1994 HSC CHEMISTRY

CORE DETAILED SUGGESTED SOLUTIONS

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NSW HIGHER SCHOOL CERTIFICATE EXAMINATION

1994 CHEMISTRY 2 UNIT CORE QUESTIONS AND SUGGESTED DETAILED SOLUTIONS

DIRECTIONS TO CANDIDATES

Section I—Core

- **ALL** questions in Section I are **COMPULSORY**.
- **Part A** 12 one-mark multiple-choice questions.
  Mark your answers in pencil on the Answer Sheet provided.
- **Part B** 6 three-mark questions.
  Write your answers in the Part B Answer Book.
- **Part C** 6 five-mark questions.
  Write your answers in the Part C Answer Book.
- Write your Student Number and Centre Number on each Answer Book.
- You may keep this Question Book, which you may use for rough work.
  Anything written in the Question Book will NOT be marked.

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

HIGHER SCHOOL CERTIFICATE COURSE CHEMISTRY 1995 ONWARDS

From 1995, students are required to answer questions from Core topics 8 - 11 and from ONE elective only. While the main part of each question must be from these sections of the syllabus, the question may involve work from the preliminary course as this is 'presumed knowledge'.

From 1995, the format of the HSC examination paper will be:
SECTION I (75 marks)
All questions in Section I are COMPULSORY.

Part A 15 one-mark multiple choice questions.
Part B 10 three-mark questions.
Part C 6 five-mark questions.

SECTION II (25 marks)
Answer questions for ONE Elective only.
1. Chemical Energy
2. Oxidation and Reduction
3. Biological Chemistry
4. Chemistry in the Environment

DATA SHEET

- Values of several numerical constants -

Avogadro's constant, N_A	6.022 x 10^{23} mol^{-1}
Boltzmann's constant, k	1.381 x 10-23 J K^{-1}
Elementary charge, e	1.602 x 10^{-19} C
Faraday constant, F	96 490 C mol^{-1}
Gas constant, R	8.314 J K^{-1} mol^{-1}
	0.0821 L atm K^{-1} mol^{-1}
Ionisation constant for water at 298 K (25^{o}C), K_w	1.0 x 10^{-14}
Mass of electron, m_e	9.109 x 10^{-31} kg
Mass of neutron, m_n	1.675 x 10^{-27} kg
Mass of proton, m_p	1.673 x 10^{-27} kg
Volume of 1 mole ideal gas at 101.3 kPa (1.00 atm) and	
at 273 K (0^{o}C)	22.41 L
at 298 K (25^{o}C)	24.47 L

PERIODIC TABLE

KEY

Atomic Number — Symbol of element — Name of element — Atomic Mass

																	2 He 4·003 Helium
3 Li 6·941 Lithium	4 Be 9·012 Beryllium								1 H 1·008 Hydrogen			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 32·06 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 47·90 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 58·71 Nickel	29 Cu 63·55 Copper	30 Zn 65·38 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

This sheet should be REMOVED for your convenience.

SECTION I CORE

PART A

Attempt ALL questions.
Each question is worth 1 mark.
Select the alterative A, B, C, or D that best answers the question.
Mark your answers in pencil on the Answer Sheet provided.

1 . The correct formula for beryllium nitrate trihydrate is

(A) $Be(NO_3)_3.3H_2O$

(B) $Be(NO_3)_2.3H_2O$

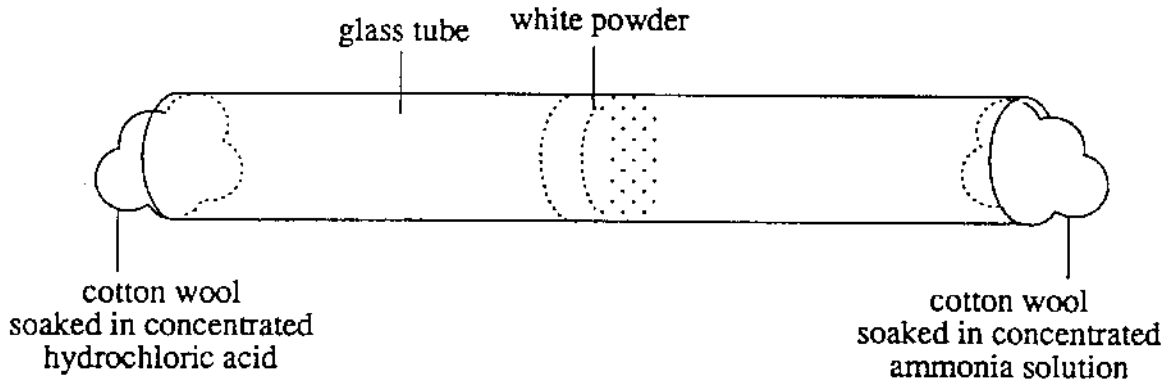
(C) $Be_2NO_3.3H_2O$

(D) $Be_2(NO_3)_3.3H_2O$

1. Suggested solution B

Beryllium is in Group II of the periodic table. Hence, it will readily form the ion Be^{2+}. The nitrate ion has the formula NO_3^-. Hence, two nitrate ions will combine with one beryllium ion. Trihydrate means 'three' water molecules attached. $Be(NO_3)_2.3H_2O$.

2 . A cotton plug soaked in concentrated hydrochloric acid was inserted into one end of a glass tube. A similar plug, soaked in concentrated ammonia solution, was inserted into the other. A white powder quickly formed in the tube, as shown below.



The reaction which occurs is represented by

(A) $NH_3(g) + HCl(g) \rightarrow NH_4Cl(s)$

(B) $NH_3^+(g) + Cl^-(g) \rightarrow NH_3Cl(s)$

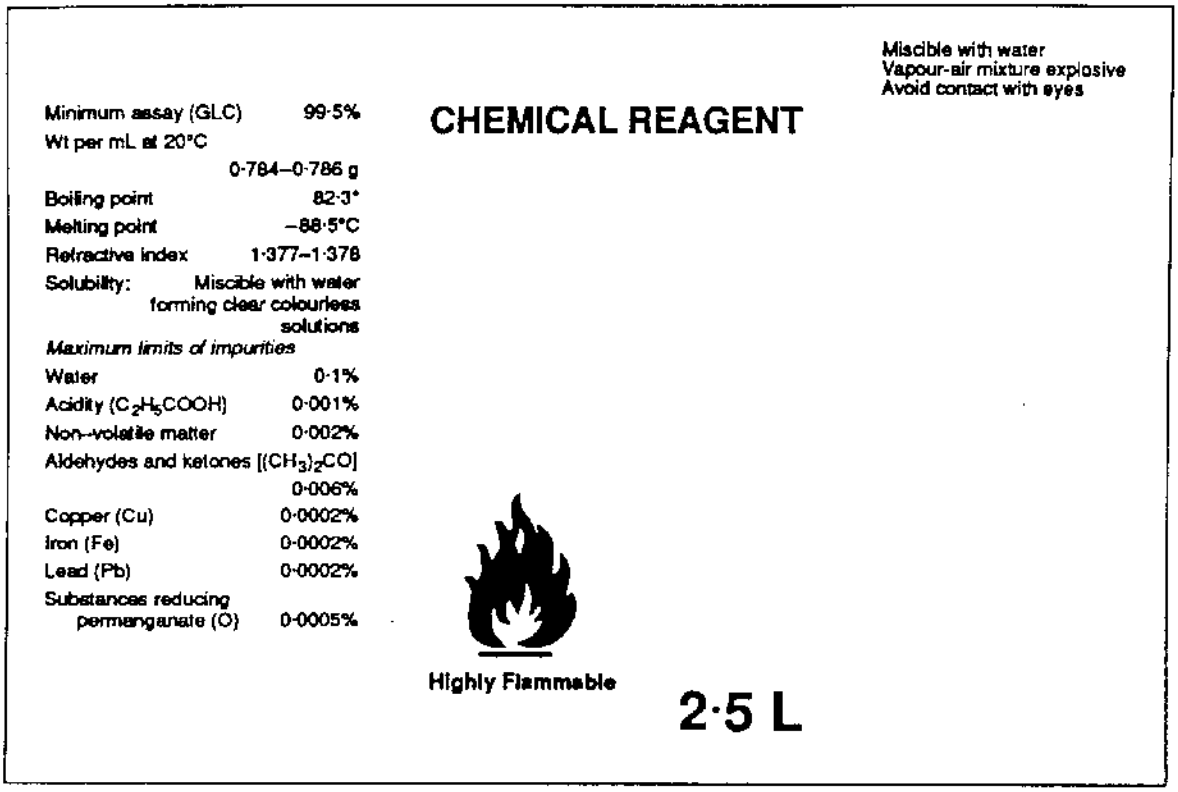
(C) $NH_4^+(g) + Cl^-(g) \rightarrow NH_3Cl(s) + \frac{1}{2} H_2(g)$

(D) $NH_4(g) + HCl(g) \rightarrow NH_3Cl(s) + H_2(g)$

2. Suggested solution A

Hydrochloric acid is hydrogen chloride gas dissolved in water. Ammonia solution is ammonia gas dissolved in water. Both hydrochloric acid and ammonia solution are volatile. That is, the gases readily come out of solution. The gases, HCl(g) and $NH_3(g)$ mix and react to form the white solid, NH_4Cl. The reaction is $NH_3(g) + HCl(g) \rightarrow NH_4Cl(s)$

3 . The label below gives information about a chemical reagent.



At room temperature the reagent is a

(A) liquid, insoluble in water, *not* flammable.

(B) liquid, soluble in water, flammable.

(C) solid, insoluble in water, *not* flammable.

(D) solid, soluble in water, flammable.

3. Suggested solution B

Since the boiling point is 82.3^{o} and the melting point is -88.5^{o}, the reagent is a liquid at room temperature. The label states that it is miscible with water. This means that it is soluble in water in all proportions. The label also indicates that this liquid is highly flammable.

4 . In the atmosphere, ozone can be converted to oxygen according to the equation below.

$$2O_3(g) \rightarrow 3O_2(g)$$

The mass of oxygen, in grams, formed by complete conversion of 9.27×10^{l8} molecules of ozone is

(A) 1.54×10^{-5}

(B) 3.69×10^{-4}

(C) 4.93×10^{-4}

(D) 7.39×10^{-4}

4. Suggested solution D

Mass of oxygen produced = mass of ozone consumed
= number of mole of ozone x relative molecular mass of ozone

$$= \frac{9.27 \times 10^{18}}{6.022 \times 10^{23}} \times 48 = 7.39 \times 10^{-4} \text{ g.}$$

5. When hydrochloric acid reacts with magnesium metal, hydrogen gas is evolved and magnesium ions are produced.

In this reaction

(A) electrons are transferred from the chloride ions to the metal.

(B) hydrogen ions are a strong reducing agent.

(C) hydrogen ions oxidise magnesium.

(D) hydrogen is more reactive than magnesium.

5. Suggested solution C

The ionic equation for this reaction is: $Mg(s) + 2H^+(aq) \rightarrow Mg^{2+}(aq) + H_2(g)$.
In this reaction, magnesium metal is oxidised (oxidation number changes from 0 to +2, loss of electrons) and hydrogen ions are reduced (oxidation number changes from +1 to 0, gain of electrons). The hydrogen ions oxidise the magnesium metal.

6 . Four elements A, B, C, D, have been classified as follows:

- element A is a non-metal;
- element B is a transition element;
- element C does not occur naturally;
- element D is in group 6 in the periodic table.

Which one of the following sets of elements is consistent with these classifications?

(A) Element A is phosphorus, B is platinum, C is lawrencium, D is selenium.

(B) Element A is selenium, B is platinum, C is phosphorus, D is lawrencium.

(C) Element A is platinum, B is lawrencium, C is phosphorus, D is selenium.

(D) Element A is phosphorus, B is selenium, C is lawrencium, D is platinum.

6. Suggested solution A

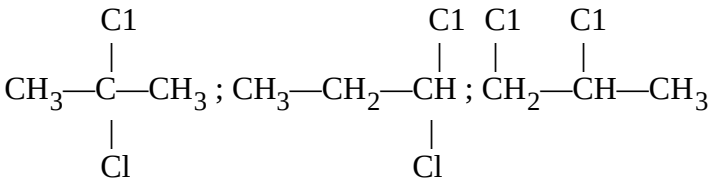
Phosphorus is a non-metal. Platinum is a transition metal. The element lawrencium does not occur naturally. Selenium is in group 6 of the periodic table.

7 . Three isotopes of the one substance are

(A) black phosphorus; red phosphorus; white phosphorus

(B) water, steam; heavy water

(C) ^{12}C; ^{13}C; ^{14}C

(D) 

7. Suggested solution C

Isotopes are atoms of the same element with different number of neutrons. ^{12}C has 6 neutrons; ^{13}C has 7 neutrons; ^{14}C has 8 neutrons. Black phosphorus, red phosphorus and white phosphorus are allotropes of phosphorus (different structural arrangements of the same element). (D) shows structural isomers (different structural arrangements of the same molecular formula).

8 . For the substance NO_2

(A) one molecule has a mass of 46 g.

(B) one molecule occupies a volume of 24.5 L at 298 K and 101.3 kPa.

(C) one mole contains 6.022×10^{23} atoms of oxygen.

(D) one mole contains 6.022×10^{23} molecules.

8. Suggested solution D

One mole of **anything** contains 6.022×10^{23} of those things.
However, one **mole** of NO_2 has a mass of 46 g. One **mole** of NO_2 occupies a volume of 24.5 L at 298 K and 101.3 kPa. One mole of NO_2 contains **2** x 6.022×10^{23} atoms of oxygen.

9 . Consider the reaction

$$FeO(s) + CO(g) \rightarrow Fe(s) + CO_2(g) \quad \Delta H = -283 \text{ kJ}$$

A change in conditions that moves the equilibrium position of this system to the right, i.e. favouring the products, is

(A) an increase in pressure.

(B) a decrease in temperature.

(C) the addition of more-finely-powdered FeO.

(D) an increase in the concentration of carbon dioxide.

9. Suggested solution B

If the temperature is decreased, the direction of reaction will be favoured that opposes this decrease in temperature. The forward reaction is an exothermic reaction. Hence, the equilibrium position of this system will move to the right i.e. favouring the products.

10. The pH of a 5 0 x 10^{-5} mol L^{-1} solution of barium hydroxide is

(A) 4.0

(B) 4.3

(C) 9.7

(D) 10.0

10. Suggested solution D

Barium hydroxide has the formula $Ba(OH)_2$. Hence,

$[OH^-]$ = 2 x concentration of barium hydroxide = 2 x 5.0 x 10^{-5} mol L^{-1} = 10^{-4} mol L^{-1}.

$[H^+] = \frac{1.0 \times 10^{-14}}{[OH^-]} = \frac{1.0 \times 10^{-14}}{10^{-4}} = 10^{-10}$.

Hence, pH = $-\log_{10}[H^+] = -\log_{10}10^{-10} = 10$.

11. A compound contains potassium, sulfur, and oxygen only. A sample of the compound is found to contain 41.1 mg of potassium, 33.8 mg of sulfur, and 25.2 mg of oxygen.

The empirical formula of the compound is

(A) K_2SO_4

(B) K_2SO_3

(C) $K_2S_2O_3$

(D) K_2SO_2

11. Suggested solution C

$n(K) = \frac{41.1 \times 10^{-3}}{39.10}$ = ; $n(S) = \frac{33.8 \times 10^{-3}}{32.06}$; $n(O) = \frac{25.2 \times 10^{-3}}{16.00}$.

Hence, the **ratio**, n(K) : n(S) : n(O)
= 1.05 : 1.05 : 1.575
(divide all numbers by 1.05)
= 1 : 1 : 1.5
(multiply all numbers by 2)
= 2 : 2 : 3
The empirical formula is $K_2S_2O_3$

12. Four elements, with atomic numbers 1, 8, 9, 12 form chlorides. The bonding is most ionic in the chloride formed from the element with atomic number

(A) 1

(B) 8

(C) 9

(D) 12

12. Suggested solution D

The elements are hydrogen (1), oxygen (8), fluorine (9) and magnesium (12). Of these elements. the most ionic bonding will occur in the chloride of magnesium since magnesium is a metal.

PART B

Attempt ALL questions

Each question is worth 3 marks.

Answer all questions in the Answer Book provided.

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

13. Hydrocarbons are widely used as fuels, and undergo combustion to give carbon dioxide and water.

(a) Given that the molar heats of combustion of ethane and propane are 1557 kJ mol^{-1} and 2217 kJ mol^{-1}, respectively, determine the *difference* in the amount of energy released when 1 kg of each is combusted.

(b) The heats of combustion of ethane and ethanol are 1557 kJ mol^{-1} and 1364 kJ mol^{-1}, respectively. Suggest why the heat of combustion of ethanol is much less than that of ethane.

13. Suggested solution

(a) $n(\text{ethane}) = \dfrac{\text{mass}}{\text{molar mass}} = \dfrac{1000}{30.068} = 33.258.$

Hence, $\Delta H = 33.258 \times 1557 = 51\ 783$ kJ kg^{-1} of ethane

$n(\text{propane}) = \dfrac{\text{mass}}{\text{molar mass}} = \dfrac{1000}{44.094} = 22.679.$

Hence, $\Delta H = 22.679 \times 2217 = 50\ 279$ kJ kg^{-1} of propane

Difference in the amount of energy released per kg of fuel = 51 783 - 50 279
= 1504 kJ **ANS**

(b) Ethanol (C_2H_5OH) already contains some oxygen. Because the ethanol is already partially oxidised, it requires less oxygen for complete combustion than ethane and therefore, has a lower heat of combustion than ethane.

14. When a piece of iron wire was placed in blue copper(II) sulfate solution, the blue colour slowly disappeared and a red-brown solid formed around the iron wire.

(a) Write a balanced equation for the reaction.
Include physical states for each species.

(b) Explain why the blue colour disappeared during the reaction.

(c) What would you observe if the iron wire was replaced with a piece of silver?
Explain your answer.

14. Suggested solution

(a) A balanced equation is: $Fe(s) + Cu^{2+}(aq) \rightarrow Cu(s) + Fe^{2+}(aq)$

(b) The blue colour is caused by the presence of the aqueous copper(II) ion, $Cu^{2+}(aq)$ As the reaction proceeds, this ion is used up as it is converted to solid copper.

(c) There would be no reaction visible since silver is less active than copper and therefore, will not react with $Cu^{2+}(aq)$.

15. Chemical species may be classified as basic, acidic, or amphiprotic (amphoteric).

(a) Select from the following oxides

SO_2, Na_2O, P_2O_5, Al_2O_3, MgO

(i) a basic oxide

(ii) an acidic oxide.

(b) Write a balanced equation for a reaction which illustrates the nature of one of the oxides in part (a).

(c) Beryllium hydroxide is amphiprotic. Briefly describe chemical tests that you could use to confirm this property.

15. Suggested solution

(a) (i) Most of the oxides of group I and group II metals are basic.
For example, Na_2O and MgO.

(ii) Most oxides of non-metals are acidic.
For example, SO_2 and P_2O_5.

(b) For the examples given above the equations are:

(i) $Na_2O(s) + H_2O(l) \rightarrow 2NaOH(aq)$

and $MgO(s) + H_2O(l) \rightarrow Mg(OH)_2(aq)$

(ii) $SO_2(g) + H_2O(l) \rightarrow H_2SO_3(aq)$

and $P_2O_5(s) + 3H_2O(l) \rightarrow 2H_3PO_4(aq)$

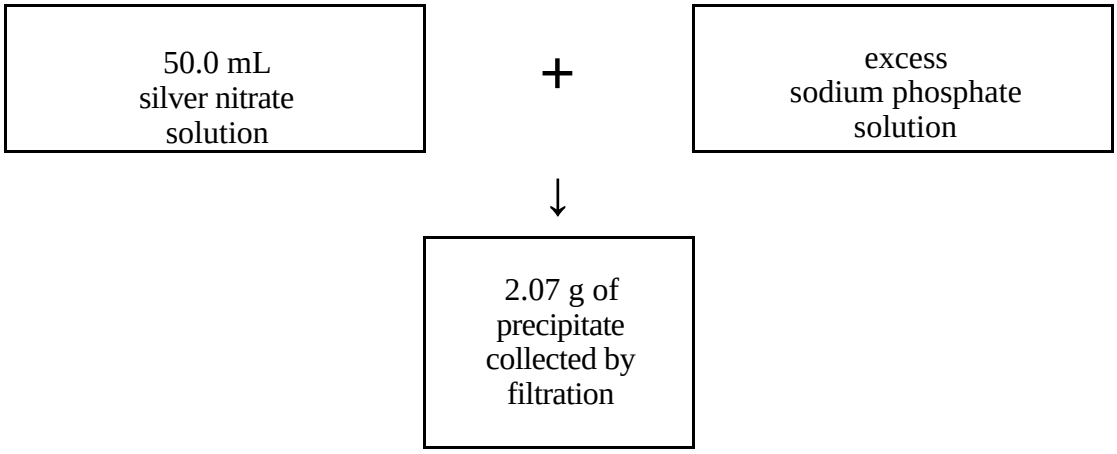
(c) To show that beryllium hydroxide is amphiprotic (amphoteric), it is necessary to show that it reacts with both acids and bases.
Use, for example, HCl(aq) and NaOH(aq). The reactions would be:

$Be(OH)_2(s) + 2HCl(aq) \rightarrow BeCl_2(aq) + 2H_2O(l)$

and

$Be(OH)_2(s) + 2NaOH(aq) \rightarrow Na_2Be(OH)_4(aq)$

16. A student was asked to determine the concentration of silver ions in a solution of silver nitrate. The student transferred 50.0 mL of the silver nitrate solution to a beaker, stirred in an excess of sodium phosphate solution, and collected the resulting precipitate of silver phosphate by filtration.
The precipitate was then dried and the final mass was found to be 2.07 g.



(a) Write a balanced equation for the precipitation reaction.

(b) Calculate the concentration of silver ions, in mol L^{-1}, in the original solution.
Show your working.

16. Suggested solution

(a) The balanced molecular equation is:

$$Na_3PO_4(aq) + 3AgNO_3(aq) \rightarrow Ag_3PO_4(s) + 3NaNO_3(aq)$$

The balanced ionic equation is:

$$PO_4^{3-}(aq) + 3Ag^+(aq) \rightarrow Ag_3PO_4(s)$$

(b) Number of mole of precipitate, Ag_3PO_4 $= \dfrac{\text{mass}}{\text{molar mass}}$

$= \dfrac{2.07}{418.67}$

$= 4.9442 \times 10^{-3}$ mol

Hence, from the balanced equation in (a) above,

number of mole of $Ag^+(aq)$ reacting = number of mole of $Ag^+(aq)$ in the original solution (since the sodium phosphate is in excess)

= 3 x no. of moles Ag_3PO_4 = $3 \times 4.9442 \times 10^{-3}$ = 1.4833×10^{-2} mol

$[Ag^+(aq)]$ in the original solution $= \dfrac{1.4833 \times 10^{-2}}{0.05}$

$= 0.297$ mol L^{-1}

$= 0.3$ mol L^{-1} **ANS**

17. A cigarette lighter holds 5.0 g of butane. The equation for the complete combustion of butane gas is:

$$C_4H_{10}(g) + \frac{13}{2} O_2(g) \rightarrow 4CO_2(g) + 5H_2O(l) \quad \Delta H = -2874 \text{ kJ}$$

(a) Calculate the amount of heat that may be generated by the complete combustion of 5.0 g of butane.

(b) Sometimes in the combustion of butane, soot (carbon) is formed.

(i) Write a balanced equation for the combustion of butane where one of the products is soot (carbon).

(ii) What determines whether soot (carbon) is formed in a combustion reaction?

17. Suggested solution

(a) Number of mole of butane = $\frac{\text{mass}}{\text{molar mass}} = \frac{5.0}{58.12} = 0.086$ mol.

the complete combustion of 5.0 g of butane will release 0.086 x 2874 kJ = 247.25 kJ

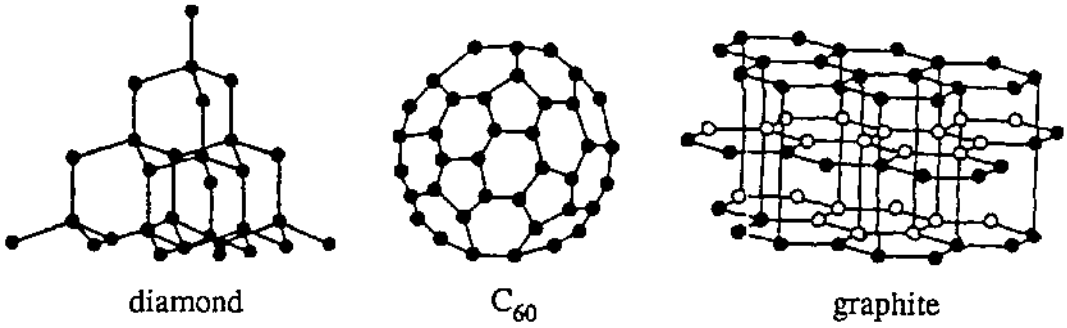
$= 2.5 \times 10^2$ kJ **ANS**

(b) (i) If **only** carbon (soot) and water are produced, the balanced equation is:

$$C_4H_{10}(g) + \frac{5}{2} O_2(g) \rightarrow 4C(s) + 5H_2O(g)$$

(ii) If insufficient oxygen is present the reaction will not go to completion with the formation of carbon dioxide and water. Soot can be regarded as an intermediate product in the production of carbon monoxide and finally carbon dioxide.

18. There are three allotropes of carbon, the newest one 'Buckminster fullerene', commonly known as 'Buckyballs', consisting of spherical *molecules* of C_{60}. The structures of these three allotropes are represented by the diagrams below.



(a) Define the term 'allotrope'.

(b) Complete the table in the Answer Book for the two allotropes diamond and graphite by stating:

(i) a use for each;

(ii) a physical feature of each.

(c) The melting points of diamond and graphite are both greater than $3550^{o}C$. Would you expect the Buckyballs allotrope to have a higher or lower melting point than 3550° C? *Explain your answer*.

18. Suggested solution

(a) Allotropes are different structural arrangement of the atoms of an element. Because the structures are different, the physical properties are different. Because the atoms are the same, the chemical properties are the same.

(b)

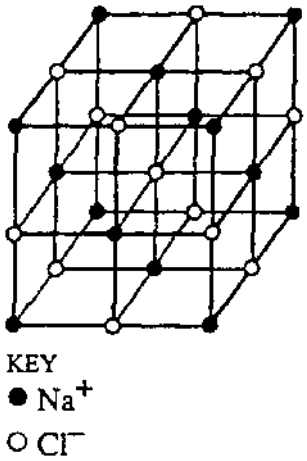
Allotrope	Use	Physical Feature
Diamond	grinding and cutting; decorative jewellery	very hard, high melting point; high refractive index
Graphite	lubrication; battery electrodes	low friction; conducts electricity

(c) It would be expected that the melting point of buckyballs would be lower than that of diamond and graphite because C_{60} is a covalent molecular substance with strong covalent bonding inside the molecules but weak inter-molecular forces between the molecules of C_{60}. When buckyballs melt, the molecules remain intact but are separated from each other. On the other hand, diamond and graphite are both covalent network substances with strong covalent bonding throughout the structures. To melt either of these requires the breaking of these strong covalent bonds.

PART C

Attempt ALL questions. Each question is worth 5 marks.
Answer all questions in the Answer Book provided
In questions involving calculations, you are advised to show working, as marks may be awarded for relevant working.

19. The arrangement of sodium ions and chloride ions in solid sodium chloride is represented in the following diagram (the arrangement would extend in three dimensions to represent a crystal).



In this structure, there are 6 chloride ions arranged in a regular manner about each sodium ion.

(a) (i) What is the arrangement about each chloride ion?

(ii) Would it be possible for calcium chloride to have the same structure as sodium chloride? *Explain your answer.*

(iii) What are the forces holding the sodium ions and chloride ions together in the crystal lattice?

(b) (i) The melting point of sodium chloride (801^oC) is much higher than that of carbon tetrachloride (tetrachloromethane) (-23^oC).
Explain why this is so.

(ii) Describe how measurements of electrical conductivity could be used to distinguish sodium chloride from carbon tetrachloride.

19. Suggested solution

(a) (i) From the diagram, there are six sodium ions around each chloride ion.

(ii) It would not be possible for $CaCl_2$ to have the same structure because the ratio between the positive ions and the negative ions is different in each case (1 : 1 and 1 : 2)

(iii) The forces involved are electrostatic forces - the attraction between positive and negative charges.

(b) (i) The ionic bonds which hold the sodium chloride crystal together are much stronger than the intermolecular forces holding the tetrachloromethane molecules together. These dispersion forces or Van der Waals forces are quite weak.

(ii) Tetrachloromethane does not conduct an electric current. Sodium chloride will conduct an electric current either in the molten state or in aqueous solution (but not in the solid state).

20. (a) The element E with atomic number 114 has not yet been discovered. However, based on the structure of the periodic table, it is reasonable to predict some of its properties.

(i) Would you expect E to be a metal or a non-metal? How could this be confirmed experimentally for a sample of this element?

(ii) Give the formula of a chloride of this element E.

(b) Element E will be radioactive and likely to undergo alpha emission.

(i) Predict the atomic number of the product left after the emission of the first alpha particle.

(ii) The first ionisation energy of the element immediately above E in the periodic table is 722 kJ mol^{-1}. Would you expect the first ionisation energy for 1 mole of E to be larger or smaller than 722 kJ?
Give a reason.

20. Suggested solution

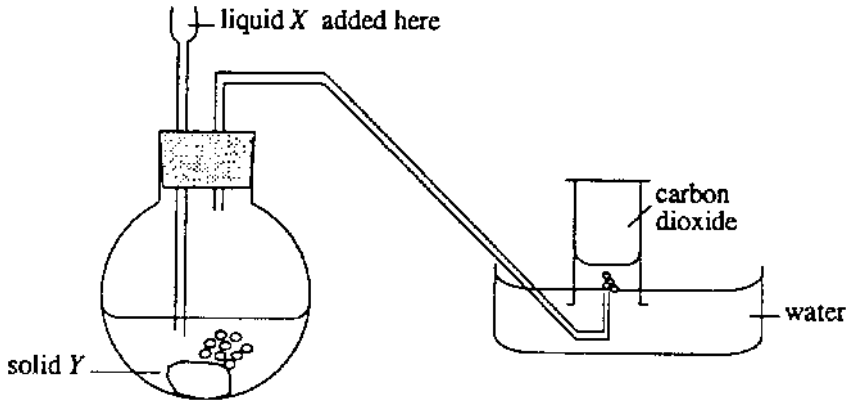
(a) (i) From the structure of the periodic table, it can be seen that element 114 will occur immediately below the element lead in group IV. Hence, it will be a metal. Confirm this by testing its electrical conductivity.

(ii) The formula of the chloride would be ECl_2 like $PbCl_2$.

(b) (i) An alpha particle has two protons and two neutrons. When element 114 loses two protons, it will become element 112.

(ii) It would be expected that the first ionisation energy of element E would be less than 722 kJ mol^{-1} because the electron is being removed from a shell that is further from the nucleus.

21.



(a) The above apparatus may be used in school laboratories for the production of carbon dioxide gas. In the experiment, liquid X is added to solid Y.

(i) Suggest what liquid X and solid Y might be.

(ii) Describe a laboratory test that could be used to confirm the presence of carbon dioxide gas.

(iii) Why would this apparatus be unsuitable for the collection of hydrogen chloride gas?

(b) For the production and testing of hydrogen in a school laboratory, a similar apparatus is used, except that the gas is bubbled through detergent and not collected in a gas jar.

(i) State which reagents could be used to produce hydrogen gas.

(ii) The purpose of using detergent is to collect hydrogen in small bubbles. Why is it undesirable to test large volumes of hydrogen?

21. Suggested solution

(a) (i) X is hydrochloric acid and Y is calcium carbonate (marble chips)

(ii) When carbon dioxide is bubbled through limewater, a milky white precipitate is produced according to the equation:

$CO_2(g) + Ca(OH)_2(aq) \rightarrow CaCO_3(s) + H_2O(l)$

(iii) Hydrogen chloride gas is very soluble in water. Hence, it cannot be collected by the method shown because it would dissolve in the water to form hydrochloric acid.

(b) (i) Hydrogen gas can be produced by the reaction between magnesium metal and hydrochloric acid according to the equation:

$Mg(s) + 2HCl(aq) \rightarrow MgCl_2(aq) + H_2(g)$

(ii) Hydrogen gas forms an explosive mixture with air according to the equation: $2H_2(g) + O_2(g) \rightarrow 2H_2O(l)$

Hence, only very small quantities of hydrogen gas should be ignited in air.

22. Hydrogen sulfide is a highly poisonous gas and stringent precautions are required in its handling.

(a) Briefly explain why H_2S (hydrogen sulfide) is considered an acid according to the Brønsted-Lowry theory.

(b) Write a balanced equation for an acid-base reaction between hydrogen sulfide and water.

Indicate the conjugate acid-base *pairs* involved.

(c) Hydrogen sulfide gas may be prepared in the fume cupboard by the reaction of hydrochloric acid with iron(lI) sulfide. In an experiment to prepare H_2S, 100 mL of 0.500 mol L^{-1} HCl solution was added to 1.10 g of solid FeS.

(i) Which reagent is in excess? *Show your working.*

(ii) What volume of hydrogen sulfide is produced at 298 K and 101.3 kPa in this experiment?

22. Suggested solution

(a) H_2S is acting as a proton donor.
Hence, it is classified as a Lowry-Bronsted acid.

(b) The balanced equation is: $H_2S(g) + H_2O(l) \rightarrow H_3O^+(aq) + HS^-(aq)$.
The conjugate acid-base pairs in this reaction are
$H_2S(g)/HS^-(aq)$ and $H_3O^+(aq)/H_2O(l)$

(c) (i) The balanced equation is: $FeS(s) + 2HCl(aq) \rightarrow FeCl_2(aq) + H_2S(g)$
Number of mole of HCl initially = c x V = 0.500 x 0.1 = 0.05 mol.
Number of mole of FeS initially = $\frac{\text{mass}}{\text{molar mass}} = \frac{1.10}{87.91}$ = 0.0125 mol.
From the balanced equation, number of mole of HCl used
= 2 x number of mole of FeS
= 2 x 0.0125 = 0.025.
Hence, the HCl is in excess by 0.05 - 0.025 = 0.025 mol. **ANS**

(ii) From the balanced equation,
number of mole of H_2S produced = number of mole of FeS used
= 0.0125 mol.
Hence, volume of H_2S produced = 0.0125 x 24.47 = 0.31 L **ANS**

23. The production of ammonia from nitrogen and hydrogen is an important example of an equilibrium reaction. The reaction involves an energy change of 92 kJ per mole of $N_2(g)$ used at 25^oC. The yield of ammonia depends on both the temperature and pressure of the reactants. In the following table, the percentage yield of ammonia, at a pressure of 200×10^2 kPa for the reaction mixture, is given.

Temperature (°C)	*Percentage yield of ammonia*
200	90
300	64
350	51
400	39
500	20

(a) Predict whether the production of ammonia in this process is exothermic or endothermic. *Explain your answer.*

(b) Write a balanced equation for the equilibrium involved in the production of ammonia. *Include the energy term and the physical states for all species.*

(c) Predict how an increase in temperature would affect the rate of production of ammonia in this reaction.

(d) An increase in pressure favours an increase in the yield of ammonia. *Explain this statement.*

(e) A catalyst is used in the industrial process. *Explain why this is so.*

23. Suggested solution

(a) The table shows that as temperature is increased, the percentage yield of ammonia decreases. Hence, the increase in temperature is favouring the reverse reaction (endothermic reaction). Hence, the forward reaction is exothermic. The production of ammonia is exothermic.

(b) The balanced equation is: $N_2(g) + 3H_2(g) \Leftrightarrow 2NH_3(g)$ $\Delta H = -92$ kJ mol^{-1}
(92 kJ is released per mole of equation as written)

(c) An increase in temperature would increase the rate of production of ammonia

(d) If the pressure is increased the equilibrium will move in such a way as to decrease the pressure by shifting towards the right (products) since there are fewer moles of gas in the products than the reactants and, therefore, less pressure.

(e) A catalyst is used to increase the rate at which equilibrium is achieved, thereby enabling the reaction to occur at a lower temperature.

24. Ethanol is used in certain countries as an alternative to hydrocarbon fuels. It can be prepared on a large scale by the fermentation of glucose ($C_6H_{12}O_6$), which produces ethanol and carbon dioxide only.

(a) (i) Write a balanced equation for the fermentation reaction of glucose.

(ii) What property of ethanol would allow it to be separated from the glucose-water mixture?

(iii) Calculate the maximum mass of ethanol obtained from the fermentation of 30 g of glucose.

(b) Glucose is used in the process of respiration as a source of energy in living things. What are the chemical by-products of this process?

(c) The use of ethanol as a fuel depends on its high value for ΔH_c (1364 kJ mol^{-1}). Despite this high value, ethanol does not combust spontaneously at room temperature. *Explain why this is so.*

24. Suggested solution

(a) (i) The balanced equation is:
$C_6H_{12}0_6(aq) \rightarrow 2CH_3CH_20H(aq) + 2CO_2(g)$

(ii) Ethanol has a lower boiling point than the glucose-water solution and can be separated by fractional distillation.

(iii) From the balanced equation, the number of mole of ethanol produced
= 2 x the number of mole of glucose reacting = $2 \times \frac{30}{180.16} = 0.333$ mol.
Hence, the maximum mass of ethanol which could be obtained
= 0.333 x 46.07 = 15.34 g **ANS**

(b) The chemical by-products of respiration are carbon dioxide and water as shown in the equation: $C_6H_{12}0_6(aq) + 6O2(g) \rightarrow 6C0_2(g)$ and $6H_20(l)$

(c) At room temperature, there is not enough energy to over come the activation energy barrier for the reaction between ethanol and oxygen.

END OF NSW HSC CHEMISTRY CORE 1994
QUESTIONS AND SUGGESTED SOLUTIONS

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