

SMJK YU HUA, KAJANG
UPPER SIX CHEMISTRY 2008
STPM TRIAL EXAMINATION
PAPER 2 (2 1/2 HOURS)

Pn. Maziah

Date : _____
Time : _____

Prepared by : Pn. Wong MP
Checked by : Pn. Maziah
Certified by : _____

Instructions to candidates

Answer all the questions in section A in the spaces provided. All working must be shown. For numerical answers, units must be quoted wherever they are appropriate.

Answer any four questions from section B. For this section, write your answers on the school answer sheet. Begin each answer on a fresh sheet of paper. Arrange your answers in numerical order. Tie your answer sheets to this question paper.

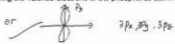
You can refer to data book.

Section A (40 marks)
Answer ALL questions in this section

1. (a) Chemists of ancient times prepared phosphorus, P from urine.
i) Write the electronic configuration of the phosphorus atom.



- ii) Draw the shape of one orbital containing the valence electrons of the phosphorus atom.



- iii) State one of the phosphorus atomic orbital that are filled according to Hund's rule

2p / 3p

- iv) In urine, the phosphorus element exists as phosphate ion, PO₄³⁻. What is the shape of this ion?

tetrahedral

- (b) Element X reacts with element Y to form compound Z. The electronegativity values of X and Y are 1.0 and 3.5 respectively.

- i) State the type of chemical bond in Z.

ionic bond

- ii) The Lewis symbols for atoms X and Y are shown below. What is the chemical formula of Z?



yy

iii) State two physical properties of Z.

- high melting / boiling point
- conduct electric current in molten / aqueous

iv) The chemical bond in Z is stronger than that in Na_2O . State two factors that explain this difference.

- charge of $\text{X}^{2+} > \text{Na}^+$
- size of $\text{X}^{2+} < \text{Na}^+$

[10m]

2. (a) In a titration experiment, 30.0 cm^3 of 0.80 mol dm^{-3} aqueous ammonia ($K_b = 1.8 \times 10^{-5}$) was titrated with 1.00 mol dm^{-3} nitric acid.

i) Sketch a labeled pH titration curve for the reaction.

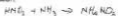
$$[\text{OH}^-] = \sqrt{K_b C}$$

$$= \sqrt{1.8 \times 10^{-5} \times 0.8}$$

$$= 3.79 \times 10^{-3}$$

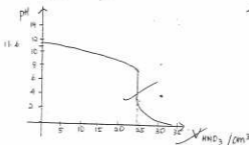
$$\text{pH} = 14 - \lg 3.79 \times 10^{-3}$$

$$= 11.6$$



$$V_{\text{HNO}_3} = \frac{30.0 \times 0.80}{1.00}$$

$$= 24 \text{ cm}^3$$



(b) A buffer solution was prepared from a mixture of 150 cm^3 of 0.80 mol dm^{-3} NH_3 and 50 cm^3 of 1.80 mol dm^{-3} NH_4NO_3 .

i) Calculate the pH of this buffer solution.

$$\text{pOH} = \text{p}K_b - \lg \frac{[\text{NH}_4^+]}{[\text{NH}_3]}$$

$$= -(\lg 1.8 \times 10^{-5}) - \lg \frac{(50 \times 1.8)}{(150 \times 0.8)}$$

$$= 4.74 - (-0.18)$$

$$= 4.92$$

$$\text{pH} = 9.08$$

- ii) What will be the pH of the resulting solution if 20.0 cm³ of 0.05 mol dm⁻³ H₂SO₄ is added to the buffer solution?



$$n_{H^+ \text{ added}} = \frac{20 \times 0.05 \times 2}{1000}$$

$$= 2 \times 10^{-3} \text{ mol}$$

$$n_{NH_3} = \left(\frac{150 \times 0.05}{1000} - 2 \times 10^{-3} \right)$$

$$= 0.118 \text{ mol}$$

$$n_{NH_4^+} = \left(\frac{50 \times 0.05}{1000} + 2 \times 10^{-3} \right)$$

$$= 0.032 \text{ mol}$$

$$pOH = 4.74 - \lg \frac{0.032}{0.118}$$

$$= 4.90$$

$$pH = 9.10$$

[10m]

3. The tetrachloride of Group 14 are Carbon tetrachloride, CCl₄; Silicon tetrachloride, SiCl₄; Germanium tetrachloride, GeCl₄; Tin tetrachloride, SnCl₄; and Lead tetrachloride, PbCl₄.

- (a) (i) What is the hybridisation of the Group 14 elements in each of the tetrachloride?

sp³

- (ii) What is the shape of each molecule?

tetrahedral

- (b) Which of the above tetrachlorides

- (i) is not hydrolysed at all in water? Explain your answer.

CCl₄ / Carbon atom has no available d-orbital to accept e⁻ pair from an oxygen atom in water molecule

- (ii) has the highest boiling point? Explain your answer.

PbCl₄ / strongest van der Waals forces with the largest molecules

- (c) Explain why carbon tetrachloride is used in fire extinguishers.

- Chemically inert

- (d) Several of the above compound decompose when heated.

- (i) Name one of the compound.

lead tetrachloride

- (ii) Explain why this compound is not thermally stable.

The Pb-Cl bond is longer and weaker.

- (iii) Write an equation for the decomposition



[10m]

4. An organic compound X has the composition by mass as follows

Carbon, 72.0%, Hydrogen, 6.7%, Oxygen, 21.3%

The relative molecular mass of X is 150. When X is refluxed with aqueous sodium hydroxide and then the mixture is distilled, the distillate does not contain any organic compound. When the mixture is treated with an excess of dilute mineral acid, two compounds Y and Z are formed. Action of bromine water on compound Z gives a white precipitate W.

- (a) (i) Calculate the empirical formula of X.

100 of mass

$\frac{C}{72} = 6$	$\frac{H}{6.7} = 6.7$	$\frac{O}{21.3} = 1.32$
5	5	1
9	10	2

Simplest ratio: 4.5 : 5 : 1

Empirical formula: $C_9H_{10}O_2$

- (ii) Determine the molecular formula of X.





$$(C_9H_{10}O_2)_n = 150$$

$$150n = 150$$

$$n = 1$$

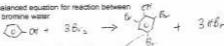
Molecular formula: $C_9H_{10}O_2$

- (b) Draw the structural formula of compounds X, Y, Z and W.

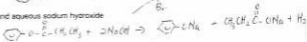
<p>Compound X</p> 	<p>Compound Z</p> 
<p>Compound Y</p> 	<p>Compound W</p> 

- (c) Write a balanced equation for reaction between

- (i) Z and bromine water



- (ii) X and aqueous sodium hydroxide



- (iii) Z and ethanoyl chloride



5 a) i) Rate = $k[AB_2]^a [F_2]^b$

by comparing Exp 1 & 2

$$\frac{6.5 \times 10^{-5}}{2.4 \times 10^{-2}} = \frac{k[0.25]^a [0.25]^b}{k[0.25]^a [0.25]^b}$$

$$0.27 = 0.25$$

$$b = 2$$

by comparing Expt 1 & 3

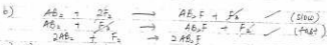
$$\frac{6.5 \times 10^{-5}}{1.3 \times 10^{-2}} = \frac{k[0.25]^a [0.25]^b}{k[0.25]^a [0.25]^b}$$

$$0.5^a = 0.5$$

$$a = 1$$

$$\therefore \text{Rate} = k[AB_2] [F_2]^2$$

(ii) $6.5 \times 10^{-5} = k[0.25][0.5]^2$
 $k = 0.104 \text{ mol}^{-2} \text{ dm}^3 \text{ s}^{-1}$



c) i) $k = \frac{0.25 \times (0.5)^2}{1.296}$
 $= 129.6 \text{ mol}^{-2} \text{ dm}^3 \text{ s}^{-1}$

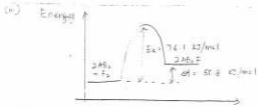
(ii) $k = A e^{-\frac{E_a}{RT}}$
 $\ln k = \ln A + (-\frac{E_a}{RT})$
 $\ln k = -\frac{E_a}{R}(\frac{1}{T}) + \ln A$

$$\frac{\ln 0.104}{\ln 129.6} = -\frac{E_a}{R}(\frac{1}{360}) - (-\frac{E_a}{R})(\frac{1}{500})$$

$$- = -12 = -\frac{E_a}{8.314}(\frac{1}{360} - \frac{1}{500})$$

$$E_a = 76108 = 7 \text{ J/mol}$$

$$= 76.1 \text{ kJ/mol}$$



$$K_c = \frac{[\text{NO}_2]^2}{[\text{N}_2\text{O}_4]}$$

$$= \frac{(0.12)^2}{(0.04)}$$

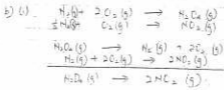
$$= 0.36 \text{ mol dm}^{-3}$$

(ii) $n_T = 0.12 + 0.04$
 $= 0.16 \text{ mole}$

$$pV = nRT$$

$$= \frac{0.16 \times 8.314 \times 283}{1 \times 10^{-2}}$$

$$= 5.09 \times 10^2 \text{ Pa}$$



$$\Delta H_f^\circ = -9.67 \text{ kJ/mol}$$

$$\Delta H_c^\circ = +33.9 \text{ kJ/mol}$$

$$\Delta H = -9.67$$

$$\Delta H = +33.9 \times 2$$

Enthalpy of dissociation = $-9.67 + (2)(+33.9)$
 $= +58.13 \text{ kJ/mol}$

- (ii)
- forward reaction is an endothermic reaction
 - K_c will favour forward reaction
 - K_c increases with temp
 - K_c is $\frac{[F]^2}{[E]}$
 - K_c increases

- 7 a) - Group 2 carbonates decompose on heating to form metal oxides.
- the thermal stability depends on
 - (i) the charge density on the cation
 - (ii) the polarisability of the anion
 - when going down the group, size of the cation \uparrow charge density \downarrow .
 - the polarising power of cations on CO_3^{2-} ions \downarrow .
 - thermal stability of carbonates \uparrow on going down the group.

- b) (i) Al_2O_3 consists of the Al^{3+} and O^{2-} ions
- Al^{3+} ion has high charge density
 - polarise the e^- cloud of O^{2-} anions
 - give a high degree of covalent character in the ionic bond.
 - ionic character give the basic property while the covalent character give the acidic property.

(ii) - AlCl_3 dissociate in water form Al^{3+} , Cl^- ions.

$$\text{AlCl}_3(\text{s}) + \text{aq} \rightarrow \text{Al}^{3+}(\text{aq}) + 3\text{Cl}^-(\text{aq})$$

- Al^{3+} exist as the hexaqua complex.
- $$\text{Al}^{3+}(\text{aq}) + 6\text{H}_2\text{O}(\text{l}) \rightarrow [\text{Al}(\text{H}_2\text{O})_6]^{3+}(\text{aq})$$
- due to the high charge density of the Al^{3+} ion
 - the co-ordinated H_2O molecules are highly polarised and act as a proton donor.
- $$[\text{Al}(\text{H}_2\text{O})_6]^{3+}(\text{aq}) + \text{H}_2\text{O}(\text{l}) \rightleftharpoons [\text{Al}(\text{H}_2\text{O})_5\text{OH}]^{2+}(\text{aq}) + \text{H}_3\text{O}^+(\text{aq})$$
- the formation of H_3O^+ ion makes the solution acidic.

- 8) a) (i) - Catalyst is a substance that can alter the rate of a chemical reaction by providing an alternative reaction pathway that requires a lower activation energy.
- a heterogeneous catalyst is in a different phase from the reactants.

- (ii) - nickel has empty d-orbitals that can be used to form temporary bonds.
- alkene and hydrogen molecules are adsorbed onto the surface of nickel.
 - forming dmperty bonding
 - weaken the existing bonding between nickel and reactant
 - \downarrow the activation energy
 - adsorption process increase the concentration of reactant molecules on the catalyst surface
 - collision frequency b/w reactant molecules increase

- b) (i) $[CoCl_4]^{2-}$ - tetrachlorocobalt(II) ion
- tetrahedral
 - do not show isomerism

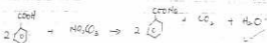
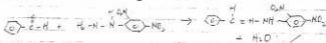
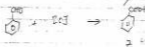
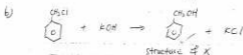
- (ii) $[Co(NH_3)_2Cl_3]$ - triamminetrichlorocobalt(III)
- octahedral
 - fac & mer isomer

2) a) The possible structure of W



- Chlorine atom that attached directly to the benzene ring is unreactive towards nucleophile (OH^-)

- Structure of W is CH_2Cl



c) Mechanism



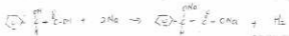
Rate = $k[\text{OH}^-][\text{CH}_2\text{Cl-Ph}]$

- ii) DQ - A is a primary compound
 - only flame test that is new = high degree of unsaturation.
 - Since C is a primary alcohol, A provides $\frac{255}{12 \times 100}$ moles H_2
 - A has one O - with oxygen
 - A has the $-COOH$ group because it forms an ester with methanol which is refluxed with ethanol and sulphuric acid
 - Since B is a ketone, F is a secondary alcohol

Structure of A



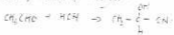
Structure of B



b) - heated with copper at $400^\circ C$



- HCN, alkaline medium



- refluxed with dilute sulphuric acid

