HWA CHONG INSTITUTION
2008 C2 H2 CHEMISTRY 9746 PRELIMINARY EXAMINATION
(SUGGESTED ANSWERS)

PAPER 1 MCQ

1	**C**	6	**C**	11	**B**	16	**C**	21	**D**	26	**B**	31	**B**	36	**B**
2	**B**	7	**B**	12	**D**	17	**C**	22	**D**	27	**B**	32	**D**	37	**B**
3	**B**	8	**D**	13	**B**	18	**C**	23	**C**	28	**C**	33	**B**	38	**C**
4	**C**	9	**A**	14	**A**	19	**C**	24	**A**	29	**A**	34	**D**	39	**A**
5	**C**	10	**B**	15	**D**	20	**A**	25	**D**	30	**D**	35	**D**	40	**A**

PAPER 2 STRUCTURED

1 (a) All 3 elements exist as simple covalent molecules with weak van der Waals' forces (OR dispersion forces) between the molecules.

S_8 has the largest number of electrons, compared to P_4 and ClI_2; it has the strongest van der Waals' forces, hence it needs the largest amount of energy to overcome these attractions during melting.

(b) (i) disproportionation

(ii) Reduction : $S(s) + 2e^- \rightarrow S^{2-}(aq)$
Oxidation : $2S(s) + 6OH^-(aq) \rightarrow S_2O_3^{2-}(aq) + 4e^- + 3H_2O(l)$
Overall : $4S(s) + 6OH^-(aq) \rightarrow S_2O_3^{2-}(aq) + 2S^{2-}(aq) + 3H_2O(l)$

(c) (i) $AlCl_3(s)$ dissolves in water to form $[Al(H_2O)_6]^{3+}(aq)$ OR $Al^{3+}(aq)$ ions.
$AlCl_3(s) + 6H_2O(l) \rightarrow [Al(H_2O)_6]^{3+}(aq) + 3Cl^-(aq)$

A hydrolysis reaction occurs for Al^{3+}, making the solution acidic.
$[Al(H_2O)_6]^{3+}(aq) + H_2O(l) = [Al(H_2O)_5(OH)]^{2+}(aq) + H_3O^+(aq)$

Or use "combined" equation:
$AlCl_3(s) + 6H_2O(l) = [Al(H_2O)_5(OH)]^{2+}(aq) + H^+(aq) + 3Cl^-(aq)$

(ii) $Al(OH)_3$

(iii) $Al(OH)_3(s) + OH^-(aq) \rightarrow [Al(OH)_4]^-(aq)$
OR $Al(OH)_3(s) + NaOH(aq) \rightarrow Na[Al(OH)_4](aq)$

(iv) starting pH at 7 for NaCl
downward trend of pH

2 **(a)** Egs:
Equation for reaction: $N_2(g) + 3H_2(g) = 2NH_3(g)$
Heterogeneous catalyst: Fe(s)

Equation for reaction: $CH_2{=}CH_2(g) + H_2(g) \rightarrow CH_3CH_3(g)$
Heterogeneous catalyst: Ni(s)

Equation for reaction: $2H_2O_2(aq) \rightarrow 2H_2O(l) + O_2(g)$
Heterogeneous catalyst: $MnO_2(s)$

(b) Adsorption of reactant molecules (N_2 and H_2) onto catalyst surface.

State one effect of adsorption: process brings reactant molecules closer together, this increases their concentrations at the catalyst surface; weakens the bonds in them; and allows these molecules to be orientated in the right positions for reaction. The catalysed pathway thus involves lower activation energy.

Product molecules desorb from catalyst surface, catalytic sites free to catalyse more reactions.

(c) Impurities may bind (irreversibly or strongly) to catalytic sites on catalyst surface. This prevents adsorption of actual reactant molecules.

3 (a) (i) $\Delta H_r^{\ominus} = -925 - 2(-286) =$ **$\underline{-353\ \text{kJ mol}^{-1}}$**

(ii) Mg is the limiting reactant; so all 2.4 g of it reacts.

$$100 \times 4.2 \times (T - 25) = 2.4/24 \times 353 \times 1000$$
$$T = 109\ ^{o}C$$

So the heat is more than sufficient to raise the temperature.

(b) (i) Mg^{2+} has a higher charge and smaller ionic size than Na^{+}

(ii) $\Delta H_{soln} = -L.E. + \Delta H_{hyd}$

For NaOH: $-44 = 896 + (-390) + \Delta H_{hyd}(OH^-)$
$\Delta H_{hyd}(OH^-) = -550\ \text{kJ mol}^{-1}$

For $Mg(OH)_2$: $x = 2995 - 1890 + 2(-550) =$ **$\underline{+5\ \text{kJ mol}^{-1}}$**

(iii) There is a decrease in entropy (or ΔS is negative) as H_2O molecules are attached to the metal ion and lose their degree of freedom. As more water molecules are attached to the Mg^{2+} ion on the average, the entropy (of the system) decreases more (or ΔS is more negative) than for the case of NaOH.

(iv) $Mg(OH)_2$ dissolves with the formation of more particles (aqueous ions); so the entropy (of the system) increases (or ΔS is positive).

4 (a) (i)

	C		H
Mass in 100 g	80		20
No. of moles	6.66		20
ratio	1	:	3

Empirical formula of B is CH_3, B is likely to be C_2H_6

(ii) $2CH_3CO_2^-(aq) \rightarrow 2CO_2(g) + C_2H_6(g) + 2e^-$
OR $2CH_3CO_2H(aq) \rightarrow 2CO_2(g) + C_2H_6(g) + 2H^+(aq) + 2e^-$

(iii) Anode: O_2 evolved; Bulb brighter

(b) $M(OH)_2.nH_2O \xrightarrow{\Delta} M(OH)_2 + nH_2O$
1.295 g → 0.590 g

No. of moles of H_2O = 0.590 / 18 = 0.0328

$M(OH)_2 \xrightarrow{\Delta} MO + H_2O$
0.0740 g

No. of moles of H_2O = 0.0740 / 18 = 4.11×10^{-3} = No. of moles of $M(OH)_2$
$\therefore$ n = 0.0328 / 4.11×10^{-3} = **8**
OR n = 0.590 / 0.0740 = 8

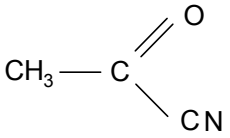
No. of moles of $M(OH)_2.8H_2O$ = 4.11×10^{-3}
Molar mass of $M(OH)_2.8H_2O$ = 1.295 / 4.11×10^{-3} = 315 g mol^{-1}
A_r of M = 315 – 2(16+1) – 8(18) = 137, $\therefore$ M is **barium**

(c) Let minimum $[M(OH)_2(aq)]$ be c mol dm^{-3}
At the point of mixing, $[M^{2+}] = 5 \times c / 105$ mol dm^{-3}
$[SO_4^{2-}] = 100 \times 0.01 / 105$ mol dm^{-3}

For precipitation to just occur, ionic product = K_{sp}
$\therefore$ (5c / 105) (100 × 0.01 / 105) = 1.30×10^{-10}
c = **2.87×10^{-7} mol dm^{-3}**

(d) (i) Step I: red P and Br_2, heat OR PBr_3, heat
Step II: dilute H_2SO_4, heat

(ii)

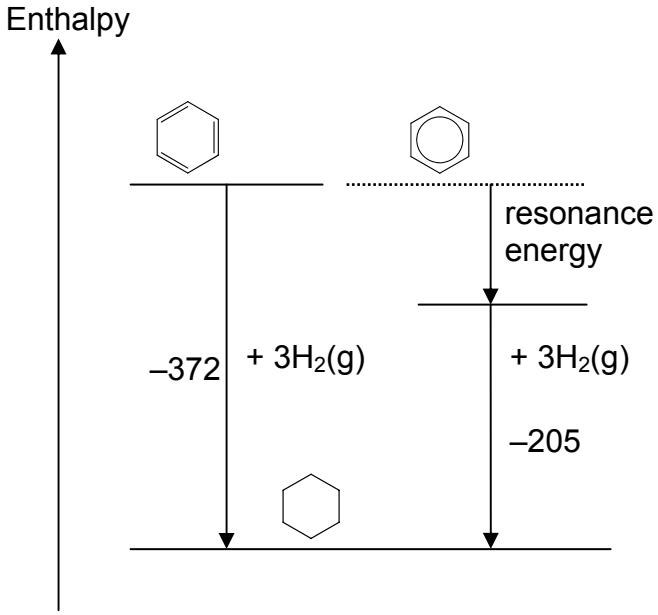


(iii) Nucleophilic substitution

(iv) H_2, Ni, heat
Reject: LiA/H_4 in dry ether

5 (a) (i) ΔH_r = +610 – 350 + 436 – 2(410) = **<u>–124 kJ mol^{-1}</u>**

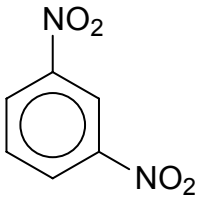
(ii) The benzene ring is stabilised by resonance
(or the six π electrons are delocalised around the ring)
Hence, actual $\Delta H_{hydrogenation}$ is less exothermic than 3(–124) = –372 kJ mol^{-1}



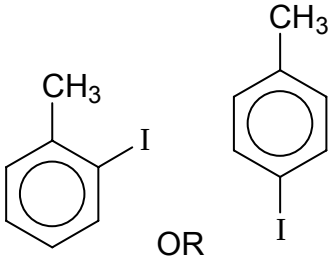
(b) (i) Electrophilic substitution
Equation showing nitronium ion reacting with benzene to form arenium ion
Equation showing loss of H^+ by arenium ion to form nitrobenzene

*Must show:
- slow step
- correct electron movements in both steps
- correct structure of all intermediates

(ii)

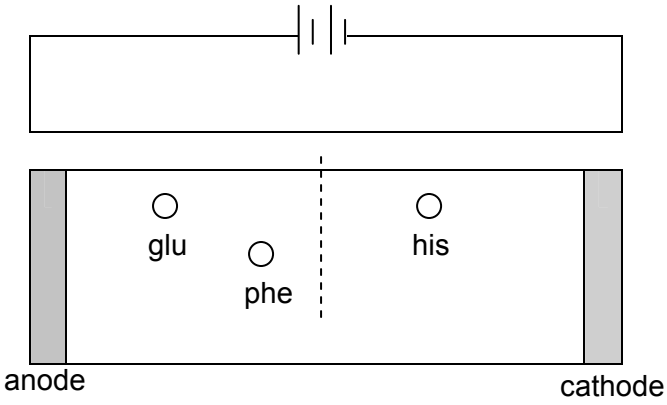


(c)



6 **(a)** **(i)** gly-pro-val-asp-gly-thr-phe-leu-ser-pro-glu

(ii) position of his; relative positions of phe and glu



(b) **(i)** The three-dimensional conformation of a protein where the secondary structure is held by interactions between the side chain groups

(ii) phe contains a non-polar benzene group that has dispersion forces while thr has a OH group that participates in hydrogen bonding.

As the strength of H bonding is stronger than VDW, the change in the R group can cause the folding of the enzyme to differ.

(c) optical isomerism
diagram of both isomers with mirror line

(d)

Step	Error
Step I	HCN should be used for nucleophilic substitution of aldehyde so that cyanohydrin can be formed.
Step III	PCl_5 will react with both acid and alcohol group.
Step IV	Concentrated NH_3 should be used. Aqueous NH_3 could only react with –COOH and not substitute out the halogen.