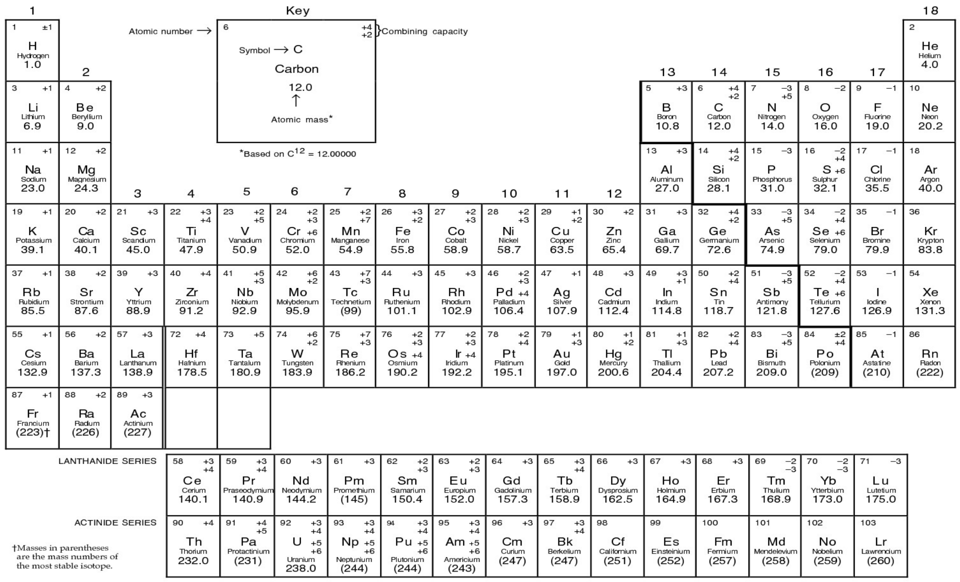
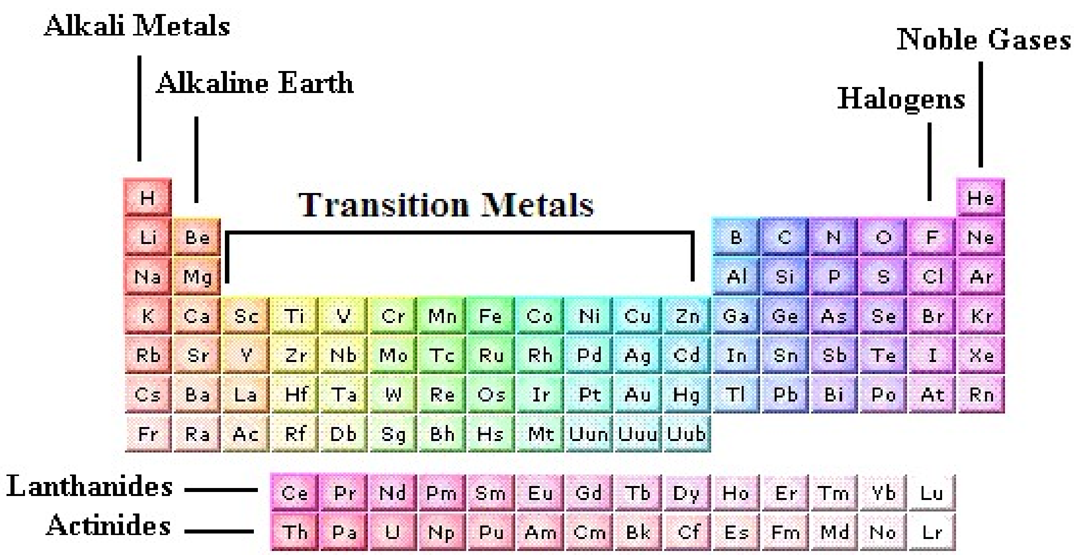
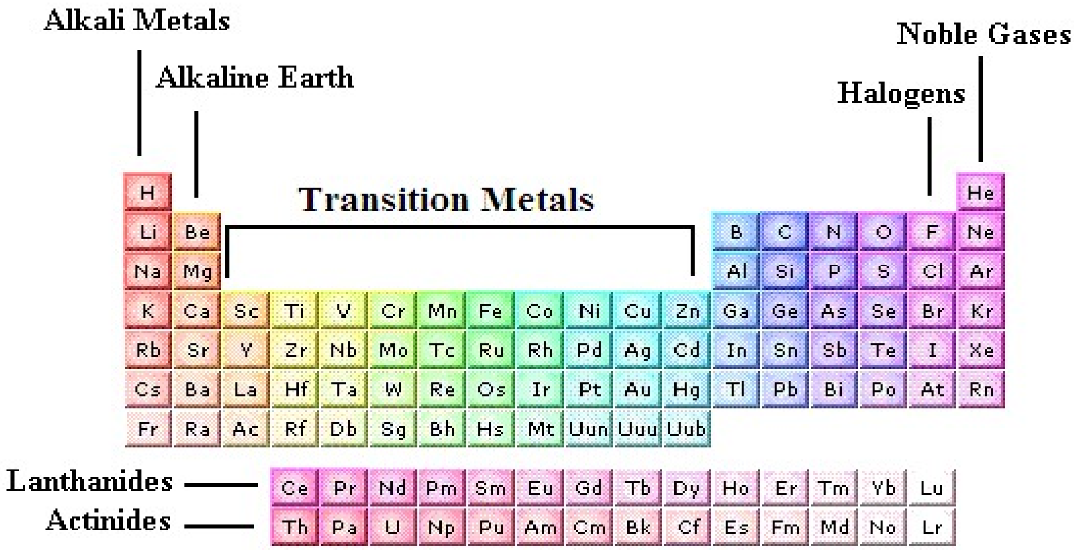
The Modern Periodic Table of the Elements







VOLUMETRIC ANALYSIS - TITRATIONS

1.1 Introduction to volumetric analysis

Volumetric analysis: is a means of estimating quantities of certain substances such as acids and alkalis by an analytical process.

This process involves measurement of volumes of solutions, using pipettes, burettes and measuring cylinders.

Titration: is the estimation of the concentration of a solution of an acid by reacting with a standard alkali solution using a burette, pipette and conical flask. Titration also applies to the estimation of the concentration of solution of an alkali by reaction with a standard acid solution.

The point at which the acid has been added to the alkali in the mole proportions indicated by the equation for the reaction is known as the **end-point** of the reaction.

The end-point of an acid- base reaction is commonly determined using a substance known as an **indicator**, which usually changes colour according to whether the solution is predominantly acidic or alkaline.

The three indicators commonly used in acid-base titrations are phenolphthalein, methyl orange and litmus indicators.

1.2 Acid-base indicators and their use

Acid-base indicators are substances that change colour according to pH. The pH scale is a number scale which shows the degree of acidity or alkalinity of a solution in water. pH is measured on a scale from **0** to **14**.

1	2	3	4	5	6	7	8	9	10	11	12	13	14

INCREASING ACIDITY ⟵ ↓ ⟶ INCREASING ALKALINITY

NEUTRAL

Below are the common laboratory indicators and their colour changes in the different conditions of pH.

Laboratory indicator	Colour in Acid	Colour in Alkali
Litmus (Blue or Red)	Red	Blue
Methyl orange (Orange)	Red (Purple)	Yellow
Phenolphthalein (Colourless)	colourless	Pink

An indicator is normally used to decide the 'end point' of the reaction, i.e. the point at which the volumes of the solutions have completely reacted and there has been complete neutralization of the acid by the base to form salt and water. This whole procedure is carried in a process called **titration**, and the results obtained are **titre values**.

1.3 Performing the titration and presentation of results

The first titration should be treated as a rough titration and should be used as a clue of the end point in subsequent procedures. More accurate results can be determined in the subsequent titrations.

The solution to be pipetted is placed into the conical flask and two or three drops of the indicator are added to it. The burette is filled with the other solution. The tap of the burette is opened to allow the solution in it to run into that in the conical flask, each time, the flask in shaken to allow thorough mixing of the solution.

For clear appearance of colour of the solution and also for easy detection of colour changes in the titration flask, a white piece of paper or white tile is placed below the conical flask. The end point is when the indicator changes colour. The colour change is sudden; even a drop of the solution is enough to turn the whole colour to that expected. Therefore, care must be taken to ensure that this change is with your full knowledge.

The titration must be repeated until two or more readings lie within a range of $\pm$ 0.1 cm^3. The success of volumetric analysis is all about *accuracy* during titration, establishing end point of the reaction, reading of the burette and recording of results.

The titration flask must be rinsed thoroughly with clean water after each titration before conducting the next titration. When taking burette readings, the eye must be in level with meniscus. (Note that the lower meniscus is read, not the upper).

The readings on the burette are recorded to two decimal places. E.g burette reading can be written as 17.00cm^3 or 24.50cm^3.
The capacity (volume) of the pipette used is recorded as 20cm^3 or 25cm^3. However, some times as 20.0cm^3 or 25.0cm^3 but not as 20.00cm^3 or 25.00cm^3.

The results obtained from titrations are recorded in a table as illustrated below.

Burette readings	1	2	3
Final burette reading (cm^3)	20.20	40.30	30.20
Initial burette reading (cm^3)	0.00	20.20	10.00
Volume of solution used (cm^3)	20.20	20.10	20.10

Values used for calculating average volume of solution

20.20 cm and 20.10 cm

Average volume of solution used

$$\frac{\mathbf{20.20 + 20.10}}{\mathbf{2}} = \frac{\mathbf{40.30}}{\mathbf{2}} = \mathbf{20.15\ cm^3}$$

1.4 Volumetric analysis is useful for calculating the following

(i) Stoichiometric ratio of reacting substances and equation of reactions
(ii) Basicity of acids
(iii) Concentration of substances in moles per litre and grams per litre
(iv) Formulae of compounds
(v) Relative Formula Mass (R.F.M) or Molar Mass (M.M) and Relative Atomic Mass (R.A.M) of compounds.
(vi) Number of moles of water of crystallization in one mole of hydrated compound.
(vii) Percentage purity of a sample of a given substance.

1.5 Steps to be followed when calculating from titration results

- The volume of pipette used ($20cm^3$ or $25cm^3$) and the average volume obtained, are the volumes that you will use in calculations.
- Ensure that you know the concentration in moles per litre (molarity) of one of the two solutions involved. If this is not given directly, it will be necessary to work it out from the mass of solids dissolved in a certain known volume of solution.
- Write down the balanced equation for the reaction if possible.
- Calculate the number of moles used for the solution whose concentration is known.
- From the equation, determine the mole ratio, and then calculate the number of moles of the other substance that reacted.
- Then calculate the molarity of the other substance using number of moles obtained.
- From here, you can proceed to determine;
  (i) Concentration in grams per litre (mass).
  (ii) R.F.M (M.M) or R.A.M
  (iii) Number of moles of water of crystallization of hydrated compound.
  (iv) Percentage purity of a given sample of substance.

Note: Stoichiometric ratio (ratio of the number of moles of solutions that reacted) and Basicity can be calculated immediately after getting number of moles of the two solutions.

1 Worked examples on Volumetric Analysis

1.1 Experiment to determine the Basicity of an acid

You are provided with solution BA1 a 0.2M sodium hydroxide solution and BA1 a 0.1M solution of acid HnX.
You are required to determine the Basicity of the acid HnX.

Procedure
Pipette $20cm^3$ or $25cm^3$ of BA1 into a conical flask. Add 2-3 drops of phenolphthalein indicator (solution turns to pink). Titrate the solution with BA2 from the burette (the end point is when the solution mixture just turns colourless).
Repeat the procedure until when you obtain consistent readings. Record your readings in the table below.

Sample results
Volume of pipette used =

Burette reading	1	2	3
Final burette reading (cm^3)			
Initial burette reading (cm^3)			
Volume of BA2 used (cm^3)			

Titre values used to determine the average volume of BA2.

Average volume of BA2 used

Questions:

(a) Determine the number of moles of;
(i) Sodium hydroxide solution that reacted.

(ii) Acid HnX that reacted

(b) Determine the mole ratio of NaOH : HnX

(c) What is the Basicity of the acid HnX?

Note: *Basicity is the number of moles of sodium hydroxide that reacted with one mole of that particular acid. Therefore, to determine the Basicity of a given acid, you need to obtain the mole ratio of an acid : base.*

1.2 Experiment to determine the Molarity of a solution

You are provided with BA1, a 0.1M hydrochloric acid solution and BA2 is a solution of sodium hydroxide of unknown concentration.
You are required to determine the Molarity of the sodium hydroxide solution.

Procedure

Pipette 20cm^3 or 25cm^3 of BA1 into a conical flask. Add 2-3 drops of methyl orange indicator (the solution turns red). Titrate the solution with BA2 from the burette (the end point is when the solution mixture just turns to yellow).
Repeat the procedure until you obtain consistent readings. Record your reading in the table below.

Sample results

Volume of pipette used =

Burette reading	1	2	3
Final burette reading (cm^3)			
Initial burette reading (cm^3)			
Volume of BA2 used (cm^3)			

Titre values used to determine the average volume of BA2

Average volume of BA2 used

Questions

(a) Determine the number of moles of
   (i) Hydrochloric acid that reacted

   (ii) Sodium hydroxide that reacted

(b) Determine the Molarity of BA2.

1.3 Experiment to determine the percentage purity of a substance (UNEB 2011 Chemistry 545/3)

You are provided with the following:
BA1, which is a solution containing 12.8g of impure acid, $H_2X.2H_20$ per litre of solution.
BA2, which is a 0.2M sodium hydroxide solution.
You are required to determine the percentage of the acid in **BA1**.

Procedure:
Pipette 25cm^3 (or 20cm^3) of **BA2** into a conical flask. Add 2-3 drops of phenolphthalein indicator. Titrate this solution with **BA1** from the burette.
Repeat the titration until you obtain consistent results.
Record your results in the table below.

Volume of pipette used

Final burette reading (cm^3)			
Initial burette reading (cm^3)			
Volume of **BA1** used (cm^3)			

Titre values used to obtain average volume of **BA1**.

Average volume of **BA1** used

Questions:
(a) Write an equation for the reaction between hydroxide and the acid.

(b) Calculate the

(i) Concentration of the acid in moles per litre of **BA1.**

(ii) Mass in grams of the acid, $H_2X.2H_20$ in 1litre of **BA1**.

(iii) Percentage by mass of the acid in solution **BA**

1.4Experiment to determine the Atomic Mass of an element

(or ion) (UNEB 2012 Chemistry 545/3)

You are provided with the following:
BA1, which is a 0.1M sodium hydroxide solution.
BA2, which is a solution containing 3.5g of metal ion, $\mathbf{X^{2+}}$ per litre of the solution.
BA3, which is a 0.1M hydrochloric acid.

Metal ion, $\mathbf{X^{2+}}$ reacts with sodium hydroxide according to the following equation;

$$X^{2+}(aq) + 2OH^{-}(aq) \longrightarrow X(OH)_2(s)$$

The hydroxide of $\mathbf{X^{2+}}$ reacts with hydrochloric acid according to the following equation;

$$X(OH)_2(s) + 2H^{+}(aq) \longrightarrow X^{2+}(aq) + 2H_2O(l)$$

You are required to determine the mass of one mole of $\mathbf{X^{2+}}$ ions.

Procedure:

(i) Pipette $20.0cm^3$ (or $25cm^3$) of **BA2** into a conical flask. Add an equal volume of **BA1** and shake to mix well.
(ii) Titrate the mixture with **BA3** from the burette until the blue precipitate just dissolves completely.
(iii) Repeat steps (i) and (ii) to obtain consistent results.
(iv) Record your results in the table below.

Results:

Volume of pipette used

Experiment	**1**	**2**	**3**
Final burette reading (cm^3)			
Initial burette reading (cm^3)			
Volume of **BA3** used (cm^3)			

Volume of BA3 used for calculating the average volume

Average volume of BA3 used.

Questions:

Calculate;

(i) The number of moles of hydrochloric acid in BA3 that reacted.

(ii) The number of moles of **X^{2+}** ion in BA2 that reacted.

(iii) The number of moles of **X^{2+}** ions.

1.5 Experiment to determine the number of atoms present in a given atom(s).
(UNEB 2013 Chemistry 545/3)

You are provided with the following:
BA1, which is a 0.1M sodium hydroxide solution
BA2, which is a solution containing 12.7g of an organic acid,
$CH_3(CH_2)_{\mathbf{n}}COOH$ per litre of solution.
You are required to determine the value of **n**.

PROCEDURE

Pipette 25.0cm^3 (or 20.0cm^3) of BA1 into a conical flask.
Titrate with BA2 from the burette using phenolphthalein indicator.
Repeat the titration until you obtain consistent results.
Record your results in the table below.

RESULTS

Volume of pipette used =

Final burette reading (cm^3)			
Initial burette reading (cm^3)			
Volume of BA2 used (cm^3)			

Volume of BA2 used to calculate the average volume.

Average volume of BA2 used.

Questions:

(a) Calculate the;

(i) Number of moles of sodium hydroxide that reacted.

(ii) Number of moles of the organic acid per litre of solution BA2. (Sodium hydroxide reacts with the organic acid in the ratio 1 : 1).

(iii) Relative molecular mass of the organic acid.

(b) Determine the value of n in $CH_3(CH_2)_{\boldsymbol{n}}COOH$ $[H = 1, C = 12, O = 16]$

1.6 Experiment to determine the formula mass of an element (UNEB 2012 Chemistry 545/5)

You are provided with the following:
BA1, which is a solution containing 1.36g of hydroxide ions (**OH^-**) per litre of solution.
BA2, which is a solution containing 7.6g of a dibasic acid, **H_2X** per litre of solution.
You are required to determine the value of **X** in **H_2X**.

PROCEDURE:

Pipette 25cm^3 (or 20.0cm^3) of **BA1** into a conical flask. Add 2-3 drops of phenolphthalein indicator. Titrate with **BA2** from the burette.
Repeat the titration until you obtain consistent results.

RESULTS:

Volume of pipette used =

Final burette reading (cm^3)			
Initial burette reading (cm^3)			
Volume of **BA2** used (cm^3)			

Titre values used to calculate average volume of **BA2** used.

Average volume of **BA2** used.

QUESTIONS:

(a) (i) Determine the Molarity of **BA2**. $[H = I, O = 16]$

(b) Determine;

(i) The number of moles of **BA1** that reacted

(ii) The number of moles of **BA2**, H_2X that reacted.

(iii) The Molarity of **BA2**.

(iv) The formula mass of **X.**

EXERCISES ON VOLUMETRIC ANALYSIS

1.6 UNEB 2010 545/4 (experiment to determine the formula mass)

You are provided with the following.

BA1,which is a0.1 M hydrochloric acid

BA2, which is a solution of a sodium salt,$Na_2X.5H_2O$ containing 11.64g of the sodium salt per litre or solution

You are required to determine the formula mass of X.

Procedure

Pipette 25.0 cm3 or 20.0 cm3 of BA2 into a conical flask . add 2-3 drops of methyl orange indicator and titrate with BA1 from the burette.

Repeat the titration until you get consistent results.

Record your results in the table below.

Results .

Volume of pipette used...cm3 (1/2 mk)

Final burette reading (cm3)			
Initial burette reading(cm3)			
Volume of BA1 used(cm3)			

Volume of BA1 used for calculating the average volume used
(41/2mk)

....
....

Average volume of BA1 used

....
....
....

Question

a) calculate the
(I) number of moles of BA1 that reacted

(iii) number of moles of BA2 that reacted .(the sodium salt reacts with hydrochloric acid in the ratio of 1:2)

(iv) Molarity

(b) determine the formula mass of X.(H=1, O=16;Na=23)

1.7 UNEB 2012 545/5 (Experiment to determine the value 0f X in H2X)

You are provided with the following ;

BA1, which is a solution containing 1.36g of hydroxide ions (OH) per litre of solution.

BA2, which is a solution containing 7.6 g of a dibasic acid , H_2X per litre of solution.

You are required to determine the value of X in H_2X.

PROCEDURE

Pipette 25.0or 20.0cm^3 of BA1 into a conical flask

Add 2-3 drops of phenolphthalein indicator . titrate with BA2 from the burette.

Repeat the titration until you obtain a consistent results

RESULTS.

Volume of pipette used...cm^3

Final burette reading (cm$^{3)}$)			
Initial burette reading(cm^3)			
Volume of BA2 used (cm^3)			

Titre values used to calculate average volume of BA2 used...

Average volume of BA2 used

....
....

QUESTION

(a) determine the Molarity of BA1 (H=1, O=16)

(b) (i)determine the number of moles of BA1 that reacted with BA2

(II)the number of moles of H_2X that reacted

(iv) The Molarity of BA2

(v) The formula mass of X

1.8 UNEB 2013 545/4 (experiment to determine the percentage of water of crystallisation)

You are provided with the following

BA1 , which is a solution containing 11.40g of a hydrated salt, $Y.nH_2O$ per litre of solution.

BA2, which is a 0.1 M hydrochloric acid

You are required to determine the percentage of water of crystallisation in the hydrated salt

Procedure

Pipette 25.0(or 20.0 cm^3) of BA1 into a conical flask and titrate it with BA2 from the burette using methyl orange indicator.

Repeat the titration until you obtain consistent results

Record your results in the table

Results

Volume of pipette used.. cm^3

Final burette reading (cm^3)			
Initial burette reading (cm^3)			
Volume of BA2 used(cm^3)			

Titre values used to calculate average volume of BA2 used..

Average volume of BA2 used
....

....

Questions

a) Calculate
   i) The number of moles of hydrochloric acid that reacted

   ii) The number of moles of $Y.nH_2O$.

   iii) The concentration of BA1 in moles per litre

b) Determine
   i) The relative formula mass of $Y.nH_2O$

   ii) The value of n in $Y.nH_2O$

   iii) The percentage of water of crystallisation in the hydrated salts $Y.nH_2O$

1.9 UNEB 2014 545/3(experiment to determine the formula mass of the anhydrous acid)

BA1,which is a 0.043M sodium hydroxide solution.

BA2, which is a solution containing 6.35g per litre of a hydrated acid Q.

You are required to determine the formula mass of the anhydrous acid Q.

The acid Q reacts with sodium hydroxide in the ratio of 1:2

Procedure

Pipette 25.0(or 20.0) of BA1 into a conical flask. Titrate with BA2 from the burette using phenolphthalein indicator.

Repeat the titration until you obtain consistent results.

a)i) record your results in the table below

ii) volume of pipette used..cm^3

Final burette reading(cm^3)			
Initial burette reading (cm^3)			
Volume of BA2 used (cm^3)			

iv) Titre values to obtain average volume of BA2
v) Average volume of BA2 used

Calculate

c) Number of moles of sodium hydroxide that reacted

d) Number of moles of acid ,Q that reacted

e) Concentration in moles per litre of BA2

f) The formula mass of the anhydrous acid, Q(1 mole of the hydrated acid ,Q contains 36g of water of crystallisation

1.10 **UNEB 2019 545/3 (Experiment to determine the value of n in the salt)**

You are provided with the following

BA1, which is a solution made by dissolving 3.45g of a hydrated salt X.n H_2O in 250 cm^3 of water

BA2, which is a 0.1 M hydrochloric acid.

You are required to determine the value of n in the salt.

Procedure

Pipette 25cm^3(or 20 cm^3) of BA1 into a conical flask .add 2-3 drops of methyl orange indicator and titrate with BA2 from the burette.

Repeat the titration until you obtain consistent results.

Record your results in the table below

Volume of pipette used ....cm^3

Final burette reading (cm^3)			
Initial burette reading(cm^3)			
Volume of BA2 used (cm^3)			

Titre values of BA2 used for...

Average volume of BA2

Questions

a) Calculate the:
   i) Number of moles of hydrochloric acid that reacted

   ii) Number of moles of X.n H_2O that reacted(1 moles of X.n H_2O reacts with 2 moles of hydrochloric acid)

   iii) Number of moles of X.n H_2O in 250 cm^3 of BA1

b) Determine the value of n in X.nH_2O

*1.11 **UNEB 2020 545/3*** **(experiment to determine the percentage purity of the potassium hydrogen carbonate)**

You are provide with the following;

BA1, which is a 0.1 M hydrochloric acid

BA2, which is a solution of an impure sample hydrogen carbonate made by dissolving 10.0g of the impure salt in water to make 1 dm^3 of solution

a. Mole ratio of HCl: carbonate is 1;1

You are required to determine the percentage purity of the potassium hydrogen carbonate sample.

Procedure

Pipette 25.0 or 20.0 cm^3 of BA1 into a clean conical flask.

Add 2-3 drops of methyl orange indicator and titrate with BA1 from the burette. Record your results in table1

Repeat the procedure until you obtain consistent results

Volume of pipette...cm^3

Final burette reading (cm^3)			
Initial burette reading (cm^3)			
Volume of BA1 used (cm^3)			

a) i) state the volumes of BA1 used to calculate the average volume

ii) calculate the average volume of BA1 used

b) calculate the;

i) number of moles of hydrochloric acid that reacted

ii) number of moles of potassium hydrogen carbonate that reacted with hydrochloric acid in BA1

iii) concentration of potassium hydrogen carbonate in moles per dm^3

c)Determine the percentage purity of potassium hydrogen carbonate

HEAT OF REACTION

.2.1 Determination of heat of neutralization between two solutions (UNEB /UCE CHEMISTRY 545/4, 2012)

You are provided with the following:
Q, which is a solution of a base
R, which is solution of an acid
You are required to determine:
(i) the Molarity of the acid
(ii) the molar heat of reaction between the acid and the base.

PROCEDURE

(a) Using a measuring cylinder, measure 150.0cm^3 of **Q** and transfer into a 250cm^3 beaker. Add 50cm^3 of distilled water, mix and label it **BA1**.
(b) Transfer 100cm^3 of **R** into another 250cm^3 beaker using a measuring cylinder. Add 100cm^3 of distilled water, mix and label it **BA2**.
(c) Measure and record the initial temperature of **BA1**.
(d) Run 25.0cm^3 of **BA1** from the burette into a dry plastic beaker.
(e) Using a measuring cylinder, transfer at once 10cm^3 of **BA2** into the plastic beaker containing **BA1**.
Stir the mixture with thermometer and record the highest temperature attained by the mixture.
(f) Repeat the procedures (d) and (e) using 20.0, 30.0, 40.0 and 50.0cm3 of **BA2**.
(g) Record your results in the table below.

Initial temperature of BA1 = 24^oC

Table of Results

Volume of **BA2** used (cm^3)	10.0	20.0	30.0	40.0	50.0
Highest temperature attained by the mixture (^oC)	28	30	31	31.5	30

Questions:

(a) Plot a graph of highest temperature attained by the mixture against volume of **BA2** used.

(b) From the graph, determine:

(i) the volume of **BA2** required to neutralize 25.0cm^3 of **BA1**.

(ii) the maximum temperature change for the reacted

(c) Calculate the Molarity of **BA2**. [1 mole of base reacts with 1 mole of acid; Molarity of **BA1** = 1.5M]

(d) Determine the:

(h) Maximum heat evolved during the reaction. [Specific heat capacity of the mixture = 4.2Jg^{-1}K^{-1}; Density of mixture = 1gcm

(iii) molar heat of reaction between the acid and the base.

2.2 UNEB 2018 545/3 (experiment to determine the percentage purity of R)

You are provided with the following

BA1 ,which is a solution containing 80.3 g of an impure sample of base R per litre of solution.

BA2, which is a solution containing 2 moles of acid Q per litre of solution.

You are required to determine the percentage impurity of R

a) using a measuring cylinder, transfer 40.0 cm^3 of solution BA1 into a plastic beaker or cup
b) measure and record the temperature of the solution BA1 in the plastic beaker or cup.

c) Using a burette, transfer 50.0 cm^3 of BA2 into each of the six(6) test tubes.
d) To solution BA1 in the plastic beaker or cup, add solution BA2 from one of the test tube. Stir the mixture with a thermometer and record the highest temperature attained by the mixture.
e) Immediately add solution BA2 from another test-tube to the mixture obtained in (d), stir and record the highest temperature attained. continue adding solution BA2 from each of the remaining test tubes one at time, stirring the mixture and recording the highest temperature attained.
f) Record your results in the table below.

Volume of BA2 added(cm^3)	0.00	5.00	10.00	15.00	20.00	25.00	3.00
Highest temperature(c)							

a) Plot a graph of highest temperature (vertical axis) against volume of BA2 (horizontal axis)
b) From the graph, determine the volume of BA2 required to completely neutralise 40.0 cm^3 of BA1

c) Calculate the:
   i) Number of moles of Q that reacted.

   ii) Number of moles of R that reacted. (Q reacts with R in the ratio 1:2)

   iii) Concentration of R in moles per litre of BA1.

   iv) Concentration of R in gram per litre of BA1.(relative molecular mass of R=40)

d) Determine the percentage impurity of R.

2.3 UNEB 2018 545/4 (experiment to compare the enthalpies of neutralisation of alkali W and alkali Z with hydrochloric acid)

You are provided with the following:

BA1, Which is a 2 M hydrochloric acid solution.

BA2,which is a 2 M solution of an alkali W

BA3, which is a 2 M solution of an alkali Z. (keep the container of BA3 Covered)

Procedure

a) Using a measuring cylinder, transfer 20.0 cm of solution BA2 into a plastic beaker or cup.
b) Measure and record its temperature in the space provided in the table below, when volume of BA1=0.00cm^3.
c) Using a burette, transfer 5.00cm^3 of solution BA1 into each of the six(6) test-tubes.
d) To **solution BA2in** the plastic beaker or cup, add solution BA1 from one of the test-tubes, quickly stir the mixture with the thermometer, read and record the maximum temperature attained by the mixture.
   Immediately continue with the addition of **BA1** from the remaining test-tubes, one at a time, each time stirring with the thermometer and recording the maximum temperature attained by the mixture.
e) Record your results in the table below.
f) Repeat the procedure from(a) to (e) **with BA3.**

Volume of BA1 (cm^3)	Maximum temperature attained by mixture (C)	
	Mixture of BA1and BA2	Mixture of BA1 and BA3
0.00		
5.00		
10.00		
15.00		
20.00		
25.00		
30.00		

Questions .

a) Plot on the same axes, a graph of maximum temperature attained by mixture (vertical axis) against volume of **BA1** (horizontal axis)
b) Using the graphs you have plotted, determine the highest temperature for the reaction between hydrochloric acid and.
   i) W

ii)Z

c) Determine the maximum temperature change for each of the reactions.

d) Which one of the alkalis W and Z has a higher enthalpy of n neutralisation with hydrochloric acid.

e) Give a reason for your answer in (d)

2.4 UNEB 2012 545/4

You are provided with the following :

Q,which is a solution of a base

R, which is a solution of an acid

You are required to determine:

i) The Molarity of the acid.

ii) The molar heat of reaction between the acid and the base.

PROCEDURE

a) Using a measuring cylinder, measure 150.0 cm^3 of Q and transfer into a 250 cm^3beaker. Add 50 cm^3 of distilled water, mix and label it **BA1**
b) Transfer 100.0cm^3 of R into another 250 cm^3 beaker using a measuring cylinder. Add 100 cm^3 add 100 cm^3 of distilled water, mix and label it BA2
c) Measure and record the initial temperature of BA1.
d) Run 25.0 cm^3 of BA1 from a burette into a dry beaker.
e) Using a measuring cylinder, transfer at once 10.0 cm^3 of BA2 into the plastic beaker containing BA1.
Stir with the thermometer and record the highest temperature attained by the mixture.
f) Repeat procedures (d) and (e) using 20.0,30.0,40.0 and 50.0 cm^3 of BA2.
g) Record your results in the table below.
Initial temperature of **BA1**...

Table

Volume of BA2 used (cm^3)	**10.0**	**20.0**	**30.0**	**40.0**	**50.0**
Highest temperature attained by the mixture (0C)					

a) Plot a graph of highest temperature attained by the mixture against the volume of BA2 used

b)from the graph, determine;

i) the volume of BA2 required to neutralised 25.0 cm^3 of BA1

ii)the maximum temperature for the reaction.

b) Calculate the Molarity BA2.(1 mole of base reacts with 1 mole of acid; Molarity of BA1=1.5M)

c) Determine the:

h) Maximum heat evolved during the reaction

iii) **Molar** heat of reaction between the acid and the base

2.5 UNEB 2010 545/3 (experiment to determine the mole ratio of the reaction between R and Z)

You are provided with the following

BA1, which is a 1M solution of an acid **R**

BA2, which is a solution of a basic compound **Z.**

You are required to determine the mole ratio of the reaction between **R and Z**

Procedure

- **a)** Measure 60 cm^3 of **J** using a measuring cylinder and transfer into the 250mlglass beaker. Add 60 cm^3 of distilled water and stir to mix well. Label the solution
- **b)** Fill the burette with BA1, run 30 cm^3 in to the plastic beaker, measure and record its initial temperature.
- **c)** Using a measuring cylinder. Transfer 5 cm^3 of BA2into the plastic beaker. stir the mixture using the thermometer and record the maximum temperature ,**T, reached by the mixture.** wash both the thermometer and the plastic and dry them
- **d)** Repeat the procedures (b) and (c) using the set of volumes of BA1 and BA2 indicated in the table below.

e) Record in the same axes ,the values of**T_0,and △ T=T-T_0 for each experiment.**

Experiment number	1	2	3	4	5	6
volume of BA1	30	25	20	15	10	5
Volume of BA2	5	10	15	20	25	30
Initial temperature T_0 (C)						
Maximum temperature, T						
T-T $_0$ (c)						

a) **Plot a graph of T against volume of** BA1
b) **From the graph,** determine the
i) **Maximum value of T**

ii) **Corresponding volumes ofBA1 and BA2that give the maximum value of T**

c) **Calculate the mole ratio of the reaction between R and Z (concentration of BA2 is 1M**

RATE OF REACTION

3.1UNEB 2014 545/5

You are provided with the following

DA1, which is a solution of potassium iodide.

DA2, which is a solution of sodium thiosulphate

DA3, which is a solution of hydrogen peroxide.

In acidic medium, hydrogen peroxide reacts with potassium iodide to liberate iodine which after some time form a blue colouration with starch indicator.

You are required to investigate how the rate of formation of iodine varies with the amount of hydrogen peroxide

PROCEDURE

a) Run 25.0 cm^3 of DA1, from the burette into a conical flask(
b) Add 10 cm of DA2bfollowed by 5 cm of 2M sulphuric acid and 2cm of starch
c) Transfer at once using a measuring cylinder 5cm of DA3 and immediately start the stop clock.
d) Shake the mixture and record the time ,t, at which the blue colouration just appears
e) Repeat procedures (a) to (d) with the volumes of DA3 shown in the table below
f) And record your observation on the table

Volume of DA3 (cm)	Time ,t (s)	Rate 1/t(s^{-1})
5		
10		
15		
20		
25		
30		

QUESTIONS

a) Calculate the values of 1/t and record yours answers in the table.
b) Plot a graph of 1/t against volume of DA3
c) Explain how the rate of formation of iodine varies with the volume of DA3.

3.2 UNEB 2011 545/4(Experiment to determine the rate of reaction between magnesium and dilute sulphuric acid varies with concentration of sulphuric acid)

You are provided with the following.

BA1, which is a 2M sulphuric acid

Z, which is a piece of magnesium ribbon.

You are required to determine and dilute sulphuric acid varies with concentration of sulphuric acid.

Procedure

a) Cut the piece of magnesium into five pieces each of which is 2cm long
b) Fill the burette with BA1 and run 15cm into a glass beaker. add 20 cm of water and shake well to mix

c) Add one piece of the magnesium ribbon to the solution in the beaker and start the stop clock at the same time. Swirl the solution continuously ensuring that magnesium ribbon is always inside the solution.

d) Note and record in the table below, the time taken t, in seconds for the magnesium ribbon to dissolve completely .wash and dry the beaker

e) Repeat procedures (b) to (d) for the volumes of BA1 water shown in the table below.

Table

Experiment number					
Volume of water cm					
Volume of BA1 cm					
Time , t (s)					
1/t (s^{-1})					

a) Calculate the value of 1/t for each experiment and your answers in the table above

b) Plot a graph of 1/t(vertical axis) against volume of BA1 (horizontal axis)

c) Use the graph to determine.

i) The rate of reaction (value of 1/t), when the volume of BA1=22.5 cm

ii) the concentration of BA1 in moles per dm^3

d) State the relationship between the rate of the reaction and the concentration of BA1.

e) Determine the gradient of the graph that you have plotted in (b)

3.3 UNEB 2011 545/5(experiment to determine the mole ratio of the reaction between the base and the acid.

S, which is a solution of an acid .

T, which is a solution of base

You are required to determine the mole ratio of the reaction between the base and the acid.

Procedure

a) Using a measuring cylinder measure,120 cm^3 of S and transfer it into a 250cm beaker. Add 80.0 cm of distilled water, mix and label it as BA1.

b) Transfer 180.0 cm of T into another 250 cm beaker using a measuring cylinder. Add 20.0cm of distilled water, mix and label it BA2.

c) Run 25.0 cm of BA1 from the burette into a dry plastic beaker.

d) Add at once 10.0 cm of BA2 from a measuring cylinder into the plastic beaker containing BA1.gently stir with a thermometer and record the highest temperature attained by the mixture.
e) Repeat procedures (c) and (d)using 15.0 ,20.0,25.0,30.0, 35.0 and 40.0 cm of BA2
f) Record your results in the table.

Table

Volume of BA2 used(cm)	10.0	15.0	20.0	25.0	30.0	35.0	40.0
Temperature of the mixture(^0C)							

Question

a) Plot a graph of temperature of mixture against volume of BA2.
b) From the graph, determine the maximum volume of BA2 required to react with 20 cm^3 of BA1
c) Calculate:
    j) The number of moles of the base that reacted (Molarity of BA2=1.8M)

ii) the number of moles of the acid that reacted.(Molarity of BA1=1.8 M)

d) Determine the mole ratio of the reaction between the base and the acid.

QUALITATIVE ANALYSIS

6.1 Introduction

Qualitative analysis can be referred to as the determination of the chemical composition e.g determining the anions and cat ions that make up a given sample. This is done by performing chemical tests on the sample. The chemical tests are carried out on the solid of the compounds which are either soluble or insoluble in distilled water or on aqueous solutions made by dissolving the solids in distilled water. At O-level, the cat ions that will be dealt with include:

NH_4^+, Ca^{2+},Mg^{2+} , Pb^{2+}, Zn^{2+}, Al^{3+}, Fe^{2+}, Fe^{3+}, Cu^{2+},

The anions to be analysed include:

Cl^-, SO_4^{2-}, NO_3^-, CO_3^{2-}, HCO_3^-, SO_3^{2-}, Br^-, I^-

The study of qualitative analysis involves carrying out specific chemical tests, recording observations and making deductions based on the observations. The tests carried out in qualitative analysis are classified into two major categories i.e. preliminary tests and tests for ions in solution.

PRELIMINARY EXAMINATION OF SUBSTANCES

A preliminary test is an elementary test that can give a clue on nature and identity of the substance under test. Preliminary tests include:

- Noting the colour and appearance of the substance under investigation.
- The effect of heat on the substance.
- The effect of gases evolved on the litmus paper.
- The effect of dissolving the substance in water.

6.1 colour of substances (solids, solutions and gases)

These tests involve noting the colour and texture of the substance. Since cations in their solid state or as dissolved aqueous solutions have characteristic colours. Noting the colour of solid or solution gives a very important clue on the cations present.

(i) Colour of solids.

Colour	Possible identity of the solid substance
Black	Oxides or sulphides e.g CuO, PbS, FeS
White	Compounds of a non-transition metal cations e.g Zn^{2+}, Pb^{2+}, Ca^{2+}, Al^{3+},Mg^{2+}, Ba^{2+}, NH_4^+, e.t.c
Blue	Compounds containing Cu^{2+}
Yellow and brown	Fe^{3+}, Fe_2O_3 (brown)
Green or pale yellow	Fe^{2+}, copper salt or copper carbonate

(ii) Colour of solutions

Colour	Possible chemical components of the solution
Colourless	Components of non transition metal cations e.g compounds of Zn^{2+}, Pb^{2+}, Al^{3+}, Mg^{2+}, e.t.c
Brown and yellowish brown	Fe^{3+}
Green	Fe^{2+}, Cu^{2+}, e.g $CuCO_3$
Blue	Cu^{2+}
Deep Blue	$[Cu(NH_3)_4]^{2+}$

(iii) Colour of gases

Colour	**Identity of gases**
Colourless	O_2, H_2, CO_2, NH_3, SO_2 e.t.c

Green/yellow	Cl_2
Brown	NO_2

6.2 Effect of heat on substances

To investigate the effect of heat, place a sample (usually a spatula endful) of the compound in a hard test tube and heat it on a Bunsen flame gently first and then strongly until there is no further change. This ensures concise observation of the changes that take place on the substance.

During the heating, a student should bear the following points in mind:

- Observing and recording the colour changes that take place on the substance.
- Identification of vapours and gases evolved (if any). When the sample decomposes on heating, they usually give off a gas and a solid residue is formed. It is therefore important that during the heating, moist litmus paper (red and blue) is placed at the mouth of the combustion tube and this serves as the basic test that can be used to establish the identity of a gas.
- Hydrated compounds give off water of crystallization and this can be identified using white anhydrous copper(II)sulphate which should turn blue.
- Observing and recording the colour of the solid residue when hot and on cooling.

These gases can be identified by noting the colour, smell, effect of gas on litmus paper, action of gas on a burning splint, and confirmatory test can also be carried out for some gases.
The observations and deductions needed for the above points can be summarized below:

(i) Observation of the gas given out

Observation	Deduction
Water vapour give off	Water or hydrated salt present
Carbon dioxide gas given off	Carbonate present
Nitrogen dioxide gas & oxygen gas given off	Nitrate other than that of Na, K or NH_3 present
Ammonia gas given off	Ammonia salt, NH_4^+present
Chlorine gas given off	Unstable chlorides present

(ii) Effect of litmus papers on gases

Effect	Possible identity on the gas
No effect	Neutral gases e.g O_2, H_2
Turns blue litmus pink (pale red)	Weakly acidic gases e.g CO_2
Turns red litmus blue	NH_3 (the only alkaline gas)
Turns blue litmus red then bleached	Cl_2 or SO_2
Turns blue litmus red	HCl, NO_2

(iii) Smell of gases

Smell	Possible identity of the gas
Odourless/no smell	O_2, H_2, CO_2
Pungent	NH_3, NO_3, Cl_2
Irritating	HCl, NO_2, Cl_2
Choking	SO_2
Smell of rotten eggs	H_2S

(iv) Confirmatory test for gases

A confirmatory test establishes beyond doubt the identity of a substance.

The table below gives confirmatory test for the common gases

Test	Observation	Identity of gas
Glowing splint	Relit	O_2
Lighted splint	Gives a pop sound	H_2
Lime water	Turns milky	CO_2
Reaction with concentrated HCl	Gives dense white fumes	NH_3
Reaction with $KMnO_4$	Solution turns from purple to colourless	SO_2
Action on moist red litmus	Turns it blue	NH_3

(V) Observations of the solid residues left after heating

Observation	Deduction
Yellow solid when hot and turns white when cold	ZnO formed, Zn^{2+} present
Red-brown solid when hot and turns yellow when cold	PbO formed, Pb^{2+} present
Pale solid leaves a red brown solid	Fe_2O_3 formed, Fe^{2+} oxidized to form

after heating	Fe^{3+}
Green solid leaves a black solid after heating	CuO or FeO formed, Cu^{2+} or Fe^{2+}present

6.3 How to record observations during and after heating

Procedure: Put two spatula end fuls of a substance in a clean dry test tube and heat gently, then strongly.

OBSERVATION	DEDUCTION
Colourless condensate that turns white anhydrous $CuSO_4$ blue	Water of crystallization therefore hydrated salt, OH^- or HCO_3^- present.
Red-brown gas with an irritating smell, turns damp blue litmus red.	NO_2 decomposed, NO_3^- present.
Colourless gas that turns damp blue litmus pink and lime water milky.	CO_2 gas, CO_3^{2-} or HCO_3^- decomposed other than that of Na, K
Colourless gas with choking or pungent smell that turns damp red litmus blue and forms dense white fumes with conc. HCl	NH_3 gas, NH_4^+ salt decomposed. Probably due to thermal decomposition of NH_3^+ salt.
Colourless gas has an irritating smell turns blue litmus red and is bleached, the gas turns acidified dichromate solution from orange to green.	SO_2 gas, SO_3^{2-} or SO_4^{2-} decomposed.
Colourless gas with irritating smell, turns damp blue litmus red and forms dense white fumes with, conc. NH_3.	HCl gas from hydrated chloride.
Greenish yellow gas with an irritating smell bleaches damp blue litmus paper.	Cl_2 gas, evolved on heating Cl^- strongly.
White fumes (smoky) with choking smell, turns blue litmus red and turns $BaCl_2$ or $Ba(NO_3)_2$ solution milky.	SO_2 gas given off from HSO_4^- or SO_4^-.
White sublimate	NH_4^+
Solid residue, yellow when hot & white when cold .	ZnO, Zn^{2+} present
Solid residue red when hot & yellow when cold	PbO, Pb^{2+} present
Solid residue, white in colour turns black on strong heating	Cu^{2+}, white residue is anhydrous compound of copper (II) turns black due to formation of CuO
Given compound turns to black residue	Cu^{2+} metal oxide formed
Pale green solid, turns to dirty white and finally gives a red-brown residue with the evolution of water vapour	Compound of Fe^{2+} e.g $FeSO_4.7H_2O$ decomposes to give Fe_2O_3 (red brown residue)

and SO_2 gas	

6.4 The effect of dissolving the substance in water

6.4.1 Soluble and insoluble compounds

Below is a list of substances and their solubilities in water:

- All nitrates are soluble.
- All K, Na and NH_4^+ salts are soluble.
- All carbonates are insoluble except sodium, potassium and ammonium carbonates.
- All sulphates are soluble except $PbSO_4$ and $BaSO_4$ .Sulphates of calcium and silver are sparingly soluble.
- All chlorides are soluble except AgCl and $PbCl_2$. But lead(II) chloride is soluble on heating.
- All hydroxides are insoluble except NaOH, KOH and NH_4OH. Calcium hydroxide is sparingly soluble.

6.4.2 Recording observations about solubility

Procedure: You are provided with substance Q. To two spatula end fuls of Q in a test tube, add about $3cm^3$ of water and shake to dissolve it and write your observations and deductions.

Observations	Deduction
Q dissolves forming a colourless solution	Q is a soluble salt of Zn^{2+}, Al^{3+} or Pb^{2+} or NH_4^+
Q dissolves forming a pale green solution	Q is a soluble salt of Cu^{2+} or Fe^{2+}
Q dissolves forming a yellowish brown solution	Q is a soluble salt of Fe^{3+}
Q dissolves forming a pale blue solution	Q is a soluble salt of Cu^{2+}
Q is insoluble in water but dissolves in dilute nitric acid to form a green solution	Cu^{2+} ions present Fe^{2+} ions present

6.5 Terms used in qualitative analysis

There are a number of terminologies used in stating observations and deductions made during qualitative analysis. Some of them are;

Precipitate (ppt). This is an insoluble solid that separates out from a solution. It is normally made up of small particles with no definite shape. It is basically an insoluble salt formed when two solutions react.

Some of the ions that can be identified by use of precipitate formed include;

Cations	Anions
Ca^{2+}, Mg^{2+},Pb^{2+}, Fe^{2+}, Fe^{3+}, Al^{3+}, Cu^{2+}	Cl^{-}, SO_4^{2-}, CO_3^{2-}

Residue: A residue a solid substance left when a sample is heated or an insoluble substance is filtered e.g when a compound of copper is heated, a black substance CuO is left. The deduction would be “a black residue probably CuO is left”.

Soluble and insoluble: If the salt is insoluble, it will not dissolve to form a colourless or coloured solution but will form a suspension and you cannot see through it.

A suspension is a solution having undissolved solid suspended through it.

Examples of insoluble salts are listed below

Chlorides: $PbCl_2$ & AgCl, but $PbCl_2$ is soluble in hot water
Sulphates: $PbSO_4$ and $BaSO_4$
Hydroxides: $Pb(OH)_2$, $Al(OH)_3$, $Fe(OH)_3$, $Fe(OH)_2$, $Cu(OH)_2$
Carbonates: all carbonates except $(NH_4)_2CO_3$ are insoluble
Iodides: PbI_2

Sometimes you are given a mixture of two salts one of which is soluble and the other is insoluble. The soluble one forms a filtrate and the insoluble form the residue.

Hydrated and anhydrous: A hydrated substance is one which contains water either as part of its composition as water of crystallization or due to absorption, whereas an anhydrous compound is one which does not contain any water.

6.6 IDENTIFICATION OF IONS IN AQUEOUS SOLUTIONS

When soluble compounds are dissolved in water, they exist as free ions and these ions can be identified by use of chemical substances (reagents). These compounds react with the ions present in the solution to give characteristic observation.

The reagents are usually added to the solution of the substance drop wise until in excess. In the instruction, it is usually specified whether to add only a few drops of the reagents or add it drop by drop until the reagent is in excess. Drop by drop addition of a reagent makes it possible for a student to make accurate observation after each addition of a drop of the reagent.

Other ions are identified by being soluble in certain reagents e.g

Zn^{2+} soluble in both NaOH and NH_4OH
Pb^{2+} soluble only in NaOH
Al^{3+} soluble only in NaOH
Cu^{2+} soluble only in NH_4OH

Note: Sometimes you are asked to write the ionic equation for the reaction that lead to the formation of a precipitate. In this case identify the precipitate formed and then write it in form of ions. For example, when KI (aq) is reacted with $Pb(NO_3)_2$, a yellow precipitate of PbI_2 is formed according to the equation;

$$2KI\,(aq) + Pb(NO_3)_2\,(aq) \longrightarrow PbI_2\,(s) + 2KNO_3(aq)$$

Therefore, the ionic equation for the reaction above is written as;

$$2I^-\,(aq) + Pb^{2-}\,(aq) \longrightarrow PbI_2\,(s)$$

What is important here is to recall the insoluble salts under this topic of Qualitative analysis.

Example:

You are provided with substance X, which is a mixture of soluble and an insoluble salt. To two spatula endfuls of X in a test tube, add about 5cm^3 of water. Shake the mixture and filter. Keep both the filtrate and residue.

Record your observations and deductions.

Observations	**Deductions**
The filtrate is colourless solution The residue is a white a white solid	Soluble salts of Zn^{2+}, Al^{3+}, Pb^{2+} or NH_4^+ Insoluble salts of Zn^{2+}, Al^{3+} or Pb^{2+}
The filtrate is a colourless solution The residue is a green solid	Soluble salt of Zn^{2+}, Al^{3+} or Pb^{2+} Insoluble salt of Cu^{2+} or Fe^{2+}
The filtrate is a colourless solution The residue is a blue solid	Soluble salts of Zn^{2+}, Al^{3+}, Pb^{2+} or NH_4^+ Insoluble salt of Cu^{2+}
The filtrate is a pale green solution The residue is a white solid	Soluble salt of Cu^{2+} or Fe^{2+} Insoluble salt of Zn^{2+}, Al^{3+} or Pb^{2+}

6.6.1 Action of sodium hydroxide on solutions of cat ions

Procedure: To 2cm^3 of a solution in a test tube, add sodium hydroxide solution drop wise until in excess.

Observation	**Deduction**
No ppt forms, but on warming a colourless	NH_3, $NH4^+$ confirmed

gas which turns moist red litmus paper blue and forms dense white fumes with conc.HCl is evolved	
White ppt formed, insoluble in excess	Ca^{2+} or Mg^{2+} present
White ppt formed, soluble in excess, forming a colourless solution	Zn^{2+}, Al^{3+} or Pb^{2+} present
Green ppt formed, insoluble in excess, turns brown on standing in air	Fe^{2+} present
Brown ppt, insoluble in excess	Fe^{3+}
Blue ppt formed, insoluble in excess	Cu^{2+}

Green ppt insoluble (Fe^{2+})

No ppt formed (NH4) **Blue ppt insoluble (Cu^{2+})**

white ppt soluble **NaOH** white ppt insoluble (Ca^{2+},Mg^{2+} CAM)

(Zn^{2+},Al^{3+}, Pb2+ ZAP) **brown ppt insoluble (Fe^{3+})**

6.6.2 Action of dilute ammonia solution on solutions of cat ions

Procedure: To 2cm^3 of a solution in a test tube, add dilute ammonia solution drop wise until in excess.

Observation	**Deduction**
No observable changed	Ca^{2+} confirmed
White ppt formed, insoluble in excess	Al^{3+}or Mg^{2+} present
White ppt formed, soluble in excess, forming a colourless solution	Zn^{2+} confirmed
Green ppt formed, insoluble in excess, turns brown on standing	Fe^{2+} present
Brown ppt, insoluble in excess	Fe^{3+}
Blue ppt formed, soluble in excess, to give a deep blue solution n	Cu^{2+} confirmed

Copper(II) hydroxide and zinc hydroxide dissolve in excess dilute ammonia solution, forming soluble complex ions.

6.6.3 Action of sodium carbonate solution on solutions of cat ions

Procedure: Add sodium carbonate solution to test solution, warm and boil.

Observation	**Deduction**

White ppt	Ca^{2+}, Mg^{2+}, Zn^{2+}or Pb^{2++} present
White ppt, accompanied by effervescence of CO_2	Al^{3+}
Blue ppt , turns black on heating	Cu^{2+}
Green ppt	Fe^{2+}
Brown ppt, accompanied by effervescence of CO_2	Fe^{3+}

6.6.4 Action of dilute HCl or H_2SO_4 on solutions or solids of anions

Procedure: Add cold dilute **HCl or H_2SO_4** to the residue/ solid substance in a test tube. If there is no reaction, warm gently but do not boil.

Observation	Deduction
Effervescence of a colourless gas, which turns lime water milky and moist blue litmus red	CO_2 , CO_3^{2-} or HCO_3^{2-} present
A colourless gas which turns moist blue litmus red and bleaches it; and turns acidified potassium dichromate solution green is evolved	SO_2, SO_3^{2-} confirmed
The residue dissolves in acid but no gas is given off	Cl^-, SO_4^{2-}, NO_3^-, Br^- or I^- probably present

6.6.5 Action of conc. H_2SO_4 on solutions or solids of anions

Procedure: To the residue in a test tube, add **conc. H_2SO_4** . if there is no reaction, warm gently but do not boil.

Observation	Deduction
Residue dissolves, no ppt formed or gas liberated	SO_4^{2-}
Effervescence of a colourless gas, turns lime water milky and moist blue litmus red	CO_2 , CO_3^{2-} confirmed
A colourless gas, turns moist blue litmus red and bleaches it; and turns acidified potassium dichromate solution green	SO_2, SO_3^{2-} confirmed
Effervescence of a colourless gas, turns moist blue litmus red and forms dense white fumes with conc. NH_3	HCl (g), Cl^- present
Effervescence of reddish-brown vapour, turns moist blue litmus red and brown liquid is formed	Br_2 , Br^- confirmed
A fuming colourless gas, turns blue litmus red and formed black solid on heating	HI(g), I_2 solid, I^- confirmed

6.7 CONFIRMATORY TESTS FOR CATIONS

A confirmatory test is one which is used to confirm the presence of a particular ion in solution. The reaction that leads to a confirmatory test is possible for only one ion. The rest of the ions will give different results.

TEST	OBSERVATION	ION CONFIRMED
Add aqueous ammonia solution drop wise until in excess	White ppt formed, soluble in excess, forming a colourless solution	Zn^{2+}
	Blue ppt formed, soluble in excess, to give a deep blue solution	Cu^{2+}
Add 2-3 drops of potassium iodide solution	Yellow ppt formed	Pb^{2+}
	Brown ppt formed	Cu^{2+}
Add dilute sulphuric acid	White ppt of $PbSO_4$ formed	Pb^{2+}
Add dilute hydrochloric acid and heat	White ppt of $PbCl_2$ formed. On heating, ppt dissolves forming a colourless solution and white ppt reappears on cooling	Pb^{2+}
Add potassium chromate(VI) solution	Yellow ppt formed	Pb^{2+}
(i) Add Hydrogen peroxide solution (ii) Add potassium hexa cyanoferrate (III)	A green ppt turns brown Deep blue ppt formed	Fe^{2+}
Add dilute sodium hydroxide solution and warm the mixture	No ppt forms, but on warming a colourless gas which turns moist red litmus paper blue and forms dense white fumes with conc.HCl is evolved	NH_3, NH^{4+}
Add potassium thiocyanate solution	Blood red solution formed	Fe^{3+}
Add potassium hexacyanoferrate (II) solution	Deep blue ppt formed Brown ppt formed	Fe^{3+} Cu^{2+}

6.8 TESTS FOR ANIONS IN SOLUTION AND THEIR CONFIRMATION PROCEDURES

TEST	OBSERVATION	DEDUCTION
(a) i) Add lead(II) nitrate solution	White ppt formed	Cl^- , SO_3^{2-} , SO_4^{2-} or CO_3^{2-}
ii) Add lead(II) nitrate solution followed by dilute nitric acid	White ppt, insoluble in dilute nitric acid	Cl^- or SO_4^{2-}
iii) Add lead(II) nitrate solution followed by	White ppt, insoluble in dilute nitric acid. The ppt	$PbCl_2$, Cl^- confirmed

dilute nitric acid and heat the mixture	dissolves on heating and reappears on cooling	
iv) Add lead(II) nitrate solution followed by dilute nitric acid and heat the mixture	White ppt, insoluble in dilute nitric acid. The ppt does not dissolve on heating	$PbSO_4$, SO_4^{2-} confirmed
(b) i) Add barium nitrate or barium chloride solution	White ppt formed	SO_3^{2-} , SO_4^{2-}, or CO_3^{2-}
ii) Add barium nitrate (or lead(II) nitrate) followed by dilute nitric acid	White ppt, insoluble in dilute nitric acid	SO_4^{2-} confirmed
iii) Add barium chloride followed by dilute hydrochloric acid	White ppt, insoluble in dilute hydrochloric acid	SO_4^{2-} confirmed
(c) i) Add silver nitrate solution followed by dilute nitric acid	White ppt formed	Cl^- confirmed
	Pale yellow ppt formed	Br^- confirmed
	Yellow ppt formed	I^- confirmed

WORKED EXAMPLES ON QUALITATIVE ANALYSIS

4.1 UNEB/UCE 2010 545/5 Chemistry Practical

You are provided with substance I which contains two cat ions and one anion. You are required to carry out the following tests on I and identify the cat ions and anions in I. Identify any gas(es) evolved.

TESTS	OBSERVATIONS	DEDUCTIONS
(a)Add about 10cm3 of water to two spatula end-fuls of I in a boiling tube. Boil and filter while hot. Keep both filtrate and residue. Divide the filtrate into five parts.		
(b) (i) To the first part of the filtrate, add dilute sodium hydroxide solution drop-wise until in excess.		
(ii)To the second part of the filtrate, add dilute ammonia solution drop-wise until in excess.		
(iii)Use the third part of the filtrate to carry out a test of your own choice to confirm one of the cat ions in I.		
(iv)To the fourth part of the filtrate, add dilute nitric acid followed by 2-3 drops		

of barium chloride.		
(v) To the fifth part of the filtrate, add dilute nitric acid followed by 2-3 drops of silver nitrate solution.		
(c) Wash the residue with hot water and dissolve it in hot dilute sulphuric acid. Cool and filter. Divide the filtrate into two parts.		
(i) To the first part of the filtrate, add dilute sodium hydroxide solution drop-wise until in excess.		
(ii) To the second part of the filtrate, add dilute ammonia solution drop-wise until in excess.		

(d) (i) The cat ions in I are:

(ii) The anion in I is:

4.2 UNEB/UCE 2011 545/4 CHEMISTRY PRACTICAL

You are provided with substance L, which contains two cat ions and one anion. Carry out the following tests on L to identify the cat ions and anion contained in it. Identify any gas(es) that may be evolved. Record your observations and deductions in the table below:

TESTS	**OBSERVATIONS**	**DEDUCTIONS**
(a) Shake about 2 spatula end fuls of L with about $2cm^3$ of water, add dilute sodium hydroxide drop-wise until in excess and filter. Keep both the filtrate and the residue.		
(b) To the filtrate, add dilute nitric acid drop-wise until the solution is just acidic. Divide the solution into five parts. (i) To the first part of the solution, add dilute sodium hydroxide solution drop-wise until in excess.		
(ii) To the second part of		

the solution, add dilute ammonia solution drop-wise until in excess		
(iii) use the third part of the solution to carry out a test of your own choice to confirm one of the cat ions in L. Record your tests, observations and deductions in the spaces provided.		
(iv) To the fourth part of the solution, add 2-3 drops of barium chloride solution		
(v) To the fifth part of the solution, add 2-3 drops of silver nitrate solution		
(c) Wash the residue and dissolve it in dilute nitric acid and divide the acidic solution into two portions. (i) To the first portion of the acidic solution, add dilute sodium hydroxide solution drop-wise until in excess.		
(ii) To the second portion of the acidic solution, add dilute ammonia solution drop-wise until in excess.		

(d) (i) The cat ions present in L are:

(ii) The anion present in L is

<u>4.3 UNEB/UCE 2011 545/3 Chemistry Practical</u>

You are provided with substance Y, which contains two cat ions and one anion. Carry out the following tests on Y to identify the cat ions and the anion contained in it. Identify any gas(es) that may be evolved. Record your observations and deductions in the table below:

TESTS	**OBSERVATIONS**	**DEDUCTIONS**
(a) Heat a spatula end fuls of Y strongly in a dry test tube.		
(b) Dissolve two spatula end fuls of Y in about $5cm^3$ of water (add few drops of dilute nitric acid if necessary) To the solution, add dilute sodium hydroxide until there is no further change and filter. Keep both the filtrate and the residue.		
(c) To the filtrate, add dilute nitric acid drop wise until it is just acidic. Divide the acidic solution into four parts. (i) To the first part of the acidic solution, add dilute sodium hydroxide drop wise until in excess.		
(ii) To the second part of the acidic solution, add dilute ammonia solution drop wise until in excess.		
(iii) To the third part of the acidified solution, add 2-3 drops of lead(II) nitrate.		
(iv) Use the fourth part of the acid solution to carry out a test of your own choice to confirm the anion in Y. Add barium nitrate solution and boil		
(d) Dissolve the residue in a small amount of dilute		

nitric acid. Divide the solution into two portions. (i) To the first portion of the solution, add sodium hydroxide solution drop wise until in excess.		
(ii) To the second part of the solution, add dilute ammonia solution drop wise until in excess.		

(e) (i) The cat ions in Y are:

(ii) The anion in Y is

4.3 UNEB/UCE 2012 545/5 Chemistry Practical

You are provided with substance **Q**, which contains two cat ions and one anion. Carry out the following tests on **Q** to identify the cat ions and the anion contained in it. Identify any gas(es) that may be evolved. Record your observations and deductions in the table below (17marks)

TESTS	OBSERVATIONS	DEDUCTIONS
(a) Heat a spatula end fuls of **Q** strongly in a dry test tube		
(b) To two spatula end fuls of **Q**, add dilute nitric acid drop wise with warming until the solid just dissolves		
(c) Cool and add dilute sodium hydroxide solution drop wise until in excess. Filter and keep both the filtrate and residue.		
(d) To the filtrate, add dilute nitric acid drop wise until the solution is just acid. Divide the solution into three parts.	-	-
(i) To the first part, of the solution, add dilute sodium hydroxide solution drop wise until in excess.		

(iii) To the third part of the solution, add 2-3 drops of silver nitrate solution followed by excess ammonia solution.		
(e) Wash the residue with water and dissolve it in dilute hydrochloric acid. Divide the solution into two parts.	-	-
(i) To the first part of the solution, add sodium hydroxide solution drop wise until in excess.		
(ii) To the second part of the solution, add dilute ammonia solution dropwise until in excess		
(ii) To the second part of the solution add dilute ammonia solution drop wise till excess		

f) i) the cat ions in Q are:

(ii) The anion in Q is:

4.4 UNEB/UCE 2012 545/3 CHEMISTRY PRACTICALS

You are provided with substance **X**, which contains two cations and one anion. You are required to carry out the following tests on **X** to identify the cations and the anion in **X**. Identify any gas(es) evolved and record your observations and deductions in the spaces provided. (16marks)

TESTS	OBSERVATIONS	DEDUCTIONS
(a) Heat a spatula end fuls of X strongly in a dry test tube		-
(b) To three spatula end fuls of X, add about $5cm^3$ of dilute nitric acid and warm to dissolve. Add dilute sodium hydroxide drop wise until in excess, and filter. Keep both the filtrate and residue.		

(c) To the filtrate, add dilute nitric acid drop wise until the solution is just acidic. Divide the filtrate into five parts. (i) To the first part of the filtrate add dilute sodium hydroxide solution drop wise until in excess		-
(ii) To the second part of the filtrate, add dilute ammonia solution drop wise until in excess.		
(iii) To the third part of the filtrate, add 2-3 drops of potassium iodide solution.		
(iv) To the fourth part of the filtrate, add 2-3 drops of lead(II) nitrate solution and warm.		
(v) To the fifth part of the filtrate, add 2-3 drops of barium nitrate solution.		
(d) Wash the residue and dissolve in $3cm^3$ of dilute nitric acid. Divide the solution into two parts. (i) To the first part of the solution, add dilute sodium hydroxide solution drop wise until in excess.		
(ii) To the second part of the solution, add dilute ammonia solution drop wise until in excess.		

(e) (i) The cat ions in X are:

(ii) The anion in X is:

4.5 UNEB/UCE 2013 545/3 Chemistry Practical

You are provided with substance **Y**, which contains **two** cat ions and **one** anion. Carry out the following tests to identify the cat ions and the anion in **Y**. Identify any gases evolved. Record your observations and deductions in the table below.
(18marks)

	TESTS	OBSERVATIONS	DEDUCTIONS
(a)	Heat a spatula end ful of Y strongly in a dry test tube		
(b)	To two spatula end fuls of Y, add dilute nitric acid drop wise until the solid has just dissolved. Then add dilute sodium hydroxide solution drop wise until in excess. Filter and keep both the filtrate and the residue.		
(c) (i)	To the filtrate, add dilute nitric acid drop wise until the solution is just acidic. Divide the solution into five parts. To the first part of the acidic solution, add dilute sodium hydroxide drop wise until in excess.		
(ii)	To the second part of the acidic solution, add dilute ammonia until in excess.		
(iii)	To the third part of the acidic solution, add 5 drops of concentrated nitric acid followed by 1-2 drops of starch solution.		
(iv)	To the fourth part of the acidic solution, add 2-3 drops of silver nitrate solution followed by excess dilute ammonia solution.		
(v)	To the fifth part of the acidic solution, add 2-3 drops of lead(II)nitrate solution.		
(d) (i)	Wash the residue with dilute sodium hydroxide solution and then dilute hydrochloric acid until the solid ha just dissolved. Divide the solution into three parts. To the first part of the solution, add 2-3 drops of sodium carbonate solution		
(ii)	To the second part of the solution, add dilute sodium hydroxide solution drop wise		

	until in excess.		
(iii)	To the third part of the solution, add an equal volume of water followed by dilute ammonia solution drop wise until in excess.		

(e) Identify the:

(i) cat ions in Y :

(ii) anion in Y :

TECHNICAL ADVICE TO STUDENTS

Read and adhere to the following points. Do not fail your practical out of ignorance and minor but binding mistakes.

- Take note of the conventional way of writing chemical symbols and formulae.
- Restrict yourself to only the number of ions mentioned in the question paper. E.g You are provided with substance **Y**, which contains **two** cat ions and **one** anion. In this case, in the space for your deduction, do not list more than two cat ions for each observation made, except soluble salts that form colourless filtrate (Ca^{2+}, Mg^{2+} Zn^{2+}, Al^{3+}, Pb^{2+}, NH_4^+ ions) and amphoteric salts that are soluble in sodium hydroxide solution (Zn^{2+}, Al^{3+}, Pb^{2+} ions). Likewise, do not write more than one anion for each observation made (except Cl^- and SO_4^{2-} ions which gives the same observation when reacted with lead(II)nitrate solution; and CO_3^{2-} and HCO_3^{2-} which liberates CO_2 when heated or on addition of an acid). Adding more ions than demanded, in one observation made attracts loss of marks i.e. ½ mark for each extra ion added.
- Correct deduction comes from correct observations made. Therefore, there is no mark for a correct deduction when the observation is wrong.
- There is no mark for any deduction written in the space/box of observation and vice versa.
- Negative observations can be written as; No observable change, Solution remained colourless/blue/green, the colourless/blue/green solution persisted. Writing the anticipated colour change e.g No white/yellow/brown ppt formed, is not encouraged.
- Ions written in words, e.g Zinc ions, copper(II) ions, iron(III) ions, sulphate ions, iodide ions, carbonate ions or chloride ions present under deduction is accepted. It is good for students who make mistakes in writing conventional chemical symbols and formulae.
- Take note of the last part of your question two (Qualitative analysis), e.g, Identify the cat ions/anions present in Y. The ion(s) to be written here must be the one correctly identified/confirmed in either of the deductions made, e.g in (a), (c) (ii)

and (e) (i) e.t.c. Writing ions that have not been correctly identified/confirmed or the ones from nowhere in this last part of the question carries no marks.

- Correct answer written without unit (i.e. when the unit is reflected in the question) is accepted, but correct answers with wrong units written carries no marks.
- Molarities should be written in 2decimal places e.g. as 0.15M, or more than 2 but not to 1decimal place, this caries no marks.
- Use of formula in calculations of volumetric analysis is discouraged. All calculations here should be approached through first principle method. When you use formula, you are bound to miss marks for certain methods.
- Molecular mass is given without unit in the final answer. Calculation of molecular mass that yields decimal place(s) e.g. 84.7, should first be written as 84.7 then rounded to a whole number as 85, but not written directly to 85.

EXERCISES ON QUALITATIVE ANALYSIS

4.6.1 UNEB 2014 545/3

You are provided with substance V, which contains two cat ions and one anion.

Carry out the following tests on V to identify the cat ions and the anion it contains.

Identify any gases that may be evolved.

Record your observations and deductions in the table below.

TESTS	**OBSERVATIONS**	***DEDUCTION***
a) Heat a spatula end ful of V strongly in a dry test tubes and allow the residue to cool		
(c) Dissolve the residue from (a)in dilute nitric acid and to the solution add sodium hydroxide solution drop wise until in excess and filter. Keep both the filtrate and the residue		
(d) To the filtrate , add dilute nitric acid drop wise until the is just acidic and divide the solution in to three parts (i) to the first part of the acidic solution, add sodium hydroxide solution drop-wise until in excess		

(ii)to the second part of the acidic solution, add ammonia solution drop-wise until in excess		
(ii) Use the third part of the acidic solution to carry a test of your own to confirm one of the cat ion in V		
(e) Dissolve the residue in about 3 cm of warm dilute hydrochloric acid and divide the solution into two portions.		
(i) To the first portion of the acidic solution add sodium hydroxide solution drop-wise until in excess		
(iii) To the second portion of the acidic solution add ammonia solution drop wise until in excess		

(f) (i) the cat ions in V are...

(iii) The anions in V are...

4.6.2 UNEB 2014 545/5

You are provided with substance J, which contains one cat ion and two anions. Carry out the following tests to identify the cat ion and the anions in J. identify any gas (es) that may be evolved. Record your observations and deductions in the table below.

TEST	OBSERVATIONS	DEDUCTIONS
a) Heat a spatula end fuls of J strongly in a dry test tube		
b) To two spatula end fuls of J, add dilute nitric acid drop-wise until there is no further change. Divide the solution into five parts.		
(i)To the first part of the solution, add 2-3 drops of lead (ii)nitrate solution and warm the mixture.		
Use the second part of the solution to carry out a test of your own choice to confirm one of the anion in J To the third part of the solution, add dilute sodium hydroxide solution drop-wise until in excess		
To the part of the solution, add dilute		

ammonia solution drop-wise until in excess		
To the fifth part of the solution, add a piece of magnesium ribbon and allow the mixture to stand for sometime		

c) (i) the anions in J are:

The cat ion in J is:

4.6.3 UNEB 2015 545/3

You are provided with substances L, which contains two cat ions and one anion.

You are required to identify the cat ions and the anion in L , carry out the following tests on L and identify any gas(es) evolved.

Record your observations and deductions in the table below.

TESTS	OBSERVATIONS	DEDUCTIONS
a) Heat three spatula end fuls of L strongly in a boiling tube until there is no further change. Allow it to cool.		
b) To the residue add about 5 $cm^3$of dilute nitric acid and warm to dissolve. To the solution add sodium hydroxide solution drop wise until there is no further change , filter the mixture and keep both the filtrate and the residue.		
c) To about 5 $cm^3$of the filtrate add dilute nitric acid drop wise until the solution is just acidic. Divide the acidified filtrate in to six parts i)To the first part of the acidified filtrate add sodium hydroxide solution drop wise until in excess.		
ii) to the second part of the acidified filtrate add ammonia solution drop wise until in excess		
iii)To the third part of the filtrate 2-3 drops of potassium iodide solution		
iv)TO the fourth part of the acidified filtrate add 2-3 drops of		

lead (ii) nitrate		
v)To the fifth part of the acidified filtrate add 2-3 drops of silver nitrate solution followed by drop wise addition of ammonia until in excess		
vi)Use the sixth part of the acidified filtrate to carry out a test of your own choice to confirm the anion in L		
d) Wash the residue with water and dissolve it in dilute hydrochloric acid .divide the acidic solution in to two		
i)To the first part of the acidic solution add sodium hydroxide drop wise until in excess		
ii)To the second part of the acidic solution add ammonia solution drop wise until in excess		

e) i) anions present

ii) cat ions present

4.6.4 UNEB 2016 545/3

You are provided with substance W, which contains two cat ions and one anion.

Carry out the following tests to identify the cat ions and the anion in W.

Identify any gas (es) that may be evolved.

Record your observations and deductions on the table below.(16 mk)

TESTS	***OBSERVATIONS***	**DEDUCTIONS**
(a) heat a spatula end fuls of **W** strongly in a dry test tube		
(b) To two spatula end fuls of **W** add dilute nitric acid drop wise until there is no further change. Then add sodium hydroxide drop wise until in excess and filter .keep both the filtrate and the residue.		
(c) To the filtrate ,add dilute nitric acid drop wise until the solution is just acidic and divide the solution in to four parts (i)To the first part of the solution add dilute sodium hydroxide		

solution until in excess		
ii) To the second part of the solution add dilute ammonia solution drop wise until in excess		
iii)To the third part of the solution add about 2 cm^3 of dilute sulphuric acid and allow the mixture to stand.		
iv)Use the fourth part of the solution to carry out a test of your own choice to confirm one of the cat ions in W		
d) Wash the residue twice with dilute sodium hydroxide solution and then dissolve it in dilute hydrochloric acid. Divide the acidic solution into three parts i)To the first part of the acidic solution add dilute sodium hydroxide solution drop wise un til in excess		
ii) To the second part of acidic solution add dilute ammonia solution drop wise until in excess		
iii)To third part of the acidic solution add sodium carbonate drop wise until there is no further change		

(e)(i) The cat ions in W are..

ii) The anion in W is...,,,,,

4.6.5 UNEB 2017 545/4

You are provided with substance T, which contains two cations and one anion.

Carry out the following tests on T to identify the cations and the anion it contains.

Identify any gas(es) that may be evolved.

Record your observations and deductions in the table.

TESTS	OBSERVATIONS	DEDUCTIONS
a) heat a spatula end fuls of T strongly in a dry hard glass test tube.		
b) To two spatula end fuls of T, add dilute nitric acid a little at a time .add dilute sodium hydroxide solution drop wise, until in excess . filter and keep both the resi due.		
c) To the filtrate, add		

dilute nitric acid drop wise until the solution is just acidic. Divide the acidified solution into two parts and test as follows: i)To the first portion of the acidified solution add dilute sodium hydroxide solution drop wise until in excess		
ii)To the second portion of the acidified solution add dilute ammonia solution drop wise until in excess.		
d) Wash the residue from (b) with dilute sodium hydroxide and then add dilute hydrochloric acid drop wise until the residue just dissolves. Dissolves the solution into three parts and test as follows; i)To the first part of the solution, add dilute sodium drop wise until in excess		
ii)To the second part of the solution add dilute ammonia drop wise until in excess		
iv) To the third part of the solution, add 4-5 drop of sodium sulphate solution		
e) Dissolve one spatula end ful of T in about2cm^3 of dilute nitric. divide the solution and test as follows ii) use the first parts of the solution 2-3 drops of lead (II) nitrate solution. Heat the mixture gently and cool under tap –water		
ii) use the second part of the solution to carry your own choice to confirm the anion in T		

f) i) the cations in T are and

ii) the anion in T

4.6.6 2018 UNEB 545/3

You are provided with solid X , which contains one anion and two cations.

Carry out the following tests to identify the anion and the cations present.

Identify gases that would be evolved.

Record your observations and deduction on the table

TESTS	OBSERVATIONS	DEDUCTIONS
(a) heat a spatula end full of X until no further change.		
(b) To 2 spatula end ful s of X , add dilute nitric acid a little at a time until no further change		
(c) To the acidic solution add dilute sodium hydroxide solution drop wise until in excess .filter and keep both the filtrate and the residue		
(d) To the filtrate , add dilute nitric acid in small proportion until the precipitate formed dissolves. Divided the acidified filtrate into 3 parts and test as follows (i)to the first part of the acidified filtrate , hydroxide drop wise		
(ii)To the second part of the acidified filtrate , add 2-3 drops of potassium iodide solution		
(iii)to the third part of the acidified filtrate, add dilute ammonia drop wise until in excess.		
(e) Wash the residue in sodium hydroxide solution and water , then transfer the residue in a minimum amount of dilute nitric acid . divide the resultant solution into three parts and test as follows.		
(i)To the first part of the solution, add sodium hydroxide solution drop wise until in excess		
(ii)To the second part of the solution , add excess sodium hydrogen carbonate solution and heat		

(ii)To the third part of the solution add dilute ammonia solution drop wise until in excess.		

(f) (i) the anion in X is

(ii)The cations in X are

4.6.7 UNEB2019 545/3

You are provided with solid Q, which contains one anion and two cat ions.

Carry out the following tests to identify the anion and the cat ions present. Identify gases that would be evolved. Record your observations and deduction on the table

TESTS	OBSERVATIONS	DEDUCTIONS
(a) Dissolve one spatula end-ful of Q in about 5 cm^3 of water. Add excess sodium hydroxide solution; shake well and filter. Keep both the filtrate and the residues		
(b) To the filtrate, add dilute nitric acid until the solution is just acidic. Divide the acidified solution into five portions (i)To the first portion of the acidified solution, add dilute sodium hydroxide solution drop-wise until in excess		
(ii)To the second portion of the acidified solution add aqueous ammonia drop-wise until in excess		
(iii)To the third portion of the acidified solution, add 2-3 drops of potassium iodide solution		
(iv)To the fourth port of the acidified solution, add lead (II) nitrate solution and warm		
(iv)To the fifth portion of the acidified solution, carry out a test of your own to confirm the anion in Q		

(C) Dissolve the residue in minimum dilute sulphuric acid. . divide the resultant solution into two parts (i) To the first part of the solution, add sodium hydroxide solution drop wise until in excess		
(ii)To the second parts of the solution .add 1 small piece of zinc granules and leave the solution to stand for 5 minutes. Divide the resultant solution into two portions and use them for part (d)		
(d)(i)To the first part of the solution, add sodium hydroxide solution drop-wise until in excess		
(ii)To the third part of the solution add dilute ammonia solution drop wise until in excess.		

(c) (i) the anion in Q is

(ii)The cations in Q are

4.6.8 UNEB 2019 545/4

You are provided with solid W, which contains one anion and two cat ions.

Carry out the following tests to identify the anion and the cat ions present. Identify gases that would be evolved. Record your observations and deduction on the table

TESTS	OBSERVATIONS	DEDUCTIONS
(a) Heat three spatula end-full of w in a clean dry test tube. Keep the residue		
(b) To half spatula end-ful s of W, add dilute nitric acid a little at a time until no further change		
(c) Dissolve the residue in (a), in a minimum amount of dilute nitric acid, then add about 5 $cm^3$of aqueous sodium hydroxide solution and filter.		

keep both the filtrate and the residue		
(d) To the filtrate , add dilute nitric acid until the solution is just acidic. Divide the solution into four portions. (i)To the first portion of the acidified filtrate .add sodium hydroxide drop-wise until no further change		
(ii)To the second portion of the acidified filtrate, add aqueous ammonia drop-wise until in excess.		
(iii)To the third portion of the acidified filtrate, add 3-5 drops of sodium sulphate solution.		
(iv)To the second portion of the acidified filtrate , add 2-3 drops of potassium iodide solution		
(i)To the first part of the solution, add sodium hydroxide solution drop wise until in excess		
(ii)To the third part of the solution add dilute ammonia solution drop wise until in excess.		

(f)(i) the anion in W is

(ii)The cations in W are

4.6.9 UNEB 2020 545/3

You are provided with solid T, which contains one anion and two cat ions.

Carry out the following tests to identify the anion and the cat ions present. Identify gases that would be evolved. Record your observations and deduction on the table

TESTS	OBSERVATIONS	DEDUCTIONS
(a) Heat two spatula end-full of T Strongly in a dry test tube		

.		
(b) To two spatula end-ful of T in a test tube , add dilute nitric acid drop wise until there is no further change. Add dilute sodium hydroxide solution drop wise to the resultant solution until the alkali is in excess. Filter and keep both the filtrate and the residue		
(c) To the filtrate , add dilute nitric acid until the solution is just acidic . Divide the acidic solution in to three parts and test as follows		
(i)To the first part of the acidified solution , add sodium hydroxide drop wise until in excess		
(ii)To the second part of the acidified solution , add 2-3 drops of potassium iodide solution		
(iii)to the third part of the acidified solution, carry out a test of your own choice in order to confirm one of the cations in T		
(d) Wash the residue with distilled water and then dissolve it in dilute nitric acid . Divide the solution into two parts and test as follows.		
(i)To the first part of the solution, add sodium hydroxide solution drop wise until in excess		
(ii)To the third part of the solution add dilute ammonia solution drop wise until in excess.		

(e) (i) the anion in X is

(ii)The cations in X are