## SUGGESTED ANSWERS SAJC PRELIM 2014 PAPER 3 (H2 CHEMISTRY)



(b) (i) 
$$K_p = \frac{PPClsPCls}{PPCls}$$

(ii)		$PCl_5$	$PCl_3$	$Cl_2$
	l / mol	Z	0	0
	C / mol	-0.4 <b>z</b>	+0.4 <b>z</b>	+0.4 <b>z</b>
	E / mol	0.6 <b>z</b>	0.4 <b>z</b>	0.4 <b>z</b>

Total moles = 1.4 z  $P_{PCl5} = (0.6 \text{ z} / 1.4 \text{ z}) \times 5 = 2.143 \text{ atm}$   $P_{PCl3} = P_{Cl2} = (0.4 \text{ z} / 1.4 \text{ z}) \times 5 = 1.429 \text{ atm}$  $K_p = 0.953 \text{ atm}$ 

(iii) When temperature increases, the equilibrium will favour the endothermic reaction to absorb the excess heat / to decrease the temperature. Hence, rate<sub>forward</sub> increases more than rate<sub>backward</sub>. Hence, K<sub>p</sub> increases.

[5]

(c)

(i) The energy released from forming ion-dipole interaction between aluminium oxide and water is insufficient to overcome ionic bonds in aluminium oxide.

(ii) Aluminium oxide is amphoteric. Aqueous solution of  $PCI_5$  is acidic.  $PCI_5 + 4 H_2O \rightarrow H_3PO_4 + 5 HCI$  $AI_2O_3 + 6HCI \rightarrow 2AICI_3 + 3H_2O$ 

[4]

[3]



## [4]

## (e) <u>Between F and G</u>

Add Tollen's reagent to both compounds and warm. No silver mirror seen for compound F, while silver mirror is seen for G. OR Add neutral FeCl<sub>3</sub> F forms a violet solution (complex) whilst G forms no violet solution. OR

Add Br<sub>2</sub> (aq)

F orange will turn to colourless with white ppt and G will remain orange.

OR

Add 2, 4-DNPH.

Orange ppt formed for G and no orange ppt formed for F.

## Between F and H

Add 2, 4-DNPH.

Orange ppt formed for H and no orange ppt formed for F.

OR

Add hot aq H<sub>2</sub>SO<sub>4</sub> K<sub>2</sub>Cr<sub>2</sub>O<sub>7</sub>

F turns from orange to green whilst H remains orange.

[4] [Total: 20] 2. (a)

(ii)

(i) 
$$5 \operatorname{Ca}(s) + 3 \operatorname{P}(s) + 13/2 \operatorname{O}_2(g) + \frac{1}{2} \operatorname{H}_2(g) \rightarrow \operatorname{Ca}_5(\operatorname{PO}_4)_3\operatorname{OH}(s)$$

- Energy / kJ mol<sup>-1</sup>  $5 \operatorname{Ca}^{2+}(g) + 10e + \frac{3}{4} \operatorname{P}_4(s) + 13/2 \operatorname{O}_2(g) + \frac{1}{2} \operatorname{H}_2(g)$  5(+590 + 1150) -230 + 3(-1913) -230 + 3(-1913)  $5 \operatorname{Ca}(g) + \frac{3}{4} \operatorname{P}_4(s) + 13/2 \operatorname{O}_2(g) + \frac{1}{2} \operatorname{H}_2(g)$   $5 \operatorname{Ca}(s) + \frac{3}{4} \operatorname{P}_4(s) + 13/2 \operatorname{O}_2(g) + \frac{1}{2} \operatorname{H}_2(g)$   $5 \operatorname{Ca}(s) + \frac{3}{4} \operatorname{P}_4(s) + 13/2 \operatorname{O}_2(g) + \frac{1}{2} \operatorname{H}_2(g)$ Enthalpy change of lattice energy = x -12969
  - 5(178.2) + 5(590+1150) 230 3(1913) + x = 12969 x = -16 591 kJ mol<sup>-1</sup>
- (iii)  $2Ca_5(PO_4)_3OH \rightarrow 3Ca_3(PO_4)_2 + CaO + H_2O$ Moles of hydroxyapatite = 9 / 502.5 = 0.01791 mol Moles of calcium oxide = 8.96 x 10<sup>-3</sup> mol Mass of calcium oxide = 8.96 x 10<sup>-3</sup> x (40.1+16) = 0.502 g
- (iv) Quote: Ca<sup>2+</sup>: 0.099 nm and Al<sup>3+</sup>: 0.050

 $Al^{3+}$  ion has a higher charge density, and higher polarising power than  $Ca^{2+}$ . Thus, there is more distortion of the electron cloud of the anion, hence requiring less energy to break.

[8]

- (b) (i) Given that 1 kg of fruits can contain 7mg of acephate, 1g of fruit = 7 x 10<sup>-6</sup> g Hence, 50 g of fruit = 3.5 x 10<sup>-4</sup> g of acephate
  - (ii) Nucleophilic substitution / Condensation

(b) (iii)



(iv) Alkene, (secondary or tertiary) amide, secondary alcohol OR ether

(c)

(i)



(ii)



[6] [Total: 20 marks]

[6]

- 3 (a)
- A buffer solution is a solution whose pH remains almost unchanged when a small amount of H<sup>+</sup> or OH<sup>-</sup> is added to it.



(iv)



- (b) (i) Cysteine can form disulfide linkages which are strong <u>covalent bonds</u> which are hard to break.
  - (ii) 2 -CH<sub>2</sub>SH  $\rightarrow$  -CH<sub>2</sub>S-SCH<sub>2</sub>- + 2H<sup>+</sup> + 2e<sup>-</sup> H<sub>2</sub>O<sub>2</sub> + 2H<sup>+</sup> + 2e<sup>-</sup>  $\rightarrow$  2H<sub>2</sub>O

(c) (i) 
$$H_2O_2 \longrightarrow O_2 + 2H^+ + 2e^-$$
  
 $2e^- + 2H^+ + CIO^- \longrightarrow CI^- + H_2O$   
Overall eqn:  $H_2O_2 + ClO^- \rightarrow O_2 + H_2O + Cl^-$ 

(ii) White ppt is AgCl. AgCl + 2NH<sub>3</sub>  $\rightarrow$  [Ag(NH<sub>3</sub>)<sub>2</sub>]<sup>+</sup> + Cl<sup>-</sup> AgCl  $\rightarrow$  Ag<sup>+</sup> + Cl<sup>-</sup> (Eqm 1)

The decrease in  $[Ag^+]$  due to formation of complex shifts eqm 1 to the right. Also, decrease in  $[Ag^+]$  also decreases I.P. of AgCI which becomes lower than Ksp of AgCI, hence ppt dissolves.

[8]

[3]

- (iii) CIO<sup>-</sup> can undergo disproportionation at higher temperatures to form  $CIO_3^-$ .
- (iv) For CuCl:

 $[Cu^{+}][Cl^{-}] = 1.2 \times 10^{-6}$   $[Cl^{-}] = (1.2 \times 10^{-6}) / 0.04 = 3.00 \times 10^{-5} \text{ mol dm}^{-3}$ For AgCl @ the point where IP <sub>CuCl</sub> = K<sub>sp CuCl</sub> Hence, [Ag<sup>+</sup>][Cl<sup>-</sup>] = 1.8 × 10<sup>-10</sup> [Ag<sup>+</sup>] = 6.00 × 10<sup>-6</sup> mol dm<sup>-3</sup> No of moles of AgCl formed = 250 / 1000 × 0.05 - 250 / 1000 × 6.00 × 10<sup>-6</sup> = 0.012499 mol Total moles of Cl<sup>-</sup> needed = Cl<sup>-</sup> in AgCl + Cl<sup>-</sup> in saturated solution = 0.012499 + 250 / 1000 × 3.00 × 10<sup>-5</sup> = 0.012507 mol Maximum mass of NaCl that can be added = 0.012507 × (35.5 + 23) = 0.732g

[9]

4 (a)

(i) Product are  $H^+$  and  $O_2$ 

Overall equation



Q = (0.25) x (24 x 60 x 60) = 21, 600 C
From the above half equation, 1 mole of 1-phenyl-2-aminopropane requires 8F (772 000C).
Mol of 1-phenyl-2-aminopropane formed by 21,600 C = 0.0280 mol
Mass of 1-phenyl-2-aminopropane =
0.0280 x [9 (12) + 13 (1) + 14 (1)] = 0.280 x 135 = 3.78 g

[4]





(i)



- (ii) Moles of HCl = moles of 1-phenyl-2-aminopropane in 25 cm<sup>3</sup> =  $1.37 \times 10^{-3}$ . moles of 1-phenyl-2-aminopropane in 250 cm<sup>3</sup> =  $1.37 \times 10^{-2}$  mol [1-phenyl-2-aminopropane] in g dm<sup>-3</sup> = (4 x 1.37 x 10<sup>-2</sup> x 135) = 7.40 g dm<sup>-3</sup>
- (iii) Mass in 250 cm<sup>3</sup> = 1.85 g percentage purity of the 1-phenyl-2-aminopropane crystals = 1.85 / 3.78 x 100 = 49.0 %
- (c) (i)
  - (ii) Bidentate ligand can form 2 dative bonds to a central atom or ion.
  - (iii) When 1,4-diaminobutane is added, the colour of the complex changes from blue to violet as there is a ligand exchange of water by 1,4-diaminobutane. The energy absorbed for the excitation of d electrons changes as different ligands are bonded to Cu<sup>2+</sup>.
  - (iv)





(d) (i)



[5]

[4]



- (e) (i) NH CH3 COOH
  - (ii) Pyruvic is a simple covalent molecule whilst alanine is a zwitterion with giant ionic lattice structure. Intermolecular forces between the pyruvic acid molecules is hydrogen bonding while in alanine, it's held by strong electrostatic forces of attraction between oppositely charged ions. More energy is needed to break the stronger ionic bonds in alanine than the hydrogen bond in the acid.



5 (a)

(i)  $[H^+] = (10^{-3.25} \times 0.025)^{1/2} = 3.7494 \times 10^{-3} \text{ mol dm}^{-3}$ pH = 2.43





8

[Turn Over

[8]

[5]

[2]

Observations	Deductions		
A dissolves in aqueous HNO <sub>3</sub> .	A contains amine or phenylamine group.		
	Neutralisation		
B reacts with cold KMnO <sub>4</sub> to	Mild oxidation.		
form A.	B contains C=C.		
	A is a diol.		
	Brown ppt is MnO <sub>2</sub> .		
A forms yellow ppt on addition of	Nucleophilic substitution.		
ethanolic silver nitrate.	A contains iodoalkane.		
	Yellow ppt is Agl		
A decolourises aqueous	Electrophilic substitution.		
bromine and white ppt is formed.	A is phenylamine.		
B contains 3 Br atoms.			
A produces 0.125 mol of gas	Gas is H <sub>2</sub> .		
when sodium metal is added.	Redox reaction.		
	1 mol of <b>A</b> produces 1 mol of $H_2$ .		
	Two –OH group present in <b>A</b> .		
<b>D</b> is produced when hot acidified	Oxidation.		
$K_2Cr_2O_7$ is added to <b>A</b> .	Primary or secondary alcohol present in <b>A</b> .		
	Carboxylic acid or ketone in <b>D</b>		
<b>D</b> reacts with 2,4-DNPH but not	D contains ketone.		
with Tollen's.	Secondary alcohol present in <b>A</b> . (no double		
	award)		
	<b>D</b> undergoes condensation.		
A and D both form yellow ppt	H 		
with aqueous alkaline iodine.	——с́——он		
	<b>A</b> contains $c_{H_3}$ and <b>D</b> contains		
	с́сн₃.		
	E has a RCOO <sup>-</sup>		
	Yellow ppt is CHI <sub>3</sub> .		
	Oxidation.		
A:	B:		
ОН ОН	H H		
C CH <sub>2</sub> I	C CHUI		
CH <sub>3</sub>	L CH3		

(b)



[Total: 20]

