Student Number	
Mark / 35	

Chemistry

Preliminary Course

Final Examination • 2005

General Instructions

- Reading time – 5 minutes
- Working time – 50 minutes
- Write using black or blue pen
- Draw diagrams using pencil
- Board-approved calculators may be used
- A Data Sheet and a Periodic Table are provided at the back of this paper and may be removed for convenience
- Write your Student Number at the top of this page

Total Marks – 35

Part A – 9 marks
- Attempt Questions 1 – 9
- Allow about 10 minutes for this part

Part B – 26 marks
- Attempt Questions 10 – 19
- Allow about 40 minutes for this part

Part A – 9 marks
Attempt Questions 1 – 9
Allow about 10 minutes for this part

Select the alternative A, B, C or D that best answers the question. Fill in the response oval completely.

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

A ○ B ● C ○ D ○

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

A ● B ✗ C ○ D ○

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

correct

A ✗ B ✗ C ○ D ○

Answer Box for Questions 1 – 9				
1	**A** ○	**B** ○	**C** ○	**D** ○
2	**A** ○	**B** ○	**C** ○	**D** ○
3	**A** ○	**B** ○	**C** ○	**D** ○
4	**A** ○	**B** ○	**C** ○	**D** ○
5	**A** ○	**B** ○	**C** ○	**D** ○
6	**A** ○	**B** ○	**C** ○	**D** ○
7	**A** ○	**B** ○	**C** ○	**D** ○
8	**A** ○	**B** ○	**C** ○	**D** ○
9	**A** ○	**B** ○	**C** ○	**D** ○

► ***Mark your answers for Questions 1 – 9 in the Answer Box on page 2.***

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1 Study the reaction… $H_{2\,(g)} + Cl_{2\,(g)} \rightarrow 2HCl_{(g)}$

Which of the statements cannot apply to this reaction?

(A) One gram of H_2 reacts with one gram of Cl_2 to produce 2 grams of HCl.
(B) One molecule of H_2 reacts with one molecule of Cl_2 to produce 2 molecules of HCl.
(C) One litre of H_2 reacts with one litre of Cl_2 to produce 2 litres of HCl at constant conditions.
(D) One mole of H_2 reacts with one mole of Cl_2 to produce 2 moles of HCl.

2 Which of the production sequences shows the extraction of copper from its ore to 99.9% pure copper?

(A) forth flotation → crushing and grinding → smelting → electrolysis
(B) crushing and grinding → froth flotation → smelting → electrolysis
(C) crushing and grinding → smelting → froth flotation → electrolysis
(D) smelting → crushing and grinding → froth flotation → electrolysis

3 Which of the following may **not** be a consequence of thermal pollution in water?

(A) Reduction in dissolved oxygen.
(B) Disruption of aquatic organisms breeding cycles.
(C) Out of season migration of aquatic fauna.
(D) Decrease in salt concentration.

4 At 100 kPa and 25°C, 4 litres of oxygen gas contain 1×10^{21} molecules.
Which of these gas samples also contains 1×10^{21} molecules under the same conditions?

(A) 1 L of NH_3
(B) 2 L of Cl_2
(C) 4 L of CO_2
(D) 8 L of He

5 To which reaction can Gay–Lassac's law be applied?

(A) $2H_{2\,(g)} + O_{2\,(g)} \rightarrow 2H_2O_{(g)}$
(B) $2H_2O_{(l)} \rightarrow 2H_{2\,(g)} + O_{2\,(g)}$
(C) $2H_2O_{(l)} + 2Na_{(s)} \rightarrow 2Na^+_{(aq)} + 2OH^-_{(aq)} + H_{2\,(g)}$
(D) $H^+_{(aq)} + OH^-_{(aq)} \rightarrow H_2O_{(l)}$

6 Which property accounts for the moderate viscosity of water?

(A) Specific heat capacity
(B) Hydrogen bonding
(C) Density
(D) Boiling point

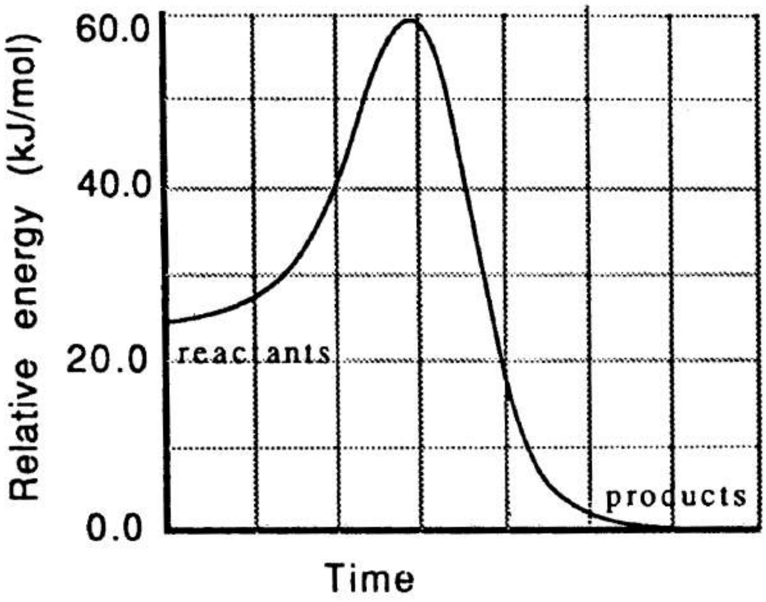
7 Metals X, M, Z and D are all very useful metals. The table shows selected properties of the metals…

Property	*X*	*M*	*Z*	*D*
Ionisation energy (kJ mol $^{-1}$)	584	751	896	766
Percentage Abundance in Earth's Crust	8	0.07	0.00001	0.07

Use the data to list the metals according to increasing market price.

(A) X < M < D < Z
(B) D < X < Z < M
(C) X < Z < M < D
(D) Z < D < M < X

Answer Questions 8 and 9 using this reaction pathway diagram…



8 Which statement correctly describes this reaction?

(A) The reaction is endothermic and the surroundings will become cooler.
(B) The reaction is exothermic and the surroundings will become cooler.
(C) The reaction is endothermic and the surroundings will become warmer.
(D) The reaction is exothermic and the surroundings will become warmer.

9 Which statement is true if a catalyst is added to the system?

(A) ΔH remains constant and the activation energy increases.
(B) Both ΔH and activation energy decrease.
(C) ΔH remains constant and the activation energy decreases.
(D) Both ΔH and activation energy remain constant.

Part B – 26 marks
Attempt Questions 10 – 19
Allow about 40 minutes for this part

► ***Show all relevant working in questions involving calculations.***

Question 10 (3 marks)

Air bags have saved thousands of lives and are now commonly fitted in new cars. An air bag inflates very rapidly by producing nitrogen gas from the decomposition of 100 grams of sodium azide…

$$2NaN_{3\,(s)} \rightarrow 2Na_{\,(s)} + 3N_{2\,(g)}$$

(a) Calculate the moles of sodium azide originally in the air bag. **(1 mark)**

___

___

___

(b) Calculate the moles of nitrogen produced and the resultant volume at 100 kPa and 25°C. **(2 marks)**

___

___

___

___

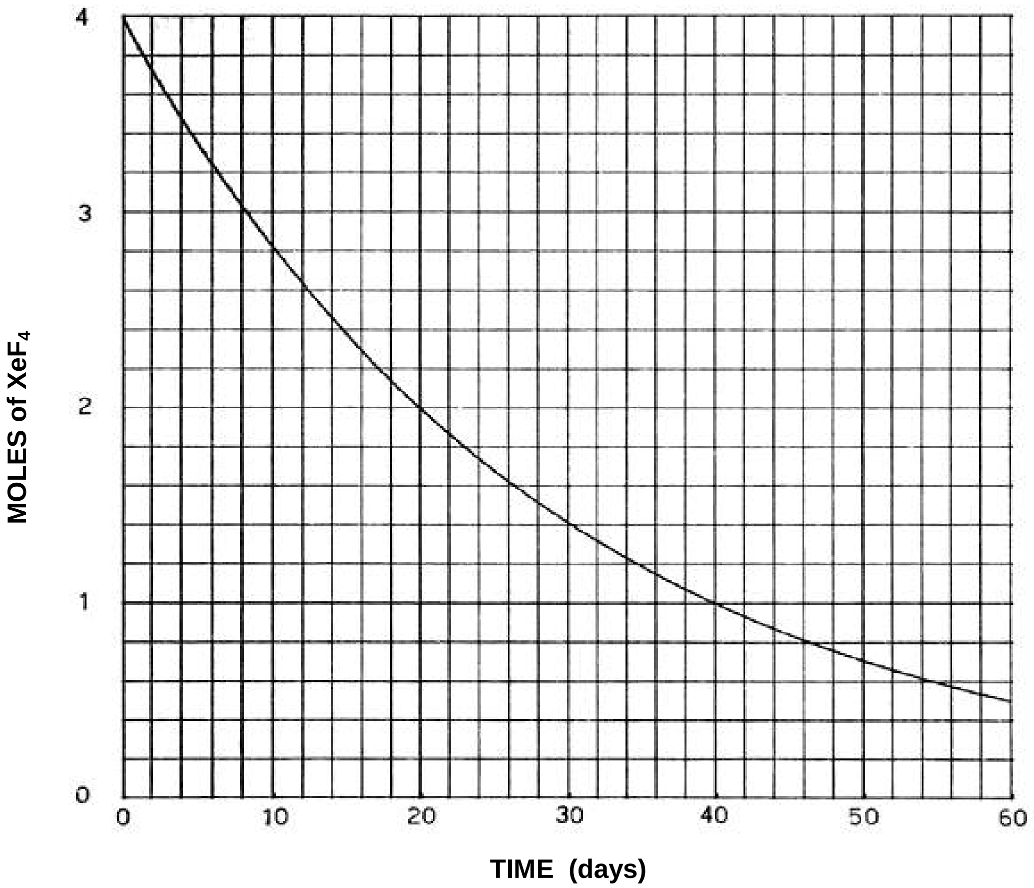
___

Question 11 (3 marks)

Xenon tetrafluoride is an unstable compound which self–decomposes…

$$XeF_{4\,(s)} \rightarrow Xe_{(g)} + 2F_{2\,(g)}$$

The graph shows the decomposition of a pure, 4 mole sample of XeF_4 over a period of 60 days.



(a) Calculate the number of moles of XeF_4 which has decomposed after 16 days. **(1 mark)**

____

(b) On which day are there equal moles of reactant and products present? **(1 mark)**

____

(c) Calculate the mass of F_2 present at 40 days. **(1 mark)**

____

____

Question 12 (2 marks)

Iron will react with hydrochloric acid and appear to “dissolve” …

$$Fe_{(s)} + 2HCl_{(aq)} \rightarrow FeCl_{2\,(aq)} + H_{2\,(g)}$$

Ken Chemiski places a 2.51 g iron nail in a beaker and prepares some dilute, 1.00 mol L^{-1} HCl.

Calculate the volume of acid required to fully react with the nail.

Question 13 (3 marks)

Héloïse prepares some beautiful golden lead(II) iodide crystals by this precipitation reaction…

$$Pb(NO_3)_{2\,(aq)} + 2KI_{(aq)} \rightarrow PbI_{2\,(s)} + KNO_{3\,(aq)}$$

She reacts 25.0 mL of 0.100 mol L^{-1} potassium iodide with excess lead(II) nitrate solution.

(a) Calculate the moles of lead(II) nitrate which reacted. **(2 marks)**

(b) Calculate the mass of PbI_2 produced. **(1 mark)**

Question 14 (3 marks)

In your studies, you performed a practical investigation to observe the effect of temperature on reaction rate. Describe your experiment, including the observed results.

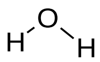
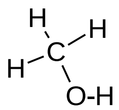
Question 15 (2 marks)

(a) Identify one pollutant produced by the incomplete combustion of an organic compound. **(1 mark)**

(b) Write a chemical equation to show the incomplete combustion of butane (C_4H_{10}). **(1 mark)**

Question 16 (2 marks)

The diagram shows liquid methanol, CH_3OH, being poured into a beaker of water.

Use the symbols,  for water and  for methanol to draw a diagram that illustrates the strongest intermolecular forces in the solution.

Question 17 (3 marks)

Outline the method required to prepare a 250 mL solution of 0.102 mol L^{-1} strontium chloride.
► *Write your answer in numbered sequential steps (1, 2, 3…).*

Question 18 (2 marks)

Tincture of iodine, a common antiseptic, is a 2% (w/w) solution of iodine in ethanol.

(a) Calculate the mass of iodine crystals is required to prepare a 250 g sample of tincture of iodine? **(1 mark)**

(b) Calculate the mass of ethanol is required? **(1 mark)**

Question 19 (3 marks)

In an experiment to measure the density of water at 28°C, an empty 100 mL measuring cylinder was found to have a mass of 150.5 grams. When 80.3 mL of water was poured into the cylinder, the mass of the cylinder and contents was 230.5 grams.

(a) Calculate the density of water at 28°C based on the data. **(1 mark)**

(b) When the measuring cylinder and water was sealed and kept inside a freezer overnight at – 10°C, the volume reading increased to 85.9 mL. Explain this observation. **(1 mark)**

(c) When water freezes it expands. Why is this process important in Nature? **(1 mark)**

HIGHER SCHOOL CERTIFICATE EXAMINATION

Chemistry

DATA SHEET

Avogadro constant, N_A .... 6.022×10^{23} mol^{-1}

Volume of 1 mole ideal gas: at 100 kPa and

at 0°C (273.15 K) .... 22.71 L

at 25°C (298.15 K) .... 24.79 L

Ionisation constant for water at 25°C (298.15 K), K_w .... 1.0×10^{-14}

Specific heat capacity of water .... 4.18×10^3 J kg^{-1} K^{-1}

Some useful formulae

$pH = -\log_{10}[H^+]$ $\Delta H = -mC\Delta T$

Some standard potentials

$K^+ + e^-$	$\rightleftharpoons$	$K(s)$	–2.94 V
$Ba^{2+} + 2e^-$	$\rightleftharpoons$	$Ba(s)$	–2.91 V
$Ca^{2+} + 2e^-$	$\rightleftharpoons$	$Ca(s)$	–2.87 V
$Na^+ + e^-$	$\rightleftharpoons$	$Na(s)$	–2.71 V
$Mg^{2+} + 2e^-$	$\rightleftharpoons$	$Mg(s)$	–2.36 V
$Al^{3+} + 3e^-$	$\rightleftharpoons$	$Al(s)$	–1.68 V
$Mn^{2+} + 2e^-$	$\rightleftharpoons$	$Mn(s)$	–1.18 V
$H_2O + e^-$	$\rightleftharpoons$	$\frac{1}{2}H_2(g) + OH^-$	–0.83 V
$Zn^{2+} + 2e^-$	$\rightleftharpoons$	$Zn(s)$	–0.76 V
$Fe^{2+} + 2e^-$	$\rightleftharpoons$	$Fe(s)$	–0.44 V
$Ni^{2+} + 2e^-$	$\rightleftharpoons$	$Ni(s)$	–0.24 V
$Sn^{2+} + 2e^-$	$\rightleftharpoons$	$Sn(s)$	–0.14 V
$Pb^{2+} + 2e^-$	$\rightleftharpoons$	$Pb(s)$	–0.13 V
$H^+ + e^-$	$\rightleftharpoons$	$\frac{1}{2}H_2(g)$	0.00 V
$SO_4^{2-} + 4H^+ + 2e^-$	$\rightleftharpoons$	$SO_2(aq) + 2H_2O$	0.16 V
$Cu^{2+} + 2e^-$	$\rightleftharpoons$	$Cu(s)$	0.34 V
$\frac{1}{2}O_2(g) + H_2O + 2e^-$	$\rightleftharpoons$	$2OH^-$	0.40 V
$Cu^+ + e^-$	$\rightleftharpoons$	$Cu(s)$	0.52 V
$\frac{1}{2}I_2(s) + e^-$	$\rightleftharpoons$	I^-	0.54 V
$\frac{1}{2}I_2(aq) + e^-$	$\rightleftharpoons$	I^-	0.62 V
$Fe^{3+} + e^-$	$\rightleftharpoons$	Fe^{2+}	0.77 V
$Ag^+ + e^-$	$\rightleftharpoons$	$Ag(s)$	0.80 V
$\frac{1}{2}Br_2(l) + e^-$	$\rightleftharpoons$	Br^-	1.08 V
$\frac{1}{2}Br_2(aq) + e^-$	$\rightleftharpoons$	Br^-	1.10 V
$\frac{1}{2}O_2(g) + 2H^+ + 2e^-$	$\rightleftharpoons$	H_2O	1.23 V
$\frac{1}{2}Cl_2(g) + e^-$	$\rightleftharpoons$	Cl^-	1.36 V
$\frac{1}{2}Cr_2O_7^{2-} + 7H^+ + 3e^-$	$\rightleftharpoons$	$Cr^{3+} + \frac{7}{2}H_2O$	1.36 V
$\frac{1}{2}Cl_2(aq) + e^-$	$\rightleftharpoons$	Cl^-	1.40 V
$MnO_4^- + 8H^+ + 5e^-$	$\rightleftharpoons$	$Mn^{2+} + 4H_2O$	1.51 V
$\frac{1}{2}F_2(g) + e^-$	$\rightleftharpoons$	F^-	2.89 V

Aylward and Findlay, *SI Chemical Data* (5th Edition) is the principal source of data for this examination paper. Some data may have been modified for examination purposes.

PERIODIC TABLE OF THE ELEMENTS

KEY

Atomic Number	79	Symbol of element
	Au	
Atomic Weight	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 47.87 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 65.41 Zinc	31 Ga 69.72 Gallium	32 Ge 72.64 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 [97.91] 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 Caesium	56 Ba 137.3 Barium	57–71 Lanthanides	72 Hf 178.5 Hafnium	73 Ta 180.9 Tantalum	74 W 183.8 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 [209.0] Polonium	85 At [210.0] Astatine	86 Rn [222.0] Radon
87 Fr [223.0] Francium	88 Ra [226.0] Radium	89–103 Actinides	104 Rf [261.1] Rutherfordium	105 Db [262.1] Dubnium	106 Sg [266.1] Seaborgium	107 Bh [264.1] Bohrium	108 Hs [277] Hassium	109 Mt [268] Meitnerium	110 Ds [271] Darmstadtium	111 Rg [272] Roentgenium							

Lanthanides

57 La 138.9 Lanthanum	58 Ce 140.1 Cerium	59 Pr 140.9 Praseodymium	60 Nd 144.2 Neodymium	61 Pm [144.9] 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

Actinides

89 Ac [227.0] Actinium	90 Th 232.0 Thorium	91 Pa 231.0 Protactinium	92 U 238.0 Uranium	93 Np [237.0] Neptunium	94 Pu [244.1] Plutonium	95 Am [243.1] Americium	96 Cm [247.1] Curium	97 Bk [247.1] Berkelium	98 Cf [251.1] Californium	99 Es [252.1] Einsteinium	100 Fm [257.1] Fermium	101 Md [258.1] Mendelevium	102 No [259.1] Nobelium	103 Lr [262.1] Lawrencium

Where the atomic weight is not known, the relative atomic mass of the most common radioactive isotope is shown in brackets.
The atomic weights of Np and Tc are given for the isotopes ^{237}Np and ^{99}Tc.

Chem 11
Final Exam – 2005

ANSWERS

1	**A**		**4**	**C**		**7**	**A**
2	**B**		**5**	**A**		**8**	**D**
3	**D**		**6**	**B**		**9**	**C**

10 (a) $n = m \div M = 100 \text{ g} \div 65.02 \text{ g mol}^{-1} =$ ***1.54 mol*** ***(1 mark)***

(b) moles N_2 = 1½ moles NaN_3 = 1½ × 1.54 mol = ***2.31 mol*** ***(1 mark)***

volume $N_2 = n \times 24.79 \text{ L mol}^{-1} = 2.31 \text{ mol} \times 24.79 \text{ L mol}^{-1} =$ ***57.2 L*** ***(1 mark)***

11 (a) 4 moles initially – 2.3 moles remaining @ Day 16 = ***1.7 moles*** decomposed (1 mark)

(b) At ***Day 8***, 3 moles of XeF_4 remain and 1 mole of XeF_4 has decomposed yielding 1 mole of Xe and 2 moles of F_2. (1 mark)

(c) At Day 40, 3 moles of XeF_4 has decomposed, yielding 6 moles of F_2.

$n = m \div M$; $m = n \times M = 6 \text{ mol} \times 38.00 \text{ g mol}^{-1} =$ ***228 g*** ***(1 mark)***

12 moles Fe $= m \div M = 2.51 \text{ g} \div 55.85 \text{ g mol}^{-1} = 0.0449$ mol

moles HCl = 2 × moles Fe = 2 × 0.0449 mol = 0.0899 mol (1 mark)

volume HCl $= n \div c = 0.0899 \text{ mol} \div 1.00 \text{ mol L}^{-1} =$ ***0.0899 L*** ***(1 mark)***

13 (a) moles $Pb(NO_3)_2$ = ½ × moles KI = ½ × c × V = ½ × 0.100 mol L^{-1} × 0.0250 L

moles $Pb(NO_3)_2$ = ***0.00125 mol*** ***(1 mark + 1 mark)***

(b) moles PbI_2 = ½ moles KI = ½ × 0.00250 mol = 0.00125 mol

mass $PbI_2 = n \times M = 0.00125 \text{ mol} \times 461 \text{ g mol}^{-1} =$ ***0.576 g*** ***(1 mark)***

14 ***Sodium thiosulfate was added to hydrochloric acid in a conical flask at various temperatures. The chemicals react to form a precipitate. The time was recorded for how long it took for the precipitate to obscure a cross drawn on the bottom of the conical flask. As the flask was heated, the time taken for the precipitate to obscure the cross became shorter.***

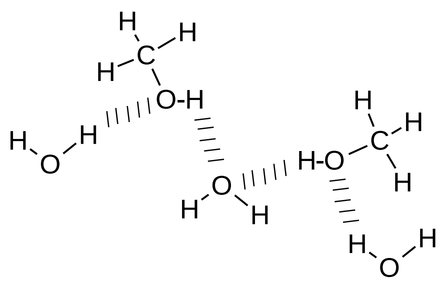
► *Detailed description and observed results.* *3 marks*
Detailed description of valid experiment. *2 marks*
Simple description of valid experiment. *1 mark*

15 (a) ***Carbon or carbon monoxide or carbon dioxide (1 mark)***

(b) e.g. $C_4H_{10\,(g)} + 7O_{2\,(g)} \rightarrow C_{(s)} + CO_{(g)} + 2CO_{2\,(g)} + 5H_2O_{(l)}$ ***(1 mark)***

► *No states required.*

16 IIIII *indicates hydrogen bonding*



Hydrogen bonding shown using dashes or any suitable representation (but not solid lines) between correct atoms. (1 mark)

Written label indicating the hydrogen bond location. (1 mark)

17

1. ***Calculate the mass of strontium chloride required to be weighed.***

   Mass of strontium chloride = 0.250 L x 0.102 mol L^{-1} ***x [87.62 x 2(35.45)] g*** mol^{-1} ***= 4.04 g***
2. ***Weigh the required quantity and dissolve in the minimum amount of water.***
3. ***Quantitatively transfer the solution to a 250 mL volumetric flask and add enough water until the lower meniscus is just touching the fill line.***
4. ***With the stopper on and held firmly in place, invert the volumetric flask several times to mix the solution.***

► *Steps 1 and 2 are credited with 1 mark. Numbers 3 and 4 are 1 mark each.*

18 (a) mass of iodine = 0.02 × 250 = ***5 g*** ***(1 mark)***

(b) mass of ethanol = mass of solution – mass of solute = ***245 g*** ***(1 mark)***

19 (a) Density = mass H_2O ÷ volume H_2O = (230.5 g – 150.5 g) ÷ 80.3 mL = ***0.996 g*** ***mL*** $^{-1}$

(b) ***At –10°C, water freezes to a structure where each molecule hydrogen bonds with four other molecules (tetrahedrally configured) creating a regular open structure which occupies more space, hence the greater volume and lower density.*** ***(1 mark)***

(c) ***Ice forms on the surface of a lake (etc.) instead of the bottom allowing life to exist under the ice during the winter.***

OR

Ice is an agent of physical weathering for rocks. Successive freezing and thawing can crack open the surface of hard rock forming a component of soil. ***(1 mark)***