PERTH MODERN SCHOOL
Exceptional schooling. Exceptional students.
INDEPENDENT PUBLIC SCHOOL

Year 11 Semester 1 Examination, 2016

Question/Answer Booklet

CHEMISTRY

Student Name: _____

Teacher _____

Time allowed for this paper

Reading time before commencing work: ten minutes
Working time for paper: three hours

Section	Marks
1	/40
2	/50
3	/70
total	/160
	%

Materials required/recommended for this paper

To be provided by the supervisor

This Question/Answer Booklet
Multiple-choice Answer Sheet
Chemistry Data Sheet

To be provided by the candidate

Standard items: pens (blue/black preferred), pencils (including coloured), sharpener, correction tape/fluid, eraser, 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
Section One: Multiple-choice	20	20	30	40
Section Two: Short answer	6	6	50	50
Section Three: Extended answer	5	5	70	70
			Total	160

Instructions to candidates

1. 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. If you make a mistake, place a cross through that square, do not erase or use correction fluid, and shade your new answer. 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 answers in this Question/Answer Booklet.

3. When calculating numerical answers, show your working or reasoning clearly. Express numerical answers to the appropriate number of significant figures and include appropriate units where applicable

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

5. Spare pages are included at the end of this booklet. They can be used for planning your responses and/or as additional space if required to continue an answer.
   - Planning: If you use the spare pages for planning, indicate this clearly at the top of the page.
   - Continuing an answer: If you need to use the space to continue an answer, indicate in the original answer space where the answer is continued, i.e. give the page number. Fill in the number of the question that you are continuing to answer at the top of the page.

6. Chemical Equations
   For full marks, chemical equations should refer only to those species consumed in the reaction and the new species produced. These species may be **ions** [for example $Ag^+(aq)$], **molecules** [for example $NH_3(g)$, $NH_3(aq)$, $CH_3COOH(l)$, $CH_3COOH(aq)$] or **solids** [for example $BaSO_4(s)$, $Cu(s)$, $Na_2CO_3(s)$].

See next page

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, do not erase or use correction fluid, and shade your new answer. 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: 30 minutes.

---

1. Which one of the following was the major contribution of Thomson to the development of the understanding of the structure of the atom?

    (a)   The idea that elements contained just one type of atom.
    (b)   The discovery of the electron as a negatively charged sub-atomic particle.
    (c)   The realisation that most of the mass of an atom was present in a relatively small nucleus.
    (d)   Providing evidence that electrons existed in shells with different energy levels.

2   The boiling point of ethanol is 77 °C. A student suggested separating a mixture of water and ethanol using distillation. Which of the statements about the process is true?

    (a)   Distillation can only be used to separate mixtures that contain two different substances.
    (b)   The concentration of ethanol in the distillate will be greater than in the original mixture.
    (c)   When the mixture starts to boil, the vapour produced will initially contain mainly water.
    (d)   The difference between the boiling points of water and ethanol is too small to allow them to be distilled.

3   Substance A is made up two components (O and P). A small sample of substance A was dotted onto chromatography paper, and a chromatogram was developed using an appropriate solvent. The result is shown below.
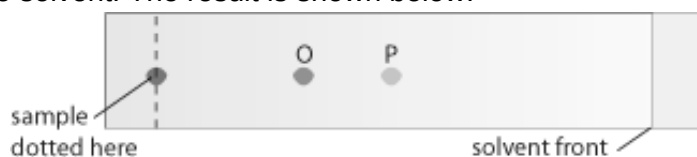
    Component O is absorbed

    (a)   more strongly onto the stationary phase and has a larger R_f value than component P.

    (b)   more strongly onto the stationary phase and has a smaller R_f value than component P.

    (c)   less strongly onto the stationary phase and has a larger R_f value than component P.

    (d)   less strongly onto the stationary phase and has a smaller R_f value than component P.

See next page

4   Which one of the following is a correct ground state electron configuration for a metallic element in Period 3 of the periodic table?

(a)   2, 5, 3
(b)   2, 3
(c)   2, 8, 2
(d)   2, 8, 7

5   Which one of the following determines which element an atom will be?

(a)   Its electric charge
(b)   Its electron configuration
(c)   Its number of neutrons
(d)   Its number of protons

6   In flame tests, compounds containing different metals produce flames of varying colours. For example, sodium compounds produce a bright orange flame and barium compounds produce a pale green flame.

Which one of the following statements about flame tests is true?

(a)   The different colours observed for sodium and barium are because they are in different groups of the periodic table.
(b)   Energy in the form of visible light is released from the atoms as electrons drop from a higher to a lower energy level.
(c)   The colours produced are caused by the absorption of light of particular wavelengths.
(d)   Atoms are ionised (electrons are lost from the atoms) in the process that generates the coloured flames.

7   Which one of the following statements about the periodic table is **false**?

(a)   Elements in the periodic table are ordered based on their atomic masses.
(b)   There are eight elements in Period 2 of the periodic table because eight is the maximum number of electrons in the second electron shell/energy level.
(c)   Elements in the same group of the periodic table tend to have similar chemical properties.
(d)   Elements in the same period of the periodic table have the same number of electron shells/energy levels.

8   Which one of the following is the number of valence electrons in the NO_3^- ion?

(a)   8
(b)   16
(c)   24
(d)   32

9   Which of the following species does NOT have the same electronic configuration as the

        chloride ion, Cl^-

        (a)   sulfide ion S^{2-}
        (b)   potassium ion K^+
        (c)   oxide ion O^{2-}
        (d)   argon atom

10   Which one of the statements below concerning the isotopes carbon-13 and carbon-14 is true?

        (a)   carbon-13 can be represented as $^{13}_{8}C$.
        (b)   carbon-14 has more protons than carbon-13.
        (c)   carbon-13 and carbon-14 are the only isotopes of carbon.
        (d)   carbon-14 has an extra neutron in its nucleus.

11   Which one of the following is the best definition of a nanomaterial?

        (a)   A material that contains particles that have a size of less than 1 nanometre.
        (b)   A material that contains particles that are smaller than molecules.
        (c)   A material that has different properties to the bulk material because of the small size of the particles that it contains.

        (d)   A material that is an allotrope of carbon that has a structure based on covalent networks.

12   Which one of following is the best explanation as to why two different metal atoms will not form a chemical bond?

        (a)   Metals cannot be mixed together as they have different densities.
        (b)   All metals have low ionisation energies.
        (c)   All metals need to lose electrons when they bond to achieve a complete valence electron shell.
        (d)   Electrons on the valence shells of adjoining metals repel each other.

13   Covalent bonds are most commonly found between:

        (a)   elements with similar but relatively high first ionisation energies.
        (b)   elements with low first ionisation energies.
        (c)   elements with a large difference in first ionisation energies.
        (d)   gaseous and solid elements.

See next page

14 Which one of the following is the relative atomic mass (atomic weight) of a carbon-12 atom?

   (a) 12.00
   (b) 1.00
   (c) 12.01
   (d) 6.00

15 The relative atomic mass (atomic weight) of gold is 197.0. Which of the following statements regarding gold is **false**?

   (a) The most common isotope of gold contains 118 neutrons.
   (b) Gold must not have any isotopes.
   (c) The average atomic masses of the isotopes of gold equals 197.0
   (d) One mole of gold atoms has a mass of 197 g.

16 The first process in a mass spectroscopy experiment is the ionisation of the sample. Which of the following statement**s** is **true**?

   (a) This ionisation can be caused by collisions with high energy electrons.
   (b) The positive ions that are produced are accelerated using a magnetic field.
   (c) Only negative ions are produced in this process
   (d) Moving through the magnetic field, the heavier ions are deflected more than the lighter ions.

17 Which of the following statements concerning intermolecular forces is/are correct?

   I   Dispersion forces exist in all molecular solids.
   II All molecules that contain polar bonds are polar molecules.
   III Hydrogen bonding only occurs for molecules containing O-H bonds.

   (a) I only

   (b) II only

   (c) lll only

   (d) I and II only

18   Which one of the following best explains why solid magnesium chloride does not
      conduct electricity but molten magnesium chloride does conduct electricity?

      (a)   The magnesium chloride only forms ions in the liquid state.

      (b)   The electrons in the magnesium are free to move in the molten magnesium
              chloride.

      (c)   The ions in the solid form are in fixed positions but when melted they are free
              to move.

      (d)   In molten magnesium chloride electrons can move from the magnesium
              atoms to the chlorine atoms.

19   Which one of the following molecules only contains single covalent bonds?

      (a) CO_2

      (b) N_2

      (c) C_2H_4

      (d) NH_3

20   Which set of the following 0.1 mol L^{-1} solutions when mixed will produce only a white
      precipitate?

      (a)   Zinc nitrate   Copper(ll) sulfate   Barium chloride   Sodium carbonate
      (b)   Lead(ll)nitrate   Potassium iodide   Sodium nitrate   Aluminium ethanoate
      (c)   Barium chloride   Sodium nitrate   Sodium hydroxide   Aluminium nitrate
      (d)   Barium nitrate   Sodium hydroxide   Potassium iodide   Copper(ll) nitrate

End of Section One

Section Two: Short answer **(50 Marks)**

This section has 6 questions. Answer **all** questions. Write your answers in the spaces provided.

When calculating numerical answers, show your working or reasoning clearly. Express numerical answers to the appropriate number of significant figures and include appropriate units where applicable.

Spare pages are included at the end of this booklet. They can be used for planning your responses and/or as additional space if required to continue an answer.
*   Planning: If you use the spare pages for planning, indicate this clearly at the top of the
            page.
*   Continuing an answer: If you need to use the space to continue an answer, indicate in
            the original answer space where the answer is continued, i.e. give the page number.
            Fill in the number of the question(s) that you are continuing to answer at the top of the
   page.

Suggested working time: 50 minutes.

Question 21 **(9 marks)**
(a)   Using your knowledge of structure and bonding, and with the aid of a diagram, explain why methane is a gas at room temperature. (3 marks)

_____

_____

_____

(b)   Using your knowledge of structure and bonding explain why magnesium hydroxide is a solid at room temperature. (3 marks)

_____

_____

_____

_____

_____

See next page

(c) For an element X, the first five successive ionisation energies can be represented on the following graph.

Successive ionisation energies

Energy (kJ/mol)

No of electrons removed
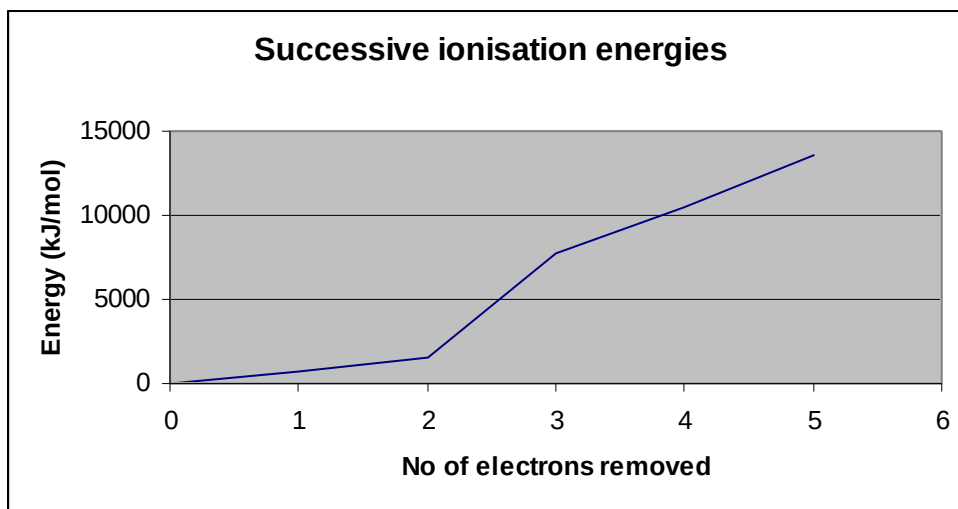
(i) How many valence electrons does element X have?

(1 mark)

(ii) What would be the formula of the compound formed when X reacts with chlorine?

(1 marks)

(iii) Name the type of bonding that this compound would have.

(1 mark)

Question 22 **(9 marks)**

Write equations and observations for any reactions that occur in the following procedures. In each case describe in full what you would observe, including any

- colours
- odours
- precipitates (state the colour)
- gases evolved (state the colour or describe as colourless).
- If no change is observed, you should write "no visible change".

(a)   Solutions of Copper(II) nitrate and sodium phosphate are mixed   (3 marks)

Equation:

_____

Observation/s:

_____

_____

(b)   Lead(II) nitrate solution is added to a solution of sodium sulfide.   (3 marks)
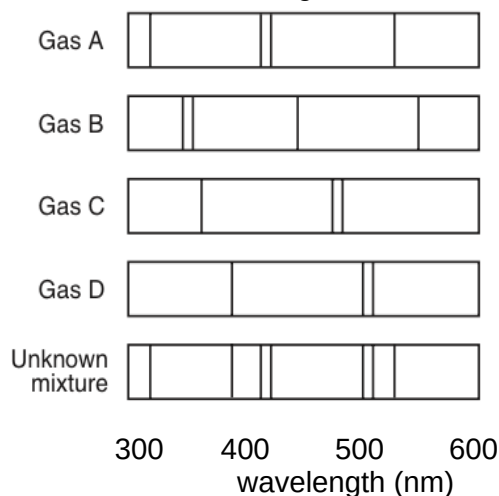
Equation:

_____

Observation/s:

_____

_____

(c)   Sodium hydroxide solution is added to a solution of barium ethanoate   (3 marks)

Equation:

_____

Observation/s:

_____

_____

Question 23 **(7 marks)**

The individual emission spectra of gases A , B, C and D are represented in the diagram below. The emission spectra of a mixture of these gases is also shown on the diagram.
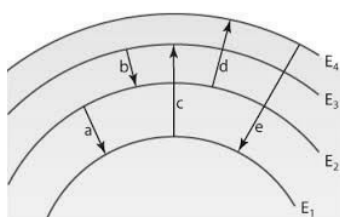

(a)   Using the information that you have been given identify the gas or gases in the mixture.

_____ (1 mark)

(b)   Explain your choice of the selection of the gas or gases in the mixture.

_____

_____
(2 marks)

The diagram below shows possible transitions of electrons between energy levels of an atom of a particular element.

(c)   Name and explain which of the transitions would be responsible for;

(i)   Emission spectra lines in an emission spectra

_____

_____

_____

(ii)   Absorption lines in continuous spectra

**See next page**

(4 marks)

Question 24 **(9 marks)**

For each molecule listed in the table below draw the structural formula, representing **all** valence shell electron pairs as $:$ or as — . Label the molecule that you have drawn as either polar or non-polar.

Species	Electron Dot Diagram (Lewis diagram)	Polar or Non-polar
Oxygen dibromide, OBr_2		
Chloromethane, CH_3Cl		
Hydrogen cyanide, HCN		

Question 25 **(9 marks)**

The diagram below shows a **Mass Spectrometry** apparatus being used to analyse a sample of chlorine, which contains the isotopes chlorine-35 and chlorine-37.
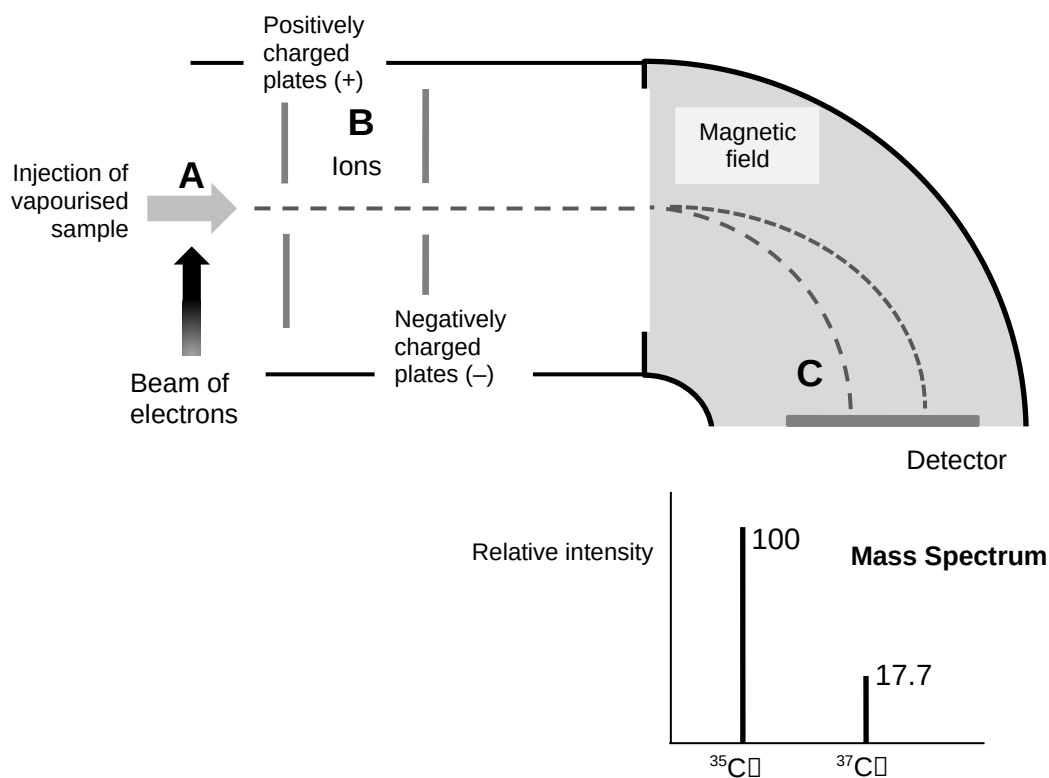
(a) Ionisation of chlorine atoms occurs at **A**. Explain what is meant by the term ionisation in this situation. In your answer explain why energy is required for ionisation to occur.

(2 marks)

_____

_____

_____

_____

_____

(b) Write the formula of the ions present at **B**. (1 mark)

_____

See next page

(c)   (i)   Name the ions of the isotope that are present at **C**?   (1 mark)

           (ii)   Explain you answer to part (c) (i).   (1 mark)

(d)   Use the results from the Mass Spectrum shown under the diagram to calculate the relative atomic mass (atomic weight) of this sample of chlorine.

                                                     (4 marks)

**This page has been deliberately left blank**

Question 26 **(7 marks)**

The approximate boiling points of the Group 14 and 17 hydrides are listed below.

Group number	Hydride	Period	Boiling Point (ºC)
14	CH_4	2	-161
	SiH_4	3	-112
	GeH_4	4	-88
	SnH_4	5	-52
17	HF	2	20
	HCℓ	3	-85
	HBr	4	-66
	HI	5	-34

(a) The Group 17 hydrides are polar molecules. List the Group 17 hydrides in order of **increasing** bond polarity (1 mark)

_____

_____

The boiling point data for the Group 14 hydrides has been plotted on the axis below.
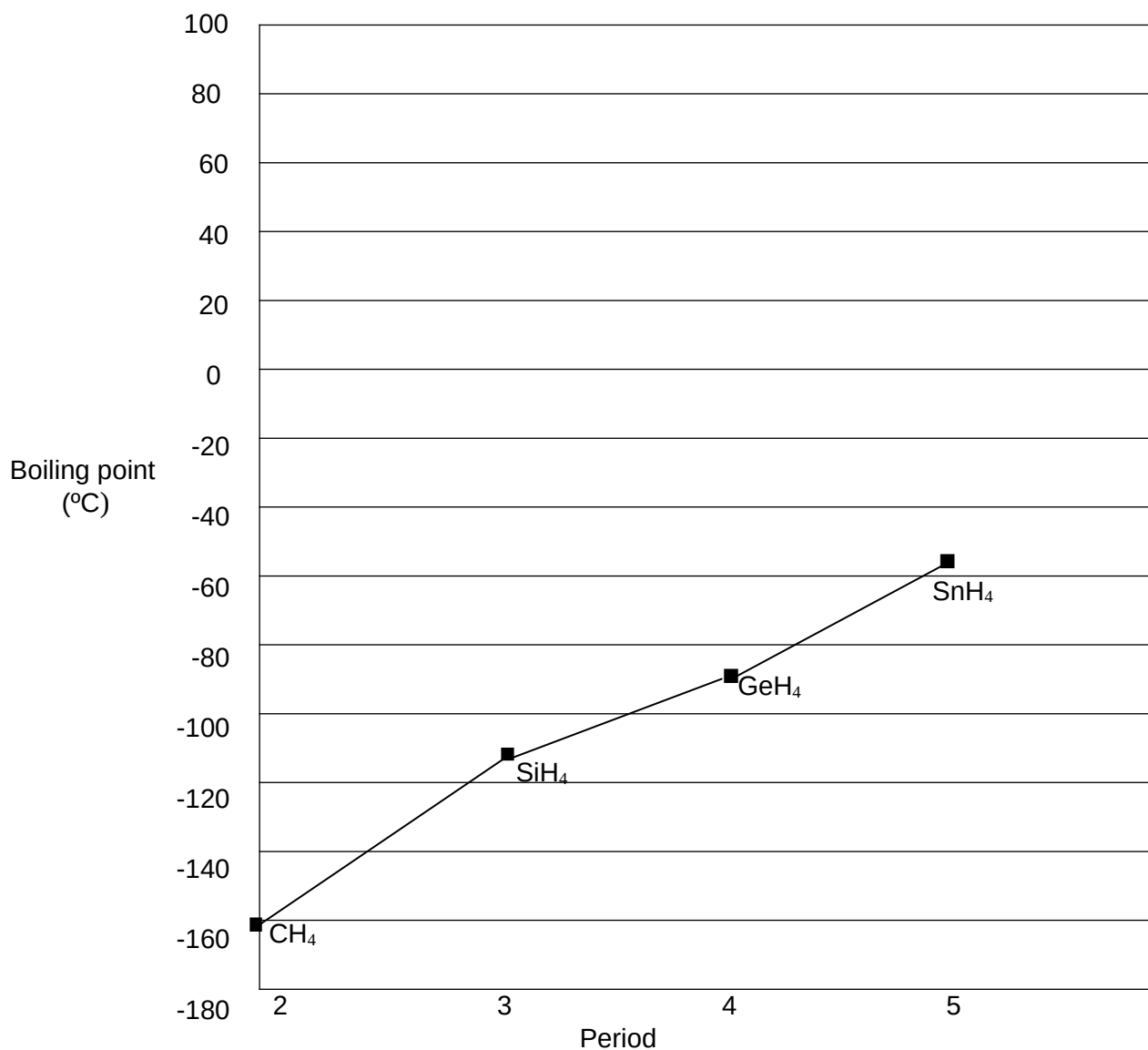
(b)   Plot the boiling point data for the Group 17 hydride HCℓ, HBr and HI onto the axes above   (2 marks)

(c)   Compare the trend in polarities of HCℓ, HBr and HI with the observed trend in their boiling points. Briefly explain your reasoning.   (4 marks)

_____

_____

_____

_____

_____

End of Section Two

See next page

Section Three: Extended answer **(70 Marks)**

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

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.

Spare pages are included at the end of this booklet. They can be used for planning your responses and/or as additional space if required to continue an answer.
*   Planning: If you use the spare pages for planning, indicate this clearly at the top of the page.
*   Continuing an answer: If you need to use the space to continue an answer, indicate in the original answer space where the answer is continued, i.e. give the page number. Fill in the number of the question(s) that you are continuing to answer at the top of the page.

Suggested working time: 70 minutes.

Question 27 **(12 marks)**

A student was given the following mixture to separate into three pure substances:

Silica (SiO_2), sodium chloride ($NaC\ell$) and copper(II) chloride ($CuC\ell_2$).

Solubility data:

	Solubility in water (g/100g) at 25 °C	**Solubility in ethanol (g/100g) at 25 °C**
SiO_2	0.012	Nil
$NaC\ell$	36	0.065
$CuC\ell_2$	61	67

Describe a step-by-step method that could be used to separate the three substances. Assume you have access to normal laboratory equipment including Bunsen burners, filter paper and funnels, evaporating dishes, ovens, stirring rods, beakers, flasks, distilled water and ethanol. Ensure that the method includes procedures that are safe.

_____

_____

_____

_____

_____

_____

Question 28 **(12 marks)**

A student carried out an investigation to measure the amount of energy released from a range of alcohols that can be used as fuels. She wanted to determine whether there was a relationship between the energy released per gram and the relative molecular mass of the alcohol.

She used the increase in the temperature of a fixed amount of water as a measure of the heat released by each fuel. The hypothesis for his experiment was that the energy released from each compound is directly proportional to the molecular mass of the compound.

The equipment was set up as shown below.
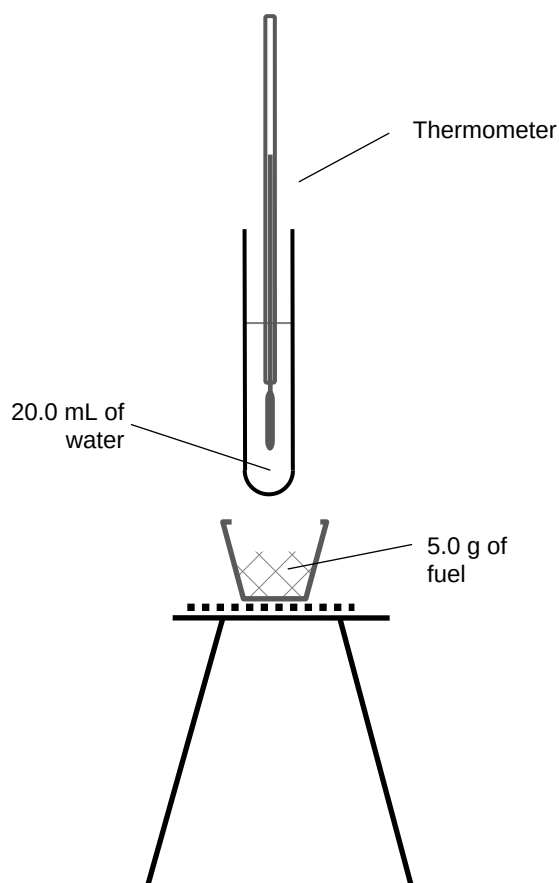
Method

1. 5.0 g of the fuel was weighed and placed in the crucible.

2. 20.0 mL of water was poured into a large test tube and placed above the crucible.

3. The temperature of the water was recorded.

4. The fuel was ignited using a match and left to burn until all the fuel had been combusted.

5. The temperature of the water was measured to calculate the increase in temperature of the water.

6. The experiment was repeated for each different fuel.

The results of the experiments are shown below.

Fuel	Formula	Relative molecular mass	Temperature of water (°C)		
			Initial	Final	Increase
Methanol	CH_3OH	32.0	22	52	30
Ethanol	C_2H_5OH	46.1	22	77	45
Propanol	C_3H_7OH	60.1	26	78	52
Butanol	C_4H_9OH	74.1	Butanol not available		
Pentanol	$C_5H_{11}OH$	88.1	24	82	58

See next page

(a) On the grid below, draw a graph showing the relationship between the increase in temperature and the molecular mass of the fuel. (5 marks)

Note: A spare grid is provided at the end of the examination if required
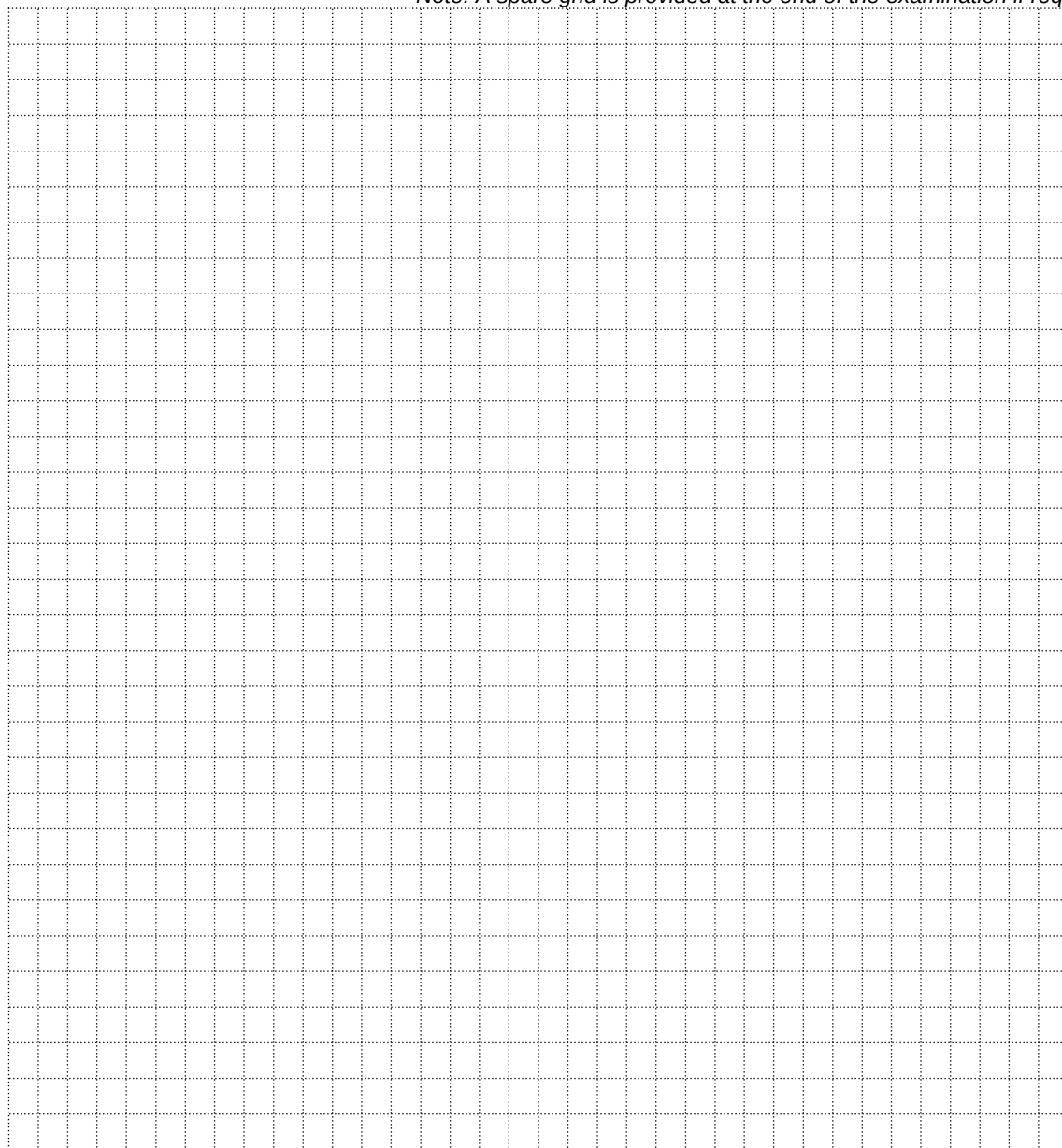
(b) For this experiment, name

(i) the independent variable. (1 mark)

_____

(ii) **four** controlled variables. (2 marks)

_____

_____

_____

_____

(c) Use your graph to predict the temperature increase that would be expected for butanol. (Show your working on the graph) (2 marks)

_____

_____

_____

(d) Consider the method described for this experiment.

(i) State **one** possible source of **random** error in the experiment. (1 mark)

_____

_____

(ii) State **one** possible source of **systematic** error in the experiment. (1 mark)

_____

_____

_____

This page has deliberately been left blank

Question 29 **(16 marks)**

The atomic radii of some of the elements in groups 1-17 of the Periodic Table are shown in the table below. Some radii have been omitted. The electronegativity of Period 2 elements have also been included in the table.

Group	1	2	13	14	15	16	17
Period 2 element	Li	Be	B	C	N	O	F
atomic radius/nm	0.134	0.125	0.090	0.077	0.075	0.073	0.071
Electronegativity (Pauling scale)	1.0	1.5	2.0	2.5	3.0	3.5	4.0
Period 3 element	Na	Mg	Al	Si	P	S	Cl
atomic radius/nm	0.154	0.145	0.130	0.118	0.110		0.099
Period 4 element	K	Ca	Ga	Ge	As	Se	Br
atomic radius/nm	0.196	0.174		0.122	1.122	0.117	0.114

(a) (i) State the trend shown in atomic radius across a period. (1 marks)

_____

(ii) Explain why this trend occurs. (4 marks)

_____

_____

_____

_____

(b) (i) State the trend shown in atomic radius down a group. (1 marks)

_____

(ii) Explain why this trend occurs. (4 marks)

_____

_____

_____

_____

See next page

(c) (i) State the trend shown in electronegativity across the second period of the Periodic table.

(1 marks)

_____

(ii) Explain why this trend occurs. (3 marks)

_____

_____

_____

_____

_____

(d) Mendeleev studied periodic data to make predictions for the properties of elements which had yet to be discovered. Using the data above, suggest values for the atomic radius of

(2 marks)

(i) S_____ nm,

(ii) Ga_____nm.

Question 30 **(15 marks)**

Carbon can exist in the form of two common allotropes, graphite and carbon, as well as a range of fullerenes such as C_{60} (also known as a 'Buckyball').

(a)   Using your knowledge of structure and bonding, and using diagrams, compare and explain the following properties of graphite and diamond.

   *   Melting point
   *   Hardness
   *   Electrical conductivity in the solid state   (10 marks)

_____

_____

_____

_____

_____

_____

_____

_____

_____

_____

_____

_____

_____

_____

_____

_____

_____

_____

_____

_____

_____

_____

(b)   Describe one use of diamond and one use of graphite that is dependent of one of the properties listed above. You can use a different property for each material. In your answer, explain how the property makes the material suitable for that use.

(5 marks)

_____

_____

_____

_____

_____

_____

_____

_____

_____

_____

_____

_____

_____

_____

_____

_____

_____

_____

_____

_____

_____

_____

_____

_____

_____

Question 31 **(15 marks)**

Water from aquifers that contains more than 200 ppm of dissolved calcium carbonate is considered to be hard and would not be considered to be suitable for household use.
The following table shows a measure of hardness expressed in ppm of $CaCO_3$.

Concentration $CaCO_3$ ppm	Classification
0 - 100	Soft
100 - 200	Moderate
200 - 300	Hard
300 - 500	Very hard
500 - 1,000	Extremely hard

A sample of ground water from an aquifer was analysed to determine its hardness in order to determine its suitability for household use.

A 500 mL sample of ground water from an aquifer was treated with excess sodium carbonate to precipitate the calcium in the water as calcium carbonate. If the mass of the 500 mL of tap water was 509 g and the mass calcium carbonate recovered was 0.117 g.

(a)   Write a balance equation showing what happened when a sodium carbonate solution was added to the ground water.

(1 mark)

(b)   Calculate the concentration of the calcium ions in mol L^{-1}

(4 marks)

(c)   Calculate the concentration of the calcium carbonate in ppm

(3 marks)

(d)   Comment on the suitability of the ground water for household use.

(1 mark)

(e)   A popular carbonated soft drink has been analysed and found to have a caffeine ($C_8H_{10}N_4O_2$) concentration of 4.93×10^{-5} mol L^{-1}. If the molar mass of caffeine is 194.19 g mol^{-1} calculate the mass of caffeine in a 375 mL can of the popular soft drink.

(3 marks)

(f)   If a 300 mL cup of black coffee contains 1.14×10^{-4} moles of caffeine calculate the concentration of caffeine in gL^{-1}.

(3 marks)

End of questions

Additional Working Space

Spare grid for Question