BOARD OF STUDIES

NEW SOUTH WALES

HIGHER SCHOOL CERTIFICATE EXAMINATION

1997
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.
  Mark your answers 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 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 Booklet.
- 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)

PART A

Attempt ALL questions.
Each question is worth 1 mark.
Select the alternative A, B, C, or D that best answers the question.
Mark your answers in pencil on the Answer Sheet provided.

1 . The IUPAC systematic name for the compound whose structure is given below is

$$\begin{array}{ccccccccc} & & & & & & \mathrm{Cl} & & \\ & & & & & & | & & \\ \mathrm{CH_3} & - & \mathrm{CH} & - & \mathrm{CH_2} & - & \mathrm{C} & - & \mathrm{CH_3} \\ & & | & & & & | & & \\ & & \mathrm{Br} & & & & \mathrm{CH_2} & - & \mathrm{CHO} \end{array}$$

(A) 2-bromo-4-chloro-hexanal.
(B) 3-chloro-3-methyl-5-bromohexanal.
(C) 5-bromo-3-chloro-3-methylhexanal.
(D) 2-bromo-4-chloro-4-methylhexanal.

2 . For the equilibrium:

$$2\mathrm{ICl}(g) \rightleftharpoons \mathrm{I_2}(g) + \mathrm{Cl_2}(g)$$

the numerical value of the equilibrium constant K is $4 \cdot 8 \times 10^{-6}$ at 25°C.

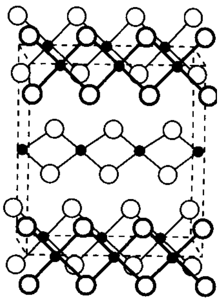
Which of the following statements is true?

At 25°C at equilibrium

(A) there will be much less I_2 and Cl_2 than ICl.
(B) there will be twice as much ICl as I_2 present.
(C) the pressures of I_2, Cl_2, and ICl will all be the same.
(D) there will be much more I_2 and Cl_2 than ICl.

3 . Which of the following diagrams of crystal forms best represents the structure of solid carbon dioxide (dry ice)?

(A)



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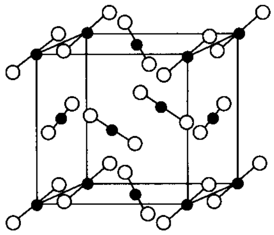

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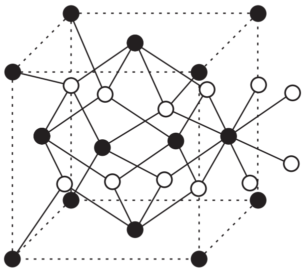
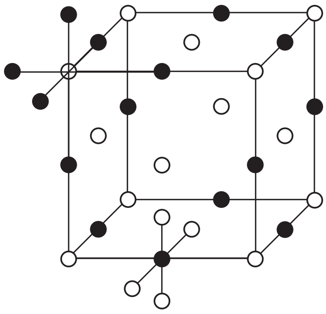


(D)



4 . Which of the following solutions would have the highest pH?

(A) $0{\cdot}10\ \text{mol L}^{-1}\ HNO_3$

(B) $0{\cdot}10\ \text{mol L}^{-1}\ H_2SO_4$

(C) $0{\cdot}10\ \text{mol L}^{-1}$ HCOOH

(D) $0{\cdot}10\ \text{mol L}^{-1}$ NaCl

5 . Consider the reaction:

$$3Fe(s) + 4H_2O(g) \rightleftharpoons 4H_2(g) + Fe_3O_4(s)$$

When the total pressure is increased,

(A) more H_2 is produced.

(B) more H_2O is produced.

(C) no change occurs.

(D) more Fe is produced.

6 . Which of the following is NOT a conjugate acid/base pair?

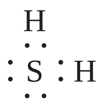
(A) H_3PO_4 / HPO_4^{2-}

(B) H_2SO_4 / HSO_4^{-}

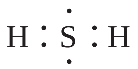
(C) H_2CO_3 / HCO_3^{-}

(D) NH_3 / NH_2^{-}

7 . A correct electron-dot formula for the hydrogen sulfide molecule is

(A) 

(B) 

(C) 

(D) 

8 . The number of moles of oxygen required to burn one mole of ethane completely is

(A) 2·0

(B) 2·5

(C) 3·0

(D) 3·5

9 . Which of the following indicators would best identify the end-point in the titration of 0·10 mol L^{-1} lactic acid $\left(K_a = 1 \cdot 4 \times 10^{-4} \text{ at } 25°C\right)$ with 0·10 mol L^{-1} KOH?

	Indicator	pH *range*
(A)	Methyl orange	3·1–4·4
(B)	Bromophenol blue	3·0–4·6
(C)	Methyl red	4·4–6·2
(D)	Phenol red	7·2–8·8

10. Iron(III) forms a variety of coloured complex ions. One such example is that produced by the reaction with salicylic acid $\left(C_7H_6O_3\right)$:

$$\underset{\text{(pale yellow)}}{Fe^{3+}(aq)} + C_7H_6O_3(s) \rightleftharpoons \underset{\text{(violet)}}{Fe\left(C_7H_5O_3\right)^{2+}(aq)} + H^+(aq)$$

The yield of the violet complex, $Fe\left(C_7H_5O_3\right)^{2+}$, may be decreased by

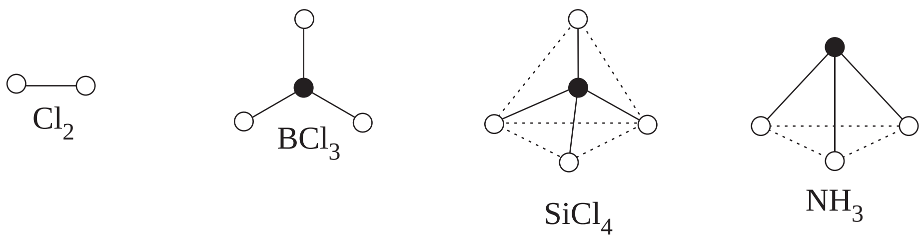
(A) adding $C_7H_6O_3(s)$ to the solution.

(B) adding Fe^{3+} ions to the solution.

(C) lowering the pH of the solution.

(D) raising the pH of the solution.

11. Consider the following four molecules: $\left(Cl_2, BCl_3, SiCl_4, \text{and } NH_3\right)$.



Which ONE of the following statements is true?

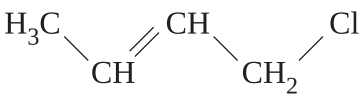
(A) None of the molecules has an overall permanent dipole.

(B) Only one of the molecules has an overall permanent dipole.

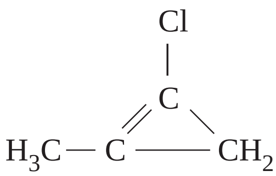
(C) None of the molecules contains dipoles.

(D) Two of the molecules have the same shape.

12. Which of the following formulae represent a pair of isomers?



(I)



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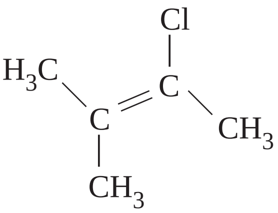
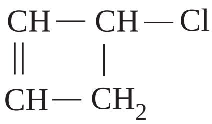


(III)



(IV)

(A) (I) and (II).

(B) (I) and (III).

(C) (I) and (IV).

(D) (II) and (IV).

13. Which of the following is true for a system at equilibrium?

(A) The number of collisions per unit time between reactants is equal to the number of collisions per unit time between products.

(B) The product of the concentrations of the reactants is equal to the product of the concentrations of the products.

(C) Reactants are reacting to form products at the same rate as products are reacting to form reactants.

(D) All concentrations of reactants and products are equal.

14. Equal volumes of four different acids are titrated with the same base at 25°C.

Information about these acids is given below.

Acid	*Concentration* (mol L^{-1})	pH
HCl	0·1	1·0
H_3PO_4	0·1	1·6
CH_3COOH	0·1	2·9
HCN	0·1	5·1

The acid requiring the greatest volume of base for complete reaction is

(A) HCl

(B) H_3PO_4

(C) CH_3COOH

(D) HCN

15. The formula for an ester with a strawberry fragrance is given below.

$$\begin{array}{l} CH_3 - CH_2 - CH_2 - C = O \\ \qquad\qquad\qquad\qquad\quad\;\, | \\ \qquad\qquad\qquad\qquad\quad\;\, O - CH_2 - CH_3 \end{array}$$

The alkanol and alkanoic acid used to make this ester were

(A) propanol and propanoic acid.

(B) ethanol and butanoic acid.

(C) butanol and ethanoic acid.

(D) butanol and butanoic acid.

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. A mixture of hydrogen and iodine gases is allowed to react at a high temperature. When equilibrium is established, the concentrations are found to be

$[H_2] = 0{\cdot}46 \text{ mol L}^{-1}$, $[I_2] = 0{\cdot}39 \text{ mol L}^{-1}$, $[HI] = 2{\cdot}6 \text{ mol L}^{-1}$.

(a) Calculate the value of the equilibrium constant from these data. Show all working.

(b) What does the equilibrium constant for this reaction indicate about the position of equilibrium? Explain your answer.

17. 24·0 mL of 0·150 mol L^{-1} NaOH is added to 25·0 mL of 0·150 mol L^{-1} HCl.

(a) Is the final solution acidic, basic, or neutral?

(b) Calculate the pH of the final solution.

18. Consider the boiling points of the three compounds ethane, ethanol, and 1,2-ethanediol.

Compound	*Boiling point* (°C)
Ethane	–88·6
Ethanol	78·3
1,2-ethanediol	198

(a) Explain why there are such large differences between the boiling points of these compounds.

(b) Name ONE industrial or domestic application for 1,2-ethanediol. Explain why its properties make it suitable for this use.

19. Two hydrocarbons can react with hydrogen chloride gas to form 2-chloro-2-methylbutane.

(a) Give the structural formulae of the two hydrocarbons.

(b) Give ONE safety precaution that should be observed when using 2-chloro-2-methylbutane.

20. Some commercial baking powders use sodium pyrophosphate $(Na_2H_2P_2O_7)$ and sodium bicarbonate $(NaHCO_3)$ to make cakes rise when cooked.

The reaction that occurs can be described by the following equation (states excluded):

$$NaHCO_3 + Na_2H_2P_2O_7 \rightarrow Na_3HP_2O_7 + H_2O + CO_2$$

(a) Write the net ionic equation for this reaction, including states.

(b) From this ionic equation, write the formula for a species behaving as a Brønsted–Lowry acid.

(c) Why does the cake rise when this reaction occurs?

21. The reaction below may be used for the industrial production of hydrogen from natural gas:

$$CH_4(g) + H_2O(g) \rightleftharpoons CO(g) + 3H_2(g)$$

(a) How is the equilibrium amount of carbon monoxide affected by decreasing the volume of the system? Explain.

(b) How is the equilibrium amount of methane affected by adding hydrogen to the system? Explain.

(c) How is the equilibrium amount of carbon monoxide affected by adding a suitable catalyst to the reaction? Explain.

22. Elements in Group I of the Periodic Table have a major similarity in their electron configuration.

(a) State this similarity.

(b) Name an element in Group I, and give its ground-state electron configuration, including subshells.

(c) Explain how the electron configurations of the Group I elements determine their chemical reactivity.

23. An excess of methanol was reacted with 2-methylpentanoic acid using a few drops of sulfuric acid as a catalyst.

(a) Write a balanced equation for this reaction using structural formulae.

(b) Give the systematic name of the organic product.

(c) How could the excess methanol be removed from the product without distillation?

24. A mixture of $N_2O(g)$, $O_2(g)$, and $NO_2(g)$ was prepared in a 5·00 L container.

The mixture originally contained 0·536 mol N_2O and was allowed to come to equilibrium according to the following equation:

$$2N_2O(g) + 3O_2(g) \rightleftharpoons 4NO_2(g) \quad \Delta H^\circ = -32\text{kJ}$$

To reach equilibrium, 0·231 mol N_2O reacts with oxygen.

(a) What is the equilibrium concentration of N_2O?

(b) The original concentration of O_2 is not given but what was the *change* in O_2 concentration?

(c) Explain the effect of a small increase in temperature on the number of moles of NO_2 at equilibrium.

25. 2-pentene reacts with bromine.

(a) Write a balanced equation for this reaction using structural formulae.

(b) 2 moles of liquid 2-pentene are mixed with one mole of liquid bromine. At the conclusion of the reaction the two compounds remaining are liquids.

(i) Name these compounds.

(ii) Draw the apparatus used to separate these liquids.

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 chemist is required to make up accurately 500 mL of a 0·0500 mol L^{-1} standard solution from anhydrous sodium carbonate.

(a) What mass of anhydrous sodium carbonate is required?

(b) Describe the steps necessary to make up this standard solution.

(c) What volume of 0·0890 mol L^{-1} HCl would be required to react completely with 25·0 mL of the standard sodium carbonate solution?

27. Salt and sand are two substances common in our everyday world. The main chemical substance present in each of these is given below.

Salt — sodium chloride $(NaCl)$

Sand — silicon dioxide (SiO_2)

(a) Explain, in terms of the structure of these substances, why

(i) a solution of salt in water will conduct electricity;

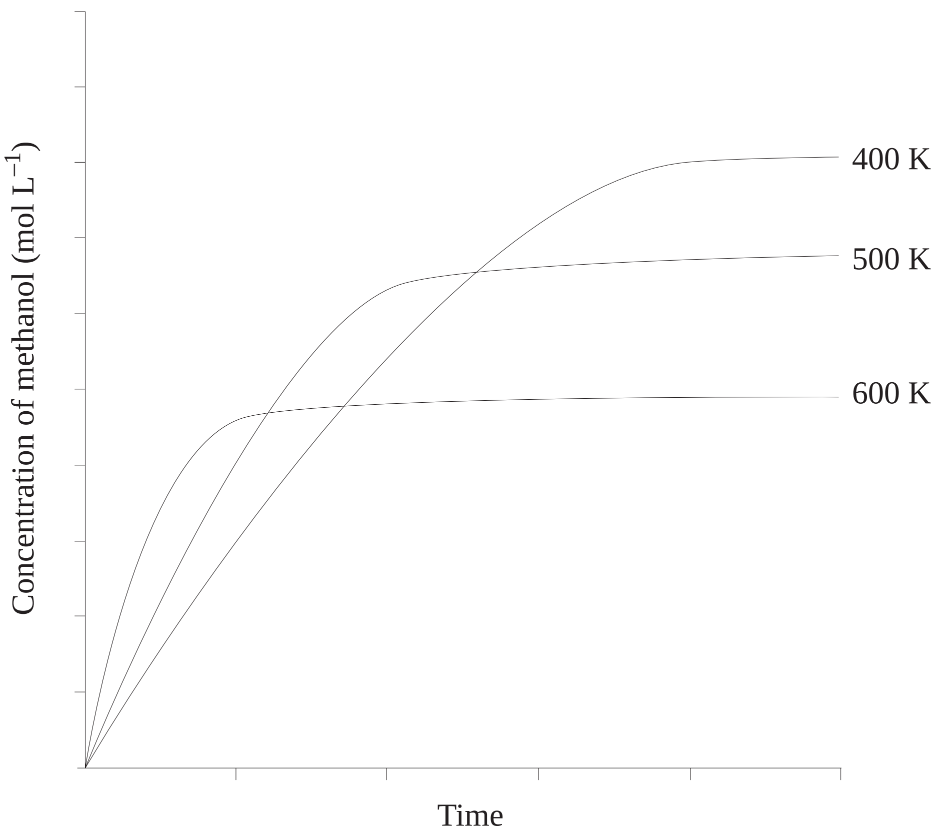
(ii) sand does not dissolve in the earth's oceans.

(b) Which compound, sodium chloride or silicon dioxide, will have the higher melting point? Give reasons.

28. Methanol can be prepared industrially according to the following equation:

$$CO(g) + 2H_2(g) \rightleftharpoons CH_3OH(g)$$

The graph below represents the formation of methanol at various temperatures in the absence of a catalyst.



(a) Explain why the curves:

(i) are initially steep;

(ii) level off with time.

(b) Is the formation of methanol endothermic or exothermic? Explain.

(c) In the space provided in your Answer Book, sketch the graph for the formation of methanol at 400 K in the presence of a catalyst.

(d) At 500 K the numerical value of the equilibrium constant for the reaction is 14·5. How would the value of this equilibrium constant change at 400 K? Explain your answer.

29. During your study of carbon chemistry you will have compared the oxidation of primary, secondary, and tertiary alkanols using suitable reagents in solution.

(a) Describe how you carried out these reactions.

(b) In the table provided in your Answer Book:

(i) write the condensed structural formulae for the primary, secondary, and tertiary alkanols you used for this experiment;

(ii) name the principal organic product formed by the oxidation of each of the alkanols named in part (b) (i).

30. Hydrogen combines with halogens to form diatomic molecules, for example, HBr, HCl, HF, and HI.

(a) Which halogen is in the third period?

(b) Draw an electron-dot diagram for the diatomic molecule formed between hydrogen and any halogen.

(c) Which halogen combines with hydrogen to form a compound with strong hydrogen bonding?

(d) Of the four compounds listed above, which would have the strongest dispersion forces between its molecules? Explain.

(e) Chlorine also forms compounds with Group I elements. State the type of bonding involved in such compounds.

31. Ethanoic acid $\left(CH_3COOH\right)$ is an example of a weak acid with $K_a = 1{\cdot}74 \times 10^{-5}$ at 25°C.

(a) What is meant by the term 'weak' in relation to an acid?

(b) 1·00 L of a solution is prepared by dissolving 0·100 mol of ethanoic acid in distilled water.

(i) Write the K_a expression for this reaction.

(ii) Calculate the pH of the solution.

(iii) Because this is an acidic solution it is assumed that the $\left[OH^-\right]$ is low. Calculate the value of $\left[OH^-\right]$ to show the validity of this assumption.

SECTION II—ELECTIVES

(25 Marks)

Attempt ONE question.

Answer the question in a *separate* Elective Answer Book.

In questions involving calculations, show all necessary working.

Marks may be awarded for relevant working.

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QUESTION 32. Chemical Energy 15

QUESTION 33. Oxidation and Reduction 18

QUESTION 34. Biological Chemistry 20

QUESTION 35. Chemistry and the Environment 23

QUESTION 32. Chemical Energy **Marks**

(a) An ethene sample in a 1·00 litre container (fixed volume) is found to have the following pressure behaviour as a function of temperature. **3**

P (kPa)	T (K)
106·6	295
107·6	298
108·7	301
109·8	304
112·0	310
113·8	315

(i) Use the data to determine whether ethene is behaving as an ideal gas over this range. Explain.

(ii) Give ONE reason for gases deviating from ideal gas behaviour.

(b) Sodium azide $\left(NaN_3\right)$ is often used to inflate automobile air-bags. When a car is involved in a collision, the impact causes the ignition of a detonator cap that in turn causes the sodium azide to decompose explosively as described in the equation: **2**

$$2NaN_3(s) \rightarrow 2Na(s) + 3N_2(g)$$

Calculate the mass of sodium azide needed to inflate a 50 L air-bag at 20°C and 110 kPa.

(c) During your study of chemical energy you determined the enthalpy change of combustion for a compound. **7**

(i) Draw a labelled diagram of the apparatus you used to determine the heat produced by the combustion reaction.

(ii) List the measurements you needed to make in determining experimentally the enthalpy change of combustion.

(iii) What is a major source of error in determining the enthalpy change of combustion? Describe ONE way that the size of this error may be reduced.

(iv) Methane gas burns completely in a Bunsen burner when the flame is blue, and incompletely when the flame is yellow. Write a balanced equation to describe a reaction for:

1. the complete combustion of methane;

2. the incomplete combustion of methane.

Question 32 continues on page 16

QUESTION 32. (Continued) **Marks**

(d) In 1985, the USA consumed about $7{\cdot}80 \times 10^{16}$ kJ of energy. **2**

(i) If that amount of heat were to be produced by the combustion of methane gas (assume $\Delta H° = -55{\cdot}5$ kJ g^{-1}), what mass of methane would need to be burnt?

(ii) Calculate $\Delta H°$ for the combustion of methane gas in kJ mol^{-1}.

(e) (i) Hydrogen can be produced industrially by the following reaction: **3**

$$C(s) + 2H_2O(g) \rightarrow CO_2(g) + 2H_2(g)$$

Find $\Delta H°$ for this reaction, given the following data:

Reaction I :	$C(s) + H_2O(g)$	$\rightarrow CO(g) + H_2(g)$	$\Delta H° = 131$ kJ mol^{-1}
Reaction II :	$CO_2(g) + H_2(g)$	$\rightarrow CO(g) + H_2O(g)$	$\Delta H° = 40$ kJ mol^{-1}

(ii) Could carbon be regarded as a fuel in Reaction I? Explain your answer.

QUESTION 32. (Continued) **Marks**

(f) Propane gas is used by campers for lighting and cooking. It is supplied in gas bottles and when burnt, the following reaction occurs: **3**

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

(i) Using the data below, calculate the standard heat of formation of liquid water.

Species	ΔH_f° (kJ mol^{-1})
$CO(g)$	–111
$CO_2(g)$	–394
$C_3H_8(g)$	–104
$C_2H_6(g)$	–85
$C_4H_{10}(g)$	–126
$H_2O(g)$	–242

(ii) Explain why butane may be safely stored in small plastic containers, while propane is supplied in strong metal bottles.

(g) Bond enthalpies can be calculated for gas phase reactions. From the following equation and bond enthalpies, calculate the bond enthalpy of hydrogen. **2**

$$H_2(g) + \tfrac{1}{2}O_2(g) \rightarrow H_2O(g) \qquad \Delta H^\circ = -242 \text{ kJ}$$

Bond	*Bond enthalpy* (kJ mol^{-1})
O—H	463
O═O	498
O—O	144

(h) Motorists are required to extinguish cigarettes and turn off their engines when they are filling up their petrol tanks at a service station. This is because petrol is very volatile and has a low ignition temperature. **3**

(i) Explain what is meant by:

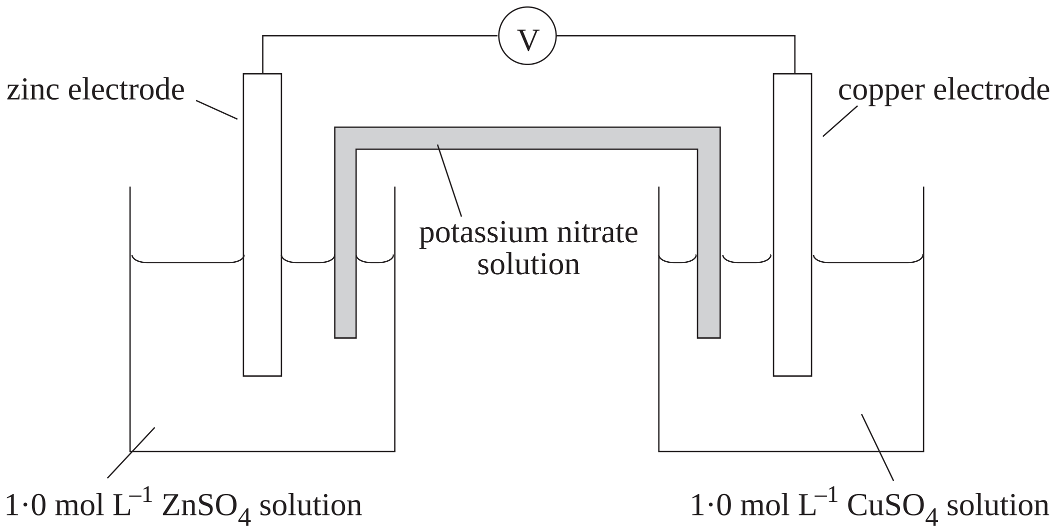
1. the volatility of a fuel;

2. the ignition temperature.

(ii) Describe the difference between ignition temperature and flashpoint temperature.

QUESTION 33. Oxidation and Reduction **Marks**

(a) An electrochemical cell was set up in the laboratory as shown. **5**



(i) What is the purpose of the potassium nitrate link between the two half-cells?

(ii) Which electrode is the cathode?

(iii) What happens to the copper electrode as the cell is operating?

(iv) Write a half-equation to show the reaction occurring in the zinc half-cell.

(v) Calculate the maximum possible voltmeter reading at 25°C for this cell. Show your working.

(b) (i) How does an electrolytic cell differ from a galvanic cell? **7**

(ii) To carry out the electrolysis of water to produce oxygen and hydrogen gases a small amount of electrolyte such as sodium sulfate is added to the water. Why is the electrolyte added?

(iii) For the electrolysis of water containing a small amount of sodium sulfate, write down the ions that migrate to:

1. the cathode;

2. the anode.

(iv) Write half-equations for the reactions occurring at:

1. the cathode;

2. the anode.

(v) If, during electrolysis of water, 50·0 mL of oxygen is collected, how much hydrogen will be obtained? Explain your answer, using a chemical equation.

QUESTION 33. (Continued) **Marks**

(c) Most wines oxidise spontaneously in air to produce ethanoic acid. For this process write: **3**

(i) the half-equations involving ethanol and oxygen;

(ii) the overall redox equation.

(d) 'Free sulfur dioxide' may be present in wines in a number of different forms, including the sulfite ion. Its concentration can be determined using the following reaction in aqueous solution: **6**

$$SO_3^{2-} + I_2 + H_2O \rightarrow SO_4^{2-} + 2H^+ + 2I^-$$

(i) What is the oxidation number of sulfur in:

1. sulfite ion?

2. sulfate ion?

(ii) From the equation, identify a reactant that is behaving as an oxidant.

(iii) A titration was performed to determine the amount of 'free sulfur dioxide' (as sulfite ion) in a 50·0 mL sample of white wine. It was found that 12·5 mL of a 0·00206 mol L^{-1} iodine solution was required to obtain the end-point. What concentration of 'free sulfur dioxide' was present in the sample?

(iv) This type of wine is considered to be 'a good wine' if the value for 'free sulfur dioxide' is greater than 30 ppm SO_2 (ppm = mg L^{-1}). Does this sample of wine rate as 'a good wine'? Show your working.

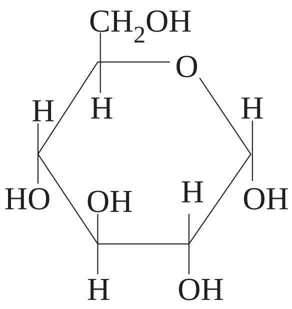
(e) (i) One problem with retrieving relics from historic shipwrecks off Australia's coastline is the amount of corrosion that occurs on the iron surfaces. Why do iron objects in a marine environment rust more quickly than those in fresh water? **4**

(ii) Investigation has shown that iron objects coated with a crust of marine colonies forming a 'concretion' layer do not corrode as quickly as an uncoated iron object. Explain.

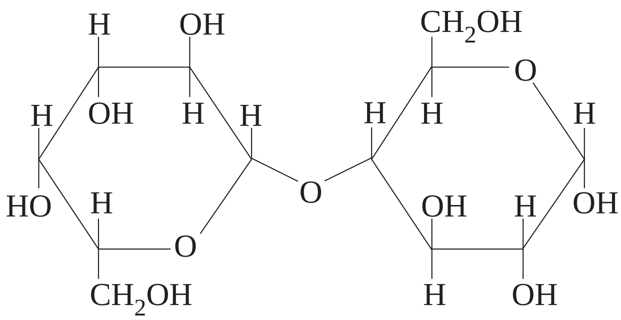
(iii) A sacrificial anode may be attached to the relic while still under water to protect it from further corrosion. Which metal would be an effective sacrificial anode? Use E° values to justify your answer.

QUESTION 34. Biological Chemistry **Marks**

(a) The diagrams below show three carbohydrates. **6**



(I)



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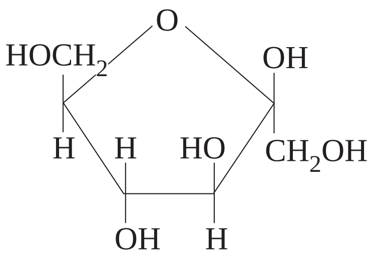


(III)

(i) What class of carbohydrate is compound II?

(ii) What is the name of compound II?

(iii) Using structural formulae, write an equation for the hydrolysis of compound II.

(iv) Compounds I and III often combine to form another compound. What is the name of the combined compound?

(v) From which natural source could you extract commercial quantities of the compound made up from I and III?

(vi) The major components of honey are compounds I and III. Honey is a syrup because it contains a small amount of water that is very difficult to remove. Why is water so difficult to remove from honey?

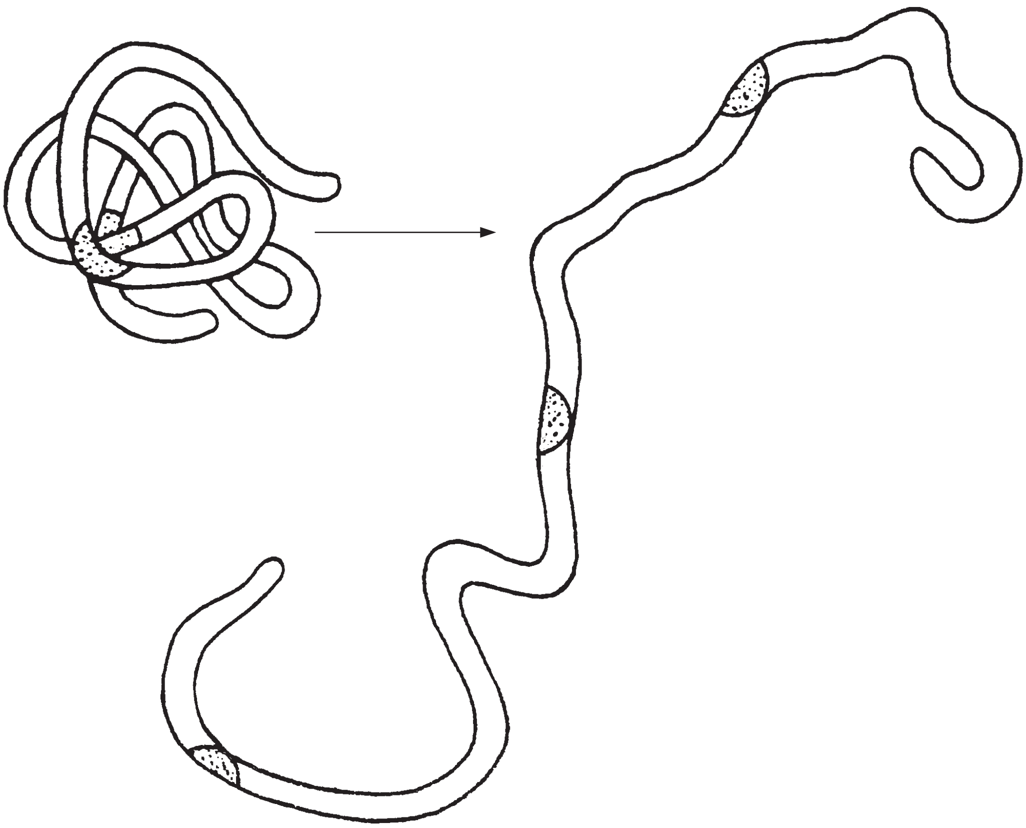
(b) (i) What is meant by the primary structure of a protein? **3**

(ii) Name the bond responsible for the primary structure of a protein.

(iii) Why are disulfide bonds important in protein structures?

QUESTION 34. (Continued) **Marks**

(c) The diagram below represents the change that occurs to a protein such as albumin when it is heated. **4**



(i) Name the process causing this change.

(ii) Explain how heating brings about this change.

(iii) Name a chemical that could produce this effect in albumin. Explain how it would bring about the change.

(iv) How would the solubility of albumin be affected by the process in part (c) (i)? Explain.

(d) (i) State the type of biomolecule (other than water) that is the major component of: **4**

1. potato;

2. egg white.

(ii) Choose ONE of the types of biomolecule named in part (d) (i). Explain how you would verify its presence using a chemical test. Indicate clearly which biomolecule you have selected.

Question 34 continues on page 22

QUESTION 34. (Continued) **Marks**

(e) Glucose is readily oxidised by cells to form carbon dioxide and water. This same reaction can be produced in a test-tube, but only if the test-tube is heated strongly. **6**

(i) Why is the application of heat not necessary to bring about this reaction in living cells?

(ii) How does the amount of energy released per gram of glucose in a cell compare with the amount released in the test-tube reaction?

(iii) A marathon runner uses energy at the rate of 68 kJ per minute. Calculate the mass of glucose needed to supply the energy to run for eight hours. (Oxidation of glucose yields 2800 kJ mol^{-1}.)

(iv) Explain the role of ATP in cellular respiration.

(f) Maltase is an enzyme that specifically converts maltose into glucose. **2**

(i) Suggest a reason for the specificity of maltase.

(ii) Sketch a graph showing the relationship between the rate of this reaction and the substrate concentration. Label axes.

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

(a) (i) When we describe a substance as radioactive, what do we mean? **6**

(ii) $^{238}_{92}U$ is a natural source of radioactivity and undergoes a fourteen-step decay to $^{206}_{82}Pb$. One of the products formed is $^{226}_{88}Ra$ that decays to form radon and an alpha particle according to the following equation:

$$^{226}_{88}Ra \rightarrow \, ^{x}_{y}Rn + \alpha$$

In this equation:

1. what is the value of x?

2. what is the value of y?

(iii) $^{238}_{92}U$ undergoes a different decay series when it is used in breeder reactors where it is bombarded by energetic particles. A disadvantage of this technique is the production of plutonium.

1. Give TWO reasons why this is a disadvantage.

2. Suggest a method for the disposal of plutonium.

(b) (i) When analysing a water sample, why is it important to measure the concentration of dissolved oxygen? **7**

(ii) Water samples are taken from a fast-running stream and from a swamp. The oxygen concentrations differ. Explain.

(iii) In the Winkler method for determining dissolved oxygen, one mole of oxygen produces two moles of iodine. The iodine is then titrated with sodium thiosulfate $(Na_2S_2O_3)$ using starch as an indicator, according to the equation:

$$I_2 + 2Na_2S_2O_3 \rightarrow 2NaI + Na_2S_4O_6$$

A 500 mL sample of river water was analysed by the Winkler method. 4·80 mL of 0·100 mol L^{-1} sodium thiosulfate solution was required to titrate the iodine that was formed.

Calculate the:

1. number of moles I_2 formed;

2. concentration of oxygen in the river water in:

   A. mol L^{-1};

   B. mg L^{-1} (ppm).

Question 35 continues on page 24

QUESTION 35. (Continued) **Marks**

(c) Photosynthesis by algae and other plant life in sunny weather can lead to higher than normal pH values in rivers. This is due to a disturbance in the carbonate/bicarbonate equilibrium. Use the equation for the equilibrium to explain how this rise in pH could occur. **2**

$$OH^- + CO_2 \underset{}{\overset{H_2O}{\rightleftharpoons}} HCO_3^- \underset{}{\overset{H_2O}{\rightleftharpoons}} H^+ + CO_3^{2-}$$

(d) The graph below shows the concentration of carbon dioxide in the air over a 140-year period. **5**

DUE TO COPYRIGHT RESTRICTIONS THIS IMAGE COULD NOT BE REPRODUCED.

(i) Describe how the carbon dioxide concentration in the air has changed over the period covered by the graph.

(ii) There have been many suggested causes for this change in concentration of carbon dioxide in the air. Name ONE cause for the increase in carbon dioxide concentration, and write a balanced chemical equation to show how it produces carbon dioxide.

(iii) Scientists predict that the increasing concentration of carbon dioxide in the air may be a serious problem in the coming years.

1. State an environmental problem that may result.
2. Explain how the higher concentration of carbon dioxide in the air would be responsible for this environmental problem.

(iv) Describe ONE method of slowing the increase in the concentration of carbon dioxide in the earth's atmosphere.

QUESTION 35. (Continued) **Marks**

(e) (i) Why is the ozone layer important to living things? **5**

(ii) In recent years, production of freons (chlorofluorocarbons) has been banned in Australia because of their effect on the ozone layer.

1. For what were freons previously used?

2. Give a structural formula for a freon.

3. Use TWO equations to explain how a freon destroys ozone.

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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
$\frac{1}{2}O_2 + 2H^+ + 2e^-$	$\rightleftharpoons$	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

KEY

Atomic Number Atomic Mass	79 Au 197·0 Gold	Symbol of element Name of element

				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												

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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This sheet should be REMOVED for your convenience.