Student Number	
Mark / 68	

Chemistry

Preliminary Course
Final Examination • 2002

General Instructions

- Reading time – 5 minutes
- Working time – 2 hours
- 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 – 68

Part A – 11 marks
- Attempt Questions 1 – 11
- Allow about 20 minutes for this part

Part B – 57 marks
- Attempt Questions 12 – 23
- Allow about 100 minutes for this part

Part A – 11 marks
Attempt Questions 1–11
Allow about 20 minutes for this part

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

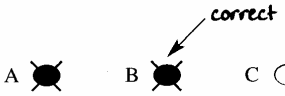
Sample: 2 + 4 = (A) 2 (B) 6 (C) 8 (D) 9

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.



A ⊗ B ⊗ C ○ D ○

Answer Box for Questions 1–11

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** ○
10	**A** ○	**B** ○	**C** ○	**D** ○
11	**A** ○	**B** ○	**C** ○	**D** ○

Mark your answers for Questions 1 – 11 in the Answer Box on page 1.

1 What is the change in mass of 1.00 gram samples of Li and Ca metals when they react with an excess of oxygen (O_2)*?*

	CHANGE IN MASS (g)	
	Li	**Ca**
(A)	1.000	1.000
(B)	2.153	1.399
(C)	1.153	0.399
(D)	0.576	0.799

2 Which of the following statements relates to a detrimental effect of thermal pollution in waterways*?*

(A) Fish populations will increase to disproportionate levels in higher water temperature.
(B) Increased water temperature will lead to less dissolved oxygen causing stress to aquatic organisms.
(C) Metabolic rates in fish are decreased.
(D) Higher water temperature results in the increased precipitation of heavy metals.

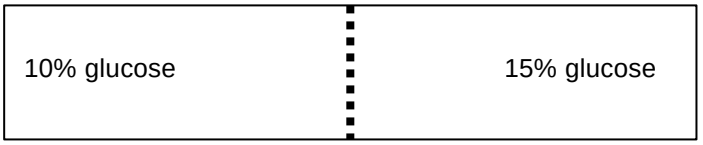
3 Which of the following ranks of coal has the highest carbon content*?*

(A) anthracite
(B) bituminous coal
(C) brown coal
(D) lignite

4 What is the mass of 2 moles of oxygen atoms*?*

(A) 8.0 grams
(B) 16 grams
(C) 32 grams
(D) 64 grams

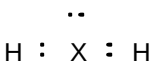
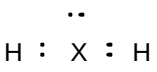
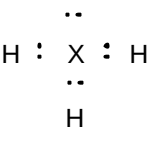
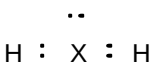
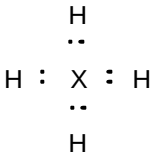
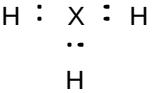
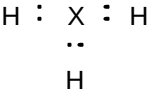
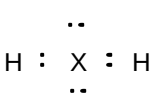
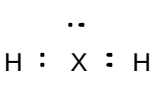
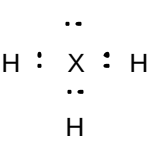
5 The diagram shows a two section compartment filled with aqueous glucose solutions separated by a semi-permeable membrane.



Which statement describes what will happen with time?

(A) Glucose molecules will move into the right side by diffusion.
(B) Water molecules will move into the left side by diffusion.
(C) Glucose molecules will move into the left side by osmosis.
(D) Water molecules will move into the right side by osmosis.

6 Water, hydrogen sulfide and ammonia are compounds of O, S and N with hydrogen.
Which of the following are correct Lewis electron dot structures, where X = N, O or S?

	WATER	**HYDROGEN SULFIDE**	**AMMONIA**
(A)			
(B)			
(C)			
(D)			

7 What is the whole number mass ratio of metal to non-metal (metal:non-metal) in barium chloride?

(A) 1:2
(B) 2:1
(C) 1:1
(D) 4:1

8 Which of the following binary compounds would have the greatest solubility in water?

(A) CH_4
(B) CO_2
(C) HCl
(D) HF

9 Which of the following equations shows the precipitation of copper(I) chloride?

(A) $Cu_{(s)} + \frac{1}{2} Cl_{2\,(g)} \rightarrow CuCl_{(s)}$
(B) $Cu_{(s)} + Cl^-_{(aq)} \rightarrow CuCl_{(s)}$
(C) $Cu^+_{(aq)} + Cl^-_{(aq)} \rightarrow CuCl_{(s)}$
(D) $Cu^+_{(aq)} + \frac{1}{2} Cl_{2\,(g)} \rightarrow CuCl_{(s)}$

10 0.10 mole of aluminium chromate, $Al_2(CrO_4)_3$, is dissolved in sufficient water to make 500 mL of solution. What are the concentrations of the resultant ions formed?

	CONCENTRATION (mol L^{-1})	
	Al^{3+}	CrO_4^{2-}
(A)	0.050	0.033
(B)	0.10	0.10
(C)	0.20	0.20
(D)	0.40	0.60

11 Which of the following is the second hydrocarbon compound in the alkyne homologous series?

(A) butyne
(B) ethyne
(C) hexyne
(D) propyne

Part B – 57 marks
Attempt Questions 12 – 23
Allow about 100 minutes for this part

Show all relevant working in questions involving calculations.

Question 12 (4 marks)

The table lists the boiling points for the first eight members of the homologous series of alkanes.

FORMULA	BOILING POINT (K)
CH_4	112
C_2H_6	184
C_3H_8	231
C_4H_{10}	273
C_5H_{12}	309
C_6H_{14}	342
C_7H_{16}	371
C_8H_{18}	399

(a) Define the term, homologous series. **(1 mark)**

_____

_____

_____

(b) Explain the trend in boiling point for the alkanes. **(1 mark)**

_____

_____

_____

(c) List two hazards of working with hydrocarbons and the precautions taken to avoid these dangers. **(2 marks)**

_____

_____

_____

_____

Question 13 (6 marks)

(a) Compare one use of each carbon allotrope and relate this use to a physical property. **(4 marks)**

ALLOTROPE	USE	PHYSICAL PROPERTY
graphite		
diamond		

(b) Carbon exists in several allotropes and several isotopes.
Differentiate between the terms, allotrope and isotope. **(2 marks)**

_____

_____

_____

_____

Question 14 (3 marks)

A student experimentally determined the molar heat of solution of calcium chloride using a calorimeter.

(a) The student used the specific heat of water in the calculation of the result.
Define the term, specific heat. **(1 mark)**

_____

_____

(b) The student found that when 5.3 grams of calcium chloride dissolved in 250 g of water the temperature rose by 3.4 Cº in the calorimeter.
Calculate the molar heat of solution from this data. **(2 marks)**

_____

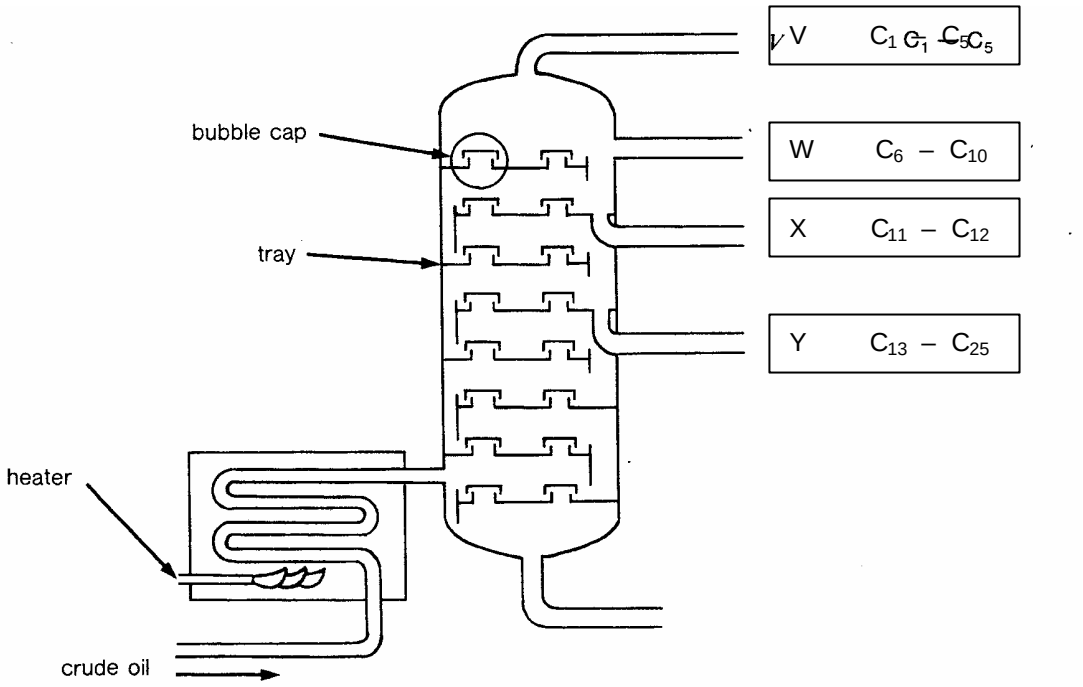
_____

_____

_____

Question 15 (7 marks)

The diagram shows a fractionating tower which is used in the processing of crude oil. Hydrocarbon fractions are removed from outlets on the right hand side of the tower. The approximate numbers of carbon atoms in molecules from each fraction are indicated.



(a) From which fraction, (V, W, or X) is petrol made? **(1 mark)**

_____

(b) Why is it incorrect to write a chemical formula for petrol? **(1 mark)**

_____

(c) Identify one use for the fraction obtained at Y. **(1 mark)**

_____

(d) Identify the physical property of hydrocarbons which allows them to be separated by the fractionating tower. **(1 mark)**

_____

Question 15 continues on page 8

Question 15 (continued)

(e) Describe the geological processes resulting in a crude oil accumulation and the method by which it is extracted from the earth. Use a diagram to illustrate your answer. **(3 marks)**

Question 16 (3 marks)

The table shows the boiling points of water, ammonia and hydrogen sulfide.
Explain the differences in the relative boiling points of each of these substances.

water	ammonia	hydrogen sulfide
100º C	– 33º C	– 62º C

Question 17 (6 marks)

Explain the implications of the following properties of water for plants and animals.

(a) The low density of ice. **(2 marks)**

(b) Adhesion and cohesion. **(2 marks)**

(c) Surface tension. **(2 marks)**

Question 18 (3 marks)

(a) What is the empirical formula of a compound of bismuth and chlorine, which is 66% (w/w) bismuth. **(2 marks)**

(b) If a sample of this compound contained 2 g of bismuth, what would be the total mass of the sample? **(1 mark)**

Question 19 (4 marks)

A 10.0 g sample of impure zinc metal, heavily corroded with zinc hydroxide on its surface, was chemically analysed to determine the amount of zinc metal present. The sample was 'dissolved' in excess 1.00 mol L^{-1} hydrochloric acid solution and 3.05 L of hydrogen gas was produced at 25ºC and 101.3 kPa.

(a) Write a balanced chemical equation for the reaction producing hydrogen gas. **(1 mark)**

_____

(b) How many moles of zinc metal reacted to produce the hydrogen gas*?* **(1 mark)**

_____

_____

_____

(c) Calculate the mass percentage of zinc metal in the original sample. **(1 mark)**

_____

_____

_____

(d) Calculate the volume of acid which reacted with the whole sample. **(1 mark)**

_____

_____

_____

Question 20 (2 marks)

Briefly describe an experiment to identify the effect of mass of added salt to a fixed mass of water on the boiling point of water.

_____

_____

_____

_____

_____

_____

Question 21 (5 marks)

(a) A chemist requires an accurately prepared solution of barium chloride.

Solution specifications	
volume	500.0 mL
concentration	0.250 mol L^{-1}
solute	barium chloride–2–water
warning	toxic

Describe the steps involved in the preparation of this solution.
Include calculations and mention any specialised apparatus used. **(4 marks)**

(b) Convert the molarity of the barium chloride solution into a percentage concentration (w/w).
Assume the solution's density is 1.00 g mL^{-1}. **(1 mark)**

Question 22 (7 marks)

(a) Complete the table showing examples of bonding types and aqueous solubilities. **(5 marks)**

Bonding type	Common example	Aqueous solubility (in general)
metallic	zinc	insoluble
	cellulose	
covalent network		
	hydrogen chloride	
non-polar covalent		
	sodium sulfate	

(b) The dissolving of oxygen in water can be correctly represented as… $O_{2\,(g)} \leftrightharpoons O_{2\,(aq)}$

Identify two reasons why the dissolving of HCl in water cannot be represented as…

$$HCl_{(g)} \leftrightharpoons HCl_{(aq)}$$ **(2 marks)**

Question 23 (7 marks)

Use the solubility table to answer the questions which follow.

SOLUBILITY TABLE

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

(a) Complete the table indicating the solubility of the salts. Use **S for soluble** and **I for insoluble**. **(3 marks)**

	CH_3COO^-	**Cl^-**	**CO_3^{2-}**	**S^{2-}**
Ag^+	I	I		
Ca^{2+}	S		I	
Hg_2^{2+}	S	I		

Question 23 continues on page 14

(b) A solution of lead(II) nitrate is accidentally spilled into a pond.
Identify a problem resulting from this spill. **(1 mark)**

_____

_____

(c) The lead(II) nitrate can be chemically removed by precipitation.
Identify a compound which will react with lead(II) nitrate and form a precipitate. **(1 mark)**

_____

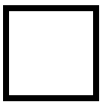
(d) Write a balanced chemical equation for the precipitation reaction in (c). **(1 mark)**

_____

(e) Write the net ionic equation for the precipitation reaction in (e). **(1 mark)**

_____

- End of Examination -



DATA SHEET

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

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 ..... 1.0×10^{-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* (4th 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 — Symbol of element — Name of element

Atomic Weight

Example: 79 Au 197.0 Gold

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

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.

MARKING SCHEME
and
OUTCOMES MAP

Chemistry

Preliminary Course
Final Examination • 2002

Outcomes Map

QUESTION	OUTCOMES
1	P10
2	P3
3	P9
4	P10
5	P2
6	P6, P13
7	P10
8	P6, P8
9	P8, P10
10	P10
11	P9
12	P4, P6
13	P9
14	P7, P10, P14
15	P4, P9
16	P6
17	P4, P6
18	P10
19	P10
20	P13
21	P10, P13
22	P6, P8
23	P4, P6, P8, P10

Answer Box for Questions 1–11

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 ○
10	A ○	B ○	C ○	D ◎
11	A ○	B ○	C ○	D ◎

1 What is the change in mass of 1.00 gram samples of Li and Ca metals when they react with an excess of oxygen (O_2)*?*

	CHANGE IN MASS (g)	
	Li	**Ca**
(A)	1.000	1.000
(B)	2.153	1.399
(C)	1.153	0.399
(D)	0.576	0.799

2 Which of the following statements relates to a detrimental effect of thermal pollution in waterways*?*

(A) Fish populations will increase to disproportionate levels in higher water temperature.
(B) Increased water temperature will lead to less dissolved oxygen causing stress to aquatic organisms.
(C) Metabolic rates in fish are decreased.
(D) Higher water temperature results in the increased precipitation of heavy metals.

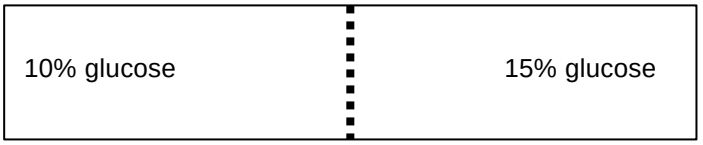
3 Which of the following ranks of coal has the highest carbon content*?*

(A) anthracite
(B) bituminous coal
(C) brown coal
(D) lignite

4 What is the mass of 2 moles of oxygen atoms*?*

(A) 8.0 grams
(B) 16 grams
(C) 32 grams
(D) 64 grams

5 The diagram shows a two section compartment filled with aqueous glucose solutions separated by a semi-permeable membrane.



Which statement describes what will happen?

(A) Glucose molecules will move into the right side by diffusion.
(B) Water molecules will move into the left side by diffusion.
(C) Glucose molecules will move into the left side by osmosis.
(D) Water molecules will move into the right side by osmosis.

6 Water, hydrogen sulfide and ammonia are compounds of O, S and N with hydrogen.
Which of the following are correct Lewis electron dot structures, where X = N, O or S?

	WATER	**HYDROGEN SULFIDE**	**AMMONIA**
(A)	H : X : H	H : X : H	H : X : H H
(B)	H : X : H	H H : X : H H	H : X : H H
(C)	H : X : H	H : X : H	H : X : H H
(D)	H : X : H	H : X : H	H : X : H H

7 What is the whole number mass ratio of metal to non-metal (metal:non-metal) in barium chloride?

(A) 1:2
(B) 2:1
(C) 1:1
(D) 4:1

8 Which of the following binary compounds would have the greatest solubility in water?

(A) CH_4
(B) CO_2
(C) HCl
(D) HF

9 Which of the following equations shows the precipitation of copper(I) chloride?

(A) $Cu_{(s)} + \frac{1}{2} Cl_{2\,(g)} \rightarrow CuCl_{(s)}$
(B) $Cu_{(s)} + Cl^-_{(aq)} \rightarrow CuCl_{(s)}$
(C) $Cu^+_{(aq)} + Cl^-_{(aq)} \rightarrow CuCl_{(s)}$
(D) $Cu^+_{(aq)} + \frac{1}{2} Cl_{2\,(g)} \rightarrow CuCl_{(s)}$

10 0.10 mole of aluminium chromate, $Al_2(CrO_4)_3$, is dissolved in sufficient water to make 500 mL of solution. What are the concentrations of the resultant ions formed?

	CONCENTRATION (mol L^{-1})	
	Al^{3+}	CrO_4^{2-}
(A)	0.050	0.033
(B)	0.10	0.10
(C)	0.20	0.20
(D)	0.40	0.60

11 Which of the following is the second hydrocarbon compound in the alkyne homologous series?

(A) butyne
(B) ethyne
(C) hexyne
(D) propyne

Part B – 57 marks
Questions 12 – 23

Question 12 (4 marks)

The table lists the boiling points for the first eight members of the homologous series of alkanes.

FORMULA	BOILING POINT (K)
CH_4	112
C_2H_6	184
C_3H_8	231
C_4H_{10}	273
C_5H_{12}	309
C_6H_{14}	342
C_7H_{16}	371
C_8H_{18}	399

(a) Define the term, homologous series. **(1 mark)**

A family of compounds which can be represented by one general formula is called an homologous series (each successive member of the series differs by a set increment, e.g. alkanes differ successively by CH_2

(b) Explain the trend in boiling point for the alkanes. **(1 mark)**

Boiling point increases with increasing mass because dispersion forces increase as the molecules get bigger.

(c) List two hazards of working with hydrocarbons and the precautions taken to avoid these dangers. **(2 marks)**

Hazards:
Extremely flammable, extremely volatile, some are toxic.

Precautions:
Store only in approved containers/well maintained cylinders.
Keep away from naked flames/sparks. Handle in well ventilated areas.
Minimise stored quantities.
Use narrow necked containers. In the lab, use under a fume cupboard.

Question 13 (6 marks)

(a) Compare one use of each carbon allotrope and relate this use to a physical property. **(4 marks)**

ALLOTROPE	USE	PHYSICAL PROPERTY
graphite	electrodes dry lubricant lead pencils	electrical conductivity layers slip off each other easily
diamond	jewellery drill, cutting tools	sparkle hardness

(b) Carbon exists in several allotropes and several isotopes.
Differentiate between the terms, allotrope and isotope. **(2 marks)**

Allotropes are different forms of the same element that have different chemical properties and different physical properties, e.g. diamond and graphite.

Isotopes are different atoms of the same element that have different numbers of neutrons, e.g. C–12, C–13.

Question 14 (3 marks)

A student experimentally determined the molar heat of solution of calcium chloride using a calorimeter.

(a) The student used the specific heat of water in the calculation of the result.
Define the term, specific heat. **(1 mark)**

The specific heat of a substance is the energy required to raise the temperature of 1 gram by 1C°.

(b) The student found that when 5.3 grams of calcium chloride dissolved in 250 g of water the temperature rose by 3.4 C^{o} in the calorimeter.
Calculate the molar heat of solution from this data. **(2 marks)**

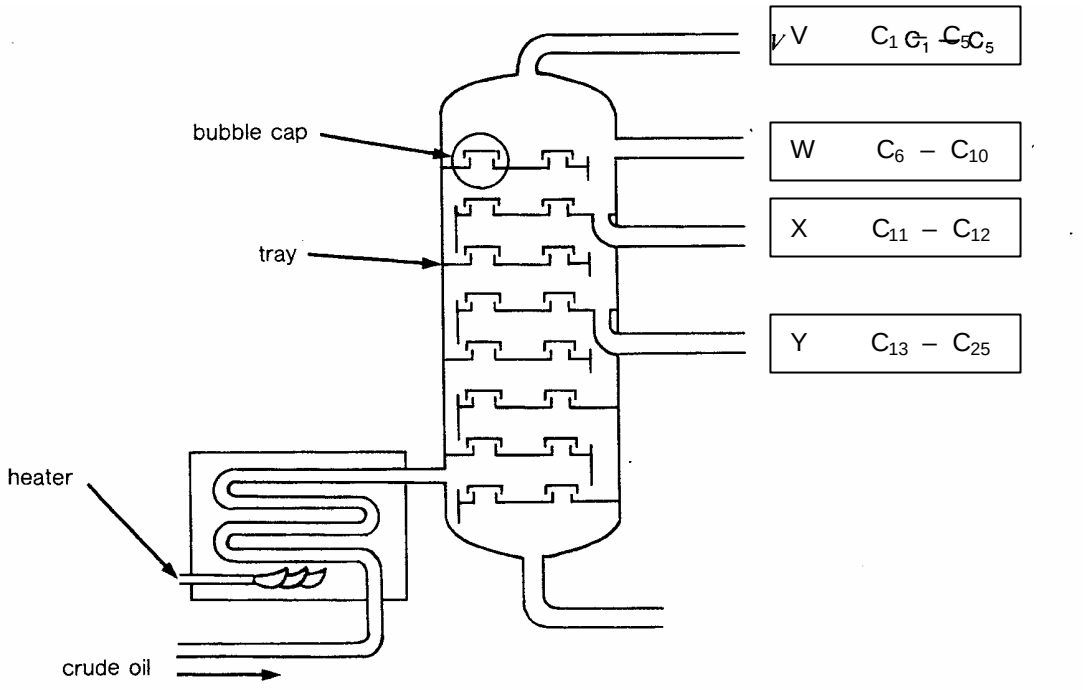
? H = – m C ? T = – (250 g) (4.18) (3.4 C^{o}) = –3553 J **(1 mark)**

Molar mass $CaCl_2$ = 111 g **(or 1 mark)**

Molar ? H_{soln} = (111 g) (–3553 J) ÷ 5.5 g = –74412 = –74000 J **(1 mark)**

Question 15 (7 marks)

The diagram shows a fractionating tower which is used in the processing of crude oil. Hydrocarbon fractions are removed from outlets on the right hand side of the tower. The approximate numbers of carbon atoms in molecules from each fraction are indicated.



(a) From which fraction, (V, W, or X) is petrol made? **(1 mark)**

W

(b) Why is it incorrect to write a chemical formula for petrol? **(1 mark)**

Petrol is a mixture.

(c) Identify one use for the fraction obtained at Y. **(1 mark)**

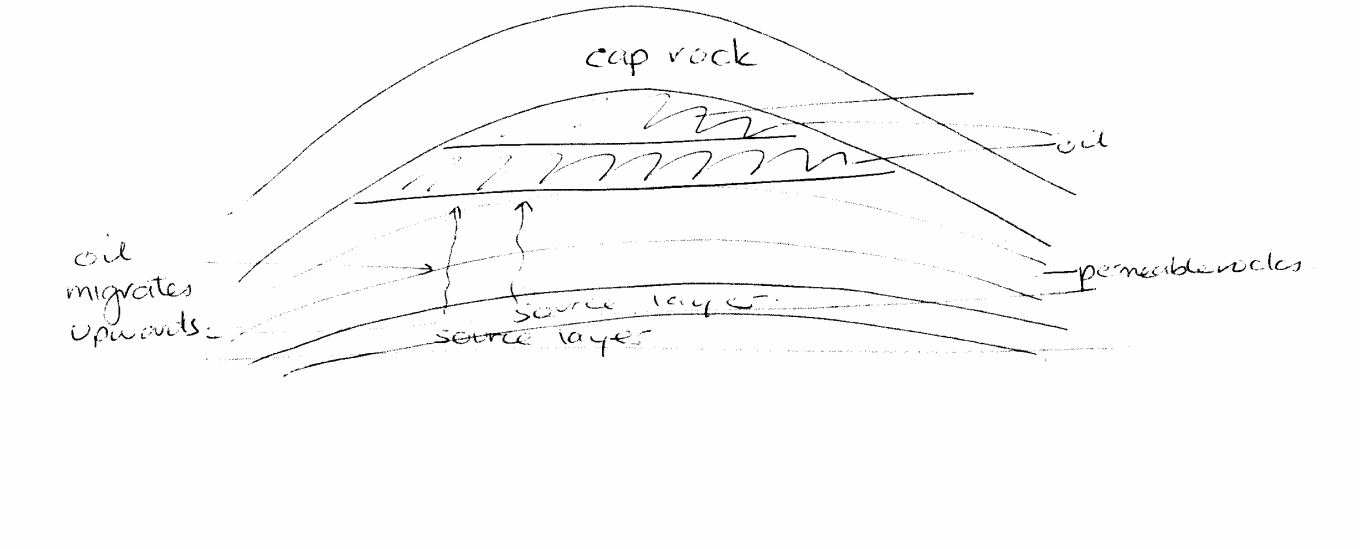
Heating oil or diesel or lubricating oil

(d) Identify the physical property of hydrocarbons which allows them to be separated by the fractionating tower. **(1 mark)**

Different boiling points

Question 15 (continued)

(e) Describe the geological processes resulting in a crude oil accumulation and the method by which it is extracted from the earth. Use a diagram to illustrate your answer. **(3 marks)**



Oil producing sediments are compacted under pressure. They are overlain by other sediments. Through decomposition, oil is produced and it migrates up through permeable layers until it hits a cap rock. The oil pools under domed structures and cap rock and can be extracted by drilling. The oil initially gushes through the pipe under pressure.

<u>Description</u>: 1 mark
<u>Extraction Method (drilling)</u>: 1 mark
<u>Diagram</u>: 1 mark

Question 16 (3 marks)

The table shows the boiling points of water, ammonia and hydrogen sulfide.
Explain the differences in the relative boiling points of each of these substances.

water	ammonia	hydrogen sulfide
100º C	– 33º C	– 62º C

_____

_____

_____

_____

_____

Question 17 (6 marks)

Explain the implications of the following properties of water for plants and animals.

(a) The low density of ice. **(2 marks)**

_____

_____

_____

(b) Adhesion and cohesion. **(2 marks)**

_____

_____

_____

(c) Surface tension. **(2 marks)**

_____

_____

_____

Question 18 (3 marks)

(a) What is the empirical formula of a compound of bismuth and chlorine, which is 66% (w/w) bismuth. **(2 marks)**

Assume 100 g sample of compound...
\ (66 g Bi ÷ 209.0 g/mol) = 0.3158 mol Bi
\ (34 g Cl ÷ 35.45 g/mol) = 0.9590 mol Cl
\ empirical formula = $\underline{BiCl_3}$

(b) If a sample of this compound contained 2 g of bismuth, what would be the total mass of the sample*?* **(1 mark)**

0.66x = 2 g
\ x = 3.03 = $\underline{3}$ g

Question 19 (4 marks)

A 10.0 g sample of impure zinc metal, heavily corroded with zinc hydroxide on its surface, was chemically analysed to determine the amount of zinc metal present. The sample was 'dissolved' in excess 1.00 mol L^{-1} hydrochloric acid solution and 3.05 L of hydrogen gas was produced at 25ºC and 101.3 kPa.

(a) Write a balanced chemical equation for the reaction producing hydrogen gas. **(1 mark)**

$Zn_{(s)} + 2HCl_{(aq)} \rightarrow ZnCl_{2\,(aq)} + H_{2\,(g)}$

(b) How many moles of zinc metal reacted to produce the hydrogen gas? **(1 mark)**

Moles Zn = Moles H_2 = 3.05 L ÷ 24.47 L mol^{-1} = 0.1246 = <u>0.125 mol</u>

(c) Calculate the mass percentage of zinc metal in the original sample. **(1 mark)**

(0.1246 mol Zn) (65.39 g/mol) = 8.1476 g Zn

(8.1476 g Zn) ÷ (10.0 g sample) = 81.476% = <u>81.5% Zn</u>

(d) Calculate the volume of acid which reacted with the whole sample. **(1 mark)**

grams $Zn(OH)_2$ = 10.0 g sample – 8.15 g Zn = 1.85 g
mole $Zn(OH)_2$ = 1.85 g ÷ 99.406 g/mol = 0.0186 mol
mole HCl = 2(mol Zn) + 2[mol $Zn(OH)_2$]= 2(0.125) + 2(0.01860) = 0.2872 mol
volume HCl = 0.2872 mole HCl ÷ 1.00 mol L^{-1} = <u>0.287 L</u>

Question 20 (2 marks)

Briefly describe an experiment to identify the effect of mass of added salt to a fixed mass of water on the boiling point of water.

_____

_____

_____

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Question 21 (5 marks)

(a) A chemist requires an accurately prepared solution of barium chloride.

Solution specifications	
volume	500.0 mL
concentration	0.250 mol L^{-1}
solute	barium chloride–2–water
warning	toxic

Describe the steps involved in the preparation of this solution.
Include calculations and mention any specialised apparatus used. **(4 marks)**

Calculation: ***grams solute = (0.250 M) (0.500 L) (244.232) = 30.529 g*** **(1 mark)**

Technique:

Weigh out 30.53 g of solute into a 500 mL beaker.
Add about 250 mL of distilled water. Stir and dissolve.
Transfer and rinse the solution into a 500 mL volumetric flask.
(1 mark for mentioning volumetric flask)

Add distilled water until the solution's meniscus matches the graduation line on the flask.
(1 mark for proper filling)

Safety: (1 mark)

Wear safety goggles, gloves; label solution toxic; wash hands afterwards.

(b) Convert the molarity of the barium chloride solution into a percentage concentration (w/w). Assume the solution's density is 1.00 g mL^{-1}. **(1 mark)**

Trick Question!

grams $BaCl_2$ = (0.250 M) (0.500 L) (208.2) = 26.025 g
N.B. formula mass of anyhydrous salt!

\ 26.025 g/500mL = 5.205 g/100g = 5.205% = 5.21%

Question 22 (7 marks)

(a) Complete the table showing examples of bonding types and aqueous solubilities. **(5 marks)**

Bonding type	Common example	Aqueous solubility (in general)
metallic	zinc	insoluble
macro-molecule	cellulose	**insoluble**
covalent network	**silicon dioxide**	**insoluble**
polar covalent	hydrogen chloride	**soluble**
non-polar covalent	**methane**	**insoluble**
ionic	sodium sulfate	**soluble**

Marking: 10 @ ½ mark

(b) The dissolving of oxygen in water can be correctly represented as… $O_{2\,(g)} \leftrightharpoons O_{2\,(aq)}$

Identify two reasons why the dissolving of HCl in water cannot be represented as…

$$HCl_{(g)} \leftrightharpoons HCl_{(aq)}$$ **(2 marks)**

1. ***HCl reacts with water and ionises; it does not remain molecular.*** **(1 mark)**
2. ***The reaction it not an equilibrium reaction.*** **(1 mark)**

Question 23 (7 marks)

Use the solubility table to answer the questions which follow.

SOLUBILITY TABLE

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

(a) Complete the table indicating the solubility of the salts. Use **S for soluble** and **I for insoluble**. **(3 marks)**

	CH_3COO^-	Cl^-	CO_3^{2-}	S^{2-}
Ag^+	I	I	**I**	**I**
Ca^{2+}	S	**S**	**I**	**S**
Hg_2^{2+}	S	I	**I**	**I**

Marking: 6 @ ½ mark

Question 23 (continued)

(b) A solution of lead(II) nitrate is accidentally spilled into a pond.
Identify a problem resulting from this spill. **(1 mark)**

Lead is a heavy metal and its solutions are toxic.
This spill could result in death to aquatic organisms in the pond.

(c) The lead(II) nitrate can be chemically removed by precipitation.
Identify a compound which will react with lead(II) nitrate and form a precipitate. **(1 mark)**

Sodium sulfate **(many other possibilities, but must be <u>soluble</u>, e.g. $CaSO_4$ is incorrect)**

(d) Write a balanced chemical equation for the precipitation reaction in (c). **(1 mark)**

$Pb(NO_3)_2 + Na_2SO_4 \rightarrow PbSO_{4\,(s)} + 2NaNO_3$ ***(many other possibilities)***

(e) Write the net ionic equation for the precipitation reaction in (e). **(1 mark)**

$Pb^{2+} + SO_4^{2-} \rightarrow PbSO_{4\,(s)}$ ***(Must have $_{(s)}$ included)***