BOARD OF STUDIES
NEW SOUTH WALES

HIGHER SCHOOL CERTIFICATE EXAMINATION

1998

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 blue or black pen, or in pencil 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.

Select the alternative A, B, C or D that best answers the question.

Complete your answers in blue or black pen, or in pencil on the Answer Sheet provided.

1. Which of the following forms a bond with chlorine with the most ionic character?

(A) Al

(B) Br

(C) K

(D) P

2. Which equation describes the fermentation of glucose?

(A) $C_6H_{12}O_6 \rightarrow 2C_3H_6O_3$

(B) $C_6H_{12}O_6 \rightarrow 2C_2H_5OH + 2CO_2$

(C) $C_6H_{12}O_6 + 6O_2 \rightarrow 6CO_2 + 6H_2O$

(D) $C_6H_{12}O_6 + 2O_2 \rightarrow 2CH_3COOH + 2CO_2 + 2H_2O$

3. Metals are better conductors of electricity than non-metals because

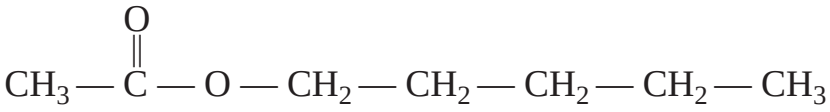
(A) metallic bonds are stronger than covalent bonds.

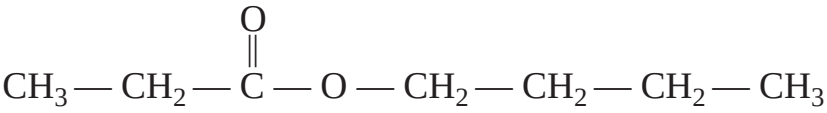
(B) metals have a higher melting point than non-metals.

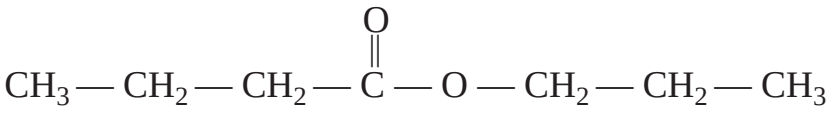
(C) metals have delocalised valence electrons.

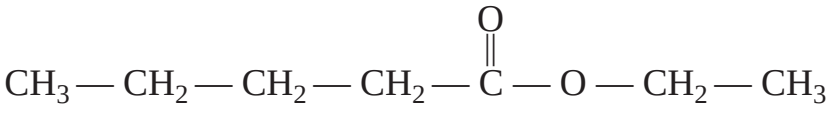
(D) metal atoms are smaller than non-metal atoms.

4. Which of the following is the structural formula for butyl propanoate?

(A) 

(B) 

(C) 

(D) 

5. When carbon dioxide gas is dissolved in water, the following equilibrium occurs.

$$CO_2(g) + H_2O(l) \rightleftharpoons H^+(aq) + HCO_3^-(aq)$$

If this solution is heated, carbon dioxide gas escapes.

Which of the following occurs when this solution is heated?

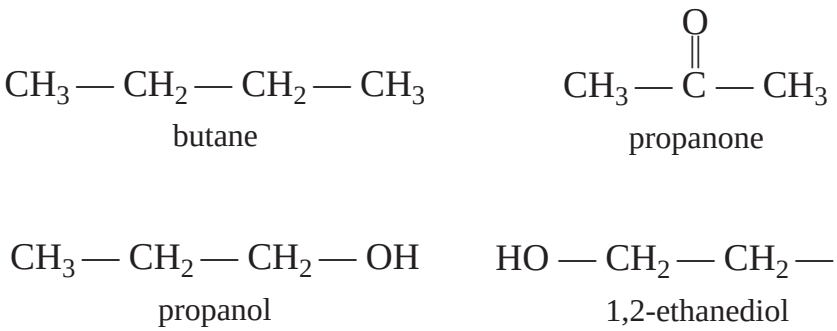
(A) The pH increases.

(B) The pH remains constant.

(C) The hydrogen carbonate concentration increases.

(D) The hydrogen carbonate concentration remains constant.

6. The four substances below have similar molar masses.



The substance with the highest boiling point is

(A) butane.

(B) propanol.

(C) propanone.

(D) 1,2-ethanediol.

7. In which of the following do ALL species have an electron configuration of $1s^2\ 2s^2\ 2p^6$?

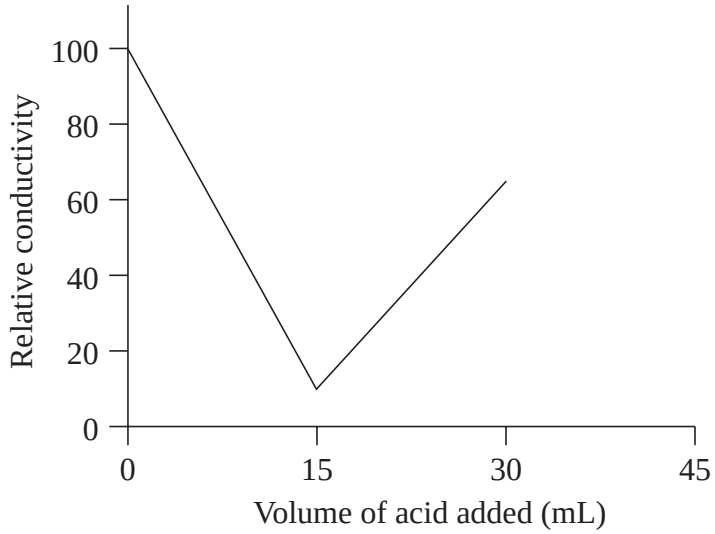
(A) Al^{3+} O^{2-} Be^{2+}

(B) O^{2-} He Na^{+}

(C) F^{-} Na^{+} Ne

(D) Mg^{2+} F^{-} Ar

8. 20 mL of KOH solution was titrated with 0·20 mol L^{-1} H_2SO_4 solution in a conductivity cell. The data obtained were plotted to give the graph shown below.



The concentration of the KOH solution was

(A) 0·30 mol L^{-1}

(B) 0·15 mol L^{-1}

(C) 0·12 mol L^{-1}

(D) 0·075 mol L^{-1}

9. The Brønsted–Lowry theory applies in both aqueous and non-aqueous systems.

The following reactions may take place in solvents other than water.

Which is NOT a Brønsted–Lowry reaction?

(A) $NH_4^+ + NH_2^- \rightleftharpoons 2NH_3$

(B) $CO_2 + OH^- \rightleftharpoons HCO_3^-$

(C) $HClO_4 + CH_3COOH \rightleftharpoons CH_3COOH_2^+ + ClO_4^-$

(D) $CH_3CH_2O^- + CH_3NH_3^+ \rightleftharpoons CH_3CH_2OH + CH_3NH_2$

10. When hot acidic potassium permanganate is used to oxidise an alkene, a colour change occurs.

What colour change would be observed?

(A) Colourless to purple

(B) Orange to brown

(C) Brown to colourless

(D) Purple to colourless

11. The brown gas nitrogen dioxide (NO_2) generally exists in equilibrium with the colourless gas dinitrogen tetroxide (N_2O_4).

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

Which of the following changes would cause an increase in the equilibrium concentration of $N_2O_4(g)$?

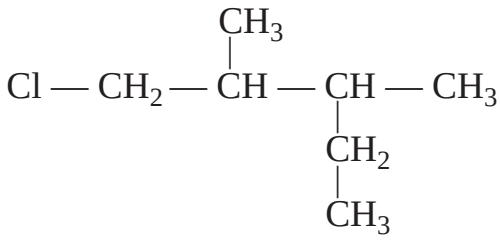
(A) Adding nitrogen (N_2) gas.

(B) Introducing a catalyst.

(C) Decreasing the temperature in the container.

(D) Increasing the volume of the container.

12. What is the IUPAC systematic name for the compound whose structure is given below?



(A) 1-chloro-2,3-dimethylbutane

(B) 1-chloro-2-methyl-3-ethylbutane

(C) 1-chloro-2-ethyl-3-methylpentane

(D) 1-chloro-2,3-dimethylpentane

13. The function of a buffer in a natural system such as blood is to resist changes in

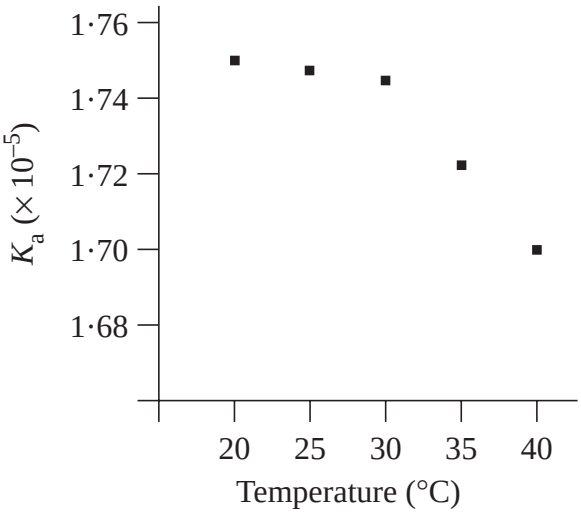
(A) salt concentration.

(B) reaction rate.

(C) temperature.

(D) pH.

14. The K_a of ethanoic acid changes with temperature as shown in the graph below.



Chemistry for Senior Students, Wiecek, C, Brooks Waterloo, 1989, p 385.
Reproduced with permission of Jacaranda Wiley Australia Ltd.

The graph indicates that within the temperature range shown, as the temperature increases the acid becomes

(A) more ionised.

(B) less ionised.

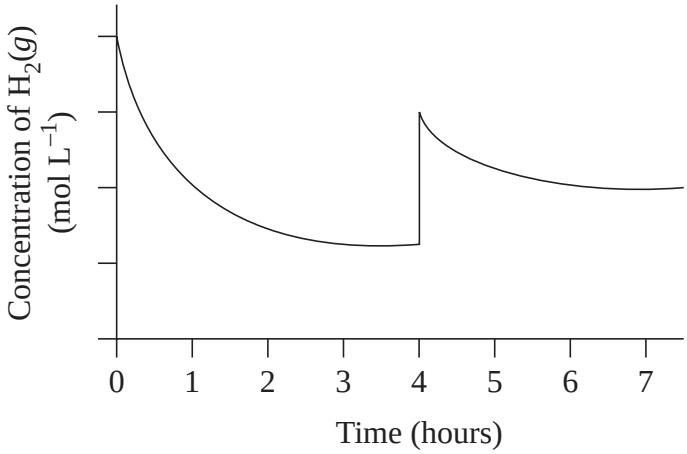
(C) more concentrated.

(D) less concentrated.

15. The reaction between phosphorus (P_4) and hydrogen (H_2) can result in the formation of phosphine (PH_3) as shown:

$$P_4(s) + 6H_2(g) \rightleftharpoons 4PH_3(g)$$

The graph shows the change in concentration of hydrogen for this reaction in which the system was disturbed after four hours.



Conquering chemistry, Smith, R. 2nd ed. McGraw Hill Book Company, Sydney, 1994, p 308. Reproduced with permission.

Which of the following could explain the change in hydrogen concentration at time = 4 hours?

(A) The volume of the reaction vessel was decreased.

(B) A catalyst was added.

(C) The pressure on the reaction mixture was decreased.

(D) More phosphorus was added.

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. Chlorine forms compounds with sodium and phosphorus.

Compound	*Melting point* (°C)	*Boiling point* (°C)
sodium chloride	801	1465
phosphorus (III) chloride	–94	76

(a) Explain the difference in melting points in terms of

(i) bonding.

(ii) structure.

(b) Explain why chlorine gas has a lower melting point than phosphorus (III) chloride.

17. 0·300 g of solid NaOH was added to 1·00 L of $5{\cdot}00\times 10^{-3}$ mol L^{-1} HNO_3.

(a) Which reactant was in excess? Explain your answer.

(b) Assuming no volume change, what is the pH of the final solution?

18. The electron configurations for the elements *p*, *q*, *r*, *s*, *t* are given:

p $1s^2\ 2s^2\ 2p^5$

q $1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^1$

r $1s^2\ 2s^2\ 2p^4$

s $1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6$

t $1s^2\ 2s^2\ 2p^6\ 3s^2$

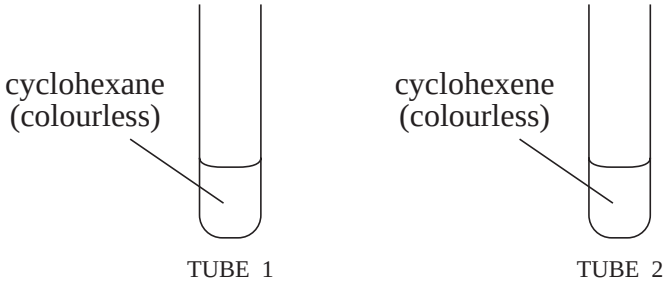
From the above elements:

(a) identify a noble gas;

(b) identify one that has metallic bonding;

(c) give the empirical formula of the compound formed between *p* and *t*.

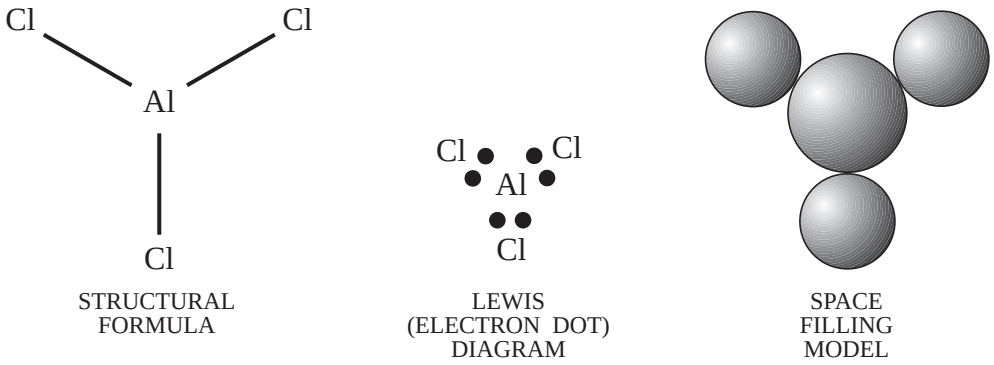
19. Cyclohexane and cyclohexene are two common hydrocarbons. They can be distinguished in the laboratory using bromine water $Br_2(aq)$. The diagrams below show the appearance of two test tubes containing these hydrocarbons before bromine water was added.



(a) Draw the structural formula of cyclohexene.

(b) On the diagrams in the Answer Booklet, show the appearance of the test tubes after the bromine water has been added, shaken and the layers allowed to settle. Clearly label the name and colour of each liquid.

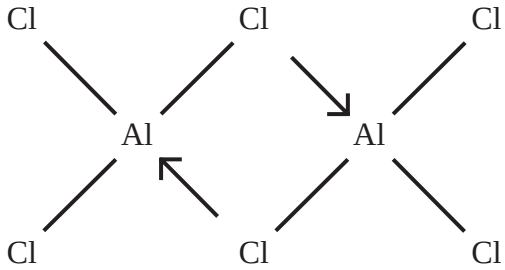
20. Aluminium chloride is a trigonal planar molecule. In this molecule, aluminium does not obey the octet rule. Here are several representations of the molecule.



(a) Is the aluminium–chlorine bond polar or non-polar? Explain your answer.

(b) Is the aluminium chloride molecule polar or non-polar? Explain your answer.

(c) As a gas, aluminium chloride achieves an octet by forming the dimer, Al_2Cl_6.



What type of bond, as shown by the arrows, is formed in this process?

21. The hydrogen ion concentrations of 1·00 mol L^{-1} ethanoic acid and chloroethanoic acid at 25°C are given in the table.

Acid	*Formula*	$[H^+]$ (mol L^{-1})
ethanoic acid	CH_3COOH	$4{\cdot}18 \times 10^{-3}$
chloroethanoic acid	$ClCH_2COOH$	$3{\cdot}74 \times 10^{-2}$

(a) What is the pH of 1·00 mol L^{-1} chloroethanoic acid?

(b) What is the K_a of chloroethanoic acid?

(c) Compare the strength of ethanoic acid with that of chloroethanoic acid and explain your answer in terms of K_a.

22. A student prepared a saturated solution of calcium hydroxide by dissolving excess solid in water.

(a) The student claimed: 'In this saturated solution, the amount of solid dissolved does not change but ionic bonds continue to be broken'.

Is this student correct? Explain your answer.

(b) Calcium hydroxide is an ionic compound. Write an equation for the equilibrium that exists between solid calcium hydroxide and its ions in solution.

(c) What would be the effect of adding a concentrated sodium hydroxide solution to the equilibrium in part (b)?

23. Initially, a mixture has 0·400 mol each of CO_2 and H_2 in a 1·00 L vessel kept at 980°C.

The reaction is $CO_2(g) + H_2(g) \rightleftharpoons CO(g) + H_2O(g)$

and at this temperature the equilibrium concentration of CO is 0·225 mol L^{-1}.

(a) What is the equilibrium concentration of H_2?

(b) Write the equilibrium constant expression for this reaction.

(c) Calculate the equilibrium constant at 980°C.

24. An alkene of molar mass 56 g mol^{-1} reacts with hydrogen iodide.

Give:

(a) the systematic name of an alkene with this molar mass;

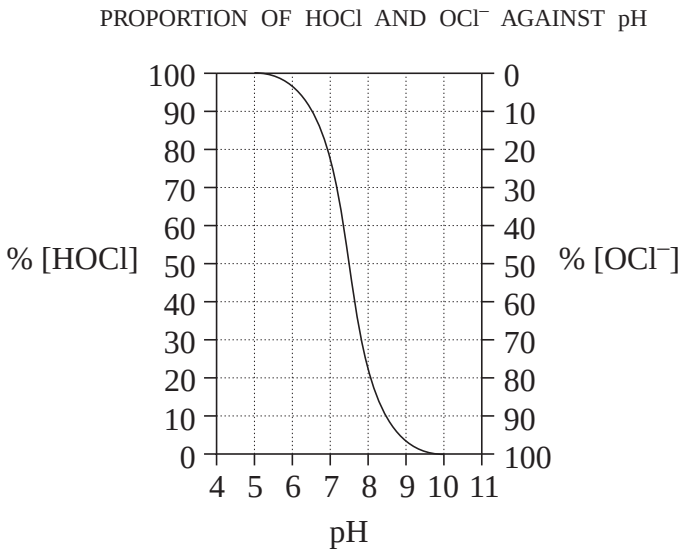
(b) the structural formula of the product formed by the reaction of the alkene in part (a) with hydrogen iodide;

(c) the structural formula for an isomer of the alkene named in part (a).

25. Hypochlorous acid (HOCl) is often used in swimming pools as a means of killing bacteria. The HOCl dissociates as shown:

$$HOCl \rightleftharpoons H^+ + OCl^-$$

The curve below shows the distribution of [HOCl] and [OCl^-] in water at 25°C.



(a) What is the effect on pH when OCl^- ions are added to the water?

(b) At pH = 8·5, what is the ratio of [OCl^-] : [HOCl]?

(c) Using your answer in part (b), calculate K_a for hypochlorous acid.

PART C

Attempt ALL questions.

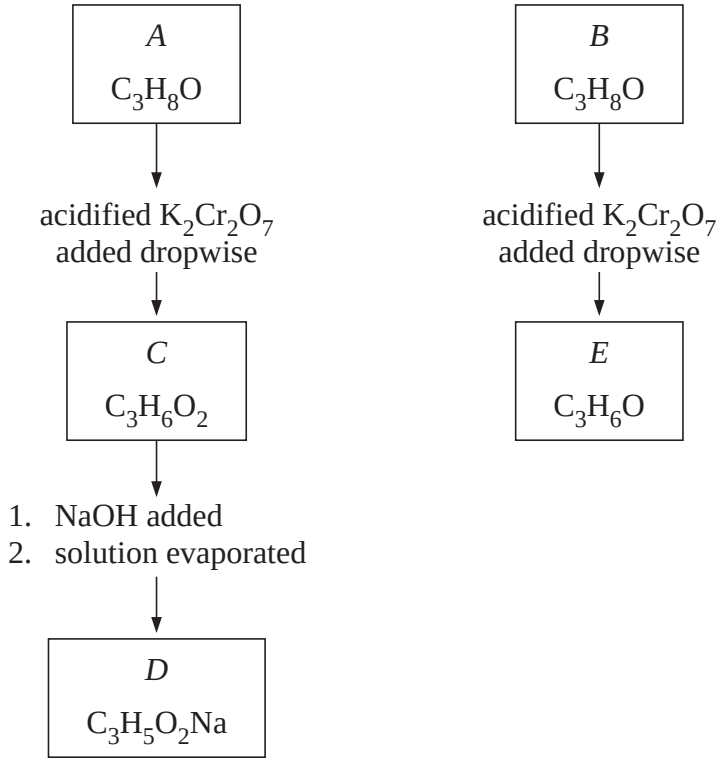
Each question is worth 5 marks.

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. Two different compounds *A* and *B* are isomers with the molecular formula C_3H_8O.

A and *B* undergo a series of reactions as shown below.



(a) Give the structural formula for:

(i) *C*

(ii) *E*

(b) How is compound *A* different from compound *B*?

(c) Describe the colour change seen in going from *A* to *C*.

(d) Give the structural formula for the compound produced if *B* and *C* react in the presence of a small amount of concentrated sulfuric acid.

27. During your study of structure and bonding you will have compared the physical and chemical properties of chlorides or oxides across the third period of the periodic table.

(a) Name ONE ionic compound you studied. For this compound, describe:

(i) one of its physical properties;

(ii) one of its chemical properties.

(b) Explain the difference in the electrical conductivity of solid and molten magnesium chloride or magnesium oxide.

(c) Draw electron dot formulae for:

(i) an ionic compound

(ii) a covalent compound

that you studied when comparing chlorides or oxides of the third period.

28. Methane and hydrogen sulfide were reacted together in a 2·00 L vessel at a constant high temperature. The following reaction occurred:

$$CH_4(g) + 2H_2S(g) \rightleftharpoons CS_2(g) + 4H_2(g)$$

At equilibrium, the following concentrations were determined:

$[CH_4] = 1{\cdot}242 \text{ mol } L^{-1}$ $\quad$ $[H_2S] = 1{\cdot}543 \text{ mol } L^{-1}$

$[CS_2] = 0{\cdot}016 \text{ mol } L^{-1}$ $\quad$ $[H_2] = 0{\cdot}064 \text{ mol } L^{-1}$

(a) Write down the equilibrium constant expression for this reaction.

(b) Calculate the equilibrium constant for the reaction under these conditions.

(c) Explain why all reactions appear to have stopped at equilibrium.

(d) More methane is added to the equilibrium reaction without changing the temperature or volume of the system. Equilibrium is re-established. What effect does this addition have on the value of the equilibrium constant?

(e) The reaction takes place in the presence of a catalyst. What is the function of the catalyst?

29. Phosphoric acid is a polyprotic acid. It dissociates in water in three steps.

Step 1 $H_3PO_4 + H_2O \rightleftharpoons H_3O^+ + H_2PO_4^-$ K_{a1}

Step 2 $H_2PO_4^- + H_2O \rightleftharpoons H_3O^+ + HPO_4^{2-}$ K_{a2}

Step 3 $HPO_4^{2-} + H_2O \rightleftharpoons H_3O^+ + PO_4^{3-}$ K_{a3}

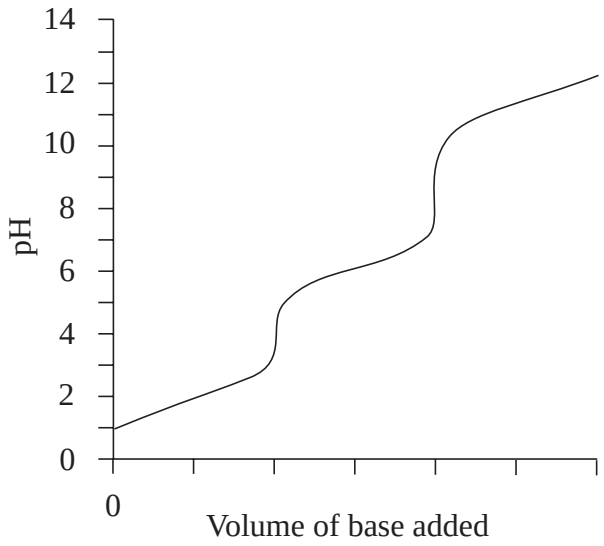
(a) Which species is the conjugate acid of $H_2PO_4^-$?

(b) Which step would have the highest K_a value? Explain your answer.

(c) The following table shows the colours and pH ranges of various indicators.

Indicator	*Colour low pH*	*Colour high pH*	*pH range for colour change*
Methyl red	pink	yellow	4·4–6·2
Bromothymol blue	yellow	blue	6·0–7·6
Phenolphthalein	colourless	magenta	8·3–10·0

The titration curve below was obtained when H_3PO_4 was titrated with a strong base.



Which indicator would be best to detect the end point for Step 2 in the dissociation of phosphoric acid?

(d) Steps 1–3 above involve several amphiprotic species. Name a different amphiprotic species. Give equations to show its amphiprotic behaviour.

30. An alkane has the molecular formula C_6H_{14}.

(a) Draw the structure of a branched alkane that has this molecular formula.

(b) Give the systematic name of the alkane in part (a).

(c) Give the equation for the complete combustion of this alkane.

(d) Draw the structure of an organic product of the reaction between the alkane in part (a) and bromine in the presence of UV light.

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

31. The acidity of wine is due mainly to potassium tartrate (cream of tartar), a weak monoprotic acid of molar mass 188 g mol^{-1}. Three 50 mL samples of wine were titrated with 0·010 M NaOH. The results of these titrations were as follows.

	First titration	*Second titration*	*Third titration*
Final reading	9·8 mL NaOH	10·1 mL	10·2 mL
Initial reading	0·0 mL NaOH	0·0 mL	0·1 mL
Volume used	9·8 mL NaOH	10·1 mL	10·1 mL

(a) With what would you rinse your pipette before beginning the experiment?

(b) Calculate the moles of NaOH used in this titration.

(c) What is the molar concentration of potassium tartrate in this wine?

(d) What is the concentration of potassium tartrate in g L^{-1}?

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.

Pages

QUESTION 32. Chemical Energy 18–20

QUESTION 33. Oxidation and Reduction 21–23

QUESTION 34. Biological Chemistry 24–26

QUESTION 35. Chemistry and the Environment 27–29

QUESTION 32. Chemical Energy **Marks**

(a) Define the term *fuel*. **1**

(b) Ethyne lamps were once used by cavers. The lamps worked by dripping water onto a supply of calcium carbide (CaC_2), thereby generating a constant supply of ethyne gas. Light was obtained by igniting the ethyne gas. **7**

(i) Ethyne has a low *flashpoint*. What is meant by this term?

(ii) The combustion in an ethyne lamp is incomplete. Suggest ONE advantage and ONE disadvantage of this partial combustion.

(iii) Give an industrial use for ethyne.

(iv) Use the following data to calculate the standard heat of formation of ethyne gas.

$$\Delta H_c^\circ\ C_2H_2(g) = -1301\ \text{kJ mol}^{-1}$$

$$\Delta H_f^\circ\ CO_2(g) = -394\ \text{kJ mol}^{-1}$$

$$\Delta H_f^\circ\ H_2O(l) = -286\ \text{kJ mol}^{-1}$$

(c) A major component of natural gas used in the home and in industry is methane. **5**

(i) Using appropriate bond energies from the table given below, calculate ΔH° for

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

Bond energies (kJ mol^{-1})			
C—H	414	O—O	144
C—C	346	O═O	498
C—O	358	O—H	463
C═O	804		

(ii) Given that ΔH_v° for water is 44 kJ mol^{-1}, calculate the heat of combustion of methane using the above data.

Question 32 continues on page 19

QUESTION 32. (Continued) **Marks**

(d) Propane, C_3H_8, is a gas used as a fuel when camping. The equation for the combustion of propane is given below: **8**

$$C_3H_8(g) + 5O_2(g) \rightarrow 3CO_2(g) + 4H_2O(l) \qquad \Delta H° = -2220 \text{ kJ mol}^{-1}$$

A camper boils 1 litre of water from 20°C. This uses 350 kJ of heat.

(i) What mass of propane must the camper carry to enable him to do this?

(ii) What volume would this gas occupy at 101·3 kPa and 20°C?

(iii) Give ONE safety feature of a container that could be used by the camper to carry propane.

(iv) The propane gas used by the camper is synthesised from carbon and hydrogen:

$$3C(s) + 4H_2(g) \rightarrow C_3H_8(g)$$

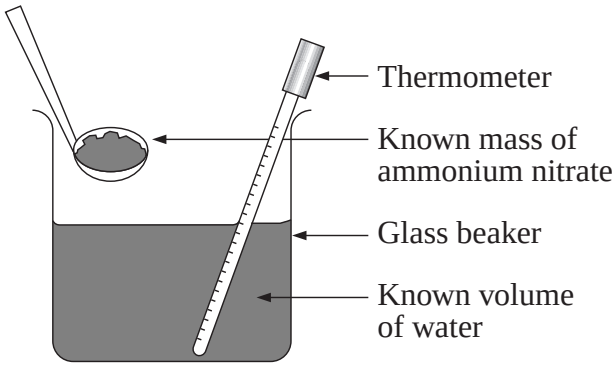
Using the equations above and the following two equations, calculate the enthalpy of the reaction to synthesise propane.

$$C(s) + O_2(g) \rightarrow CO_2(g) \qquad \Delta H° = -394 \text{ kJ mol}^{-1}$$

$$H_2(g) + \tfrac{1}{2}O_2(g) \rightarrow H_2O(l) \qquad \Delta H° = -285 \text{ kJ mol}^{-1}$$

(v) Is the synthesis of propane exothermic or endothermic? Explain your answer.

(e) Using the equipment below, students measured the enthalpy change when ammonium nitrate was dissolved in water. The reaction is endothermic. **2**



Their result did not agree with the standard enthalpy value.

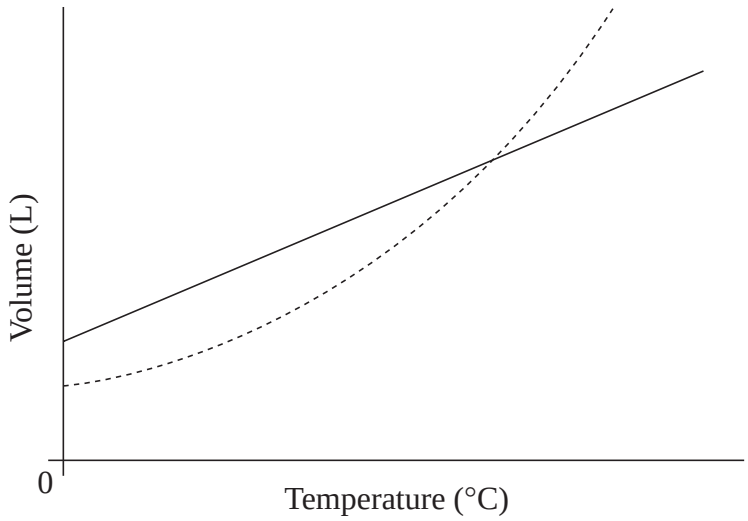
(i) Would their result be lower or higher than the standard value? Explain your answer.

(ii) Give ONE modification that would improve their result.

Question 32 continues on page 20

QUESTION 32. (Continued) **Marks**

(f) **2**



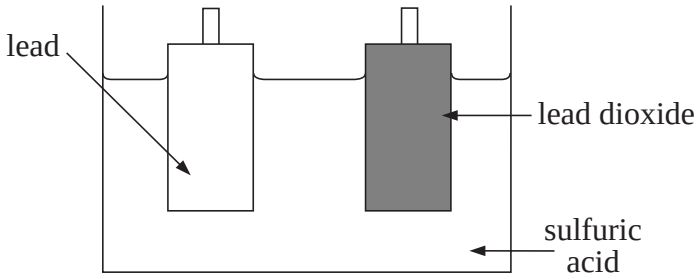
(i) The straight line represents the relationship between the volume and temperature of an ideal gas at constant pressure.

At what temperature would the gas volume theoretically be zero?

(ii) The curved line represents the relationship between volume and temperature of a non-ideal gas at constant pressure. Give ONE explanation for the difference in behaviour between ideal and non-ideal gases.

QUESTION 33. Oxidation and Reduction **Marks**

(a) The lead–acid battery is used in cars as a rechargeable source of electric power. A lead–acid battery usually consists of six cells each consisting of Pb and PbO_2 plates. One cell is shown below. **4**



During discharge, the overall cell reaction is

$$Pb(s) + PbO_2(s) + 4H^+(aq) + 2SO_4^{2-}(aq) \rightarrow 2PbSO_4(s) + 2H_2O(l).$$

(i) Why are separate electrode compartments unnecessary?

(ii) What is the purpose of multiple cells in the battery?

(iii) Which electrode is the cathode? Explain your answer.

(iv) Explain how acid concentration can be used as a measure of the state of the charge of the cell.

Question 33 continues on page 22

QUESTION 33. (Continued) **Marks**

(b) The iron content of steel can be determined by dissolving the steel in acid and titrating with acidic potassium dichromate ($K_2Cr_2O_7$). **8**

1·00 g steel was dissolved in acid to give a solution of Fe^{2+} and the solution made up to 250 mL with water. Duplicate 25·0 mL samples were titrated with standard potassium dichromate solution (0·0100 mol L^{-1}). The average titration volume was 28·4 mL.

(i) Identify the oxidant in the titration reaction.

(ii) Write the balanced half-equation for $Fe^{2+} \rightarrow Fe^{3+}$.

(iii) Write the balanced half-equation for $Cr_2O_7^{2-} \rightarrow Cr^{3+}$.

(iv) Write the overall redox equation for this reaction.

(v) Calculate the number of moles of potassium dichromate in the average titration.

(vi) Calculate the number of moles of Fe^{2+} present in the 250 mL sample.

(vii) Calculate the percentage (g/100 g) of iron in the steel.

(c) In your study of the Oxidation and Reduction elective, you will have carried out a simple electroplating experiment. **4**

(i) Draw a diagram of the experimental setup you used. Label the:

1. object being plated;

2. cathode in the electrolytic cell;

3. direction of electron flow.

(ii) Name the solution used.

(d) To preserve biological tissues, chemists use a solution of methanal gas in water. Methanal (CH_2O) is readily oxidised by acidic $KMnO_4$. **2**

(i) What is the oxidation number of carbon in methanal?

(ii) Write a balanced half-equation for the oxidation of methanal.

Question 33 continues on page 23

QUESTION 33. (Continued) **Marks**

(e) When chlorine is bubbled through a solution of sodium iodide, a dark brown colour appears in the solution. **4**

(i) What species has the dark brown colour?

(ii) The brown colour also appears under certain conditions when oxygen is bubbled through a solution of sodium iodide. Use the table of standard potentials to determine whether the reaction is spontaneous under acidic or basic conditions. Show your working.

(f) Corrosion is responsible for the annual loss of billions of dollars in metal products. The most common kind of corrosion is the redox process in which metals are oxidised by oxygen in the presence of moisture. **3**

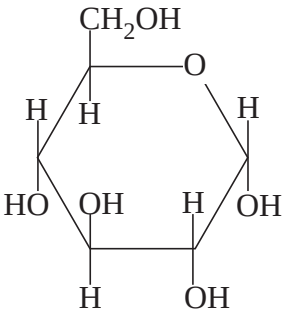
(i) The steel hull of a ship may be protected by having blocks of titanium attached to it. Use the standard potentials to explain this protection.

$$Ti^{2+} + 2e^- \rightarrow Ti(s) \qquad E^\circ = -1{\cdot}60\ V$$

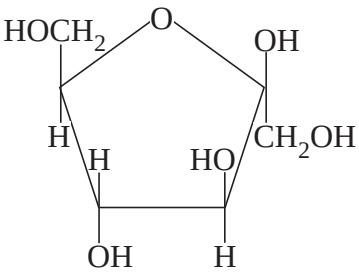
(ii) Give another method for protecting a metal from corrosion.

QUESTION 34. Biological Chemistry **Marks**

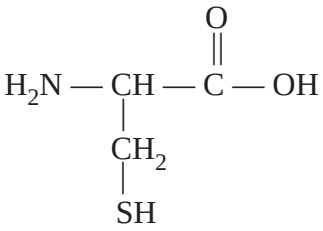
(a) The diagrams below represent six biomolecules. **10**



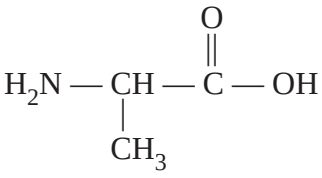
(I)



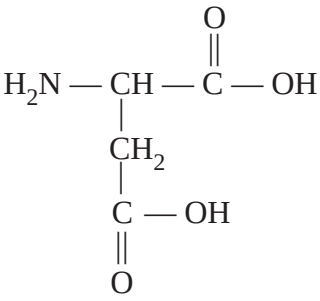
(II)



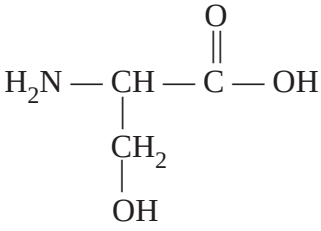
(III)



(IV)



(V)



(VI)

(i) To provide an instant source of energy, athletes use drinks containing monosaccharides. Monosaccharides can be metabolised rapidly. From the above diagrams, give the number and corresponding name of a compound that could be used for such a drink.

(ii) Draw the structure of the disaccharide maltose.

(iii) What is meant by the term *reducing sugar*?

(iv) Give the structure of a disaccharide that is not a reducing sugar.

(v) What is meant by the term *dipeptide*?

(vi) Draw the structure of a dipeptide made from any of the compounds in the above diagrams.

(vii) Describe a chemical test that would discriminate between a monosaccharide and a dipeptide.

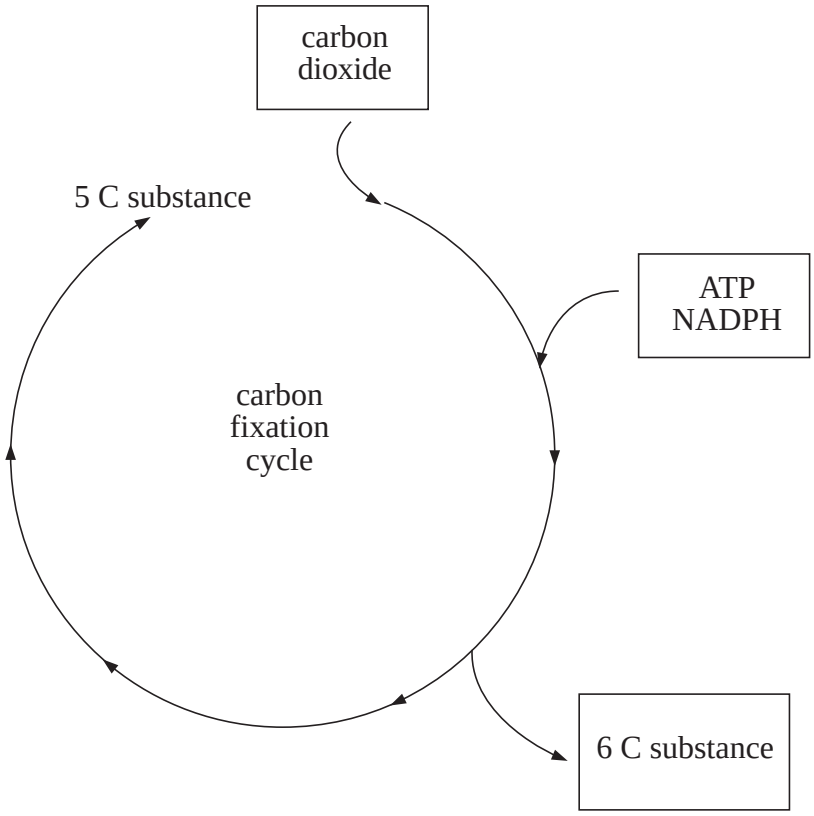
(viii) What is meant by the tertiary structure of a protein?

(ix) Give the number of the compound in the above diagrams that is most important in maintaining the tertiary structure of a protein.

Question 34 continues on page 25

QUESTION 34. (Continued) **Marks**

(b) Carbon fixation occurs in the process of photosynthesis. A simple diagram of this process is shown below. **2**



(i) What is meant by *carbon fixation*?

(ii) Is photosynthesis an exothermic or endothermic reaction? Explain your answer.

(c) (i) Wheat flour contains starch and protein. Describe characteristic tests to identify: **4**

1. protein;

2. starch.

(ii) Give ONE similarity and ONE difference between the polysaccharides starch and cellulose.

Question 34 continues on page 26

QUESTION 34. (Continued) **Marks**

(d) (i) Explain why the enzyme maltase will catalyse the hydrolysis of maltose but not the hydrolysis of sucrose. **3**

(ii) What would be the effect on the rate of an enzyme reaction if some ethanol were split accidentally into the reaction? Give reasons for your answer.

(iii) What would be the effect of raising the temperature on the rate of an enzyme reaction?

(e) (i) What is meant by the term *glycolysis*? **6**

(ii) What is the role of the Krebs' cycle in carbohydrate metabolism?

(iii) When yeast grows anaerobically, it obtains energy by converting glucose to ethanol. This process is called fermentation. How does fermentation differ from glycolysis?

(iv) Most beers contain about 4 per cent (4 g/100 mL) ethanol. How many grams of glucose must be fermented to fill a 375 mL bottle with beer containing 4 per cent ethanol?

QUESTION 35. Chemistry and the Environment **Marks**

(a) The oxygen cycle describes the way in which oxygen is in equilibrium in the atmosphere. Oxygen is consumed and produced as part of this cycle. **4**

(i) One method of oxygen consumption in the lower atmosphere is through the oxidative weathering of minerals such as FeO to Fe_2O_3.

1. Write an equation for the oxidation of FeO to Fe_2O_3.

2. What mass of oxygen is removed from the atmosphere by the weathering of 2000 tonnes of FeO?

(ii) Give an example of another process in which oxygen is removed from the lower atmosphere (troposphere). Write an equation for this process.

(iii) A sample of air is taken at altitudes of 10 km and 90 km. Give ONE difference in the composition of these samples.

(b) One of the problems associated with burning fossil fuels such as coal is that impurities, such as sulfur, are themselves pollutants. **4**

(i) When sulfur is burnt, SO_2 is emitted into the atmosphere. How does it act as a pollutant?

(ii) An instrumental method based on fluorescence may be used to measure SO_2 concentration in the air. Monitoring at a city site using this method led to a result of $6{\cdot}50 \times 10^{-9}$ mol L^{-1} being obtained. If levels of SO_2 greater than $0{\cdot}115$ mg L^{-1} (ppm) are hazardous, is this result cause for concern? Support your answer with calculations.

(iii) Another source of SO_2 in the atmosphere is the decay of organic matter producing H_2S. This is then converted to SO_2 by reaction with oxygen.

How is the presence of H_2S detected?

(c) Many nuclear reactors use U-235 as a fuel source. Uranium has a half-life of approximately 7×10^8 years. **4**

(i) From what natural source is U-235 obtained?

(ii) What is meant by the term *half-life*? Use U-235 as an example.

(iii) Name ONE advantage of using nuclear power.

(iv) What is ONE method used for the disposal of nuclear wastes from a nuclear reactor?

Question 35 continues on page 28

QUESTION 35. (Continued) **Marks**

(d) Nitrogen dioxide (NO_2) usually reacts in the upper atmosphere with gaseous chlorine atoms ($Cl^{\bullet}$) to produce nitrogen monoxide (NO) and chlorine nitrate ($ClONO_2$). This can be simplified to **5**

$$2NO_2(g) + Cl^{\bullet}(g) \rightleftharpoons NO(g) + ClONO_2(g)$$

During the extreme cold of the Antarctic winter, $NO_2(g)$ is removed from the atmosphere by the formation of polar stratospheric clouds (mainly crystalline nitric acid).

(i) What would happen to the concentration of gaseous chlorine atoms in the atmosphere over Antarctica during winter? Explain in terms of equilibrium.

(ii) Once spring arrives, the ozone layer in the upper atmosphere becomes severely depleted.

1. What causes the depletion of ozone at the beginning of spring?

2. Why is the depletion of the ozone layer a concern?

(iii) In the lower atmosphere, nitrogen dioxide contributes to the production of photochemical smog.

1. Name one major source of $NO_2(g)$ in the lower atmosphere.

2. Briefly describe some of the effects of photochemical smog on humans.

Question 35 continues on page 29

QUESTION 35. (Continued) **Marks**

(e) Students monitoring water quality took a 1·00 L sample from a river. The site was in natural bushland. The students tested the sample for: **8**

- hardness
- biological oxygen demand
- phosphates
- halides.

(i) The students determined the hardness by calculating the concentration of Ca^{2+} present in the sample. 25·0 mL aliquots of the sample required an average of 6·00 mL of 0·015 mol L^{-1} sodium carbonate solution to convert all the Ca^{2+} present to calcium carbonate. Calculate:

1. the number of moles of calcium carbonate formed in each 25 mL water sample;

2. the concentration of calcium ions in the water sample in mol L^{-1};

3. the concentration of calcium ions in the water sample in ppm (mg L^{-1}).

(ii) A biological oxygen demand (BOD) of less than 5 mg L^{-1} is expected in unpolluted natural waters. The students' results gave a BOD of 9 mg L^{-1}.

1. Suggest a possible cause for the increased BOD.

2. Why is increased BOD a concern?

(iii) Describe a test for a halide that the students could have carried out on this water sample.

(iv) The phosphate level was found to be 0·2 mg L^{-1}. This value is higher than is acceptable. Why is excess phosphate concentration a concern?

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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
$\frac{1}{2}Cl_2(aq) + e^-$	$\rightleftharpoons$	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* (3rd 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 — Au — Name of element — 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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