BOARD OF STUDIES
NEW SOUTH WALES

HIGHER SCHOOL CERTIFICATE EXAMINATION

1999
CHEMISTRY
2 UNIT

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

DIRECTIONS TO CANDIDATES

- Board-approved calculators may be used.

Section I—Core

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

Section II—Electives

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

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

SECTION I—CORE

(75 Marks)

Attempt ALL questions.

PART A

Attempt ALL questions.

Each question is worth 1 mark.

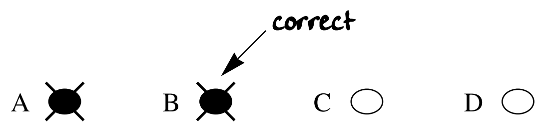
Instructions for answering multiple-choice questions

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

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

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

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



1 For each move down group I in the periodic table, the number of *valence* electrons

(A) remains constant.

(B) increases by 1.

(C) increases by 2, then 8, then 18, then 32.

(D) changes in an unpredictable manner.

2 What is the electronic configuration of the sulfide ion?

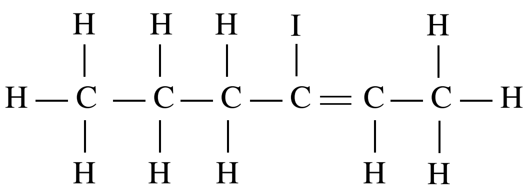
(A) $1s^2\ 2s^2\ 2p^6$

(B) $1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^2$

(C) $1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^4$

(D) $1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6$

3 What is the IUPAC name for the compound whose structure is given below?



(A) 4-iodo-4-hexene

(B) 3-iodo-2-hexene

(C) 4-iodo-5-hexene

(D) 2-iodo-2-hexene

4 Which of the following 0·1 mol L^{-1} aqueous solutions has the highest pH?

(A) Glucose

(B) Ammonium sulfate

(C) Sodium chloride

(D) Ammonia

5 In ultraviolet light, fluorine molecules dissociate into fluorine atoms.

$$F_2(g) \rightleftharpoons 2F(g)$$

The concentrations at equilibrium are

$$[F_2] = 1{\cdot}0 \times 10^{-2} \text{ mol L}^{-1}$$
$$[F] = 3{\cdot}0 \times 10^{-4} \text{ mol L}^{-1}$$

What is the correct value for the equilibrium constant?

(A) $9{\cdot}0 \times 10^{-6}$

(B) $3{\cdot}0 \times 10^{-2}$

(C) $6{\cdot}0 \times 10^{-2}$

(D) $1{\cdot}1 \times 10^{5}$

6 The pH of 0·1 mol L^{-1} hydrochloric acid (HCl) is about 1·0 and the pH of 0·1 mol L^{-1} phosphoric acid (H_3PO_4) is about 1·6.

The pH of the phosphoric acid solution is higher because

(A) HCl dissociates more fully than H_3PO_4 in water.

(B) H_3PO_4 has more hydrogen atoms.

(C) HCl is a weaker acid than H_3PO_4.

(D) H_3PO_4 is amphiprotic in water.

7 Chlorine gas is added to 2-pentene in the dark.

What is the major organic product?

(A) $Cl—CH_2—CH_2—CH_2—CH_2—CH_2—Cl$

(B) $CH_3—CH_2—CH_2—CH(Cl)—CH_3$ (Cl on the fourth carbon)

(C) $CH_3—CH_2—CH(Cl)—CH(Cl)—CH_3$ (Cl on the third and fourth carbons)

(D) $CH_3—CH_2—CH(Cl)—CH_2—CH_3$ (Cl on the third carbon)

8 Consider the reaction:

$$2A(s) + 3B(l) \rightleftharpoons C(aq) + 4D(aq)$$

Which of the following is the correct expression for the equilibrium constant?

(A) $\dfrac{[A]^2[B]^3}{[C][D]^4}$

(B) $[C][D]^4$

(C) $\dfrac{[C][4D]}{[2A][3B]}$

(D) $\dfrac{[C][D]^4}{[A]^2[B]^3}$

9 2-Butanol is heated under reflux with acidified potassium dichromate solution.

What is the major organic product?

(A) butanal

(B) butyl butanoate

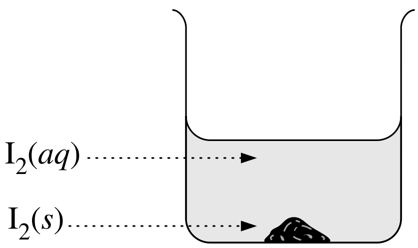
(C) butanone

(D) butanoic acid

10 Iodine is a solid that forms a brown solution in water.

$$I_2(s) \rightleftharpoons I_2(aq)$$

The system is at equilibrium.



Adding more solid iodine will

(A) make the solution darker brown.

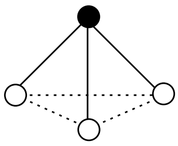
(B) make the solution lighter brown.

(C) have no effect on the equilibrium.

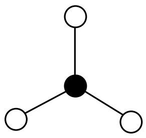
(D) result in an increase in the concentration of $I_2(aq)$.

11 The shapes of four gaseous molecules are shown below.

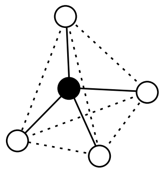
Which gas would have the strongest dipole–dipole interactions?

(A) 

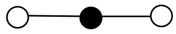
NH_3

(B) 

BBr_3

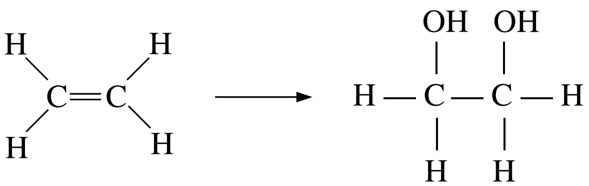
(C) 

CH_4

(D) 

CO_2

12 The following equation represents an oxidation reaction of ethene.



The best conditions for this reaction are

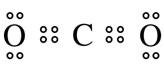
(A) hot, acidified $K_2Cr_2O_7$

(B) cold, alkaline $KMnO_4$

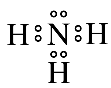
(C) O_2 + spark

(D) H_2O/H^+

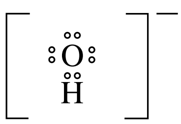
13 Which of the following chemical species contains a coordinate covalent bond?

(A) 

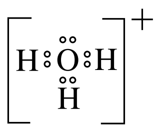
carbon dioxide

(B) 

ammonia

(C) 

hydroxide ion

(D) 

hydronium ion

14 At 25°C, the pH of a 0·050 mol L^{-1} $Ba(OH)_2$ solution is

(A) 1·0

(B) 1·3

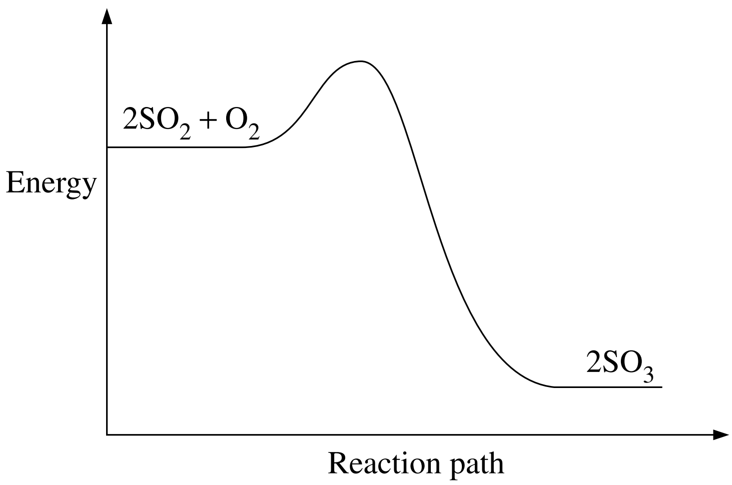
(C) 12·7

(D) 13·0

15 Sulfur trioxide (SO_3) is used industrially to prepare sulfuric acid. It is formed by combining sulfur dioxide (SO_2) with an excess of air. Vanadium pentoxide (V_2O_5) may be used as a catalyst for this reaction.

$$2SO_2(g) + O_2(g) \overset{V_2O_5}{\rightleftharpoons} 2SO_3(g)$$

The energy profile for this reaction is shown below.



Which of the following would alter the equilibrium in favour of the formation of sulfur trioxide AND also increase the rate of reaction?

(A) Decreasing the volume of the reaction vessel at constant temperature.

(B) Increasing the temperature of the reaction vessel at constant pressure.

(C) Decreasing the temperature of the reaction vessel at constant pressure.

(D) Increasing the amount of vanadium pentoxide.

PART B

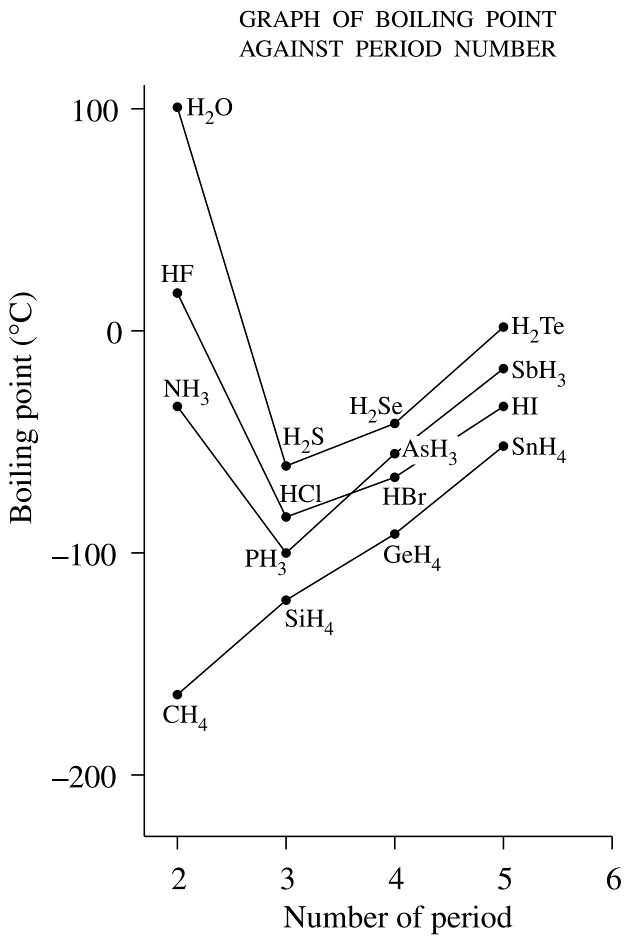
Attempt ALL questions.

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 The graph shows the boiling points of four sets of hydrides with similar formulae.



Ramsden, EN,
A Level Chemistry,
Stanley Thorne,
Cheltenham, 1985.

In the set CH_4, SiH_4, GeH_4 and SnH_4, the boiling points increase with increasing period number. However, the hydrides NH_3, H_2O and HF have boiling points much higher than would be expected from the trends shown by the other members of their set.

(a) In general, what forces have to be overcome for boiling to occur in the hydrides shown in the graph?

(b) Why do the boiling points increase with increasing period number in the CH_4 set?

(c) Why are the boiling points much higher than expected for NH_3, H_2O and HF?

17 Potassium hydrogen phosphate (K_2HPO_4) forms an amphiprotic species in water that is involved in the buffering of living cells.

(a) Write an equation showing how HPO_4^{2-} can act as an acid in water.

(b) Write an equation showing how HPO_4^{2-} can act as a base in water.

(c) From ONE of your equations above, identify a conjugate pair.

18 Phosphorus trichloride (PCl_3) reacts with chlorine (Cl_2) to produce phosphorus pentachloride (PCl_5).

$$PCl_3(g) + Cl_2(g) \rightleftharpoons PCl_5(g)$$

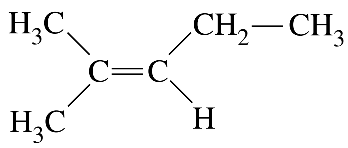
Consider this system at equilibrium.

(a) Compare the rate of the forward reaction with the rate of the reverse reaction.

(b) If the gases are in a sealed container and the volume is suddenly increased, explain any shift in the *equilibrium position*.

(c) If the temperature is kept constant as more $Cl_2(g)$ is added, what effect will this have on the *equilibrium constant*?

19 An alkene has the following structure.



(a) Give the systematic name of the alkene.

(b) Oxidation of the alkene with hot acidic potassium permanganate produces two organic products. Give the structural formulae of these two products.

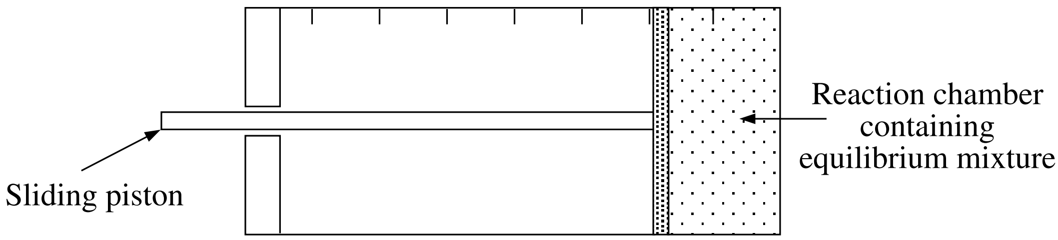
20 Propanoic acid gives Swiss cheese its characteristic 'nutty' flavour. Its concentration is important in the quality of the cheese. The pH of a 0·200 mol L^{-1} solution of propanoic acid is 2·78.

Calculate the value of its K_a under the same conditions. Show all working.

21 A student investigated the equilibrium system involving brown nitrogen dioxide (NO_2) and colourless dinitrogen tetroxide (N_2O_4).

$$\underset{\text{brown}}{2NO_2(g)} \rightleftharpoons \underset{\text{colourless}}{N_2O_4(g)}$$

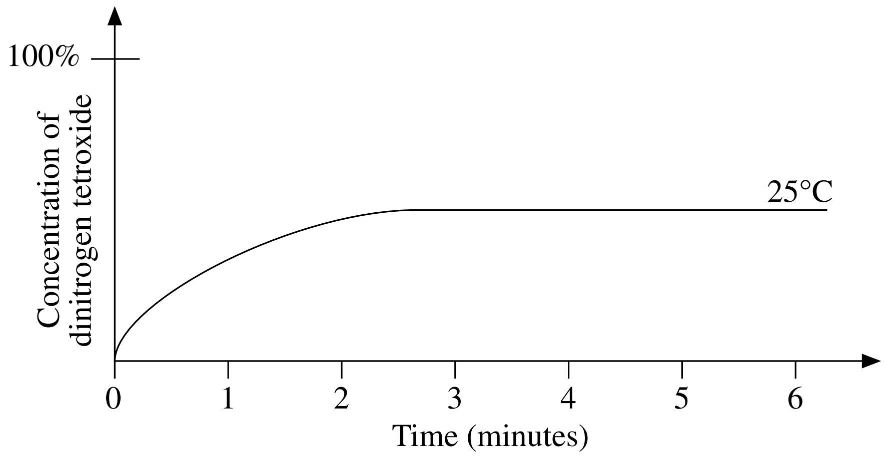
Nitrogen dioxide gas was placed into a reaction chamber as shown and allowed to reach equilibrium.



The colour of the equilibrium mixture was compared under different reaction conditions.

Temperature (°C)	*Pressure* (kPa)	*Colour*
0	1·0	light brown
25	1·0	brown
100	1·0	dark brown

The graph represents the change in concentration of N_2O_4 as the reaction proceeds to equilibrium at 25°C.



(a) On graph (a) in the Part B Answer Book, sketch another curve showing the change in concentration of N_2O_4 as the reaction proceeds to equilibrium at 100°C.

(b) On graph (b) in the Part B Answer Book, continue the curve to show the change in concentration of N_2O_4 if the piston had been compressed after three minutes.

22 In their liquid states, Cl_2, HF and CO each have different dominant intermolecular forces.

(a) In the table provided in the Part B Answer Book, match each molecule given above with its dominant intermolecular force.

(b) List the types of intermolecular forces in order of increasing strength.

(c) What type of intermolecular force is dominant in carbon tetrachloride (tetrahedral shape)?

23 Acetic (ethanoic) acid is an organic acid.

(a) Give the structural formula for acetic acid.

(b) On your structural formula, circle any acidic hydrogen.

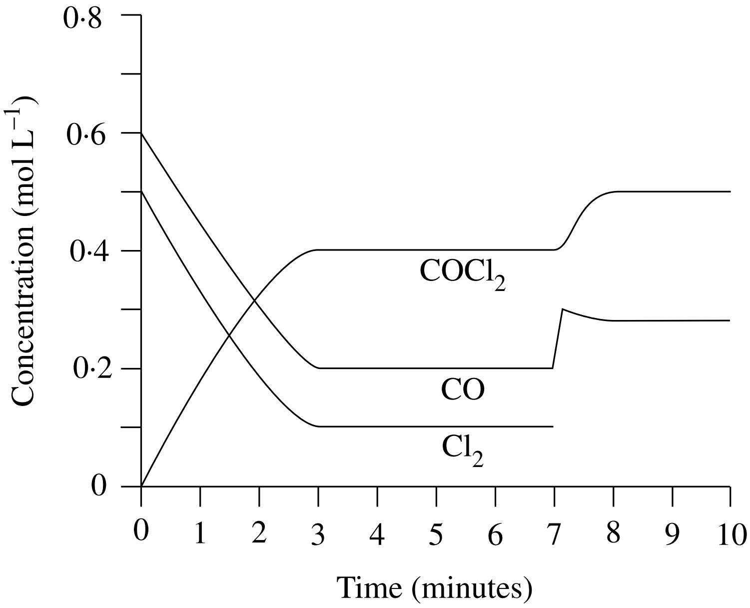
(c) Acetic acid that has been diluted with water causes dry, blue litmus paper to turn red. However, pure (glacial) acetic acid does not cause a colour change with dry, blue litmus paper. Explain this observation.

Please turn over

24 Phosgene is produced from chlorine and carbon monoxide according to the equation:

$$CO(g) + Cl_2(g) \rightleftharpoons COCl_2(g)$$

When CO and Cl_2 are mixed in the presence of activated carbon, the concentrations of each gas change according to the graph below.



(a) Calculate a value for the equilibrium constant.

(b) The change in concentration of chlorine after 7 minutes is not shown on this graph.

(i) What was added at 7 minutes?

(ii) Predict the effect of this addition on the concentration of Cl_2. A calculation is not required.

25 Sodium reacts violently with water to produce hydrogen gas in a strongly exothermic reaction.

0·23 g of sodium was placed carefully in 100 mL of water containing 3 drops of phenolphthalein indicator. The resulting solution was pink in colour.

(a) Write a balanced chemical equation to show the reaction that occurred between the water and the sodium.

(b) Calculate the pH of the solution that resulted from the addition of 0·23 g of sodium to 100 mL of water at 25°C.

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

SOME PROPERTIES OF WATER, CARBON MONOXIDE AND FLUORINE			
Property	*Water*	*Carbon monoxide*	*Fluorine*
Shape of molecule	bent	linear	linear
Polarity	polar	polar	non-polar
Melting point (°C)	0	–205	–220

Use the information from the table as well as your own knowledge of structure and bonding to answer the following questions.

(a) Explain the difference in polarity of water and fluorine.

(b) Explain the differences in melting points of the three molecular substances in terms of intermolecular bonding.

27 In your study of Equilibrium, you have completed a practical study in which you measured the equilibrium constant of a system.

For the system you studied:

(a) name or briefly describe the system;

(b) write a balanced equation (including states) for this equilibrium system;

(c) write an expression for the equilibrium constant of this system;

(d) describe clearly how you measured the concentration of each species in your equilibrium expression.

28 Use the table to answer parts (a), (b) and (c).

SOME COMMON ACID–BASE INDICATOR pH RANGES		
Name	*Colour* low pH–high pH	*pH range*
Cresol red	red–yellow	0·2–1·8
Thymol blue	red–yellow	1·2–2·8
Methyl orange	red–yellow	3·1–4·4
Methyl red	pink–yellow	4·4–6·2
Litmus	red–blue	5·0–8·0
Phenol red	yellow–red	6·8–8·4
Phenolphthalein	colourless–red	8·3–10·0

(a) The equivalence point in a titration between 0·10 mol L^{-1} HCl(*aq*) and 0·10 mol L^{-1} NH_3(*aq*) occurs at about pH 5·5.

(i) Give ONE reason why phenolphthalein is not a suitable indicator.

(ii) Select an indicator you would expect to be suitable and explain your decision.

(b) From the data, suggest a reason why litmus is not widely used in volumetric analyses.

(c) Sketch the expected titration curve when an excess of 0·10 mol L^{-1} hydrochloric acid is added to 0·10 mol L^{-1} ammonia.

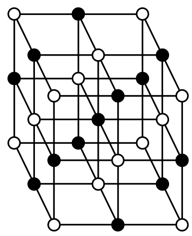
29 Propyl acetate (propyl ethanoate) is formed by heating an alkanol and an alkanoic acid under reflux in the presence of a trace of sulfuric acid.

(a) Draw a labelled diagram of the apparatus required to perform this reaction.

(b) Give the structural formula of the alkanol.

(c) Propyl acetate is insoluble in water. Explain how it may be separated from the reaction mixture without distillation.

30 The arrangement of potassium ions and fluoride ions in solid potassium fluoride is represented in the following diagram. The arrangement extends in three dimensions to represent a crystal.



KEY
● = K^+
○ = F^-

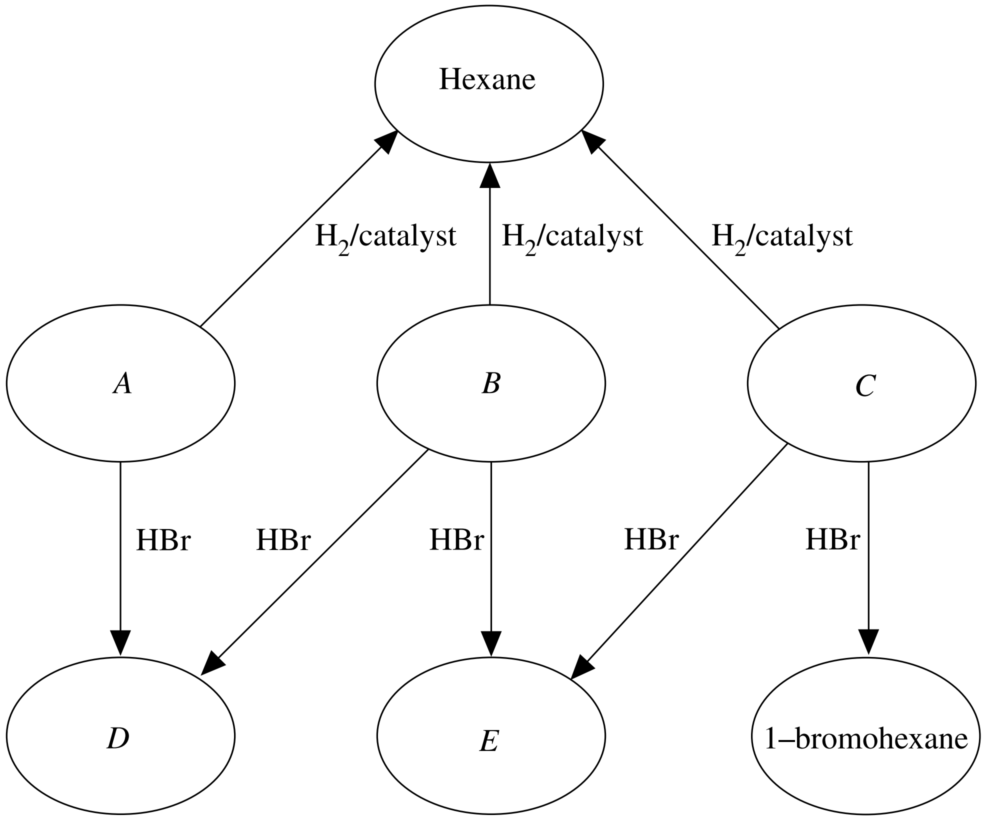
(a) What is the empirical formula of potassium fluoride?

(b) Would it be possible for magnesium fluoride to have the same structure as potassium fluoride? Explain your answer.

(c) In terms of the bonds involved, explain why potassium fluoride has a much higher melting point (857°C) than carbon tetrafluoride (–184°C).

(d) Aqueous potassium fluoride is a good conductor of electricity, while solid potassium fluoride is not. Explain.

31 *A*, *B* and *C* are three isomers of molecular formula C_6H_{12}. When they are treated with hydrogen and a catalyst, each produces hexane. When they are treated with HBr, three different compounds *D*, *E* and 1-bromohexane are produced, according to the diagram.



Draw structural formulae for *A*, *B*, *C*, *D* and *E*.

SECTION II—ELECTIVES

(25 Marks)

Attempt ONE question.

Answer the question in a SEPARATE Elective Answer Book.

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

QUESTION 32 Chemical Energy **Marks**

(a) Nitroglycerine ($C_3H_5(NO_3)_3$) is an unstable compound used as an explosive. It explodes according to the following equation. **5**

$$4C_3H_5(NO_3)_3(l) \rightarrow 12CO_2(g) + 10H_2O(g) + 6N_2(g) + O_2(g)$$

(i) Is ΔH for this reaction positive or negative? Explain.

(ii) 22·7 grams of nitroglycerine was exploded in a sealed 2·00 L container. What pressure would the products exert at a temperature of 500°C?

(b) As part of your practical work, you have performed an experiment to discover how the volume of a sample of gas depends on pressure if the temperature is kept constant. **4**

(i) Briefly describe how you carried out this experiment. A diagram may be used in your answer.

(ii) On appropriately labelled axes, sketch a graph showing the results that would be expected from such an experiment.

(c) The formation of ammonia gas from its elements is an exothermic process, with 46 kJ of energy released for each mole of ammonia formed. **4**

(i) Write an equation, including a ΔH term, for the formation of ammonia gas.

(ii) The table shows average bond enthalpies at 25°C.

Bond	*Average bond enthalpy* (kJ mol^{-1})
H—H	436
N≡N	945

Use the data provided in this question to determine the enthalpy change when one mole of N—H bonds forms.

Question 32 continues on page 19

QUESTION 32 (Continued) **Marks**

(d) The data below show the enthalpy of combustion ($\Delta_c H^\ominus$) for ethanol and octane. **5**

Fuel	$\Delta_c H^\ominus$ (kJ mol^{-1})	*Molar mass* (g mol^{-1})
Ethanol	–1367	46·1
Octane	–5470	114·2

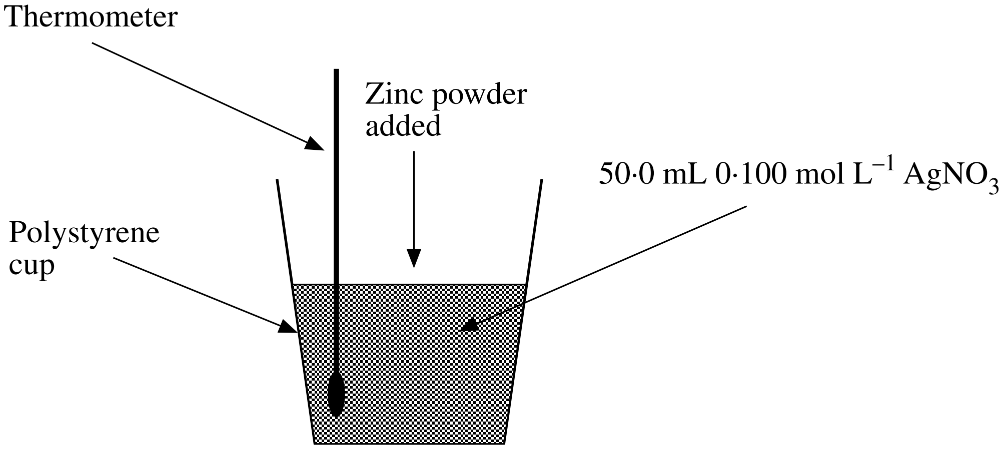
(i) What is the amount of energy given out per gram of ethanol?

(ii) What are TWO advantages of using ethanol as a fuel instead of octane?

(iii) Write a balanced equation showing a combustion reaction between ethanol and air where the fuel : air ratio is too high.

(iv) The ignition temperature of octane is 390°C. What is meant by the term *ignition temperature* in relation to a fuel?

(e) An excess of zinc powder was added to 50·0 mL of 0·100 mol L^{-1} $AgNO_3$ in a polystyrene cup. Initially the temperature of the solution was 21·10°C and during the reaction it rose to 25·40°C. **3**



Assume the density of the solution is 1·00 g mL^{-1} and its specific heat capacity is 4·18 J g^{-1} K^{-1}.

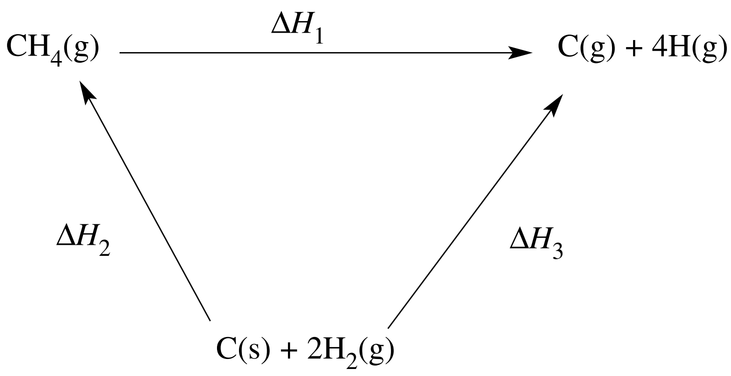
Ignoring the heat capacity of the metals, calculate the enthalpy change for the reaction:

$$Zn(s) + 2Ag^+(aq) \rightarrow Zn^{2+}(aq) + 2Ag(s)$$

Question 32 continues on page 21

QUESTION 32 (Continued) **Marks**

(f) ΔH_1, ΔH_2 and ΔH_3 are energy values for steps in the energy cycle below. **4**



Given the following standard enthalpies:

- formation of methane = –74 kJ mol^{-1}
- atomisation of carbon = +717 kJ mol^{-1}
- atomisation of hydrogen = +218 kJ mol^{-1}

(i) which enthalpy is represented by ΔH_2?

(ii) calculate ΔH_3;

(iii) determine ΔH_1.

End of question

QUESTION 33 Oxidation and Reduction **Marks**

(a) The equation for the redox reaction between zinc and chlorine is shown below. **2**

$$Zn(s) + Cl_2(g) \rightarrow ZnCl_2(s)$$

(i) Explain why this reaction is classified as an oxidation–reduction reaction.

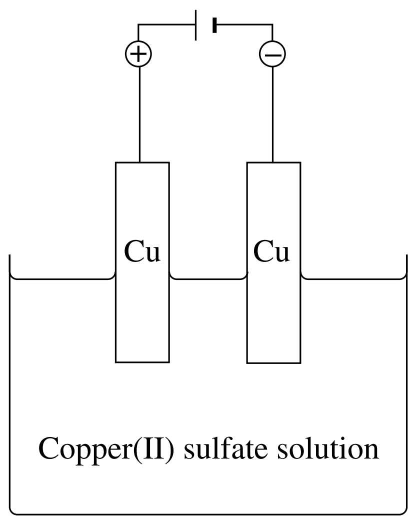
(ii) Which reactant is the reducing agent? Explain your answer.

(b) A piece of magnesium is immersed in a copper(II) sulfate solution. **3**

(i) Describe TWO changes you would see.

(ii) Write the net ionic equation for the overall reaction.

(c) Pure copper is required for electrical purposes. The final purification of extracted copper is by electrolysis. An electric current is passed into an aqueous copper(II) sulfate solution with copper electrodes. The diagram shows the electrolysis cell before the current flows. **3**



(i) Draw and label the appearance of this cell after the current has been flowing for some time.

(ii) Explain what is happening at each electrode, using relevant half-equations.

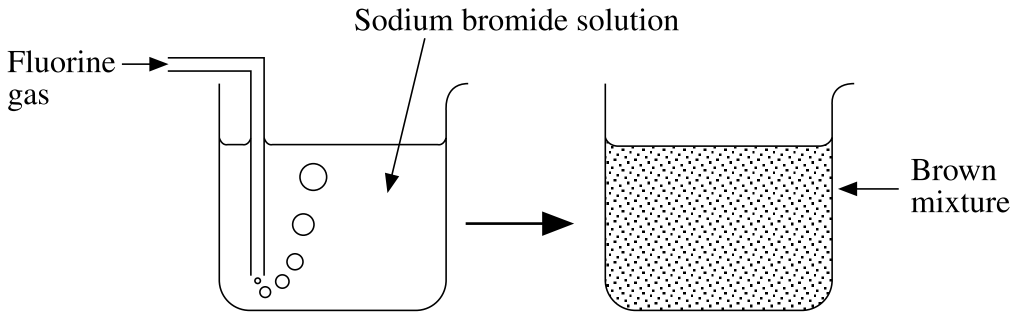
Question 33 continues on page 22

QUESTION 33 (Continued) **Marks**

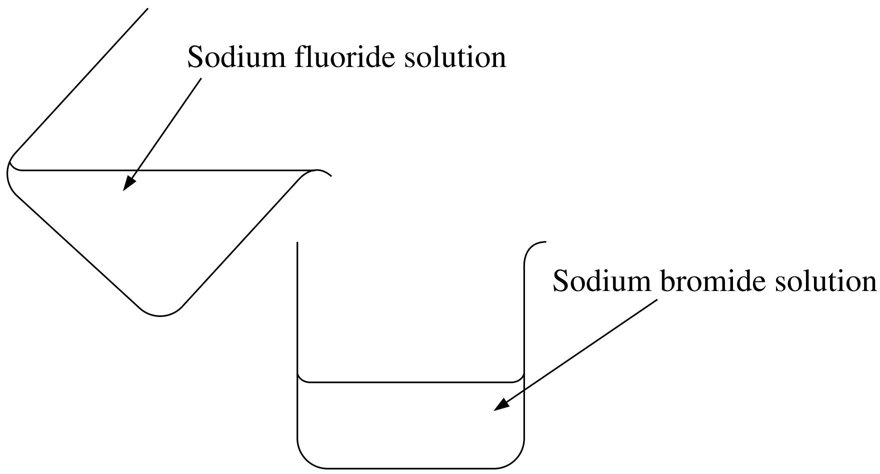
(d) Two experiments were carried out. In the first, fluorine gas was bubbled through a colourless solution of sodium bromide. The solution turned brown. **3**

In the second experiment, sodium fluoride solution was added to sodium bromide solution.

Experiment 1:



Experiment 2:



(i) Write a balanced ionic equation to describe the reaction that took place in Experiment 1.

(ii) Explain the colour change that occurred during Experiment 1.

(iii) What would you expect to happen when sodium fluoride solution is added to sodium bromide solution? Explain your answer.

Question 33 continues on page 23

QUESTION 33 (Continued) **Marks**

(e) An electrochemical cell was set up using two half-cells. One of the half-cells consisted of aluminium metal and aluminium sulfate solution. The other half-cell consisted of zinc metal and zinc sulfate solution. **7**

(i) Draw a labelled diagram of the complete electrochemical cell including the direction of electron flow.

(ii) Write a balanced ionic equation for the reaction that occurs in the electrochemical cell. Show relevant half-equations.

(iii) Calculate the theoretical cell voltage for the electrochemical cell using the data provided.

(iv) A student who set up this cell measured the cell voltage to be 0·65 V. Suggest a reason for the difference between the theoretical and experimental cell voltages.

(f) Ships are generally made of steel. A major component of steel is iron, which will rust readily in sea water. One method used to prevent rusting of ships is to paint them. **2**

(i) Outline another method that can be used to prevent the iron in ships from rusting.

(ii) Explain how this method prevents ships from rusting.

(g) The following *unbalanced* equation partially describes the process that occurs when potassium bromate solution, $KBrO_3$, is mixed with oxalic acid, $(COOH)_2$. **5**

$$BrO_3^-(aq) + (COOH)_2(aq) \rightarrow Br^-(aq) + CO_2(g)$$

(i) What is the oxidation number of bromine in the bromate ion?

(ii) Which species is being oxidised?

(iii) Write the balanced oxidation half-equation.

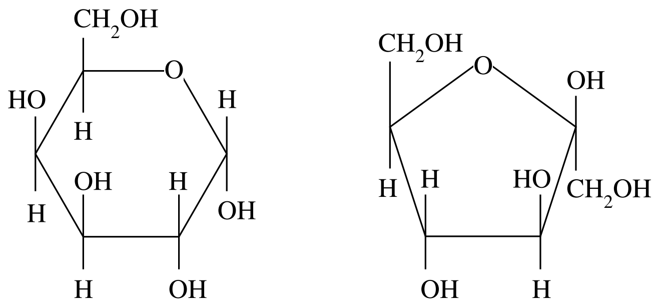
(iv) Write the balanced reduction half-equation.

(v) Write the balanced overall equation for the reaction.

End of question

QUESTION 34 Biological Chemistry **Marks**

(a) Three monosaccharides are shown below. **7**



I II III

(i) Which of these monosaccharides make up the structure of the disaccharide found in:

1 milk?

2 malt?

(ii) A colourless solution is believed to contain sucrose. How could you confirm this chemically?

(iii) What is the basic difference between glycogen and cellulose?

(iv) Give TWO properties of cellulose that make it useful for clothing.

(b) (i) What is the difference between aerobic and anaerobic glycolysis? **7**

(ii) What role do cytochromes play in the metabolism of glucose?

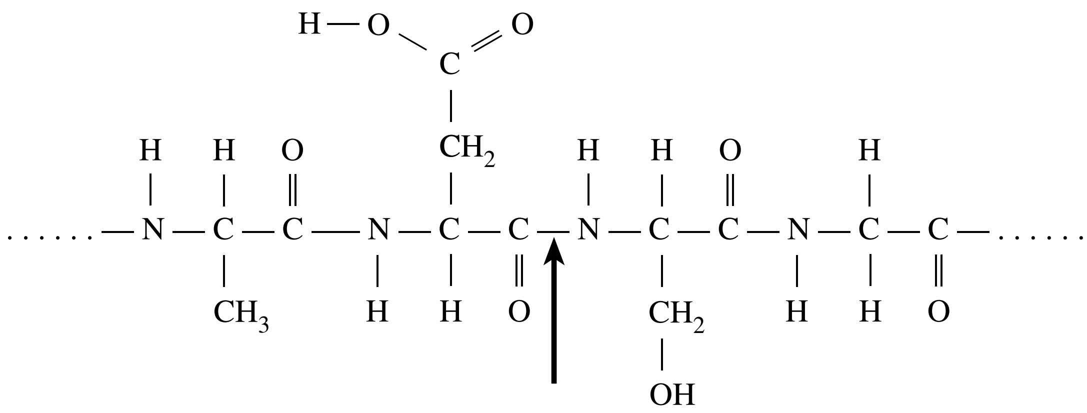
(iii) What is meant by the *light reaction of photosynthesis*?

(iv) How much glucose is produced from 1000 kg of water during photosynthesis?

Question 34 continues on page 25

QUESTION 34 (Continued) **Marks**

(c) The diagram is a representative section of a protein showing four units. **11**



(i) What units make up proteins?

(ii) Draw a general formula for one of the units in part (i) as a zwitterion.

(iii) What type of bond is indicated by the arrow?

(iv) Give an example of a secondary structure found within a protein.

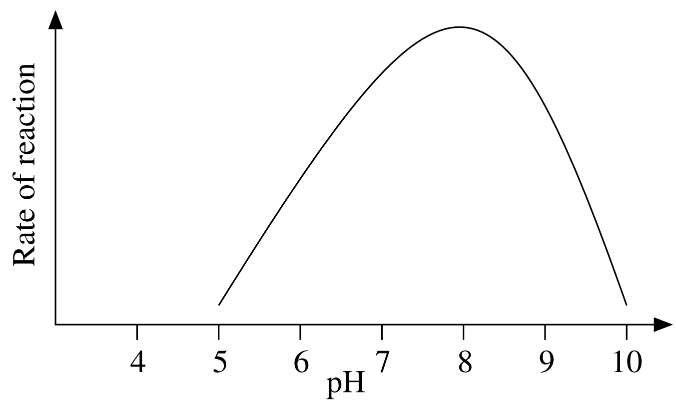
(v) What types of bonds hold the tertiary structure of proteins together?

Caspase-3 is an enzyme. It can break the bond indicated by the arrow in the diagram above. It cannot break any other bond shown.

(vi) What are *enzymes*?

(vii) Why would this enzyme break only this particular bond?

The graph shows the rate of reaction of caspase-3 relative to pH.



(viii) What is the optimum pH for caspase-3?

(ix) Above pH 10 there is no activity. What has happened to the enzyme?

(x) What other method could be used to produce this change in enzyme activity?

End of question

QUESTION 35 Chemistry and the Environment **Marks**

(a) Uranium is exported to Europe primarily in the form of *yellowcake*. **6**

(i) What is the chemical formula for *yellowcake*?

(ii) State ONE hazardous gaseous by-product associated with uranium mining.

(iii) The *yellowcake* is converted into uranium hexafluoride to separate the U-235 from U-238. Describe briefly the process used to separate the isotopes.

(iv) The U-235 enriched uranium is converted to uranium dioxide. Give TWO uses of the uranium dioxide.

(b) The Rum Jungle uranium mine was closed over ten years ago. However, the mine tailings (spent uranium ore) contain large amounts of pyrites. Bacteria break down pyrites into metal ions and sulfuric acid. These waste products end up in the Finniss River. **6**

(i) If the tailings produce $1{\cdot}0 \times 10^9$ L of $0{\cdot}15$ mol L^{-1} sulfuric acid every year, how many tonnes of slaked lime (calcium hydroxide) should be added per year to neutralise the acid? (1 tonne = 1000 kg)

(ii) Why should the drainage from the mine tailings be neutralised?

(iii) The sulfuric acid also releases metal ions such as zinc and copper.

1 These should also be removed from the mine drainage. Why?

2 How could this be done?

Question 35 continues on page 27

QUESTION 35 (Continued) **Marks**

(c) Samples of water were taken from a creek over one week. The samples were taken every second day at 8.00 am. The results for these tests are shown below. **6**

Parameter	*Day 1*	*Day 3*	*Day 5*	*Day 7*
pH	7·5	7·4	7·5	7·4
Relative turbidity	5·5	4·9	17·3	13·5
Temperature (°C)	17	15	15	16
Dissolved oxygen (mg/L)	9·0	11·0	13·0	8·8
Faecal coliforms (CFU/100 mL)	1000	1100	320	300
Total nitrates (mg/L)	4·5	5·2	12·3	4·2
Sodium chloride (mg/L)	200	250	250	240

(i) Suggest a reason for the increase in turbidity between Day 3 and Day 5. Justify your answer with reference to one other parameter.

(ii) Suggest a reason for the increase in dissolved oxygen between Day 1 and Day 3. Justify your answer with reference to one other parameter.

(iii) Describe how you would perform the test for faecal coliforms.

(iv) The sodium chloride concentration was calculated by adding excess silver nitrate solution to a 50·0 mL sample of creek water. On Day 1, what mass of silver chloride would be formed from the sample?

(d) (i) Chlorofluorocarbons and carbon dioxide are *greenhouse gases*. **7**

1 What is meant by the term *greenhouse gas*?

2 How do *greenhouse gases* produce their effect?

3 Give an example of another *greenhouse gas*.

(ii) Give an equation to show how acid rain could form.

(iii) Draw a diagram to show the processes that occur in the nitrogen cycle.

End of paper

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CHEMISTRY DATA SHEET

Values of several numerical constants

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

Some standard potentials

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

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

PERIODIC TABLE

KEY

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