Part A – Multiple-choice questions

Total marks (12)
Attempt Questions 1 – 12
Allow about 20 minutes for this part

RECORD ALL ANSWERS TO PART A ON PAGE 5

1 Which *sphere* contains the lowest percentage of water?

(A) hydrosphere

(B) lithosphere

(C) atmosphere

(D) biosphere

2 When Mendeleev formulated his Periodic Table in the 1860s, he studied the properties of the known elements. Which property was not used by Mendeleev?

(A) electronic configuration

(B) melting point and boiling point

(C) density

(D) reactivity

3 If plants are watered with sea water which of the following will occur?

(A) Water will move into plant root cells by diffusion.

(B) Salt will move into plant root cells by osmosis.

(C) Salt will move out of plant root cells by diffusion.

(D) Water will move out of plant root cells by osmosis.

4 Which equation shows a gas molecule dissolving in water forming an alkaline solution?

(A) $NH_{3\,(g)} + H_2O_{(l)} \rightarrow NH_4^+ + OH^-$

(B) $Cl_{2\,(g)} + H_2O_{(l)} \rightarrow H^+ + Cl^- + HOCl$

(C) $CO_{2\,(g)} + H_2O_{(l)} \rightarrow 2H^+ + CO_3^{2-}$

(D) $SO_{2\,(g)} + H_2O_{(l)} \rightarrow 2H^+ + SO_3^{2-}$

5 In which set do both compounds have hydrogen bonding capability?

(A) H_2O and H_2S

(B) CF_4 and H_2O

(C) C_2H_5OH and H_2O

(D) CF_4 and H_2SO_4

6 Some lead oxide and carbon powder were mixed together and heated in a crucible to a high temperature. Small globules of metal were formed.

Which statement is correct concerning the reaction?

(A) The carbon is reduced to carbon dioxide.

(B) The lead is reduced to lead oxide.

(C) The lead oxide and carbon are both reduced by heat.

(D) The lead oxide is reduced to lead.

7 Which of the sequences arranges the elements according to increasing electronegativity?

(A) Al, H, O, F

(B) Al, O, F, H

(C) F, O, H, Al

(D) F, O, Al, H

8 A student is required to prepare 1 L of 1.00 mol L^{-1} solution of copper(II) sulfate - 5 - water. Which procedure should be followed?

(A) Weigh out 159.62 g of copper sulfate crystals and transfer to a one litre volumetric flask. Add exactly 1000 mL of distilled water, then stopper and shake until dissolved.

(B) Weigh out 249.70 g of copper sulfate crystals into a one litre beaker. Add about 800 mL of distilled water. Stir until dissolved. Transfer the solution to a one litre volumetric flask and add more water to make one litre of solution. Stopper and shake to mix uniformly.

(C) Weigh out 249.70 g of copper sulfate crystals and transfer to a one litre volumetric flask. Add exactly 1000 mL of distilled water, then stopper and shake until dissolved.

(D) Weigh out 159.62 g of copper sulfate crystals into a one litre beaker. Add about 800 mL of distilled water. Stir until dissolved. Transfer the solution to a one litre volumetric flask and add more water to make one litre of solution. Stopper & shake to mix uniformly.

9 In which set do both compounds have polar molecules?

(A) carbon dioxide and water

(B) hydrogen bromide and water

(C) hydrogen bromide and carbon tetrachloride

(D) carbon dioxide and carbon tetrachloride

10 Aluminium, gold, iron and tin are metals of great importance in modern technology. Historically, they were discovered in the order… gold, tin, iron, aluminium.

Which statement explains the order of chemical discovery?

(A) Aluminium is the most abundant metal in the earth's crust.

(B) Iron is the most reactive of the metals.

(C) Gold is the most expensive of the metals.

(D) Unreactive metals are easier to extract from compounds.

11 When water comes in contact with some substances, such as glass, the water surface curves up to form a meniscus. What property of water causes this to happen?

(A) Surface tension

(B) Adhesion

(C) Cohesion

(D) Viscosity

12 In the near future, element 120 may be synthesised. Which element would it most closely resemble?

(A) Francium

(B) Radium

(C) Cerium

(D) Actinium

GO TO QUESTION 13 PRINTED ON PAGE 6

James Ruse Agricultural High School

2001

PRELIMINARY COURSE
FINAL EXAMINATION

CANDIDATE NUMBER	
EXAMINATION MARK / 67	

Part A – Multiple-choice questions

Select the alternative A, B, C or D that best answers the question. Fill in the response completely.

Sample 2 + 4 = (A) 2 ● 6 (C) 8 (D) 9

If you think you have made a mistake, put a cross through the incorrect answer and fill in the new answer.

● 2 ✕ 6 (C) 8 (D) 9

If you change your mind and have crossed out what you consider to be the correct answer, then indicate this by writing the word *correct* and drawing an arrow as follows:

✕ 2 ✕ 6 (C) 8 (D) 9

correct

Question 1	Ⓐ	Ⓑ	Ⓒ	Ⓓ
Question 2	Ⓐ	Ⓑ	Ⓒ	Ⓓ
Question 3	Ⓐ	Ⓑ	Ⓒ	Ⓓ
Question 4	Ⓐ	Ⓑ	Ⓒ	Ⓓ
Question 5	Ⓐ	Ⓑ	Ⓒ	Ⓓ
Question 6	Ⓐ	Ⓑ	Ⓒ	Ⓓ
Question 7	Ⓐ	Ⓑ	Ⓒ	Ⓓ
Question 8	Ⓐ	Ⓑ	Ⓒ	Ⓓ
Question 9	Ⓐ	Ⓑ	Ⓒ	Ⓓ
Question 10	Ⓐ	Ⓑ	Ⓒ	Ⓓ
Question 11	Ⓐ	Ⓑ	Ⓒ	Ⓓ
Question 12	Ⓐ	Ⓑ	Ⓒ	Ⓓ

Part B

Total marks (55)
Attempt Questions 13 – 26
Allow about 100 minutes for this part

Use blue or black ink to write your answers.
Do not use pencil.

Show all relevant working in questions involving calculations.

Question 13 (5 marks)

The table shows the percentage composition (volume/volume) of dry air.

nitrogen	78.08 %
oxygen	20.95 %
argon	0.93 %

(a) Calculate the volume of oxygen in a 100 mL sample of air. **(1)**

(b) Calculate the number of moles of oxygen in 100 mL of air at STP. **(1)**

(c) Calculate the percentage of oxygen in air in terms of moles, i.e. mole %/total moles of gas. **(2)**

(d) Identify the chemical law used to calculate your result in (c). **(1)**

Question 14 (6 marks)

Complete the table listing the solubility in water (nil, low, high) and the structure (ionic, polar molecular, covalent network, non-polar molecular or large molecule) of the substances.

Substance	Solubility in water	Structure
sucrose		
hydrogen chloride		
cellulose		
silicon dioxide		
iodine		
sodium chloride		

Question 15 (7 marks)

Chalcocite is a copper ore which has a mass composition of 20.2% sulfur and 79.8% copper.

(a) Calculate the empirical formula of chalcocite. **(2)**

_____

_____

_____

(b) Copper metal is commonly extracted from chalcocite by heating the liquid ore in the presence of oxygen producing liquid copper metal and sulfur dioxide, a toxic gas.

Write a balanced chemical equation for the extraction reaction described above. **(1)**

_____

(c) Calculate the volume of sulfur dioxide gas produced at STP when 10 kilograms of chalcocite is completely decomposed. **(2)**

_____

_____

_____

(d) Give two factors that justify the recycling of copper metal. **(2)**

_____

_____

Question 16 (2 marks)

(a) Classify each of the following as *molecular formula* or *empirical formula*. **(1)**

(i) $MgCl_2 \cdot 6H_2O$ _____

(ii) C_4H_8 _____

(iii) H_2O_2 _____

(iv) CH_4 _____

(b) If any of the above formulas are molecular, re-write as empirical formulas. **(1)**
Write your answers on the lines provided above.

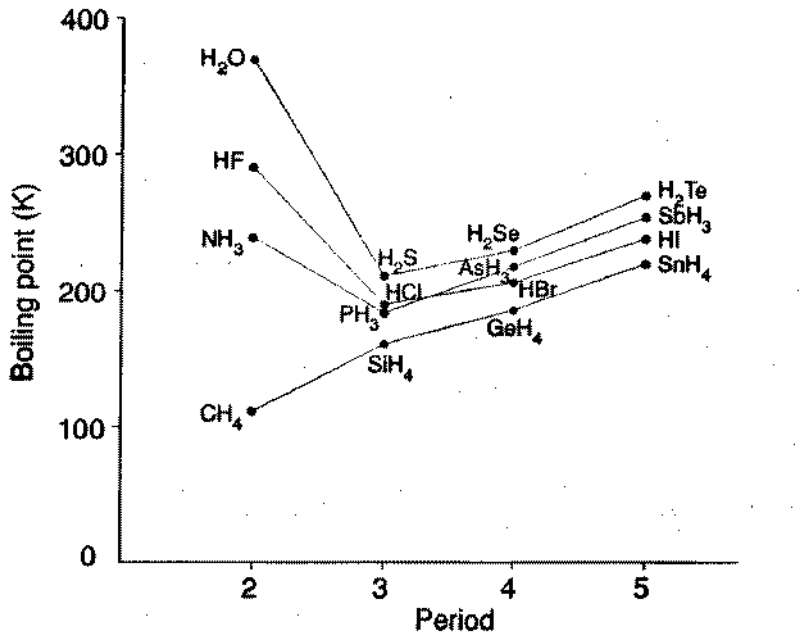
Question 17 (3 marks)

Complete the table by providing the electron dot structures and molecular shapes.

	Water	**Tetrachloromethane** (Carbon tetrachloride)	**Ammonia**
Formula	H_2O	CCl_4	NH_3
Electron dot structure			
Molecular shape			

Question 18 (2 marks)

The graph shows the boiling points of some hydrides.



(a) Identify the type of intermolecular force responsible for the increase in the boiling point of the group IV hydrides. **(1)**

_____

(b) Briefly explain the reason for the exceptionally high boiling points of HF, H_2O and NH_3. **(1)**

_____

Question 19 (5 marks)

(a) Explain why brass, which consists of copper and zinc, is not considered a compound. **(1)**

_____

_____

(b) Calcium is the third most abundant metal in the earth's crust. Explain why calcium is not used as a metal. **(1)**

_____

Question 19 continues on page 10

Question 19 (continued)

(c) Steel and solder are both alloys, but with very different properties.

(i) For each alloy describe one of its characteristic properties. **(1)**

_____

_____

(ii) Identify a use of each alloy which relates to the property described in (i). **(1)**

_____

_____

(d) The engine block (the outside casing) of modern cars is usually made of aluminium rather than traditional cast iron. Aluminium is significantly more expensive than iron. Identify a reason why car makers would use aluminium despite its higher cost. **(1)**

_____

Question 20 (3 marks)

Ken Chemiski conducted a series of experiments involving the reaction of a selection of metals with water, dilute hydrochloric acid, and oxygen. He then compared his results with an activity series table printed in a textbook.

(a) One of the experiments involved reacting calcium with water. Write a balanced equation for the reaction. **(1)**

_____

(b) Ken's results correlated well with the text's activity series except for aluminium. Explain the unexpected result observed for aluminium. **(1)**

_____

(c) Write a balanced equation for the reaction of aluminium with dilute hydrochloric acid. **(1)**

_____

Question 21 (2 marks)

International negotiations concerning the reduction of CO_2 gas emissions have received heavy coverage in the media in recent months. Nations which plant forests can receive carbon credits to meet their international obligations for CO_2 gas reduction.

(a) Write a balanced equation showing how photosynthesis removes CO_2 from the atmosphere. Include any special conditions above and/or below the reaction arrow (→). **(1)**

(b) A large tree can remove 180 g of carbon dioxide from the air by photosynthesis every day. Calculate the volume of oxygen produced at 25°C and 101.3 kPa during the process. **(1)**

Question 22 (4 marks)

Chang performs an experiment to determine the molar heat of solution of potassium nitrate. The table shows his data.

Mass of water in calorimeter	151.48 g
Mass of potassium nitrate dissolved	8.78 g
Initial temperature of water	18.5° C
Final temperature of solution	14.0° C
Specific heat of water (constant)	4.18 J/g °C

(a) Calculate the molar heat of solution from the data. **(2)**

(b) Identify whether the molar heat of solution is exothermic or endothermic. **(1)**

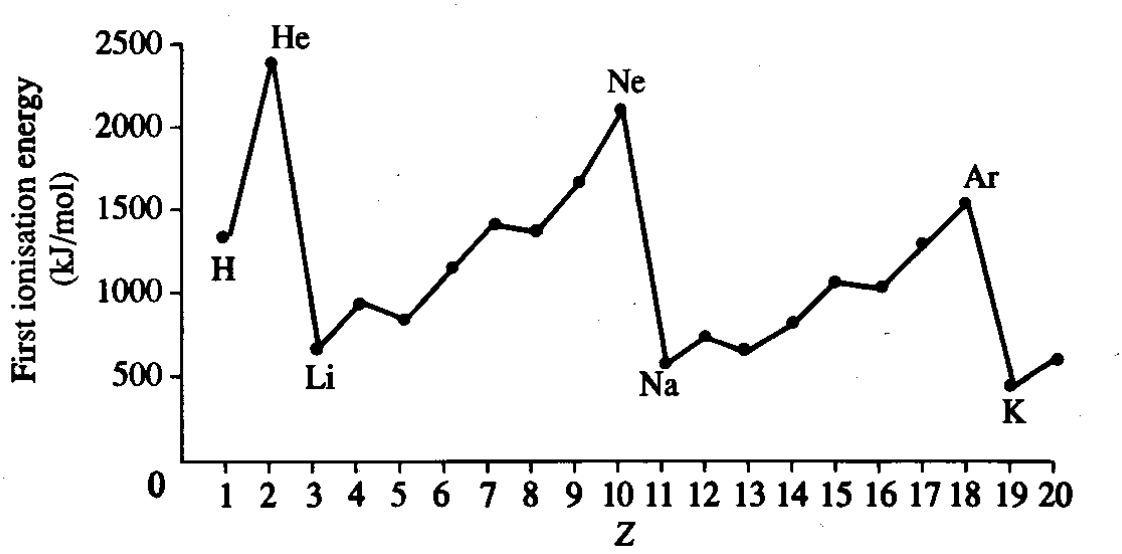
Question 22 continues on page 12

Question 22 (continued)

(c) The calorimetry calculation makes use of the specific heat of water, but the specific heat of water is of far greater importance to the survival of life. Explain why water's exceptionally high specific heat is so important to living things. **(1)**

Question 23 (3 marks)

The graph shows the ionisation energy of some elements.



(a) Describe the trend in the ionisation energy down Group I? **(1)**

(b) Is there a link between the ionisation energy of an element and its reactivity? Explain your answer. **(1)**

(c) Explain why the noble gases have the highest ionisation energies within a period. **(1)**

Question 24 (2 marks)

The monitoring of hazardous chemicals in drinking water is of prime concern to public health. Cadmium is classified as a toxic heavy metal which can pollute waterways by the improper disposal of depleted nickel-cadmium batteries. The maximum permissible limit for cadmium in drinking water is 0.01 mg L^{-1}.

(a) Calculate the maximum permissible limit for cadmium in terms of moles L^{-1}. **(1)**

_____

_____

_____

(b) Identify another toxic heavy metal which is monitored in natural waterways. **(1)**

_____

Question 25 (9 marks)

Carbon is a unique element with very special bonding capabilities.

(a) Name and draw the structural formulas of three hydrocarbons which illustrate carbon forming single, double, and triple carbon/carbon bonds. **(3)**

_____

_____

_____

(b) Some of the carbon on Earth is bound up ('fixed') in the valuable forms of coal, petroleum and natural gas. Explain how mobile carbon (CO_2) became fixed as fuels using chemical and geological concepts. **(3)**

_____

_____

_____

_____

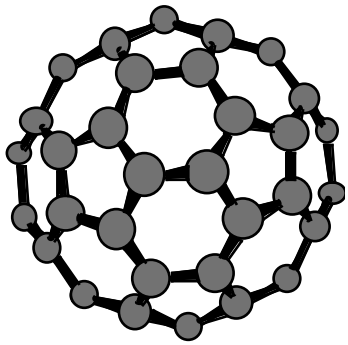
_____

_____

_____

Question 25 continues on page 14

Question 25 (continued)



(c) In 1985, chemists prepared molecules of carbon containing 60 atoms shaped like a soccer ball. This C_{60} molecule is called buckminsterfullerene and is commonly known as a *bucky ball*. The properties of buckminsterfullerene are very different from the other allotropes of carbon. It is a yellow coloured solid with a melting point of about 350°C and it dissolves in benzene forming a purple coloured solution.

(i) Explain why C_{60} has a relatively low melting point. **(1)**

_____

_____

_____

(ii) Describe the bonding structure (type and shape) found in graphite and diamond. **(2)**

_____

_____

_____

_____

_____

Question 26 is printed on page 15

Question 26 (2 marks)

Barium nitrate, silver nitrate and magnesium nitrate solutions are mixed with solutions X, Y, Z which are known to be sodium carbonate, sodium chloride and sodium sulfate (not in this order). The table shows the results of the mixing. (NR = no reaction; ppt = precipitate)

	X	Y	Z
Barium nitrate	NR	ppt	ppt
Silver nitrate	ppt	ppt	ppt
Magnesium nitrate	NR	NR	ppt

Use the solubility table printed below to answer the questions.

(a) Identify which of the solutions (X, Y, Z) is sodium sulfate and which is sodium chloride. **(1)**

_____

(b) Write the net ionic equation for the reaction of silver nitrate with solution Z. **(1)**

_____

SOLUBILITY TABLE

Compound	Generally	Exceptions
K^+, Na^+ NH_4^+ salts	Soluble	–
Nitrates	Soluble	–
Sulphates	Soluble	Ba^{2+}, Pb^{2+} (Ca^{2+}, Ag^+, Hg_2^{2+} are slightly soluble)
Chlorides	Soluble	Ag^+, Hg_2^{2+} (Pb^{2+} slightly soluble)
Carbonates Oxides Sulphides Phosphates	Insoluble	K^+, Na^+, NH_4^+
Hydroxides	Insoluble	K^+, Na^+, NH_4^+ (Ba^{2+}, Ca^{2+} slightly soluble)

End of paper

James Ruse Agricultural High School

2001

PRELIMINARY COURSE FINAL EXAMINATION

OUTCOMES and MARKING SCHEME

Part A – Multiple-choice questions

1 Which *sphere* contains the lowest percentage of water?

(A) hydrosphere
(B) lithosphere
(C) atmosphere
(D) biosphere

2 When Mendeleev formulated his Periodic Table in the 1860s, he studied the properties of the known elements. Which property was not used by Mendeleev?

(A) electronic configuration
(B) melting point and boiling point
(C) density
(D) reactivity

3 If plants are watered with sea water which of the following will occur?

(A) Water will move into plant root cells by diffusion.
(B) Salt will move into plant root cells by osmosis.
(C) Salt will move out of plant root cells by diffusion.
(D) Water will move out of plant root cells by osmosis.

4 Which equation shows a gas molecule dissolving in water forming an alkaline solution?

(A) $NH_{3\,(g)} + H_2O_{(l)} \rightarrow NH_4^+ + OH^-$
(B) $Cl_{2\,(g)} + H_2O_{(l)} \rightarrow H^+ + Cl^- + HOCl$
(C) $CO_{2\,(g)} + H_2O_{(l)} \rightarrow 2H^+ + CO_3^{2-}$
(D) $SO_{2\,(g)} + H_2O_{(l)} \rightarrow 2H^+ + SO_3^{2-}$

5 In which set do both compounds have hydrogen bonding capability?

(A) H_2O and H_2S
(B) CF_4 and H_2O
(C) C_2H_5OH and H_2O
(D) CF_4 and H_2SO_4

6 Some lead oxide and carbon powder were mixed together and heated in a crucible to a high temperature. Small globules of metal were formed.

Which statement is correct concerning the reaction?

(A) The carbon is reduced to carbon dioxide.
(B) The lead is reduced to lead oxide.
(C) The lead oxide and carbon are both reduced by heat.
(D) The lead oxide is reduced to lead.

7 Which of the sequences arranges the elements according to increasing electronegativity?

(A) Al, H, O, F
(B) Al, O, F, H
(C) F, O, H, Al
(D) F, O, Al, H

8 A student is required to prepare 1 L of 1.00 mol L^{-1} solution of copper(II) sulfate - 5 - water. Which procedure should be followed?

(A) Weigh out 159.62 g of copper sulfate crystals and transfer to a one litre volumetric flask. Add exactly 1000 mL of distilled water, then stopper and shake until dissolved.
(B) Weigh out 249.70 g of copper sulfate crystals into a one litre beaker. Add about 800 mL of distilled water. Stir until dissolved. Transfer the solution to a one litre volumetric flask and add more water to make one litre of solution. Stopper and shake to mix uniformly.
(C) Weigh out 249.70 g of copper sulfate crystals and transfer to a one litre volumetric flask. Add exactly 1000 mL of distilled water, then stopper and shake until dissolved.
(D) Weigh out 159.62 g of copper sulfate crystals into a one litre beaker. Add about 800 mL of distilled water. Stir until dissolved. Transfer the solution to a one litre volumetric flask and add more water to make one litre of solution. Stopper & shake to mix uniformly.

9 In which set do both compounds have polar molecules?

(A) carbon dioxide and water
(B) hydrogen bromide and water
(C) hydrogen bromide and carbon tetrachloride
(D) carbon dioxide and carbon tetrachloride

10 Aluminium, gold, iron and tin are metals of great importance in modern technology. Historically, they were discovered in the order… gold, tin, iron, aluminium.

Which statement explains the order of chemical discovery?

(A) Aluminium is the most abundant metal in the earth's crust.
(B) Iron is the most reactive of the metals.
(C) Gold is the most expensive of the metals.
(D) Unreactive metals are easier to extract from compounds.

11 When water comes in contact with some substances, such as glass, the water surface curves up to form a meniscus. What property of water causes this to happen?

(A) Surface tension
(B) Adhesion
(C) Cohesion
(D) Viscosity

12 In the near future, element 120 may be synthesised. Which element would it most closely resemble?

(A) Francium
(B) Radium
(C) Cerium
(D) Actinium

Outcomes

Question 1	Ⓐ	Ⓑ	**Ⓒ**	**Ⓓ**	**P14**
Question 2	**Ⓐ**	Ⓑ	Ⓒ	Ⓓ	**P1**
Question 3	Ⓐ	Ⓑ	Ⓒ	**Ⓓ**	**P6**
Question 4	**Ⓐ**	Ⓑ	Ⓒ	Ⓓ	**P8**
Question 5	Ⓐ	Ⓑ	**Ⓒ**	Ⓓ	**P14**
Question 6	Ⓐ	Ⓑ	Ⓒ	**Ⓓ**	**P14**
Question 7	**Ⓐ**	Ⓑ	Ⓒ	Ⓓ	**P4**
Question 8	Ⓐ	**Ⓑ**	Ⓒ	Ⓓ	**P14**
Question 9	Ⓐ	**Ⓑ**	Ⓒ	Ⓓ	**P10**
Question 10	Ⓐ	Ⓑ	Ⓒ	**Ⓓ**	**P6**
Question 11	Ⓐ	**Ⓑ**	Ⓒ	Ⓓ	**P8**
Question 12	Ⓐ	**Ⓑ**	Ⓒ	Ⓓ	**P8**

Part B

Total marks (55)
Attempt Questions 13 – 26

Show all relevant working in questions involving calculations.

Question 13 (5 marks) Outcomes – P1, P10, P14

The table shows the percentage composition (volume/volume) of dry air.

nitrogen	78.08 %
oxygen	20.95 %
argon	0.93 %

(a) Calculate the volume of oxygen in a 100 mL sample of air. **(1)**

(100 mL) x (20.95%) = 20.95 mL (1 mark)

(b) Calculate the number of moles of oxygen in 100 mL of air at STP. **(1)**

(20.95 mL) ÷ (22,410 mL/mol) = 9.349×10^{-4} mol (1 mark)

(c) Calculate the percentage of oxygen in air in terms of moles, i.e. mole %/total moles of gas. **(2)**

(100 mL of gas) ÷ (22,410 mL/mol) = 4.462×10^{-3} mol of gas (1 mark)

(9.349×10^{-4} mol) ÷ (4.462×10^{-3} mol) = 20.95% (1 mark)

(d) Identify the chemical law used to calculate your result in (c). **(1)**

Avogadro's Law (1 mark)

Question 14 (6 marks) Outcomes – P2, P13

Complete the table listing the solubility in water (nil, low, high) and the structure (ionic, polar molecular, covalent network, non-polar molecular or large molecule) of the substances.

Substance	Solubility in water	Structure
sucrose	**high**	**polar molecular**
hydrogen chloride	**high**	**polar molecular**
cellulose	**nil**	**large molecule**
silicon dioxide	**nil**	**covalent network**
iodine	**low**	**non-polar molecular**
sodium chloride	**high**	**ionic**

(1 mark for each pair)

Question 15 (7 marks) Outcomes – P5, P10, P13, P14, P16

Chalcocite is a copper ore which has a mass composition of 20.2% sulfur and 79.8% copper.

(a) Calculate the empirical formula of chalcocite. **(2)**

(79.8) ÷ (63.55) = 1.256 mol Cu per 100 g sample (1 mark)

(20.2) ÷ (32.07) = 0.6299 mol S per 100 g sample, thus empirical formula = Cu_2S (1 mark)

(b) Copper metal is commonly extracted from chalcocite by heating the liquid ore in the presence of oxygen producing liquid copper metal and sulfur dioxide, a toxic gas.

Write a balanced chemical equation for the extraction reaction described above. **(1)**

$Cu_2S_{(l)} + O_{2(g)} \rightarrow 2Cu_{(l)} + SO_{2(g)}$ + All four states must be correct!

(c) Calculate the volume of sulfur dioxide gas produced at STP when 10 kilograms of chalcocite is completely decomposed. **(2)**

[(10) x (1000)] ÷ 159.17 = 62.83 mol Cu_2S

mol SO_2 = mol Cu_2S = 63 mol (1 mark)

volume SO_2 = (62.83 mol) x 22.41 L/mol = 1408 = 1400 L (1 mark)

Question 15 (continued)

(d) Give two factors that justify the recycling of copper metal. **(2)**

Recycling requires less energy than extraction from the ore. (1 mark)

Recycling produces less pollution. (1 mark)

Recycling is a cheaper overall process. (alternative)

Recycling conserves copper ore resources. (alternative)

Question 16 (2 marks) Outcomes – P13

(a) Classify each of the following as *molecular formula* or *empirical formula*. **(1 mark)**

(i) $MgCl_2 \cdot 6H_2O$ **empirical**

(ii) C_4H_8 **molecular; CH_2**

(iii) H_2O_2 **molecular; HO**

(iv) CH_4 **molecular**

(b) If any of the above formulas are molecular, re-write as empirical formulas. **(1 mark)**
Write your answers on the lines provided above.

Question 17 (3 marks) Outcomes – P6

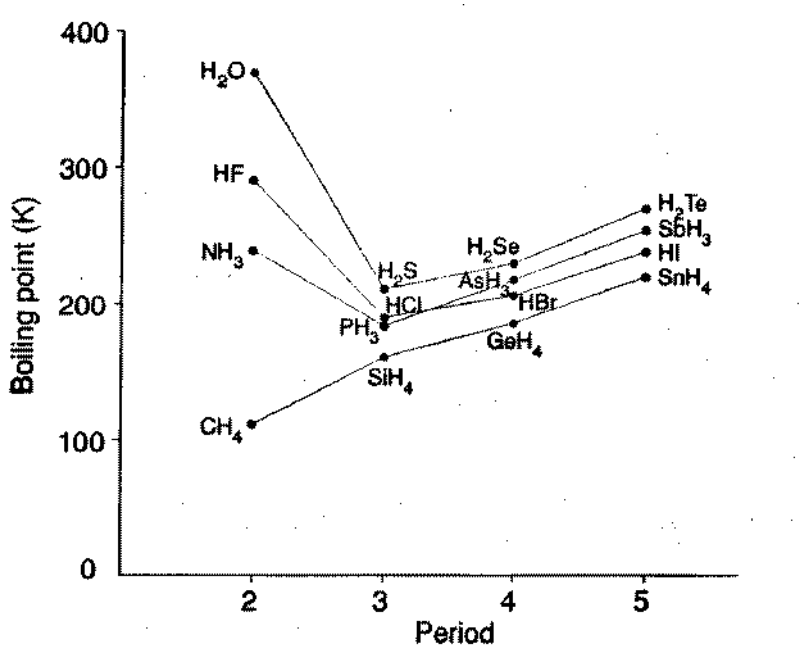
Complete the table by providing the electron dot structures and molecular shapes.

	Water	**Tetrachloromethane** (Carbon tetrachloride)	**Ammonia**
Formula	H_2O	CCl_4	NH_3
Electron dot structure	**H O H**	**Cl** **Cl C Cl** **Cl**	**H N H** **H**
Molecular shape	**bent**	**tetrahedral**	**pyramid**

(1 mark for each pair)

Question 18 (2 marks) Outcomes – P6

The graph shows the boiling points of some hydrides.



(a) Identify the type of intermolecular force responsible for the increase in the boiling point of the group IV hydrides. **(1)**

Dispersion force (1 mark)

(b) Briefly explain the reason for the exceptionally high boiling points of HF, H_2O and NH_3. **(1)**

All three have the ability to engage in hydrogen bonding. (1 mark)

Question 19 (5 marks) Outcomes – P3

(a) Explain why brass, which consists of copper and zinc, is not considered a compound. **(1)**

Brass is a mixture. The copper and zinc are combined physically not chemically. (1 mark)

(b) Calcium is the third most abundant metal in the earth's crust. Explain why calcium is not used as a metal. **(1)**

Calcium is too active to be used as a metal. (1 mark)

(c) Steel and solder are both alloys, but with very different properties.

(i) For each alloy describe one of its characteristic properties. **(1)**

Steel is noted for its mechanical strength.

Solder is noted for its low melting point. (1 mark for the pair)

Question 19 (continued)

(ii) Identify a use of each alloy which relates to the property described in (i). **(1)**

Steel is commonly used for fasteners and structural components.

Solder is used to join metals together, e.g. electrical wires, water pipes. (1 mark for the pair)

(d) The engine block (the outside casing) of modern cars is usually made of aluminium rather than traditional cast iron. Aluminium is significantly more expensive than iron. Identify a reason why car makers would use aluminium despite its higher cost. **(1)**

Aluminium is lightweight, thus decreases fuel consumption. (1 mark)
Aluminium is corrosion resistant. (alternative)

Question 20 (3 marks) Outcomes – P8

Ken Chemiski conducted a series of experiments involving the reaction of a selection of metals with water, dilute hydrochloric acid, and oxygen. He then compared his results with an activity series table printed in a textbook.

(a) One of the experiments involved reacting calcium with water. Write a balanced equation for the reaction. **(1)**

$Ca_{(s)} + 2H_2O_{(l)} \rightarrow Ca(OH)_{2\,(aq)} + H_{2\,(g)}$ **(1 mark; must include states)**

(b) Ken's results correlated well with the text's activity series except for aluminium. Explain the unexpected result observed for aluminium. **(1)**

Aluminium has a thin, tough, tenacious oxide layer which hinders its reactivity/activity. (1 mark)

(c) Write a balanced equation for the reaction of aluminium with dilute hydrochloric acid. **(1)**

$2Al_{(s)} + 6HCl_{(aq)} \rightarrow 2AlCl_{3\,(aq)} + 3H_{2\,(g)}$ **(1 mark; must include states)**

Question 21 (2 marks) Outcomes – P4, P10

International negotiations concerning the reduction of CO_2 gas emissions have received heavy coverage in the media in recent months. Nations which plant forests can receive carbon credits to meet their international obligations for CO_2 gas reduction.

(a) Write a balanced equation showing how photosynthesis removes CO_2 from the atmosphere. Include any special conditions above and/or below the reaction arrow ($\rightarrow$). **(1)**

$6CO_{2\,(g)} + 6H_2O_{(l)} \xrightarrow{\text{chlorophyll + light}} C_6H_{12}O_{6\,(aq)} + 6O_{2\,(g)}$ **(1 mark)**

+ $C_6H_{12}O_6$ may also be shown as $C_6H_{12}O_{6\,(s)}$

Question 21 (continued)

(b) A large tree can remove 180 g of carbon dioxide from the air by photosynthesis every day. Calculate the volume of oxygen produced at 25°C and 101.3 kPa during the process. **(1)**

(180 g) ÷ (44.01) = 4.09 mol CO_2 = 4.09 mol O_2

(4.09 mol) x (24.47 L/mol) = <u>100 L O_2</u> (1 mark)

Question 22 (4 marks) <u>Outcomes – P7</u>

Chang performs an experiment to determine the molar heat of solution of potassium nitrate. The table shows his data.

Mass of water in calorimeter	151.48 g
Mass of potassium nitrate dissolved	8.78 g
Initial temperature of water	18.5° C
Final temperature of solution	14.0° C
Specific heat of water (constant)	4.18 J/g °C

(a) Calculate the molar heat of solution from the data. **(2)**

ΔH = m C ΔT = (151.48 g) x (4.18 J/g °C) x (14.0 – 18.5°C) = 2849 J = <u>2.85 kJ</u> (1 mark)
Alternative answer where m includes mass of solute = <u>3.01 kJ</u>

Molar ΔH = (2.85 kJ) ÷ (8.78 g) x (101.11) = <u>32.8 kJ/mol</u> (1 mark)
Alternative answer where m includes mass of solute = <u>34.7 kJ/mol</u>

(b) Identify whether the molar heat of solution is exothermic or endothermic. **(1)**

<u>The molar heat of solution is endothermic</u>. (1 mark)

Question 22 (continued)

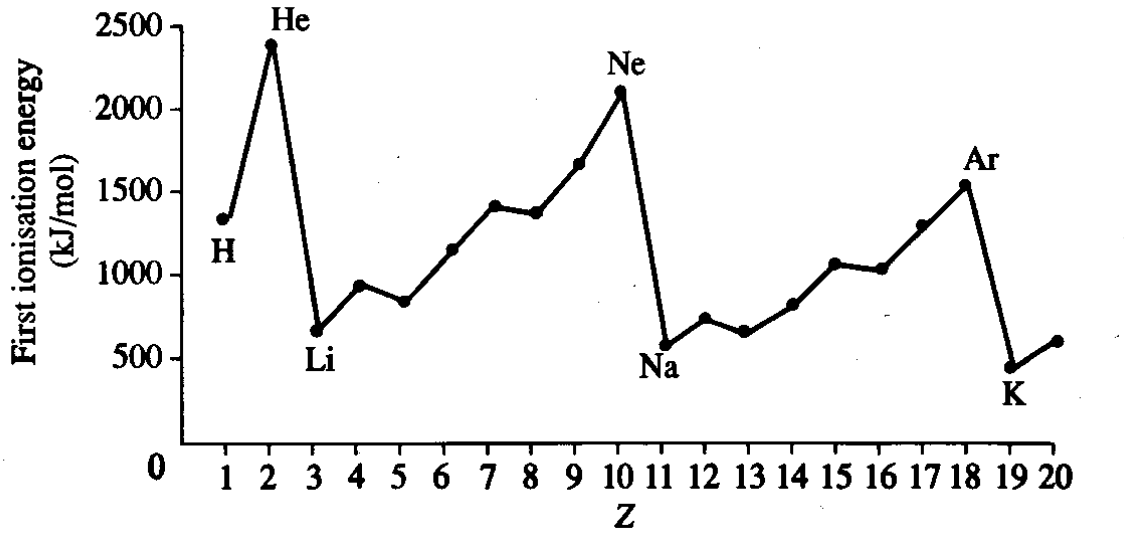
(c) The calorimetry calculation makes use of the specific heat of water, but the specific heat of water is of far greater importance to the survival of life. Explain why water's exceptionally high specific heat is so important to living things. **(1)**

<u>Water's exceptionally high heat capacity greatly moderates temperature changes in bodies of water, i.e. high heat inputs do not result in big temperature changes</u>. <u>This prevents heat stress ensuring the survival of aquatic life</u>. (1 mark)

\+ **Other answers with similar ideas are acceptable, but the student should not confuse heat capacity with heat of vaporisation which explains the cooling effect of sweating.**

Question 23 (3 marks) Outcomes – P6

The graph shows the ionisation energy of some elements.



(a) Describe the trend in the ionisation energy down Group I? **(1)**

Proceeding down Group I, the ionisation energy values decrease. (1 mark)

(b) Is there a link between the ionisation energy of an element and its reactivity? Explain your answer. **(1)**

No. The most reactive metals have the lowest ionisation energies, while the most reactive non-metals have high ionisation energies. (1 mark)

(c) Explain why the noble gases have the highest ionisation energies within a period. **(1)**

A noble gas is the smallest atom within a period. A small atom holds its valence electrons very tightly, thus the ionisation energy is high. (1 mark)

Question 24 (2 marks) Outcomes – P4, P10

The monitoring of hazardous chemicals in drinking water is of prime concern to public health. Cadmium is classified as a toxic heavy metal which can pollute waterways by the improper disposal of depleted nickel-cadmium batteries. The maximum permissible limit for cadmium in drinking water is 0.01 mg L^{-1}.

(a) Calculate the maximum permissible limit for cadmium in terms of moles L^{-1}. **(1)**

mol = m ÷ M = (0.00001 g) ÷ (112.4) = 8.9 x 10^{-8} = 9 x 10^{-8} mol/L (1 mark)

+ No credit awarded if the conversion from mg to g was not made.

(b) Identify another toxic heavy metal which is monitored in natural waterways. **(1)**

Mercury (1 mark) + Other possible answers include lead, zinc, copper.

Question 25 (9 marks) <u>Outcomes – P9, P8</u>

Carbon is a unique element with very special bonding capabilities.

(a) Name and draw the structural formulas of three hydrocarbons which illustrate carbon forming single, double, and triple carbon/carbon bonds. **(3)**

ethane	$H_3C - CH_3$	**1 mark**
ethene	$H_2C = CH_2$	**1 mark**
ethyne	$H - C \equiv C - H$	**1 mark**

\+ **Other answers possible.**

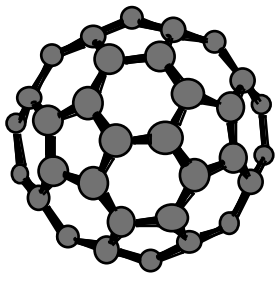
(b) Some of the carbon on Earth is bound up ('fixed') in the valuable forms of coal, petroleum and natural gas. Explain how mobile carbon (CO_2) became fixed as fuels using chemical and geological concepts. **(3)**

Firstly, carbon dioxide was converted into a carbohydrate form (glucose/starch/cellulose) by the process of <u>photosynthesis</u>. (1 mark)

Secondly, organic remains (mainly plants) were covered over with water and sediments which excluded oxygen and allowed decomposition to proceed via <u>anerobic bacteria</u>. (1 mark)

Thirdly, further sedimentation occurred which caused an <u>increase in pressure and temperature</u>. These conditions allowed for the slow formation of coal, petroleum and natural gas. (1 mark)

(c) In 1985, chemists prepared molecules of carbon containing 60 atoms shaped like a soccer ball. This C_{60} molecule is called buckminsterfullerene and is commonly known as a *bucky ball*. The properties of buckminsterfullerene are very different from the other allotropes of carbon. It is a yellow coloured solid with a melting point of about 350°C and it dissolves in benzene forming a purple coloured solution.



(i) Explain why C_{60} has a relatively low melting point. **(1)**

<u>When C_{60} melts, weak dispersion forces are broken and the liquid state is achieved. Since no bonds are broken the melting point is relatively low</u>. (1 mark)

Question 25 (continued)

(ii) Describe the bonding structure (type and shape) found in graphite and diamond. **(2)**

Graphite's bonding structure is <u>covalent network</u> composed of a <u>planar hexagonal</u> lattice. (1 mark)

Diamond's bonding structure is <u>covalent network</u> composed of a <u>tetrahedral</u> lattice. (1 mark)

Question 26 (2 marks) <u>Outcomes – P8</u>

Barium nitrate, silver nitrate and magnesium nitrate solutions are mixed with solutions X, Y, Z which are known to be sodium carbonate, sodium chloride and sodium sulfate (not in this order). The table shows the results of the mixing. (NR = no reaction; ppt = precipitate)

	X	Y	Z
Barium nitrate	NR	ppt	ppt
Silver nitrate	ppt	ppt	ppt
Magnesium nitrate	NR	NR	ppt

(a) Identify which of the solutions (X, Y, Z) is sodium sulfate and which is sodium chloride. **(1)**

<u>Sodium sulfate</u> = Y

<u>Sodium chloride</u> = X (1 mark for the pair)

(b) Write the net ionic equation for the reaction of silver nitrate with solution Z. **(1)**

$2Ag^+_{(aq)} + CO_3^{2-}{}_{(aq)} \rightarrow Ag_2CO_{3\,(s)}$ (1 mark)

+ Must include (s)

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