JURONG PIONEER JUNIOR COLLEGE
2019 JC2 H2 CHEMISTRY (9729)
Preliminary Examination Paper 4
(Suggested Answers)

1 Determination of the identity of the halogen, X, in CH_2XCO_2H

(a) (ii) Titration results

Titration number	1	2
Final burette reading / cm^3	24.90	34.95
Initial burette reading / cm^3	0.00	10.00
Volume of FA3 used / cm^3	24.90	24.95
	✓	✓

(iii) average volume of **FA 3** used , $V_{FA3} = \dfrac{24.90 + 24.95}{2} = 24.93\ cm^3$

(b) (i) n(H_2SO_4) in 10.0 cm^3 of **FA 2** $= 2.00 \times \dfrac{10.0}{1000} = 0.0200$ mol

= n(H_2SO_4) in 250 cm^3 **FA 3**

[H_2SO_4] in **FA 3** $= 0.020 \div \dfrac{250}{1000} = 0.0800\ mol\ dm^{-3}$

or

Using $c_1V_1 = c_2V_2$,

[H_2SO_4] in **FA 3** $= \dfrac{2.00 \times 10.0}{250} = 0.0800\ mol\ dm^{-3}$

(ii) n(H_2SO_4) reacted in titration $= \dfrac{24.93}{1000} \times 0.0800 = 0.001996$ mol

Since $1H_2SO_4 \equiv 2\ NaOH$,

n(NaOH) in 25.0 cm^3 of **FA 1** $= 0.001992 \times 2 = 0.00399$ mol

(iii) n(NaOH) in 250 cm^3 of **FA 1**

$= 0.00399 \times \dfrac{250}{25.0} = 0.0399$ mol

= n(NaOH) left unreacted after reaction with **W**

n(NaOH) added to **W** $= \times 0.40 = 0.100$ mol

n(NaOH) reacted with **W** $= 0.100 - 0.0399 = 0.0601$ mol

(iv) From equation 1 and 2, since 1**W** ≡ 2NaOH,

n(**W**) in 4 g = ½ × 0.0601 = 0.03004 mol

M_r of W = 4 ÷ 0.03004 = 133.2 ≈ 133 (no units)

A_r of X = 133.2 – 59 = 74.2 (no units)

X is bromine/ Br

(c) **(i)** max. % error in volume of **FA3** used = $\frac{2(\pm 0.05)}{24.95} \times 100 = \pm\, 0.401\ \%$

(ii) Error : Mass measurement of W was not precise as the mass was given to nearest g.

Modification : Use a more precise weighing balance that can measure to 3.d.p.

or

Error : Substitution of halogeno group may be incomplete.

Modification : Heat W with NaOH for a longer period of time.

or

Error : Loss of product through heating.

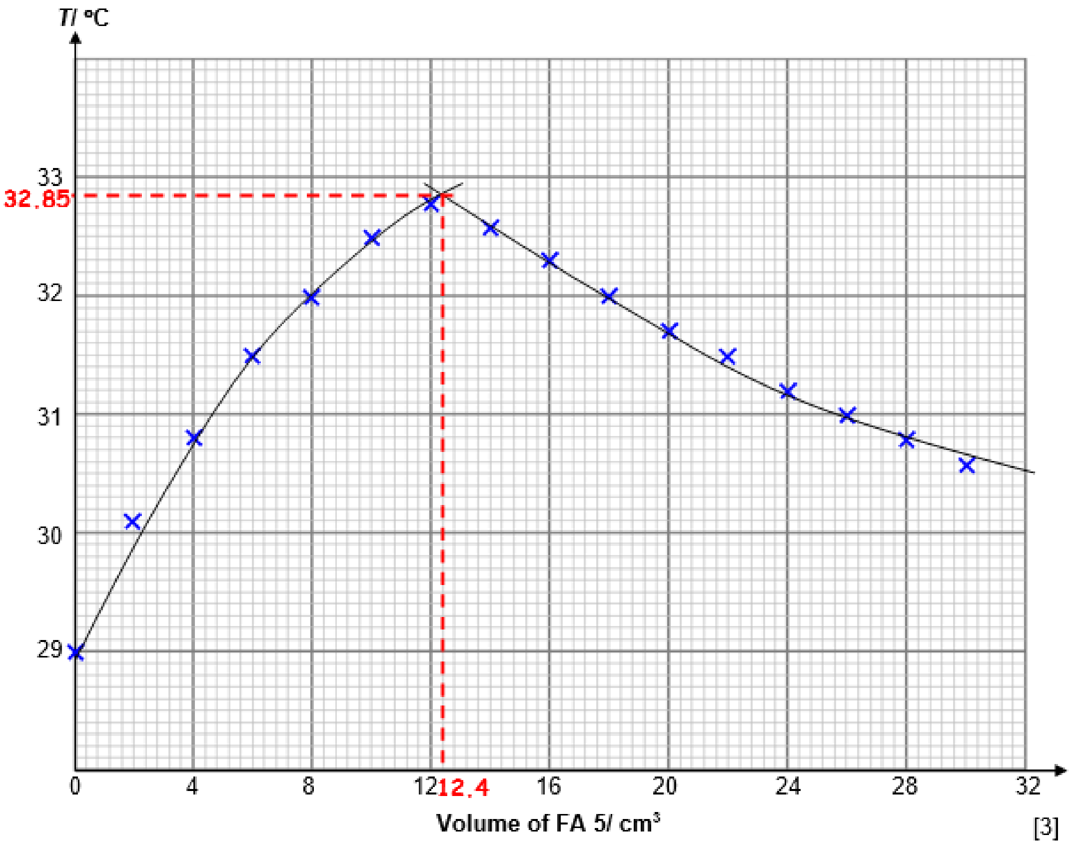
Modification : Heat the reaction mixture under reflux

2 **An experiment to investigate the behaviour of acids and bases in aqueous solutions**

(a) **Determination of the enthalpy change of reaction between FA 4 and FA 5**

Total volume of FA 5 added/ cm^3	Maximum temperature/ °C
0.00	29.0
2.00	30.1
4.00	30.8
6.00	31.5
8.00	32.0
10.00	32.5
12.00	32.8
14.00	32.6
16.00	32.3
18.00	32.0
20.00	31.7
22.00	31.5
24.00	31.2
26.00	31.0
28.00	30.8
30.00	30.6

(b) **(i)**



[3]

(ii) & (iii) correctly reads T_{max} to ±½ small square + correctly calculates ΔT_{max} + correctly reads $V_{equivalence}$ to ±½ small square.

(iv) $n(NaHCO_3)$ used = $\frac{25.0}{1000} \times 1.00$ = 0.0250 mol = n(NaOH) reacted

[NaOH] in **FA 5** = 0.0250 ÷ $\frac{12.4}{1000}$ = 2.02 mol dm^{-3}

(v) From the graph, $V_{equivalence}$ = 12.4 cm^3.

heat evolved, q = (25.0 + 12.4)(4.18)(3.85)= 603 J

$\Delta H_3 = -(603 \times 10^{-3}) \div 0.0250 = -24.1$ kJ mol^{-1}

(c) **The reaction between FA 4 and FA 2**

(d) $T_{average} = \frac{(40.0 \times 28.6) + (15.0 \times 28.9)}{(40.0 + 15.0)}$ = 28.7 °C

heat absorbed, q = (40.0 + 15.0)(4.18)(28.7 – 28.2) = 115 J

$n(NaHCO_3)$ used = 1.00 × $\frac{40.0}{1000}$ = 0.0400 mol

Since $NaHCO_3$ is the limiting reagent,

$\Delta H_4 = +(115 \times 10^{-3}) \div 0.0400 = +2.87$ kJ mol^{-1}

(e)

$$\begin{array}{lr} H^+ + OH^- \rightarrow H_2O & \Delta H_{neutralisation} = -57.0 \\ HCO_3^- + OH^- \rightarrow CO_3^{2-} + H_2O & \Delta H_3 = -24.1 \\ H_2O + CO_2 \rightarrow HCO_3^- + H^+ & -\Delta H_4 = -(+2.87) \\ \hline \text{Overall: } 2OH^-(aq) + CO_2(g) \rightarrow CO_3^{2-}(aq) + H_2O(l) & \Delta H_5 \end{array}$$

$\Delta H_5 = (-57.0) + (-24.1) -(+2.87) = -84.0 \text{ kJ mol}^{-1}$

(g) **reaction 3**

role of HCO_3^- ions Bronsted acid

explanation HCO_3^- is a proton donor (or loses a proton).

reaction 4

role of HCO_3^- ions Bronsted base

explanation HCO_3^- is a proton acceptor (or gains a proton).

3 **Investigation of some reactions involving transition element ions.**

		tests	observations
(a)	**(i)**	Add one spatula of **FA 6** to a hard-glass test-tube. Heat gently for about 10s and then strongly for about 20s. Leave the test-tube and residue to cool completely. Keep the residue for use in **3(a)(ii)**. **While waiting, you can start on 3(d).**	O_2 gas relights glowing splint. Black residue obtained.
	(ii)	Add deionised water to a small beaker until it is about half full. Place the beaker on a white tile. Pour the cooled residue from **3(a)(i)** **slowly** into the deionised water in the beaker. **Observe the solution closely.** Swirl the solution and filter a small portion of this solution into a clean test-tube. The filtrate is **FA 7**.	Solid dissolves to form green solution which then turns purple. Purple filtrate obtained. Dark brown residue obtained.
	(iii)	Add 1 cm depth of **FA 7** to a test-tube. Add Fe^{2+}(aq), slowly with shaking, until no further change is seen.	Purple FA 7 turns yellow/orange/ brown and then pale green/ colourless.

(b) **(i)** The green solution obtained immediately when water is added to the residue is MnO_4^{2-}.

$E_{cell} = E_{red} - E_{ox} = (+2.26) - (+0.56)$

$= +1.70 \text{ V} > 0$ (energetically feasible)

Green MnO_4^{2-} is oxidised to purple MnO_4^- and reduced to brown MnO_2 ppt.

(ii) disproportionation

(c) $2KMnO_4 \rightarrow K_2MnO_4 + MnO_2 + O_2$

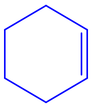
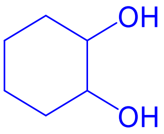
(d)

	tests	observations
(i)	Add 2 cm depth of aqueous sodium hydroxide in a test-tube. Add 5 drops of **FA 8** to this test-tube. Add a few drops of aqueous potassium manganate(VII).	Solution turns green. Green solution then turns brown/brown ppt. formed.
(ii)	Add 2 cm depth of aqueous sulfuric acid in a test-tube. Add 5 drop of **FA 8** to this test-tube. Add a few drops of aqueous potassium manganate(VII). Place the mixture in the hot water bath for a few minutes.	Purple FA 9 decolourises.
(iii)	Add 5 cm depth of deionised water in a test-tube. Add 1 drop of **FA 8** to this test-tube. Add aqueous bromine slowly, with shaking, until no further change is seen.	Yellow aqueous bromine decolourises

(e) **(i)** molecular formula of **FA 8** C_6H_{10}

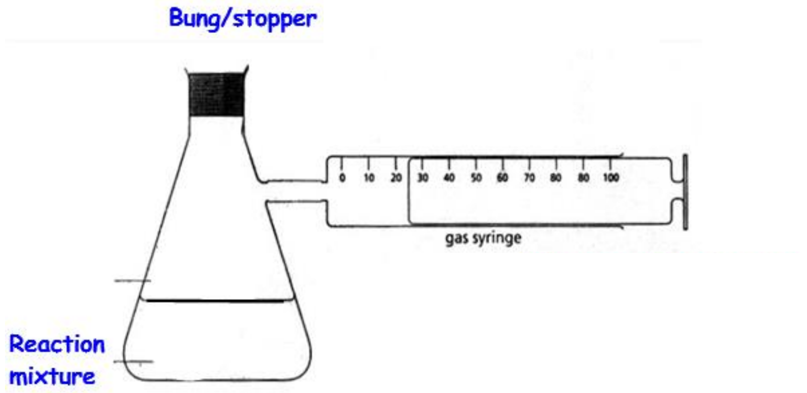
explanation **FA 8** undergoes oxidation from alkene to give diol.

(ii)

FA 8	compound **Z**
	

4 **Planning**

(a)



1. Use a burette to transfer 50.00 cm^3 of $KMnO_4$ into a conical flask.
2. Using a 50.0 cm^3 measuring cylinder, transfer 50.0 cm^3 of H_2SO_4 into the same conical flask. Using a dropper, add 1 cm^3 of $MnSO_4$(aq) to the conical flask.
3. Using a 50.0 cm^3 measuring cylinder, measure 50.0 cm^3 of $Na_2C_2O_4$.
4. Transfer the $Na_2C_2O_4$ to the conical flask and quickly insert the bung into the conical flask. Immediately start the stopwatch and swirl the conical flask.
5. Record time taken using stopwatch when 40 cm^3 of gas is collected in the gas syringe.
6. Repeat steps 1 to 5 for 4 other experiments, using the volumes as shown in the table below. Measure deionised water using a measuring cylinder.

Expt	Vol $KMnO_4$ /cm^3	Vol deionised water/cm^3	Vol H_2SO_4 /cm^3	Vol $Na_2C_2O_4$ /cm^3	Vol Mn^{2+} /cm^3	t/s
1	50.00	0.0	50.0	50.0	1	
2	40.00	10.0	50.0	50.0	1	
3	30.00	20.0	50.0	50.0	1	
4	20.00	30.0	50.0	50.0	1	
5	10.00	40.0	50.0	50.0	1	

(b)

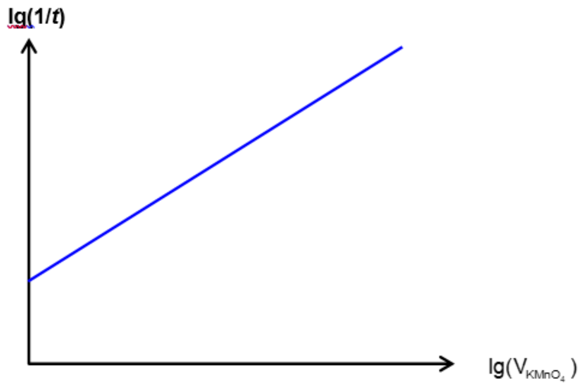


Fig 4.1

Rate = $k'[KMnO_4]^a$

Since rate $\propto 1/t$ and $[KMnO_4] \propto V_{KMnO4}$ since total volume is kept constant,

$1/t = k'(V_{KMnO4})^a$

$\lg(1/t) = \lg k' + a \lg(V_{KMnO4})$

$\lg(1/t) = a \lg(V_{KMnO4}) + \lg k'$ which is similar to a y = mx + c straight line graph

(c) Gradient of the line = order of reaction

(d) **(i)** The reaction is slow as it has high activation energy due to the repulsion between both the negatively charged MnO_4^- and $C_2O_4^{2-}$.

(ii) Homogenous catalyst since $Mn^{2+}(aq)$ is in the same phase as the reactants.

(iii)