CHEMISTRY VIRTUAL LAB MANUAL

INTRODUCTION: The followings are the step by step procedures for running your virtual laboratory App, evirtuallab.com. The instructions to click for running your experiment are highlighted in RED.

(A) ACID-BASE TITRATION STEPWISE OPERATION

*** Steps (i) to (iv) is to pour the Alkali (NaOH) into the Beaker by Clicking:**
(i) BEAKER – Bring Beaker on the table
(ii) ALKALI – Bring the Alkali bottle to the table
(iii) PIPETTE – Bring Pipette to draw a given volume of Alkali (20, 25, 50 ml)
(iv) CONICAL FLASK – Bring Conical flask to te table and pour in the Alkali
*** Steps (v) to (x) are to pour Acid (HCl) from its bottle into the burette mounted on the Burette Stand using the Funnel**
(v) MEASURING CYLINDER – bring the Measuring Cylinder to measure the amount of Acid to be Poured into the Burette (in case it is not filled to the top)
(vi) ACID – Bring the Acid bottle to the table
(vii) BURETTE – Bring the Burette to the table
(viii) FUNNEL – Put the funnel on the Burette
(ix) CYLINDER – Pour the Acid in the Funnel into the Burette
(x) FUNNEL – Remove the Funnel from the Burette
*** Steps (xi) to (xii) are to bring the Conical Flask of Base and put the Indicator**
(xii) CONICAL FLASK - bring the conical flask of the base
(xiii) INDICATOR - put droplets of Indicator into the Base Conical Flask
(xiv) CONICAL FLASK – put the Conical Flask of Alkali with Indicator under the Burette in preparation for titration
(xv) TITRATE – Carry out Titration by clicking
(xvi) START

**** NOTE ****
Watch the titration to observe the end point when there is colour change and click STOP
**** After stopping the Titration the System will display your Titer volume in (ml)**

**** You are to carry out two more titrations to obtain average Titer Volume of the three titrations**
**** You will be required to make necessary calculations using your average titer volume and enter the computed values on the space provided**
**** Note that the number of moles of Alkali or Base you are to calculate is the total number of moles in the total volume of Alkali given to you and not the moles in the Pipette volume.**
**** The result of your experiment and the correct values will be displayed as you click "RESULT", then "PRINT RESULT"**

ACID – BASE EQUATIONS FOR CALCULATIONS

1. **For: $aHCl + bNaOH \rightarrow NaCl + H_2O$**
2. **$aC_aV_a = bC_bV_b$** ---------- **(1)**
3. **Concentration of Base (mol/l)**
4. Cb = 1000w/Vbase*Mob ---------- (2)
5. **$N_a = V_{titer}\ C_a/1000$** ---------- **(3)**
6. **$N_b = C_b\ V_{base}/1000$** ---------- **(4)**

Where:

V_{titer} = Average titer volume from the 3 titrations
w= weight of base or Alkali in initial volume of Alkali
C_b = Concentration of Alkali prepared
C_a = Calculated unknown concentration of Acid
N_b = Number of moles of Alkali or Base in total volume of Alkali, V_{base}
N_a = Number of moles of acid in average titer volume V_{titer}
Mob = Molar Mass of Base
Vbase = Total initial Volume of Base

WATER OF CRYSTALIZATION.

1. **WEIGHING BALANCE – Bring the weighing Balance to the table to weigh the salt**
2. **PETRI DISH –** bring the Petri dish put on the Balance
3. **SALT –** Start to add salt (NaOH) to weigh the required quantity
4. **BEAKER – bring the** beaker into which salt is to be dissolved
5. **PETRI DISH – pour the salt in the Petri dish inside the beaker**
6. **WATER –** Add water to the salt in the beaker
7. **ROUND BOTTOM FLASK –** bring the flask into which salt solution is to be poured
8. **FUNNEL - put the funnel on the flask**
9. **BEAKER with salt solution – bring the beaker with salt solution and pour into the flask through the funnel**
10. **WATER BOTTLE – pour water into the salt solution in the flask up to the marked level**
11. **CORK – cover the flask with cork**
12. **SHAKE FLASK – shake the flask to ensure total dissolution of salt, and set aside**
13. **BURETTE –** mount Burette on the Retort stand
14. **FUNNEL –** put funnel on Burette to pour Acid
15. **ACID –** pour Acid to fill the Burette
16. **FUNNEL –** remove the funnel
17. **PIPETTE – using Pipette draw salt solution (20, 25, 50 ml) and pour in the Conical Flask**
18. **INDICATOR – add droplets of indicator into the conical flask**
19. **START – start titration**
20. **STOP –** stop titration when color changes at end point

REPEAT TITRATION 2 MORE TIMES – obtain the 3 titre volumes and calculate average titer volume for your subsequent calculations

PERCENT WATER OF CRYSTALIZATION EQUATIONS

Concentration of Acid (HNO_3), Ca (mol/l)

$$Ca = \frac{1000*w}{Moa*Vat} \text{ ---------- (1)}$$

Concentration of pure Base (Na2CO3) Ca (mol/l)

$$\mathbf{Cb} = \frac{Ca*Va*nb}{Vb*na} \text{ ---------- (2)}$$

Weight of pure Sodium Carbonate, X (g)

$$X = Vt*Cb*Mob/1000 \text{ ----------(3)}$$

Number of Molecules of Water, Nw

$$Nw = \frac{1000(wi-X)}{18*Vt*Cb} \text{ ----------(4)}$$

Weight of Water, y (g)

$$Y = wi - x \text{ ---------- (5)}$$

Percent Water of Crystallization, % Water

$$\%\ Water = \frac{100*(wi-x)}{wi} \text{ ---------- (6)}$$

Where:

w = weight of acid in total acid vol, is 1/4 of the given number of grams of the acid in Vat ml of water.

wi = weight of Sodium carbonate hydrate
Moa = Molar mass of HNO3 acid (72)
Vat = Total volume of Acid initially
Vt = Initial volume of hydrate Salt (Sodium Carbonate) (ml)
Vb = Pipette Volume (ml)
Mob = Molar Mass of Base (Sodium Carbonate)
Va + Avg titer Volume of acid

PERCENT PURITY

Steps (1) to (6) are to weigh a given amount of hydrated Sat, Sodium Carbonate into the beaker and add Water to dissolve it

1. Enter laboratory
2. Weighing balance - bring the weighing Balance to the Table
3. Petri dish - bring the Petridish to put the Salt
4. Salt - weigh the salt - Put Salt in the Petri-dish on the Balance and weigh
4 Beaker- bring the Beaker
5. Petri dish with salt - pour salt into the beaker
6. Water bottle - add water to the salt in the beaker and Stir

Steps (7) to (10) are to transfer the salt solution into the Flask and make up to the top mark

7. Round bottom flask- bring the round bottomed Flask
8. Funnel - bring the Funnel and put on the Flask

9. Beaker filled - Pour the salt solution in the beaker into the Flask
10. Water bottle - bring Bottle of water and pour into the salt solution Flask to the marked point
11. Cork - bring Cork to cover the flask
12. Shake round bottom flask

Steps (13) to (16) are to fill the Burette with Acid (HCl)

13. Burette mounted - bring Burette mounted on Stand
14. Funnel - bring Funnel and put on Burette
15. Acid - fill the Burette with Acid
16. Funnel - to remove it

Steps (17) and (18) are to measure the salt (sodium Hydroxide) solution with Pipette and pour into the Conical Flask

17. Pipette - fill the Pipette with base and pour into the conical flask
18. Indicator - bring indicator and add droplets into the base in flask, color changes to yellow
19. Start - start titration
20. Stop - stop titration when color changes to pink

. Repeat the titration twice

PERCENT PURITY EQUATIONS

To calculate the concentration of Acid, Ca

$C_a = \frac{1000*y}{Moa*Vat}$ ---------- (1)

To calculate the concentration of Pure Salt, Cb (Sodium Hydroxide)

$C_b = \frac{Va*Ca}{Vb}$

To calculate total number of moles of pure Sodium Hydroxide, N_b

N_b = Cb*Vbt/1000 …… (2)

To calculate total mass of pure Sodium Hydroxide, Mb (g)

$M_b = 40* N_b$ ---------- (3)

To calculate %Purity

% Purity $= \frac{Mb*100}{w}$ ---------- (4)

Where: y = 0.25 x weight of ACID dissolved in Vat volume of water
Vat = volume of water containing y (g) of acid
w = weight of impure Sodium Hydroxide (g)
Vbt = Volume of water containing w (g) Sodium Hydroxide,
Vb = Pipitte volume (ml)

Va = average acid Titer volume (ml)
Moa = Molar mass of acid

(C) REDOX

Steps (1) to (6) are to fill Burette with Potassium Permanganate and drain it slightly
(1)BURETTE - Bring Burette mounted on Stand to the table
(2)FUNNEL BURETTE - Put Funnel on the Burette
(3)ALKALI BOTTLE - Bring Potassium Permanganate bottle and pour into the Burette
(4)FUNNEL - remove Burette
(5)BEAKER - bring a beaker to drain little base from Burette
(6)BURETTE RUN - drain the burette slightly
(7) BEAKER - remove beaker
Steps (8) to 18 are to pour Oxalic Acid into the Conical Flask and warm with Bunsen burner
(8) BEAKER ACID - bring Oxalic acid beaker
(9) PIPETTE - bring Pipette (20, 25, 50 ml) to measure Oxalic acid
(10) CONICAL FLASK - bring Conical Flask to drain Oxalic Acid
(11) FUNNEL - put Funnel on the Conical Flask
(12) ACID BOTTLE - bring mineral Acid bottle and pour small into the Oxalic Acid
(13) FUNNEL - remove Funnel from the Conical Flask
(14) BUNSEN BURNER - bring Bunsen Burner
(15) FIRE - light the bunsen Burner and warm the mixture of Oxalic Acid and Acid
(16) BUNSEN BURNER - quench Bunsen Burner
(17) CONICAL FLASK REMOVE - remove flask from Bunsen Burner

- **BUNSEN BURNER remove Bunsen Burner**
- **TITRATION**

REDOX EQUATIONS

(1) Concentration of Oxalic Acid, Ca (mol/L)

$$C_a = \frac{1000 * w}{Moa * Vat}$$

(2) Concentration of Potassium Permanganate, C_b (mol/L)

$$C_b = \frac{5 * Ca * Va}{2Vb}$$

(3) Mass Concentration of Potassium Permanganate

Mb = Molar mass x C_b = 158 C_b

(4) Volume of carbon dioxide, V_c (L) (STP)

Cb = moles of CO_2 x 22.4 L = 0.0448 C_aV_a
Where:

Va = Average Titer Volume of Permanganate
W = mass of the initial vol, Va
Vb = Pipette Volume of Oxalic Acid
Vat = Initial total volume of Oxalic Acid
Moa = Molar mass of Oxalic Acid ( )

(D) MOLAR MASS & RELATIVE ATOMIC MASS

Steps (1) to (7) are to dilute the Acid with water to a specified Volume in the flat bottomed Flask
1. Cylinder - bring the Cylinder to the table
2. Water - Measure a quantity of water in the Cylinder
3. Left Round bottom Flask - pour the water into the Flask
4. Cylinder - Bring a measuring Cylinder
5. Acid - measure a given volume of concentrated acid with the cylinder and pour into the Water Flask
6. Shake round bottom flask
7. Add Water - Bring water bottle and add water to the flask up to the mark
Steps (8) to (15) are to measure and make a solution of the unknown salt.
8. Balance - bring the weighing Balance
9. Petri Dish - bring the Petri Dish and place on the Balance
10. Salt - measure the specified amount of unknown salt
11. Round bottom Flask right - bring the flat bottom flask and add some water
12. Water
13. Petri Dish: salt poured into Flask - pour the salt inside the Petridish into the the water in the Flask
14. Shake the Flask
15. Add water to Flask to make up - bring water bottle and add more water to the top mark of the flask
Steps (16) to (18), fill the Burette with the Acid solution on the Burette stand
16. Burrette Stand - bring the Burette stand and the Burette
17. Burrette
18. Round bottom flask (Acid) left - bring the Flask with Acid and fill the Burette
Steps 19 to 21 are to measure the Base into the Conical Flask
19. Round Bottom Flask with Pipette (right) - bring the Flask of the Base
20. Pipette - with the Pipette draw the base (20,25,50 mls)
21. Conical Flask - pour the measured Base into the Conical Flask
22. Indicator - add droplets of Indicator
23. Titrate (end point is 2nd, permanent color change
24. Repeat Titration 2 more times

RELATIVE ATOMIC MASS & MOLAR MASS EQUATIONS

$aH_2SO_4 + bXOH = X_2SO_4 + H_2O$

1. Concentration of Acid

$Ca = 0.018 * V_1$ (mol/L) ---------- (1)

2. Concentration of Base

$Cb = \frac{2*Ca*Va}{Vb}$ (mol/L) ---------- (2)

3. Mass Concentration of Base = w g/dm^3 ---- (3)

4. Molar Mass of unknown Base

Molar Mass = $\frac{w}{Cb}$ ---------- (4)

5. Relative Atomic Mass

Relative Atomic Mass = $\frac{w}{Cb}$ - 17 ---------- (5)

Where:

V_1 = Total volume of concentrated Sulfuric acid in 1 dm^3 dilute acid(mls)
w = mass of unknown XOH
V_b = Pipette Volume of base
V_a = Average Titer Volume of Acid

(E) BACK TITRATION

1. **Burette -** bring the Burette mounted on the stand to the table
2. **ACID - bring the Acid in the beaker**
2. **Salt - pour the salt (Sodium Carbonate) into the acid in the Beaker**
3 **Stirer - bring the Stirrer and stir the Beaker content to dissolve**
4. **Funnel - bring Funnel and pour Acid- Salt solution into the Burette**
5. **Beaker - bring the Beaker containing the Base**
6. **Pipette - bring the Pipette, draw Base and pour it into the Conical Flask**
7. **Indicator - bring the Indicator bottle and add droplets to the Conical Flask**
8. **Conical flask - put Conical Flask under Burette for Titration**
9. **Titrate - prepare to start Titration**
10 **Start - start Titration**
11. **STOP - stop the Titration when the colour changes**
12. **Repeat Titration two more times**

BACK TITRATION EQUATIONS

1. Reaction of with Excess HCl

2. $n_{a1}HCl + n_cNa_2CO_3 \rightarrow NaCl + CO_2 + H_2O + HCl$ (xs)

3. Titration Reaction of Xs HCl with NaOH

4. $n_{a2}HCl + n_bNaOH \rightarrow NaCl + H_2O$

5. To calculate the initial concentration of excess acid:

6. Cai = $\frac{1000*Z}{Vat*Moa}$ ---------- (1)

7. Concentration, C_b of Base (NaOH), mol/L

8. Cb = $\frac{1000*y}{Vbt*Mob}$ ----------(2)

9. To calculate the concentration of acid in the Titration:

10. Ca = ($\frac{Cb*Vb}{Va}$) ----------(3)

11. Number of moles of Na_2CO_3 salt, Nc (moles)

12. Nc = $\frac{nc*Vat(Cai-Ca)}{1000*na1}$ (mol) ---------- (4)

13. Mass X (g) of Salt (Na_2CO_3)

14. X (g) = $\frac{nc*Vat*Moc*(Cai-Ca)}{1000*na1}$ ---------- (5)

Where:

X = Mass of Salt, C (Na_2CO_3) (g)
Vat =Total volume of HCl (ml)
Va = Average Titer volume of acid
Moc = Molar mass of C (Na_2CO_3)
Mob = Molar mass of Base, NaOH
y = Mass of Base, NaOH in its solution (g)
Vbt = total volume of Base containing y (g)
Vb = Pipette Volume (ml)
Moa = Molar mass of Acid, HCl
Z = Mass of conc. HCl in total acid volum e Vat

SOLUBILITY .

Steps (1) to (5) are to measure a given volume of water and pour it into a Beaker

1. Measuring Cylinder - bring a measuring Cylinder to the table
2. water.- bring a bottle of Water at experimental Temperature and measure x ml into the Cylinder
3. Weighing Balance - bring the weighing Balance
4. Beaker on balance - bring a Beaker and place it on the Weighing Balance
5. Filled measuring cylinder on balance - Bring cylinder of water and pour in the Beaker
6. Reset weighing balance - reset the balance to zero reading
7. Salt - bring the salt
8. Start dissolving salt start to pour salt gradually into the beaker while stirring -
9. Stop - stop adding salt when the white grain of undissolved salt appears

10 Read the amount of salt, w (g) dissolved in 100 ml of water

SOLUBILITY EQUATION

Solubility, S ($g/100cm^3$) = 100 x w / V

Where: w is the weight (g) of dissolved salt
V is the volume (ml) of water in which the salt dissolved

CATION DETECTION

PROCEDURE FOR CATION EXPERIMENT

1. Bunsen burner: Select the Bunsen burner and place it on the lab table
2. Fire: Ignite the Bunsen burner with fire
3. Adjust flame: Adjust the blame to blue flame
4. Beaker: Select the beaker and place it on the lab table
5. Acid: Select the bottle of acid and pour some quantity into the beaker
6. Iron-spatula: Select the iron-spatula and dip it in the acid
7. Iron-spatula: Select the iron-spatula and put it in the flame to burn off the impurities/contaminants
8. Petri dish: Select the petri dish and place it on the lab table
9. Salt: Select the salt and pour it in the petri dish
10. Iron-spatula: Select the iron-spatula and dip it in the acid to cool it
11. Iron-spatula: Select the iron-spatula and dip it in the salt to prepare it for the flame test
12. Iron-spatula: Select the iron-spatula and put it the flame for the test for cation
The flame changes to a color of a particular cation, and the student will type the cation's name in the box.
The experiment will be repeated the second time.

ANION IDENTIFICATION STEPWISE OPERATION

EXPERIMENT 1
Run 1
(i) Click on the 'mount the test tube' icon and click on the lab space to introduce the test tube on the lab table
(ii) Click on the 'water' icon and bring it to the lab table to add water to the test tube
(iii) Pick the 'clean test tube' and bring it to the lab table to clean the test tube with water
(iv) Click on the unknown 'sample' icon and bring it to the lab environment to add the unknown sample to the test tube
(v) Add 3 cm^3 of $AgNO_3$ by clicking on the icon and bring it to the lab table to add it to the sample in the test tube
(vi) Add 2 cm^3 of HNO_3 by clicking on the icon and bring it to the lab table to add it to the sample in the test tube
(vii) Add 2 cm^3 of NH_3 by clicking on the icon and bring it to the lab table to add it to the sample in the test tube
Enter your suspected anion in the text box provided
(ix) Click on 'submit' and then close the app
Run 2
(i) Repeat Run 1 going through the steps (i) to (ix) as outlined. You need to log in afresh to start Run 2
(ii) After the second experimental run, click on 'show result'

(iii) Click on 'print report' to check the experiment certificate
(iv) Log out of the environment to start another anion identification experiment

EXPERIMENT 2
Run 1
(i) Click on the 'mount the test tube' icon and click on the lab space to introduce the test tube on the lab table
(ii) Click on the 'water' icon and bring it to the lab table to add water to the test tube
(iii) Pick the 'clean test tube' and bring it to the lab table to clean the test tube with water
(iv) Click on the unknown 'sample' (2 cm^3) icon and bring it to the lab environment to add the unknown sample to the test tube
(v) Add 2 cm^3 of $BaCl_2$ by clicking on the icon and bring it to the lab table to add it to the sample in the test tube
(vi) Add two (2) drops of HCl by clicking on the icon and bring it to the lab table to add it to the sample in the test tube
(vii) Add 2 cm^3 of HCl by clicking on the icon and bring it to the lab table to add it to the sample in the test tube

Enter your suspected anion in the text box provided
Click on 'submit' and then close the app
Run 2
(i) Repeat Run 1 going through the steps (i) to (ix) as outlined. You need to log in afresh to start Run 2
(ii) After the second experimental run, click on 'show result'
(iii) Click on 'print report' to check the experiment certificate
(iv) Log out of the environment to start another anion identification experiment

EXPERIMENT 3
Run 1
(i) Click on 'mount the test tube' icon and click on the lab space to introduce the test tube on the lab table
(ii) Click on the 'water' icon and bring it to the lab table to add water to the test tube
(iii) Pick the 'clean test tube' and bring it to the lab table to clean the test tube with water
(iv) Click on the unknown 'sample (2 cm^3)' icon and bring it to the lab environment to add the unknown sample to the test tube
(v) Add 2 cm^3 of $BaCl_2$ by clicking on the icon and bring it to the lab table to add it to the sample in the test tube
(vi) Add two (2) drops of HCl by clicking on the icon and bring it to the lab table to add it to the sample in the test tube
(vii) Add 3 cm^3 of HCl by clicking on the icon and bring it to the lab table to add it to the sample in the test tube
(viii) Click on the lime water beaker and add it to the test tube on the lab table
(ix) Click on the 'put glass rod in lime water' icon
(x) Put lime water rod in the test tube

(Enter your suspected anion in the text box provided
(xii) Click on submit and then close the app
Run 2
(xiii) Repeat Run 1, going through the steps (i) to (xii) as outlined. You need to log in afresh to start Run 2
(xiv) After the second experimental run, click on 'show result'
(xv) Click on 'print report' to check the experiment certificate
(xvi) Log out of the environment to start another anion identification experiment

EXPERIMENT 4
Run 1
(i) Click on the 'mount the test tube' icon and click on the lab space to introduce the test tube on the lab table

(ii) Click on the 'water' icon and bring it to the lab table to add water to the test tube
(iii) Pick the 'clean test tube' and bring it to the lab table to clean the test tube with water
(iv) Click on the unknown 'sample (2 cm^3)' icon and bring it to the lab environment to add the unknown sample to the test tube
(v) Add 3 cm^3 of $PbNO^3$ by clicking on the icon and bring it to the lab table to add it to the sample in the test tube
(vi) Enter your suspected anion in the text box provided
(vii) Click on submit and then close the app
Run 2
(viii) Repeat Run 1, going through the steps (i) to (vii) as outlined. You need to log in afresh to start Run 2
(ix) After the second experimental run, click on 'show result'
(x) Click on 'print report' to check the experiment certificate
(xi) Log out of the environment to start another anion