Student Number	
Mark / 64	

Chemistry

Final Examination
Preliminary Course • 2003

General Instructions

- Reading time – 5 minutes
- Working time – 120 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
- Write your Student Number at the top of this page

Total Marks – 64

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

Part B – 54 marks
- Attempt Questions 11 – 23
- Allow about 110 minutes for this part

Part A – 10 marks
Attempt Questions 1–10
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.

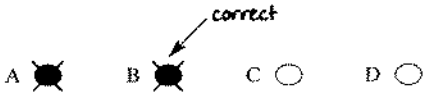
Sample: $2 + 4 =$ (A) 2 (B) 6 (C) 8 (D) 9

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.



Answer Box for Questions 1–10				
1	**A** ○	**B** ○	**C** ○	**D** ○
2	**A** ○	**B** ○	**C** ○	**D** ○
3	**A** ○	**B** ○	**C** ○	**D** ○
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9	**A** ○	**B** ○	**C** ○	**D** ○
10	**A** ○	**B** ○	**C** ○	**D** ○

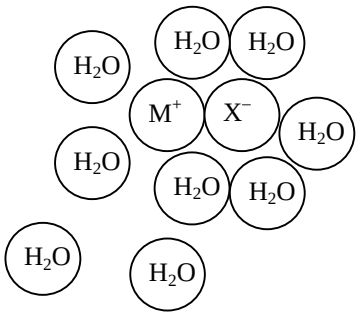
► **Mark your answers for Questions 1 – 10 in the Answer Box on page 1.**

1 Which is a toxic gas pollutant from the incomplete combustion of petrol in cars*?*

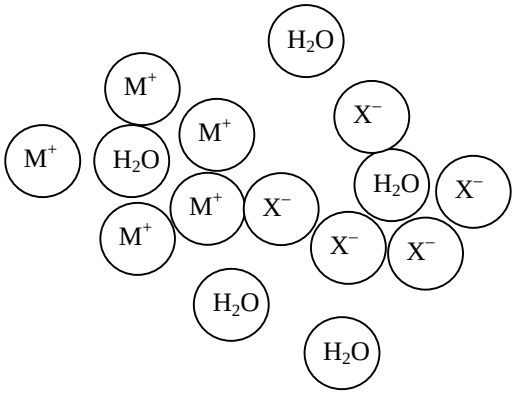
(A) ammonia
(B) carbon monoxide
(C) soot
(D) carbon dioxide

2 Which diagram shows the complete dissolution of an ionic solid (M^+X^-) in water*?*

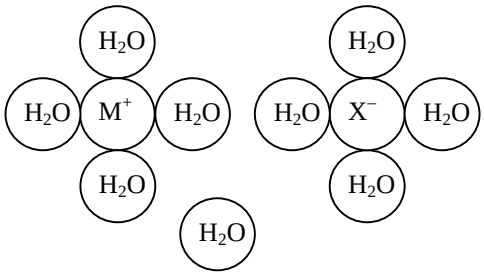
(A)



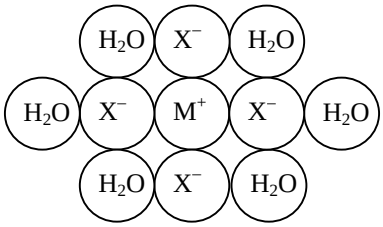
(B)



(C)



(D)



3 Which shows the correct percentage of water in the corresponding sphere?

	sphere	percentage water
(A)	atmosphere	0.5 – 10%
(B)	hydrosphere	90 – 94%
(C)	lithosphere	< 10%
(D)	biosphere (living matter)	45 – 90%

4 Which statement is true for a system undergoing an exothermic reaction?

(A) The final energy content of the system is greater than the initial energy content.
(B) The activation energy has a negative value.
(C) The temperature decreases.
(D) The ΔH has a negative value.

5 Organisms living in an aquatic habitat experience less temperature extremes than nearby organisms living on the land. Which factor explains the moderating effect of the water?

(A) extensive hydrogen bonding
(B) strong dispersion forces
(C) high viscosity
(D) high density

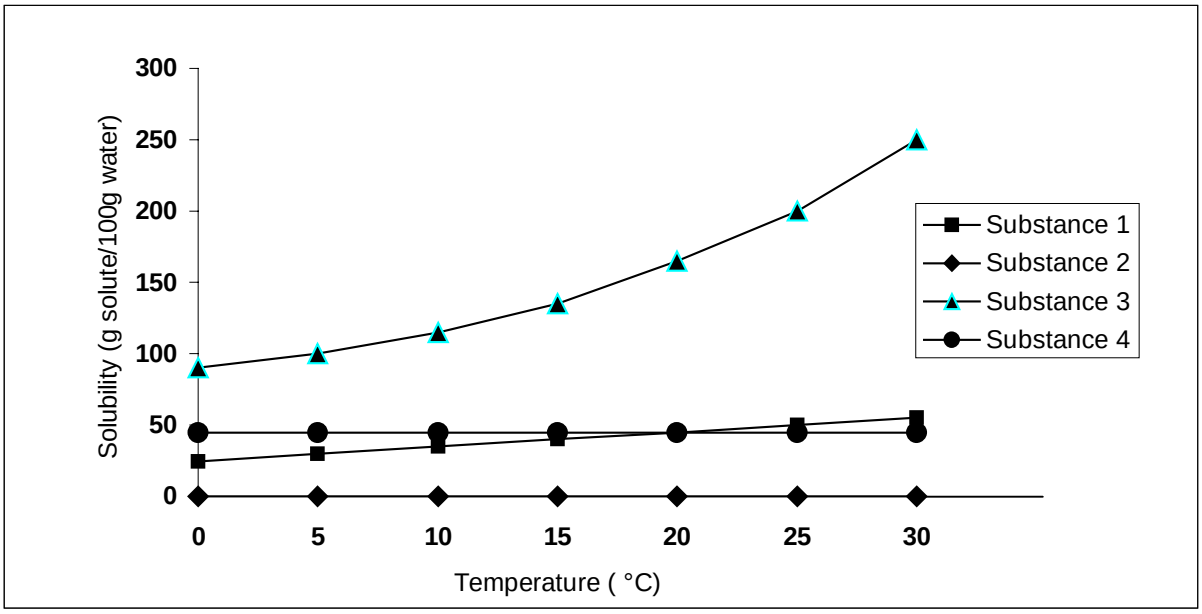
6 What is the mass of magnesium oxide (MgO) produced by burning 6.075 g of magnesium?

(A) 0.250 g
(B) 6.075 g
(C) 10.075 g
(D) 40.300 g

7 What is the mass of potassium hydroxide (KOH) needed to prepare 200 mL of a 0.25 mol L^{-1} solution?

(A) 2.8 g
(B) 28 g
(C) 280 g
(D) 2800 g

8 The graph shows the solubilities of four solid substances in water at different temperatures.



Which substance would be a covalent network solid?

(A) Substance 1
(B) Substance 2
(C) Substance 3
(D) Substance 4

9 What is the number of molecules present in 22 g of CO_2 at 298 K and 100 kPa?

(A) 3.0×10^{23}
(B) 6.0×10^{23}
(C) 12×10^{23}
(D) $6.0 \times 10^{11.5}$

10 A slight increase in temperature often causes a dramatic increase in the rate of a chemical reaction. Which statement best explains this effect?

(A) The average frequency of collisions between particles increases.
(B) The ΔH for the reaction decreases.
(C) The activation energy is lowered.
(D) The number of molecules with energy greater than the activation energy increases.

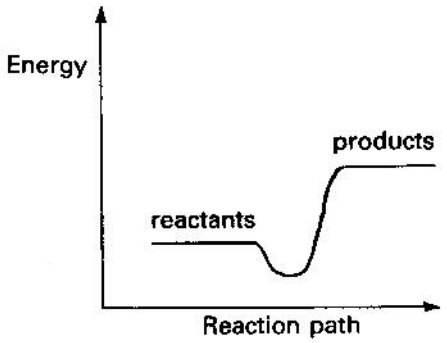
Part B – 54 marks
Attempt Questions 11 – 23
Allow about 110 minutes for this part

► Show all relevant working in questions involving calculations.

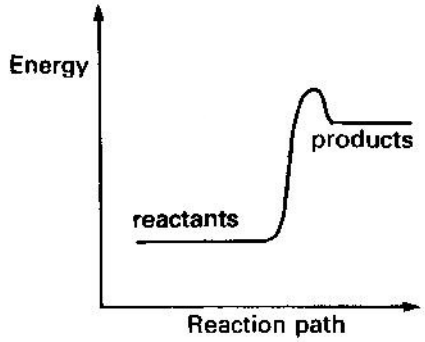
Question 11 (3 marks)

The graphs show the energy changes during the course of four different situations (I – IV)…

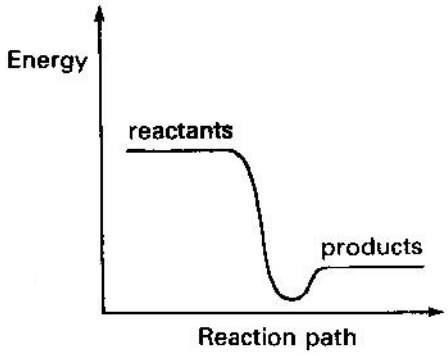
I



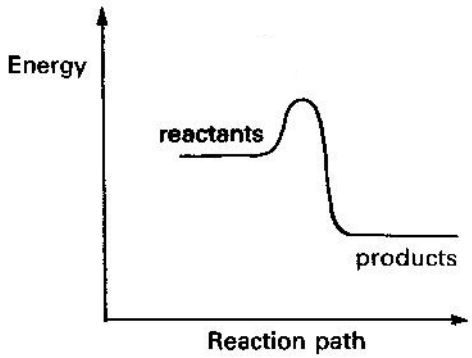
III



II



IV



(a) Which graph could correspond to the reaction: $NO_{2\,(g)} \rightarrow \frac{1}{2}N_{2\,(g)} + O_{2\,(g)}$ $\Delta H = -33.7$ kJ mol $^{-1}$?

_____ **(1 mark)**

(b) Which graph could correspond to the melting of ice? _____ **(1 mark)**

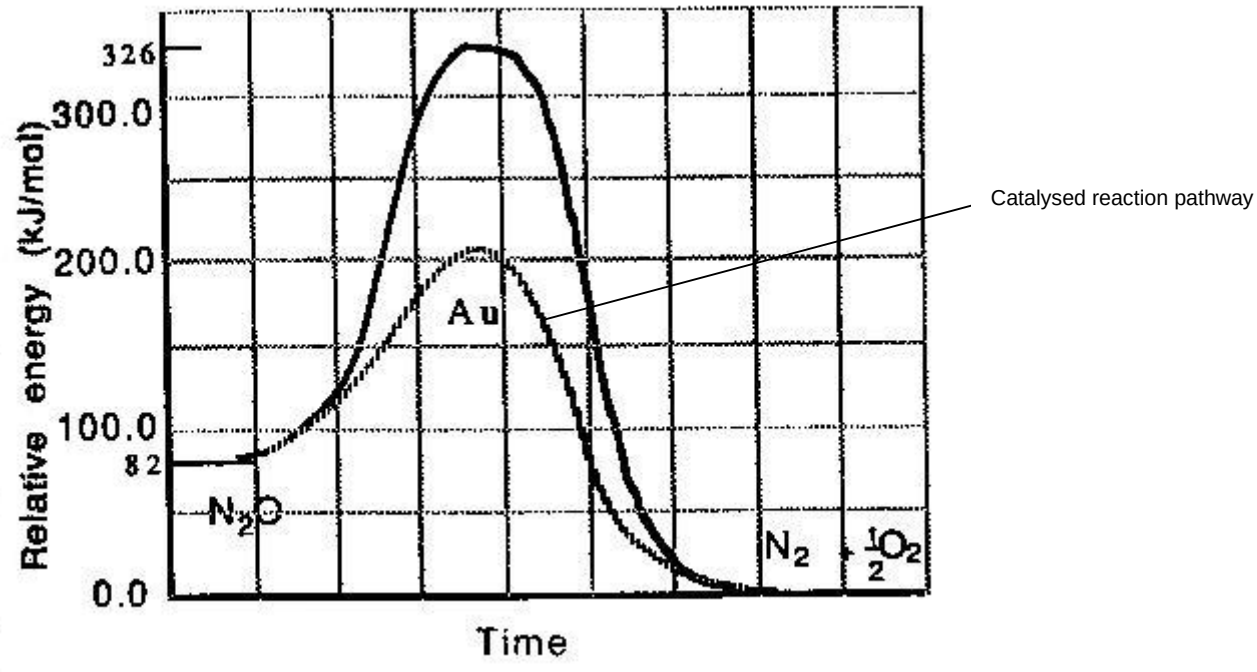
(c) Which graph could correspond to the combustion of methane? _____ **(1 mark)**

Question 12 (4 marks)

(a) Explain how fine coal dust in a coal mine can be an explosive hazard. **(2 marks)**

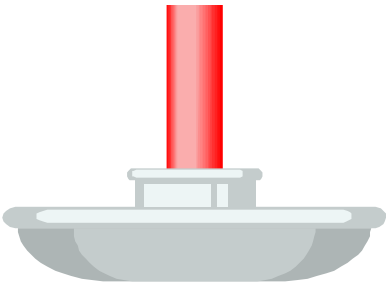
(b) Suggest one safety feature adopted by industries to avoid dust explosions. **(1 mark)**

(c) Dinitrogen monoxide can be thermally decomposed to nitrogen and oxygen.
The reaction is catalysed by gold… $N_2O_{(g)} \rightarrow N_{2(g)} + \frac{1}{2}O_{2(g)}$ $\Delta H = -82$ kJ mol $^{-1}$



What is the activation energy for the reverse reaction… $N_{2(g)} + \frac{1}{2}O_{2(g)} \rightarrow N_2O_{(g)}$
in the absence of the gold catalyst? **(1 mark)**

Question 13 (3 marks)



A candle without a wick will not burn

A candle with a wick will burn readily

(a) Identify two physical changes occurring during the burning of a candle. **(2 marks)**

_____

_____

(b) Explain why only the candle with the wick burns. **(1 mark)**

_____

_____

Question 14 (6 marks)

(a) Construct the Lewis electron dot structures for ammonia and water. **(2 marks)**

Question 14 continues on page 8.

Question 14 (continued)

(b) Describe the shape of the hydrogen sulfide molecule and explain why hydrogen sulfide has this shape. **(2 marks)**

(c) Draw a diagram of an ammonia molecule showing its correct shape. **(1 mark)**
Identify the shape. **(1 mark)**

Question 15 (3 marks)

(a) Which of hydrogen sulfide and water has the higher boiling point? **(1 mark)**

(b) Explain your answer to (a). **(2 marks)**

Question 16 (3 marks)

(a) What property of water enables an insect to walk on water? **(1 mark)**

_____

(b) Explain the nature of the property of water identified in (a) in terms of intermolecular forces. **(2 marks)**

_____

_____

_____

_____

Question 17 (3 marks)

You have already done an experiment where you used water's ability to absorb heat to measure energy changes in reactions.

(a) Identify or describe the apparatus you used to perform the experiment. **(1 mark)**

_____

_____

_____

(b) Identify one measurement required to do this experiment. **(1 mark)**

_____

(c) Write the equation you used to determine the amount of heat absorbed. **(1 mark)**

_____

Question 18 (5 marks)

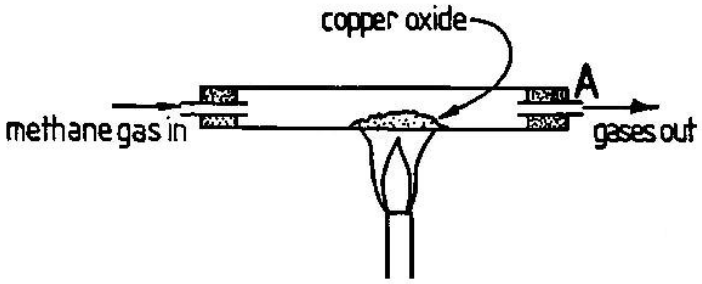
A cargo helicopter accidentally dropped 1200 kg of chemical in a pond containing 50,000 litres of water. When the chemical dissolved in the pond, the temperature increased.

(a) How much heat was released to the water in the pond, if the water temperature in the pond increased from 15°C to 21°C? **(2 marks)**

(b) Outline three implications (other than directly killing organisms) for aquatic life subjected to thermal pollution. **(3 marks)**

Question 19 (5 marks)

The diagram shows methane gas passing over heated copper(II) oxide reacting to produce copper metal and gaseous products of carbon dioxide and water vapour which leave the apparatus at A…



(a) Write the balanced formulae equation for the reaction of copper(II) oxide with methane (CH_4).
(1 mark)

(b) If 15.9 g of copper(II) oxide is completely reacted, calculate the mass of copper metal formed.
(2 marks)

(c) Calculate the percentage of copper in the copper(II) oxide sample. **(1 mark)**

(d) Calculate the volume of CO_2 produced at 25°C and 100 kPa from 15.9 g of copper(II) oxide. **(1 mark)**

Question 20 (4 marks)

(a) Legislation states that the concentration of alcohol, C_2H_5OH, in the blood of an experienced driver of a motor car is not to exceed 0.05% (w/v).

Calculate the corresponding C_2H_5OH concentration in the blood in moles per litre. **(2 marks)**

(b) Identify a different measurement of concentration to that mentioned above (i.e. w/v) and describe a use for this measurement. **(2 marks)**

Question 21 (4 marks)

(a) Calculate the mass of sodium sulfate required to prepare 50.0 mL of 0.150 mol L^{-1} solution.
(1 mark)

(b) What volume of this solution would you need to dilute, to prepare 125 mL of 0.0500 mol L^{-1} solution?
(1 mark)

(c) What is the concentration of the sodium ions and sulfate ions in the 0.0500 mol L^{-1} solution?
(2 marks)

Question 22 (4 marks)

The table shows data for the compound hydrazine…

Composition	Hydrazine is a compound of nitrogen and hydrogen
Complete combustion of gaseous hydrazine at 400 K and 100 kPa	$\underset{1.0\ L}{\text{hydrazine}_{(g)}} + \underset{3.0\ L}{\text{oxygen}_{(g)}} \rightarrow \underset{2.0\ L}{\text{nitrogen dioxide}_{(g)}} + \underset{2.0\ L}{\text{water}_{(g)}}$

(a) Explain how the data for combustion illustrates Gay-Lussac's Law of Combining Gas Volumes. **(1 mark)**

(b) Determine the molecular formula of hydrazine.
Show all working. **(2 marks)**

(c) What is the empirical formula of hydrazine? **(1 mark)**

Question 23 (7 marks)

2.08 g of barium chloride was dissolved in water to make 50.0 mL of solution and then added to 50.0 mL of an aqueous solution containing 2.84 g of sodium sulfate. A white precipitate formed.

(a) Write the net ionic equation for the reaction forming the precipitate. **(1 mark)**
► *Use the solubility table below to determine the identity of the precipitate.*

ANION	CATION	COMPOUND
All	Group I metals	soluble
All	Ammonium, NH_4^+	soluble
Nitrate, NO_3^-	All	soluble
Acetate/ethanoate CH_3COO^-	All except Ag^+	soluble
Chloride, Cl^- Bromide, Br^- Iodide, I^-	Ag^+, Pb^{2+}, Hg_2^{2+}, Cu^+	insoluble
	All others	soluble
Sulfate, SO_4^{2-}	Ca^{2+}, Sr^{2+}, Ba^{2+}, Pb^{2+}, Ag^+, Hg_2^{2+}	insoluble
	All others	soluble
Sulfide, S^{2-}	Group I and II metals, NH_4^+	soluble
	All others	insoluble
Hydroxide, OH^-	Group I metals, NH_4^+, Sr^{2+}, Ba^{2+}	soluble
	All others	insoluble
Carbonate, CO_3^{2-} Phosphate, PO_4^{3-} Sulfite, SO_3^{2-}	Group I metals, NH_4^+	soluble
	All others	insoluble

Question 23 continues on page 15

Question 23 (continued)

(b) What is the mass of the precipitate formed? Show working. **(4 marks)**

(c) Calculate the concentration (mol L^{-1}) of sulfate ions in the final solution. Show working. **(2 marks)**

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

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

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

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 65.39 Zinc	31 Ga 69.72 Gallium	32 Ge 72.61 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 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 [210.0] 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 [263.1] Seaborgium	107 Bh [264.1] Bohrium	108 Hs [265.1] Hassium	109 Mt [268] Meitnerium	110 Uun — Ununnilium	111 Uuu — Unununium	112 Uub — Ununbium	113	114 Uuq — Ununquadium	115	116 Uuh — Ununhexium	117	118 Uuo — Ununoctium

KEY

Atomic Number — 79 — Symbol of element

Atomic Weight — 197.0 — Name of element: Gold

Lanthanides

57 La 138.9 Lanthanum	58 Ce 140.1 Cerium	59 Pr 140.9 Praseodymium	60 Nd 144.2 Neodymium	61 Pm [146.9] 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 [239.1] Plutonium	95 Am [241.1] Americium	96 Cm [244.1] Curium	97 Bk [249.1] Berkelium	98 Cf [252.1] 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.

ANSWERS and MARKING SCHEME

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1 Which is a toxic gas pollutant from the incomplete combustion of petrol in cars*?*

(A) ammonia
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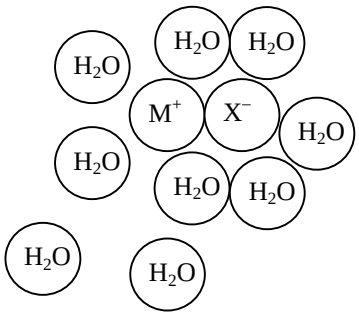
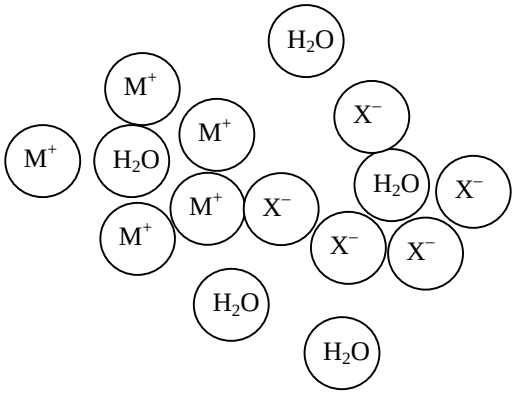
(C) soot
(D) carbon dioxide

2 Which diagram shows the complete dissolution of an ionic solid (M^+X^-) in water*?*

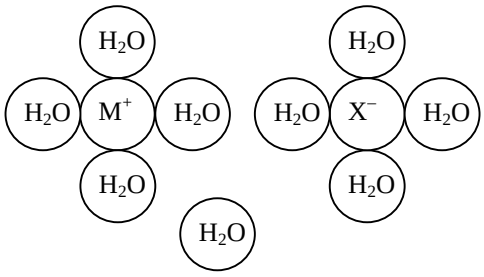
(A)



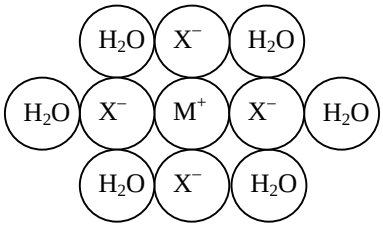
(B)



(C)



(D)



3 Which shows the correct percentage of water in the corresponding sphere?

	sphere	percentage water
(A)	atmosphere	0.5 – 10%
(B)	hydrosphere	90 – 94%
(C)	lithosphere	< 10%
(D)	biosphere (living matter)	45 – 90%

4 Which statement is true for a system undergoing an exothermic reaction?

(A) The final energy content of the system is greater than the initial energy content.
(B) The activation energy has a negative value.
(C) The temperature decreases.
(D) The ΔH has a negative value.

5 Organisms living in an aquatic habitat experience less temperature extremes than nearby organisms living on the land. Which factor explains the moderating effect of the water?

(A) extensive hydrogen bonding
(B) strong dispersion forces
(C) high viscosity
(D) high density

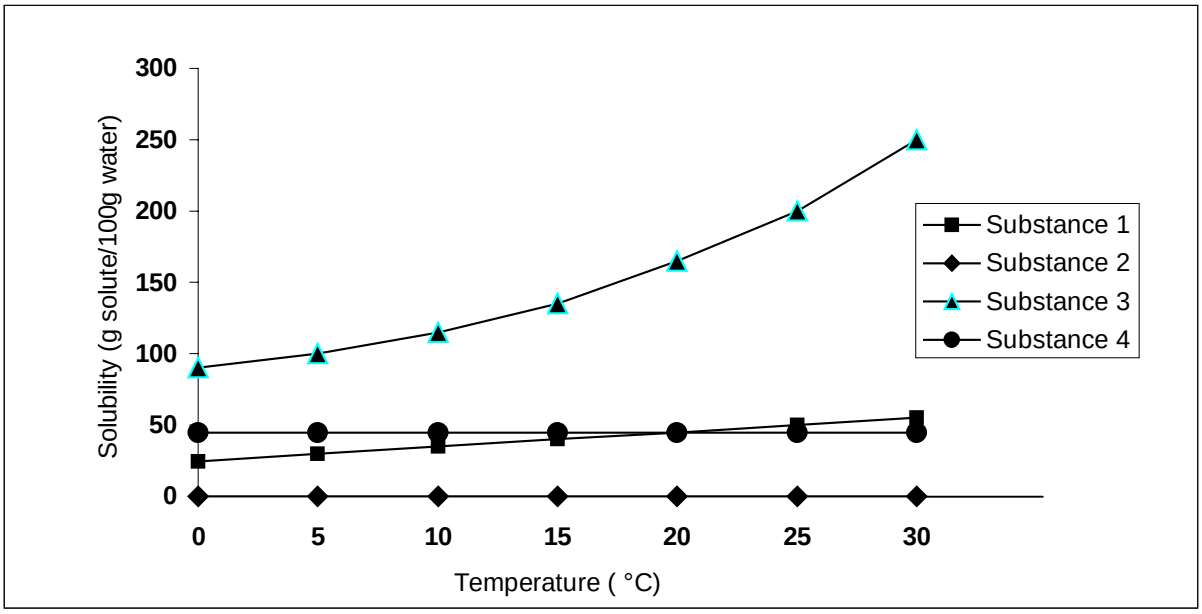
6 What is the mass of magnesium oxide (MgO) produced by burning 6.075 g of magnesium?

(A) 0.250 g
(B) 6.075 g
(C) 10.075 g
(D) 40.300 g

7 What is the mass of potassium hydroxide (KOH) needed to prepare 200 mL of a 0.25 mol L^{-1} solution?

(A) 2.8 g
(B) 28 g
(C) 280 g
(D) 2800 g

8 The graph shows the solubilities of four solid substances in water at different temperatures.



Which substance would be a covalent network solid?

(A) Substance 1
(B) Substance 2
(C) Substance 3
(D) Substance 4

9 What is the number of molecules present in 22 g of CO_2 at 298 K and 100 kPa?

(A) 3.0×10^{23}
(B) 6.0×10^{23}
(C) 12×10^{23}
(D) $6.0 \times 10^{11.5}$

10 A slight increase in temperature often causes a dramatic increase in the rate of a chemical reaction. Which statement best explains this effect?

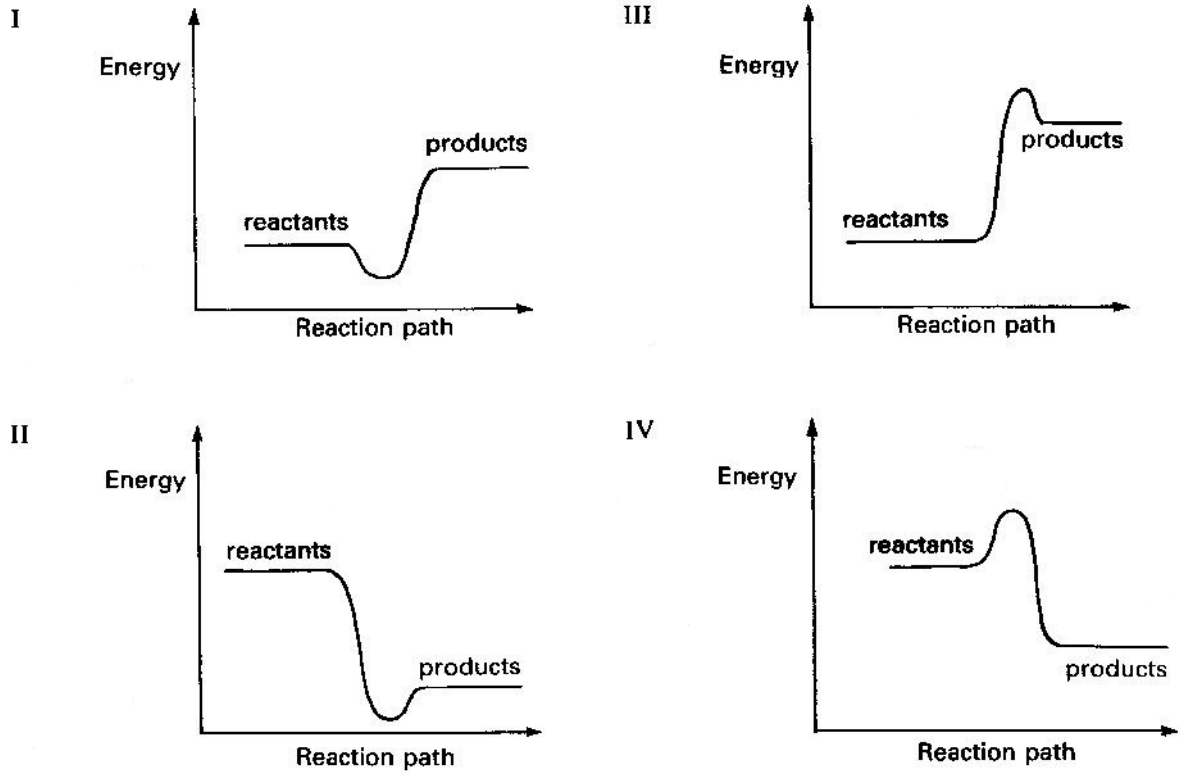
(A) The average frequency of collisions between particles increases.
(B) The ΔH for the reaction decreases.
(C) The activation energy is lowered.
(D) The number of molecules with energy greater than the activation energy increases.

Part B – 54 marks
Attempt Questions 11 – 23
Allow about 110 minutes for this part

► Show all relevant working in questions involving calculations.

Question 11 **O/C – P7** **(3 marks)**

The graphs show the energy changes during the course of four hypothetical reactions or processes (I – IV)…



(a) Which graph could correspond to the reaction: $NO_{2\,(g)} \rightarrow \frac{1}{2}N_{2\,(g)} + O_{2\,(g)}$ $\Delta H = -33.7$ kJ mol $^{-1}$?

Graph IV **(1 mark)**

(b) Which graph could correspond to the melting of ice? **Graph III** **(1 mark)**

(c) Which graph could correspond to the combustion of methane? **Graph IV** **(1 mark)**

Question 12 (4 marks)

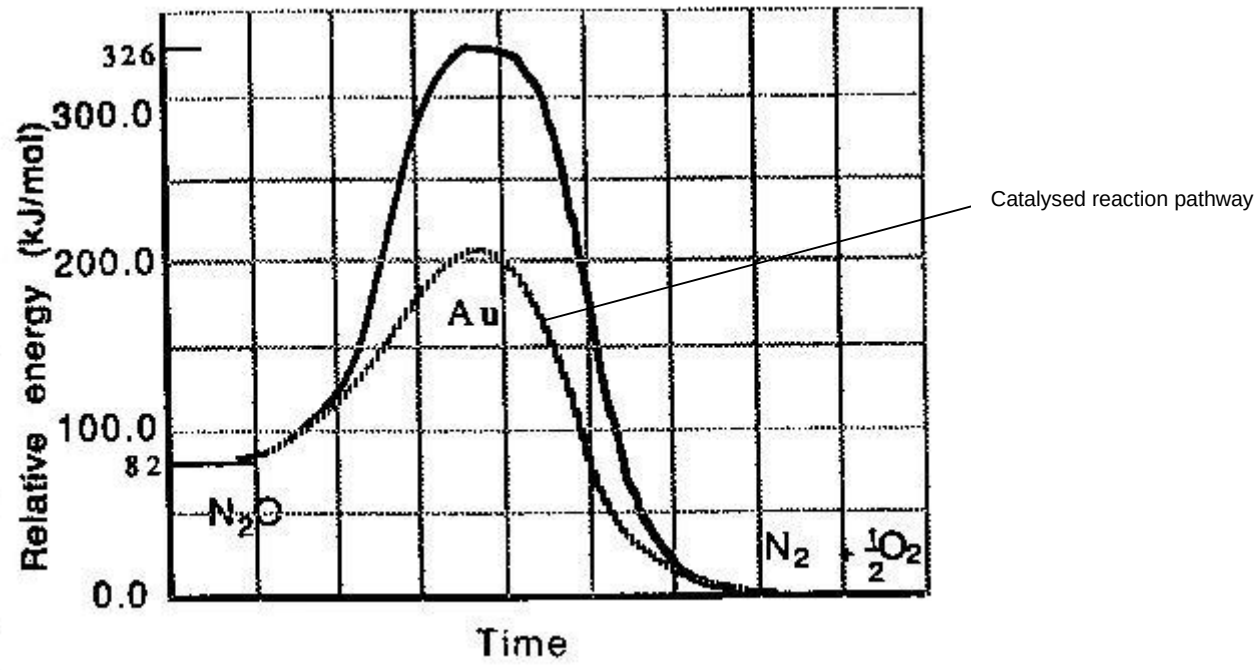
(a) Explain how fine coal dust in a coal mine can be an explosive hazard. **O/C – P4 (2 marks)**

The total surface area of the particles is large (1 mark) and each particle has a ready supply of oxygen available. As the reaction is exothermic (1 mark), heat released supplies the activation energy to hasten further reactions and an explosion ensues.

(b) Suggest one safety feature adopted by industries to avoid dust explosions. **O/C – P4 (1 mark)**

Ensuring there is no build-up of fine flammable particles by well-ventilating the worksite.

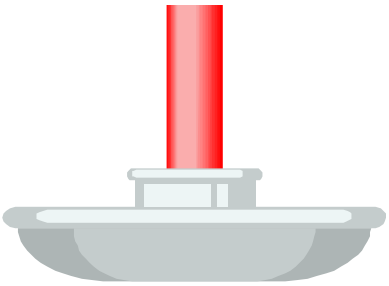
(c) Dinitrogen monoxide can be thermally decomposed to nitrogen and oxygen.
The reaction is catalysed by gold… $N_2O_{(g)} \rightarrow N_{2(g)} + \frac{1}{2}O_{2(g)} \quad \Delta H = -82 \text{ kJ mol}^{-1}$



What is the activation energy for the reverse reaction… $N_{2(g)} + \frac{1}{2}O_{2(g)} \rightarrow N_2O_{(g)}$
in the absence of the gold catalyst? **O/C – P7, 14 (1 mark)**

326 kJ

Question 13 **O/C – P7** **(3 marks)**



A candle without a wick will not burn

A candle with a wick will burn readily

(a) Identify two physical changes occurring during the burning of a candle. **(2 marks)**

Melting or fusion or solid → liquid

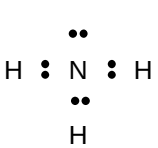
Vaporisation or liquid → gas

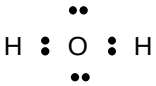
(b) Explain why only the candle with the wick burns. **(1 mark)**

Wax cannot burn directly as a solid. A burning wick provides heat to melt and vapourise the wax which can then be fed up the wick (by capillary action) to sustain the flame and hence continue the combustion process.

Question 14 **(6 marks)**

(a) Construct the Lewis electron dot structures for ammonia and water. **O/C – P7** **(2 marks)**





Question 14 (continued)

(b) Describe the shape of the hydrogen sulfide molecule and explain why hydrogen sulfide has this shape. **O/C – P14 (2 marks)**

Hydrogen sulfide is a bent molecule (1 mark) due to the central sulfur atom having two lone (non-bonding) pairs of electrons. This causes repulsion of the covalent bonds (1 mark).

► ***The four pairs of electrons around the central sulfur atom will automatically orientate towards maximum repulsion resulting in a tetrahedral placement in 3D space. However, the shape of a molecule is determined by the placement of the bonded atoms, ∴ in this case, bent.***

(c) Draw a diagram of an ammonia molecule showing its correct shape. **(1 mark) O/C – P14**

Identify the shape. **(1 mark)**

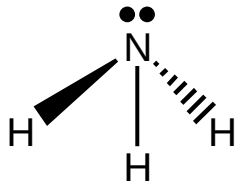


Diagram (1 mark)

Ammonia is a trigonal pyramid (1 mark)

► ***'pyramidal' accepted as per Smith text***

Question 15 (3 marks)

(a) Which of hydrogen sulfide and water has the higher boiling point? **O/C – P14 (1 mark)**

Water has the higher boiling point.

(b) Explain your answer to (a). **O/C – P14 (2 marks)**

Water forms two hydrogen bonds per molecule.
Hydrogen bonding is the strongest intermolecular force. (1 mark)

Hydrogen sulfide, however, has dipole–dipole forces (and dispersion forces).
These are not as strong as hydrogen bonding. (1 mark)

Question 16 (3 marks)

(a) What property of water enables an insect to walk on water? **O/C – P14** **(1 mark)**

Surface tension

(b) Explain the nature of the property of water identified in (a) in terms of intermolecular forces. **O/C – P7 (2 marks)**

Water molecules at the surface form hydrogen bonding only with water molecules that are adjacent and below. There are no molecules (or attractions) from above. (1 mark)
These unbalanced forces on surface molecules result in a downward or inward force acting on surface molecules, ∴ surface tension. (1 mark)

Question 17 O/C – P4, 7 (3 marks)

You have already done an experiment where you used water's ability to absorb heat to measure energy changes in reactions.

(a) Identify or describe the apparatus you used to perform the experiment. **(1 mark)**

Calorimeter or plastic foam cup + thermometer

(b) Identify one measurement required to do this experiment. **(1 mark)**

- **Mass/volume of water/solution in the calorimeter.**
- **Change in temperature of the water/solution in the calorimeter.**
- **Mass of reagent involved in the reaction.**

► ***Any one of the above.***

(c) Write the equation you used to determine the amount of heat absorbed. **(1 mark)**

- **$q = m C \Delta T$**
- **$\Delta H = - m C \Delta T$**
- **$\Delta H = m C \Delta T$**

► ***Any one of the above.***

Question 18 **O/C – P4, 7, 10, 16** **(5 marks)**

A cargo helicopter accidentally dropped 1200 kg of chemical in a pond containing 50,000 litres of water. When the chemical dissolved in the pond, the temperature increased.

(a) How much heat was released to the water in the pond, if the water temperature in the pond increased from 15°C to 21°C? **(2 marks)**

$q = m\,C\,\Delta T = 50{,}000\ kg \times 4.18 \times 10^{3}\ J\ kg^{-1}\ K^{-1} \times (21°C - 15°C) = 1.254 \times 10^{9}\ J = \underline{1.3 \times 10^{6}\ kJ}$

Consistent use of units = 1 mark

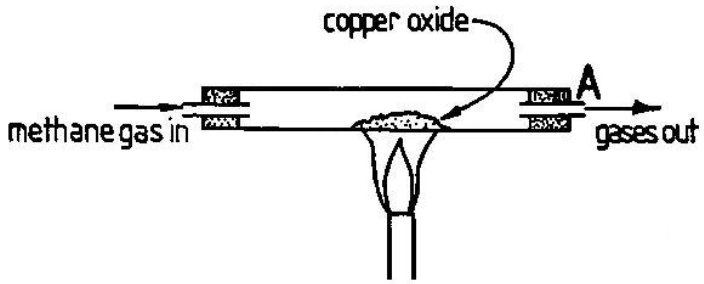
Correct calculation = 1 mark

(b) Outline three implications (other than directly killing organisms) for aquatic life subjected to thermal pollution. **(3 marks)**

- **Less dissolved oxygen causing stress to organism**
- **Increased metabolic rates which increases the demand for oxygen and so aggravates the low dissolved oxygen problem**
- **Fish eggs do not develop or hatch if temperature is too high**
- **False temperature cues are given to aquatic life,**
  ∴ setting of migration and spawning at the wrong times of the year.

Question 19 **O/C – P10, 13, 14** **(5 marks)**

The diagram shows methane gas passing over heated copper(II) oxide reacting to produce copper metal and gaseous products of carbon dioxide & water vapour which leave the apparatus at A…



(a) Write the balanced formulae equation for the reaction of copper(II) oxide with methane (CH_4). **(1 mark)**

$2CuO_{(s)} + CH_{4(g)} \rightarrow CO_{2(g)} + 2H_2O_{(g)} + 2Cu_{(s)}$

(b) If 15.9 g of copper(II) oxide is reacted completely, calculate the mass of copper metal formed. **(2 marks)**

moles CuO = n = m ÷ M = 15.9 g ÷ 79.55 g mol $^{-1}$ = 0.200 mole (1 mark)

moles CuO = moles Cu

mass Cu = m = n x M = 0.200 mol x 63.55 g mol $^{-1}$ = 12.7 g (1 mark)

(c) Calculate the percentage of copper in the copper(II) oxide sample. **(1 mark)**

Cu% = mass Cu ÷ mass CuO x 100 = 12.7 g ÷ 15.9 g x 100 = 79.9%

(d) Calculate the volume of CO_2 produced at 25 °C and 100 kPa from 15.9 g of copper(II) oxide. **(1 mark)**

moles CO_2 = ½ moles CuO = ½ x 0.200 mol = 0.100 mol

Volume CO_2 = moles x molar volume = 0.100 mol x 24.79 L mol $^{-1}$ = 2.48 L

Question 20 O/C – P13 (4 marks)

(a) Legislation states that the conncentration of alcohol, C_2H_5OH, in the blood of an experienced driver of a motor car is not to exceed 0.05% (w/v).

Calculate the corresponding C_2H_5OH concentration in the blood in moles per litre. **(2 marks)**

0.05% (w/v) = 0.05 g/100 mL (1 mark)

moles ethanol = 0.05 g ÷ 46.068 g/mol = 1.085×10^{-3} mol

∴ $[C_2H_5OH] = 1.085 \times 10^{-3}$ mol ÷ 0.100 L = $\underline{0.01 \text{ mol L}^{-1}}$ (1 mark)

(b) Identify a different measurement of concentration to those mentioned above (i.e. w/v) and describe a use for this measurement. **(2 marks)**

ppm (or ppb, v/v, w/w) (1 mark)

ppm is a convenient unit for measuring concentrations of pollutants, e.g. lead ions in waterways. (1 mark)

Question 21 O/C – P10, 14 (4 marks)

(a) Calculate the mass of sodium sulfate required to prepare 50.0 mL of 0.150 mol L^{-1} solution. **(1 mark)**

mol of Na_2SO_4 = 0.15 mol L^{-1} x 50×10^{-3} L = $\underline{0.0075 \text{ mol}}$

mass of Na_2SO_4 = 0.0075 mol x 142.05 g/mol = 1.065 = $\underline{1.07}$ g

(b) What volume of this solution would you need to dilute, to prepare 125 mL of 0.0500 mol L^{-1} solution? **(1 mark)**

$c_1v_1 = c_2v_2$; $v_1 = c_2v_2 \div c_1$ = 0.0500 mol L^{-1} x 0.125 L ÷ 0.150 mol L^{-1} = 0.0417 L = $\underline{41.7 \text{ mL}}$

(c) What is the concentration of the sodium ions and sulfate ions in the 0.0500 mol L^{-1} solution? **(2 marks)**

$Na_2SO_{4\,(s)} \rightarrow 2Na^+_{(aq)} + SO_4^{2-}{}_{(aq)}$

∴ $[Na^+] = 0.0500 \text{ mol L}^{-1} \times 2 = \underline{0.100 \text{ mol L}^{-1}}$ (1 mark)
∴ $[SO_4^{2-}] = \underline{0.0500 \text{ mol L}^{-1}}$ (1 mark)

Question 22 **O/C – P1, 2, 13** **(4 marks)**

The table shows data for the compound hydrazine…

Composition	Hydrazine is a compound of nitrogen and hydrogen
Complete combustion of gaseous hydrazine at 400 K and 100 kPa	hydrazine $_{(g)}$ (1.0 L) + oxygen $_{(g)}$ (3.0 L) → nitrogen dioxide $_{(g)}$ (2.0 L) + water $_{(g)}$ (2.0 L)

(a) Explain how the data for combustion illustrates Gay-Lussac's Law of Combining Gas Volumes. **(1 mark)**

The gas volumes are in simple whole number ratios.

(b) Determine the molecular formula of hydrazine.
Show all working. **(2 marks)**

$N_xH_{y\,(g)} + 3O_{2\,(g)} \rightarrow 2NO_{2\,(g)} + 2H_2O_{\,(g)}$ (1 mark)

∴ x = 2; y = 4
∴ N_2H_4 (1 mark)

(c) What is the empirical formula of hydrazine*?* **(1 mark)**

NH_2 (1 mark)

Question 23 **O/C – P10, 13, 14** **(7 marks)**

2.08 g of barium chloride was dissolved in water to make 50.0 mL of solution and then added to 50.0 mL of an aqueous solution containing 2.84 g of sodium sulfate. A white precipitate formed.

(a) Write the net ionic equation for the reaction forming the precipitate. **(1 mark)**

$Ba^{2+} + SO_4^{2-} \rightarrow BaSO_{4\,(s)}$

(b) What is the mass of the precipitate formed? Show working. **(4 marks)**

moles Ba^{2+} = moles $BaCl_2$ = 2.08 g ÷ 208.2 g/mol = <u>0.00999 or 0.0100 mol</u> (1 mark)

moles SO_4^{2-} = moles of Na_2SO_4 = 2.84 g ÷ 142.05 g/mol = <u>0.0200 mol</u> (1 mark)

∴ moles $BaSO_4$ ppt. = <u>0.0100 mol</u> (1 mark)

mass $BaSO_4$ = 0.0100 mol x 233.37 g/mol = <u>2.33</u> g (1 mark)

(c) Calculate the concentration (mol L^{-1}) of sulfate ions in the final solution. Show working. **(2 marks)**

moles SO_4^{2-} excess remaining in solution = 0.0100 mol (1 mark)

∴ $[SO_4^{2-}]$ = 0.0100 mol ÷ 0.100 L = <u>0.100 mol L^{-1}</u> (1 mark)