CHEMISTRY PRACTICAL GUIDE

SPECIFIC OBJECTIVES OF CHEMISTRY PRACTICAL;

i. To test if the student is able to select & handle apparatus for use in an experimental work
ii. To test if the student is able to use his/her theoretical understanding of chemistry to make accurate observations and draw conclusions from those observations
iii. To test if the student is able to make accurate measurements

AREAS COMMONLY TESTED IN PRACTICAL;

1. Qualitative analysis (organic & inorganic)
2. Quantitative analysis
3. Graphical work

A) QUALITATIVE ANALYSIS

Refers to the process of carrying out chemical tests on substances with the sole aim of identifying them

TO BE ABLE TO GET GOOD RESULTS;

a) Accurately identify the test reagents
b) Identify what these reagents test
c) Predict the expected results

I. INORGANIC

Test for cations (12 cations involved; Na^+, K^+, NH_4^+, Ca^{2+}, Ba^{2+}, Mg^{2+}, Al^{3+}, Zn^{2+}, Pb^{2+}, Cu^{2+}, Fe^{2+} & Fe^{3+})

1) Addition of NaOH drop wise until in excess

Observation	Inference
• White precipitate, soluble in excess OR • White precipitate, insoluble in excess OR • No white precipitate OR	Zn^{2+}, Al^{3+}, Pb^{2+} ~~ZAP~~ Mg^{2+}, Ca^{2+} Na^+, K^+, NH_4^+ present Zn^{2+}, Al^{3+}, Pb^{2+}, Mg^{2+}, Ca^{2+} absent

• Blue precipitate, insoluble in excess OR • Green precipitate, insoluble in excess OR • Brown precipitate, insoluble in excess	Cu^{2+} Fe^{2+} Fe^{3+}

2) Addition of aq. Ammonia drop wise, until in excess

Observation	Inference
• White precipitate, soluble in excess OR • White precipitate, insoluble in excess OR • No white precipitate formed OR • Light blue precipitate, soluble in excess to give a deep blue solution OR • Green precipitate, insoluble in excess OR • Brown precipitate, insoluble in excess	Zn^{2+} Al^{3+}, Pb^{2+}, Mg^{2+} Na^{+}, K^{+}, Ca^{2+} Zn^{2+}, Al^{3+}, Pb^{2+}, Mg^{2+} Absent Cu^{2+} Fe^{2+} Fe^{3+}

3) Dip a nichrome wire into the solution and burn in a non luminous flame (Flame test for cations)

Observation	Inference
• Burns with a yellow flame OR	Na^{+}

• Burns with a red flame OR • Burns with a purple flame OR • Burns with a white flame	Ca^{2+} K^{+} Mg^{2+}

4) Addition of three drops of H_2SO_4/Na_2SO_4/K_2SO_4

Observation	Inference
• White precipitate	Ca^{2+}, Ba^{2+}, Pb^{2+}

5) Addition three drops of HCl/NaCl/KCl

Observation	Inference
• White precipitate	Pb^{2+}, Ag^{+}

6) Addition of two drops of potassium iodide

Observation	Inference
• Yellow precipitate	Pb^{2+}

TEST FOR ANIONS (SIX ANIONS; SO_4^{2-}, SO_3^{2-}, CO_3^{2-}, Cl^-, NO_3^- & HCO_3^-)

1) Addition of two drops of barium nitrate

Observation	Inference
• White precipitate	SO_4^{2-}, SO_3^{2-}, CO_3^{2-}

2) Addition of two of drops of barium nitrate followed by five drops of nitric (V) acid

Observation	Inference
• White precipitate, dissolves upon addition of nitric (V) acid • Bubbles of colourless gas produced	SO_3^{2-}, CO_3^{2-}
OR	
• White precipitate, insoluble upon addition of nitric (V) acid	SO_4^{2-}

3) Addition of two drops of acidified barium nitrate

Observation	Inference
• White precipitate.	SO_4^{2-}

4) Addition of three drops of lead (II) nitrate

Observation	Inference
• White precipitate.	SO_4^{2-}, SO_3^{2-}, CO_3^{2-}, Cl^-

5) Addition of two drops of lead (II) nitrate followed by five drops of nitric (V) acid

Observation	Inference
• White precipitate, soluble on addition of nitric (V) acid. • Bubbles of colourless gas	SO_3^{2-}, CO_3^{2-}
OR	
• White precipitate, insoluble upon addition of nitric (V) acid	SO_4^{2-}, Cl^-

6) Addition of two drops of lead (II) nitrate, followed by worming

Observation	Inference
• White precipitate, soluble upon worming	Cl^-
OR	
• White precipitate, insoluble upon worming	SO_4^{2-}, SO_3^{2-}, CO_3^{2-}

7) Addition of two drops of acidified lead (II) nitrate

Observation	Inference
• White precipitate	SO_4^{2-}, Cl^-

8) Addition of two drops of acidified potassium dichromate (VI)

Observation	Inference
• Bubbles of colourless gas, • Colour of $H^+/K_2Cr_2O_7$ turns from orange to green OR • Bubbles of colourless gas • $H^+/K_2Cr_2O_7$ retains its orange colour	SO_3^{2-} CO_3^{2-}

9) Take about ½ of the solid provided into a dry test tube and heat it gently then strongly

Observation	Inference
• Colourless liquid formed on upper cooler parts of the test tube	The solid is hydrated
• Blue litmus paper turns red and red litmus paper remains red	Acidic gas produced
• Red litmus paper turns blue & blue litmus paper remains blue	NH_4^+
• Bubbles of colourless gas that blows of a burning splint	CO_3^{2-}/HCO_3^-
• Brown fumes	NO_3^-
• Relights a glowing splint	NO_3^-
• Residue white when cold & yellow when hot	ZnO formed
• White solid formed on cooler parts of test tube	Contains a solid that sublime

10) Put the solid into a boiling tube, add about 10ml of distilled water and shake

Observation	Inference
• **<u>Dissolves</u>** to form a **<u>colourless</u>** solution	The solid is **soluble** in water Cu^{2+}, Fe^{2+}, Fe^{3+} absent

11) Put the solid into a boiling tube, add water, shake then filter

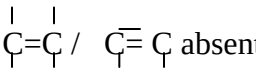
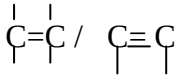
Observation	Inference
• Partially dissolves to form a **white residue** and a **Colourless** filtrate	The solid is a mixture of **soluble** and **insoluble** salts. Cu^{2+}, Fe^{2+}, Fe^{3+} absent both in the residue & in the filtrate

12) Transfer the residue from filter paper using a spatula into a boiling tube, add about 2 ml of nitric (V) acid

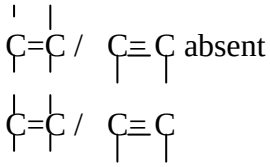
Observation	Inference
• Bubbles of colourless gas • The solid dissolves	SO_3^{2-}, CO_3^{2-}

II. ORGANIC

1) Put the solid in a metallic spatula and burn it in a Bunsen burner flame

Observation	Inference
• Melts, • Burns with a blue non sooty flame OR • Melts, • Burns with a yellow/sooty flame **NB;** Melts is not a must to be observed, only if it is observed	 absent 

2) Put 4 drops of the liquid on a watch glass and burn it

Observation	Inference
• Burns with a blue non sooty flame OR • Burns with a yellow sooty flame	 absent

3) Put the liquid in a boiling tube, add water then shake

Observation	Inference
• Miscible, forming uniform solution	Polar organic compound

4) Put the solid into a boiling tube, add about 10 ml of distilled water and shake

Observation	Inference
• **Dissolves** to form a **colourless** solution	Polar organic compound

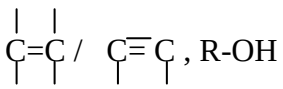
5) Put the solid into a boiling tube, add ethanol & shake

Observation	Inference
• **Dissolves** to form a **colourless** liquid	Polar organic compound

6) Determine the pH of the solution provided (Use of universal indicator)

Observation	Inference
• pH=6.5 **OR** • pH=7 **OR** • pH=2 **OR** • pH=8 **OR** • pH=14	Weakly acidic Neutral Strongly acidic Weakly alkaline Strongly alkaline **NB;** 4 to 6.5 is weakly acidic, 1 to 3 is strongly acidic, 8 to 10 is weakly alkaline & 11 to 14 is strongly alkaline. This will help you with other pH values that have not been included under the observation column

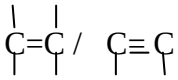
7) Add 4 drops of acidified potassium manganate (VII)

Observation	Inference
• Purple potassium manganate (VII) is decolorized	 , R-OH

8) Add 4 drops of acidified potassium dichromate (VI)

Observation	Inference
• Potassium dichromate (VI) turns from orange to green	R-OH NB; used for testing for R-OH, not for double and triple bonds

9) Addition of 4 drops of bromine water

Observation	Inference
• Bromine water is decolorized	

10) Add the solid Na_2CO_3/$NaHCO_3$ provided into the solution

Observation	Inference
• Bubbles of colourless gas produced	H^+/R-COOH

CURRENT TRENDS IN SETTING

1) (Compiled from Nyakach girls Chemistry contest 2018 edition)

You are provided with;

- Solid Q suspected to be **Zinc Sulphate**
- 2 M Sodium hydroxide solution
- 2 M Aqueous ammonia
- 2 M Nitric (V) acid
- 0.5 M Barium Chloride solution
- Distilled water

(a) Using the provided chemicals, write down three tests and expected observations to completely confirm the identity of solid Q

(i) Test 1	**Expected observation(s)**
Put solid Q into a boiling tube, add 10 ml of distilled water, then shake to dissolve solid Q. Divide the solution formed into 3 portions; To the 1st portion, add sodium hydroxide drop wise until in excess	White precipitate, soluble in excess
(ii) Test 2	**Expected observation(s)**
To the 2nd portion, add aqueous ammonia drop wise until in excess	White precipitate, soluble in excess
(iii) Test 3	**Expected observation(s)**
To the 3rd portion, add two drops of barium chloride, followed by about 10 ml of nitric (V) acid	White precipitate formed upon adding barium chloride, the white precipitate do not dissolve when acid is added

2) You are provided with;

- Solid R suspected to be **Aluminium Chloride**
- 2 M Sodium hydroxide solution
- Sodium Carbonate solution
- 0.5 M Lead (II) nitrate
- 0.2 M Barium Nitrate
- Distilled water

(b) Using the provided chemicals, write down four tests and expected observations to completely confirm the identity of solid R

(i) Test 1	**Expected observation(s)**
Put solid R into a boiling tube, add 10 ml of distilled water, then shake to dissolve solid R. Divide the solution formed into 4 portions; To the 1st portion, add sodium hydroxide drop wise until in excess	White precipitate, soluble in excess

(ii) Test 2	**Expected observation(s)**
To the 2nd portion, add two drops of Sodium carbonate	No white precipitate formed
(iii) Test 3	**Expected observation(s)**
To the 3rd portion, add two drops of Lead (II) nitrate	White precipitate is formed
(iv) Test 4	**Expected observation(s)**
To the 4th portion, add two drops of barium nitrate	No white precipitate is formed

3) You are provided with;

- Solid S suspected to be **Zinc Sulphate**
- 2 M Aqueous ammonia
- Lead (II) nitrate solution
- 2 M Nitric (V) acid
- Barium Nitrate solution
- Distilled water

(a) Using the provided chemicals, write down three tests and expected observations to completely confirm the identity of solid S

(i) Test 1	**Expected observation(s)**
Put solid S into a boiling tube, add 10 ml of distilled water, then shake to dissolve solid S. Divide the solution formed into 3 portions; To the 1st portion, add aqueous ammonia drop wise until in excess	White precipitate, soluble in excess
(ii) Test 2	**Expected observation(s)**
Add two drops of lead (II) nitrate	White precipitate
(iii) Test 3	**Expected observation(s)**
Add two drops of barium nitrate followed by about 10 ml of nitric (V) acid	White precipitate, insoluble when acid is added

4) You are provided with;

- Solid T suspected to be **Lead (II) nitrate**
- 2 M Sodium hydroxide solution
- Sodium Chloride solution
- Aluminium foil
- Red and blue litmus papers
- Distilled water
- Test tube holder
- Source of heat

(a) Using the provided chemicals, write down three tests and expected observations to completely confirm the identity of solid T

(i) Test 1	**Expected observation(s)**
Put solid T into a boiling tube, add 10 ml of distilled water, then shake to dissolve solid T. Divide the solution formed into 3 portions; To the 1st portion, add sodium hydroxide drop wise until in excess	White precipitate, soluble in excess
(ii) Test 2	**Expected observation(s)**
To the 2nd portion, add two drops of sodium chloride	White precipitate formed
(iii) Test 3	**Expected observation(s)**
To the 3rd portion, add 6 drops of NaOH, drop a piece of aluminium foil into the mixture then heat to boil and test any gas produced using litmus papers	Bubbles of colourless gas. Red litmus paper turns blue and blue litmus remains blue

NB; *The theory behind test 3; aluminium foil reduces NO_3^- to NH_4^+ then NH_4^+ formed reacts with NaOH to produce NH_3 (**KCSE 2012**)*

5) You are provided with;

- Solid U suspected to be **Magnesium Sulphate**
- 2 M Sodium hydroxide solution
- 2 M Aqueous ammonia
- 0.5 M Barium Nitrate solution
- 2 M Nitric (V) acid
- Distilled water

(a) Using the provided chemicals, write down three tests and expected observations to completely confirm the identity of solid U

(i) Test 1	**Expected observation(s)**
Put solid U into a boiling tube, add 10 ml of distilled water, then shake to dissolve solid U. Divide the solution formed into 3 portions; To the 1st portion, add sodium hydroxide drop wise until in excess	White precipitate, insoluble in excess
(ii) Test 2	**Expected observation(s)**
To the 2nd portion, add aqueous ammonia drop wise until in excess	White precipitate, insoluble in excess

(iii) Test 3	Expected observation(s)
To the 3rd portion, add 2 drops of barium nitrate followed by addition of about 10 ml of nitric (V) acid	White precipitate formed which do not dissolve when the acid is added

NB; *Forget about barium when using NaOH and aqueous ammonia drop wise until in excess, a mention of Ba^{2+} will be treated as a contradictory ion (**Refer KCSE 2015**).* This will help test 1 be easier to understand.

6) (Compiled from KCSE 2017)

You are provided with;

- Solid V suspected to be **Lead (II) carbonate**
- Aqueous sodium sulphate
- 2 M Aqueous ammonia
- 2 M Nitric (V) acid
- Wooden splint

(a) Using the provided chemicals, write down three tests and expected observations to completely confirm the identity of solid V

(i) Test 1	Expected observation(s)
To solid V in a boiling tube, add about 5 ml of nitric (V) acid and test for any gas produced using a burning splint. Divide the solution formed into 2 portions for tests 2 and 3 below	Bubbles of colourless gas produced, Burning splint goes off

(ii) Test 2	Expected observation(s)
To the 1st portion, add ammonia solution drop wise until in excess	White precipitate insoluble in excess

(iii) Test 3	Expected observation(s)
To the 2nd portion, add 2 drops of sodium sulphate	White precipitate formed

7). (An exam sample; for inorganic compounds)

You are provided with

- Solid Y, 0.5 g
- Sodium hydroxide
- Aqueous ammonia
- Solution F; aqueous lead (II) Nitrate
- Distilled water in wash bottle
- Source of heat

a) Describe the appearance of solid Y (1 mk)

- ✓ Colourless crystals

b) Add about 10 cm^3 distilled water to substance Y in a boiling tube and shake

Observation	Inference
Dissolves to form a colourless solution ($^1/_2\ mk$)	Solid Y is soluble in water ($^1/_2\ mk$)

c) Substance Y is suspected to be **calcium chloride**
From the reagents provided and results in procedure (b) above select and describe **three** tests that could be carried out consecutively to confirm whether substance Y is indeed calcium chloride. Write the tests and expected observations in the spaces provided.

Test 1

Description of test	Expected observation
Divide the solution formed in (b) into 3 portions; To the 1st portion, add sodium hydroxide drop wise until in excess (1mk)	White precipitate, insoluble in excess (1mk)

Test 2

Description of test	Expected observation
To the 2nd portion, add ammonia solution drop wise until in excess (1mk)	No white precipitate is formed **NB; Don't think about barium ions when using NaOH & Aq. Ammonia solutions until in excess** (1mk)

Test 3

Description of test	Expected observation
To the 3rd portion, add 2 drops of lead (II) nitrate followed by warming (1mk)	White precipitate that dissolves upon warming (1mk)

d) Carry out the tests described in (c) above using substance Y and record the observations and inferences in the spaces provided.

NB; Remember that you were told that the solid is **suspected** to be $CaCl_2$, this gives room for it to be something else as well. Let's therefore assume that the actual salt that was provided was $MgCl_2$

i) Test 1

Observation	Inference
White precipitate, insoluble in excess (1 mk)	Mg^{2+}, Ca^{2+} (1mk)

ii) Test 2

Observation	Inference
White precipitate, insoluble in excess (1 mk)	Mg^{2+} (1mk)

iii) Test 3

Observation	Inference
White precipitate that dissolves upon warming (1mk)	Cl^- (1mk)

8). You are provided with the following to use in this question;

- Solid X
- Bromine water
- Distilled water
- Acidified potassium dichromate (VI) solution

Solid X is suspected to be **a polar saturated alkanol**

a) Describe three consecutive tests you would carry out to confirm whether solid X is a polar saturated alkanol

(i) Test 1	Expected observation(s)
Place solid X into a boiling tube, add 5ml of distilled water and shake	Solid X dissolves forming a colourless solution
(ii) Test 2	**Expected observation(s)**
To a portion of the solution formed in test 1, add 4 drops of bromine water	Bromine water is not decolorized
(iii) Test 3	**Expected observation(s)**
To another portion of the solution formed in test 1, add 4 drops of acidified potassium dichromate (VI) solution	Acidified potassium dichromate (VI) solution turns from orange to green

9). **You are provided with the following to use in this question;**

- Solid W
- Bromine water
- Distilled water
- Solid sodium carbonate

Solid W is suspected to be **a polar unsaturated alkanoic acid**

b) Describe three consecutive tests you would carry out to confirm whether solid W is a polar unsaturated alkanoic acid.

(i) Test 1	Expected observation(s)
Place solid W into a boiling tube, add 5ml of distilled water and shake	Solid W dissolves forming a colourless solution
(ii) Test 2	**Expected observation(s)**
To a portion of the solution formed in test 1, add 4 drops of bromine water	Bromine water is decolorized
(iii) Test 3	**Expected observation(s)**
To another portion of the solution formed in test 1, add solid sodium carbonate	Bubbles of colourless gas produced

10). (Full exam format. Compiled from KISIOMI Chemistry joint examinations; 2018)

You are provided with the following to use in this question;

- Solid Z
- Bromine water
- Distilled water
- Acidified Potassium manganate (VII) solution

Solid Z is suspected to be **a polar unsaturated organic compound**

(a) Describe three consecutive tests you would carry out to confirm whether solid Z is polar and unsaturated.

i) Test I

Description of Test	Expect Observation
Place solid Z into a boiling tube, add 5ml of distilled water and shake (½mk)	Solid Z dissolves forming a colourless solution (½mk)

ii) Test 2

Description of Test	Expect Observation
To a portion of the solution formed in test 1, add 4 drops of acidified potassium manganate (VII) (1mk)	potassium manganate (VII) is deolourized (1mk)

iii) Test 3

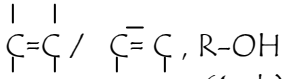
Description of Test	Expect Observation
To another portion of the solution formed in test 1, add 4 drops of bromine water (½mk)	Bromine water is decolourized (½mk)

(b) Carry out the tests outlined in part (a) and record the observations and inferences

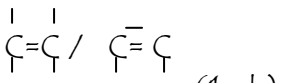
i)

Test I	Observation	Inferences
	Solid Z dissolves forming a colourless solution (½mk)	Polar organic compound (½mk)

(ii)

Test 2	Observation	Inferences
	Potassium manganate (VII) decolourizes (½mk)	 (1mk)

(iii)

Test 3	Observation	Inferences
	Bromine water decolourized (1mk)	 (1mk)

QUANTITATIVE ANALYSIS

CALCULATIONS

CONDITIONS;

- Students MUST transfer the values intact, that is, if the answer above is to 4 d.p. and should be used in the subsequent working, therefore the student cannot round it off in the air and use it when it is now 3 d.p
- Answers to at least 4 decimal places is OK either rounded off or truncated (chopped off)
- Presenting two **different** workings attracts full penalty on that particular question
- RAM & RFM should not have units on the answer

GRAPH WORK

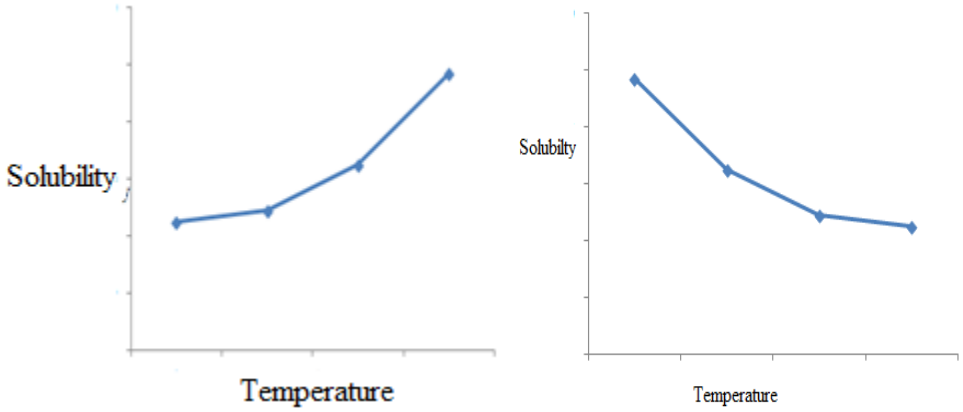
CONDITIONS;

- The scale chosen should be able to accommodate all the points in the table and it should have consistent scale intervals
- Label, units are not necessary as units would attract penalties e.g., just stating Time is sufficient, not a must to state Time (**seconds**)
- Scale should be big enough to cover at least ½ of the grid provided, that is, the student should ensure that he/she uses at least ½ of the big boxes on the vertical & on the horizontal axes
- Students should avoid committing zero at the origin; it is safer that way
- Total coincidence of ruler with grid lines when doing y- and x-axes lines, extra keenness.
- Points should be plotted intact ie, as they appear on the table
- The curve/line should pass through the initial plot, as this was the first experiment done under a lot of purity.
- Use broken lines when reading from a graph
- Temperature graphs (temperature axis) are normally broken but not ΔT graphs.

SOLUBILITY & SOLUBILITY CURVES

Solubility; Maximum mass of solute required to saturate 100 g of solvent at a given temperature
Solubility curve; a graph of solubility against temperature for a particular solute

EXPECTED SHAPES FOR SOLUBILITY CURVES;



NB;

i. Do a curve of best fit, don't use a ruler & don't look for points
ii. No extrapolation of a curve (don't extend a curve)
iii. Temperature values in the table of whole numbers are better than 1dp

ENERGY CHANGES (THERMOCHEMISTRY)

TABLE FOR THERMOMETER READINGS

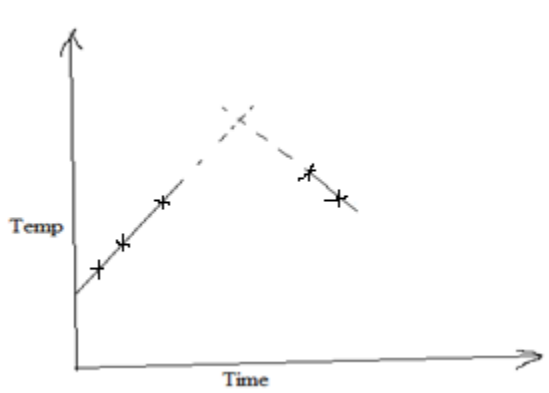
- Thermometer readings of whole numbers are convenient and safe

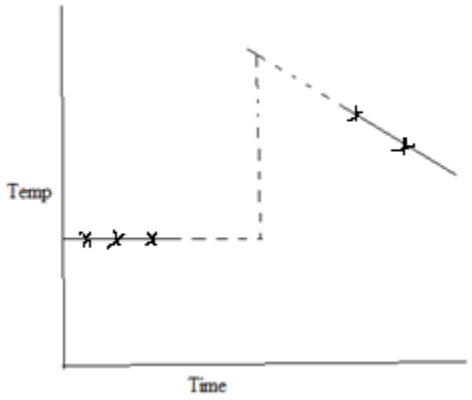
1) ENTHALPY OF SOLUTION

Definition; the enthalpy change that occurs when one mole of a substance completely dissolves in water

EXPECTED SHAPES FOR ENTHALPY OF SOLUTION

a) For exothermic processes





When no break in temperature readings When there is break in temperature readings

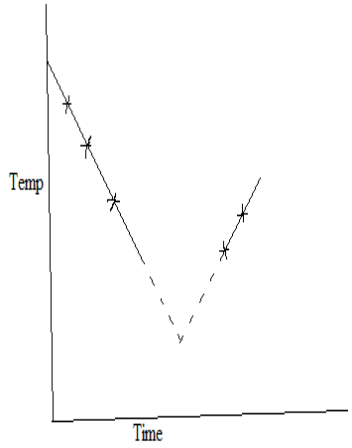
TABLE WITH A BROCKEN READING

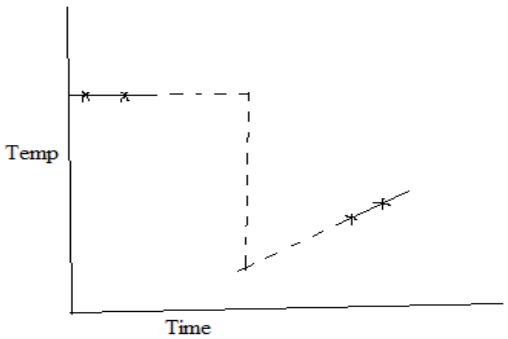
Time (Min)	0	0.5	1	1.5	2	2.5	3	3.5	4	4.5	5	5.5	6
Temp (°C)	26	26	26	26		29	30	31	32	33	33	32	31

TABLE WITHOUT A BROCKEN READING

Volume of solution B (cm^3)	0	5	10	15	20	25	30	35	40	45	50
Temp (°C)	24.0	24.5	25.0	25.5	26.0	26.5	26.5	26.5	26.0	25.5	25.0

b) For endothermic processes





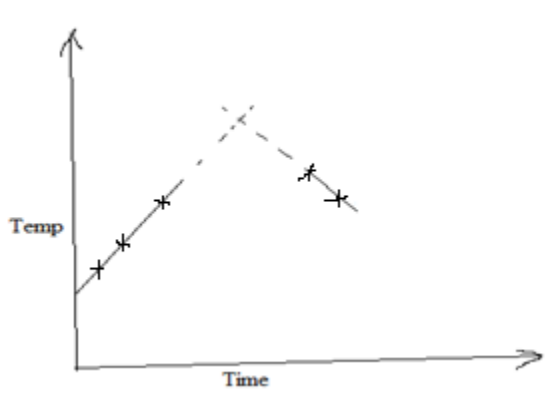
When no break in temperature readings When there is a break in temperature readings

2) ENTHALPY OF DISPLACEMENT

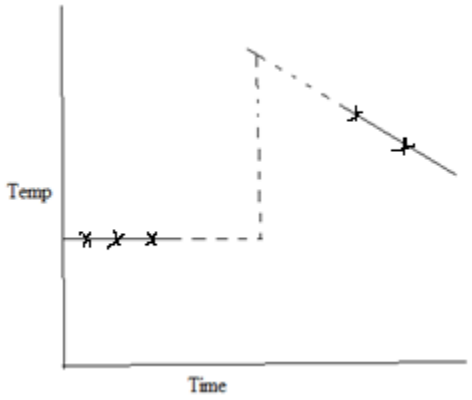
Definition; the enthalpy change that occurs when one mole of a substance is displaced from a solution of its ions

EXPECTED SHAPES FOR ENTHALPY OF DISPLACEMENT

a) For exothermic processes

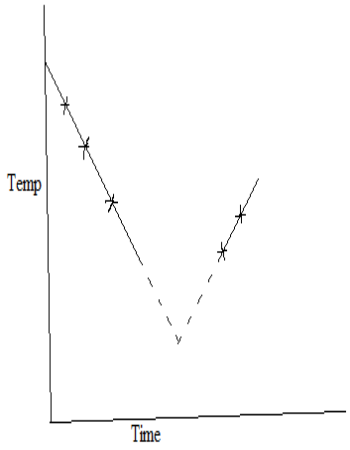


When no break in temperature readings

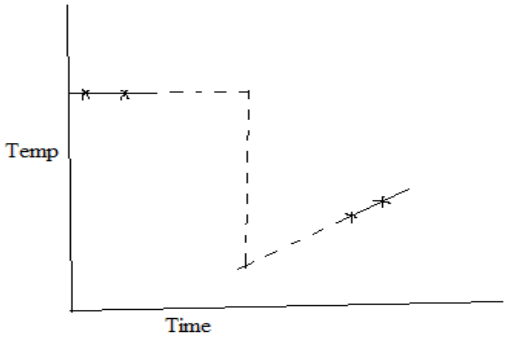


When there is break in temperature readings

b) For endothermic processes



When no break in temperature readings

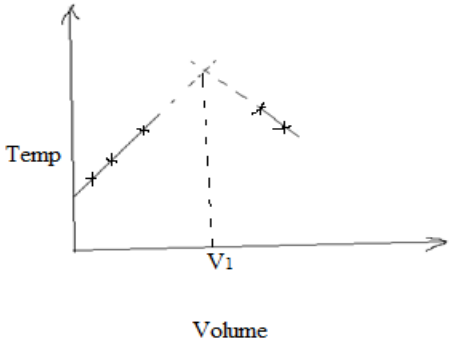


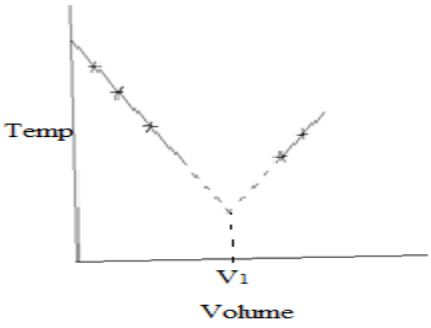
When no break in temperature readings

3) ENTHALPY OF NEUTRALIZATION

Definition; the enthalpy change that occurs when one mole of H^+ ion from an acid is completely neutralized by an alkali to form one mole of water

EXPECTED SHAPES FOR ENTHALPY OF NEUTRALIZATION





For exothermic processes For endothermic processes

NB; V_1 is the volume of the acid/base that completely neutralize the other

$\Delta H = mc\Delta T$

RATES OF REACTION;

Definition; Change in concentration of reactants/products per unit time

RATES TABLE

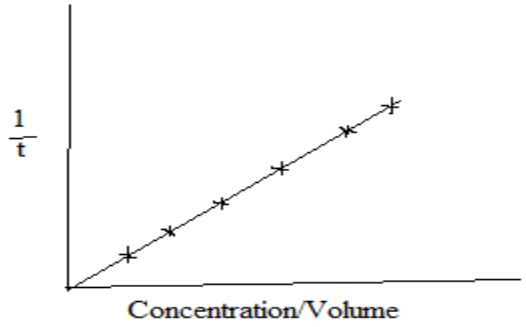
- Time readings of whole numbers are better than 1 or 2 dp readings
- $\frac{1}{t}$ values should be to 3 dp & consistent unless for cases where values work out to less than 3 dp
- Temperature or time readings in the table must either increase or decrease continuously

EXPECTED SHAPES FOR RATES

The shape can either be a straight line or a smooth curve depending on the quantities being plotted

e.g,

(i) Effect of concentration on the rate of reaction is a straight line from origin



(ii) **Effect of temperature on the rate of reaction is a smooth curve**