Basic principles of Chemistry

PRACTICAL

Introduction/Rationale

Chemistry is a science.
Chemistry practical all over the world is emphasized to all candidates sitting for a Chemistry paper.
There are about seven main basic universal emphasis for all chemistry candidates sitting for a chemistry paper;

        (i)Titration /volumetric analysis
        (ii)Thermochemistry(energy changes)
        (iii)Chemical kinetic(rates of reaction)
        (iv)Qualitative analysis(organic/inorganic)
        (v)Solubility and solubility curves
        (vi)Flame test
        (vii)Physical / general chemistry

   (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**.

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

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 <u>concentrations</u> of the solutions s/he presented to her/his candidates. Bonus mark is awarded for averaged reading **within 0.1** school value as Final answer. Calculations involved after the titration require candidates **thorough practice mastery** on the:

(i)relationship <u>among</u> 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.

<u>Never</u> <u>round</u> <u>off answers.</u>

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 **<u>absorption</u>** (Endothermic) or **<u>evolution/ production</u>** (Exothermic)of heat.

Practically:

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

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

(iii)temperature is measure using a **<u>thermometer.</u>**

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

(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 **<u>level downward.</u>**

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

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

Chemical changes 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 depends 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. i.e

A (**s**) ========A(**l**)
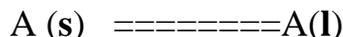
Boiling/vaporization/evaporation is the physical change of a **liquid** to **gas/vapour**.
Condensation/liquidification is the physical change of **gas/vapour** to **liquid**.
Boiling/vaporization/evaporation and condensation/liquidification are therefore two
opposite but **same** reversible physical processes. i.e

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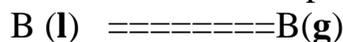
Practically

(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** ($+\Delta H$)process that require/absorb energy from the
surrounding.

(ii)Freezing/fusion/solidification involves cooling a 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** ($+\Delta H$) process that require/absorb energy
from the surrounding.

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

It involves gaseous particles losing energy to the surrounding to form a liquid.It is an
exothermic($+\Delta H$) 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.

$H_2O(\mathbf{s})$ -> $H_2O(\mathbf{l})$ $\Delta H = +\textbf{6.0kJ mole}^{-1}$ (endothermic process)
$H_2O(\mathbf{l})$ -> $H_2O(\mathbf{s})$ $\Delta H = -\textbf{6.0kJ mole}^{-1}$ (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.

$H_2O(\mathbf{l})$ -> $H_2O(\mathbf{g})$ $\Delta H = +\textbf{44.0kJ mole}^{-1}$ (endothermic process)
$H_2O(\mathbf{g})$ -> $H_2O(\mathbf{l})$ $\Delta H = -\textbf{44.0kJ mole}^{-1}$ (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
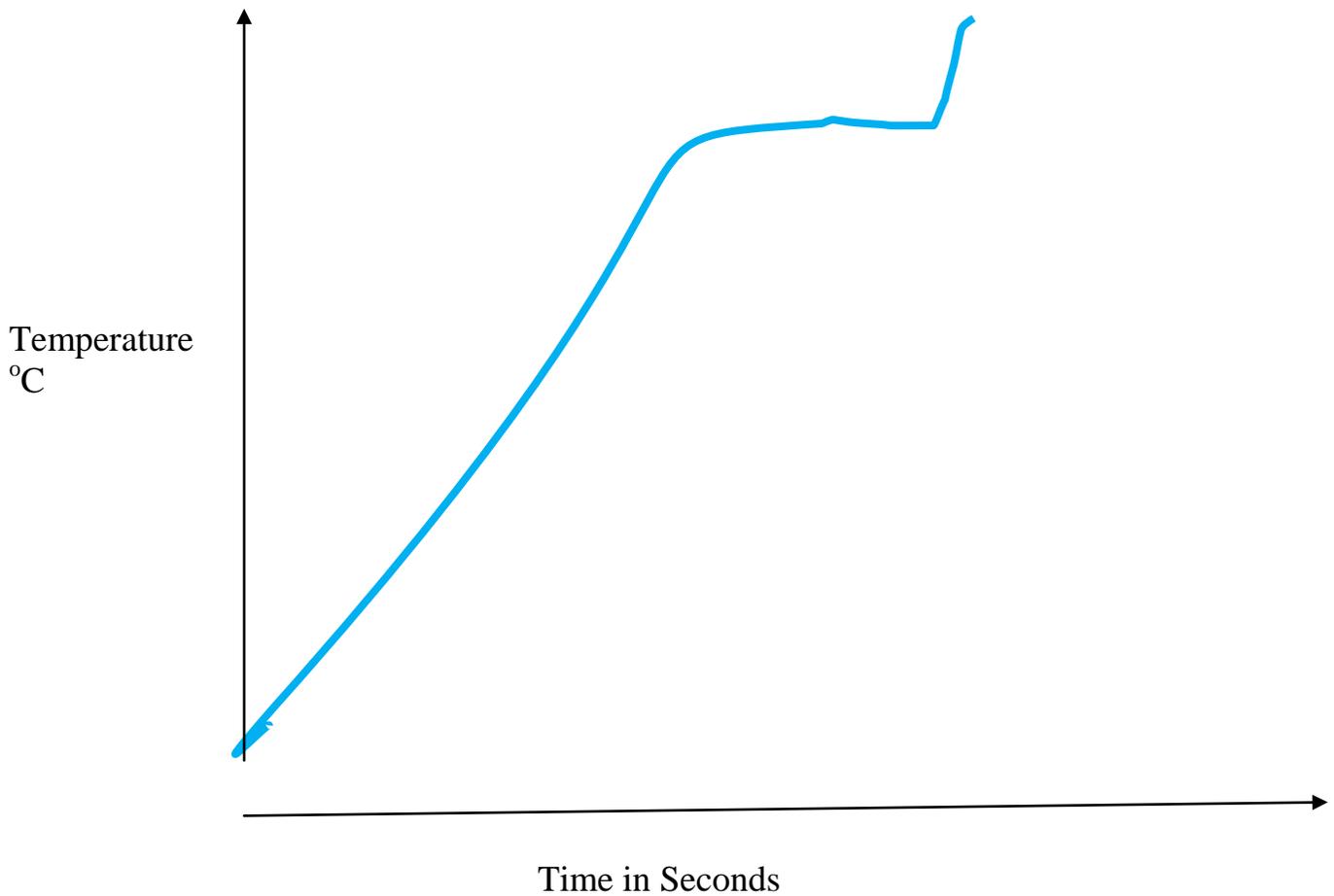
Sample results

Time (seconds)	0	30	60	90	120	150	180	210	240
Temperature(^{o}C)	25.0	45.0	85.0	95.0	96.0	96.0	96.0	97.0	98.0

Questions

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

Sketch graph of temperature against time

Temperature
ºC

Time in Seconds

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

Note:

Water boils at $100^{o}C$ at sea level/one atmosphere pressure/101300Pa but boils at below $100^{o}C$ at higher altitudes.

The sample results above are from Kiriari Girls High School-Embu County on the slopes of Mt Kenya in Kenya. Water here boils at $96^{o}C$.

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

Working:

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

$$= \frac{\text{Quantity of heat}}{\text{Molar mass of } H_2O}$$

$$\Rightarrow \quad \frac{-5.964kJ}{18} = -0.3313 \text{ kJ mole}^{-1}$$

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 (^{o}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

96 °C

melting point(69^0C)

Temperature(^0C)

25°C

time(seconds)

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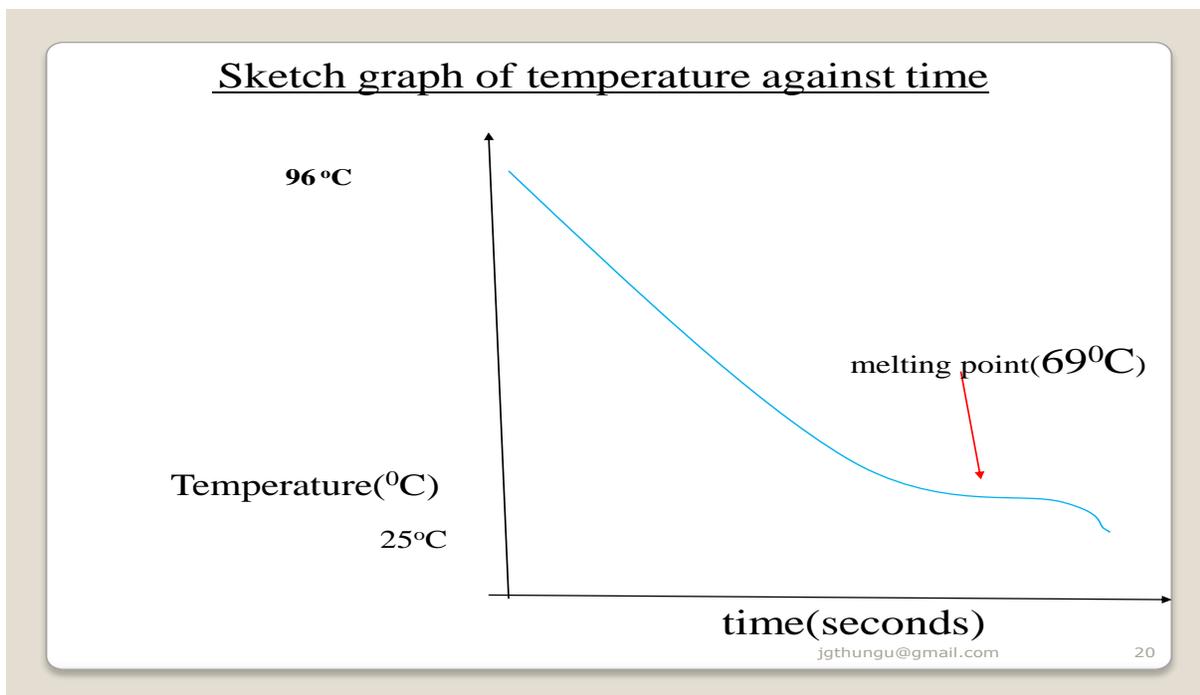
b)Energy changes in chemical processes
(i)Standard enthalpy/heat of displacement ΔH^{θ}_d
(ii)Standard enthalpy/heat of neutralization ΔH^{θ}_n
(iii)Standard enthalpy/heat of solution/dissolution ΔH^{θ}_s

(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)$Zn(s) + CuSO_4(aq) -> Cu(s) + ZnSO_4(aq)$
Ionically: $Zn(s) + Cu^{2+}(aq) -> Cu(s) + Zn^{2+}(aq)$

(ii)$Fe(s) + CuSO_4(aq) -> Cu(s) + FeSO_4(aq)$
Ionically: $Fe(s) + Cu^{2+}(aq) -> Cu(s) + Fe^{2+}(aq)$
(iii)$Pb(s) + CuSO_4(aq) -> Cu(s) + PbSO_4(s)$
This reaction stops after some time as insoluble $PbSO_4(s)$ coat/cover unreacted lead.
 (iv)$Cl_2(g) + 2NaBr(aq) -> Br_2(aq) + 2NaCl(aq)$
Ionically:
 $Cl_2(g) + 2Br^-(aq) -> Br_2(aq) + 2Cl^-(aq)$
To determine the molar standard enthalpy/heat of **displacement(ΔH^{θ}_d) of copper**
Procedure

7

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 $0.5^{\circ}C$- T_2 .
Repeat the experiment to complete table 1 below
Sample results Table 1

Experiment	I	II
Final temperature of solution(T_2)	$30.0^{\circ}C$	$31.0^{\circ}C$
initial temperature of solution(T_1)	$25.0^{\circ}C$	$24.0^{\circ}C$
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
$$=> \underline{5.0 + 6.0} = \mathbf{5.5^{o}C}$$
$$2$$
(ii)the number of moles of solution used
Moles used = $\underline{\text{molarity x volume of solution}}$ = $\underline{0.2 \times 20}$ = **0.004 moles**
$$1000 \qquad\qquad 1000$$
(iii) the enthalpy change ΔH for the reaction
Heat produced ΔH = mass of solution(**m)** x specific heat capacity (**c**)x ΔT
$$=> \underline{20 \times 4.2 \times 5.5} = \underline{462} \text{ Joules} = \mathbf{-0.462 \ kJ}$$
$$1000 \qquad\qquad 1000$$
(iv)State two assumptions made in the above calculations.
Density of solution = density of water = $1gcm^{-3}$
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 ΔH_d = $\underline{\text{Heat produced } \Delta H}$
$$\text{Number of moles of fuel}$$
$$=> \qquad \underline{0.462 \ kJ} \qquad = \mathbf{-115.5 \ kJmole^{-1}}$$
$$0.004$$
3.Write an ionic equation for the reaction taking place.
$$Zn(s) + \ Cu^{2+}(aq) \ -> \ Cu(s) + \ Zn^{2+}(aq)$$
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.
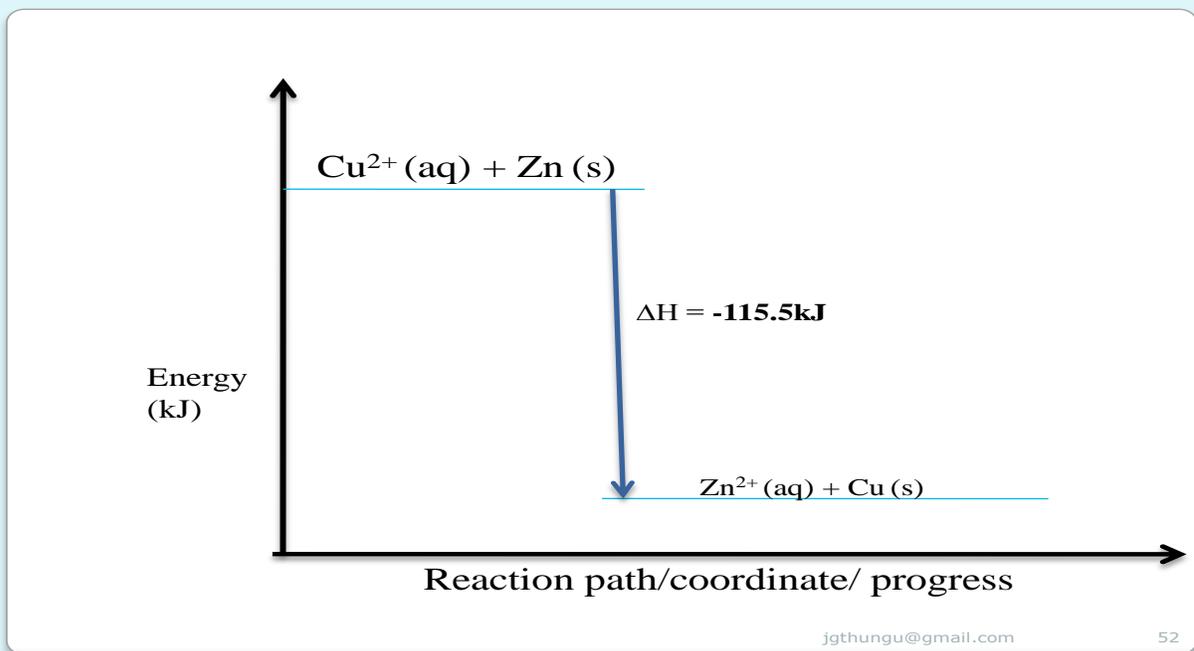
8. **The enthalpy of displacement ΔH_d of copper(II)sulphate (VI) solution is 12k6kJmole^{-1}.Calculate the molarity of the solution given that 40cm3 of this solution produces 2.204kJ of energy during a displacement reaction with excess iron filings.**

 Number of moles $=$ Heat produced ΔH
                     Molar heat of displacement ΔH_d

$\Rightarrow$ $\dfrac{2.204\ kJ}{126\ moles}$ $=$ **0.0206moles**

Molarity of the solution $=$ moles x 1000
                               Volume of solution used

$=$ $\dfrac{0.0206moles\ x\ 1000}{40}$ $=$ **0.5167 M**

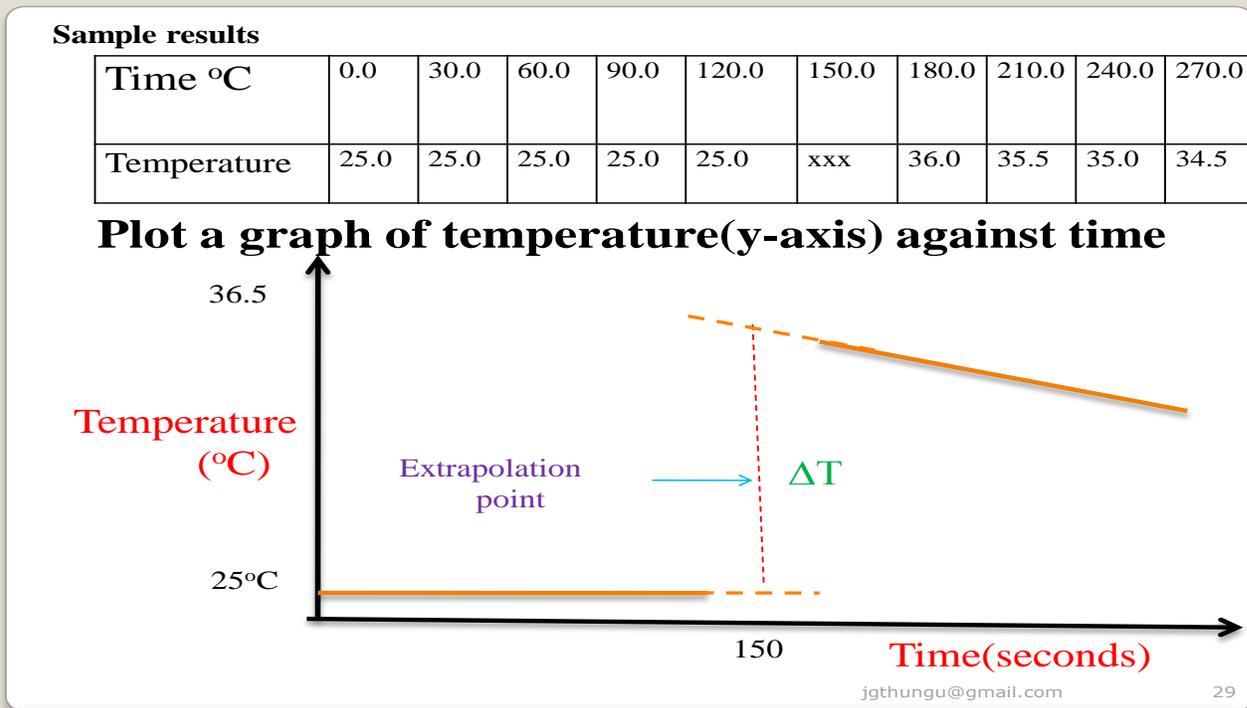**Graphical determination of the molar enthalpy of displacement of copper**
Procedure:
Place 20cm3 of 0.2M copper(II)sulphate (VI) solution into a calorimeter/50cm3 of plastic beaker wrapped in cotton wool/tissue paper.

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 $0.5^{o}C$.

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

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

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Questions
1.Show and determine the change in temperature ΔT
From a well constructed graph ΔT= T2 –T1 at **150** second by **extrapolation**
$$\Delta T = 36.5 - 25.0 = 11.5^{o}C$$
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 **ΔH** = mass of solution(**m**) x specific heat capacity (**c**)x **ΔT**
$$\Rightarrow 20 \times 4.2 \times 11.5 = \underline{966 \text{ J}}\text{oules} = \textbf{-0.966 kJ}$$
$$1000$$
Number of moles = $\underline{\text{   Heat produced } \Delta H   }$
Molar heat of displacement ΔH_d
$$\Rightarrow \underline{0.966 \text{ kJ}} \qquad = \quad \textbf{-0.007728moles}$$
$$125 \text{ moles} \qquad \textbf{-7.728 x 10}^{-3}\textbf{moles}$$

10

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

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

=>$\underline{\text{7.728 x 10}^{-3}\text{moles x 1000}}$ = **0.3864M**
                    20

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

(c)Standard enthalpy/heat of neutralization ΔH^0_n
The molar standard enthalpy/heat of **neutralization ΔH^0_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) -> 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(-ΔH) 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.

11

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 and T_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 $0.5^{o}C$ T_4 as the final temperature of the mixture.
Repeat the experiment to complete table 1.

(ii)enthalpy change ΔH of neutralization.
ΔH = (**m**)mass of solution(acid+base) x (**c**)specific heat capacity of solution x $\Delta T(T_6)$
=> (50 +50) x 4.2 x 13.5 = **5670Joules** = **5.67kJ**

   (iii) the molar heat of neutralization the acid.
   ΔH_n = Enthalpy change ΔH => 5.67kJ = **56.7kJ mole^{-1}**
         Number of moles   0.1moles

(c)Write the ionic equation for the reaction that takes place
      $OH^{-}(aq)$+ $H^{+}(aq)$ -> $H_2O(l)$
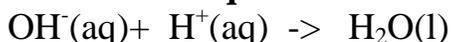
(d)The theoretical enthalpy change is 57.4kJ. Explain the difference with the results above.

The theoretical value is higher
Heat/energy loss to the surrounding/environment lowers $\Delta T/T_6$ 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 (^oC)	22.5	22.5
Temperature of base T_2 (^oC)	22.0	23.0
Final temperature of solution T_4 (^oC)	35.5	36.0
Initial temperature of solution T_3 (^oC)	22.25	22.75
Temperature change(T_5)	13.25	13.75

(a)**Calculate T_6 the average temperature change** T_6 =
$\underline{13.25 + 13.75}$ =   **13.5 ^oC**   2
(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**
        number of moles = $\underline{\text{molarity x volume}}$ => $\underline{2 \times 50}$ =   **0.1moles**
                                              1000   1000
(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.

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

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

13

sodium hydroxide was 20cm3, what was the volume of hydrochloric acid used if the reaction produced a 5.0°C rise in temperature?

Working:

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

$\Rightarrow$ $\dfrac{0.5\text{ M x 20cm3}}{1000}$ = **0.01 moles**

Enthalpy change ΔH = $\dfrac{\Delta H_n}{\text{Moles sodium hydroxide}}$ $\Rightarrow$ $\dfrac{51.5}{0.01 \text{ moles}}$ = **0.515kJ**

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

$\Rightarrow$ $\dfrac{0.515\text{kJ x 1000}}{4.2 \text{ x } 5}$ = **24.5238g**

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

$\Rightarrow$24.5238 - 20.0 = **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°C.

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

| 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(°C)	22.0	24.0	26.0	28.0	28.0	27.0	26.0	25.0	24.0
Initial temperature(°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

14

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

=> $28.7 - 22.0 = \mathbf{6.7\ 0\ ^oC}$
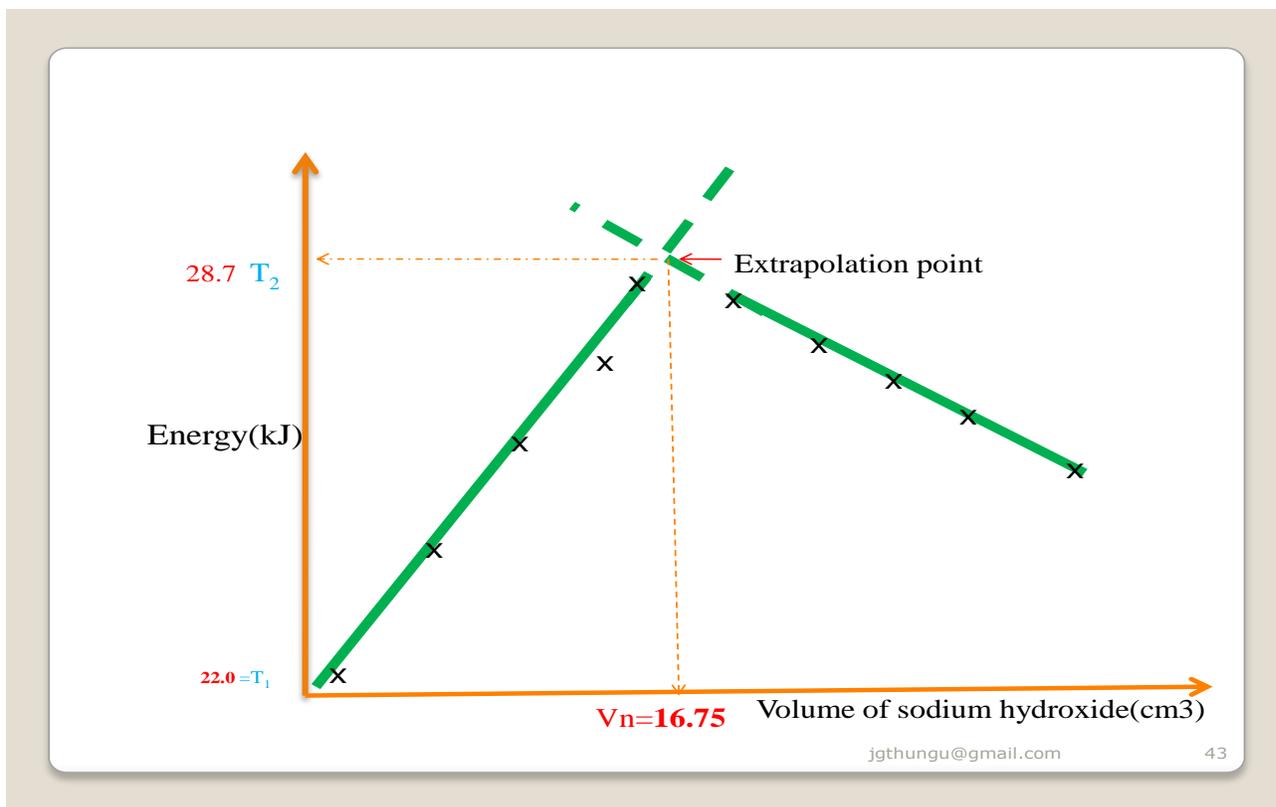
(ii) the volume of sodium hydroxide used for complete neutralization
From correctly plotted graph = **16.75 cm3**

(iii) Calculate the number of moles of the alkali used
Moles NaOH = molarity x volume ()Vn=
                    1000

=> $\dfrac{2\ x\ 16.75}{1000}$ = **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

       = $\dfrac{\underline{\mathbf{1174.845\ J}}}{1000}$ =   **1.174845 kJ**

15

(iii) Calculate the molar enthalpy of the alkali:

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

$$= 35.0699 \text{kJ mole}^{-1}$$

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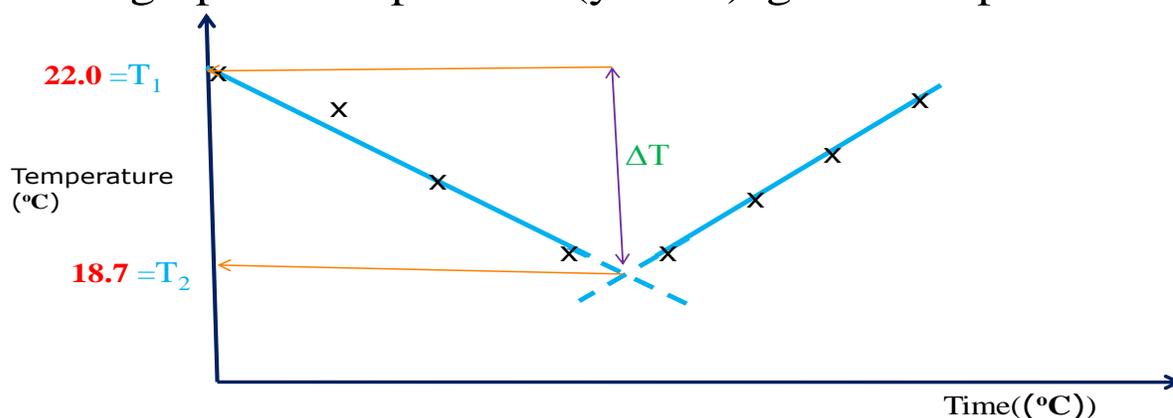
Stir the mixture using the thermometer and record the temperature change after every ½ minute to complete table1.

Continue stirring throughout the experiment.

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:

16

(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

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

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

Moles = $\dfrac{mass}{molar\ mass}$ => $\dfrac{5.0}{80}$ = **0.0625 moles**

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

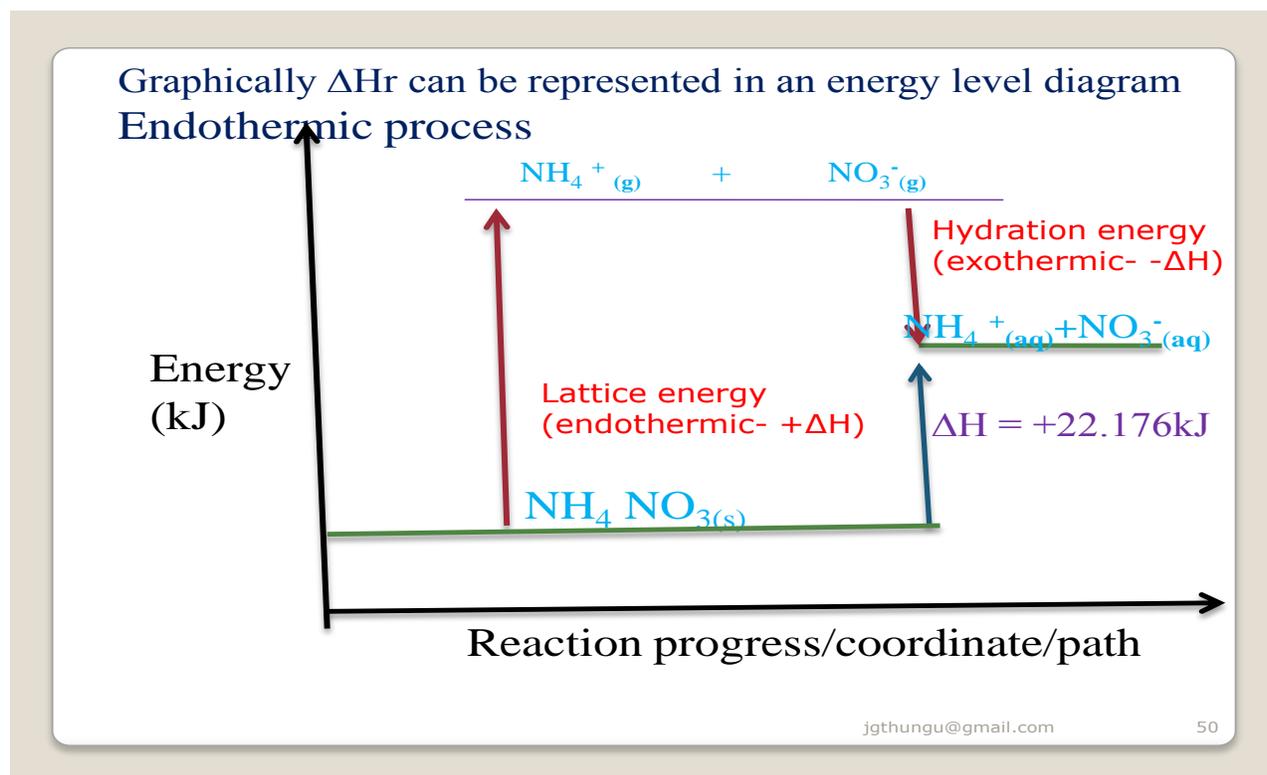$\Delta H = \dfrac{\text{Heat change}}{\text{Number of mole}} = \dfrac{+\,1.386\ kJ}{0.0625\ moles} = \textbf{+ 22.176 kJmole}^{-1}$

(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 ΔHr can be represented in an energy level diagram
Endothermic process

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

Hydration energy (exothermic- -ΔH)

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

Energy (kJ)

Lattice energy (endothermic- +ΔH)

$\Delta H = +22.176kJ$

$NH_4\ NO_{3(s)}$

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 $40 gdm^{-3}$ 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

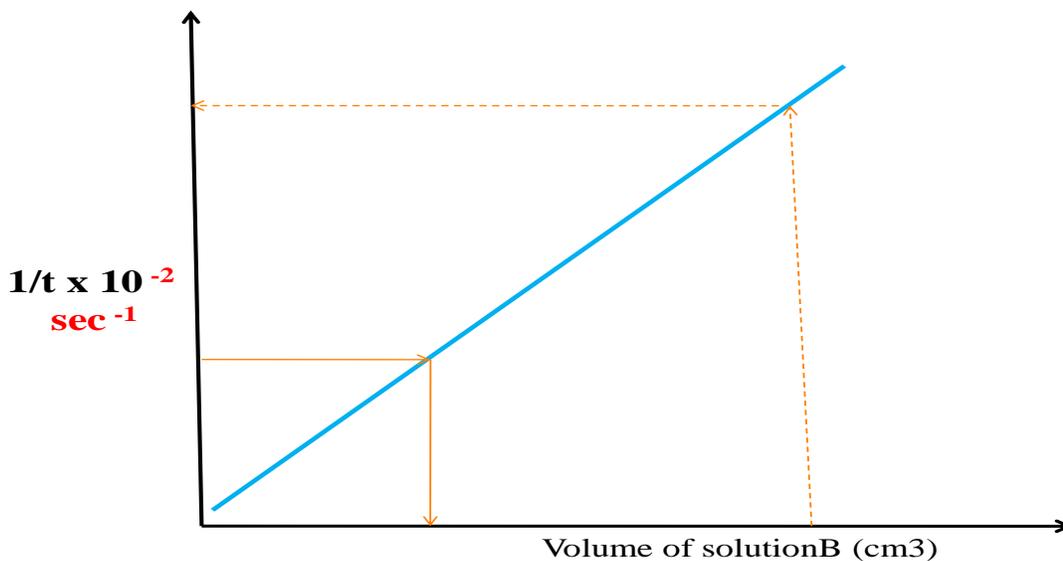| Volume of solution A (cm3)	40	40	40	40	40	40
Volume of solution B (cm3)	40	35	30	25	20	15
Volume of water (cm3)	0	5	10	15	20	25
Time taken for x to be invisible	14	17	21	25	50	120
1/t	0.0714	0.0588	0.0351	0.04	0.02	0.0083

Calculate 1/t in each case

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

$1/t \times 10^{-2}$ sec^{-1}

Volume of solutionB (cm3)

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 the 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 $10\,^{o}C/10K$ 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)**

When using 2M sodium hydroxide:

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

(ii) No white precipitate is formed if **NH$_4^+$** ions are present but a clourless 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 **S^{2-}** ions

(iii) A white ppt shows presence of SO$_4^{2-}$,SO$_3^{2-}$,CO$_3^{2-}$ Cl$^-$

(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 <u>absence</u> of SO_3^{2-} /<u>presence</u> 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 <u>continous practice</u> discussion

Sample presentation of results

You are provided with solid Y(aluminium (III)sulphate(VI)hexahydrate).Carry out the following tests and record your observations and inferences in the space provided.

1(a) Appearance

Observations	inference (1mark)
White crystalline solid	Coloured ions Cu^{2+}, Fe^{2+}, Fe^{3+} <u>absent</u>

(b)Place about a half spatula full of the solid into a clean dry boiling tube. Heat gently then strongly.

Observations	inference (1mark)
Colourless droplets formed on the cooler part of the test tube Solid remains a white residue	Hydrated compound/compound containing water of crystallization

(c)Place all the remaining portion of the solid in a test tube .Add about 10cm3 of distilled water. Shake thoroughly. Divide the mixture into five portions.

Observation	Inference (1mark)
Solid dissolves to form a colourless solution	Polar soluble compound Cu^{2+}, Fe^{2+}, Fe^{3+} <u>absent</u>

(i)To the first portion, add three drops of sodium hydroxide then add excess of the alkali.

Observation   Inference   (1mark)
White ppt, soluble in excess Zn^{2+} , Pb^{2+} , Al^{3+}

(ii)To the second portion, add three drops of aqueous ammonia then add excess of the alkali.

Observation   Inference   (1mark)
White ppt, insoluble in excess Pb^{2+} , Al^{3+}

(iii)To the third portion, add three drops of sodium sulphate(VI)solution.

Observation   Inference   (1mark)
No white ppt Al^{3+}

(iv)I.To the fourth portion, add three drops of Lead(II)nitrate(IV)solution. **Preserve**

Observation   Inference   (1mark)
White ppt CO_3^{2-}, SO_4^{2-}, SO_3^{2-}, Cl^-,

   II.To the portion in (iv) I above , add five drops of dilute hydrochloric acid.
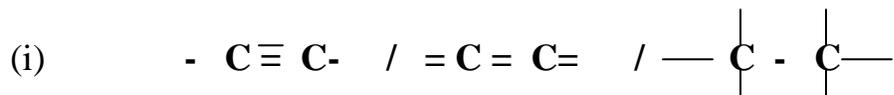
Observation   Inference   (1mark)
White ppt persist/remains SO_4^{2-}, Cl^-,

   III.To the portion in (iv) II above, heat to boil.

Observation   Inference   (1mark)
White ppt persist/remains SO_4^{2-},

Organic analysis:

This involve mainly identification of the functional group:

(i)   - $C \equiv C$-   / $= C = C=$ / $— \overset{|}{C} - \overset{|}{C}—$
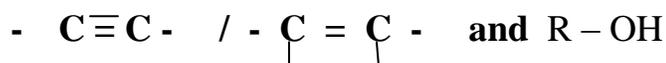
(ii) $R — OH$

(iii) $R — COOH$ / H^+

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

      - $C \equiv C$ -   / - $\overset{|}{C} = \overset{|}{C}$ -   **and** $R - OH$

(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 usually 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)

(f)Sample practicals

Name …………….....……………………**Class**…………..**Index No**……………..

Candidate's signature……………………………..

Date done………………Date marked………… .……Date revised……………...….….

233/3
CHEMISTRY Paper 3
PRACTICAL.
Pre-KCSE Practice **1**: 2013
MARKS SCHEME

Instruction to Candidate
Write your name and index number in the spaces provided above.
Sign and write the date of examination in the spaces provided above
*Answer **all** questions in the spaces provided.*
Mathematical tables and electronic calculators may be used.
*All working **must** be clearly shown where necessary.*
This paper consist of 8 printed pages.
Candidates should check the question paper to ascertain that all the pages are printed and indicated and that no questions are missin

For examiners use only

Question	Maximum score	Candidates core
1	**20**	20
2	**10**	10
3	**10**	10
Total score	**40**	**40**

26

1. You are provided with:
    (i) solution L containing 5.0g per litre of a dibasic organic acid $H_2X.2H_2O$.
    (ii) solution M which is acidified potassium manganate(VII)
    (iii) solution N a mixture of sodium ethanedioate and ethanedioic acid
    (iv) 0.1M sodium hydroxide solution P
    (v) 1.0M sulphuric(VI)
You are required to:
    (i) standardize solution M using solution L
    (ii) use standardized solution M and solution P to determine the % of sodium ethanedioate in the mixture.

Procedure 1
Fill the burette with solution M. Pipette 25.0cm3 of solution L into a conical flask. Heat this solution to about $70^{o}C$ (**but not to boil**). Titrate the hot solution L with solution M until a permanent pink colour just appears .Shake thoroughly during the titration. Repeat this procedure to complete table 1.

Table 1

	1	2	3
Final burette reading (cm3)	20.0	20.0	20.0
Initial burette reading (cm3)	0.0	0.0	0.0
Volume of N used (cm3)	20.0	20.0	20.0

Table 1
CT=$^1/_2$ mk
DP=$^1/_2$ mk
AC=$^1/_2$ mk
AV= 1 mk
FA=$^1/_2$ mk
Total=3 mk

(2marks)

(a) Calculate the average volume of solution L used
(1mk)
$$\frac{20.0 + 20.0 + 20.0}{3} = 20.0cm3$$

(b) Given that the concentration of the dibasic acid is 0.05molesdm^{-3}.determine the value of x in the formula $H_2X.2H_2O$ (H=1.0,O=16.0)
    (1mark)

Molar mass $H_2X.2H_2O$ $= \frac{mass / litre}{moles / litre}$ =>

$\frac{5.0g/litre}{0.05molesdm^{-3}} = $ **100 g**

$H_2X.2H_2O$ =100
X = 100 – ((2 x1) + 2 x (2 x1) + (2 x 16) => 100 – 34 = **62**

27

(c) Calculate the number of moles of the dibasic acid $H_2X.2H_2O$.   (1mark)

Moles = molarity x pipette volume   =>
           1000

       0.05 x 25   =   **0.00125 / 1.25 x10^{-3} moles**
       1000

(d)Given the mole ratio manganate(VII)(MnO_4^-): acid H_2X is 2:5, calculate the number of moles of manganate(VII) (MnO_4^-) in the average titre.   (1mark)

Moles H_2X = $^2/_5$ moles of MnO_4^-
=> $^2/_5$ x 0.0125/1.25 x10^{-2} moles = 0.0005 / 5.0 x 10^{-4} moles

(e)Calculate the concentration of the manganate(VII)(MnO_4^-) in moles per litre.
           (1mark)

Moles per litre/molarity =   moles   x   1000
             average burette volume

=>   0.0005/5.0 x 10^{-4}moles x 1000 = 0.02083 moles l^{-1}/ M
         24.0

Procedure 2

With solution M still in the burette ,pipette 25.0cm3 of solution N into a conical flask. Heat the conical flask containing solution N to about 70°C.Titrate while hot with solution M. Repeat the experiment to complete table 2.

Table 2 (2marks)

	1	2	3
Final burette reading (cm3)	12.5	12.5	12.5
Initial burette reading (cm3)	0.0	0.0	0.0
Volume of N used (cm3)	12.5	12.5	12.5

Table 1
CT=$^1/_2$ mk
DP=$^1/_2$ mk
AC=$^1/_2$ mk
AV= 1 mk
FA=$^1/_2$ mk
Total=3 mk

(a)Calculate the average volume of solution L used
    (1mk)

         12.5 + 12.5 + 12.5   =   12.5 cm3
           3

(b)Calculations:

    (i)How many moles of manganate(VII)ions are contained in the average volume of solution M used?   (1mark)

  Moles = molarity of solution M x average burette volume
           1000

  =>   0.02083 molesl^{-1}/ M x 12.5   = 0.00026 / 2.6 x 10^{-4} moles
        1000

    (ii)The reaction between manganate(VII)ions and ethanedioate ions that reacted with is as in the equation:

$2MnO_4^-$ (aq) $+$ $5C_2O_4^{2-}$ (aq) $+$ $16H^+$ (aq) $->$ $2Mn^{2+}$(aq) $+$ $10CO_2$(g) $+$ $8H_2O$(l)

Calculate the number of moles of ethanedioate ions that reacted with manganate (VII) ions in the average volume of solution M.

(1mark)

From the stoichiometric/ionic equation:

$$\text{mole ratio } MnO_4^- \text{ (aq): } C_2O_4^{2-} \text{ (aq)} = 2:5$$
$$=> \text{ moles } C_2O_4^{2-} = {}^5/_2 \text{ moles } MnO_4^-$$
$$=> {}^5/_2 \text{ x } 0.00026 / 2.5 \text{ x } 10^{-3} \text{ moles}$$
$$= \underline{0.00065} / \underline{6.5 \text{ x}10^{-4}} \text{ moles}$$

(iii)Calculate the number of moles of ethanedioate ions contained in 250cm3 solution N.　　　(1mark)

25cm3 pipette volume　->　$0.00065 / 6.5 \text{ x}10^{-4}$ moles

250cm3　　　　　　　->　$\underline{0.0065 / 6.5 \text{ x}10^{-3} \text{ moles x } 250}$ = $\underline{0.0065} / \underline{6.5 \text{ x}10^{-3}}$ moles
**　　　　　　　　　　　　　25**

Procedure 3

Remove solution M from the burette and rinse it with distilled water. Fill the burette with sodium hydroxide solution P. Pipette 25cm3 of solution N into a conical flask and add 2-3 drops of phenolphthalein indicator. Titrate this solution N with solution P from the burette. Repeat the procedure to complete table 3.

Table 3

	1	2	3
Final burette reading (cm3)	12.5	12.5	12.5
Initial burette reading (cm3)	0.0	0.0	0.0
Volume of N used (cm3)	12.5	12.5	12.5

Table 1
CT=$^1/_2$ mk
DP=$^1/_2$ mk
AC=$^1/_2$ mk
AV= 1 mk
FA=$^1/_2$ mk
Total=3mk

(2 mark)

(a)Calculate the average volume of solution L used　　　　　　　　(1mk)

$$\frac{12.5 + 12.5 + 12.5}{3} = \underline{12.5} \text{ cm3}$$

(b)Calculations:

(i)How many moles of sodium hydroxide solution P were contained in the average volume?

(1mark)

Moles = $\underline{\text{molarity of solution P x average burette volume}}$
**　　　　　　　　1000**

$$=> \underline{\frac{0.1 \text{ molesl}^{-1} \text{ x } 24.9}{1000}} = \underline{0.00249} / \underline{2.49 \text{ x } 10^{-3}} \text{ moles}$$

(ii)Given that NaOH solution P reacted with the ethanedioate ions from the acid only and the equation for the reaction is:

$2NaOH$ (aq) $+$ $H_2C_2O_4$ (aq) $->$ $Na_2C_2O_4$(g) $+$ $2H_2O$(l)

29

Calculate the number of moles of ethanedioic acid that were used in the reaction.(1 mk)
From the stoichiometric equation,mole ratio

NaOH(aq): $H_2C_2O_4$ (aq)   =   2:1
=>   moles $H_2C_2O_4$ = $^1/_2$ moles NaOH
=> $^1/_2$ x 0.00249 / 2.49 x 10^{-3} moles
=0.001245/1.245 x10^{-3} moles.

(iii)How many moles of ethanedioic acid were contained in 250cm3 of solution N? (1mark)

25cm3 pipette volume   ->   0.001245/1.245 x10^{-3}
250cm3   ->   0.001245/1.245 x10^{-3} moles x 250
25
=   0.01245/1.245 x10^{-2} moles

(iii)Determine the % by mass of sodium ethanedioate in the mixture
(H= 1.0,O=16.0,C=12.0 and total mass of mixture =2.0 g in 250cm3 solution) (1mark)
Molar mass $H_2C_2O_4$= 90.0g
Mass of $H_2C_2O_4$ in 250cm3 =
moles in 250cm3 x molar mass $H_2C_2O_4$
=>0.01245/1.245 x10^{-2} moles x 90.0
= 1.1205g
% by mass of sodium ethanedioate
=(Mass of mixture   - mass of $H_2C_2O_4$) x 100%
Mass of mixture
=> 2.0 - 1.1205 g   = 43.975%
2.0

2. You are provided with 5.0 g solid B. You are to determine the molar mass of solid B.
Procedure
 Place 100cm3 of liquid L into a plastic beaker. Determine its temperature and record it at time = 0 in Table 2 below. Stir continuously using the thermometer and record the highest temperature change to the nearest $0.5^{\circ}C$ after every 30 seconds. After 120 seconds, add all solid B. Continue stirring and recording the temperature to

table 2.

Table 2

Time (seconds)	0.0	30	60	90	120	150	180	210	240	270	300
Temperature ($^{\circ}C$)	**20**	**20**	**20**	**20**	✕	**18**	**16**	**14**	**14**	**15**	**16**

Table 2
CT=$^1/_2$ mk
DP=$^1/_2$ mk
AC=$^1/_2$ mk
TR=$^1/_2$ mk
Total=2 mk

(2mark)

(a)Plot a graph of temperature against time(x-axis)(3marks)

(b)From the graph show and determine (2 mark)

(i) the highest temperature change ΔT

$$\Delta T = T_2 - T_1 \qquad => \quad 13.4 - 20 = \underline{\mathbf{6.6^o\,C}}$$

Note ΔT is not   - 6.6^{o}C

(ii) the temperature of the mixture at 130 seconds

From extrapolation at 130 seconds = **19.2** ^{o}C

(iii)the time when all the solid first dissolved

From extrapolation of the lowest temperature = **220** Seconds

31

(d) Calculate the heat change for the reaction.(Assume density of liquid L is $1.0gcm^{-3}$) specific heat capacity is $4.2Jkg^{-1}K^{-1}$(1mark)

ΔH = mass of liquid L x c x ΔT =>100 x 4.2 x 6.6 = + 2772 J = + 2.772 kJ
                                                                      1000

(e) Given the molar enthalpy of dissolution of Solid B in liquid L is + 22.176kJ mole^{-1},determine the number of moles of B used(1mark)

Moles of B = $\dfrac{\Delta H}{\Delta Hs}$ => $\dfrac{+ 2.772\ kJ}{+ 22.176kJ\ mole^{-1}}$ = 0.125 moles

(f)Calculate the molar mass of B (1mark)

Molar mass of B = $\dfrac{Mass\ used}{Moles\ used}$ => $\dfrac{5.0}{0.125\ moles}$ =>40 g

3(a)You are provided with solid Y. Carry out the following tests and record your observations and inferences in the space provided.
(i) Appearance

Observations	inference
(1mark)	
White crystalline solid	**Coloured Fe^{2+} ,Fe^{3+} , Cu^{2+} ions absent**

(ii)Place about a half spatula full of the solid into a clean dry boiling tube. Heat gently then strongly.

Observations	inference
(1mark)	
Colourless droplets forms on the cooler parts of test tube	**Hydrated compound/salt**
Solid remain white	

(ii)Place all the remaining portion of the solid in a test tube .Add about 10cm3 of distilled water. Shake thoroughly. Divide the mixture into five portions.

Observation	Inference
(1mark)	
Solid dissolves to form a colourless solution	**Coloured Fe^{2+} , Fe^{3+} , Cu^{2+} ions absent**

I. To the first portion add three drops of universal indicator.   (1mark)

Observation	Inference
pH= 4	**weakly acidic solution**

II.To the second portion, add three drops of aqueous ammonia then add excess of the alkali.

Observation (1mark)	Inference
White ppt, insoluble in excess	Al^{3+} , Pb^{2+}

III.To the third portion, add three drops of sodium sulpide solution.

Observation (1mark)	Inference
No black ppt	Al^{3+}

IV.To the fourth portion, add three drops of acidified Lead(II)nitrate(IV)solution. Heat to boil

Observation (1mark)	Inference
White ppt , persist/remains on boiling	SO_4^{2-}

(b)You are provided with solid P. Carry out the following tests and record your observations and inferences in the space provided.

(i)Place a portion of solid P on a clean metallic spatula and introduce it on a Bunsen flame.

($^1/_2$ mark)

Solid burns with a yellow sooty flame	$-C=C-$ // $-C\equiv C-$ bonds

(ii)Add all the remaining solid to about 10cm3 of water in a test tube and shake well. Divide the mixture into 4 portions. ($^1/_2$ mark)

Solid dissolves to form a clourless solution	Polar organic compound

I. To the 1st portion, test with litmus papers ($^1/_2$ mark)

Red litmus paper remain red	H^+ ions
Blue litmus paper turn blue	

II. To the 2nd portion, add a little sodium hydrogen carbonate($^{1}/_{2}$ mark)

Effervescence/fizzing/bubbles	**H^+ ions**
Colourless gas produced	

III.To the 3rd portion, and three drops of solution M. Warm($^{1}/_{2}$ mark)

Acidified $KMnO_4$ is decolorized	**$R-OH, -\overset{\mid}{C}=\overset{\mid}{C}-$ $\#C\equiv C-$ bonds**
// solution M is decolorized	

IV.To the 4th portion, add three drops of bromine water ($^{1}/_{2}$marks)

Bromine water is decolorized	**$\overset{\mid}{C}=\overset{\mid}{C}$ $//$ $\overset{\mid}{\underset{\mid}{C}}\overset{\mid}{\underset{\mid}{C}}$ C bonds**

233/3 CHEMISTRY
Pre-KCSE 2013
Practice 1
Moi High School-Mbiruri

Requirements for each Candidates:

0.05 M Oxalic acid labeled **Solution L**

0.01M Potassium manganate (VII) labeled **Solution M**

0.03M oxalic acid labeled **Solution N**

0.1M Sodium hydroxide labeled **Solution P**

1.0M sulphuric(VI)acid.

15 0cm3 distilled water labeled Liquid L

50cm3 burette

25cm3 pipette

Two clean conical flasks

Pipette filler

-10 -110^{0}C Thermometer

Stop watch/clock

200cm3 clean beaker

5.4g ammonium chloride/**8.0**g Ammonium nitrate(V) labeled **Solid B**
weighed   accurately

About 2.0 g of hydrated Aluminium sulphate labeled **Solid Y**

About 2.0g of Citric acid labeled **Solid P**

One boiling tube

Six clean dry test tubes

Pair of litmus papers(red and blue)

Clean metallic spatula

Access to bench reagents/apparatus

Means of heating

2M aqueous ammonia

0.1M acidified Lead(II)nitrate(V)

Bromine water

0.1M sodium sulphide

About 0.1g Sodium hydrogen carbonate

Universal indicator solution

pH chart

Name …………………………………………….Index Number……………..
233/3   Candidates signature………………
CHEMISTRY   Dates………………………..
Paper 3
PRACTICAL
Practice 2012
$2\frac{1}{4}$ hours

You are provided with :
- Solution A containing an oxidizing agent A;
- Solution B ,0.05M aqueous sodium thiosulphate;
- Solution C containing a reducing agent C;
- Aqueous Potassium iodide;
- Solution D, starch solution.

You are required to determined the:
Concentration of solution A
Rate of reaction between the oxidizing agent A and the reducing agent C.

Procedure 1
1. Using a pipette and **pipette filter** ,place 25.0cm3 of solution A into a 250ml conical flask.
2. Meassure 10cm3 of aqueous potassium iodide and add it to solution A in the conical flask.
   Shake the mixture .Add 10cm3 of 2M sulphuric(VI)acid to the mixture and shake.
3. Fill a burette with solution **B** and use it to titrate the mixture in the conical flask until it just turns **orange yellow**.Add 2cm3 of solution D to the mixture in the conical flask .Shake thoroughly. Continue titrating until the mixture **just turns colourless**. Record your results in **table 1** below.
4. Repeat the procedure and complete table 1.**Retain the remainder** of solution **A** and **D** for use in procedure II
   Table I

	I	II	III
Final burette reading	20.0	20.0	20.0
Initial burette reading	0.0	0.0	0.0
Volume of solution B used (cm3)	20.0	20.0	20.0

36

(4mks)

(a)Calculate the:

    (i) average volume of solution B used(1mk)

$$\frac{20.0 + 20.0 + 20.0}{3} \checkmark = 20.0 \checkmark \text{cm3}$$

    (ii)number of moles of sodium thisulphate(1mk)

Moles = $\dfrac{\text{molarity x burette volume}}{1000}$

$$\Rightarrow \frac{0.05 \text{ x}20.0}{1000} \checkmark = 0.001 / 1.0 \text{ x}10^{-3} \checkmark \text{ moles}$$

(b)Given that one mole of A reacts with six moles of sodium thiosulphate ,calculate the:

(i)number of moles of A that were used (1mk)

Mole ratio A:B = 1:6 $\checkmark$

$$\Rightarrow \text{Moles A} = \frac{0.001 / 1.0 \text{ x}10^{-3} \text{moles}}{6} = 0.00016/1.6 \text{ x}10^{-4} \checkmark \text{ moles}$$

(ii)concentration of solution A in moles per litre(2mk)

Molarity of solution A = $\dfrac{\text{moles x 1000}}{\text{Pipette volume}}$

$$\Rightarrow \frac{0.00016/1.6 \text{ x}10\text{-}4 \text{ moles x}1000}{20} \checkmark = 0.008/8.0 \text{ x}10^{-4} \text{ M} \checkmark$$

Procedure II

1. Label six test tubes as 1,2,3,4 ,5 and 6 and place them on a test tube rack.
2. Using a clean burette, measure the volumes of distilled water as shown in table 2 into the labeled test tubes.
3. Using a burette ,measure the volumes of solution A shown in table 2 into each of the test tubes .
4. Clean the burette and rinse it with about 5cm3 of solution C
5. Using the burette ,measure 5cm3 of solution C and place it into a 100ml beaker.
6. Using a 10ml measuring cylinder ,measure 5cm3 of solution D and add it to the beaker containing solution C .Shake the mixture.
7. Pour the contents of test tube number 1 to the mixture in the beaker and immediately start off stop watch/clock. Swirl the contents of the beaker.Record the time taken for a blue colour to appear in table 2.

8. Repeat steps 5 to7 using the contents of test-tube 2,3,4,5 and 6.
9. Complete table 2 by computing Rate = $\dfrac{1}{Time}$ (S^{-1})

Table 2(Sample results)

Test-tube number	1	2	3	4	5	6
Volume of distilled water(cm3)	0	2	3	5	6	7
Volume of solution A(cm3)	10	8	7	5	4	3
Time(seconds)	40.0	60.0	70.0	90.0	100.0	110.0
Rate = $\dfrac{1}{time}$ (S^{-1})	0.025 2.5×10^{-2}	0.0167 1.67×10^{-2}	0.0143 1.43×10^{-2}	0.0111 1.11×10^{-2}	0.0.1 1.11×10^{-2}	0.0083 8.3×10^{-3}

Plot a graph of rate(y-axis)against volume of solution A(3mk)

Sketch graph of rate against time

Rate

S^{-1}

Volume of solution A(cm3)
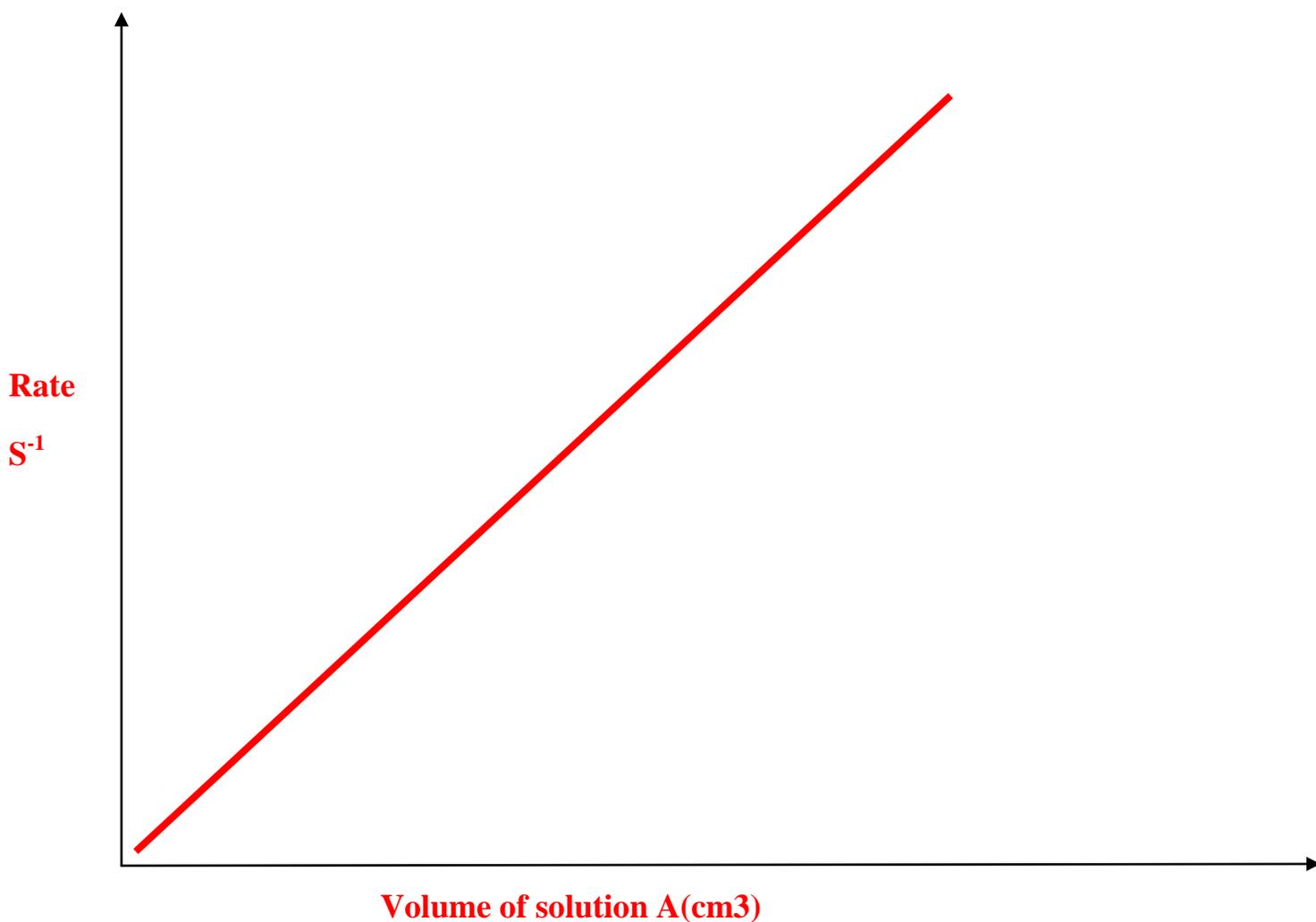
(b)What time would be taken for the blue colour to appear if the experiment was repeated using 4cm3 of distilled water and 6cm3 of solution A?(2mk)

From a correctly plotted graph
1/t at 6cm3 = 0.0125 √ =>   t = 1/0.0125 = 80seconds√

2. You are provided with solid E. Carry out the experiments below. Write your observations and inferences in the spaces provided
(a)Place all solid in a boiling tube .Add 20cm3 of distilled water and shakeuntil all the solid dissolves.Label the solution as solution E.Use solution E for experiment (i)and (ii)
(i)To 2cm3 of solution E in a test tube in each of experiment I,II,III and IV add:

I. two drops of aqueous sodium sulphate(VI)

Observation(1mk)	**Inferences**(1mk)
White precipitate	Pb^{2+} Ba^{2+} Ca^{2+}

II.five drops of aqueous sodium chloride

Observations (1mk)	**Inferences**(1mk)
White ppt	Ca^{2+} Ba^{2+}

III.two drops of barium chloride

Observations(1mk)	**Inferences(1mk)**
No white ppt	SO_4^{2-} SO_3^{2-} CO_3^{2-}

IV .two drops of lead(II)nitrate(V)

Observations(1mk)	**Inferences(1mk)**
No white ppt	Cl^-

(ii) To 2cm3 of solution E in a test tube ,add 5 drops of aqueous sodium hydroxide .Add the piece of aluminium foil provided to the mixture and shake. Warm the mixture and test any gas produced with both blue and red litmus papers

Observations(1mk)	Inferences(1mk)
Blue litmus paper remain blue **Red limus paper turn blue** **Effervescence /fizzing/ bubbles**	**NO_3^-**

<u>**Note:**</u>
<u>**Solid E is Calcium nitrate(V) / Barium nitrate(V)**</u>

3.You are provided with solid F. Carry out the following test.Write your observations and inferences in the spaces provided.
(a)Place all of solid F in a boiling tube. Add about 20cm3 of distilled water and shake until all the solid dissolves. Label the solution as solution F.

Add about half of the solid sodium hydrogen carbonate provided to 2cm3 of solution F

Observations(1mk)	Inferences (1mk)
No effervescence/fizzing	**H^+ absent**

(b)(i)Add about 10cm3 of dilute hydrochloric acid to the rest of solution F in the boiling tube. Filter the mixture. Wash the residue with about 2cm3 of distilled water.Dry the residue between filter papers. Place about one third of the dry residue on a metallic spatula and burn it in a Bunsen burner flame.

Observations(1mk)	Inferences(1mk)
Solid burns with a yellow sooty flame	**C=C // C≡C**

(ii)Place all the remaining residue into a boiling tube. Add about 10cm3 of distilled water and shake thoroughly. **Retain** the mixture for the tests in (c)

Observations ($^1/_2$mk)	Inferences($^1/_2$mk)
Solid dissolves to a colourless solution	**Polar compound**

40

(c)Divide the mixture into two portions:

(i)to the first portion ,add the rest of the solid sodium hydrogen carbonate
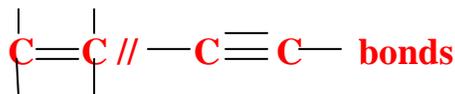
Observations (1mk)	Inferences(1mk)
Effervescence/fizzing	**H^+**

(ii)to the second portion ,add two drops of bromine water.

Observations (1mk)	Inferences(1mk)
Bromine water decolorized	**$C=C$ // $-C\equiv C-$ bonds**

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