BOARD OF STUDIES
NEW SOUTH WALES

**HIGHER SCHOOL CERTIFICATE EXAMINATION**

# 1996

# 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 .** Which of the following substances will conduct electricity in both the solid and liquid states?

(A) sodium

(B) lithium fluoride

(C) sulfur

(D) silicon dioxide

**2 .** For a given weak acid, HA, the numerical value of $K_a$

(A) will change with the pH.

(B) will change with the temperature.

(C) cannot be less than $10^{-7}$.

(D) cannot be greater than $10^{-7}$.

**3 .** When solid iodine is heated, it changes into a purple gas without passing through the liquid state. In this process

(A) covalent bonds between iodine atoms are broken.

(B) covalent bonds between iodine molecules are broken.

(C) ionic forces between iodine atoms are overcome.

(D) attractive forces between iodine molecules are overcome.

**4 .** Two atoms X and Y have electronic configurations as shown below:

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

Y $1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^5$

The compound formed when X and Y combine is most likely to be

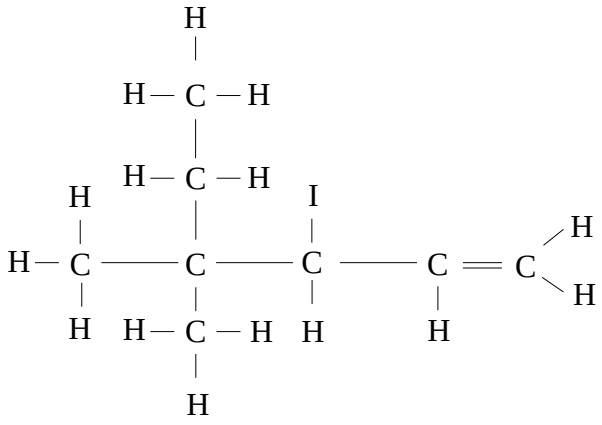
(A) ionic, with formula $X_2Y$

(B) ionic, with formula $XY_2$

(C) covalent, with formula $XY_4$

(D) covalent, with formula $X_2Y_5$

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



(A) 2-ethyl-3-iodo-2-methyl-4-pentene.

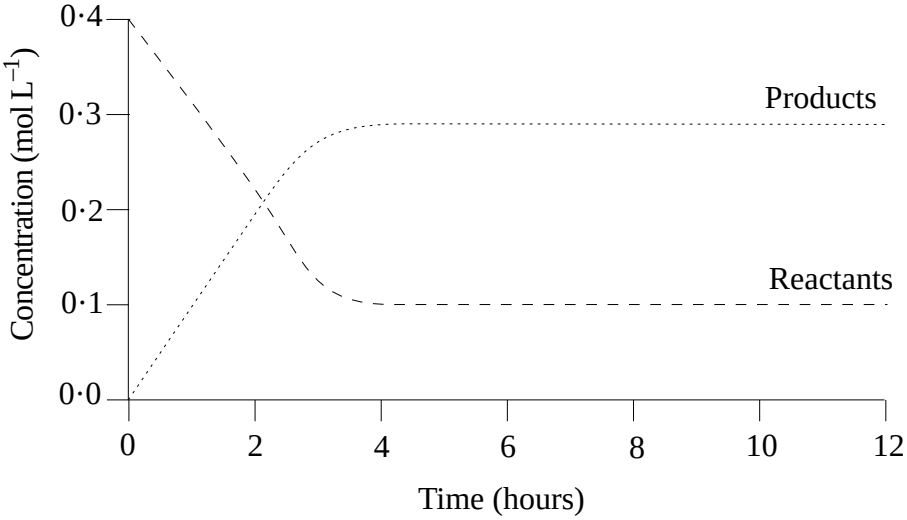
(B) 4-ethyl-3-iodo-4-methyl-1-pentene.

(C) 3-iodo-4,4-dimethyl-1-hexene.

(D) 4-dimethyl-3-iodo-1-hexene.

**6 .** The graph below shows how the concentration of reactants and products change over time for the reaction:

$$CH_3COOC_2H_5 + H_2O \rightleftharpoons CH_3COOH + C_2H_5OH$$



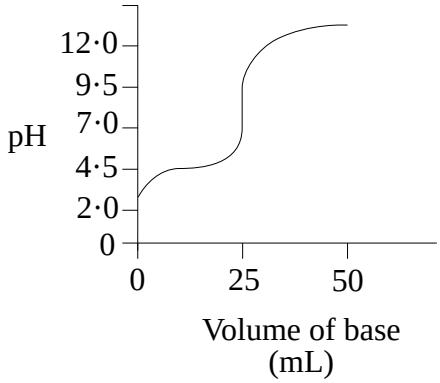

From this graph we can determine that

(A) the equilibrium concentrations were 0·2 mol $L^{-1}$.
(B) the forward reaction stopped after four hours.
(C) the system reached equilibrium after two hours.
(D) the reaction did not go to completion.

**7 .** Reaction of hot acidified potassium permanganate with 1-butene would give

(A) propanoic acid and carbon dioxide.
(B) propanone and carbon dioxide.
(C) propanone and methanoic acid.
(D) propanol and methanoic acid.

**8 .** A pH meter was used to trace the progress of an acid–base titration. 50 mL of 0·100 mol $L^{-1}$ sodium hydroxide solution was added in 1 mL aliquots (samples) to 50 mL of an acid. The pH of the acid–base mixture was measured after each 1 mL aliquot was added. The results were plotted on the graph below.




Using the information above, it is reasonable to conclude that the acid was

(A) ethanoic (acetic) acid.

(B) hydrochloric acid.

(C) nitric acid.

(D) sulfuric acid.

**9 .** Arrange the following reactions in order of their increasing tendency to reach completion.

| | | |
|---|---|---|
| I | $4NH_3(g) + 3O_2(g) \rightleftharpoons 2N_2(g) + 6H_2O(g)$ | $K = 1{\cdot}0 \times 10^{228}$ |
| II | $2HF(g) \rightleftharpoons H_2(g) + F_2(g)$ | $K = 1{\cdot}0 \times 10^{-13}$ |
| III | $2NOCl(g) \rightleftharpoons 2NO(g) + Cl_2(g)$ | $K = 4{\cdot}7 \times 10^{-4}$ |
| IV | $N_2(g) + O_2(g) \rightleftharpoons 2NO(g)$ | $K = 5{\cdot}0 \times 10^{-31}$ |

(NOTE: For each reaction, the equilibrium constant was determined under different conditions.)

(A) I, III, II, IV

(B) III, II, IV, I

(C) IV, II, III, I

(D) I, IV, II, III

**10.** 0·100 mol $L^{-1}$ solutions of four different monoprotic acids were prepared. Their pH was measured at 298 K and recorded in the table below.

| *Acids* | pH |
|---|---|
| *A* | 1·0 |
| *B* | 2·2 |
| *C* | 4·0 |
| *D* | 5·2 |

The strongest acid is

(A) acid *A*.

(B) acid *B*.

(C) acid *C*.

(D) acid *D*.

**11.** Which of the following pairs of substances are NOT isomers?

(A) 2-pentanone and 3-methylbutanal

(B) butanoic acid and 1,2-cyclobutanediol

(C) 3-methylhexane and 2,2,3-trimethylbutane

(D) methylcyclopentane and hexane

**12.** The numerical value of $K_a$ for HCN is $6{\cdot}17 \times 10^{-10}$. The pH of a 0·100 mol $L^{-1}$ solution of HCN is

(A) 1·00

(B) 5·10

(C) 6·17

(D) 9·21

**13.** In 1908 in Germany, Fritz Haber showed:

$$N_2(g) + 3H_2(g) \rightleftharpoons 2NH_3(g) \qquad \Delta H = -92 \text{ kJ}$$

This is now an important industrial process. Which of the following changes is most likely to increase the yield of $NH_3$?

(A) Increasing the temperature.

(B) Decreasing the pressure.

(C) Increasing the amount of $N_2$ gas.

(D) Decreasing the amount of $H_2$ gas.

**14.** The pH of blood is critical. If the pH falls below 7·4, the condition called acidosis results.

The following equilibrium system is involved in maintaining blood pH.

$$CO_2(aq) + H_2O(l) \rightleftharpoons H_2CO_3(aq) \rightleftharpoons H^+(aq) + HCO_3^-(aq)$$

Acidosis may be reduced by

(A) introducing more water from cells to shift equilibrium to the right.

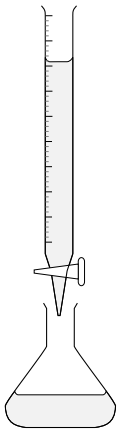
(B) adding an enzyme to catalyse this reaction.

(C) introducing NaCl into the blood to change pH levels.

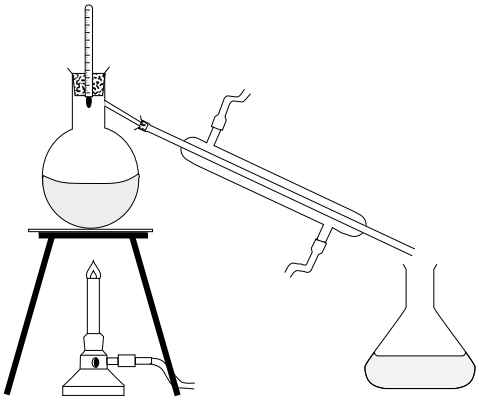
(D) rapid breathing to reduce $CO_2$ levels in the blood.

**15.** In a laboratory experiment, a student prepares an ester by refluxing an acid and an alcohol for thirty minutes. After this time, it is necessary to separate the product from the reaction mixture. The correct apparatus for carrying out this separation is

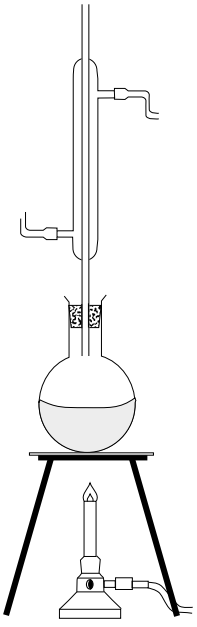
(A)



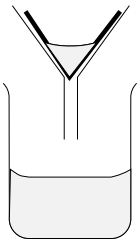
(B)



(C)



(D)



## PART B

Attempt ALL questions.

Each question is worth 3 marks.

Answer all questions in the Part B Answer Book provided.

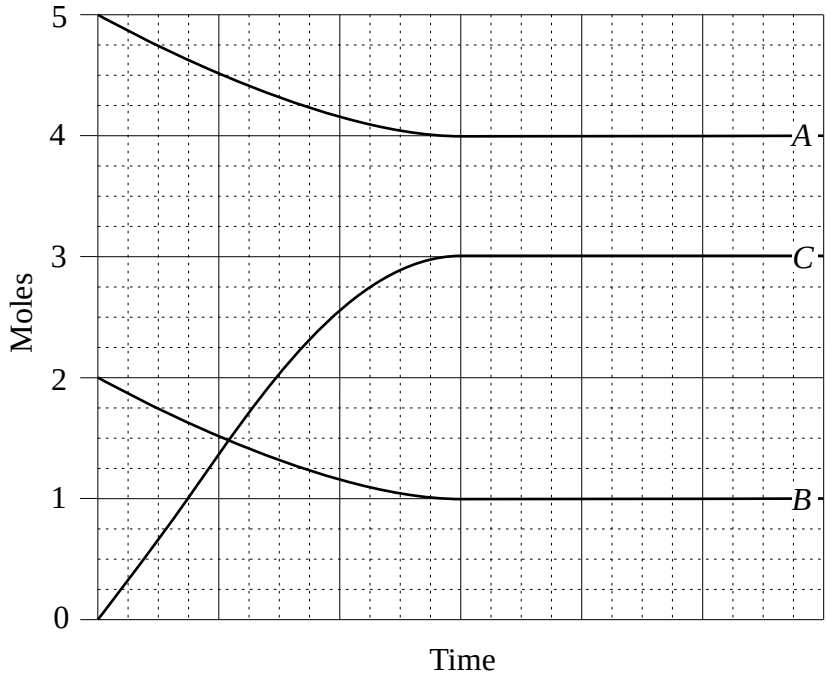
*In questions involving calculations, you are advised to show working, as marks may be awarded for relevant working.*

**16.** Sodium and sulfur are examples of third-period elements that form stable oxides. Complete the table in your Answer Book which compares the properties of these oxides.

**17.** Two substances *A* and *B* react according to the equation:

$$A + B \rightleftharpoons 3C$$

5 moles of *A* and 2 moles of *B* are mixed in a 2 L closed container. The reaction is allowed to come to equilibrium at temperature *T*. The graph below shows the variation in moles of *A*, *B*, and *C* over time.




Calculate the value of the equilibrium constant, *K*, for the reaction at temperature *T*. Show your working.

**18.** Intermolecular forces play an important role in determining the properties of substances. These intermolecular forces include:

- *dipole–dipole interactions*
- *dispersion forces*
- *hydrogen bonding.*

From the following list of substances:

- methane
- ammonia
- ethanol
- propanone
- chloromethane
- sodium chloride
- calcium oxide

(a) choose ONE substance in which hydrogen bonding occurs. Use a diagram to show how it occurs in this substance.

(b) name a substance from the list in which the major intermolecular forces are:

(i) dispersion forces;

(ii) dipole–dipole interactions (excluding hydrogen bonds).

**19.** Two hydrocarbons have the same molecular formula $C_5H_{10}$. One decolorises bromine quickly; the other does not.

(a) Give a possible structure for *each* of the TWO hydrocarbons.

(b) Give an equation, using structural formulae, for the fast reaction of the hydrocarbon with bromine.

**20.** Methane can be produced by the following reaction:

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

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

(b) At equilibrium, a 5·0 L vessel contains 0·55 mol $CH_4$, 0·125 mol $H_2S$, 0·15 mol $CS_2$, and 0·15 mol $H_2$.

Calculate the value of the equilibrium constant for this reaction at the temperature of the experiment.

**21.** Ethene is a hydrocarbon that is insoluble in water.

(a) Why is ethene insoluble in water?

(b) Ethane and ethene both react with halogens.

(i) Explain why ethene reacts more readily with halogens than does ethane.

(ii) Write a balanced equation for a reaction between ethane and a halogen.

**22.** At 1000°C the numerical value of the equilibrium constant for $C(s) + S_2(g) \rightleftharpoons CS_2(g)$ was found to be 5·60.

(a) Equal numbers of moles of $S_2(g)$ and $CS_2(g)$ are placed in a closed vessel that contains carbon at 1000°C. Which reaction, forward or reverse, will predominate until equilibrium is reached? Explain your answer.

(b) If the pressure in the container is increased by decreasing the volume, how is the equilibrium affected?

**23.** (a) Calculate the formula mass of barium hydroxide.

(b) 250 mL of a solution contains 0·857 g of barium hydroxide.

(i) Determine the hydroxide ion concentration of the solution.

(ii) What is the pH of the solution?

**24.** Ethyl ethanoate (ethyl acetate) is a sweet-smelling ester, widely used as a solvent.

(a) Give the structural formula of ethyl ethanoate.

(b) Ethyl ethanoate may be prepared from ethanol as the only *organic* starting material. Give equations for each step in this preparation.

**25.** Understanding of acids and bases has changed since Arrhenius first developed his theory. Although an acid–base reaction is known as neutralisation, the resulting salt solution is not always neutral. For example, a solution of the salt sodium sulfate is neutral, but a solution of sodium ethanoate (acetate) is basic.

(a) Write an equation to describe the formation of sodium sulfate from an acid–base reaction. Name the reactants.

(b) Explain why a solution of sodium ethanoate ($CH_3COONa$) is basic, while a sodium sulfate solution of the same concentration has a pH of 7·0. Write ionic equations to describe any reactions.

## 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 solution of nitric acid was needed for the analysis of a series of copper samples, but before it could be used for this purpose, its exact concentration had to be determined. Anhydrous sodium carbonate was selected as a primary standard and 250 mL of $0{\cdot}100$ mol $L^{-1}$ solution was prepared. $25{\cdot}0$ mL aliquots (samples) of this solution were titrated using the nitric acid. The titration was carried out several times and the results were recorded in the table.

| *Titration number* | *Volume of nitric acid* (mL) |
|---|---|
| 1 | $27{\cdot}7$ |
| 2 | $24{\cdot}8$ |
| 3 | $24{\cdot}8$ |
| 4 | $24{\cdot}7$ |

(a) For the concentration of nitric acid to be accurately determined, it was necessary for the sodium carbonate to be anhydrous. Describe how this can be achieved.

(b) Name and draw the glassware in which the 250 mL of $0{\cdot}100$ mol $L^{-1}$ sodium carbonate solution was prepared.

(c) Write a balanced equation to describe the reaction between sodium carbonate and nitric acid.

(d) Calculate the concentration of the nitric acid solution.

**27.** The following table shows the colours and pH ranges for various indicators.

| *Indicator* | *Colour (low pH)* | *Colour (high pH)* | *pH range for colour change* |
|---|---|---|---|
| Methyl orange | Red | Yellow | 3·1–4·4 |
| Bromophenol blue | Yellow | Blue | 3·0–4·6 |
| Bromocresol green | Yellow | Blue | 3·8–5·4 |
| Methyl red | Pink | Yellow | 4·4–6·2 |
| Bromothymol blue | Yellow | Blue | 6·0–7·6 |
| Phenol red | Yellow | Red | 6·8–8·4 |
| Thymol blue | Yellow | Blue | 8·0–9·6 |
| Phenolphthalein | Colourless | Magenta | 8·3–10·0 |

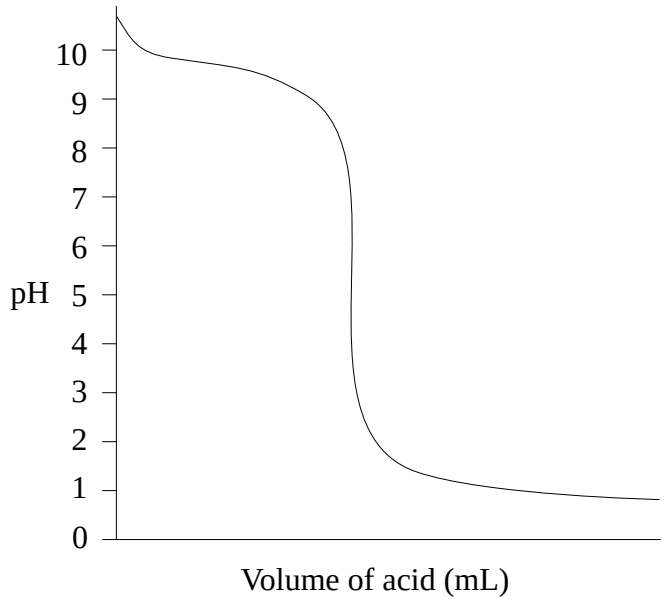
(a) 0·10 mol $L^{-1}$ potassium nitrite ($KNO_2$) was tested with bromothymol blue and a blue colour was seen. On the basis of this result, write an ionic equation for the reaction between potassium nitrite and water.

(b) At 25°C, a solution tested with bromothymol blue gives a blue colour, and with thymol blue gives a yellow colour.

(i) Estimate the pH of the solution.

(ii) Using your estimate, calculate the hydroxide ion concentration of the solution.

(c) Aqueous ammonia is titrated with hydrochloric acid. The titration curve obtained by using a pH meter is shown below. If a pH meter was not available, what would be a suitable indicator for this titration? Explain your choice.




(d) Explain why it is necessary to use a minimum volume of an indicator solution for titration reactions.

**28.** A stage show requiring a frothing 'blood-like' liquid used dry ice $\left(CO_2(s)\right)$ and iron complexes to produce this effect.

One such iron complex consists of an alkaline solution containing iron (III) chloride and sodium thiocyanate. This produces the following equilibrium reaction:

$$\underset{\text{(yellow)}}{Fe(OH)^{2+}} + SCN^- \rightleftharpoons \underset{\text{(bright red)}}{Fe(SCN)^{2+}} + OH^-$$

(a) The numerical value of $K$ at 25°C for this reaction was found to be $2{\cdot}3 \times 10^{-4}$.

(i) What does the value of $K$ tell us about the equilibrium concentrations of the $Fe(SCN)^{2+}$ and $OH^-$ ions?

(ii) Predict the colour of the solution at 25°C.

(b) If dry ice is added to this solution, the pH changes from about pH 10 to pH 4. What causes this pH change?

(c) Explain how the addition of dry ice achieves the effect of the blood-like liquid.

**29.** Ammonium chloride is a white solid formed when ammonia gas reacts with hydrogen chloride gas.

(a) Write the equation for this reaction.

(b) Draw an 'electron-dot' formula for the ammonium ion.

(c) Give the electron configuration for the chloride ion using subshells.

(d) Name the special type of covalent bonding involved in the formation of the ammonium ion from ammonia.

(e) Explain, in terms of bonding, why ammonium chloride is a solid at room temperature.

**30.** Explain each of the following facts in terms of the bonding and structure present in the substance involved.

(a) Copper is a good conductor of heat and electricity.

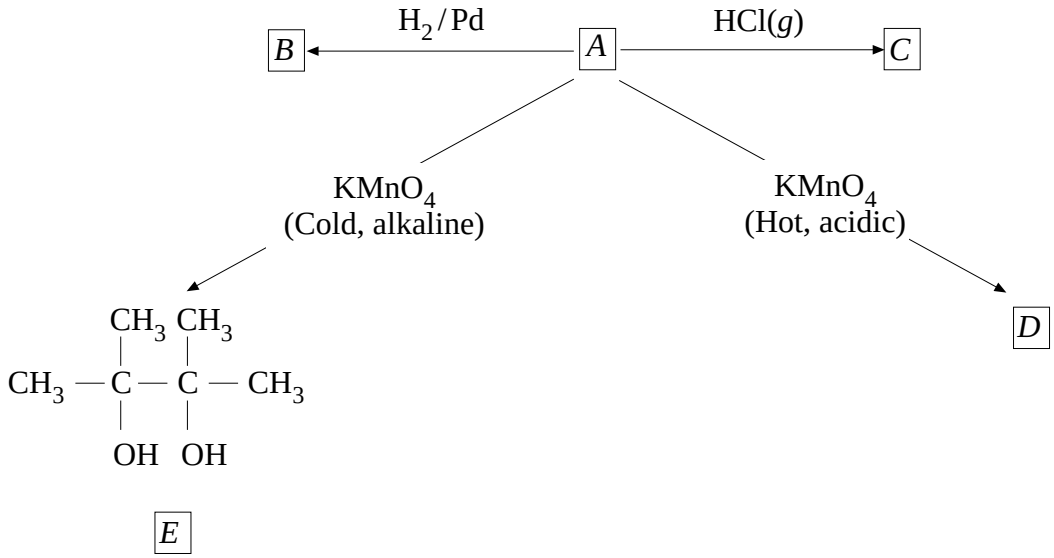
(b) Diamond is one of the hardest known substances.

(c) Water has a higher boiling-point than hydrogen sulfide.

(d) Ethanol dissolves readily in water.

(e) Helium has an extremely low boiling-point (–269°C).

**31.** The hydrocarbon *A* undergoes a series of reactions to produce compounds *B, C, D,* and *E* as shown below.




(a) *A* has an empirical formula $CH_2$ and molar mass 84 g $mol^{-1}$. What is the molecular formula for *A*?

(b) Give the structural formula for:

(i) *A*;

(ii) *C*;

(iii) *D*.

(c) Name compound *E*.

## 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.

**QUESTION 32. Chemical Energy** **Marks**

(a) During the study of Chemical Energy, a student was asked to discover how the volume of a sample of gas depends on pressure. The student measured the volume of a sample of carbon dioxide gas at different pressures. The experiment was carried out at 25°C and the results were recorded in the table below. **9**

| *Pressure* (kPa) | *Volume* (mL) |
|---|---|
| 148 | 15 |
| 117 | 19 |
| 85 | 26 |
| 70 | 31 |
| 63 | 36 |

(i) Describe what happens to the volume of the gas as the pressure changes.

(ii) What relationship between pressure and volume can be derived from these results?

(iii) Sketch a graph showing the relationship in part (ii).

(iv) Calculate the volume of the carbon dioxide gas if the pressure was increased to 160 kPa. Show your working.

(v) If the sample of carbon dioxide was subjected to extremely high pressures, would the relationship in part (ii) still hold? Explain your answer.

(vi) Find the number of moles of carbon dioxide used in the experiment.

(vii) The student replaced the carbon dioxide with an equal number of moles of hydrogen and repeated the experiment. What differences would you expect to find in this new set of results? Explain your answer.

QUESTION 32. ( Continued) **Marks**

(b) Ethyne (acetylene) is a commonly used fuel. **4**

(i) Give a major use of ethyne as a fuel.

(ii) Calculate the heat of combustion of ethyne from the bond enthalpies below.

| *Bond* | *Enthalpy* (kJ $mol^{-1}$ at 25°C) |
|---|---|
| C—C | 346 |
| C═C | 614 |
| C≡C | 839 |
| C═O | 804 |
| O═O | 498 |
| O—H | 463 |
| C—H | 414 |

(c) When 4·0 g of solid sodium hydroxide was added to 100 mL of 0·50 mol $L^{-1}$ sulfuric acid, the temperature of the solution increased from 20·5°C to 33·4°C. (Take the specific heat of the solution as 4·18 J $g^{-1}$ $K^{-1}$ and the density of the acid solution as 1·0 g $mL^{-1}$.) **6**

(i) Calculate the enthalpy change for this reaction (in kJ $mol^{-1}$ of NaOH).

(ii) Use the answer from part (i) to calculate the enthalpy change (in kJ $mol^{-1}$ NaOH) for the reaction between a solution of sodium hydroxide and dilute sulfuric acid, given:

$$NaOH(s) \rightarrow NaOH(aq) \qquad \Delta H = -43 \text{ kJ mol}^{-1}.$$

(iii) You have been asked to check the answer calculated in part (ii) experimentally. A 2·0 mol $L^{-1}$ solution of sodium hydroxide and a 1·0 mol $L^{-1}$ sulfuric acid solution are provided.

1. List THREE pieces of apparatus that are necessary for the experiment.

2. What volume of sodium hydroxide solution, and what volume of sulfuric acid, would you use?

3. What is the major source of error in this experiment, and how may it be reduced through the selection of apparatus?

**Question 32 continues on page 18**

QUESTION 32. ( Continued) **Marks**

(d) The following enthalpies of formation are given: **3**

| *Substance* | $\Delta H_f$ at 25°C (kJ mol$^{-1}$) |
|---|---|
| Ethanol | –235 |
| Carbon dioxide | –394 |
| Water | –286 |

Use these data to calculate the maximum amount of heat evolved when 100 g of ethanol is completely burnt.

(e) The quantities of heat available from common fuels are shown below: **3**

| *Heat released on combustion* (kJ) | *Hydrogen gas* | *Liquid hydrogen* | *Methane gas* | *LPG* | *Liquid octane* |
|---|---|---|---|---|---|
| per mole | 286 | 285 | 890 | 2 220 | 5 470 |
| per gram | 142 | 141 | 55 | 50 | 48 |
| per litre | 12 | 9 970 | 36 | 25 600 | 34 000 |

(i) Give ONE advantage of hydrogen as a fuel.

(ii) Give ONE disadvantage of hydrogen as a fuel.

(iii) Write an equation for the complete combustion of octane. Include the enthalpy term in your equation.

**QUESTION 33. Oxidation and Reduction** **Marks**

(a) Drinking and driving is a dangerous combination. It is illegal to drive with a blood-alcohol level above a stated limit. In New South Wales the limit for P-plate drivers is 0·02% (i.e. 0·02 g alcohol per 100 g blood). To determine the level of blood alcohol, a sample of blood plasma can be titrated with potassium dichromate solution. Incomplete half-equations for the redox reactions are shown below: **7**

1. $C_2H_5OH \rightarrow CH_3COOH$
   ethanol

2. $Cr_2O_7^{2-} \rightarrow Cr^{3+}$
   dichromate

(i) Write a balanced half-equation for reaction 1 and label it either *oxidation* or *reduction*.

(ii) Write a balanced half-equation for reaction 2.

(iii) Combine reactions 1 and 2 to give the simplest whole-number balanced redox reaction.

(iv) Determine if a person is legally drunk if 42·5 mL of 0·0100 mol $L^{-1}$ dichromate is required to titrate a 50·0 g sample of blood plasma. Assume that the only substance in blood plasma that reacts with dichromate is ethanol.

(b) During your study of this elective, you have carried out experiments that demonstrate metal displacement reactions. **4**

It is required that lead be displaced from a solution of aqueous lead nitrate. Use the table of standard potentials on the Chemistry Data Sheet, as required, to answer the following.

(i) Select TWO reductants that would be suitable for this purpose.

(ii) Which of these reductants would displace the lead with more ease. Justify your choice.

(iii) Write an overall equation for the displacement reaction in part (ii).

(c) A student studying oxidation and reduction reactions is confused about the terms ‘oxidant’ and ‘oxidised’. **3**

Define these terms, giving examples, to show your understanding of the difference.

**Question 33 continues on page 20**

QUESTION 33. ( Continued) **Marks**

(d) Many metals, on contact with air, react to give a surface layer of oxide. **3**

(i) An item of camper's equipment produces heat by mixing powdered magnesium and water according to the following equation:

$$Mg(s) + 2H_2O(l) \rightarrow Mg(OH)_2(aq) + H_2(g)$$

One problem in the development of this product was the formation of an insoluble magnesium oxide layer. Why was this oxide layer a problem?

(ii) It is often important to prevent the formation of an oxide layer ($Fe_2O_3$) on iron.

1. Why is this oxide layer a problem?

2. What is ONE method used to prevent the build-up of an oxide layer on iron?

(e) Which of the following reactions are spontaneous at standard conditions? Show your working. **3**

(i) $O_2(g) + 4H^+(aq) + 4Cl^-(aq) \rightarrow 2H_2O(l) + 2Cl_2(g)$

(ii) $I_2(s) + 2Br^-(aq) \rightarrow Br_2(l) + 2I^-(aq)$

(iii) $Zn(s) + 2Fe^{3+}(aq) \rightarrow Zn^{2+}(aq) + 2Fe^{2+}(aq)$

(f) A spoon is to be plated with nickel, using an electrolytic cell with one platinum electrode and an aqueous solution of nickel sulfate. **5**

(i) Draw and label an appropriate electrolytic cell, showing the battery connections and their polarity.

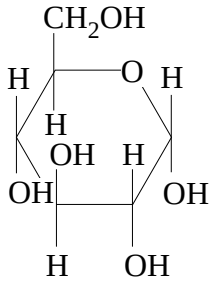
(ii) Give the anode reaction.

(iii) Give the cathode reaction.

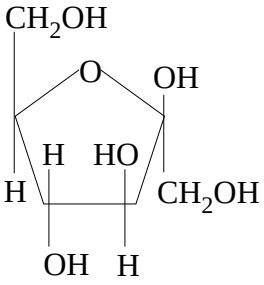
(iv) Calculate the minimum voltage required to plate the spoon.

**QUESTION 34. Biological Chemistry** **Marks**

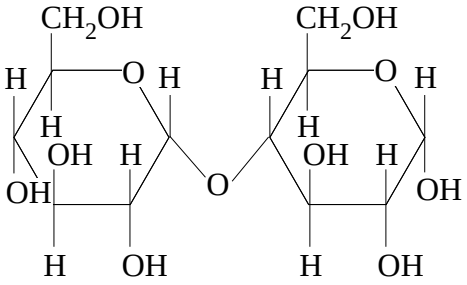
(a) The diagrams below show three carbohydrates. **9**




I




II




III

(i) Compound I is one of the cyclic forms of glucose. Give:

1. its molecular formula;

2. its empirical formula.

(ii) Name compound II.

(iii) Name compound III.

(iv) Compounds I, II, and III all dissolve in water. Explain this in terms of functional groups.

(v) Using structural formulae, write an equation for the formation of compound III from monosaccharides.

(vi) Which of the compounds I, II, and III are reducing sugars?

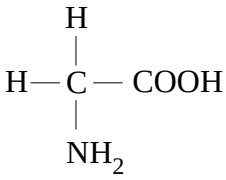
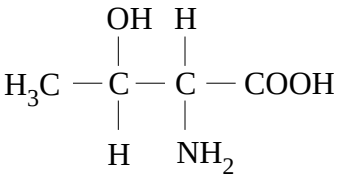
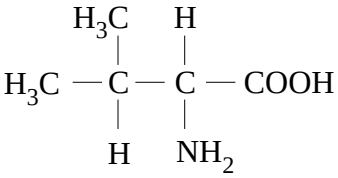
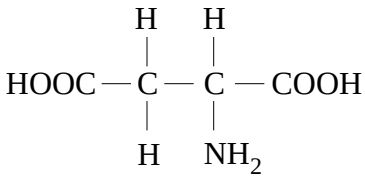
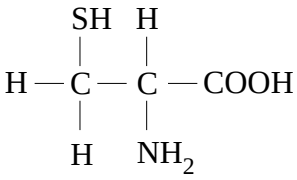
(vii) Describe a chemical reaction to determine whether a carbohydrate is a reducing sugar.

(viii) Name a polysaccharide which is made from carbohydrate I.

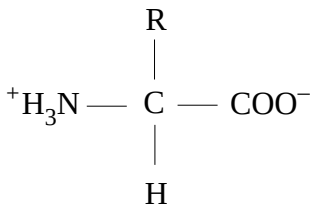
**Question 34 continues on page 22**

QUESTION 34. (Continued) **Marks**

(b) The structures of amino acids are often drawn as in the table below. **4**

| *Abbreviation* | *Name* | *Formula* |
|---|---|---|
| gly | glycine |  |
| thr | threonine |  |
| val | valine |  |
| asp | aspartic acid |  |
| cys | cysteine |  |

(i) However, amino acids really exist as zwitterions (also known as hybrid ions, double ions, or dipolar ions):

 where R varies.

Draw the zwitterionic structure of threonine.

QUESTION 34. (Continued) **Marks**

(ii) Give a piece of evidence that supports the zwitterionic structure of amino acids.

(iii) Name the functional groups in valine.

(iv) Draw the structure of a dipeptide made from valine and cysteine.

(c) What is meant by 'denaturation of a protein'? Use a specific example in your explanation. **1**

(d) Enzymes are essential to the functioning of all organisms. **4**

(i) To which group of biological molecules do most enzymes belong?

(ii) Give TWO reasons for their usefulness to a cell.

(iii) Sketch a graph to show the relationship between the initial rate of an enzyme reaction and the enzyme concentration.

(iv) A solution contains either *sucrase* (also called invertase) or *sucrose*. Describe a reaction that would allow you to decide which compound was present.

(e) One of the main outcomes of photosynthesis is the conversion of carbon dioxide in the air into glucose and subsequently various polymers of glucose. **7**

(i) Write the overall equation for photosynthesis.

(ii) Calculate the mass of glucose formed from the photosynthesis of 1500 L of carbon dioxide at 27°C. Assume that one mole of a gas at 27°C occupies a volume of 24·6 L.

(iii) In what form do animals usually store glucose?

(iv) Why do animals oxidise glucose?

(v) Yeast can grow both aerobically and anaerobically. When it grows anaerobically, it produces a substantial amount of ethanol and a modest increase in its own mass. However, when it grows aerobically, it produces very little ethanol, but its own mass increases very markedly. Explain the differences between the aerobic and anaerobic growth of yeast.

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

(a) The data given in the table below are results of tests on the quality of water samples taken from two rivers, *A* and *B*. **5**

| | *River A* | *River B* |
|---|---|---|
| Dissolved oxygen (mg/L) | 12·0 | 16·8 |
| pH | 6·0 | 8·9 |
| Hardness (mg/L) | 80 | 300 |
| Suspended solids ($\mu$g/L) | 100 | 48 |
| Faecal bacteria (CFU/100 mL)* | 35 000 | 3 300 |
| Metal ions (mg/L) | 110 | 305 |

* CFU = colony forming unit

(i) Which of the two rivers, *A* or *B*, has been more affected by animal activity? Justify your choice, using the data in the table.

(ii) Suggest possible reasons for the differences in

1. dissolved oxygen;

2. pH.

(iii) Given a sample of water from river *B*, how would you show the presence of micro-organisms?

(iv) Name a reagent you could use to neutralise a sample of river *A* water. Justify your choice.

(b) Hardness is an undesirable characteristic in water used in steam irons and car radiators. **3**

(i) Why is it undesirable?

(ii) What causes hardness in water ?

(iii) How may hardness in water be detected?

(c) A certain sample of rainwater has been found to contain $6{\cdot}7 \times 10^{-3}$ mol $L^{-1}$ sulfate ion. **3**

(i) Calculate the mass of barium chloride required to precipitate all the sulfate ions present in 50·0 mL of the rainwater.

(ii) Suggest a possible reason for the presence of sulfate ion in rainwater.

QUESTION 35. (Continued) **Marks**

(d) Strontium-90 is a radioactive isotope with a half-life of 28·1 years. It decays to release a beta particle. This isotope can be produced by some nuclear reactors. It is particularly dangerous because it replaces calcium in milk and bone tissue. **5**

(i) Write an equation to describe the nuclear decay of strontium-90.

(ii) Why is strontium-90 able to replace calcium in milk and bone tissue?

(iii) What will be the approximate mass of strontium-90 remaining from a 1·0 g sample if it is allowed to decay naturally for 85 years?

(iv) Describe one way in which the emission of beta particles from strontium-90 would be dangerous if it were incorporated into bone tissue.

(v) Suggest a method for the safe disposal of strontium-90.

(e) A power station uses fossil fuel. The waste gases from this station were analysed to ensure cleaner wastes and greater efficiency. **6**

(i) A sample of the waste gas was found to contain oxides of nitrogen. Why is it important to control the emission of these gases?

(ii) It is suspected that sulfur dioxide is being emitted in the waste gases. Describe a test for sulfur dioxide.

(iii) A 600 g sample of the waste gas was found to contain only nitrogen, oxygen, and carbon dioxide. The gas was passed through a solution of sodium hydroxide, dried, and weighed. It was then passed through an alkaline pyrogallol solution to absorb the oxygen, and was again dried and weighed. The mass of the gas after each stage is shown below.

| *Waste gas* | *Mass* (g) |
|---|---|
| Original sample | 600 |
| After NaOH treatment | 532 |
| After pyrogallol treatment | 462 |

Determine the percentage composition by mass of the waste-gas sample.

(iv) One concern over the use of fossil fuels has been the increase in carbon dioxide in the atmosphere. This may lead to a condition called the 'greenhouse effect'.

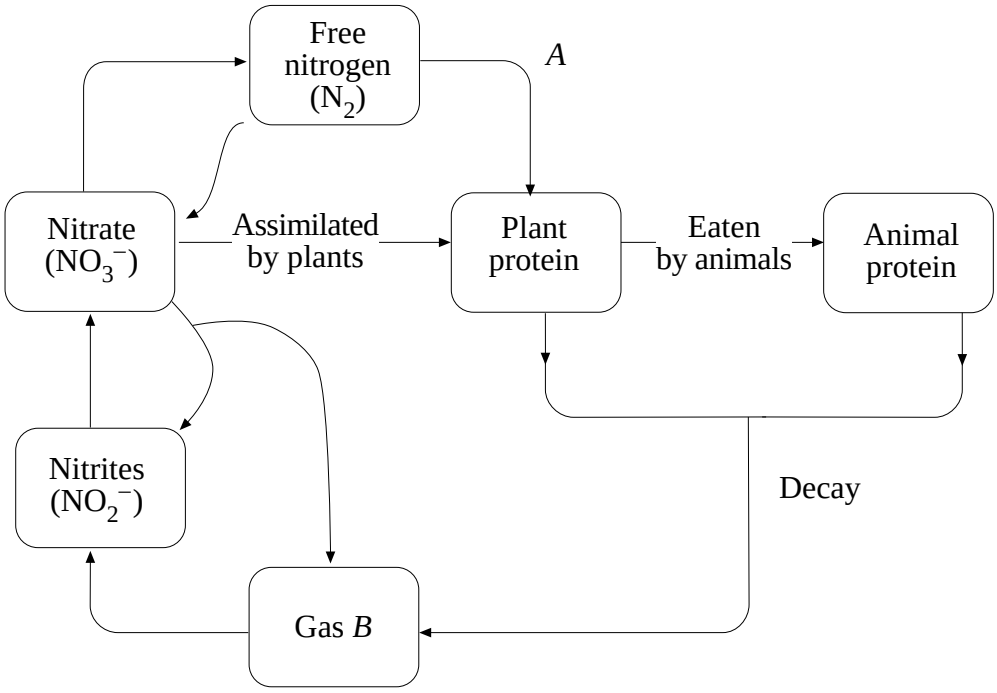
1. How does an increase in carbon dioxide concentration lead to the greenhouse effect?

2. Describe an effective measure to reduce carbon dioxide emission.

**Question 35 continues on page 26**

QUESTION 35. (Continued) **Marks**

(f) **3**




The diagram above represents some of the paths by which nitrogen is cycled through the living world.

(i) Why is nitrogen an important element for living things?

(ii) Explain how step *A* is achieved.

(iii) Give the formula for gas *B*.

# 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

| | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | 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

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 |

This sheet should be REMOVED for your convenience.

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# 1996

# CHEMISTRY

## 2 UNIT

## 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.

**EXAMINER'S USE ONLY**

| PART | Mark | Examiner | Check |
|---|---|---|---|
| B | | | |

EXAMINER'S USE ONLY

## PART B

Questions 16 to 25 (3 marks each).

Attempt ALL questions.

Answer the questions in the spaces provided.

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

**16.**

| | *Oxide of sodium* | *Oxide of sulfur* |
|---|---|---|
| Formula | | |
| Type of bonding | | |
| Litmus colour in aqueous solution | | |

**17.** .....

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**18.** (a)

(b) (i) .....

(ii) .....

EXAMINER'S USE ONLY

**19.** (a)

(b)

**20.** (a) .....

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(b) .....

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EXAMINER'S USE ONLY

**21.** (a) .....

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(b) (i) .....

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(ii) .....

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**22.** (a) .....

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(b) .....

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EXAMINER'S USE ONLY

**23.** (a) .....

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(b) (i) .....

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(ii) .....

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EXAMINER'S USE ONLY

**24.** (a)

(b) .....

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**25.** (a) .....

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(b) .....

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# 1996

# CHEMISTRY

## 2 UNIT

## 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.

**EXAMINER'S USE ONLY**

| PART | Mark | Examiner | Check |
|---|---|---|---|
| C | | | |

EXAMINER'S USE ONLY

## PART C

Questions 26 to 31 (5 marks each).

Attempt ALL questions.

Answer the questions in the spaces provided.

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

**26.** (a) .....

.....

(b) Name .....

(c) .....

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(d) .....

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EXAMINER'S USE ONLY

**27.** (a) .....

(b) (i) .....

(ii) .....

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(c) .....

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(d) .....

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**28.** (a) (i) .....

.....

(ii) .....

(b) .....

.....

.....

(c) .....

.....

.....

.....

EXAMINER'S USE ONLY

**29.** (a) .....

(b)

(c) .....

(d) .....

(e) .....

.....

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**30.** (a) .....

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(b) .....

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(c) .....

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(d) .....

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(e) .....

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EXAMINER'S USE ONLY

**31.** (a) .....

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(b) (i)

(ii)

(iii)

(c) .....

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