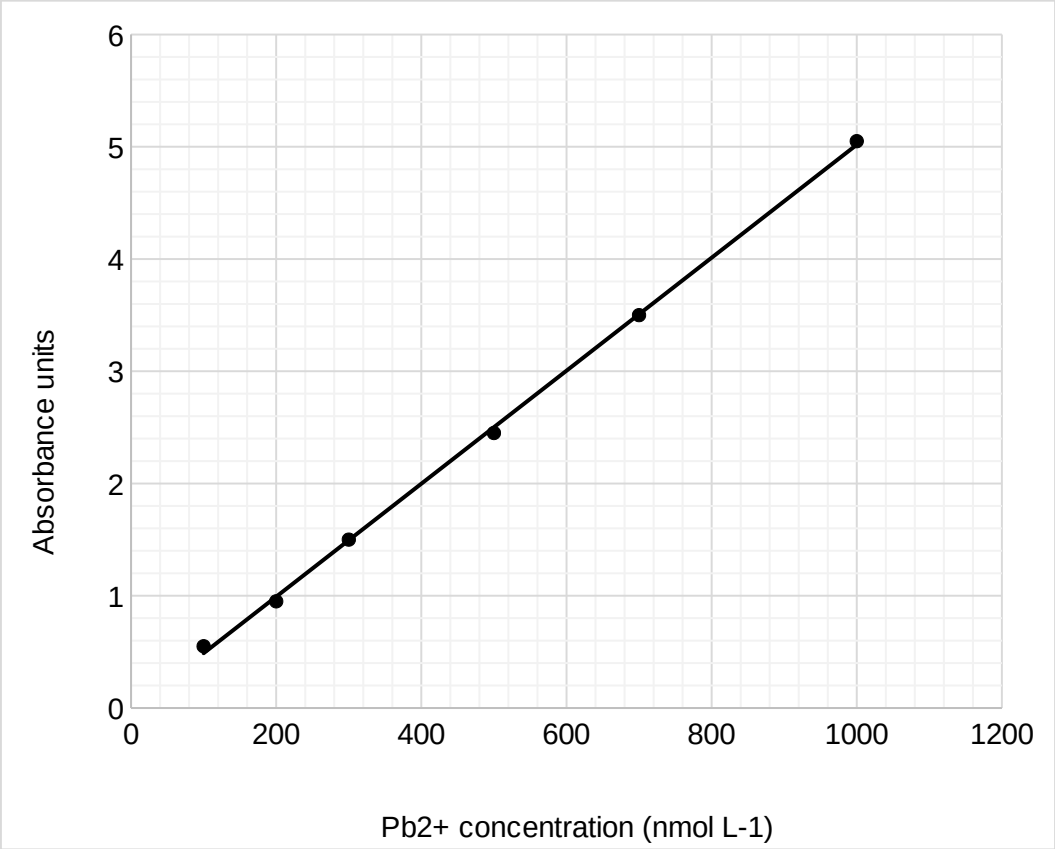
Question 33 **(8 marks)**

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)

(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)

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

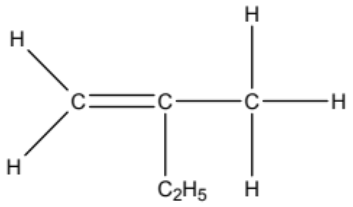
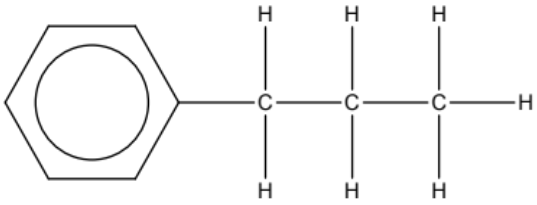
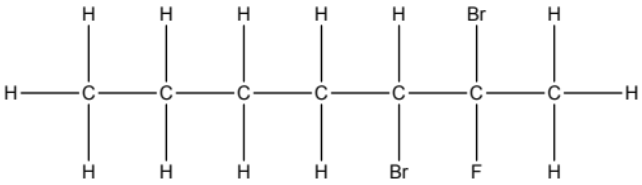
(c) Name the most likely source of lead to have caused the child's illness. (1 mark)

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

Question 34 **(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		
B		
C		

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)

End of Section Two

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Section Three: Extended answer **40% (92 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.

Question 35 **(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)

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)

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

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)

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)

KEY

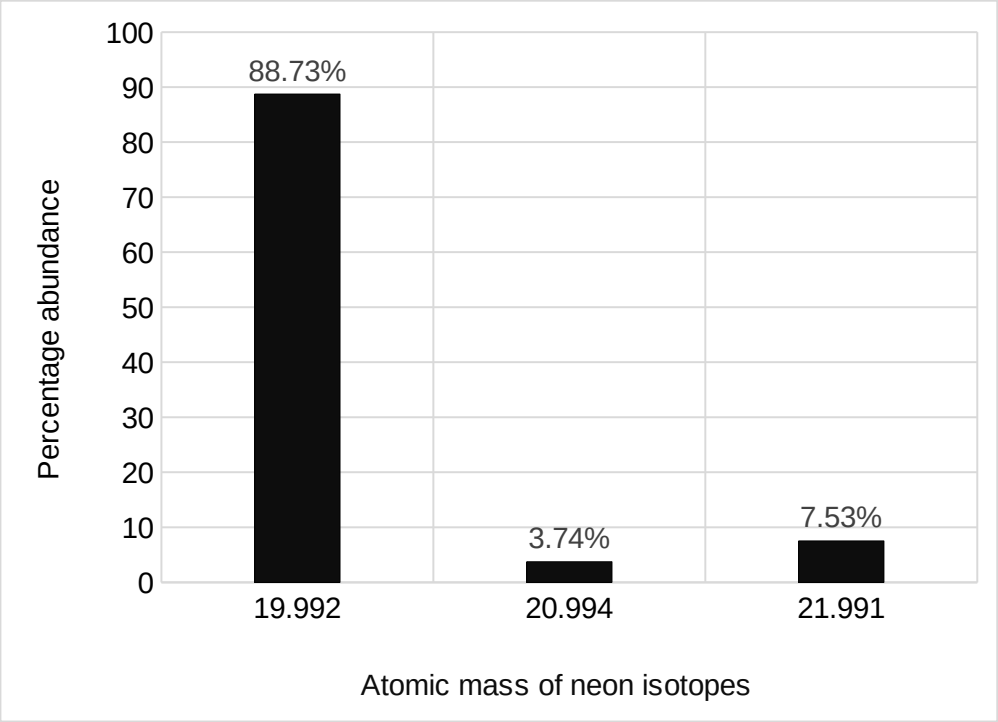
(p) proton
(n) neutron
(e) electron

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)

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)

Question 36 **(19 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)

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)

The copper extracted is cast into slabs, each weighing 125 kg.

(c) Calculate the number of slabs that could be cast from this sample of ore. (4 marks)

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**.

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

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.

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

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

A particular copper nanoparticle contained 64500 atoms of copper.

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

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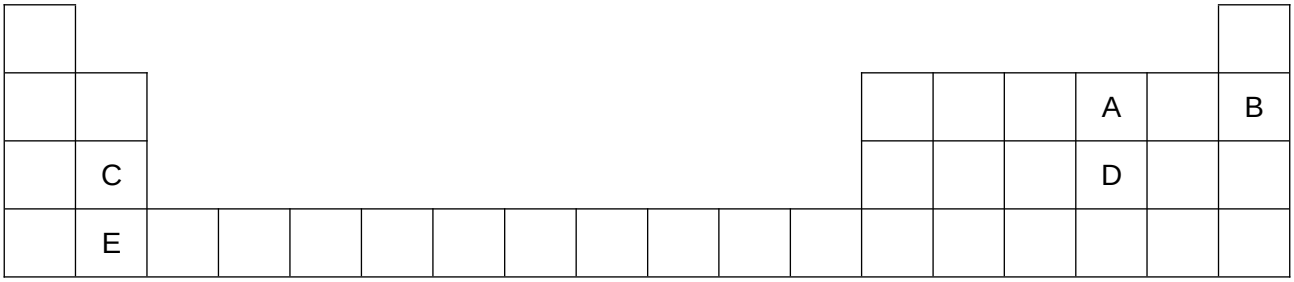
Question 37 **(14 marks)**

Consider the elements labelled A to E on the blank periodic table below.



The atomic radii for elements A to E are listed below, in no particular order. All measurements are given in picometres, pm. (Note that 1 pm = 10^{-12} m.)

130 73 102 174 69

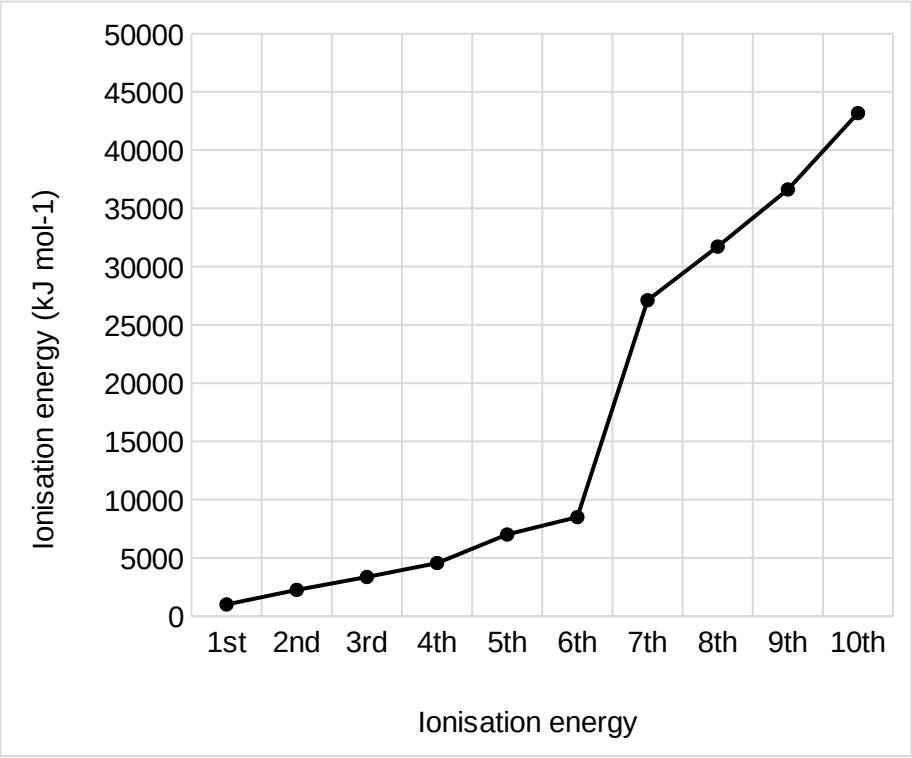
(a) Match each of the elements with its atomic radius. (3 marks)

Element	Atomic radius (pm)
A	
B	
C	
D	
E	

(b) Which of these elements has the highest electronegativity? Justify your answer. (3 marks)

(c) Which of these elements has the highest first ionisation energy? Justify your answer. (3 marks)

The graph below shows the first ten (10) **successive** ionisation energies for **one** of the elements A to E.



(d) Which element is this? Justify your answer. (3 marks)

(e) Why are elements A and D placed in the same group? (1 mark)

(f) Why are elements C and D placed in the same period? (1 mark)

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Question 38 **(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.

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

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

	Natural gas
Advantage	
Disadvantage	

	Biogas
Advantage	
Disadvantage	

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)

(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)

(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	
Biogas	

(This space has been left blank for any working out, if required.)

Gas fuels are often measured in terms of volume rather than mass. The density of each fuel source is shown in the table below.

(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}	
Biogas	0.85 g L^{-1}	

(This space has been left blank for any working out, if required.)

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

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

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

(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)

Question 39 **(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.

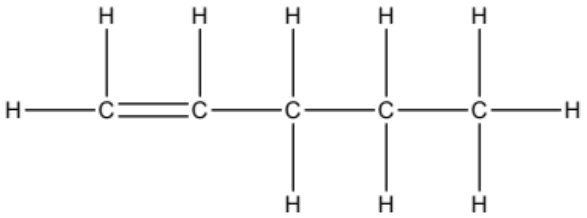
This paint mixture is heated to around 200 ˚C and sprayed onto the road surface where it quickly dries.

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 ˚C.

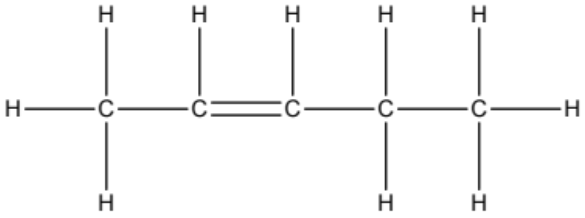
(a) Name the type of bonding present in the ‘synthetic resin’. Describe how and why this type of bonding forms. (4 marks)

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

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)

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)

(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)

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)

End of questions

Spare answer page

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Question number: _____