CHEMISTRY VIRTUAL LAB MANUAL

INTRODUCTION:

Evirtuallab App is a novel system developed to make it possible for secondary or High School Students to perform all the nine major chemistry laboratory practicals without a physical laboratory on a laptop or an Android Handset. The student will set up all the apparatus and carry out the experiments including Titrations through clicking instructions on their system. The solubility experiment can be carried out at various Temperatures. On completion of the experiment, the App will supply the experimental results like Titer volume, etc for the student to make necessary calculations and feed back into the system. The system will show the final results based on the experiment, student's calculation and the actual expected experimental values. Finally the the percentage errors indicating the student's accuracy of experiment, and the accuracy of calculation will be displayed in form of percentage error on a certificate bearing the student's identity and the actual date of experiment. This system gives each student a set of experimental data likely different from the next student. The student can carry out the experiment independently on his Android hand set for personal exercise.

Registration Procedure for Access to Chemistry Laboratory Virtual App is as follow:

1. From your web browser enter www.evirtuallab.com
2. Enter your active email address into the space allocated through the login details
3. Enter the provided PIN as the password
4. Click log in to have access to any of the nine experiments listed on the App to take you to the lab environment.

Experimental Procedure:

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. Following the experimental procedures are the relevant formulae for the required calculations.

Note:To bring an Apparatus to the experimental table (Platform), click on the desired apparatus and then click on the platform.

(A) ACID-BASE TITRATION STEPWISE OPERATION

AIM: To determine the unknown concentration of Acid (or Base)

*** 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 cm3)
(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. **Concentration of Base (mol/dm3)**
3. $C_b = 1000w/V_b * M_{ob}$ ---------- (1)
4. $C_a = aC_bV_b/bV_a$ ---------- (2)
5. $N_a = V_aC_a/1000$ ---------- (3)
6. $N_b = V_bC_b/1000$ ---------- (4)
7. $N_{bt} = C_bV_{bt}/1000$ ---------- (5)

Where:
V_a = Average titer volume from the 3 titrations (cm3)
V_{at} = Total Acid volume (cm3)
w= weight of base or Alkali in initial volume of Alkali (g)

C_b = Concentration of Alkali prepared (mol/dm3)
C_a = Calculated unknown concentration of Acid (mol/dm3)
N_b = Number of moles of Alkali or Base in Pipette volume V_b
N_{bt} = Total number of moles of Alkali or Base in total volume of Alkali, V_{bt}
N_a = Number of moles of acid in average titer volume V_a
Mob = Molar Mass of Base
Vbt = Total initial Volume of Base

(B) WATER OF CRYSTALIZATION.

aHCl + bNa2CO3 →

AIM: To determine the fraction or percentage of water in hydrated Salt

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 cm3) 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 (HCl), Ca (mol/dm3)

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

Concentration of pure Base (Na2CO3) Ca (mol/dm3)

Cb = $\frac{Ca*Va*b}{Vb*a}$ ---------- (2)

Weight of pure Sodium Carbonate, X (g)

X = Vbt*Cb*Mob/1000 ----------(3)

Number of Molecules of Water, Nw

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

Weight of Water, y (g)

Y = wi - x ---------- (5)

Percent Water of Crystallization, % Water

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

Where:

w = weight of acid in total acid vol, Vat of water (g).
wi = weight of Sodium carbonate hydrate (g)
Moa = Molar mass of HCl acid (36.5)
Vat = Total volume of Acid initially (cm3)
Vbt = Initial volume of hydrate Salt (Sodium Carbonate) (cm3)
Vb = Pipette Volume (cm3)
Mob = Molar Mass of Base (Sodium Carbonate)
Va = Avg titer Volume of acid (cm3)

(C) PERCENT PURITY

aHCl + bNaOH →

AIM: To determine the percentage of impurity in an impure salt or base

Steps (1) to (6) are to weigh a given amount of impure Base, Sodium Hydroxide 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 base
4. Salt - weigh the base - Put base in the Petri-dish on the Balance and weigh
5. Beaker- bring the Beaker
6. Petri dish with salt - pour base into the beaker
7. Water bottle - add water to the base in the beaker and Stir

Steps (8) to (11) are to transfer the base solution into the Flask and make up to the top mark

8. Round bottom flask- bring the round bottomed Flask
9. Funnel - bring the Funnel and put on the Flask
10. Beaker filled - Pour the salt solution in the beaker into the Flask
11. Water bottle - bring Bottle of water and pour into the base solution Flask to the marked point

12. Cork - bring Cork to cover the flask
13. Shake round bottom flask

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

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

Steps (18) and (19) are to measure the salt (sodium Hydroxide) solution with Pipette and pour into the Conical Flask

18. Pipette - fill the Pipette with base and pour into the conical flask
19. Indicator - bring indicator and add droplets into the base in flask, color changes to yellow
20. Start - start titration
21. 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 base, Cb (Sodium Hydroxide)

$\mathbf{C_b} = \frac{b*Va*Ca}{a*Vb}$

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 = 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, (cm3)

Vb = Pipitte volume (cm3)
Va = average acid Titer volume (cm3)
Moa = Molar mass of acid

(D) REDOX

AIM: To determine the mass concentration of Potassium Manganate (vii) through its oxidation-Reduction reaction with Ethanedioic acid

Steps (1) to (6) are to fill Burette with Potassium Manganate (vii) 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 Manganate (vii) 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 Ethanedioic Acid into the Conical Flask and warm with Bunsen burner
(8) BEAKER ACID - bring Ethanedioic acid beaker
(9) PIPETTE - bring Pipette (20, 25, 50 ml) to measure Ethanedioic acid
(10) CONICAL FLASK - bring Conical Flask to drain Ethanedioic Acid
(11) FUNNEL - put Funnel on the Conical Flask
(12) ACID BOTTLE - bring mineral Acid bottle and pour small into the Ethanedioic 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 Ethanedioic 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 Ethanedioic Acid, Ca (mol/d3)

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

(2) Concentration of Potassium Manganate (vii), C_b (mol/dm3)

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

(3) Mass Concentration of Potassium Manganate (vii)

M_b = Molar mass x C_b = 158 C_b

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

Vc = moles of CO_2 x 22.4 dm3 = 0.0448 C_aV_a

Where:

V_b = Average Titer Volume of Manganate (vii), cm3
W = mass of the initial Ethanedioic acid vol, Va, g
Va = Pipette Volume of Ethanedioic Acid, cm3
Vat = Initial total volume of Ethanedioic Acid, cm3
Moa = Molar mass of Ethanedioic Acid

(E) MOLAR MASS & RELATIVE ATOMIC MASS

AIM: To determine the Molar Mass and Atomic Mass of an unknown Base, B(OH)n

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 Cylinder1
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 cm3)
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

aAcid + bB(OH)n = Salt + H_2O

1. Concentration of Acid, Ca

Ca = 1000*X/(Moa*Vat) (mol/dm3) ---------- (1)

2. Concentration of Base, Cb

Cb = $\frac{b*Ca*Va}{a*Vb}$ (mol/dm3) ---------- (2)

3. Mass Concentration of Base. w = 1000*y/V_{bt} g/dm^3 --- (3)

4. Molar Mass of unknown Base

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

5. Relative Atomic Mass

Relative Atomic Mass = (w/Cb) - 17*n ---------- (5)

Where:

X = mass of concentrated acid dissolved in Vat vol of dilute acid, g
Vat = Total volume of dilute acid (cm3)
y = mass of unknown B(OH)n, g
V_b = Pipette Volume of base, cm3
V_a = Actual Average Titer Volume of Acid, cm3
Moa = Molar mass of acid

(F) BACK TITRATION

AIM; To use Acid-Base Titration method to determine the quantity of Sodium Carbonate through its reaction with excess Acid

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/dm3

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

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

10. $Ca = \left(\frac{Cb*Vb}{Va}\right)$ ----------(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 (cm3)
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 (cm3)
Moa = Molar mass of Acid, HCl
Z = Mass of conc. of HCl in total acid volume Vat

(G) SOLUBILITY .

AIM: To determine the amount of a salt that will dissolve in 100 cm3 water at different Temperatures

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 cm3 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 (cm3) of water in which the salt dissolved

(H) FLAME TEST

AIM: To Identify the Cation or Metallic Ion in a Salt

(Note that the symbol you write and the one given by the App are without the positive signs, +, 2+, 3+ but in reality they must accompany the symbols to represent ions.)

PROCEDURE FOR THE FLAME TEST 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 TEST

AIM: To identify the anion (negative ion) present bin a salt
(Note that the symbol you write and the one given by the App are without the negative signs, -, 2-, 3- but in reality they must accompany the symbols to represent ions.)

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 PbNO3 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