BOARD OF STUDIES
NEW SOUTH WALES

HIGHER SCHOOL CERTIFICATE EXAMINATION

2000
CHEMISTRY
2 UNIT

Time allowed—Three hours
(Plus 5 minutes reading time)

DIRECTIONS TO CANDIDATES

- Board-approved calculators may be used.

Section I—Core

- Attempt ALL questions.
- **Part A** 15 multiple-choice questions, each worth 1 mark.
  Complete your answers in either blue or black pen on the Answer Sheet provided.
- **Part B** 10 questions, each worth 3 marks.
  Answer this Part in the Part B Answer Book.
- **Part C** 6 questions, each worth 5 marks.
  Answer this Part in the Part C Answer Book.
- Write your Student Number and Centre Number on the cover of each Answer Book.
- You may keep this Question Book. Anything written in the Question Book will NOT be marked.

Section II—Electives

- Attempt ONE question.
- Each question is worth 25 marks.
- Answer the question in a separate Elective Answer Book.
- Write your Student Number and Centre Number on the cover of each Elective Answer Book.
- Write the Course, Elective Name, and Question Number on the cover of each Elective Answer Book.
- You may ask for extra Elective Answer Books if you need them.

A Data Sheet and Periodic Table are provided as a tear-out sheet at the back of this paper.

SECTION I—CORE

(75 Marks)

Attempt ALL questions.

PART A

Attempt ALL questions.

Each question is worth 1 mark.

Instructions for answering multiple-choice questions

- Complete your answers in either blue or black pen.
- Select the alternative A, B, C or D that best answers the question. Fill in the response oval completely.

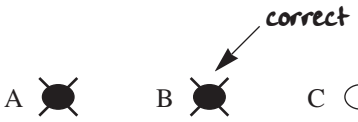
Sample: 2 + 4 = (A) 2 (B) 6 (C) 8 (D) 9

A ○ B ● C ○ D ○

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

A ● B ⊗ C ○ D ○

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



A ⊗ B ⊗ C ○ D ○

1 Lithium is a soft, light, reactive metal. Its electronic configuration is $1s^2\ 2s^1$.

Which statement is correct?

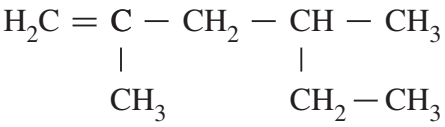
(A) Lithium will gain an electron to reach the structure $1s^2\ 2s^2$ when bonding occurs.

(B) $2s^1$ represents the valence electron.

(C) The lithium ion is $1s^2\ 2s^1$.

(D) All the electrons shown take part in bonding.

2 What compound is shown?



(A) 2-methyl-4-ethyl-1-pentene

(B) 2,4-dimethyl-1-hexene

(C) 3,5-dimethyl-5-hexene

(D) 4-ethyl-2-methyl-1-pentene

3 The hydrogen carbonate ion (HCO_3^-) is amphiprotic. Which statement is correct?

(A) HCO_3^- is the conjugate base of CO_3^{2-}

(B) H_2CO_3 is the conjugate acid of CO_3^{2-}

(C) CO_3^{2-} is the conjugate base of H_2CO_3

(D) H_2CO_3 is the conjugate acid of HCO_3^-

4 Reading from left to right across period three in the Periodic Table, oxides and chlorides change from ionic to covalent in properties.

What is the major cause of this?

(A) Increasing atomic volume of the period three elements

(B) Decreasing first ionization energies of the period three elements

(C) Increasing electronegativity of the period three elements

(D) Decreasing number of valence electrons of the period three elements

5 Consider the reaction at equilibrium at 1000°C:

$$2CO(g) + O_2(g) \rightleftharpoons 2CO_2(g) \qquad \Delta H = -566 \text{ kJ mol}^{-1}$$

Which change would result in a larger concentration of CO_2?

(A) Decreasing the volume

(B) Increasing the temperature

(C) Adding a catalyst

(D) Decreasing the partial pressure of $CO(g)$

6 A student wishes to determine the concentration of a weak acid by titration with a base of known concentration.

What is the most important property of the base?

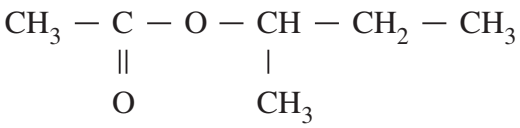
(A) It should be weak.

(B) It should be strong.

(C) It should be a primary standard.

(D) It should not react with carbon dioxide.

7 Which chemicals will react to produce the compound shown?



(A) 2-propanol and acetic (ethanoic) acid

(B) 2-butanol and ethanol

(C) acetic (ethanoic) acid and 2-butanol

(D) butanoic acid and ethanol

8 An experiment is carried out to investigate the effect of temperature change on the reaction represented by the equation:

$$N_2O_4(g) \rightleftharpoons 2NO_2(g) \qquad \Delta H = 54{\cdot}8 \text{ kJ mol}^{-1}$$

What will result if the temperature increases?

(A) The value of the equilibrium constant will remain the same, but equilibrium will be reached more quickly.

(B) The value of the equilibrium constant will remain the same, but equilibrium will be reached more slowly.

(C) The value of the equilibrium constant will increase.

(D) The value of the equilibrium constant will decrease.

9 Water has a higher melting point than hydrogen fluoride.

What is the main reason for this?

(A) Water forms more extensive hydrogen bonds than hydrogen fluoride.

(B) The covalent bond between O and H is stronger than that between F and H.

(C) Water contains more ions than hydrogen fluoride.

(D) Water is more polar than hydrogen fluoride.

10 Which of the following solutions has the lowest pH?

(A) 0·08 mol L^{-1} sulfuric acid

(B) 0·08 mol L^{-1} hydrochloric acid

(C) 0·20 mol L^{-1} acetic (ethanoic) acid

(D) 0·20 mol L^{-1} nitric acid

11 The table shows some properties of four solids, *W*, *X*, *Y* and *Z*.

Properties	*W*	*X*	*Y*	*Z*
Melting point (°C)	2300	800	80	1200
Soluble in water	no	yes	no	no
Solid state conducts electricity	no	no	no	yes
Molten state conducts electricity	no	yes	no	yes

What is the correct classification of the solids?

	Metallic	*Network covalent*	*Ionic*	*Molecular*
(A)	*W*	*X*	*Y*	*Z*
(B)	*X*	*Y*	*Z*	*W*
(C)	*Y*	*Z*	*W*	*X*
(D)	*Z*	*W*	*X*	*Y*

12 When chloride ions are added to a solution containing $Co(H_2O)_6^{2+}$ the following equilibrium is established:

$$\underset{\text{Pink}}{Co(H_2O)_6^{2+}} + 4\,Cl^- \rightleftharpoons \underset{\text{Blue}}{CoCl_4^{2-}} + 6\,H_2O$$

Solutions containing $Co(H_2O)_6^{2+}$ and Cl^- are frequently violet in colour owing to the presence of significant amounts of both $Co(H_2O)_6^{2+}$ and $CoCl_4^{2-}$.

Which of the following statements concerning such solutions is true?

(A) Diluting the solution with water will make the colour turn blue.

(B) If the reaction is endothermic, cooling the solution will make the colour turn pink.

(C) If the reaction is exothermic, heating the solution will make the colour turn blue.

(D) Adding a large amount of solid NaCl to the solution will make the colour turn pink.

13 Which of these substances can be oxidised to produce propanoic acid?

(A) 2-propanol

(B) propanone

(C) 1-butanol

(D) 1-butene

14 50 mL of a 0·200 mol L^{-1} solution of sodium hydroxide is diluted to 2·0 L with distilled water.

What is the pH of the diluted solution?

(A) 11·7

(B) 12·3

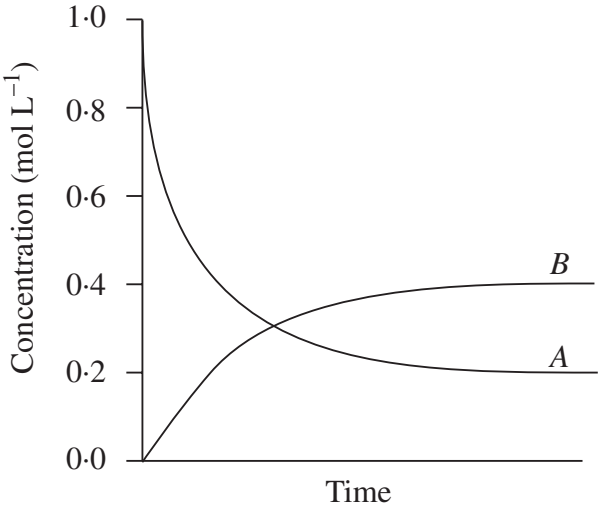
(C) 12·7

(D) 13·3

15 If compound *A* is heated, it decomposes according to the equation:

$$2A(g) \rightleftharpoons B(g) + C(g)$$

The following diagram shows the progress of the reaction.



What is the equilibrium constant for the reaction?

(A) 0·8

(B) 2·0

(C) 4·0

(D) 10·0

PART B

Attempt ALL questions.

Each question is worth 3 marks.

Answer all questions in the Part B Answer Book provided.

In questions involving calculations you are advised to show working, as marks may be awarded for relevant working.

16 Calcium is a reactive, alkaline earth metal.

(a) In terms of shells and subshells, give the:

(i) electronic configuration of the calcium atom;

(ii) electronic configuration of the calcium ion.

(b) Give the formula of an ion, from the third period, that has the same electronic configuration as the calcium ion.

17 In the Part B Answer Book, complete the table which describes industrial and domestic applications of some organic compounds.

18 A sodium acetate ($NaCH_3COO$) solution has a pH of 8, while an ammonium chloride (NH_4Cl) solution has a pH of 5.

(a) Write *ionic* equations to show why:

(i) a solution of $NaCH_3COO$ has a pH higher than 7;

(ii) a solution of NH_4Cl has a pH lower than than 7.

(b) The pH of 1·0 mol L^{-1} acetic (ethanoic) acid is 2·38, while the pH of 1·0 mol L^{-1} formic (methanoic) acid is 1·87. Explain this difference.

19 The table shows the effect of temperature on the equilibrium constant (K) for the reaction:

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

Temperature (°C)	*K*
700	2·63
800	0·915
900	0·384
1000	0·184
1100	0·098

(a) Plot the data on the grid provided in the Part B Answer Book. Include a curve of best fit to show the trend clearly.

(b) Is the reaction endothermic or exothermic? Give a reason for your answer.

20 Explain the following observations.

(a) Water has a lower molar mass than hydrogen sulfide, but its melting point is more than 80°C higher.

(b) Magnesium metal conducts electricity, but solid magnesium chloride does not.

(c) Lithium chloride is a solid with a melting point of more than 500°C, while boron trichloride is a gas at room temperature.

21 Two compounds *X* and *Y* have the molecular formula C_4H_8. On reaction with HBr, compound *X* gives a single product, while compound *Y* gives two products.

(a) Give a structural formula for compound *Y.*

(b) Give the systematic name of compound *X.*

(c) Give the structural formula of the product formed by the reaction of *X* with HBr.

22 Natural gas (methane; CH_4) is an abundant fuel used for cooking, heating and power production. Its use in transportation is limited because it cannot be easily liquefied. There is considerable interest in finding an efficient catalyst for the following reaction, which produces methanol, a convenient liquid fuel:

$$2CH_4(g) + O_2(g) \rightleftharpoons 2CH_3OH(g)$$

(a) If the equilibrium mixture is cooled, methanol liquefies. What will this do to the concentration of methane (CH_4)?

(b) What effect will increasing the partial pressure of oxygen have on the equilibrium constant?

(c) Why is it easier to liquefy methanol than methane?

23 In an experiment, a student mixed 15·0 mL of 0·030 mol L^{-1} HCl with 20·0 mL of 0·010 mol L^{-1} $Ba(OH)_2$.

Calculate the pH of the resulting solution.

24 A student has three unlabelled test tubes. They contain three different, but apparently identical, colourless liquids. One is l-butanol, another is 2-methyl-2-propanol, and the third is 1-hexene. Describe the *chemical* tests the student should carry out to determine which liquid is in each test tube. In your answer, include expected observations.

25 The production of hydrogen iodide from hydrogen and iodine is given by the equation:

$$H_2(g) + I_2(g) \rightleftharpoons 2HI(g)$$

1·0 mol hydrogen and 1·0 mol iodine were introduced into a sealed 1 L reaction vessel at 500°C and allowed to come to equilibrium. It was then found that 1·55 mol hydrogen iodide had been produced.

(a) Calculate the equilibrium concentrations of H_2 and I_2 under these conditions.

(b) Calculate the value of the equilibrium constant (K) for the reaction.

PART C

Attempt ALL questions.

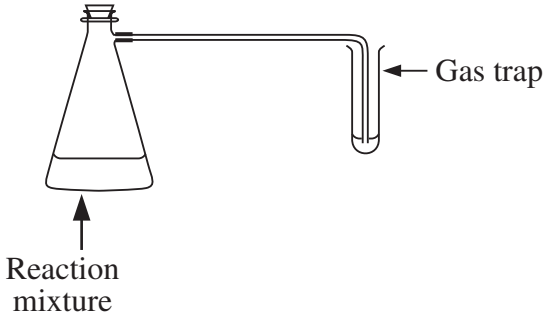
Each question is worth 5 marks.

Answer all questions in the Part C Answer Book provided.

In questions involving calculations you are advised to show working, as marks may be awarded for relevant working.

26 A student placed 25 g of glucose into a conical flask containing 80 mL water. She added a few crystals of citric acid and about 2 g of yeast and then mixed the contents by shaking.

She stood the apparatus in a warm place at about 30°C for 2–3 days. The evolution of bubbles in the gas trap indicated that a reaction had occurred.

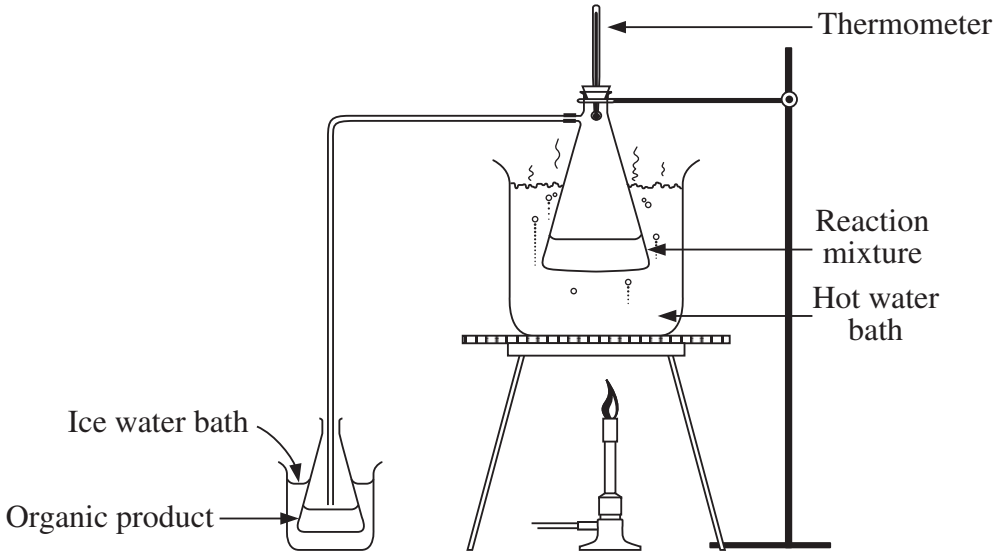


(a) Write a balanced equation for the reaction.

(b) Calculate the maximum possible yield of organic product.

The student purified the organic product using the apparatus shown in the diagram.

(c) Explain the purpose of each of the water baths.



27 Construct a table that describes the trend in ONE physical and ONE chemical property of EITHER of these groups of compounds:

sodium chloride, aluminium chloride and phosphorus trichloride;

OR

sodium oxide, aluminium oxide and diphosphorus pentoxide.

28 A chemist dissolved the calcium carbonate in a section of blocked pipe by soaking the section in an excess (100·0 mL) of 0·200 mol L^{-1} hydrochloric acid. After the calcium carbonate had dissolved, the unused hydrochloric acid was titrated with 0·100 mol L^{-1} sodium hydroxide. 33·3 mL of 0·100 mol L^{-1} sodium hydroxide was required.

(a) Write the equation for the reaction of calcium carbonate with hydrochloric acid.

(b) How many moles of sodium hydroxide were required to neutralise the unreacted hydrochloric acid?

(c) How many moles of hydrochloric acid reacted with the calcium carbonate?

(d) How many grams of calcium carbonate were in the pipe?

(e) Would the pH at the equivalence point of the titration have been acidic, neutral or basic? Explain your answer.

29 An alkene has the molecular formula C_5H_{10}.

(a) Give the balanced equation for the complete combustion of this alkene.

(b) Draw the structure of a straight chain alkene that has this molecular formula.

(c) Draw the structure of an alkane that has this molecular formula.

(d) Draw the structure of an organic product of the reaction between the alkene you drew in part (b) and cold alkaline $KMnO_4$.

(e) Give ONE safety precaution that must be used while carrying out the reaction in part (d).

30 The pH of blood in healthy humans is controlled by a number of buffer systems. One of the most important of these is the hydrogen carbonate/carbonic acid equilibrium:

$$H^+(aq) + HCO_3^-(aq) \rightleftharpoons H_2CO_3(aq)$$

Aqueous carbonic acid exists in equilibrium with water and gaseous carbon dioxide as follows:

$$H_2CO_3(aq) \rightleftharpoons H_2O(l) + CO_2(g)$$

One mechanism by which the body can respond to changes in blood pH is through altering the rate of breathing. For example, rapid breathing results in greater removal of $CO_2(g)$ from the body.

(a) What are the relative rates of the forward and reverse reactions in the hydrogen carbonate/carbonic acid equilibrium in a healthy human?

(b) In a healthy human, concentrations of the components of the hydrogen carbonate/carbonic acid buffer system do not change. However, consumption of radioactive $NaHCO_3$ by a healthy human results in the presence of measurable amounts of radioactive CO_2 in their breath. Explain this observation.

(c) Antacids contain hydrogen carbonate salts and are used to combat acid indigestion. Explain why the consumption of antacid tablets can lead to an increased tendency to burp (belch).

(d) Explain what effect rapidly blowing up several balloons will have on the $[H^+]$ of blood.

31 Benzoic acid (C_6H_5COOH), molar mass 122 g, is a weak monoprotic acid.

(a) When 0·20 g of benzoic acid was dissolved in 1 L of water, the resulting $[H^+]$ was determined to be $2{\cdot}9 \times 10^{-4}$ mol L^{-1}. What is the K_a for benzoic acid?

(b) A solid sample weighing 0·600 g contained benzoic acid and inert matter. The entire sample was analysed by dissolution in water and titration with 0·100 mol L^{-1} KOH. If 24·50 mL of KOH was required to reach the end point, what was the mass of benzoic acid in the solid sample?

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SECTION II—ELECTIVES

(25 Marks)

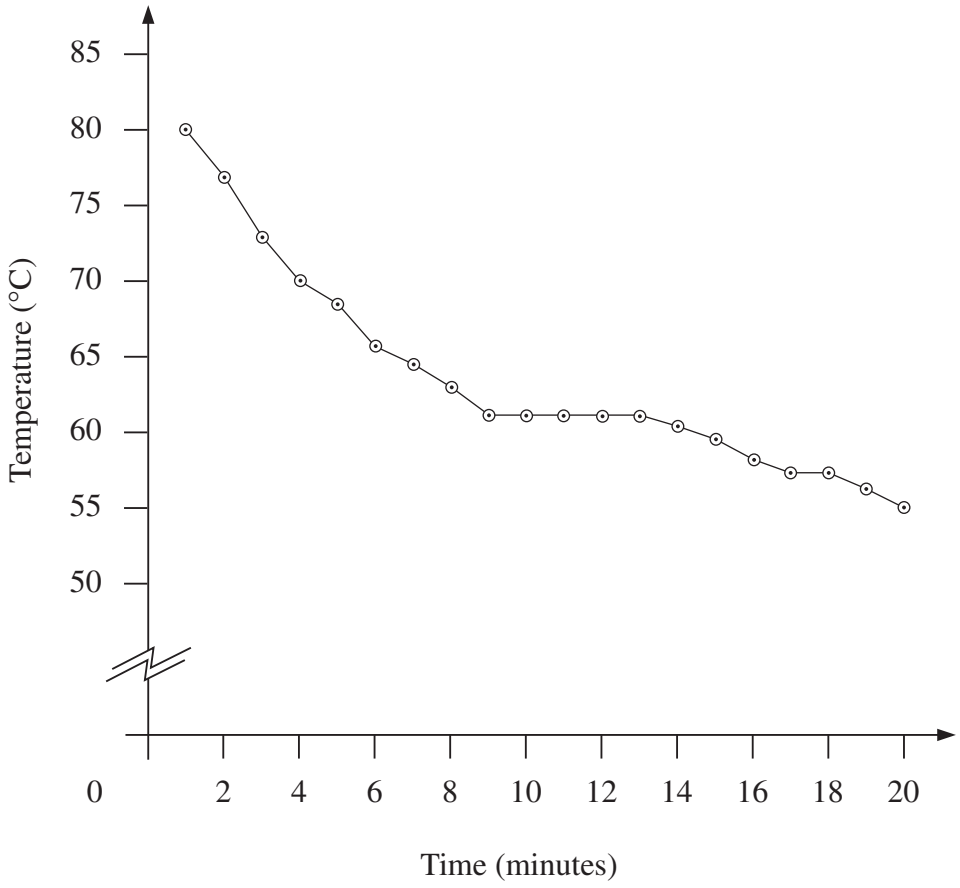
Attempt ONE question.

Answer the question in a SEPARATE Elective Answer Book.

In questions involving calculations you are advised to show working, as marks may be awarded for relevant working.

QUESTION 32 Chemical Energy **Marks**

(a) A student wanted to find the melting point of some beeswax. He heated it carefully in a waterbath until the wax melted. He then placed a thermometer into the molten beeswax and measured the temperature every minute for 20 minutes. A graph of his results is shown. **2**



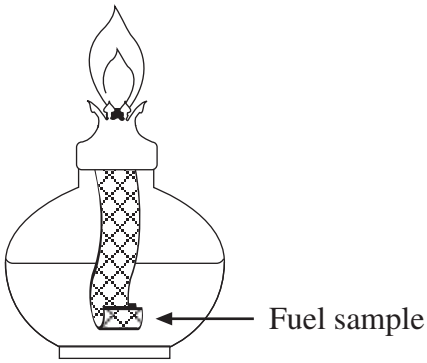
(i) What is happening to the beeswax between 9 and 13 minutes?

(ii) Explain why the curve is flat at this time.

Question 32 continues on page 17

QUESTION 32 (Continued) **Marks**

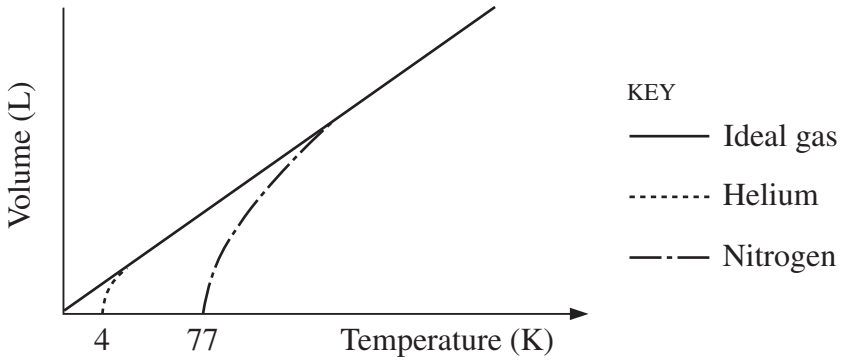
(b) (i) Draw a diagram showing how this spirit burner and other apparatus could be used to measure the heat of combustion of ethanol. **6**



(ii) What measurements must be taken to determine the experimental value for the heat of combustion of ethanol?

(iii) When the experiment is done, the value obtained is less than the theoretical value. Account for this.

(c) The graph shows the relationship between volume and absolute temperature for an ideal gas and two real gases. **4**



(i) Describe the relationship for the ideal gas shown in this graph.

(ii) What experimental condition is necessary for this relationship to be true?

(iii) Explain what happens to the nitrogen at 77 K.

(iv) Why does helium behave more like an ideal gas than does nitrogen?

Question 32 continues on page 18

QUESTION 32 (Continued) **Marks**

(d) A sample of hydrogen gas occupied 15 L at 25°C. The temperature was raised to 50°C at a constant pressure of 101·3 kPa. **2**

(i) Although the temperature had doubled, from 25°C to 50°C, the volume was less than 30 L. Explain this observation.

(ii) What volume would be measured at 50°C?

(e) (i) Write the equation for the complete combustion of domestic heating oil. (Assume that the oil consists only of the hydrocarbon $C_{15}H_{32}$.) **4**

(ii) The table shows average bond dissociation energies. Calculate the energy released by the complete combustion of one mole of domestic heating oil.

Bond	*Bond dissociation energy* (kJ mol^{-1})
C—C	346
C═C	614
C≡C	839
H—H	436
O═O	498
C—H	414
C—O	358
C═O	804
H—O	463

(iii) Why should domestic fuel heaters be cleaned regularly for efficiency and safety reasons?

Question 32 continues on page 19

QUESTION 32 (Continued) **Marks**

(f) Fuels have various properties that have to be considered when using them. The table compares four fuels. This information may be used together with your own knowledge when answering part (f) (i) – part (f) (iv). **7**

Property	*Petrol*	*Kerosene*	*Hydrogen*	*Ethanol*
Heat of combustion (kJ mol^{-1})	5 460	10 000	285	1 360
Ignition temperature (°C)	495	260	560	363
Flash point (°C)	– 40	+ 55	–	+ 13
Volatility (°C)	126	300	– 253	78
Density (g mL^{-1})	0·69	0·78	–	0·78
Molar mass (g)	114	210	2	46

(i) Which fuel provides the greatest amount of energy per gram?

(ii) A car has a 70 L petrol tank. Determine the energy released by the combustion of one full tank of petrol. (Assume complete combustion of the fuel.)

(iii) How many litres of hydrogen gas at 25°C and 101·3 kPa would be needed to supply the same amount of energy as 70 L of petrol?

(iv) Describe ONE advantage and ONE disadvantage of using ethanol as a fuel, compared with petrol.

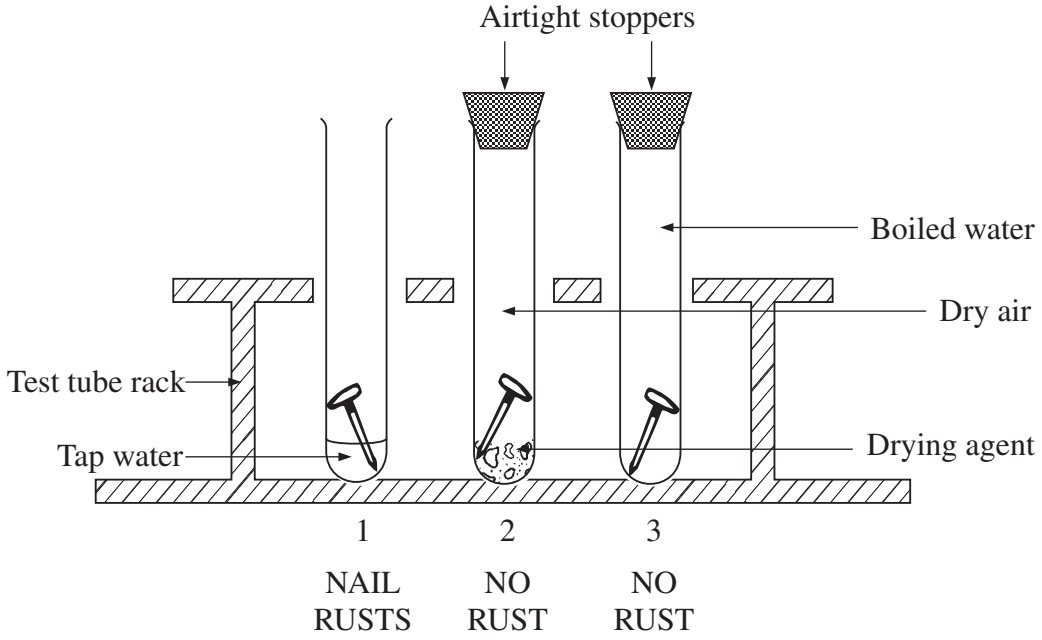
End of question

QUESTION 33 Oxidation and Reduction **Marks**

(a) A method for cleaning silver 'the easy way' involves purchasing an aluminium plate with holes in it and a 'mysterious salt' (Na_2CO_3). The aluminium plate is placed in a plastic bucket with warm water and the salt. When the tarnished silverware is placed in the water in contact with the aluminium for a few minutes, the shine of the silverware is restored. **1**

Name the oxidant and the reductant in this reaction.

(b) The diagram shows a simple experiment done as part of the junior science course in many high schools. **5**



(i) From this experiment, what would you conclude is necessary for iron to rust?

(ii) Rust is a complex mixture of compounds that forms after Fe^{2+} ions and OH^- ions are initially produced.

Write the half-equations and overall equation that produce the Fe^{2+} ions and the OH^- ions.

(iii) Adding salt to test tube 1 would accelerate the rusting process. Explain.

(iv) Describe another method to prevent iron from rusting.

Question 33 continues on page 21

QUESTION 33 (Continued) **Marks**

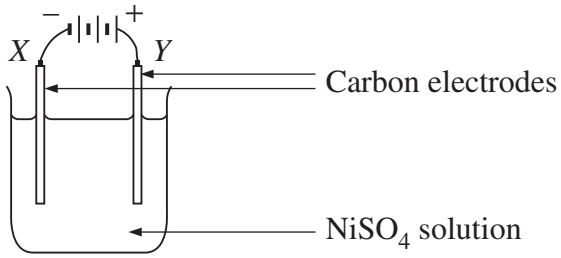
(c) When random breath testing was first introduced in NSW, drivers were asked to 'blow into the bag'. This involved blowing a particular volume (a 'bag full') of air across crystals containing orange dichromate ions ($Cr_2O_7^{2-}$) and some acid. The dichromate oxidised any ethanol present to acetic (ethanoic) acid, and was itself reduced to the green chromium ion (Cr^{3+}). **4**

If the crystals turned green, this indicated that a driver was under the influence of alcohol.

(i) What is the oxidation state of chromium in the dichromate ion?

(ii) Write a balanced equation for the reaction that occurs between ethanol and the dichromate ion. Show relevant half-equations.

(d) A common laboratory experiment is to electroplate a carbon electrode with a metal. The diagram shows a possible set-up for a nickel plating experiment. **5**



(i) Which electrode, *X* or *Y*, will be nickel plated? State the sign of the charge on the electrode, and whether it is the anode or cathode.

(ii) Write the half-equation for the reaction that occurs at:

1 the anode;

2 the cathode.

(iii) A different reaction would occur at the anode if it were replaced by a nickel electrode.

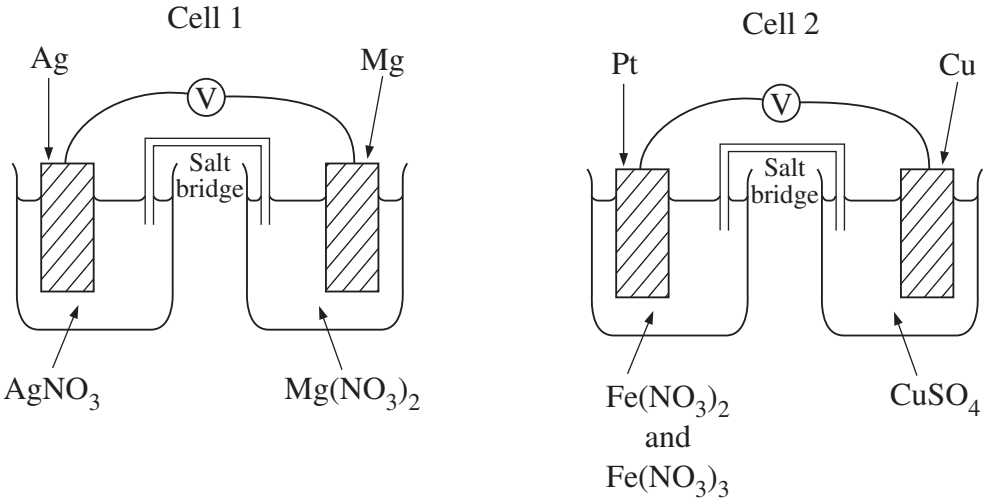
Write the half-equation for the reaction that would occur.

Explain why it would occur in preference to the original reaction in part (d) (ii) 1.

Question 33 continues on page 22

QUESTION 33 (Continued) **Marks**

(e) A student constructed two electrochemical cells as shown. The aqueous cell solutions had a concentration of 1 mol L^{-1} with respect to the metal ions present. **10**



(i) Use equations to describe the chemical changes that occur in Cell 1 as the cell operates.

(ii) In Cell 2, the solution in one half-cell is initially an orange colour due to the mixture of the pale green Fe^{2+} ions and the orange Fe^{3+} ions. The other half is coloured blue due to the Cu^{2+} ions. Describe the colour changes the student would see in each half of Cell 2 if the reaction proceeded until no further change took place.

(iii) Calculate the initial potential difference across Cell 1.

(iv) As the reaction proceeds, the voltage in the cell drops. Explain.

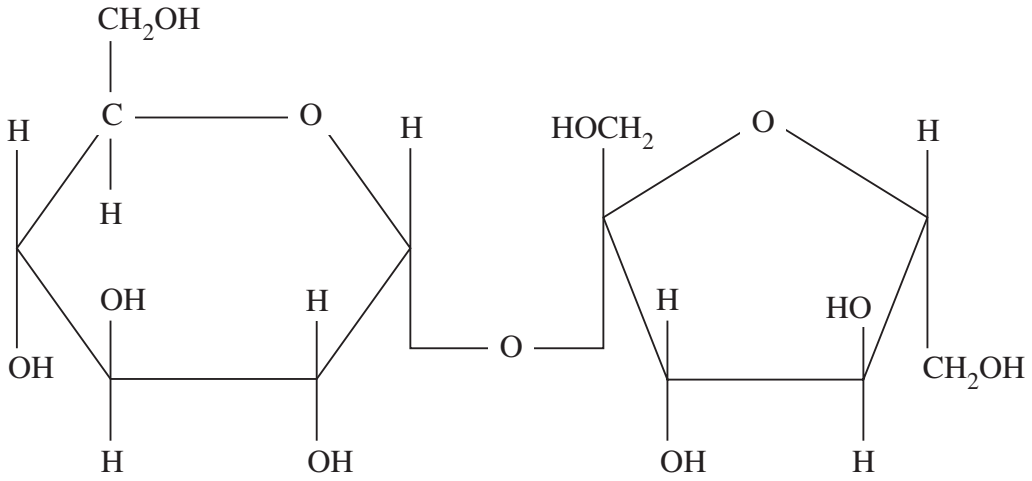
(v) What is the purpose of the salt bridge joining each half-cell?

(vi) In Cell 2, what is the oxidising agent, and at which electrode does oxidation occur?

End of question

QUESTION 34 Biological Chemistry **Marks**

(a) Invertase catalyses the hydrolysis of the disaccharide sucrose to a mixture of two different monosaccharides, known as invert sugar. Invert sugar is present in confectionery and in the syrup of canned fruits, and is sweeter than sucrose. The structure of sucrose is shown in the diagram. **6**



(i) Draw the structures of the two monosaccharides present in invert sugar, and name them.

(ii) Name TWO polymers composed of one of the monosaccharides named in part (i).

(iii) What is the function of one of the polymers named in part (ii)?

(b) It is estimated that $7{\cdot}92 \times 10^{25}$ g of carbon dioxide is used in photosynthesis each year. **5**

(i) In what form do plants store glucose?

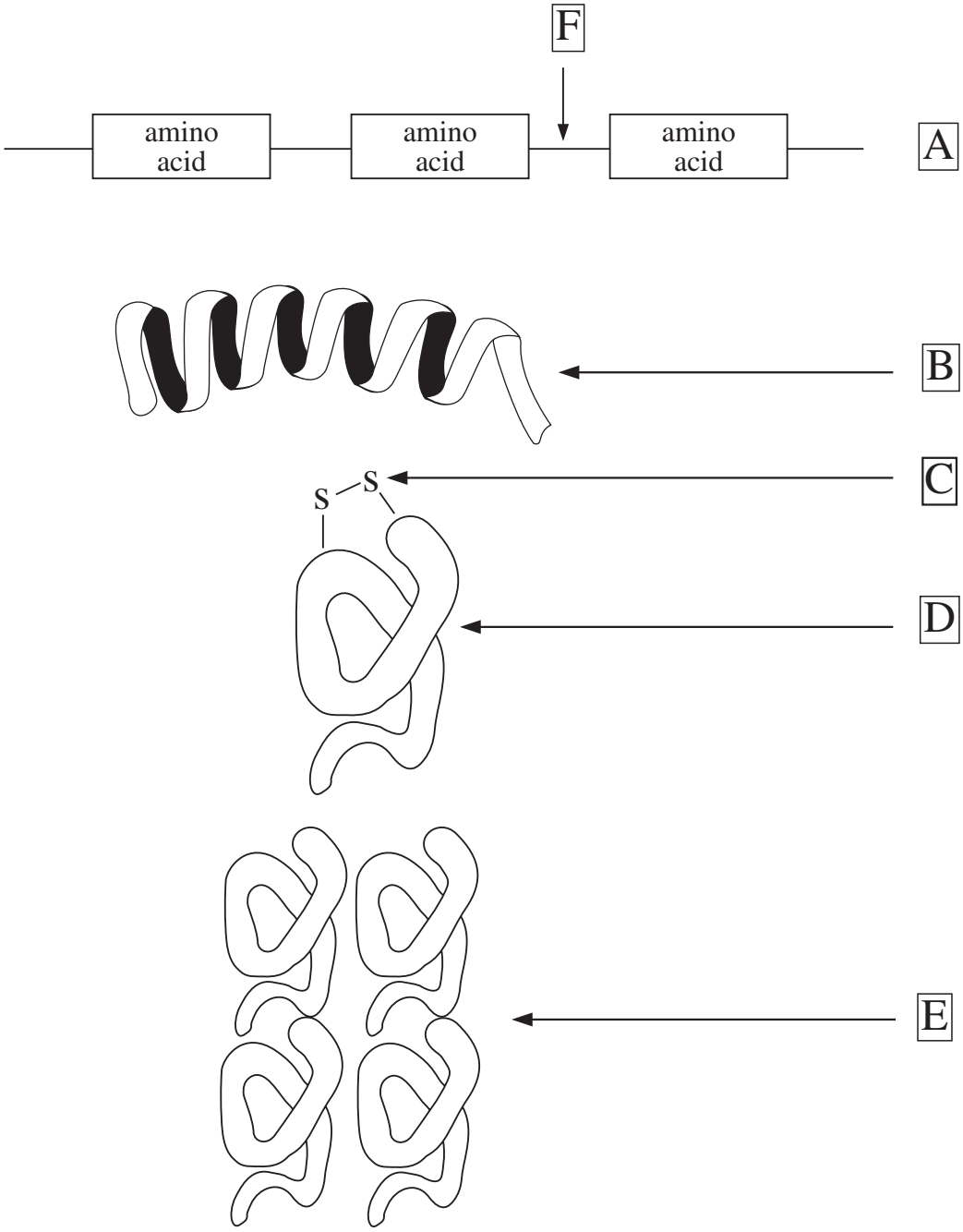
(ii) What mass of glucose is produced from photosynthesis each year?

(iii) Explain the role of water in the light and dark reactions of photosynthesis.

Question 34 continues on page 24

QUESTION 34 (Continued) **Marks**

(c) The diagrams show different aspects of protein structure. **6**



(i) Write the letter(s) from the diagrams that correspond(s) to:

1 the primary structure of a protein;

2 the secondary structure of a protein;

3 the tertiary structure of a protein.

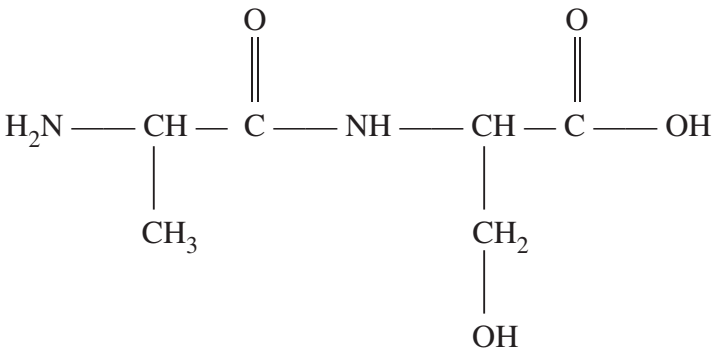
(ii) Give TWO examples of forces within a protein that determine its tertiary structure.

(iii) Name the type of covalent bond that links the primary structure.

Question 34 continues on page 25

QUESTION 34 (Continued) **Marks**

(d) The structure of a dipeptide is **2**



Draw the structures of the amino acids from which it is made.

(e) (i) What *chemical* test could you use to tell the difference between a slice of apple and a slice of potato? Describe the test, and state what would be observed in each slice. **5**

(ii) Placing starch on the tongue for several minutes slowly results in a distinct, sweet taste. By contrast, placing cellulose on the tongue does not result in a sweet taste. Explain why this occurs.

(iii) Explain how an enzyme increases the rate of a chemical reaction.

(iv) The enzyme pepsin is found in the stomach, which has a pH of about 1. Would you expect pepsin to be able to function in the small intestine, which has a pH of about 8? Explain your answer.

(f) Organisms that use the Krebs cycle have an advantage over those that do not. What advantage does the Krebs cycle give to an organism? **1**

End of question

QUESTION 35 Chemistry and the Environment **Marks**

(a) Water samples were taken by students from rain water, sea water and the effluent of a chrome-plating factory. The results are shown. **7**

	A	*B*	*C*
pH	6·5	2·3	7·2
O_2	high	nil	high
Total solids	nil	high	low
Halides	nil	very high	high
Micro-organisms	nil	nil	low

(i) Identify the samples *B* and *C*, and state your reasons.

(ii) The pH of freshly distilled water is 7·0. After standing for a short time, the pH drops below 7.

Why is this so? Give an equation to support your answer.

(iii) How would the students have determined the level of:

1 halides;

2 total solids;

3 micro-organisms;

in the samples of water?

(b) Nitrogen monoxide (nitric oxide) and nitrogen dioxide are important components of photochemical smog. Write equations to show their formation from atmospheric gases. **2**

(c) Acid rain, predominantly sulfuric acid, is having a major corrosive effect on the monuments of the Parthenon in Athens. These monuments are made of marble (calcium carbonate). **6**

(i) Write equations to show how sulfur dioxide is converted to sulfuric acid in acid rain.

(ii) Write an equation to show the reaction of sulfuric acid with marble.

(iii) Over a two-year period, 5 g of marble corrodes from a statue. How many grams of sulfur dioxide are needed to cause this corrosion?

Question 35 continues on page 27

QUESTION 35 (Continued) **Marks**

(d) Ozone is an allotrope of oxygen. **4**

(i) Ozone is both toxic and essential to humans. Explain this statement.

(ii) CF_4 and CF_2Cl_2 can both be used as refrigerants and propellants. Which can destroy ozone? Explain your answer, giving equations where appropriate.

(e) Carbon monoxide, carbon dioxide and hydrogen sulfide are gases found in the atmosphere. Describe a test for each gas. **3**

(f) Disposal of radioactive waste is a growing environmental problem. **3**

(i) Name a major waste product of nuclear reactors.

(ii) Discuss TWO factors that must be considered in the disposal of nuclear waste.

End of paper

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CHEMISTRY DATA SHEET

Values of several numerical constants

Avogadro's constant, N_A	$6{\cdot}022 \times 10^{23}$ mol^{-1}
Gas constant, R	$8{\cdot}314$ J K^{-1} mol^{-1}
	$0{\cdot}0821$ L atm K^{-1} mol^{-1}
Mass of electron, m_e	$9{\cdot}109 \times 10^{-31}$ kg
Mass of neutron, m_n	$1{\cdot}675 \times 10^{-27}$ kg
Mass of proton, m_p	$1{\cdot}673 \times 10^{-27}$ kg
Volume of 1 mole ideal gas:	
at 101·3 kPa (1·00 atm) and	
at 273 K (0°C)	22·41 L
at 298 K (25°C)	24·47 L
Ionisation constant for water	
at 298 K (25°C), K_w	$1{\cdot}0 \times 10^{-14}$

Some standard potentials

$K^+ + e^-$	$\rightleftharpoons$	$K(s)$	–2·94 V
$Ba^{2+} + 2e^-$	$\rightleftharpoons$	$Ba(s)$	–2·91 V
$Ca^{2+} + 2e^-$	$\rightleftharpoons$	$Ca(s)$	–2·87 V
$Na^+ + e^-$	$\rightleftharpoons$	$Na(s)$	–2·71 V
$Mg^{2+} + 2e^-$	$\rightleftharpoons$	$Mg(s)$	–2·36 V
$Al^{3+} + 3e^-$	$\rightleftharpoons$	$Al(s)$	–1·68 V
$Mn^{2+} + 2e^-$	$\rightleftharpoons$	$Mn(s)$	–1·18 V
$H_2O + e^-$	$\rightleftharpoons$	$\frac{1}{2}H_2(g) + OH^-$	–0·83 V
$Zn^{2+} + 2e^-$	$\rightleftharpoons$	$Zn(s)$	–0·76 V
$Fe^{2+} + 2e^-$	$\rightleftharpoons$	$Fe(s)$	–0·44 V
$Ni^{2+} + 2e^-$	$\rightleftharpoons$	$Ni(s)$	–0·24 V
$Sn^{2+} + 2e^-$	$\rightleftharpoons$	$Sn(s)$	–0·14 V
$Pb^{2+} + 2e^-$	$\rightleftharpoons$	$Pb(s)$	–0·13 V
$H^+ + e^-$	$\rightleftharpoons$	$\frac{1}{2}H_2(g)$	0·00 V
$SO_4^{2-} + 4H^+ + 2e^-$	$\rightleftharpoons$	$SO_2(aq) + 2H_2O$	0·16 V
$Cu^{2+} + 2e^-$	$\rightleftharpoons$	$Cu(s)$	0·34 V
$\frac{1}{2}O_2(g) + H_2O + 2e^-$	$\rightleftharpoons$	$2OH^-$	0·40 V
$Cu^+ + e^-$	$\rightleftharpoons$	$Cu(s)$	0·52 V
$\frac{1}{2}I_2(s) + e^-$	$\rightleftharpoons$	I^-	0·54 V
$\frac{1}{2}I_2(aq) + e^-$	$\rightleftharpoons$	I^-	0·62 V
$Fe^{3+} + e^-$	$\rightleftharpoons$	Fe^{2+}	0·77 V
$Ag^+ + e^-$	$\rightleftharpoons$	$Ag(s)$	0·80 V
$\frac{1}{2}Br_2(l) + e^-$	$\rightleftharpoons$	Br^-	1·08 V
$\frac{1}{2}Br_2(aq) + e^-$	$\rightleftharpoons$	Br^-	1·10 V
$\frac{1}{2}O_2(g) + 2H^+ + 2e^-$	$\rightleftharpoons$	H_2O	1·23 V
$\frac{1}{2}Cl_2(g) + e^-$	$\rightleftharpoons$	Cl^-	1·36 V
$\frac{1}{2}Cr_2O_7^{2-} + 7H^+ + 3e^-$	$\rightleftharpoons$	$Cr^{3+} + \frac{7}{2}H_2O$	1·36 V
$\frac{1}{2}Cl_2(aq) + e^-$	$\rightleftharpoons$	Cl^-	1·40 V
$MnO_4^- + 8H^+ + 5e^-$	$\rightleftharpoons$	$Mn^{2+} + 4H_2O$	1·51 V
$\frac{1}{2}F_2(g) + e^-$	$\rightleftharpoons$	F^-	2·89 V

Aylward and Findlay, *SI Chemical Data* (4th Edition) is the principal source of data for this examination paper. Some data may have been modified for examination purposes.

PERIODIC TABLE

				1 H 1·008 Hydrogen													2 He 4·003 Helium
3 Li 6·941 Lithium	4 Be 9·012 Beryllium											5 B 10·81 Boron	6 C 12·01 Carbon	7 N 14·01 Nitrogen	8 O 16·00 Oxygen	9 F 19·00 Fluorine	10 Ne 20·18 Neon
11 Na 22·99 Sodium	12 Mg 24·31 Magnesium											13 Al 26·98 Aluminium	14 Si 28·09 Silicon	15 P 30·97 Phosphorus	16 S 32·07 Sulfur	17 Cl 35·45 Chlorine	18 Ar 39·95 Argon
19 K 39·10 Potassium	20 Ca 40·08 Calcium	21 Sc 44·96 Scandium	22 Ti 47·88 Titanium	23 V 50·94 Vanadium	24 Cr 52·00 Chromium	25 Mn 54·94 Manganese	26 Fe 55·85 Iron	27 Co 58·93 Cobalt	28 Ni 58·69 Nickel	29 Cu 63·55 Copper	30 Zn 65·39 Zinc	31 Ga 69·72 Gallium	32 Ge 72·59 Germanium	33 As 74·92 Arsenic	34 Se 78·96 Selenium	35 Br 79·90 Bromine	36 Kr 83·80 Krypton
37 Rb 85·47 Rubidium	38 Sr 87·62 Strontium	39 Y 88·91 Yttrium	40 Zr 91·22 Zirconium	41 Nb 92·91 Niobium	42 Mo 95·94 Molybdenum	43 Tc 98·91 Technetium	44 Ru 101·1 Ruthenium	45 Rh 102·9 Rhodium	46 Pd 106·4 Palladium	47 Ag 107·9 Silver	48 Cd 112·4 Cadmium	49 In 114·8 Indium	50 Sn 118·7 Tin	51 Sb 121·8 Antimony	52 Te 127·6 Tellurium	53 I 126·9 Iodine	54 Xe 131·3 Xenon
55 Cs 132·9 Cesium	56 Ba 137·3 Barium	57 La 138·9 Lanthanum	72 Hf 178·5 Hafnium	73 Ta 180·9 Tantalum	74 W 183·9 Tungsten	75 Re 186·2 Rhenium	76 Os 190·2 Osmium	77 Ir 192·2 Iridium	78 Pt 195·1 Platinum	79 Au 197·0 Gold	80 Hg 200·6 Mercury	81 Tl 204·4 Thallium	82 Pb 207·2 Lead	83 Bi 209·0 Bismuth	84 Po — Polonium	85 At — Astatine	86 Rn — Radon
87 Fr — Francium	88 Ra 226·0 Radium	89 Ac — Actinium	104	105	106												

KEY

Atomic Number — 79 — Symbol of element

Atomic Mass — 197·0 — Name of element

Au — Gold

58 Ce 140·1 Cerium	59 Pr 140·9 Praseodymium	60 Nd 144·2 Neodymium	61 Pm — Promethium	62 Sm 150·4 Samarium	63 Eu 152·0 Europium	64 Gd 157·3 Gadolinium	65 Tb 158·9 Terbium	66 Dy 162·5 Dysprosium	67 Ho 164·9 Holmium	68 Er 167·3 Erbium	69 Tm 168·9 Thulium	70 Yb 173·0 Ytterbium	71 Lu 175·0 Lutetium
90 Th 232·0 Thorium	91 Pa 231·0 Protactinium	92 U 238·0 Uranium	93 Np 237·0 Neptunium	94 Pu — Plutonium	95 Am — Americium	96 Cm — Curium	97 Bk — Berkelium	98 Cf — Californium	99 Es — Einsteinium	100 Fm — Fermium	101 Md — Mendelevium	102 No — Nobelium	103 Lr — Lawrencium

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BOARD OF STUDIES
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PART B ANSWER BOOK

DIRECTIONS TO CANDIDATES

- Write your Student Number and Centre Number at the top right-hand corner of this page.
- You should receive this Answer Book with an Answer Sheet for Part A, a Part C Answer Book and an Elective Answer Book.
- Answer Questions 16 to 25 in this Answer Book.

MARKER'S USE ONLY

PART	Mark	Marker	Check
B			

PART B

MARKER'S USE ONLY

Questions 16 to 25 are worth 3 marks each.

Attempt ALL questions.

Answer the questions in the space provided.

You should show sufficient working to allow the marker to follow your method.

16 (a) (i) .....

(ii) .....

(b) .....

17

IUPAC name of compound	*Domestic/industrial application*
	Antifreeze
Butane	
Ethene	

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18 (a) (i) .....

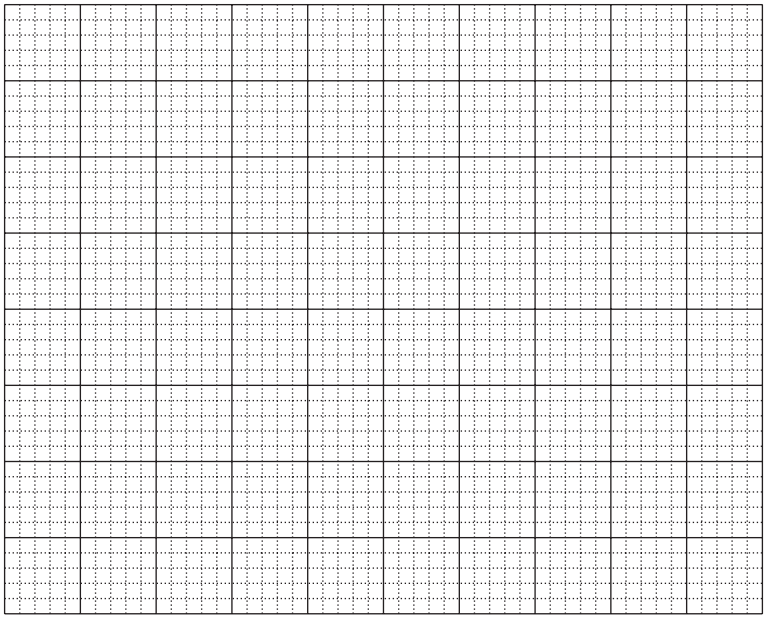
(ii) .....

(b) .....

.....

MARKER'S USE ONLY

19 (a)



(b) .....

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20 (a) .....

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(b) .....

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(c) .....

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MARKER'S USE ONLY

21 (a)

(b) .....

(c)

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22 (a) .....

(b) .....

(c) .....

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MARKER'S USE ONLY

23

24 .....

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Please turn over

MARKER'S USE ONLY

25 (a)

(b)

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PART C ANSWER BOOK

DIRECTIONS TO CANDIDATES

- Write your Student Number and Centre Number at the top right-hand corner of this page.
- You should receive this Answer Book with an Answer Sheet for Part A, a Part B Answer Book and an Elective Answer Book.
- Answer Questions 26 to 31 in this Answer Book.

MARKER'S USE ONLY

PART	Mark	Marker	Check
C			

PART C

MARKER'S USE ONLY

Questions 26 to 31 are worth 5 marks each.

Attempt ALL questions.

Answer the questions in the space provided.

You should show sufficient working to allow the marker to follow your method.

26 (a) .....

(b)

(c) Hot water bath .....

.....

.....

Ice water bath .....

.....

.....

MARKER'S USE ONLY

27

28 (a) .....

(b)

(c)

(d)

(e) .....

.....

MARKER'S USE ONLY

29 (a) .....

(b)

(c)

(d)

(e) .....

MARKER'S USE ONLY

30 (a) .....

(b) .....

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(c) .....

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(d) .....

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Please turn over

MARKER'S USE ONLY

31 (a)

(b)

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