HWA CHONG INSTITUTION

2009 C2 Higher 2 CHEMISTRY 9746 PRELIMINARY EXAMINATION

PAPER 1 Multiple Choice Questions (ANSWERS)

Question	Answer
1	**A**
2	**B**
3	**C**
4	**A**
5	**D**
6	**A**
7	**B**
8	**B**
9	**C**
10	**B**
11	**C**
12	**B**
13	**A**
14	**D**
15	**D**
16	**A**
17	**C**
18	**C**
19	**B**
20	**C**

Question	Answer
21	**D**
22	**B**
23	**A**
24	**A**
25	**D**
26	**C**
27	**D**
28	**C**
29	**C**
30	**B**
31	**D**
32	**C**
33	**B**
34	**D**
35	**A**
36	**B**
37	**C**
38	**B**
39	**A**
40	**D**

PAPER 2 Structured Questions (ANSWERS)

1 (a) The alkaline earth metals exhibit +2 oxidation state in their compounds because they have 2 valence electrons which are lost to achieve stable octet.

They do not exhibit +1 oxidation state due to the low lattice energy of the compounds formed.

+3 oxidation state is also not favourable due to the very high 3rd ionization energy required to remove the third electron from the inner quantum shell.

(b) (i) $[Ba^{2+}]\,[F^-]^2 = 1.84 \times 10^{-7}$ where $[Ba^{2+}] = 0.05 \text{ mol dm}^{-3}$

$\therefore [F^-] = \sqrt{(1.84 \times 10^{-7} / 0.05)}$

$= 1.92 \times 10^{-3} \text{ mol dm}^{-3}$

(ii) $[Ca^{2+}]_{\text{remaining}} = 3.45 \times 10^{-11} / (1.92 \times 10^{-3})^2$

$= 9.38 \times 10^{-6} \text{ mol dm}^{-3}$

2 (a) (i) no. of moles of glycolic acid = 0.20/76.0 = 2.63×10^{-3} mol

volume of NaOH required = $2.63 \times 10^{-3}/0.10 \times 1000 = 26.3 \text{ cm}^3$

(ii) no. of moles of CH_2OHCOO^- salt formed at equivalence = 2.63×10^{-3} mol

conc. of CH_2OHCOO^- = $2.63 \times 10^{-3} /(26.3 + 20.0) = 0.0568 \text{ mol dm}^{-3}$

	CH_2OHCOO^-	+	H_2O	$\rightleftharpoons$	$CH_2OHCOOH$	+	OH^-
Initial conc. / mol dm^{-3}	0.0568				–		–
Eqm conc./ mol dm^{-3}	0.0568 - x				x		x

K_b of glycolate = K_w/K_a of glycolic acid = $1 \times 10^{-14}/ 1.48 \times 10^{-4}$

$= 6.76 \times 10^{-11} \text{ mol dm}^{-3}$

$K_b = x^2/(0.0568 - x) \approx x^2/0.0568$ (assume $x << 0.0568 \text{ mol dm}^{-3}$)

$x = 1.959 \times 10^{-6} \text{ mol dm}^{-3}$

pOH = 5.708

pH = 14 – 5.708 = 8.29

(iii) Metacresol purple because its working range coincides with the sharp jump of the titration curve which lies in the alkaline pH region (equivalence pH = 8.29).

(b) (i) Step 1: $LiAlH_4$ in dry ether

Step 2: PCl_5 (s), room temperature

Step 3: NaOH in ethanol, heat

(ii) Increasing ease of hydrolysis: **B**, **A**, **C**

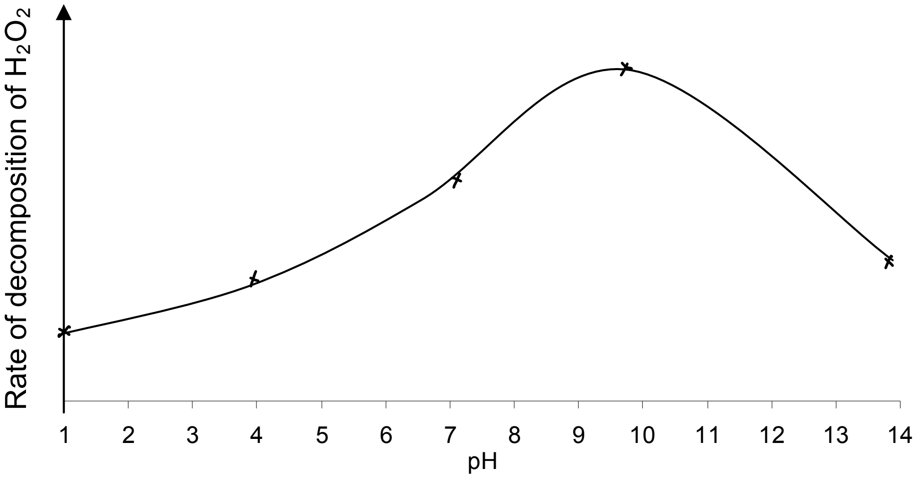
C is an acid chloride which undergoes hydrolysis more easily than **A** (halogenoalkane), because the carbon in the –COC*l* group of **C** is bonded to two electronegative atoms, O and C*l*, thus the carbon is more electron deficient and more readily attacked by nucleophile (H_2O) to undergo nucleophilic substitution.

B undergoes hydrolysis less easily than **A** because in **B**, the C–C*l* bond has partial double bond character due to the overlap of the p-orbital of C*l* with the π-electron cloud of the adjacent alkene carbons. Thus the C–C*l* bond in **B** is much stronger than in **A**, and is harder to break.
OR
The carbon of C–C*l* in **B** is less electron deficient than that in **A** due to the presence of the electron-rich π electron cloud of the double bond.

(c) **(i)** $K_2Cr_2O_7$, dilute H_2SO_4, heat
Orange dichromate turns green for glycolic acid. Solution remains orange for **D**.

(ii) Iodine, aqueous NaOH, heat
Yellow precipitate for **E**. No yellow precipitate for glycolic acid

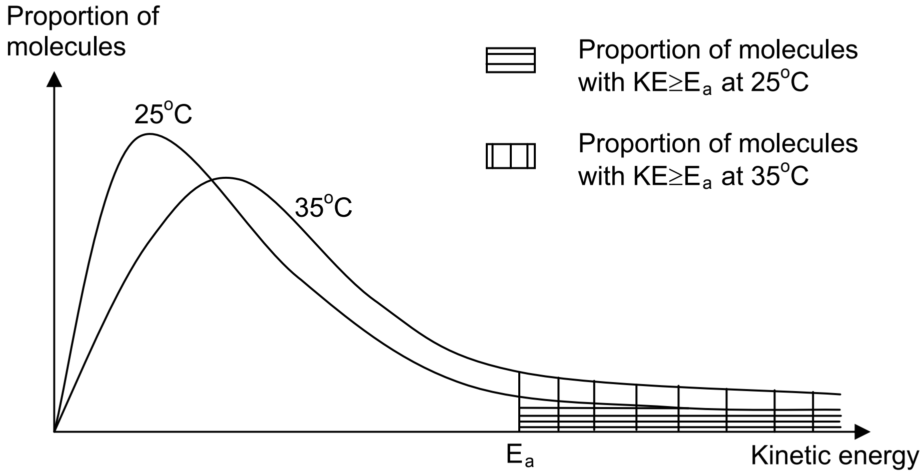
3 **(a)**



(b) At very low and very high pH, the enzyme is denatured.

This is due to the change in the shape of its tertiary structure / loss of the active site conformation / changes in the side-chain interactions of the peptide chain.

(c)



At higher temperature, average kinetic energy of molecules increases and the proportion of molecules with KE $\geq E_a$ increases.

Hence frequency of effective collisions increases and rate of reaction increases.

(d) At low [H_2O_2], rate of reaction increases with increasing [H_2O_2] (or follow first order kinetics) as there are plenty of active sites available.

At high [H_2O_2], rate of reaction remains constant with increasing [H_2O_2] (or follow zero order kinetics) as the active sites are saturated.

(e) **(i)** An ideal gas is a gas that obeys the ideal gas equation ($pV=nRT$), under all conditions of pressure and temperature.

(ii) No. At high pressure, the gas molecules are close together such that the volume of the molecules is significant compared to the volume of the container (or such that intermolecular forces are stronger).

4 **(a)** **(i)** $Q = mc\Delta T = 35.0 \times 4.18 \times 2.8 = 409.6$ J

$H_2A + 2NaOH \rightarrow 2NaA + 2H_2O$

Number of moles of mesoxalic acid = (15.0/1000) x 0.250 = 0.00375 mol

Number of moles of NaOH = (20.0/1000) x 0.400 = 0.008 mol

Therefore mesoxalic acid is the limiting reagent.

Number of moles of water formed = 0.00375 x 2 = 0.0075 mol

$\Delta H_{neut} = -(409.6/1000) / 0.0075 = -54.6 \text{ kJ mol}^{-1}$

(ii) Number of moles of NaOH = (10.0/1000) x 1.2 = 0.012 mol (still in excess)

Temperature rise = (35/25) x 2.8 = 3.92 °C

(b) **Q**: $CH_2=CHCH(Br)CH=CH_2$
R: $CH_2=CHCH(OH)CH=CH_2$

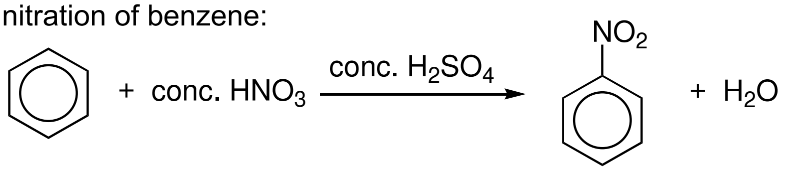
I: excess conc H_2SO_4, 170 °C
II: NaOH(aq), heat
III: $KMnO_4$(aq), dilute H_2SO_4, heat

5 **(a)** **(i)** • dehydration of alcohol to form alkene:

$$CH_3CH_2OH \xrightarrow{\text{conc. } H_2SO_4} H_2C{=}CH_2 + H_2O$$

OR esterification: $RCO_2H + R'OH \xrightarrow{\text{conc. } H_2SO_4} RCO_2R' + H_2O$

• nitration of benzene:



OR esterification: $RCO_2H + R'OH \xrightarrow{\text{conc. } H_2SO_4} RCO_2R' + H_2O$

OR hydration of alkene: $CH_2{=}CH_2 + H_2O \xrightarrow{\text{conc. } H_2SO_4} CH_3CH_2OH$

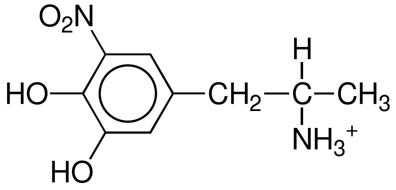
(ii) • $H_2SO_4\ (l) + NaBr\ (s) \rightarrow HBr\ (g) + NaHSO_4\ (aq)$

• $H_2SO_4\ (l) + 2HBr\ (g) \rightarrow Br_2\ (g) + SO_2\ (g) + 2H_2O\ (l)$

(b) **(i)** Tetrachloromethane / hexane (or any other non-polar organic solvent)

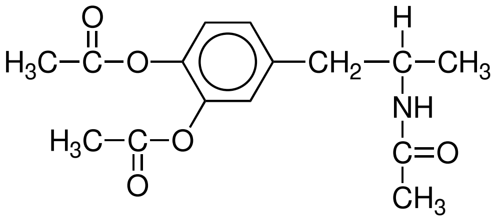
(ii) The halide is iodide.
$2I^-(aq) + Cl_2(g) \rightarrow 2Cl^-(aq) + I_2(aq)$

(c) **(i)**

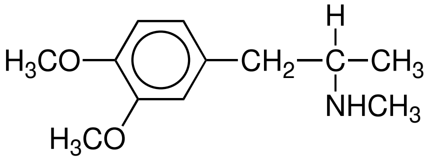


Note: nitro group can be anywhere on the ring and 1-3 substitutions.

(ii)



(iii)



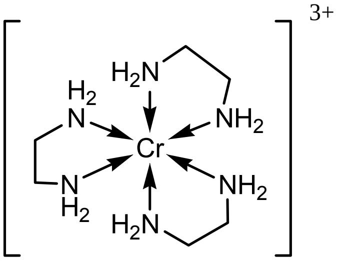
6 **(a)** **(i)** **A**: $[Cr(H_2O)_6]^{3+}$

B: $[Cr(H_2O)_6]^{2+}$

C: $Cr(OH)_3$ or $Cr(H_2O)_3(OH)_3$

D: CrO_4^{2-} or Na_2CrO_4

E:



(ii) Cr^{3+} has a high charge density. Hence $[Cr(H_2O)_6]^{3+}$ can undergo hydrolysis in water to produce H^+ ions, forming CO_2 with carbonate ions.

(iii) Ligand exchange

(b) Cr^{3+} has d^3 electronic configuration.

In an octahedral ligand field, the 6 NH_3 ligands will split the five degenerate 3d orbitals into 2 groups of different energy levels.

The difference in the two energy levels, ΔE, falls within the visible region of the electromagnetic spectrum. An electron in a lower d orbital energy level can absorb radiation in the visible spectrum and be promoted into the higher d orbital energy level.

This d→d electron transition gives rise to the colour as the complement of the absorbed colour.

(c) **(i)**

$$\text{mass of chromium} = \frac{1}{3} \times \frac{3.0 \times 45 \times 60}{96500} \times 52.0 = 1.45\ \text{g}$$

(ii) As the $Cr^{3+}(aq)$ ions are discharged at the cathode, they are replenished by reduction of $CrO_4^{2-}(aq)$ ions at the cathode.

$$CrO_4^{2-}(aq) + 8H^+(aq) + 3e \rightarrow Cr^{3+}(aq) + 4H_2O(l)$$