2012-2013 KNEC SYLLABUS

Basic Principles of Chemistry Practical

POWERPOINT VERSION

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Chemistry practical all over the world is emphasized to all candidates sitting for a chemistry paper.

Chemistry is a science.

There are about seven main basic universal **emphasis** for all chemistry candidates sitting for a chemistry paper ;

(a) Titration/volumetric analysis
(b) Thermochemistry(energy changes)
(c) Chemical kinetic(rates of reaction)
(d) Qualitative analysis(organic/inorganic)
(e) Solubility and solubility curves
(f) Flame test
(g) Physical / general chemistry

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(a)Titration/volumetric analysis

Titration is determining the end point of the burette contents that react with fixed (usually 25.0cm3 from a pipette) conical flask contents.

As **evidence** of a titration **actually** done examining body require the candidate to record their burette readings before and after the titration.

For KCSE candidates burette readings **must** be recorded in a titration table in the **format** **provided** by the Kenya National Examination Council.

As **evidence** of all titration **actually** done Kenya National Examination Council require the candidate to record their burette readings before and after the titration to complete the titration table **in the format** **provided**.

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Sample Titration table format

Final burette reading (cm3)	24.0	24.0	24.0
Initial burette reading (cm3)	0.0	0.0	0.0
Volume of solution used(cm3)	24.0	24.0	24.0

Calculate the average volume of solution used

$$\frac{24.0 + 24.0 + 24.0}{3} = \mathbf{24.0\ cm3}$$

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As evidence of understanding the degree of accuracy of burettes ,all readings must be recorded to **a** decimal point.

As evidence of accuracy in carrying the out the titration ,candidates value should be **within 0.2** of the **school value** .

The school value is the **teachers** readings presented to the examining body/council based on the concentrations of the solutions s/he presented to her/his candidates.

Bonus mark is awarded for averaged reading **within 0.1** school value as Final accuracy.

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Calculations involved after the titration require candidates **thorough practice mastery** on the:

(i)relationship among the mole, molar mass, mole ratios, concentration, molarity.

(ii) mathematical application of 1st principles. Very useful information which candidates forget appear usually in the beginning of the paper as:

"You are provided with…"

All calculation must be to the **4th decimal point** unless they divide fully to a lesser decimal point. **Never round off answers.**

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b)Thermochemistry/energy changes

Energy is the capacity to do work which is measured in Joules(J) or(k**J)** .

Chemical/physical changes take place with **absorption** (Endothermic) or **evolution/ production** (Exothermic)of heat.

Practically:

(i)endothermic changes show absorption of heat by a fall / drop in temperature and has a **+ΔH**

(ii)exothermic changes show evolution/ production of heat by a rise in temperature and has a **-ΔH**

(iii)temperature is measured using a **thermometer.**

(iv)a school thermometer is either coloured (alcohol) or colourless(mercury)

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(v) For accuracy ,candidates in the same practical session should use the same type of thermometer.

(vi) fall / drop **(+ΔH)** in temperature is movement of thermometer **level downward.**

(vii) rise **(-ΔH)** in temperature is movement of thermometer **level upwards.**

Physical changes mainly involve melting/ freezing/ fusion and boiling / vapourization.

Chemical changes mainly involve displacement ,dissolving , neutralization

a).Energy changes in physical processes

Melting/freezing/fusion/solidification and **boiling/ vaporization/evaporation** are the two physical processes.

Melting /freezing point of pure substances is fixed/ constant.

The boiling point of pure substance depend on **external** atmospheric **pressure**.

Melting/fusion is the physical change of a **solid** to **liquid**.
Freezing/fusion is the physical change of a **liquid** to **solid**.
Melting/freezing/fusion/solidification are therefore two **opposite** but **same** reversible physical processes.

A (**s**) ========A(**l**)

Boiling/vaporization/evaporation is the physical change of a **liquid** to **gas/vapour**.

Condensation/liquidification is the physical change of **gas/vapour** to **liquid**.

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Boiling and condensation are therefore two **opposite** but **same** reversible physical processes. i.e

B (**l**) =========B(**g**)

Practically

(i) Melting/liquidification/fusion involves **heating** a solid to **weaken** the strong bonds holding the solid particles together.

Solids are made up of very strong bonds holding the particles **very close** to each other

(Kinetic Theory of matter)

On heating these particles gain energy/heat from the surrounding heat source to form a liquid with **weaker** bonds holding the particles close together but with some degree of **freedom**.

Melting/fusion is an **endothermic** (+ΔH)process that require/ absorb energy from the surrounding.

(ii)Freezing/fusion/solidification involves cooling a liquid to reform /rejoin the very strong bonds to hold the particles **very close** to each other as solid and thus lose their degree of **freedom** (**Kinetic Theory of matter**).

Freezing /fusion / solidification is an **exothermic** (-ΔH)process that require particles holding the liquid together to lose energy to the surrounding.

(iii)Boiling/vaporization/evaporation involves **heating** a liquid to completely **break/free** the bonds holding the liquid particles together.

Gaseous particles have high degree of **freedom** (**Kinetic Theory of matter**).

Boiling /vaporization / evaporation is an **endothermic** (+ΔH) process that require/absorb energy from the surrounding.

(iv)Condensation/liquidification is **reverse** process of boiling /vaporization / evaporation.

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It involves gaseous particles losing energy to the surrounding to form a liquid.

It is an **exothermic**(-ΔH) process.

The quantity of energy required to **change** one mole of a solid **to** liquid or to **form** one mole of a solid **from** liquid at constant temperature is called **molar enthalpy/latent heat of fusion**. e.g.

$$H_2O(\mathbf{s}) \rightarrow H_2O(\mathbf{l}) \quad \Delta H = \mathbf{+6.0kJ\ mole^{-1}}$$

(endothermic process)

$$H_2O(\mathbf{l}) \rightarrow H_2O(\mathbf{s}) \quad \Delta H = \mathbf{-6.0kJ\ mole^{-1}}$$

(exothermic process)

The quantity of energy required to **change** one mole of a liquid **to** gas/vapour or to **form** one mole of a liquid **from** gas/vapour at constant temperature is called **molar enthalpy/latent heat of vapourization**. e.g.

$H_2O(\mathbf{l}) \rightarrow H_2O(\mathbf{g})$ $\Delta H = \mathbf{+44.0kJ\ mole^{-1}}$

(endothermic process)

$H_2O(\mathbf{g}) \rightarrow H_2O(\mathbf{l})$ $\Delta H = \mathbf{-44.0kJ\ mole^{-1}}$

(exothermic process)

To determine the boiling point of water

Procedure:

Measure 20cm3 of tap water into a 50cm3 glass beaker.

Determine and record its temperature.

Heat the water on a strong Bunsen burner flame and record its temperature after every thirty seconds for four minute

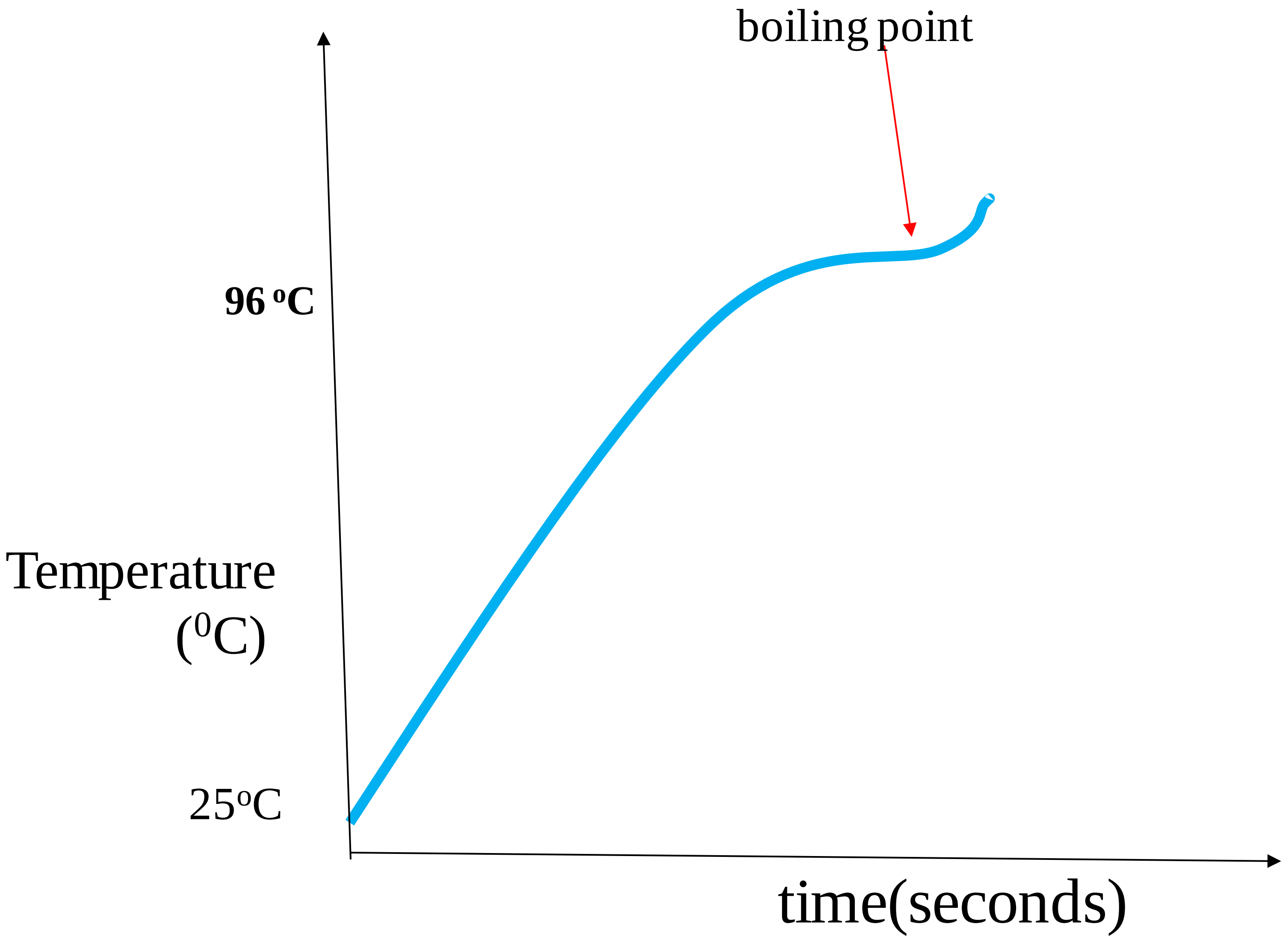
Questions

1.Plot a graph of temperature against time(y-axis)

Sample results

Time (seconds)	0	30	60	90	120	150	180	210	240
Temperature (°C)	**25.0**	**45.0**	**85.0**	**95.0**	**96.0**	**96.0**	**96.0**	**97.0**	**98.0**

Sketch graph of temperature against time



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2.From the graph show and determine the boiling point of water

Note:

Water boils at 100°C at sea level/one atmosphere pressure/ 101300Pa **but** boils at **<u>below</u>** 100°C at **higher** altitudes.

Results above are from Kiriari Girls High School-Embu County on the slopes of Mt Kenya. Water here boils at 96°C.

3.Calculate the molar heat of vaporization of water. (H= 1.0,O= 16.O)

Mass of water =density x volume =>(20 x 1) /1000 = **0.02kg**

Quantity of heat produced = mass of water x specific heat capacity of water x temperature change

=>0.02kg x 4.2 x (96 – 25) = -**5.964kJ**

Heat of vaporization of one mole H_2O

$$= \frac{\text{Quantity of heat}}{\text{Molar mass of } H_2O} \Rightarrow \frac{-5.964\text{kJ}}{18} = \mathbf{-0.3313\ kJ\ mole^{-1}}$$

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To determine the melting point of candle wax

Procedure

Weigh exactly 5.0 g of candle wax into a boiling tube.

Heat it on a strongly Bunsen burner flame until it completely melts.

Insert a thermometer and remove the boiling tube from the flame. Stir continuously.

Determine and record the temperature after every 30seconds for four minutes.

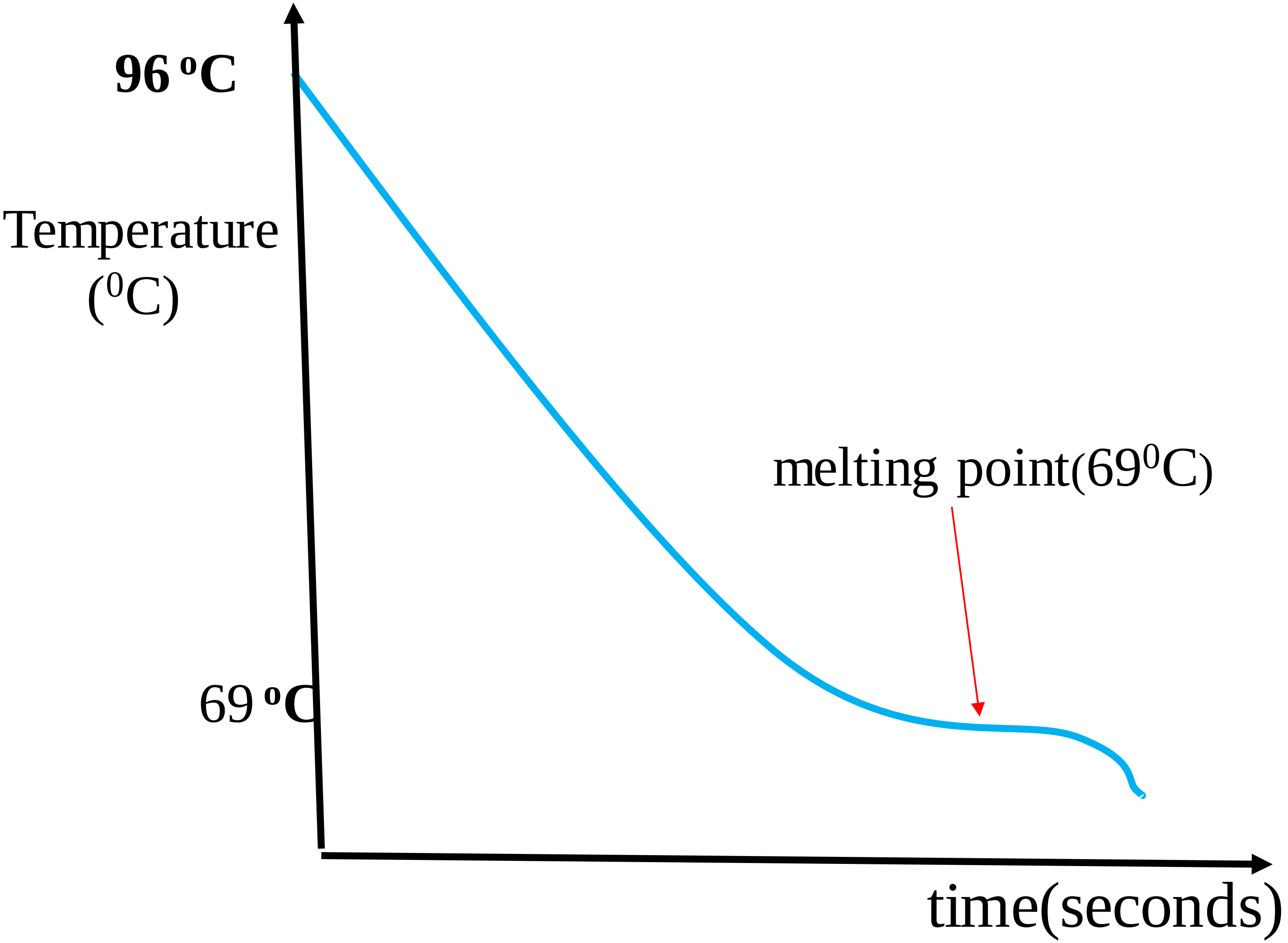
Sample results

Time (seconds)	0	30	60	90	120	150	180	210	240
Temperature (°C)	93.0	85.0	78.0	70.0	69.0	69.0	69.0	67.0	65.0

Questions

1.Plot a graph of temperature against time(y-axis)

Sketch graph of temperature against time



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b)Energy changes in chemical processes

(i)Standard enthalpy/heat of displacement ΔH^{θ}_{d}

(ii)Standard enthalpy/heat of neutralization ΔH^{θ}_{n}

(iii)Standard enthalpy/heat of solution/dissolution ΔH^{θ}_{s}

(i) Standard enthalpy/heat of displacement ΔH^{θ}_{d}

The molar standard enthalpy/heat of displacement may be defined as the energy/heat change when one mole of substance is **displaced** /removed from its **solution** at standard conditions

Some displacement reactions

(i)$Zn(s) + CuSO_4(aq) \rightarrow Cu(s) + ZnSO_4(aq)$

Ionically: $Zn(s) + Cu^{2+}(aq) \rightarrow Cu(s) + Zn^{2+}(aq)$

(ii)$Fe(s) + CuSO_4(aq) \rightarrow Cu(s) + FeSO_4(aq)$

Ionically: $Fe(s) + Cu^{2+}(aq) \rightarrow Cu(s) + Fe^{2+}(aq)$

(iii)$Pb(s) + CuSO_4(aq) \rightarrow Cu(s) + PbSO_4(s)$

This reaction stops after some time as insoluble $PbSO_4(s)$ coat/cover unreacted lead.

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(iv)$Cl_2(g) + 2NaBr(aq) \rightarrow Br_2(aq) + 2NaCl(aq)$

Ionically: $Cl_2(g) + 2Br^-(aq) \rightarrow Br_2(aq) + 2Cl^-(aq)$

To determine the molar standard enthalpy/heat of **displacement (ΔH^θ_d)** of copper

Procedure

Place 20cm3 of 0.2M copper(II)sulphate(VI)solution into a 50cm3 plastic beaker/calorimeter.

Determine and record the temperature of the solution T_1.

Put all the Zinc powder provided into the plastic beaker. Stir the mixture using the thermometer.

Determine and record the highest temperature change to the nearest 0.5°C- T_2 .

Repeat the experiment to complete table 1 below

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Sample results Table 1

Experiment	I	II
Final temperature of solution(T_2)	30.0°C	31.0°C
initial temperature of solution(T_1)	25.0°C	24.0°C
Change in temperature(ΔT)	5.0	6.0

Questions

1.(a) Calculate:

(i)average ΔT

Average ΔT = change in temperature in experiment I and II

$$=> \frac{5.0 + 6.0}{2} = 5.5^{o}C$$

(ii)the number of moles of solution used

$$\text{Moles used} = \frac{\text{molarity x volume of solution}}{1000} = \frac{0.2 \text{ x } 20}{1000}$$

= **0.004 moles**

(iii) the enthalpy change ΔH for the reaction

Heat produced Δ**H** = mass of solution(**m)** x specific heat capacity (**c**)x Δ**T**

=> $20 \times 4.2 \times 5.5 = \frac{462 \text{ Joules}}{1000}$ = **-0.462 kJ**

(iv)State two assumptions made in the above calculations.

Density of solution = density of water = $1 gcm^{-3}$

Specific heat capacity of solution=Specific heat capacity of water =$4.2\ kJ^{-1}kg^{-1}K$

This is because the solution is assumed to be **infinite dilute.**

2. Calculate the enthalpy change for one mole of displacement of Cu^{2+} (aq) ions.

Molar heat of displacement $\Delta H_d = \frac{\text{Heat produced } \Delta H}{\text{Number of moles of fuel}}$

=> $\frac{0.462 \text{ kJ}}{0.004}$ = **-115.5 kJmole^{-1}**

3.Write an ionic equation for the reaction taking place.

$Zn(s) + Cu^{2+}(aq) \rightarrow Cu(s) + Zn^{2+}(aq)$

4.State the observation made during the reaction.

Blue colour of copper(II)sulphate(VI) fades/becomes less blue/colourless.

Brown solid deposits are formed at the bottom of reaction vessel/ beaker.

5.Illustrate the above reaction using an energy level diagram.

6. The enthalpy of displacement ΔH_d of copper(II)sulphate (VI) solution is 126kJmole^{-1}.Calculate the molarity of the solution given that 40cm3 of this solution produces 2.204kJ of energy during a displacement reaction with excess iron filings.

8. The enthalpy of displacement ΔH_d of copper(II)sulphate (VI) solution is 126kJmole^{-1}.Calculate the molarity of the solution given that 40cm3 of this solution produces 2.204kJ of energy during a displacement reaction with excess iron filings.

$$\text{Number of moles} = \frac{\text{Heat produced } \Delta H}{\text{Molar heat of displacement } \Delta H_d}$$

$$\Rightarrow \frac{2.204\text{ kJ}}{126\text{ moles}} = \mathbf{0.0206moles}$$

$$\text{Molarity of the solution} = \frac{\text{moles x 1000}}{\text{Volume of solution used}}$$

$$= \frac{0.0206\text{moles x 1000}}{40} = \mathbf{0.5167\ M}$$

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$$\text{Number of moles} = \frac{\text{Heat produced } \Delta H}{\text{Molar heat of displacement } \Delta H_d}$$

$$\Rightarrow \frac{2.204\text{ kJ}}{126\text{ moles}} = \mathbf{0.0206moles}$$

$$\text{Molarity of the solution} = \frac{\text{moles x 1000}}{\text{Volume of solution used}} \Rightarrow \frac{0.0206\text{moles x 1000}}{40}$$

$$= \mathbf{0.5167\ M}$$

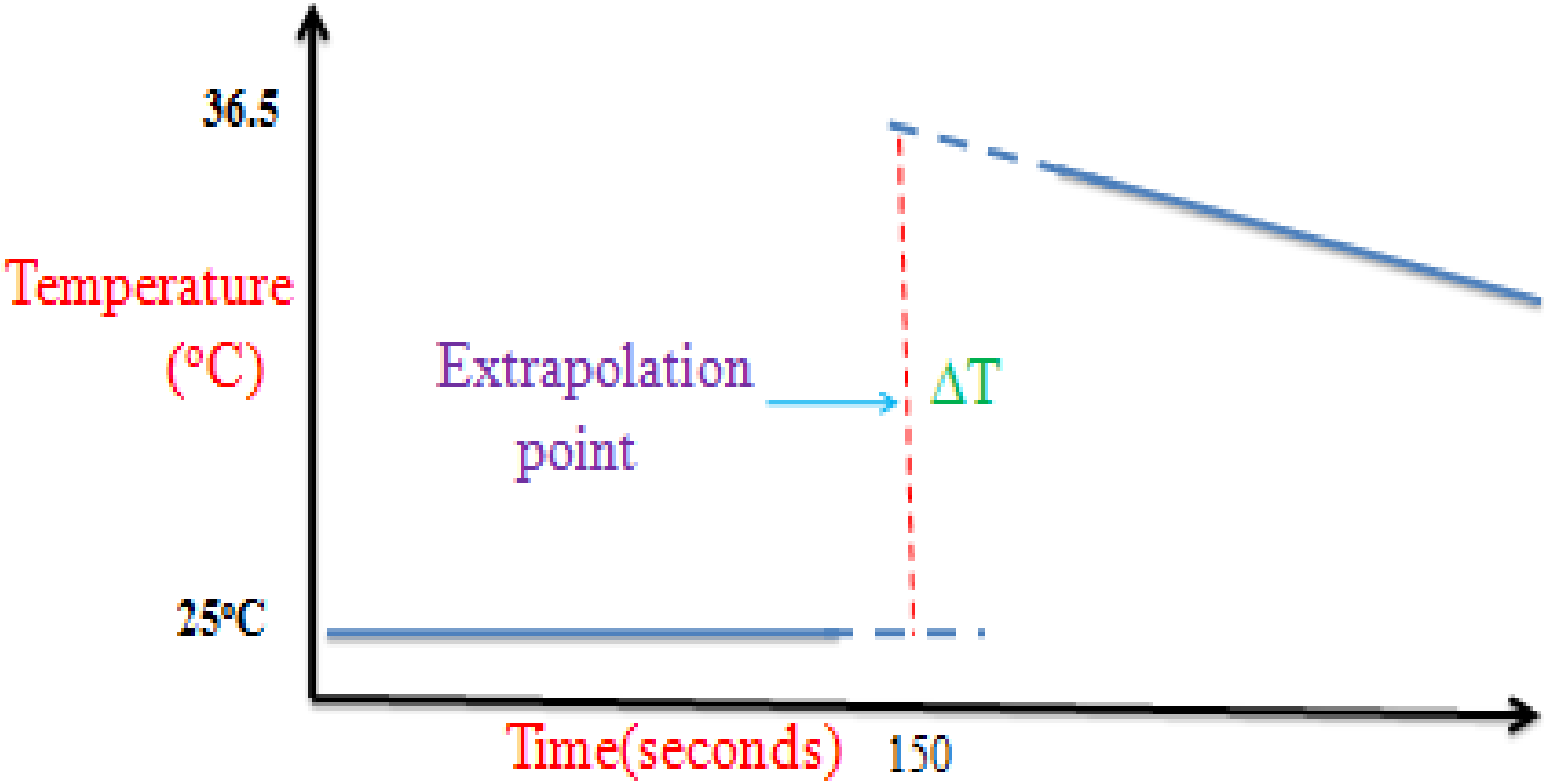
Graphical determination molar enthalpy of displacement of copper

Procedure:

Place 20cm3 of 0.2M copper(II)sulphate (VI) solution into a calorimeter/50cm3 of plastic beaker wrapped in cotton wool/tissue paper. Record its temperature at time T= 0.Stir the solution with the thermometer carefully and continue recording the temperature after every 30 seconds .Place all the (1.5g) Zinc powder provided after 1 ½ minutes. Stir the solution with the thermometer carefully and continue recording the temperature after every 30 seconds for five minutes. Determine the highest temperature change to the nearest 0.5°C.

Sample results

Time °C	0.0	30.0	60.0	90.0	120.0	150.0	180.0	210.0	240.0	270.0
Temperature	25.0	25.0	25.0	25.0	25.0	xxx	36.0	35.5	35.0	34.5



Questions

- **Show and determine the change in temperature ΔT**

From a well constructed graph $\Delta T = T2 - T1$ at **150** second by **extrapolation**

$$\Delta T = 36.5 - 25.0 \quad = \quad \mathbf{11.5^{o}C}$$

2.Calculate the number of moles of copper(II) sulphate(VI)used given the molar heat of displacement of Cu^{2+} (aq)ions is 125kJmole^{-1}

Heat produced Δ**H** = mass of solution(**m**) x specific heat capacity (**c**)x Δ**T**

$$\Rightarrow \; 20 \times 4.2 \times 11.5 = \frac{966\ \text{Joules}}{1000} = \mathbf{-0.966\ kJ}$$

$$\text{Number of moles} \; = \frac{\text{Heat produced } \Delta H}{\text{Molar heat of displacement } \Delta H_d}$$

$$\Rightarrow \; \frac{0.966\ \text{kJ}}{125\ \text{moles}} \quad = \quad \mathbf{-0.007728moles}$$

$$\mathbf{-7.728 \times 10^{-3}moles}$$

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3. What was the concentration of copper(II)sulphate(VI) in moles per litre.

$$\text{Molarity} = \frac{\text{moles x } 1000}{\text{Volume used}}$$

$$\Rightarrow \frac{7.728 \text{ x } 10^{-3}\text{moles x } 1000}{20} = \mathbf{0.3864M}$$

4.The actual concentration of copper(II) Sulphate (VI) solution was 0.4M. Explain the differences between the two.

Practical value is **lower** than theoretical

Heat/energy **loss** to the surrounding and that **absorbed** by the reaction vessel **decreases** ΔT hence **lowering** the practical number of moles and molarity against the theoretical value

(ii)Standard enthalpy/heat of neutralization ΔH^{θ}_{n}

The molar standard enthalpy/heat of **neutralization** ΔH^{θ}_{n} is defined as the energy/heat change when one mole of a H^+ (H_3O^+)ions react completely with one mole of OH^- ions to form one mole of H_2O/water.

Neutralization is thus a reaction of an acid /H^+ (H_3O^+)ions with a base/alkali/ OH^- ions to form salt and water only.

Strong acids/bases/alkalis are completely/fully/wholly dissociated to **many** free ions(H^+ /H_3O^+ and OH^- ions).
(ii) for strong acid/base/alkali neutralization, no **energy** is used to dissociate /ionize since **molecule** is wholly/fully dissociated/ionized into free H^+ H_3O^+ and OH^- ions.
The overall energy evolved is comparatively **higher / more** than weak acid-base/ alkali neutralizations.

For strong acid-base/alkali neutralization, the enthalpy of neutralization is **constant** at about **57.3**kJmole^{-1} irrespective of the acid-base used. This is because ionically:

$OH^-(aq) + H^+(aq) \rightarrow H_2O(l)$

for all wholly/fully /completely dissociated acid/base/alkali

Weak acids/bases/alkalis are partially dissociated to **few** free ions(H^+ (H_3O^+ and OH^- ions) and exist **more** as molecules.

Neutralization is an exothermic($-\Delta H$) process.

The energy produced during neutralization depend on the amount of free ions (H^+ H_3O^+ and OH^-)ions existing in the acid/base/alkali reactant:

(i)for weak acid-base/alkali neutralization,some of the **energy** is used to dissociate /ionize the **molecule** into free H^+ H_3O^+ and OH^- ions therefore the overall energy evolved is comparatively **lower/lesser/smaller** than strong acid / base/ alkali neutralizations.

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Practically ΔH^{θ}_{n} can be determined as in the examples below:

To determine the molar enthalpy of neutralization ΔH_n of Hydrochloric acid

Procedure

Place 50cm3 of 2M hydrochloric acid into a calorimeter/200cm3 plastic beaker wrapped in cotton wool/tissue paper.

Record its temperature T_1.

Using a clean measuring cylinder, measure another 50cm3 of 2M sodium hydroxide.

Rinse the bulb of the thermometer in distilled water.

Determine the temperature of the sodium hydroxide T_2.

Average T_2 andT_1 to get the initial temperature of the mixture T_3.

Carefully add all the alkali into the calorimeter/200cm3 plastic beaker wrapped in cotton wool/tissue paper containing the acid.

Stir vigorously the mixture with the thermometer.

Determine the highest temperature change to the nearest 0.5°C T_4 as the final temperature of the mixture.

Repeat the experiment to complete table 1.

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(ii)enthalpy change ΔH of neutralization.

ΔH = (**m**)mass of solution(acid+base) x (**c**)specific heat capacity of solution x Δ**T**(T_6) => (50 +50) x 4.2 x 13.5 = <u>**5670**Joules</u> = **5.67kJ**

(iii) the molar heat of neutralization the acid.

$$\Delta H_n = \frac{\text{Enthalpy change } \Delta H}{\text{Number of moles}} \Rightarrow \frac{5.67\text{kJ}}{0.1\text{moles}} = \mathbf{56.7kJ\ mole^{-1}}$$

(c)Write ionic equation for the reaction that takes place

$OH^-(aq) + H^+(aq) \rightarrow H_2O(l)$

(d)The theoretical enthalpy change is 57.4kJ. Explain the difference with the results above.

The theoretical value is higher

Heat/energy loss to the surrounding/environment lowers Δ**T**/T_6 and thus ΔH_n

Heat/energy is absorbed by the reaction vessel/ calorimeter /plastic cup lowers ΔT and hence ΔH_n

Sample results

Experiment	I	II
Temperature of acid T_1 (^{o}C)	22.5	22.5
Temperature of base T_2 (^{o}C)	22.0	23.0
Final temperature of solution T_4(^{o}C)	35.5	36.0
Initial temperature of solution T_3(^{o}C)	22.25	22.75
Temperature change(T_5)	13.25	13.75

(a)Calculate T_6 the average temperature change

$$T_6 = \frac{13.25 + 13.75}{2} = \mathbf{13.5\ ^{o}C}$$

(b)Why should the apparatus be very clean?

Impurities present in the apparatus reacts with acid /base lowering the overall temperature change and hence ΔH^{θ}_{n}.

(c)Calculate the:

(i)number of moles of the acid used

$$\text{number of moles} = \frac{\text{molarity x volume}}{1000} \Rightarrow \frac{2 \text{ x } 50}{1000} = \mathbf{0.1moles}$$

(e)Compare the ΔH_n of the experiment above with similar experiment repeated with neutralization of a solution of:

(i) potassium hydroxide with nitric(V) acid

The results would be the same/similar.

Both are neutralization reactions of strong acids and bases/alkalis that are fully /wholly dissociated into many free H^+ / H_3O^+ and OH^- ions.

(ii) ammonia with ethanoic acid

The results would be lower/ΔH_n would be less.

Both are neutralization reactions of weak acids and bases/alkalis that are partially /partly dissociated into few free H^+ / H_3O^+ and OH^- ions. Some energy is used to ionize the molecule.

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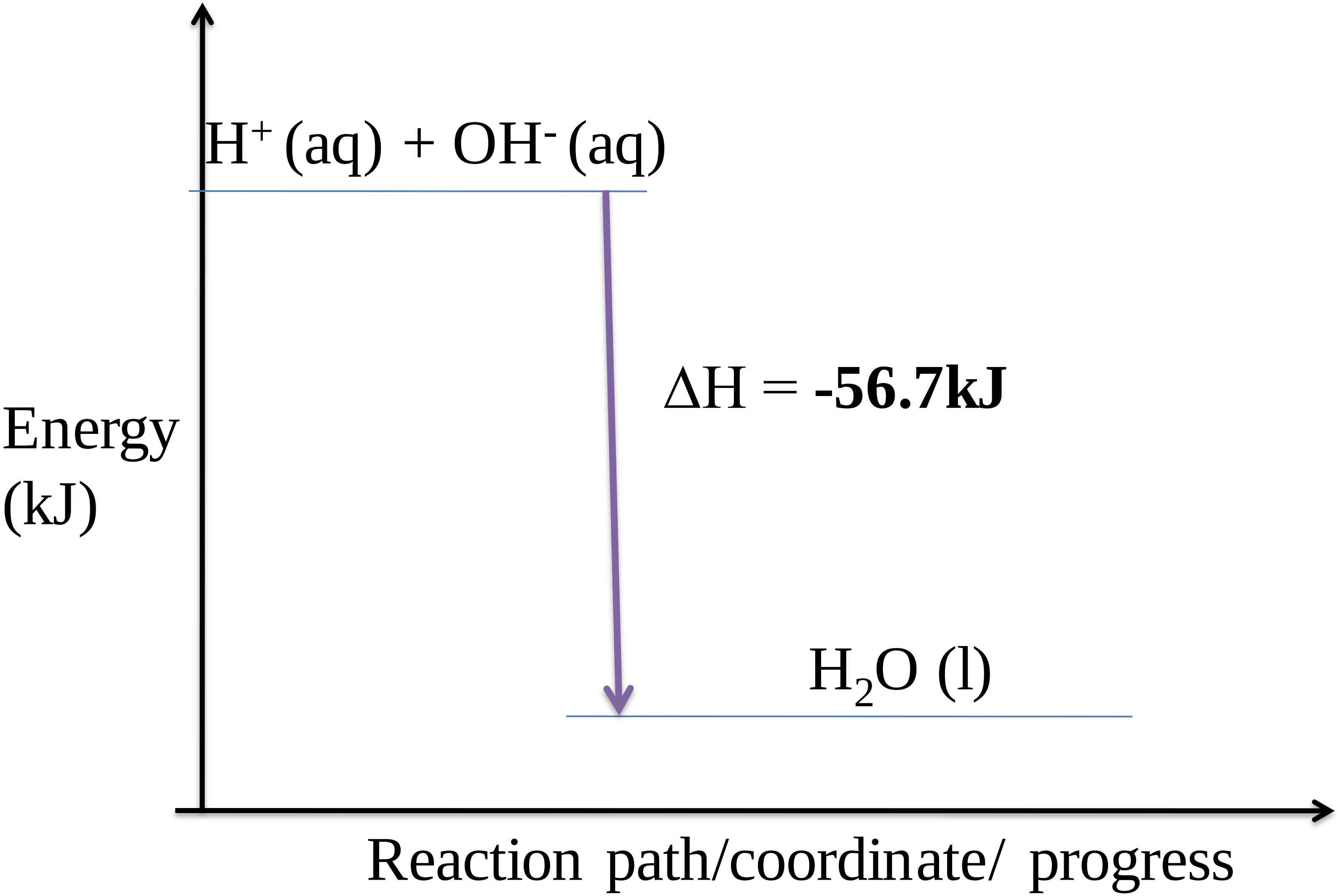
(f)Draw an energy level diagram to illustrate the energy changes



$H^+ (aq) + OH^- (aq)$

$\Delta H =$ **-56.7kJ**

Energy (kJ)

$H_2O (l)$

Reaction path/coordinate/ progress

Theoretical examples

1.The molar enthalpy of neutralization was experimentary shown to be 51.5kJ per mole of 0.5M hydrochloric acid and 0.5M sodium hydroxide. If the volume of sodium hydroxide was 20cm3, what was the volume of hydrochloric acid used if the reaction produced a 5.0^{o}C rise in temperature?

$$\text{Moles of sodium hydroxide} = \frac{\text{molarity x volume}}{1000}$$

$$\Rightarrow \frac{0.5\text{ M x }20\text{cm}3}{1000} = \mathbf{0.01\ moles}$$

$$\text{Enthalpy change } \Delta H = \frac{\Delta H_n}{\text{Moles sodium hydroxide}} \Rightarrow \frac{51.5}{0.01\text{ moles}} = \mathbf{0.515kJ}$$

$$\text{Mass of base + acid} = \frac{\text{Enthalpy change } \Delta H \text{ in Joules}}{\text{Specific heat capacity x } \Delta T}$$

$$\Rightarrow \frac{0.515\text{kJ x }1000}{4.2 \text{ x } 5} = \mathbf{24.5238g}$$

Mass/volume of HCl = Total volume – volume of NaOH

$$\Rightarrow 24.5238 - 20.0 = \mathbf{4.5238\ cm3}$$

Graphically ΔH_n can be determined as in the example below:

Procedure

Place 8 test tubes in a test tube rack .

Put 5cm3 of 2M sodium hydroxide solution into each test tube. Measure 25cm3 of 1M hydrochloric acid into 100cm3 plastic beaker.

Record its initial temperature at volume of base =0.

Put one **portion** of the base into the beaker containing the acid.

Stir carefully with the thermometer and record the highest temperature change to the nearest 0.5^{o}C.

Repeat the procedure above with other portions of the base to complete table 1 below

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Volume of acid(cm3)	25.0	25.0	25.0	25.0	25.0	25.0	25.0	25.0	25.0
Volume of alkali(cm3)	0	5.0	10.0	15.0	20.0	25.0	30.0	35.0	40.0
Final temperature(^{o}C)	**22.0**	**24.0**	**26.0**	**28.0**	**28.0**	**27.0**	**26.0**	**25.0**	**24.0**
Initial temperature(^{o}C)	**22.0**	**22.0**	**22.0**	**22.0**	**22.0**	**22.0**	**22.0**	**22.0**	**22.0**
Change in temperature	**0.0**	**2.0**	**4.0**	**6.0**	**6.0**	**5.0**	**4.0**	**3.0**	**2.0**

Complete the table to determine the change in temperature.

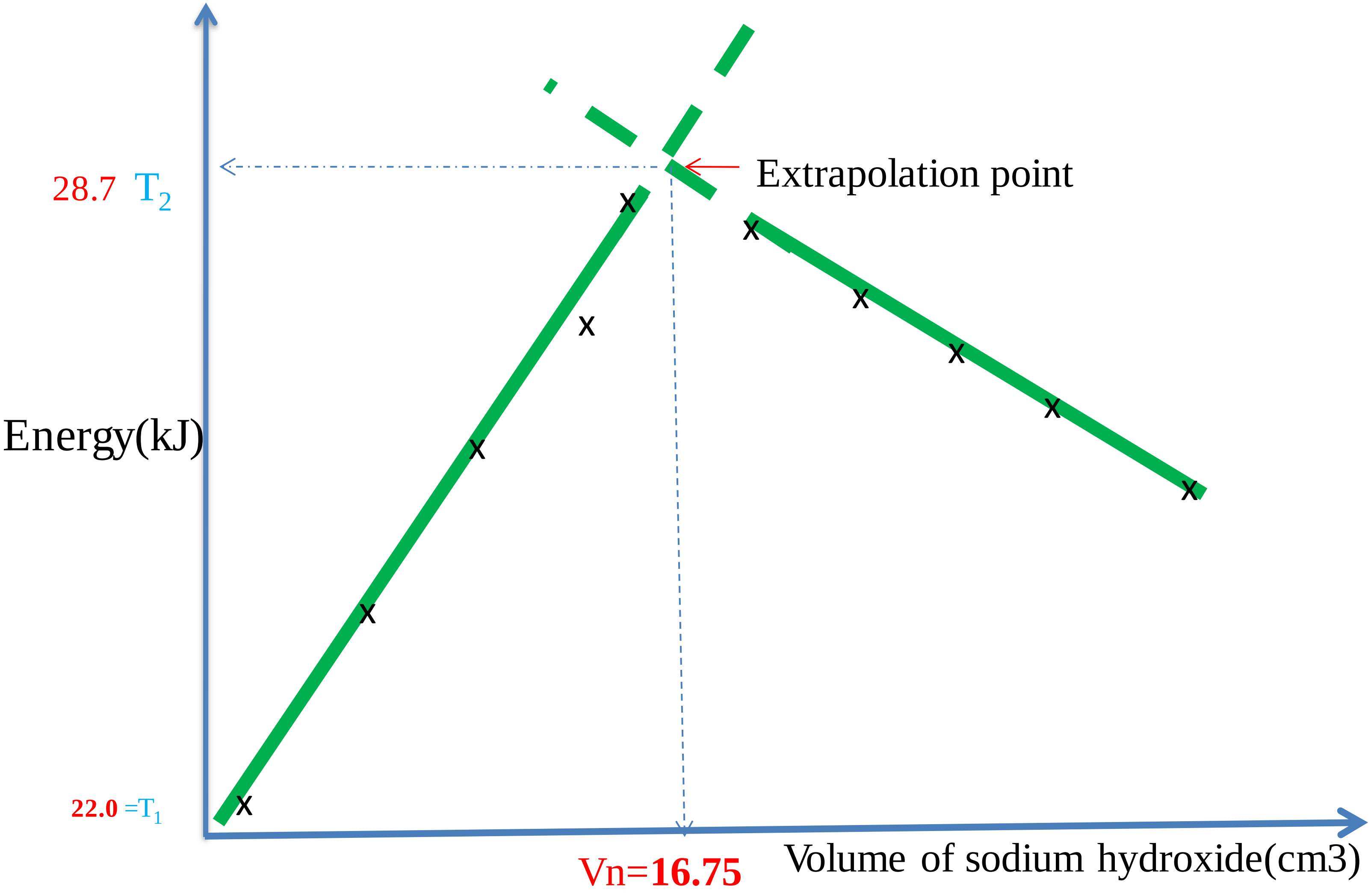
Plot a graph of volume of sodium hydroxide against temperature change.

From the graph show and determine :

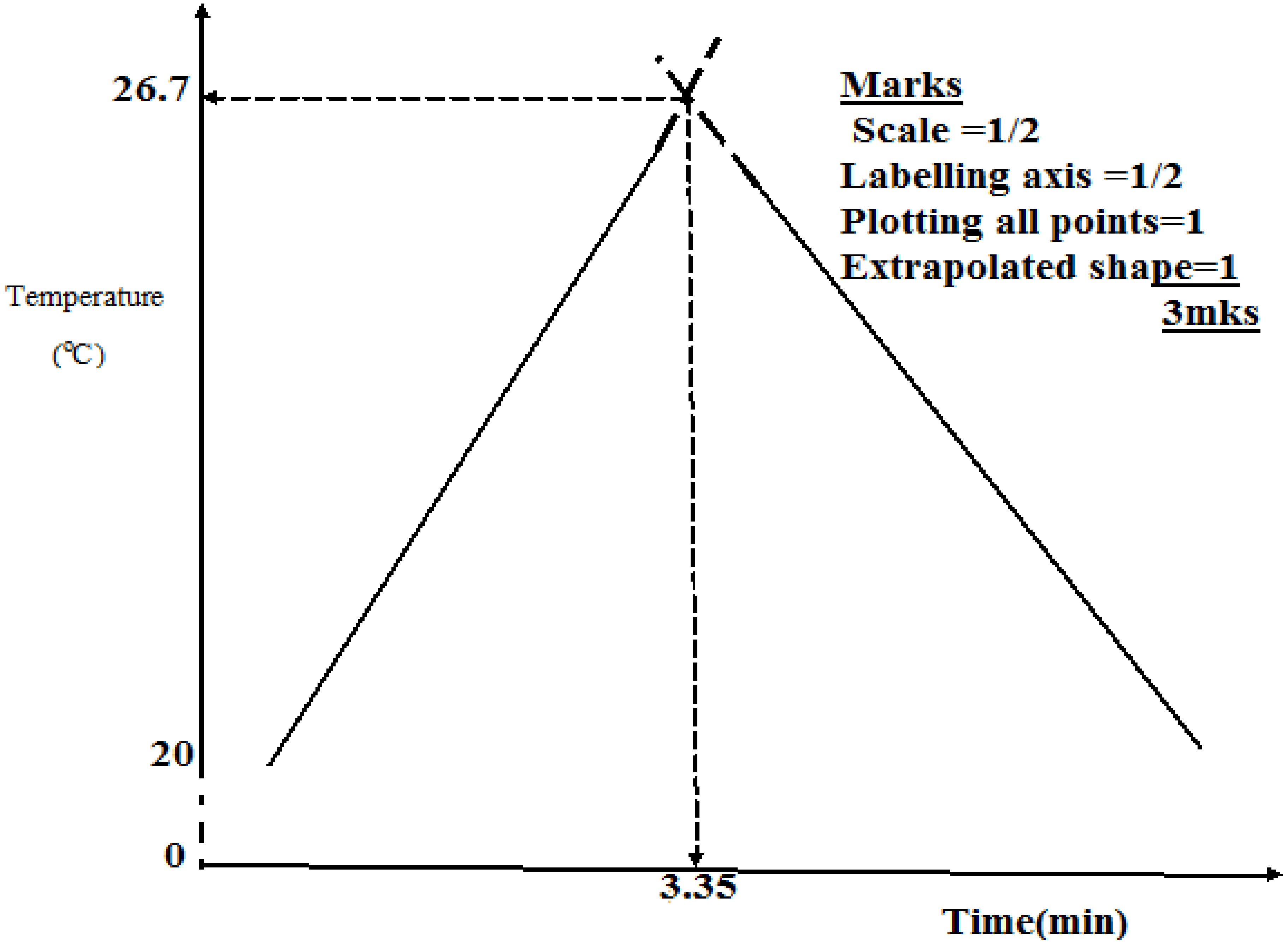
(i)the highest temperature change ΔT

$\Delta T = T_2 - T_1$: highest temperature-T_2 (from extrapolating a correctly plotted graph) less lowest temperature at volume of base=0-T_1

=> 28.7 – 22.0 = **6.7 0 ^{o}C**


28.7 T2
Extrapolation point
Energy(kJ)
22.0 =T1
Vn=16.75
Volume of sodium hydroxide(cm3)

Sketch graph of Temperature against time



Marks

Scale =1/2

Labelling axis =1/2

Plotting all points=1

Extrapolated shape=1

3mks

(ii) the volume of sodium hydroxide used for complete neutralization

From correctly plotted graph = **16.75 cm3**

(iii) Calculate the number of moles of the alkali used

Moles NaOH = $\frac{\text{molarity x volume ()Vn}}{1000}$=

=> $\frac{2 \text{ x } 16.75}{1000}$ = **0.0335 moles**

(iv) Calculate ΔH for the reaction.

ΔH = mass of solution **mixture** x c x ΔT

=> (25.0 + 16.75) x 4.2 x 6.7

= $\frac{1174.845}{1000}$ **J** = **1.174845 kJ**

(iii) Calculate the molar enthalpy of the alkali:

$\Delta H_n = \frac{\text{Heat change}}{\text{number of moles}} \Rightarrow \frac{1.174845 \text{ kJ}}{0.0335 \text{ moles}}$

= **35.0699kJ mole^{-1}**

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(iii) Standard enthalpy/heat of solution/dissolution ΔH^{θ}_{s}

The standard enthalpy of solution ΔH^{θ}_{s} is defined as the energy change when one mole of a substance is **dissolved** in excess distilled water to form an **infinite** dilute solution.

An infinite dilute solution is one which is **too** dilute to be diluted further.

Practically the heat of solution is determined by dissolving a known mass /volume of a solute in known mass/volume of water/solvent and determining the temperature change.

To determine the heat of dissolution of ammonium nitrate(V)

Place 100cm3 of distilled water into a plastic cup/beaker/calorimeter

Put all the 5.0g of ammonium nitrate(v)/potassium nitrate(V)/ ammonium chloride into the water.

Stir the mixture using the thermometer and record the temperature change after every ½ minute to complete table1.

Continue stirring throughout the experiment.

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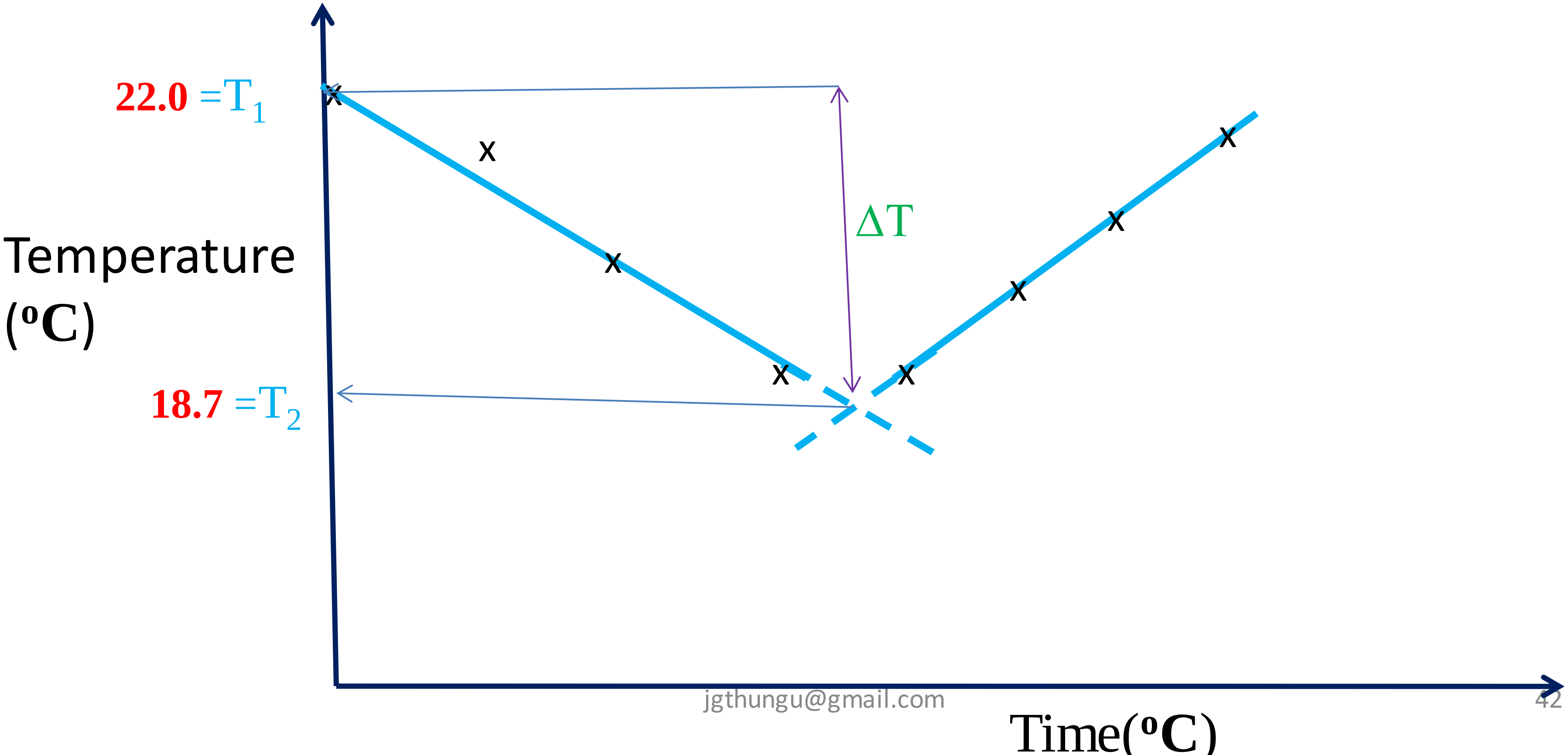
Sample results:Table1

Time(minutes)	0	½	1	1 ½	2	2 ½	3	3 ½
Temperature (ºC)	22.0	21.0	20.0	19.0	19.0	19.5	20.0	20.5

Plot a graph of temperature (y-axis)against temperature



(a)From the graph show and determine :

(i)the highest temperature change ΔT

$\Delta T = T_2 - T_1$: highest temperature-T_2 (from extrapolating a correctly plotted graph) less lowest temperature at volume of base=0-T_1

=> 18.7 – 22.0 = **3.3 ^{o}C** **(not -3.3 ^{o}C)**

(b) Calculate the total energy change ΔH during the reaction

ΔH = mass of water x c x ΔT

$$=> \Delta H = 100 \text{ x} 4.2 \text{ x } 3.3\ ^{o}C = +\frac{\mathbf{1386\ J}}{1000} = +\ \mathbf{1.386\ kJ}$$

(c) Calculate the number of moles of ammonium nitrate(v) used

$$\text{Moles} = \frac{\text{mass}}{\text{molar mass}} => \frac{5.0}{80} = \mathbf{0.0625\ moles}$$

(d)What is the molar heat of dissolution of ammonium nitrate(V)

$$\Delta H = \frac{\text{Heat change}}{\text{Number of mole}} = \frac{+1.386\text{ kJ}}{0.0625\text{ moles}} = \mathbf{+22.176\ kJmole^{-1}}$$

(e)What would happen if the distilled water is heated before experiment was performed .

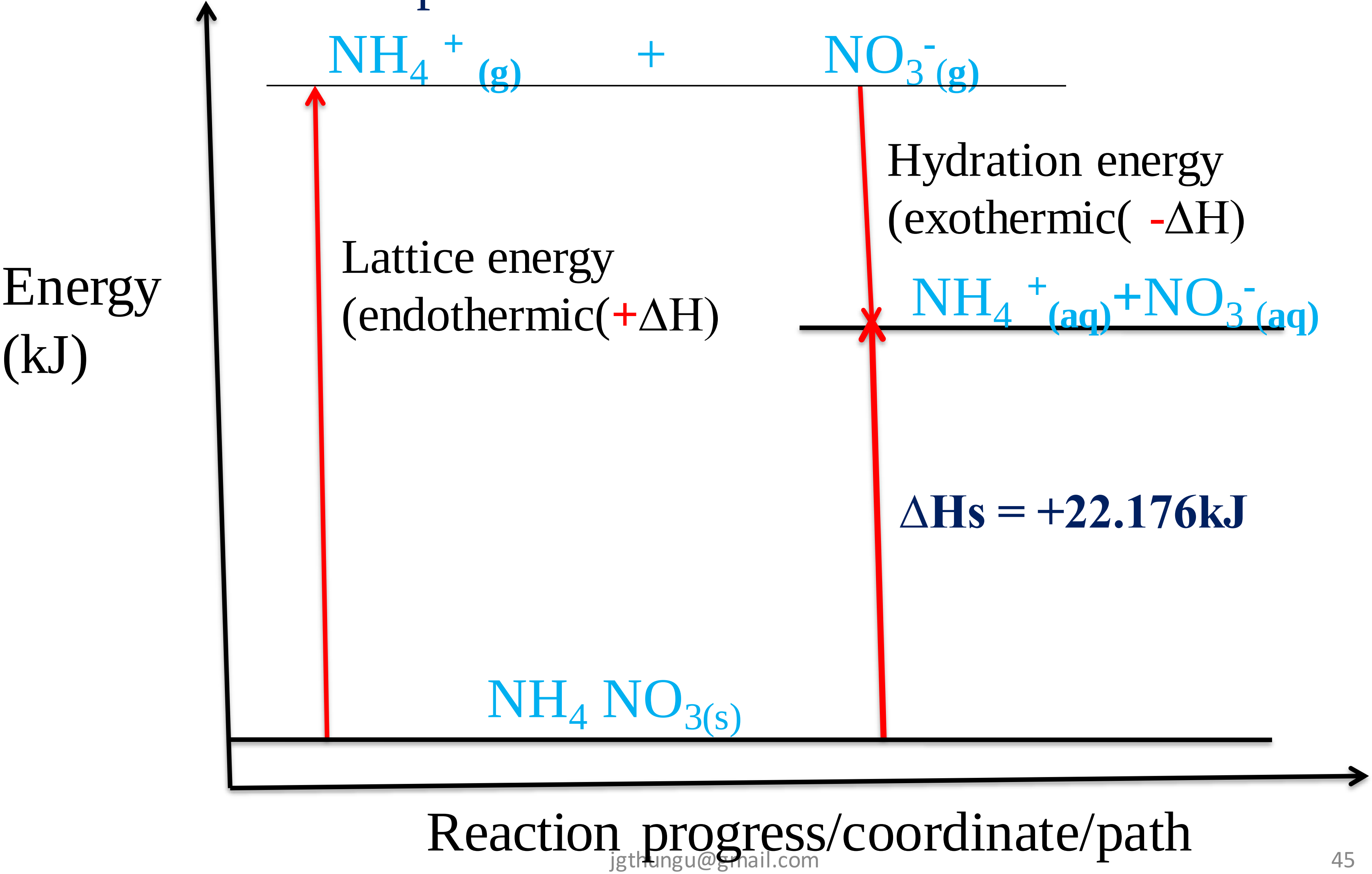
The ammonium nitrate(V) would take less time to dissolve.

Increase in temperature reduces lattice energy causing endothermic dissollution to be faster.

(e)Illustrate the above process on an energy level diagram

Graphically ΔHs can be represented in an energy level diagram

Endothermic process



$NH_4^+{}_{(g)}$ + $NO_3^-{}_{(g)}$

Hydration energy (exothermic(-ΔH)

Lattice energy (endothermic(+ΔH)

Energy (kJ)

$NH_4^+{}_{(aq)} + NO_3^-{}_{(aq)}$

ΔHs = +22.176kJ

$NH_4NO_{3(s)}$

Reaction progress/coordinate/path

c)Chemical Kinetic/Rate of reaction

The rate of a chemical reaction can be defined as the **time** taken for a known amount of reactants to form known amount of products.

Some reactions are **too slow** to be determined e.g weathering others are **instantaneous**

The SI unit of time is **seconds**. Minutes and hours are also common .

Time is determined using a **stop watch/clock**

Candidates using stop watch/clock should learn to:

(i)Press start button concurrently with starting off determination of a reaction using one hand each.

(ii)Press stop button when the reaction is over.

(iii)Record all times in seconds unless specified.

(iv)Press reset button to begin another timing (v)Ignore time beyond seconds for stop clock/watch beyond this accuracy

(vi)Avoid accidental pressing of any button before recording

It can be very **frustrating** repeating a whole procedure

The following factors theoretically and practically alter/influence/affect/determine the rate of a chemical reaction:

(a)Concentration

(b)Temperature

(a)Concentration

An **increase** in concentration increases the rate the rate of reaction by **reducing** the **time** taken to completion.

Theoretically, increase in concentration is a decrease in distance between reacting particles which increases their **collision frequency**.

Practically **decreasing** concentration is **diluting/adding water**

To demonstrate the effect of concentration on reaction rate

You are provided with

(i) sodium thiosulphate containing 40gdm $^{-3}$ solution labeled A

(ii) 2M hydrochloric acid labeled solution B

You are required to determine the rate of reaction between solution A and B

Procedure

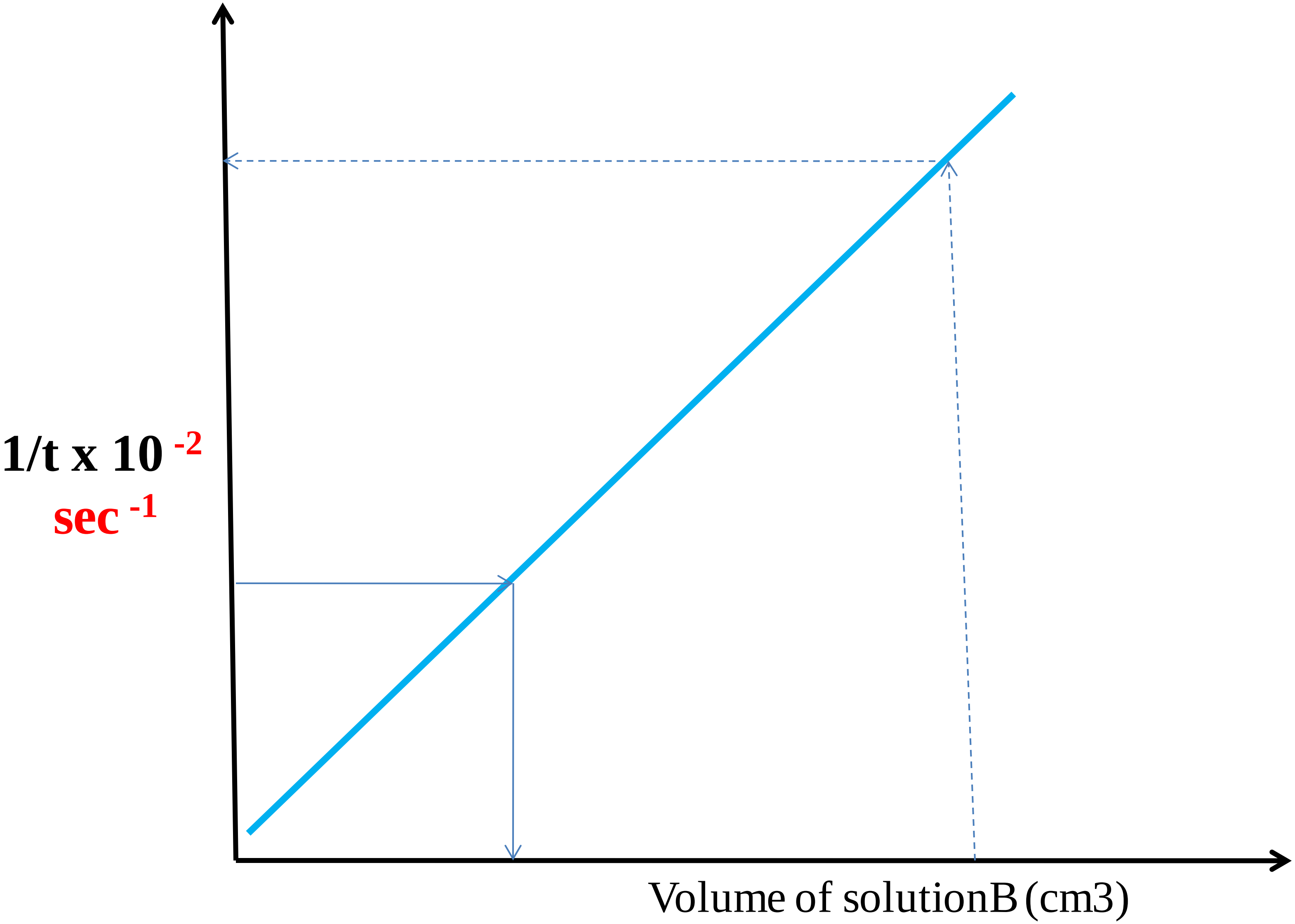
Measure 40cm3 of solution A into 100 cm3 glass beaker. Place it on top of a pen-mark "X". Measure another 40cm3 of solution B. Simultaneously put solution B into solution A and start off a stop watch/clock. Determine the time taken for the pen-mark "X" to be invisible/obscurred from above. Repeat the procedure by measuring 35cm3 of solution B and adding 5cm3 of water. Complete the table 1 below by using other values os solution B and water.

Sample results: Table 1

Volume of solution A (cm3)	40	40	40	40	40	40
Volume of solution B (cm3)	40	35	30	25	20	15
Volume of water (cm3)	0	5	10	15	20	25
Time taken for x to be invisible(seconds)	14	17	21	25	50	120
1/t	0.0714	0.0588	0.0351	0.04	0.02	0.0083

Calculate 1/t in each case

Plot a graph of 1/t (y-axis) against volume of solution B.



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Sample questions

(i)Explain the shape of the graph

(Straight line graph from the origin)

Decrease in concentration decreases the rate of reaction.

The higher the concentration of solution B the less time taken for mark x to be obscurred/invisible due to increased collision frequency between the reacting particles.

(ii)From the graph determine the time taken for the mark to be invisible at 37cm3

At 37cm3 then 1/t => 1/ 37 = 0.027

From a well plotted graph:

1/t = 0.027 => **16.2602 seconds**

(ii)From graph determine the volume of solution B at 100 seconds

100 seconds => 1/t = 1 / 1000 = 0.01

From a well plotted graph:

At 1/t = 0.01 => the volume of B = **17.0cm3**

(iii) State another factor that would alter the rate of the above reaction.

Temperature

(iii) State another factor that would not alter the rate of the above reaction.

Surface area

Pressure

Catalyst

(b) Temperature

An **increase** in temperature increases the rate of reaction.

An increase of 10 °C/10K practically doubles the rate of a chemical reaction/reduces time of completion by $^{1}/_{2}$.

An increase in temperature increase the kinetic energy of reacting particles increasing their collision frequency

Practically ,increase in temperature involves **heating the reactants** The results and presentation should be as in the effect of concentration.

Increased temperature reverses the table I time results

i.e less time as temperature increases.

d)Qualitative analysis

Process of identifying unknown compounds

Compounds may be:

(i)Inorganic

(ii)organic

Inorganic analysis:

This involve mainly identification of ionic compounds containing **cations** and **anions.**

Cations present in an ionic compounds are identified by adding a **precipitating reagent** that forms a precipitate unique to the cation/s in the compound.

The main **precipitating reagents** used are:

2M NaOH and/or **2M NH_3(aq)**

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When using 2M sodium hydroxide:

(i)No white precipitate formed if **K** $^+$ and **Na** $^+$ ions are present

(ii) No white precipitate formed if **NH**$_4^+$ ions are present but a colourless gas with pungent smell of urine is produced which may not be recognized in a school laboratory examination setting.

(iii)White precipitate that dissolves / soluble in excess if **Zn**$^{2+}$ **Pb**$^{2+}$ **Al**$^{3+}$ ions are present.

(iv)White precipitate that do not dissolves/insoluble in excess if **Ba**$^{2+}$ **Mg**$^{2+}$ **Ca**$^{2+}$ ions are present.

(v)Blue precipitate that do not dissolves /insoluble in excess if **Cu**$^{2+}$ ions are present.

(vi)Green precipitate that do not dissolves/insoluble in excess if **Fe**$^{2+}$ ions are present.

(vii)Brown precipitate that do not dissolves/insoluble in excess if **Fe**$^{3+}$ ions are present.

When using 2M aqueous ammonia

(i)No white precipitate is formed if **K^+** ,**NH_4^+** **Na^+** ions are present

(ii)White precipitate that dissolves / soluble in excess if **Zn^{2+}** ions are present.

(iii)White precipitate that do not dissolves/insoluble in excess if **Ba^{2+}** **Mg^{2+}** **Ca^{2+}** **Pb^{2+}** **Al^{3+}** ions are present.

(iv)Blue precipitate that **dissolves** /soluble in excess to form a **deep/royal blue** solution in excess if **Cu^{2+}** ions are present.

(v)Green precipitate that do not dissolves/insoluble in excess if **Fe^{2+}** ions are present.

(vi)Brown precipitate that do not dissolves/insoluble in excess if **Fe^{3+}** ions are present.

Anions present in an ionic compounds are identified by adding a specific **precipitating reagent** that forms a precipitate unique to the specific anion/s in the compound.

(i)Lead(II)nitrate(V) solution

Lead forms **insoluble** $PbSO_4$,$PbSO_3$,$PbCO_3$, PbS, PbI_2,$PbCl_2$

PbS is a **black** precipitate,

PbI_2 is a yellow precipitate.

All the others are white precipitates.

(a)If a Lead(II)nitrate(V) solution is added to a substance/ solution/ compound :

(i)A yellow ppt shows presence of I^- ions

(ii)A **black** ppt shows presence of $\mathbf{S^{2-}}$ ions

(iii) A white ppt shows presence of SO_4^{2-} ,SO_3^{2-} ,CO_3^{2-} Cl^-

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(b)If the white precipitate is added dilute nitric(V) acid:

(i)It dissolves to show presence of SO_3^{2-} ,CO_3^{2-}

(ii)It persist/remains to show presence of SO_4^{2-}, Cl^-

(c)If the white precipitate in b(i) is added acidified potassium manganate(VII)/ dichromate(VI)

(i) acidified potassium manganate(VII) is decolorized /orange colour of acidified potassium dichromate(VI) turns to green to show presence of SO_3^{2-}

(ii) acidified potassium manganate(VII) is not decolorized /orange colour of acidified potassium dichromate(VI) does not turn to green/remains orange to show absence of SO_3^{2-} /presence of CO_3^{2-}

(c)If the white precipitate in b(ii) is **boiled**:

(i)It dissolves to show presence of Cl^-

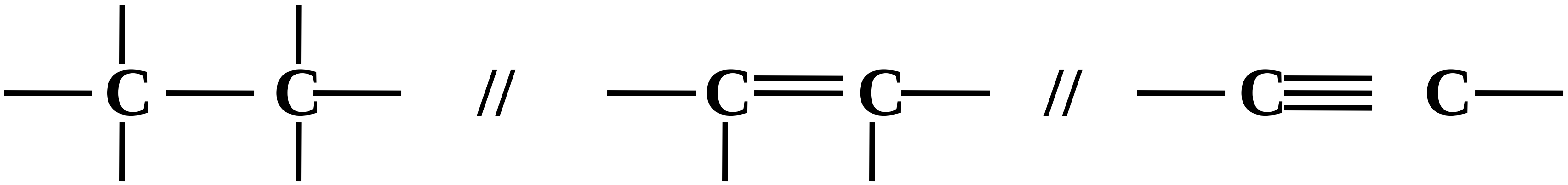
(ii)It persist/remains to show presence of SO_4^{2-}

(ii)Barium(II)nitrate(V)/Barium chloride solution

Barium(II)nitrate(V)/Barium chloride solution precipitates $BaSO_4$,$BaSO_3$, $BaCO_3$, from SO_4^{2-} ,SO_3^{2-} ,CO_3^{2-} ions. Inorganic qualitative analysis require continous practice discussion

(ii)Organic analysis:

This involve mainly identification of the functional group:

(i) 

$-\overset{|}{\underset{|}{C}}-\overset{|}{\underset{|}{C}}-$ // $-\underset{|}{C}=\underset{|}{C}-$ // $-C\equiv C-$

(ii) R — OH

(iii) R — COOH / H^+

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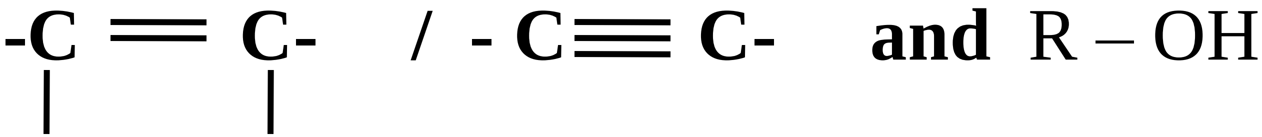
These functional groups can be identified by:

(i)burning-a substance which "catches fire" must reduce in amount. Candidates should not confuse burning with flame coloration/test

(ii)Decolorization of bromine water/chlorine water/acidified $KMnO_4$ / to show **presence** of



$$-\underset{|}{C}=\underset{|}{C}- \quad / \quad -C\equiv C- \quad \textbf{and} \quad R-OH$$

(iii)Turning orange acidified $K_2Cr_2O_7$ to green to show **presence** as in above.

(iii)pH 1/2/3 for strongly acidic solutions. pH 4/5/6 for weakly acidic solutions

(iv)Turning blue litmus paper red. red litmus paper remaining red show **presence** of **H^+ ions**

d)Flame test

The colour change on a clear colourless Bunsen flame is useful in identifying some cations / metals.

A very clean metallic spatula is recommended since dirt obscures /changes the correct coloration.

Distinct flame coloration of some compounds

Barium/barium salts	**orange**
Sodium/ sodium salts	**yellow**
Potassium/potassium salts	Purple/lilac
Lithium/Lithium salts	**Deep red**/crimson
Calcium/ calcium salts	**red**
Copper/copper salts	Blue/ green

(e)Physical chemistry

Chemistry is a science subject that **incorporate** many scientific techniques.

Examining body/council, require tabulated results/data from the candidate.

This tabulated results is ussually then put in a graph.

The general philosophy of methods of **presentation of chemistry practical data** is therefore availability of **evidence** showing:

(i)Practical done(complete table)

(ii)Accuracy of apparatus used(decimal point)

(iii)Accuracy/care in doing experiment to get collect trend(against teachers results)

(iv)Graphical work(use of mathematical science)

(v)Calculations (Scientific mathematical integration)

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THE END

Thank you!!!

Courtesy of Julius G. Thungu

Dedicated to you …

…the Chemistry Candidates

You must be awake…

for you

…to realize your dream