SAJC 2011 H1 Chemistry Prelims Paper 2 Solutions

Section A (40 marks)

Answer all the questions in this section in the spaces provided.

 1 (a) (i) BeCl₂ is a covalent compound while BeF₂ is an ionic compound. The electron cloud of Cl anion is larger than that of F⁻ anion. Hence, Cl anion is more readily polarised by the Be²⁺ cation which has a high charge density, giving rise to its covalent character.



(iii) Let x be the mole fraction of $BeCl_2$ and mole fraction of $Be_2Cl_4 = 1 - x$. x(80) + (1-x)(160) = 126 80x = 34 x = 0.425, 1 - x = 0.575

(ii) % Mass of Be in *Beryl* = $\frac{3 \times 9}{3 \times 9 + 27 \times 2 + 6 (28.1 + 16 \times 3)} \times 100$ = 5.022 % 5.022% \Rightarrow 30.6 kg 30.6

$$100\% \rightarrow \frac{30.6}{5.022} \times 100 = 609.3 \text{ kg}$$

%	Mass of	<i>Bervl</i> in	ore =	609.3	x 100 = 11.4%	
/0	111400 01	20191.11	0.0	5330		

			-			
1	(c)	(i)	∆H1:	Enthalpy change of	∆H3 :	Bond dissociation energy
				formation of Be_3N_2		of N ₂
			∆H4:	Sum of 1 st and 2 nd IE of Be	∆H6 :	Lattice Energy

- (ii) Lattice energy = -588 (324 + 994 + 3(900 + 1760) + 1404)Lattice energy = -11290 kJ mol⁻¹
- (iii) $|\Delta H_{LE}| \alpha |q+q-/r++r-|$ Product of q+ and q- of $Be_3N_2 > Product of <math>q+$ and q- of Li_2O Since product of charges outweighs the sum of ionic radii, the lattice energy

of Li_2O is less exothermic than Be_3N_2 .

- 2 (a) First ionisation energy is the energy required to remove 1 mole of electrons from 1 mole of gaseous atoms to form a mole of singly charged gaseous ions.
 - (b) (i) **P**: Group VI **Q**: Group II
 - (ii) Physical properties:
 Electrical conductor at aqueous/ molten state.
 High melting and boiling point.
 Soluble in water/insoluble in organic solvents.

3 (a) SiO₂ is insoluble in water due to the high bond dissociation energy needed to break the strong Si—O covalent bonds.
 Na₂O(s) + H₂O(l) → 2NaOH(aq)
 Na₂O is readily soluble in water to form a strongly alkaline solution.
 SiO₂(s) + 2NaOH(aq) → Na₂SiO₃(aq) + H₂O(l)
 SiO₂ is an acidic oxide which reacts readily with alkalis to form salt and water.

(b) (i) No. of moles of $S_2O_3^{2^-} = 30/1000 \times 0.100$ = 0.00300 molNo. of moles of $Br_2 = 4 \times 0.00300$ = 0.01200 mol $S_2O_3^{2^-} = 4Br_2 = 6 \text{ SiF}_4$ No. of moles of SiF₄ = 3 × 0.006 = 0.018 molMass of SiF₄ = 0.018 × (28.1 +19.0 × 4) = 1.87 g

(ii) Disproportionation

 $3Br_2 + 6OH \rightarrow 5Br + BrO_3 + 3H_2O$

4 (a)

$$\mathcal{K}_{c} = \frac{[H_{2}]^{3}[CO]}{[CH_{4}][H_{2}O]} = \frac{(\frac{2.40}{2})^{3}(\frac{0.80}{2})}{(\frac{0.24}{2})(\frac{0.18}{2})} = 64 \text{ mol}^{2} \text{ dm}^{-6}$$

(b) When temperature increases (from 550°C to 850°C), Percentage of H₂ increases, thus forward reaction is favoured, equilibrium has shifted right. By L.C.P, endothermic reaction is favoured as it helps to absorb the excess heat. Hence, production of H₂ is endothermic.

When volume changes from Z to X,

Percentage of H_2 increases thus forward reaction is favoured. When equilibrium shifts to the right, the number of moles of gas increases. By L.C.P. pressure has decreased / volume has increased.

Hence, increasing order: Z < Y < X

 5 (a) Add Tollen's reagent and warm. Silver mirror is observed for cinnamaldehyde, but no silver mirror for ethyl cinnamate.

OR

Fehlings solution, warm/ 2,4-dinitrophenylhydrazine, warm

- (b) CH_3CH_2OH , concentrated H_2SO_4 , heat
- (c) Ethyl cinnamate is more volatile. Both compounds are simple molecular. Less energy is required to overcome the weaker van der Waals' forces/pd-pd interactions between ethyl cinnamate molecules than the stronger hydrogen bonding between cinnamic acid molecules.

Section B (40 marks)

Answer two out of three questions in this section on the writing papers provided.





(ii) Hydrazine is able to form intermolecular hydrogen bonds with water.
 CO₂ is a non polar molecular that can only act as hydrogen bond acceptors to water. Hence the interaction of CO₂ with water involves less extensive hydrogen bonding.



(iii) Aluminium oxide is a giant ionic lattice structure with strong electrostatic forces of attraction between its oppositely charged ions whilst aluminium iodide is simple covalent molecule with weak induced dipole- induced dipole intermolecular forces of attraction.

Induced dipole- induced dipole is weaker than ionic bonding hence more energy is needed to overcome the ionic bonds.



- (ii) HA is a stronger acid than 2-methylpropanoic acid.
 C*l*, an electron-withdrawing group in HA will help to disperse the negative charge on the oxygen, stabilising the carboxylate anion and hence causing it to be a stronger acid.
- (iii) [H⁺] = 0.001 mol dm⁻³
 Since [H⁺] << [HA]
 Thus, HA is a weak acid.
- (iv) A buffer solution is one whose pH remains almost unchanged when a small amount of acid and base is added.

(I) When a small amount of acid is added:

 $\mathsf{H}^{\scriptscriptstyle +} + \mathsf{A}^{\scriptscriptstyle -} \xrightarrow{} \mathsf{H} \mathsf{A}$

(II) When a small amount of base is added:

 $\mathsf{HA} + \mathsf{OH}^{\scriptscriptstyle -} \xrightarrow{} \mathsf{A}^{\scriptscriptstyle -} + \mathsf{H}_2\mathsf{O}$

7 (a) (i) $1s^22s^22p^63s^23p^6$

- (ii) $CH_3CH_2OH + H_2O \rightarrow CH_3COOH + 4H^+ + 4e^ 3CH_3CH_2OH + 2Cr_2O_7^{2^-} + 16H^+ \rightarrow 3CH_3COOH + 4Cr^{3+} + 11H_2O$
- (iii) moles of potassium dichromate = $0.015 \times 0.017 = 2.55 \times 10^{-4}$ mol moles of ethanol needed = $2.55 \times 10^{-4} \times 3/2 = 3.825 \times 10^{-4}$ mol minimum vol of ethanol = $(3.825 \times 10^{-4}) \times 24000 = 9.18$ cm³
- (iv) Angle of deflection is proportional to charge / mass ratio of the ion. Chromate(VI) and dichromate both have the same charge. However, mass of dichromate(VI) is higher than chromate(VI), hence chromate(VI) will be deflected to a larger extent when passed through an electric field.
- (b) i. Excess concentrated sulfuric acid, 170 °C
 - ii. PI_3 , heat or H_3PO_4 with NaI
 - iii. $KMnO_4 / H_2SO_4$, heat OR $K_2Cr_2O_7 / H_2SO_4$, heat
 - (iv) 2-propanol upon oxidation (reaction (iii)) gives a ketone that will give an orange precipitate with 2,4-dinitrophenylhydrazine.
 1-propanol upon oxidation gives a carboxylic acid that will not give an orange precipitate with 2,4-dinitrophenylhydrazine.

 $\begin{array}{cccc} CH_{3}CH_{2}OH_{4} + 3O_{2} & \xrightarrow{} & CH_{3}COOH_{4} + H_{2}D + 20_{2} \\ (L) & (L)$

 $\Delta H^{e}_{oxidation}$ = + (-1371) - (-876) = -495 kJ mol⁻¹

(d)	Information	Deduction
	Geraniol oxidised to give R + S	Geraniol has alkene group.
	and effervescence.	Effervescence of CO2 due to
		terminal alkene or ethanedioic
		acid.
		4

R and S are ketones as they are
products of oxidation.
R and S have RCOCH_3 .
S has RCOOH.
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8 (a) (i) Using experiments 2 and 3,

[FA4] is kept constant, when [FA3] increases by 1.2 times, rate increases by 1.2 times.

Hence, order of reaction with respect to [FA3] is 1.

Using experiments 1 and 2,

$$\frac{k(10)^{n}(20)^{1}}{k(25)^{n}(15)^{1}} = \frac{8.17 \times 10^{-7}}{1.53 \times 10^{-6}}$$
$$(\frac{10}{25})^{n} = 0.4005$$
$$n = 1$$
Hence, order of reaction with respect to [FA4] is 1.

- (ii) Rate = k[2-bromo-3-methylpentane][sodium hydroxide]
- (iii) Catalyst would lower the activation energy by providing an alternative pathway for the reaction to take place, resulting in an increase in the proportion of molecules with energy greater than or equal to the activation energy. This results in an increase in frequency of effective collisions and hence the rate of reaction increases.

(b)

H H $CH_3 - C - C - CH_3CH_3 + CH_3COOH \Rightarrow H_{3O} + CH_3 - C - C - CH_2CH_3$ $OH CH_3$ $O = C - CH_3$ (i)

(ii) amount of KOH used = $0.0248 \times 0.08 = 1.984 \times 10^{-3}$ mol amount of ethanoic acid in 10 cm³ of ether = 1.984×10^{-3} mol amount of ethanoic acid in 100 cm³ of ether = 1.984×10^{-2} mol

(iii)		Compound	Ethanoic	Ester	Water	
		G	acid			
	Initial conc /	0.400	0.200	0	0	
	mol dm ⁻³	0.400	0.200	0		
	Change in					
	conc / mol	-0.0016	-0.0016	+0.0016	+0.0016	
	dm⁻³	dm ⁻³				
	Equilibrium					
	conc / mol	0.3984	0.1984	0.0016	0.0016	
	dm⁻³					

 $K_c = 3.24 \times 10^{-5}$

(iv) With increase in temperature, the equilibrium favours the reaction which absorbs heat (favouring endothermic process). Hence the equilibrium would shift towards the right (favouring the formation of the ester) so as to remove the excess heat applied to the system.

(c)	Information	Deduction		
	H sweet smelling.	Ester		
	H has C:H ≈ 1: 1	Benzene		
	H turns moist blue litmus red.	Acidic.		
	H boiled with aq. NaOH	H underwent alkaline hydrolysis &		
		acid-base neutralisation.		
	K reacts with silver diammine but	K is an aromatic aldehyde.		
	not Fehling's			
	J does not decolourise purple	3° alcohol.		
	KMnO₄			
	0.005 mole J (acidified) + Na \rightarrow	1 mole of J forms 1 mole of		
	0.005 mole hydrogen gas	hydrogen. Hence there are 2 -OH		
		groups. i.e. acid and/or alcohol.		

$$L: \bigcirc -c00H \qquad J: H0 - C - CH_3$$

$$H: \bigcirc - \overset{CH_3}{c} - 0 - \overset{CH_3}{c} - CH_3 \qquad C00 - H$$

$$H: \bigcirc - \overset{CH_3}{c} - 0 - \overset{CH_3}{c} - CH_3 \qquad H = 0$$

$$I: \bigcirc - \overset{CH_3}{c} - 0 - \overset{CH_3}{c} - CH_3 \qquad H = 0$$