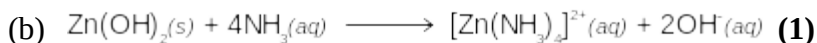


Year 12 Chemistry Semester 1 Examination 2004 - SolutionsPart 1

1A, 2A, 3C, 4B, 5D, 6C, 7D, 8B, 9D, 10A, 11C, 12A, 13C, 14B, 15C, 16B, 17C, 18C, 19B, 20A, 21D, 22B, 23B, 24A, 25B, 26D, 27C, 28A, 29B, 30A

Part 2

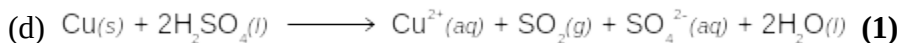
White solid dissolves and system bubbles (2)



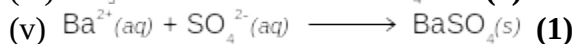
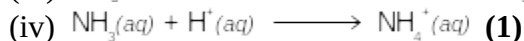
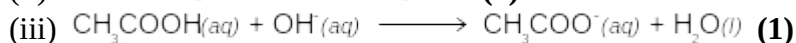
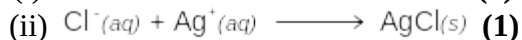
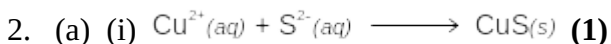
Solid dissolves. Colourless solution (2)



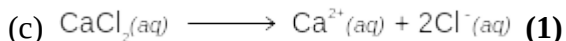
Metal dissolves and a deep green solution is formed. The system also bubbles (2)



Metal dissolves. Blue solution formed. Noxious gas created (2)



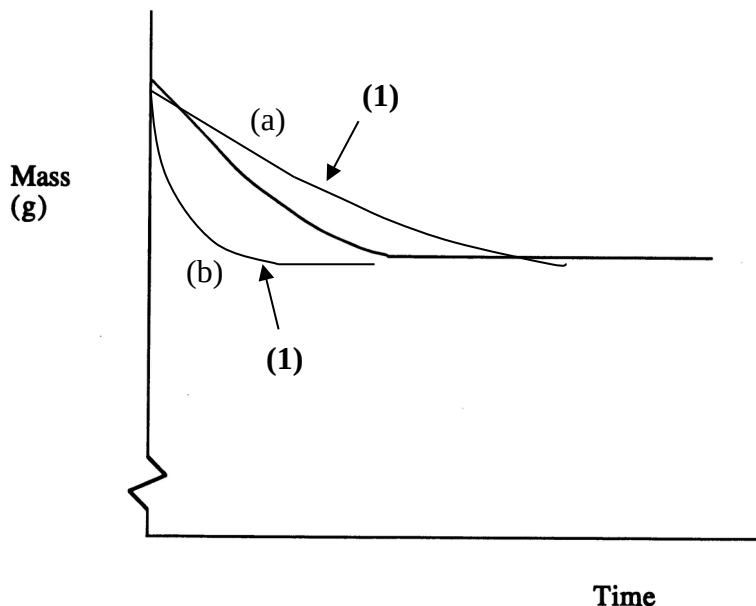
(b) W=8; X=3; Y=4; Z=9 (2)



(d) $\text{pCl} = -\log[\text{Cl}] = -\log(0.01) = 2$ (1)

3. Natural gas and air do not react at room temperature because the particles do not have enough activation energy upon collision to satisfy the activation energy barrier (½). The piece of platinum is a catalyst. Hence, it provides a lower activation energy barrier for the reactant particles it comes into contact with (½). These particles therefore have enough energy to overcome the activation energy barrier and so react (½). This process releases heat energy as the reaction is exothermic (½). This heat energy speeds up other reactant molecules so that they achieve an energy that satisfies the energy barrier and react as well (½). A chain reaction begins where heat is expelled and used to allow other particles to react (½). The sum total of all exothermic reactions manifests itself as an explosion.

4.



(a) The new concentration is lower than the original. As reaction rates increase with increased concentration of reagents, the new concentration ensures a lower rate. Hence, the gradient of the new curve is half as steep as the original. It will also take longer for the reaction to reach completion. Hence, the new curve reaches the horizontal further to the right **(1)**.

(b) Ground-up copper offers more exposure to the acid. Hence, there are more successful collision and the reaction rate therefore increases. Hence, the gradient of the new curve is steeper thus requiring less time to reach completion. This is seen by the curve reaching the horizontal further to the left **(1)**.

5. (a) 350 kJ mol^{-1} **(1)**

(b) As the nitrogen dioxide and carbon monoxide molecules get closer to each other, the kinetic energy as a result of their movement is converted to potential energy as a result of their proximity to each other. **(2)**

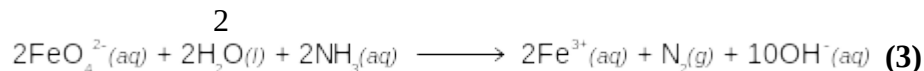
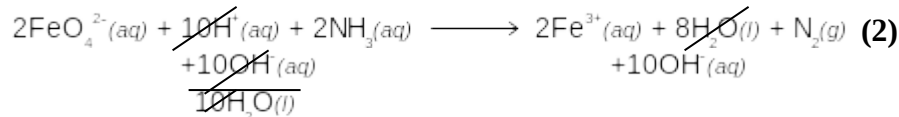
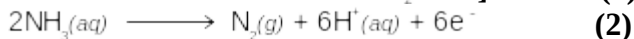
6. NO is the catalyst because it provides a convenient pathway for an oxygen atom of O_3 to break off and attach itself to a separate oxygen atom **(1)**. Furthermore, like all catalysts NO participates in the reaction but is present at the end of the reaction as it was at the beginning of the reaction **(1)**.

7. (a) $K = \frac{[\text{Cl}_2]^2[\text{H}_2\text{O}]^2}{[\text{HCl}]^4[\text{O}_2]}$ **(1)**

- (b) The reaction is an exothermic reaction ($\frac{1}{2}$). If it is at equilibrium at 450°C and suddenly heat is inputted to cause a rise in temperature to 550°C , the system according to Le Châtelier's Principle will try to oppose the change in order to re-establish equilibrium (**1**). Hence, the endothermic reaction will prevail and the equilibrium will push to the left ($\frac{1}{2}$). As this will increase the quantities of reactants, the new equilibrium constant (at 550°C) will be smaller than the original 450°C equilibrium constant (**1**).
- (c) If the pressure of the system is decreased by expanding the volume at constant temperature then the system according to Le Châtelier's Principle will try to oppose the change in order to re-establish equilibrium (**1**). Hence, an increase in particle concentration will attempt to take place. As we move from right to left in the reaction, 4 gas particles produces 5 gas particles (**1**). As this is an increase in gas particles this reaction will prevail and the equilibrium will push to the left ($\frac{1}{2}$). Hence, re-establishment of equilibrium decreases the product concentrations and increases the reactant concentrations ($\frac{1}{2}$).
- (d) No change in K (**1**).
- (e) The colour of the system. Bromine gas is reddish brown. The more the equilibrium lies to the right, the greater the intensity of the reddish brown colour (**1**).
- (f) The rate of the forward and reverse reactions as well as the macroscopic properties of the system (**2**).

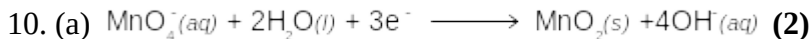
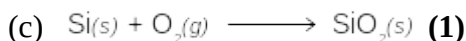


(1)



9. (a) Hypochlorous acid is able to destroy algae and bacteria because it causes the oxidation of these organisms which in turn kills the organisms **(1)**. The difference between HClO and ClO^- is the speed at which they cause oxidation. Hypochlorous acid is more effective because it tends to be reduced much more quickly than hypochlorite ion **(1)**.

(b) Coke, Iron Ore & Limestone **(3)**



- (b) Dissolve solid in hot water **(1)**; boil for 10 minutes **(1)**; cover and cool **(1)**; filter through a sintered glass crucible **(2)**; and store in a dark bottle **(1)**.

Part 3

Question 1

Take 1 L of the gas.

$$n(\text{NO}_2) = PV/RT = (101.3 \times 1)/(8.3145 \times 308) = 3.96 \times 10^{-2} \text{ mol} \text{ (1)}$$

$$m(\text{NO}_2) = n \times M = (3.96 \times 10^{-2}) \times 46.0055 = 1.82 \text{ g} \text{ (1)}$$

$$\text{density}(\text{NO}_2) = m(\text{NO}_2)/V = 1.82/1 = 1.82 \text{ gL}^{-1} \text{ (1)}$$

Question 2

Let's take 1 L of solution.

$$\text{Hence, } n(\text{HNO}_3) = 16.0 \text{ (1)}$$

$$m(\text{HNO}_3) = n \times M = 16.0 \times 63.0128 = 1008.2048 \text{ (1)}$$

$$\%(\text{HNO}_3) = [m(\text{HNO}_3) / m(\text{solution})] \times 100$$

$$70 = [1008.2048 / m(\text{solution})] \times 100$$

$$m(\text{solution}) = 1440.29 \text{ g} \text{ (1)}$$

$$\text{density}(\text{solution}) = m(\text{solution})/V = 1440.29 \text{ g} / 1 \text{ L} = 1440 \text{ gL}^{-1} = \mathbf{1.44 \text{ g/mL}} \text{ (1)}$$

Question 3

$$n(\text{CO}_2) = PV/RT = (154.2 \times 3.72)/(8.3145 \times 300) = 0.2300 \text{ mol (1)}$$

$$n(\text{Na}) = m/M = 4.52 / 22.9897 = 0.1970 \text{ mol (1)}$$

How many moles of Na is needed to consume all the CO_2 ?

$n(\text{Na}) = 4 \times [n(\text{CO}_2)/3] = 4 \times [0.2300 / 3] = 0.3066$. We only have 0.2300. Hence, sodium is the limiting reagent **(1)**.

$$n(\text{Na}_2\text{CO}_3) = 0.5 \times n(\text{Na}) = 0.5 \times 0.1970 = 0.0983 \text{ mol (1/2)}$$

$$m(\text{Na}_2\text{CO}_3) = n \times M = 0.0983 \times 105.988 = \mathbf{10.4 \text{ g (1/2)}}$$

$$n(\text{CO}_2)_{\text{used}} = (3/4) \times n(\text{Na}) = (3/4) \times 0.3066 = 0.147 \text{ (1)}$$

$$n(\text{CO}_2)_{\text{remaining}} = n(\text{CO}_2)_{\text{start}} - n(\text{CO}_2)_{\text{used}} = 0.2300 - 0.147 = \mathbf{0.0825 \text{ mol (1)}}$$

Question 4

A particular ore contains 47.2% MnO_2 . What mass of the ore must be refined to produce 2.50 tonnes of pure manganese metal?

$$\%(\text{Mn}) = [M(\text{Mn})/M(\text{MnO}_2)] \times 100 = (54.9380/86.9368) \times 100 = 63.19 \text{ (1)}$$

$$n(\text{Mn}) = m/M = (2.50 \times 10^6)/54.9380 = 4.55 \times 10^4 \text{ (1)}$$

$$n(\text{MnO}_2) = n(\text{Mn}) = 4.55 \times 10^4 \text{ (1)}$$

$$m(\text{MnO}_2) = n \times M = (4.55 \times 10^4) \times 86.9368 = 3.96 \times 10^6 \text{ g (1)}$$

$$\%(\text{MnO}_2) = [m(\text{MnO}_2)/m(\text{ore})] \times 100$$

$$47.2 = [(3.96 \times 10^6)/m(\text{ore})] \times 100 \text{ (1)}$$

$$\mathbf{m(\text{ore}) = 8.38 \times 10^6 \text{ g} = \mathbf{8.38 \text{ tonnes (1)}}$$

Question 5

$$(a) n(\text{CeO}_2) = m/M = 2.312/172.1147 = 1.343 \times 10^{-2} \text{ moles} \quad (1)$$

$$n(\text{Ce(IV)}) = n(\text{CeO}_2) = 1.343 \times 10^{-2} \text{ moles} \quad (1)$$

This Ce(IV) comes from the Ce(III) and Ce(IV) in the original mass of sample before oxidation of Ce(III).

$$\text{Hence, } n(\text{Ce(III)} + \text{Ce(IV)}) \text{ in 2.167 g sample} = 1.343 \times 10^{-2} \text{ moles}$$

$$\begin{aligned} m(\text{Ce(III)} + \text{Ce(IV)}) \text{ in 2.167 g sample} &= n \times M = (1.343 \times 10^{-2}) \times 140.1159 \\ &= 1.882 \text{ g} \quad (1) \end{aligned}$$

$$\text{In 1.528 g sample, } n(\text{NO}_3^-) = m/M = 0.5230/62.0049 = 8.435 \times 10^{-3} \text{ mol} \quad (1)$$

3 mol of NO_3^- are found in 1 mole of $\text{Ce}(\text{NO}_3)_3$

$$\text{Therefore } n(\text{Ce}(\text{NO}_3)_3) = n(\text{NO}_3^-)/3 = (8.435 \times 10^{-3})/3 = 2.812 \times 10^{-3} \quad (1)$$

$$n(\text{Ce(III)}) = n(\text{Ce}(\text{NO}_3)_3) = 2.812 \times 10^{-3} \quad (1)$$

$$m(\text{Ce(III)}) = n \times M = (2.812 \times 10^{-3}) \times 140.1159 = 0.3940 \text{ g} \quad (1)$$

$$\%(\text{Ce(III)}) = [m(\text{Ce(III)})/m(\text{sample})] \times 100 = [0.3940/1.528] \times 100 = 25.8\% \quad (1)$$

$$\text{In 2.167 g of sample, } m(\text{Ce(III)}) = (25.8/100) \times 2.167 = 0.5587 \text{ g} \quad (1)$$

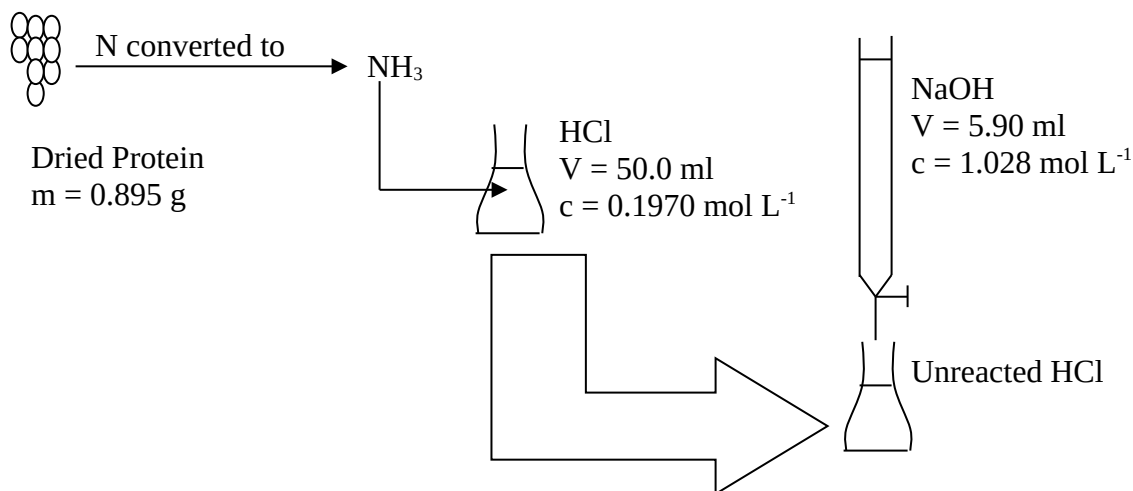
$$\text{In 2.167 g of sample, } m(\text{Ce(III)} + \text{Ce(IV)}) = 1.882 \text{ g}$$

$$\text{Therefore } m(\text{Ce(IV)}) \text{ in 2.167 g sample} = 1.882 - 0.5587 = 1.323 \text{ g} \quad (1)$$

$$\%(\text{Ce(IV)}) = [m(\text{Ce(IV)})/m(\text{sample})] \times 100 = [1.323/2.167] \times 100 = 61.1\% \quad (1)$$

$$(b) n(\text{I}_2) = 2 \times n(\text{CeO}_2) = (2 \times 1.343 \times 10^{-2}) = 2.687 \times 10^{-2} \text{ moles} \quad (1)$$

$$p(\text{I}_2) = (nRT)/V = [(2.687 \times 10^{-2}) \times 8.31451 \times 298] / 0.2554 = 261 \text{ kPa} \quad (1)$$

Question 6

$$n(\text{NaOH}) = c \times V = 1.028 \times 0.00590 = 6.065 \times 10^{-3} \text{ mol (1)}$$



$$n(\text{unreacted HCl}) = n(\text{NaOH}) = 6.065 \times 10^{-3} \text{ mol (1)}$$

$$n(\text{HCl before reaction}) = c \times V = 0.1970 \times 0.050 = 9.850 \times 10^{-3} \text{ mol (1)}$$

$$\begin{aligned} n(\text{HCl reacting with NH}_3) &= n(\text{HCl before reaction}) - n(\text{unreacted HCl}) \\ &= (9.850 \times 10^{-3}) - (6.065 \times 10^{-3}) \\ &= 3.785 \times 10^{-3} \text{ mol (1)} \end{aligned}$$

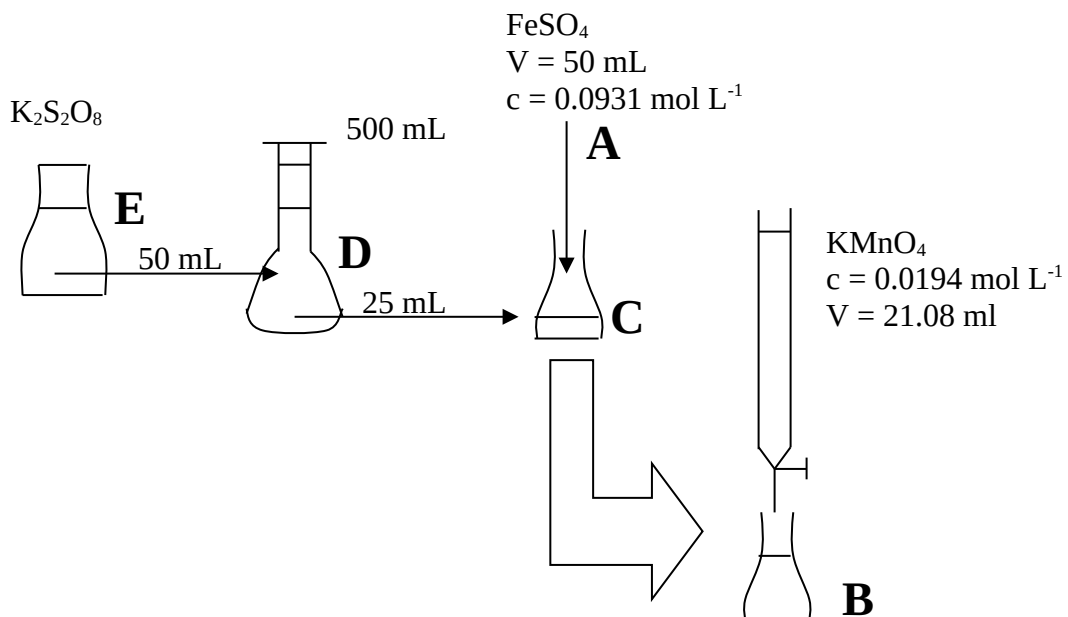


$$n(\text{NH}_3) = n(\text{HCl}) = 3.785 \times 10^{-3} \text{ mol (1)}$$

$$n(\text{N in protein}) = n(\text{NH}_3) = 3.785 \times 10^{-3} \text{ mol (1)}$$

$$m(\text{N in protein}) = n \times M = (3.785 \times 10^{-3}) \times 14.01 = 0.0530 \text{ g (1)}$$

$$\%(\text{N}) = [m(\text{N in protein}) / m(\text{protein})] \times 100 = [0.0530 / 0.895] \times 100 = 5.92\% \text{ (1)}$$

Question 7

$$n(\text{Fe}^{2+})_{\text{A}} = c \times V = 0.0931 \times 0.050 = 4.655 \times 10^{-3} \text{ mol (1)}$$

$$n(\text{MnO}_4^-) = n(\text{KMnO}_4) = c \times V = 0.0194 \times 0.02108 = 4.090 \times 10^{-4} \text{ mol (1)}$$

$$n(\text{Fe}^{2+})_{\text{B}} = 5 \times n(\text{MnO}_4^-) = (5 \times 4.090 \times 10^{-4}) = 2.045 \times 10^{-3} \text{ mol (1)}$$

$$n(\text{Fe}^{2+})_{\text{reacting with persulfate}} = n(\text{Fe}^{2+})_{\text{A}} - n(\text{Fe}^{2+})_{\text{B}} = (4.655 \times 10^{-3}) - (2.045 \times 10^{-3}) = 2.610 \times 10^{-3} \text{ mol (1)}$$

$$\begin{aligned} n(\text{K}_2\text{S}_2\text{O}_8)_{\text{C}} &= n(\text{S}_2\text{O}_8^{2-})_{\text{C}} = n(\text{Fe}^{2+})_{\text{reacting with persulfate}} / 2 \\ &= (2.610 \times 10^{-3}) / 2 \\ &= 1.3051 \times 10^{-3} \text{ mol (1)} \end{aligned}$$

$$\begin{aligned} c(\text{K}_2\text{S}_2\text{O}_8)_{\text{D}} &= c(\text{K}_2\text{S}_2\text{O}_8)_{\text{C}} = n(\text{K}_2\text{S}_2\text{O}_8)_{\text{C}} / V = \\ &= (1.3051 \times 10^{-3}) / 0.025 \\ &= 5.220 \times 10^{-2} \text{ mol L}^{-1} \text{ (1)} \end{aligned}$$

$$n(\text{K}_2\text{S}_2\text{O}_8)_{\text{D}} = c(\text{K}_2\text{S}_2\text{O}_8)_{\text{D}} \times V = (5.220 \times 10^{-2}) \times 0.5 = 2.610 \times 10^{-2} \text{ mol L}^{-1} \text{ (1)}$$

$$c(\text{K}_2\text{S}_2\text{O}_8)_{\text{E}} = n(\text{K}_2\text{S}_2\text{O}_8)_{\text{D}} / 0.05 = \mathbf{0.522 \text{ mol L}^{-1} \text{ (1)}}$$

Part 4Question 1

Process	General Points	Details
Haber and Contact	Reaction rate Requirements	High Pressures (1) and explanation in terms of collision theory. (2)
		High temperatures (1) and explanation in terms of collision theory. (2)
		Catalysts (1) and explanation in terms of collision theory. (2)
Haber	Correct Equation	$\text{N}_2(\text{g}) + 3\text{H}_2(\text{g}) \rightleftharpoons 2\text{NH}_3(\text{g}) + 92\text{kJ}$ (2)
	Equilibrium Requirements	Low temperatures (1) and explanation in terms of Le Châtelier's Principle. (2)
		High pressures (1) and explanation in terms of Le Châtelier's Principle. (2)
	Economic Requirements	Low temperatures are cheaper. (1)
		Low pressures are cheaper. (1)
	The Compromise	Iron/iron oxide catalyst (1) allows lower temperatures of about 500°C (1) . This satisfies the reaction rate and equilibrium needs. (1)
		High pressures of 350 atm used (1) . This satisfies the reaction rate and equilibrium requirements (2) , but works against the economic requirement (1) .
Contact	Equations	$\text{S}(\text{l}) + \text{O}_2(\text{g}) \longrightarrow \text{SO}_2(\text{g})$ (1)
		$2\text{SO}_2(\text{g}) + \text{O}_2(\text{g}) \rightleftharpoons 2\text{SO}_3(\text{g}) + 198\text{ kJ}$ (2)
		$\text{H}_2\text{SO}_4(\text{l}) + \text{SO}_3(\text{g}) \longrightarrow \text{H}_2\text{S}_2\text{O}_7(\text{l})$ (1)
		$\text{H}_2\text{S}_2\text{O}_7(\text{l}) + \text{H}_2\text{O}(\text{l}) \longrightarrow 2\text{H}_2\text{SO}_4(\text{l})$ (1)
	Equilibrium Requirements	Low temperatures (1) and explanation in terms of Le Châtelier's Principle. (2)
		High pressures (1) and explanation in terms of Le Châtelier's Principle. (2)
		Excess Air (1) and explanation in terms of Le Châtelier's Principle. (2)
	Economic Requirements	Low temperatures are cheaper. (marks already allocated)
		Low pressures are cheaper. (marks already allocated)
	The Compromise	High pressures not used because the costs are too high (1)
		V_2O_5 catalyst (1) allows lower temperatures of about 400°C (1) . This satisfies the reaction rate and equilibrium needs. (1)

Chemical Content: 44

Coherence and Clarity of Expression: 6

/50 Multiple by 0.4 to make /20

Question 2

Step	General Points	Details
Preparation of Na_2CO_3	Dry Na_2CO_3	Water absorbed onto Na_2CO_3 is a source of error. (1)
		Heat Na_2CO_3 in oven at 270°C for 30 minutes. (1)
		Cool in desiccator. (1)
	Weigh Na_2CO_3 and transfer to volumetric flask	Add approximately 2.65 g into a dry beaker. (1)
		Weigh accurately the container and Na_2CO_3 (1)
		Transfer solid to 500 ml volumetric flask (1) that has been rinsed out with distilled water (1)
		Weigh accurately the beaker. (1) Subtracting the 2 weights gives the exact mass of solid. This prevents the error caused by solid sticking to the beaker but being thought to exist in the volumetric flask. (1)
	Dissolve Na_2CO_3 and add water.	Add small amounts of water to the volumetric flask and shake to dissolve all the solid. (1)
		A source of error is adding too much water before all solid is dissolved. (1)
		Also shaking volumetric might cause liquid to splash. (1)
		Once dissolved, add water to the mark and invert several times. (1)
		Source of error: over-stepping or under-stepping the mark as a result of parallax error and user technique. (1)
Preparation of HCl	Concentrated HCl to volumetric flask and dilution	Measure approximately 5 ml of concentrated HCl. Add this HCl to some water in a 500 ml volumetric flask and make up to the mark with water. (1)
Standardisation of HCl Preparation of NaOH	Use of pipette, burette and indicators	Rinse burette out with the HCl solution. (1)
		If the burette is cleaned with distilled water, the HCl will change concentration when it is added to the burette as a result of the remaining water in the burette (very difficult to completely dry the burette) (1)
		Open tap to allow flow and the removal of air bubbles. (1)
		Accurately read to 2 decimal places the initial volume of the acid in the burette. (1)
		Source of error: parallax error. (1) Hence, read at eye level (1)
		Clean out pipette with Na_2CO_3 solution. (1)
		If the pipette is cleaned with distilled water, the Na_2CO_3 will change concentration when it is added to the burette as a result of the remaining water in the pipette (very difficult to completely dry the pipette) (1)
		Pipette 20 ml of Na_2CO_3 into a conical flask that has been cleaned with water. (1)
		Add a drop or 2 of methyl orange. (1) This indicator changes in the acidic range. (1)
		This is necessary because the carbon dioxide produced at neutralisation reacts with water to produce carbonic acid which makes the solution slightly acidic. (1)
		Titrate to the first permanent change in colour. (1)
		Accurately read to 2 decimal places the final volume of the acid in the burette. (1)
		Subtract the initial volume from the final volume to determine the titre. (1)
		Source of error: overstepping the end-point. (1) This is avoided by doing a rough titration so that at subsequent titrations the approximately volume is known allowing a 1 drop colour change to occur. (1)
		To minimise user error, do at least 3 accurate titrations. (1)

		Average titres that are close to each other (+/- 0.02 ml) (1)
		Sketch of Titration Curve (1)
		Reaction $\text{CO}_3^{2-}(\text{aq}) + 2\text{H}^+(\text{aq}) \longrightarrow \text{CO}_2(\text{g}) + \text{H}_2\text{O}(\text{l})$ (1)
		Calculate the concentration of HCl (1)
	Solid NaOH to volumetric flask, dissolution and dilution.	<p>Add quickly approximately 2.0 g of NaOH into a 500 ml volumetric flask that has been cleaned with distilled water. (1)</p> <p>Completely dissolve the solid by adding small amounts of distilled water. (1)</p> <p>Once dissolved, make up to the mark with distilled water. (1)</p>
Standardisation of NaOH	Use of pipette, burette and indicators	Accurately read to 2 decimal places the initial volume of the acid in the burette.
		Clean out pipette with NaOH solution. (1)
		Pipette 20 ml of NaOH into a conical flask that has been cleaned with water. (1)
		Add a drop or 2 of methyl red (1) . This indicator changes in the neutral range. (1)
		This is necessary because the products of neutralisation do not hydrolyse and so the pH remains at 7 at neutralisation. (1)
		Titrate to the first permanent change in colour.
		To minimise user error, do at least 3 accurate titrations.
		Sketch of Titration Curve (1)
		Reaction $\text{H}^+(\text{aq}) + \text{OH}^-(\text{aq}) \longrightarrow \text{H}_2\text{O}(\text{l})$ (1)
		Calculate the concentration of NaOH (1)
Determination of acetic acid in Vinegar	Density measurement	Measure the weight of a known volume of vinegar (1)
	Vinegar to volumetric flask and dilution	Clean out pipette with vinegar solution. (1)
		Pipette 20 ml vinegar into a 200 ml volumetric flask that has been cleaned out with water (1)
		This dilution is necessary because a straight titration from the original stock vinegar would require too much HCl for titration (beyond the capacity of the burette). (1)
		Rinse burette out with the NaOH solution. (1)
		Open tap to allow flow and the removal of air bubbles.
	Use of pipette, burette and indicators	Accurately read to 2 decimal places the initial volume of the base in the burette.
		Pipette 20 ml of the dilute vinegar into a conical flask that has been cleaned with water. (1)
		Add a drop or 2 of phenolphthalein. (1) This indicator changes in the basic range. (1)
		This is necessary because CH_3COO^- is produced at neutralisation. This reacts with water to form OH^- and so the pH at neutralisation is slightly basic. (1)
		Titrate to the first permanent change in colour.
		To minimise user error, do at least 3 accurate titrations.
		Sketch of Titration Curve (1)
		Reaction $\text{CH}_3\text{COOH}(\text{aq}) + \text{OH}^-(\text{aq}) \longrightarrow \text{CH}_3\text{COO}^-(\text{aq}) + \text{H}_2\text{O}(\text{l})$ (1)
		Calculate the percentage by mass of the CH_3COOH in the vinegar using the titres and the density of the vinegar. (1)

Chemical Content: 60

Coherence and Clarity of Expression: 8

/68 Multiple by 0.3 to make /20