RIVER VALLEY HIGH SCHOOL
YEAR 6 PRELIMINARY EXAMINATION

H2 CHEMISTRY 9647/02

Paper 2 Structured Questions

Suggested Answers

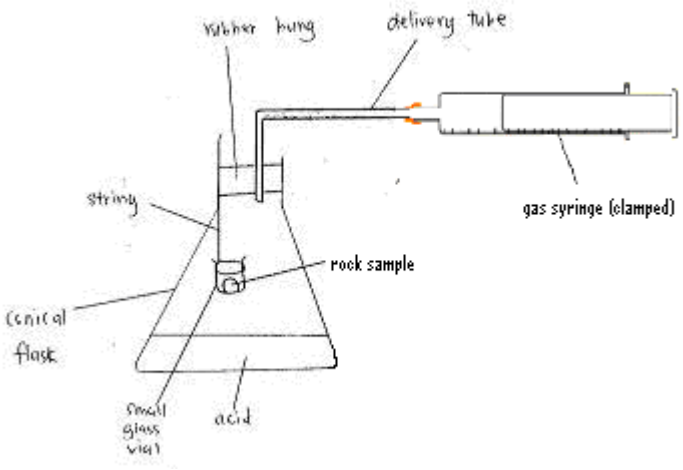
~~RIVER VALLEY HIGH SCHOOL~~
~~YEAR 6 PRELIMINARY EXAMINATION~~

~~H2 CHEMISTRY~~ ~~9647/02~~

~~Paper 2 Structured Questions~~

~~Suggested Answers~~

1. (a)



(b) Amount of $CaCO_3$ = 0.200 / Mr = 0.200 / 100.1 = 1.998×10^{-3} mol

Amount of HC*l* required = $1.998 \times 10^{-3} \times 2 = 3.996 \times 10^{-3}$ mol

If limestone sample contains 100 % $CaCO_3$,
Volume of 0.100 M HC*l* needed
= $(3.996 \times 10^{-3} / 0.100) \times 1000 = 40.0\ cm^3$
Volume used should be at least $40.0\ cm^3$.

(c) Amount of $CaCO_3$ = 0.200 / Mr = 0.200 / 100.1 = 1.998×10^{-3} mol

Amount of CO_2 gas evolved = 1.998×10^{-3} mol

Volume of CO_2 gas = $1.998 \times 10^{-3} \times 24000 = 48$ cm^3

Volume of apparatus should be at least 48 cm^3.

(d) Measure the initial volume of gas, V_i.

Lower the vial containing the rock sample into the acid to start the reaction.

Measure the final volume of gas, V_f, when **bubbling has stopped / plunger of gas syringe has stopped moving**.

Let the volume of CO_2 gas collected be V cm^3, $V = V_f - V_i$

Amount of CO_2 gas = V / 24000 mol

Amount of $CaCO_3$ in rock sample = (V / 24000) × 1 = V / 24000 mol

Mass of $CaCO_3$ in rock sample = (V / 24000) × 100.1 = 100.1V / 24000

% mass of $CaCO_3$ in rock sample

$$= \frac{100.1V}{24000} \times \frac{1}{0.200} \times 100\%$$

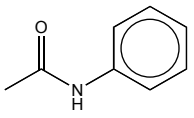
= 2.09V %

(e) CO_2 gas may escape through the joints in the above experimental setup.

Grease the joints to prevent the escape of gas.

Or any reasonable answers.

2. **(a)** Stage 1: $CH_3COOH + SOCl_2 \rightarrow CH_3COCl + SO_2 + HCl$

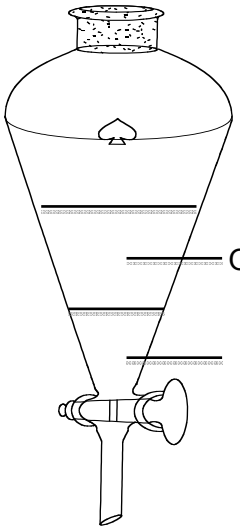
Stage 2: $CH_3COCl + C_6H_5NH_2 \rightarrow$  $+ HCl$

(b) Thionyl chloride (and/or Ethanoyl chloride formed) will react with water **[1]**, (eventually leading to a lower yield of product).

(c) **(i)** Ethanol is very soluble in water and separation of the two layers would be very difficult.

(ii) To allow for better separation of the aqueous and organic layer.

(iii)



(d) **(i)** $HCl + NaHCO_3 \rightarrow NaCl + CO_2 + H_2O$

(ii) Release the pressure in the separating funnel at intervals.

(e) **(i)** **Anhydrous** calcium chloride/magnesium sulfate/sodium sulfate.

(ii) $n_{CH_3COOH} = \dfrac{6 \times 1.05}{60} = 0.105$ mol

$n_{SOCl_2} = \dfrac{20 \times 0.94}{119.1} = 0.158$ mol

$\therefore$ CH_3COOH is the limiting reagent.

Theoretical yield of N-phenylethanamide = $0.105 \times 135 = 14.18$ g

% yield = $\dfrac{8.94}{14.18} \times 100\% =$ **<u>63.0%</u>**

(iii) Recrystallisation

3. **(a)** **(i)** Nitric acid is an oxidising agent.

(ii) $2Al + 3H_2O \rightarrow Al_2O_3 + 6H^+ + 6e$

$6NO_3^- + 12H^+ + 6e \rightarrow 6NO_2 + 6H_2O$

$2Al + 6NO_3^- + 6H^+ \rightarrow Al_2O_3 + 6NO_2 + 3H_2O$

(iii) $2Al(s) + 2NaOH(aq) + 6H_2O(l) \rightarrow 2NaAl(OH)_4(aq) + 3H_2(g)$

(b) Aluminium oxide has a **<u>giant ionic structure</u>** while aluminium chloride has a **<u>simple molecular structure</u>**. A **<u>larger amount of energy</u>** is needed to overcome the strong **<u>electrostatic force of attraction between Al^{3+} ions and O^{2-} ions</u>** than the weaker **<u>van der Waals' forces between aluminium chloride molecules</u>**.

(c) **(i)** $Mg(NO_3)_2(s) \rightarrow MgO(s) + 2NO_2(g) + ½O_2(g)$

(ii) Mg^{2+} has a **smaller ionic radius** compared to Ba^{2+}. Thus Mg^{2+} has a **higher charge density** and is able to **polarise the large NO_3^- anion to a larger extent** and the N–O bonds are weakened more. Hence magnesium nitrate decomposes at a lower temperature.

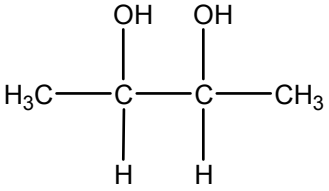
(iii) Aluminium nitrate has a lower decomposition temperature.

Al^{3+} has a smaller ionic radius (0.050 nm) and a larger charge. Thus Al^{3+} has a higher charge density and greater polarising power.

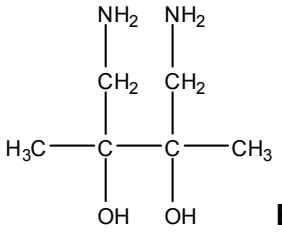
(c) **(i)** Reaction I: HCN, NaCN / trace amounts of base

Reaction II: dilute H_2SO_4, heat

(ii)



A



B

4. **(a)** Amount of Cr deposited on metal object = 3.7/52 = 7.115×10^{-2} mol

$Cr^{3+}(aq) + 3e^- \rightarrow Cr(s)$

Amount of e^- = 7.115 x $10^{-2} \times 3$ = 0.2135 mol

$Q = I \times t$

$0.2135 \times 96500 = I \times 1.5 \times 60 \times 60$

I = 3.82 A

(b) The **reduction potential for the reduction of H_2O is more positive/less negative than that for Al^{3+}**. Therefore, **H_2O will be preferentially reduced at the cathode** to form H_2 and aluminium will not be plated on the metal object.

Anode: $Al(s) \rightarrow Al^{3+}(aq) + 3e^-$

Cathode: $2H_2O(l) + 2e^- \rightarrow H_2(g) + 2OH^-(aq)$

(c) Electronic configuration of Cr^{3+}: **$1s^2 2s^2 2p^6 3s^2 3p^6 3d^3$**

In the isolated chromium(III) ion, **all five 3d-orbitals are degenerate.**

In the metal complex, the different extent of **inter-electronic repulsion** between the central chromium(III) ion and water ligands **causes the five 3d-orbitals to split into two groups** with an energy gap between them.

Electrons can move from a **3d-orbital of lower energy to one of higher energy** if they absorb sufficient energy (ΔE).

The energy absorbed ΔE in these **d-d transitions** is in the **visible region of light spectrum** and the colour of the ion is the **complement of the colour absorbed.**

(d) Formula of **P**: $[Cr(H_2O)_4Cl_2]Cl.2H_2O$

Formula of **Q**: $[Cr(H_2O)_5Cl]Cl_2.H_2O$

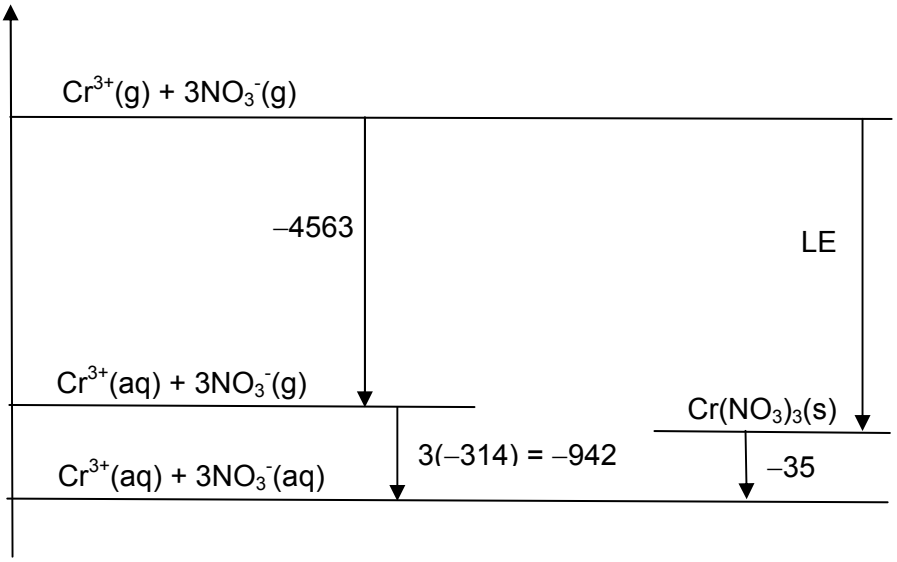
P contains **<u>1 free Cl^- ion</u>** which can be precipitated as $AgCl$ by Ag^+.

Q contains **<u>2 free Cl^- ion</u>** which can be precipitated as $AgCl$ by Ag^+.

$[Cr(H_2O)_4Cl_2]Cl.2H_2O(s) + aq \rightarrow [Cr(H_2O)_4Cl_2]^+(aq) + Cl^-(aq) + 2H_2O(l)$

$[Cr(H_2O)_5Cl]Cl_2.H_2O(s) + aq \rightarrow [Cr(H_2O)_5Cl]^{2+}(aq) + 2Cl^-(aq) + H_2O(l)$

(e) Energy



$LE = \Delta H_{hyd} - \Delta H_{soln}$

$= (-4563 - 942) - (-35)$

$= -5470\ kJ\ mol^{-1}$

5. (a) (i)

$$K_p = \frac{p_{butanal}}{p_{propene}p_{CO}p_{H_2}}$$

(ii)

	$CH_3CH{=}CH_2(g)$	+ $CO(g)$	+ $H_2(g)$	= $CH_3CH_2CH_2CHO(g)$
Initial p	40	40	40	0
Eqm p	40 – x	40 – x	40 – x	x

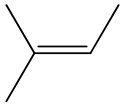
$p_{propene} = p_{CO} = p_{H_2} = 40 - 39.6 = 0.400$ atm

$$K_p = \frac{39.6}{(0.400)^3} = 619 \text{ atm}^{-2}$$

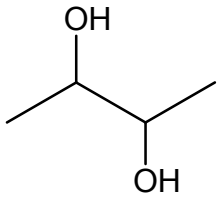
(iii) At high pressure, the **equilibrium position lies more to the right to reduce the number of gaseous molecules**, thus **increases the yield** of butanal.

(b) **(i)** Step I : nucleophilic substitution

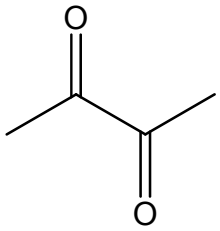
(ii)



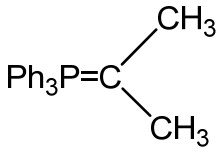
(iii) Intermediate product from step 1:



Intermediate product from step 2:



Structure of Wittig reagent:



(c) **(i)** Rate = $k(p_{butadiene})^m$

(ii)

Clear header(s) that shows how data is processed such that order of reaction can be determine, e.g. $\frac{\text{rate}}{(p_{butadiene})^2}$, OR –lg rate and –lg($p_{butadiene}$) OR ($p_{butadiene}$)^2.

Time /s	$p_{butadiene}$ /atm	Rate /atm s^{-1}	$\frac{\text{rate}}{p_{butadiene}}$ /s^{-1}	$\frac{\text{rate}}{(p_{butadiene})^2}$ /atm^{-1} s^{-1}
0	0.917	9.48×10^{-5}	1.03×10^{-4}	1.13×10^{-3}
1000	0.827	7.75×10^{-5}	9.37×10^{-5}	1.13×10^{-3}
2000	0.753	6.45×10^{-5}	8.57×10^{-5}	1.14×10^{-3}

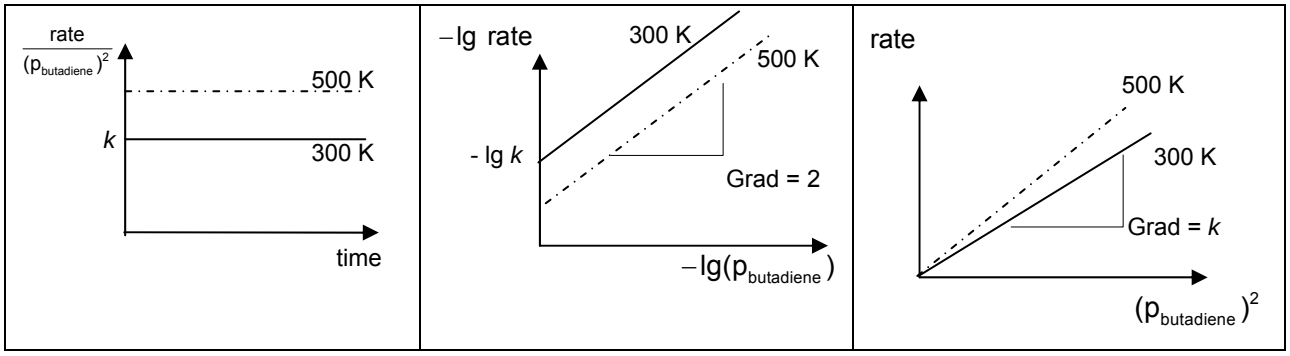
3000	0.691	5.45×10^{-5}	7.90×10^{-5}	1.14×10^{-3}
4000	0.638	4.66×10^{-5}	7.30×10^{-5}	1.14×10^{-3}

(iii) The reaction is **second order with respect to butadiene** because $\frac{\text{rate}}{(p_{butadiene})^2}$ **is a constant** throughout the reaction. Or other suitable deduction based on graph plotted.

Suitable axes and units; units not required for log or ln values

Best fit line, with y-intercept, showing the correct trend.

(iv)



Or sketch of other suitable graph showing the correct trend.