EICoM
ELECTRICAL COMPUTER MECHATRONICS

مختبر أساسيات الكيمياء

للطالبة المبدعة
ميس

إرادة - ثقة - تغيير

Read the following safety rules before going into the laboratory and abide by them.

Wear safety glasses at all times. Prescription glasses are adequate but contact lenses are not **adequate.**

تحيق

1- Always wear your laboratory coat. Do not wear clothing that hinders free movement of your hands or hangs loose outside your laboratory coat.

2- Do not work in a laboratory if no lecturer or technician is present. Read the experimental instructions carefully before starting the work. Especially note any precautions that must be taken.

3- Never eat, drink, or smoke in the laboratory. Never taste chemicals. Wash your hands well before leaving the laboratory. Also, wash your hands or any part of your body immediately with water when it comes in contact with chemicals.

4- Do not use your mouth to fill a pipette. There are special bulbs for this purpose.

5- Note the position of safety equipment like fire extinguishers, eye washers, and first aid boxes. Report all accidents immediately to a staff member or technician.

6- Use the fume hood when handling strong-smelling or irritating chemicals.

تخلص

7- Be careful about discarding away wastes.Always follow instructions.

Do not dispose of solids into the sink. Do not leave glassware or any other solid materials, including filter papers, in the sink. Put broken glassware into the labeled buckets.

Some waste liquids must be stored into special bottles, not disposed of in the sink. A staff member or technician will help you.

8- Do not leave a lit burner unattended. Always stay clear form the flame.

9- When heating anything in a test tube, do not point the mouth of the test tube towards yourself or towards any other person.

10- Before leaving the laboratory turn off any water taps and burners and dispose of solid waste in the correct container. Also, wash all apparatus used and clean up the bench top.

11- Keep your bench clean and tidy while you are working. Clean up any spills or broken glass immediately. Keep your books and papers away from water, chemicals, and flames. Position your apparatus on the bench so that it is convenient and comfortable to use. Keep unused equipment out of the way, so that you do not knock it over.

لصب

12- If you are in any doubt about anything, ask the staff member or technician for advice.

13- Request the assistance of your instructor/technician if and when you suffer a cut or a burn **or face a dangerous** situation.

Safety roles

1) not allowed in lab : eating , drinking, open sandals & short skirts
2) **Don't:**
- dispose solids into sink
- point the test tube toward you during heating or toward any person
- use your mouth to fill or taste chemicals
- use the chemicals on the side shelves, unless the lecture told you
- return any excess chemicals to the reagent bottles or bottles of solid materials

3) wear safety glass of lab coat
4) use fume hood for runs with toxic gases

Accuracy of tools

Pipette > burette > vol. flask > grad. cylinder > beaker > erl. flask

Exp. 1 Safety, Equipments & Weighing:

* Some of Safety Rules:

- Not allowed in lab: Eating, Drinking, Open Sandals, Short skirts.
- Do not return any excess chemicals to the reagent bottles or bottles of solid materials.
- Do not use the chemicals on the side shelves, unless the lecturer told u.
- Do not use your mouth to fill or taste chemicals.
- Use fume hood for rxns with toxic gases.
- Do not dispose solids into sink.
- Do not point the test tube toward u during heating or toward any person.
- Wear safety glasses & lab. coat.

---

* Decreasing in trend of accuracy of tools:

Pipette > Burette > Vol. flask > grad. cylinder > Beaker > Er. flask.

Beaker: chemical rxns.

Er. flask: for titration with swirlling

Pipette, Burette: used to transfer liquids with high accuracy

Vol. flask: used to prepare solns. with high accuracy

grad. cylinder: used to transfer liquids with low accuracy

---

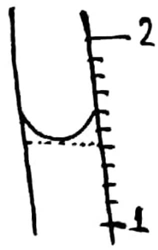
* Weighing:

- if balance has two decimals: 5g ⇒ 5.00g ∓ 0.01 ← uncertainity

  one decimal: 5g ⇒ 5.0g ∓ 0.1

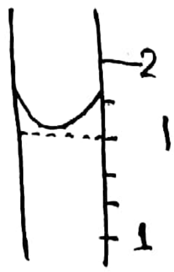
- Volumes & Thermometer & lengths:

$\frac{\text{calib.}}{2} = \frac{0.1}{2} = 0.05$

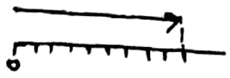


1.40ml ∓ 0.05

↑ should be added



1.60mL ∓ 0.1



1.10cm ∓ 0.05

Student Name: ____________________________ Section No.: ____________________

ID Number: ____________________________ Date : ____________________

Partner Name: ____________________________ Group No.: ____________________

Experiment (2)

Empirical Formula of a Compound

PreLab

1. How many grams of magnesium combine with 1.50 g of chloride ions in $MgCl_2$?

____

____

____

____

____

2. If 11.80 g of iron reacts with 5.06 g of oxygen. Determine the empirical formula of the resulting oxide?

____

____

____

____

____

____

____

____

____

Experiment (2)

Empirical Formula of a Compound

Objective:

- To determine the Chemical formula of magnesium oxide.

Introduction:

The empirical formula of a compound is the smallest whole – number ratio of atoms in the compound. The following are examples of empirical formulas: Fe_2O_3, ZnO, Mg_3N_2, CH_3, CH_2, CH, CO_2, MgS, and MnO_2. The empirical formula of a compound is usually determined either by chemical analysis (decompositions) or by synthesis. In the chemical analysis method, a known mass of the compound is decomposed (or burned) and the masses of the products are determined. These masses are converted to number of moles of the elements present in the compound. From the number of moles, the relative number of atoms of each element is determined, and this will give the empirical formula.

تحليل تحليل توليف

Purpose of exp :- Determine the ratio of x, y

Example 1:

Nicotine is a compound containing C, H, and N. A 2.50 g sample of the compound is burned and produces 6.78 g of CO_2, 1.94 g of H_2O, and 0.43 g of N_2. what is the empirical formula of nicotine?

First we calculate the number of moles of each element present.

$$\text{mole C} = \text{mole } CO_2 = .\frac{6.78g}{44.0g/mol} = 0.154 \text{ mole}$$

$$\text{mole H} = 2 \text{ x mole } H_2O = 2 \text{ x } .\frac{1.94g}{18.0g/mol} = 0.216 \text{ mole}$$

$$\text{mole N} = 2 \text{ x mole } N_2 = 2 \text{ x } .\frac{0.43g}{28.0g/mol} = 0.031 \text{ mole}$$

ratio of moles = ratio of atoms

The empirical formula is $C_{0.154} : H_{0.216} : N_{0.031}$

Dividing by 0.031, (the smallest number) this will give the smallest whole-number ratio:

C_5H_7N = the empirical formula

In the chemical synthesis method, a known mass of a metal is combined with a non metal. The product is weighed and the mass of nonmetal is determined. From the mass of the metal and nonmetal, the number of moles is calculated and then the empirical formula is determined.

Example 2:

When 0.288 g of P is burned, 0.660 g of white phosphorus oxide is obtained, determine the empirical formula of this oxide?

mass of oxygen = 0.660 – 0.188 = 0.372 g

mole P $= . \dfrac{0.288g}{31.0g/mol} =$ 0.0093 mole

mole O $= . \dfrac{0.372g}{16.0g/mol} =$ 0.0233 mole

mole P: mole O = 0.0093: 0.0233 = 2 : 5

Empirical formula is P_2O_5

In today's experiment you will prepare magnesium oxide by burning a known mass of magnesium in air (O_2). From the mass of product, and magnesium, the empirical formula of magnesium oxide is determined.

Apparatus and Chemicals:

Balance, Bunsen burner, Crucible and cover, Clay triangle, Crucible tongs, Iron ring, clamps, stand, Mg ribbon and Steel wool.

Experimental Procedure:

Record all observations and data directly on report sheet IN **INK.**

1. Place a clean, dry, partially covered crucible on the clay triangle. Heat with hot flame for two or three minutes. This step removes any moisture from the crucible. See fig (1) for correct assembly.
2. Turn off the flame and allow the crucible and cover to cool on the clay triangle.
3. WHEN THE CRUCIBLE STOPS FEELING WARM TO YOUR HAND, bring the crucible and cover to a balance and weigh them to two decimal places(± 0.01 g). If the crucible is too hot you will not get an accurate weight.
4. Polish about 2 cm of Mg ribbon and cut it into small pieces. Use steel wool for polishing. Place about 0.25 g of the element in the crucible and weigh the crucible + Mg accurately to (± 0.01 g) .
5. Replace cover and heat the crucible and contents slowly at the beginning. Lift the cover occasionally to introduce oxygen to react with Mg. Do not lift the cover widely, because too much air will burn the Mg brightly (with flame). If this happens cover the crucible immediately.
6. Continue heating until all Mg is converted to ash, then remove the cover and heat the crucible until the crucible bottom becomes red.
7. Remove the burner and Cool the crucible, add a few drops of distilled water to decompose any magnesium nitride, Mg_3N_2, that may have formed during combustion.
8. Heat the open crucible slowly until the ash is completely dry.
9. Allow the crucible to cool for 2 minutes on the clay triangle. Then place the covered crucible in the desiccators and cool to **room temperature**, about 15 to 20 minutes. **DO NOT PLACE THE HOT CRUCIBLE ON THE LAB BENCH AS IT WILL BURN THE BENCH**.
10. When the crucible cools to room temperature (that is, not warm to the touch), transfer it with the cover to the balance and weigh them to two decimal places.

✿ Main rxns :-

$Mg + O_2 \longrightarrow Mg_2O_3$

✳ Side rxns :-

$\underbrace{Mg + N_2}_{\text{side rxns}} \longrightarrow \underbrace{Mg_3N_2}_{\text{side products}}$

نفتح الغطاء عن
oxide
للتخلص من
Side product

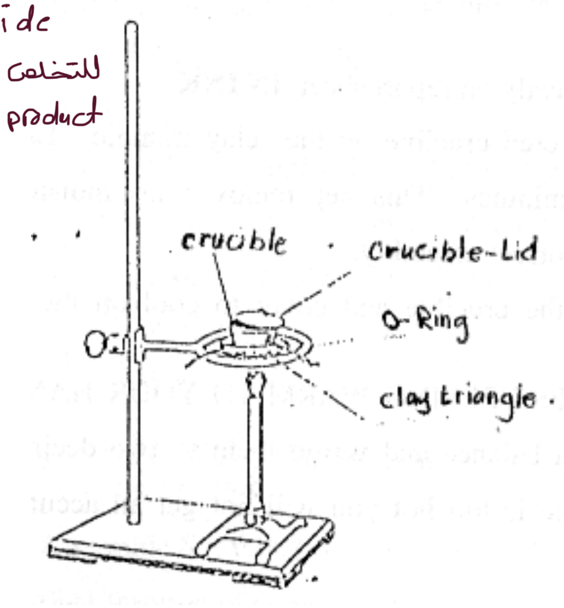


Fig. (1): Setup for magnesium oxide determination.

How many grams of Mg combine with 1.5g of Cl ions in MgCl2 ?

المطلوب mass Mg

في السؤال موجود Mr

لإيجاد mass Mg ← يجب أن أحول إلى mols

$$\text{mols of Cl} = \frac{1.5}{35.45} = 0.0423 \text{ mol}$$

$$\left.\begin{array}{l} 2 \text{ mols Cl} \longrightarrow 0.0423 \\ 1 \text{ mols Mg} \longrightarrow x \end{array}\right] \xrightarrow[\text{التبادلي}]{\text{بعد الضرب}} x = 0.0245 \text{ mols of Mg}$$

$$\text{mols of Mg} = \frac{\text{mass}}{Mr} \Longrightarrow \text{mass of Mg} = 0.54\,g$$

If 11.8g of Fe reacts with 5.06g of O2 ! Determine the empirical formula of the resolution oxide?

mass of Fe = 11.8g

mass of O_2 = 5.06g

we find the mols of atoms:-

$n_{Fe} = \frac{5.06}{16} = 0.316$

$n_{O_2} = \frac{11.8}{55.85} = 0.211$

Fe : O_2

0.316 : 0.211

(1.5 : 1) * 2

3 : 2

$\boxed{Fe_3O_2}$

Nicotine is a compound (cpd) containing C,H&N ... 2.5g sample of the cpd is burned & produces 6.78g of CO2 , 1.94g of H2O , 0.43g of N2 . What the E.F of nicotine ?

1) نحسب Mr لكل مركب $[CO_2, H_2O, N_2]$

2) نحسب لكل عنصر $[C, H, N]$ عدد ال mols

3) نقسم على أقل mols

C : H : N

CO_2 | H_2O | N_2

$C \rightarrow n_{CO_2} = \frac{6.78}{\boxed{44}} * \underline{1} = 0.154$

عدد ذرات C في CO_2

Mr_{CO_2} < حساب من السؤال

$H \rightarrow n_{H_2O} = \frac{1.94}{18} * 2 = 0.216$

$N \rightarrow n_{N_2} = \frac{0.43}{28} * 2 = 0.031$

$\frac{0.154}{0.031} = 5$ $\frac{0.216}{0.031} = 7$ $\frac{0.031}{0.031} = 1$

E.F = $\boxed{C_5H_7N}$

When0.288g of P is burned, 0.66g of white phosphorescent oxide is obtained , determine the E.F of the oxide ?

1 mass of P = 0.288g

2 mass of oxide = 0.66 g

mass of O = 2 - 1

= 0.372

$\text{mols}_P = \frac{m}{Mr} = 0.0093$

$\text{mols}_O = \frac{m}{Mr} = 0.0233$

نقسم على أقل mols

	P	:	O
mass	0.288	:	0.372
mols	0.0093	:	0.0233
	(1	:	2.5) * 2
	2	:	5

$\boxed{P_2O_5}$

2.00g sample of bromide oxide is converted to 2.936g of AgBr , calculate the E.F of the oxide?

1 mass of Br_xO_y = 2 g

2 mass of AgBr = 2.936 g

mass of O = $\underline{2} - \underline{1}$

= 0.75g

mols of AgBr = $\frac{2.936}{\boxed{187.78}}$ = 0.0156 mols

حساب من السؤال < Mr للمركب

عدد ذرات Br في AgBr

mols of Br $\rightarrow n_{AgBr} = 0.0156 * \boxed{1}$

= 0.0156 mols of Br

mass of Br = mols * Mr_{Br}

= 0.0156 * 80 = 1.25g

	Br	:	O
mass	1.25	:	0.75
mols	0.0156	:	0.0468
	1	:	3

$\boxed{BrO_3}$

Student Name: ______________________ Section No.: ________________
ID Number: ______________________ Date : ________________
Partner Name: ______________________ Group No.: ________________

Experiment (2)

Empirical Formula of a Compound

Report Sheet

Data:

		Trial I	Trial II
1.	Mass of empty crucible الوعاء		
2.	Mass of Mg		
3.	Mass of Crucible and oxide المركب عند احتراق Mg		
4.	Mass of magnesium oxide		
5.	Mass of oxygen		
6.	Moles of Mg (FM of Mg = 24.3 g /mole)		
7.	Moles of oxygen (FM of O = 16.0 g/ mole)		
8.	Mole Mg: Mole O		
9.	Empirical formula of magnesium oxide		
10.	% of O in the compound		
11.	% of Mg in the compound		

Show your calculation for steps of 6-11 :-

1) احسب وزن الوعاء
2) أصفر الميزان
3) اوزن Mg (0.1→0.2)
4) اضع الوعاء على Stand
5) اشغل النار
6) عند الاحتراق يتكون المركب Mg_xO_y
7) بس يبرد الوعاء نضع (3-4) نقاط من الماء
[يتكون بخار ورائحة نتيجة تكون الأمونيا ناتج ثانوي]
8) نضع الوعاء مرة أخرى على النار 3min

9) نضع الوعاء على الميزان
[قراءة الميزان تمثل وزن الوعاء + المركب]
10) للحصول على وزن المركب فقط
[نطرح وزن 9 من وزن 1]
mass Mg_xO_y =
11) للحصول على وزن الأكسجين
[نطرح وزن 10 من وزن 3]
mass oxygen =
12) نقسم mass Mg على Mr للحصول على mols
ونقسم mass O على ← Mr للحصول على mols

13) للحصول على نسبة الأكسجين
$\frac{\text{mass O}}{\text{mass oxide}} \times 100\%$
14) للحصول على نسبة Mg
$\frac{\text{mass Mg}}{\text{mass oxide}} \times 100\%$

Experiment (2)

Empirical Formula of a Compound

PostLab

جواب السؤال نفسه اذا سأل ماذا يحدث للنسبة $\frac{Mg}{O}$ اذا لم نضع الماء

نسبة Mg رح تكون أقل، لأن جزء من Mg رح يتفاعل مع N_2 ← رح تقل نسبة Mg المتفاعلة مع O_2

1. What is the effect of Mg_3N_2 if it is not decomposed on the reported **(Mg to oxygen)** mole ratio?

If the water is not added to the compound

$\downarrow\frac{Mg}{O} = \text{ratio}\downarrow$ // $\frac{O}{\downarrow Mg} = \text{ratio}\uparrow$

2. Describe the effect of each of the following factors, whether increases, decreases, or has no effect on the reported value of (Mg to O) mole ratios:

a. If carbon is deposited on the crucible's surface (because of improper heating) and the crucible with contents is weighed without removing the carbon residue by further heating. mass O_2 تزداد قيمة ← (شحبار) عا يكون اللهب اصفر يتكون

$\frac{Mg}{\uparrow O} = \text{ratio}\downarrow$ // $\frac{\uparrow O}{Mg} = \text{ratio}\uparrow$

b. If the magnesium oxide ash is not dried completely. الماء موجودة ولم يتم الترسخين ← mass O_2 تصبح أكبر

$\frac{Mg}{\uparrow O} = \text{ratio}\downarrow$ // $\frac{\uparrow O}{Mg} = \text{ratio}\uparrow$

c. If rapid oxidation of magnesium occurs by too much air, and some Mg is lost.

لم يتكون الرماد بشكل كلي

mass O تقل

$\frac{Mg}{\downarrow O} = \text{ratio}\uparrow$ // $\frac{\downarrow O}{Mg} = \text{ratio}\downarrow$

d. If air is not sufficient to react with all the magnesium.

لم يكون الهواء كافي

mass O اقل

$\frac{Mg}{\downarrow O} = \text{ratio}\uparrow$ // $\frac{\downarrow O}{Mg} = \text{ratio}\downarrow$

3. Explain how magnesium nitride is formed during heating? Write a chemical equation for its formation.

$Mg + N_2 \rightarrow Mg_3N_2$

What is the formation of Mg3N2 ?

4. Explain, by a chemical equation, the effect of the added water in the decomposition of magnesium nitride.

$Mg_3N_2 + H_2O \rightarrow Mg(OH)_2 + NH_3$

$Mg(OH)_2 \xrightarrow{\Delta} Mg + H_2O$

What the rxn heating Mg.Hydr ?

1) How can avoiding the side rxn ?
2) What the rxn between Mg , N & water ?

1) Why heating before starting?
To remove moisture

2) why don’t weight the crucible when it’s hot ?
It give wrong accurate

3) why don’t cover the crucible widely ?
It burns Mg brightly

4) why adding a few water drops ?
To decompose Mg3N2

*Nonvolatide & unreactive impurities in the crucible during oxidation?
Decrease وجود مود غير متطايره أثناء التأكسد

* Nonvolatile & unreactive impurities in the crucible form the begins ?
No effect وجود مواد غير متطايره قبل التأكسد

---

1) when a metal (M) with atomic mass 56g/mol was oxidized to a metal oxide that contains 36.4% by mass O , the E.F of the metal oxide is :

$M_r(M) = 56$
$M_r(O) = 16$
oxide contain 36.4% (O)
oxide contain 63.6% (M)

* النسبة = الكتلة *

M : O
mass 63.6 : 36.4
mols 1.135 : 2.275
1 : 2

$\boxed{MO_2}$

---

2) In the E.F exp. which statement below is incorrect:
— (Mg to O) mole ratio will not affect, if the balance is always read 0.05g higher the actual value
— the side product that formed is Mg3N2
— if the Mag.Oxide isn’t dried completely the reported value of (Mg to O)mole ratio will decrease
— (Mg to O) mole ratio will increase if air isn’t sufficient to react with all the Mg
— (Mg to O) mole ratio will decrease if a rapid oxidation is occur & some of Ma is lost

---

3) cpd of iridium (Ir) & (O) was produced in Lab by heating (Ir) in a crucible, the data was collected:
- mass of crucible 38.26g
- mass of crucible &Ir 39.63g
- mass of crucible & Ir oxide 39.74g

What’s the E.F of the cpd?
— IrO2 —IrO. — Ir2O3. —Ir3O4

mass of Ir = 1.37g
mass of O = 0.11g

Ir : O
mass 1.37 : 0.11
mole 0,0071 : 0,0068
ratio 1 : 1

$\boxed{IrO}$

Experiment (3)

Limiting Reactant

Objectives:

- To determine the limiting reactant in a salt mixture.
- To determine the percent composition of a salt mixture.

Introduction:

In a chemical reaction, the reacting materials are often mixed in stoichiometric quantities (according to fixed mole ratios), i.e., in exactly the correct amounts so that all reactants are used up during the reaction.

When reactants are not mixed in the correct mole ratio, only limited amount of product is formed, and this amount is determined by the reactant present in less amount and thus is consumed first in a reaction. This reactant is called the limiting reactant.

Limiting reactant: It is the reactant that is consumed first, and thus determines the amount of product formed.

The theoretical yield of a product is the maximum amount that can be produced with a given amount of the limiting reactant. The ***actual yield*** is often less than the theoretical yield. The % yield is represented as: The amount of the product that is product (actually, experimentaly , practically)

$$\% \text{ yield} = \frac{\boxed{\text{Actual yield}}}{\text{Theoretical yield}} \times 100\%$$

في السؤال

حساب

Let us discuss the concept of limiting reactant by examining the reaction between $Na_3PO_4.12H_2O$ and $BaCl_2.2H_2O$.

This is a precipitation reaction which produces $Ba_3(PO_4)_{2(s)}$. The equation in molecular form is:

$$2Na_3PO_4.12H_2O + 3BaCl_2.2H_2O \rightarrow Ba_3(PO_4)_{2(s)} + 6NaCl + 30H_2O$$

and the ionic equation is:

$$6Na^+ + 2PO_4^{3-} + 24H_2O + 3Ba^{2+} + 6Cl^- + 6H_2O \rightarrow Ba_3(PO_4)_{2(s)} + 6Na^+ + 6Cl^- + 30H_2O$$

The net ionic equation of the reaction is:

$$3Ba^{2+} + 2PO_4^{3-} \rightarrow Ba_3(PO_4)_{2(S)}$$

In this reaction:
3 moles of Ba^{2+} ions react with 2 moles of PO_4^{3-} ions, or
3 moles of $BaCl_2.2H_2O$ react with 2 moles of $Na_3PO_4.12H_2O$

The Act. Yield = mass of product

The Theo. Yield = mass of products that are calculated from questions

Act. Yield < Theo. Yield

راسب

The supernatant : the clear solution over ppt
This rxns is endothermic
ppt contains : excess+product (Act. Yield)

Example 1:

A mixture containing 40.00 g of $Na_3PO_4.12H_2O$ and 30.00 g of $BaCl_2.2H_2O$ is dissolved in water. A precipitate of $Ba_3(PO_4)_2$ weighing 22.65 g is produced. Calculate the % yield of $Ba_3(PO_4)_{2(s)}$.
(FM) of $Na_3PO_4.12H_2O$ = 380.2 g/mole; (FM) of $BaCl_2.12H_2O$ = 244.2 g/mole.
The net ionic equation is:

$$\mathbf{3Ba^{2+} + 2PO_4^{3-} \rightarrow Ba_3(PO_4)_{2(s)}}$$

mole PO_4^{3-} = mole $Na_3PO_4.12H_2O$ = 40.00g /380.2 g mole^{-1} = 0.105 mole
mole Ba^{2+} = mole $BaCl_2.2H_2O$ = 30.00 g / 244.2 g mole^{-1} = 0.123 mole
0.105 mole PO_4^{3-} requires 0.105 x 3/2 = 0.185 mole Ba^{2+}. Since we have only 0.123 mole of Ba^{2+}, so the **limiting reactant** is Ba^{2+}, and the **reactant in excess** is PO_4^{3-}.

The **theoretical yield** of product is calculated from the limiting reactant as follows:

$$\text{mole } Ba_3(PO_4)_2 = \text{moles } Ba^{2+} \times \frac{1 \text{ mole } Ba_3(PO)_2}{3 \text{ mole } Ba^{2+}}$$

$$= 0.123 \times \frac{1}{3}$$

$$= 0.041 \text{ mole}$$

mass of $Ba_3(PO_4)_2$ = 0.041 mole x 602.2 g mole^{-1} = 24.69 g (this is the theoretical yield)

$$\% \text{ yield} = .\frac{22.65g}{24.69g} \times 100 = 91.7\ \%$$

Example 2:

10.0 g of a unknown mixture containing $Na_3PO_4.12H_2O$ and $BaCl_2.2H_2O$ is dissolved in distilled water. The mass of $Ba_3(PO_4)_2$ precipitated is 3.50 g. Calculate the % of each salt present in the mixture if $BaCl_2$ is the limiting reactant?

$$3Ba^{2+} + 2PO_4^{3-} \rightarrow Ba_3(PO_4)_{2(s)}$$

$$\text{mole } Ba_3(PO_3)_2 = \frac{3.50g}{602.2g/mol} = 5.81 \text{ X } 10^{-3} \text{ mole}$$

mole Ba^{2+} = mole $BaCl_2.2H_2O$ = 3 x (mole $Ba_3(PO_4)_2$)

mole $BaCl_2.2H_2O$ = 5.81 X 10^{-3} x 3 = 1.74 x 10^{-2} mole

mass of $BaCl_2.2H_2O$ = 1.74 x 10^{-2} mole X 244.2 g mole^{-1} = 4.25 g

mass of $Na_3PO_4.12H_2O$ = 10.0-4.25 = 5.75 g

$$\%\ BaCl_2.2H_2O = \frac{4.25}{10.0} \times 100 = 42.5\%$$

$$\% \ Na_3PO_4.12H_2O = \frac{5.75}{10.0} \times 100 = 57.5\%$$

In the following experiment you will receive an unknown mixture of $BaCl_2.2H_2O$ and $Na_3PO_4.12H_2O$. The mixture is weighed and then dissolved in water, the precipitate formed is dried and weighed. From the weights of mixture and precipitate, the composition of the unknown mixture is determined.

Apparatus and Chemicals:

Balance	400- mL beaker
Bunsen Burner	100-mL beakers
Iron ring	Filter flask
Ring stand and clamps	Buchner funnel
Wire gauze	Filter paper (Whatman No. 42)
Watch glass	$BaCl_2$
Stirring rod	Na_3PO_4
Rubber policeman	Unknown mixture of ($BaCl_2.2H_2O$) and ($Na_3PO_4.12H_2O$)

Experimental Procedure:

Two trials are required. Weigh **duplicate** unknown salt mixtures and perform the following steps for each.

(1) Precipitation of $Ba_3(PO_4)_2$:

1. Weigh on a weighing paper about 1.0 g of an **unknown mixture** containing $BaCl_2.2H_2O$ and $Na_3PO_4.12H_2O$. Report the mass to ±0.01 g.
2. Transfer to a 400 mL beaker, add 200 mL of distilled water and **stir the mixture for one minute.**
3. Cover the beaker with a watch glass and **heat gently** with stirring for 30 minute. **Do not boil the solution**, keep the temperature at about 80-90°C
4. Allow the precipitate to settle, then decant two 50mL volume of the supernatant liquid into two 100 mL beakers, labeled beaker 1& 2 to be used in part (II).
5. Weigh a filter paper (± 0.01 g) and seal it into the Buchner funnel with a small amount of distilled water. While the solution is hot, **filter the precipitate** by vacuum as shown in Fig.1. Transfer any precipitate remaining in the beaker into the funnel with a policeman and hot water.
6. **Wash the precipitate** with **two portions of distilled water**, remove the filter paper and put it in the oven and dry the precipitate at a temperature of 100°C for about 1 hour.
7. Remove the filter paper from the oven and weight the precipitate and paper to (± 0.01 g)

(2) Determination of the limiting reactant:

The limiting reactant is determined using the solutions in beakers 1 & 2 as follows:
Test for excess PO_4^{-3}: add 2 drops of 0.5 M $BaCl_2$ to the solution in beaker 1. If a precipitate is formed, then PO_4^{3-} is in excess and Ba^{2+} is the limiting reactant.
Test for excess Ba^{2+}: add 2 drops of 0.5 M Na_3PO_4 to the solution in beaker 2.
If a ppt. is formed, then Ba^{2+} is in excess and PO_4^{3-} is the limiting reactant.

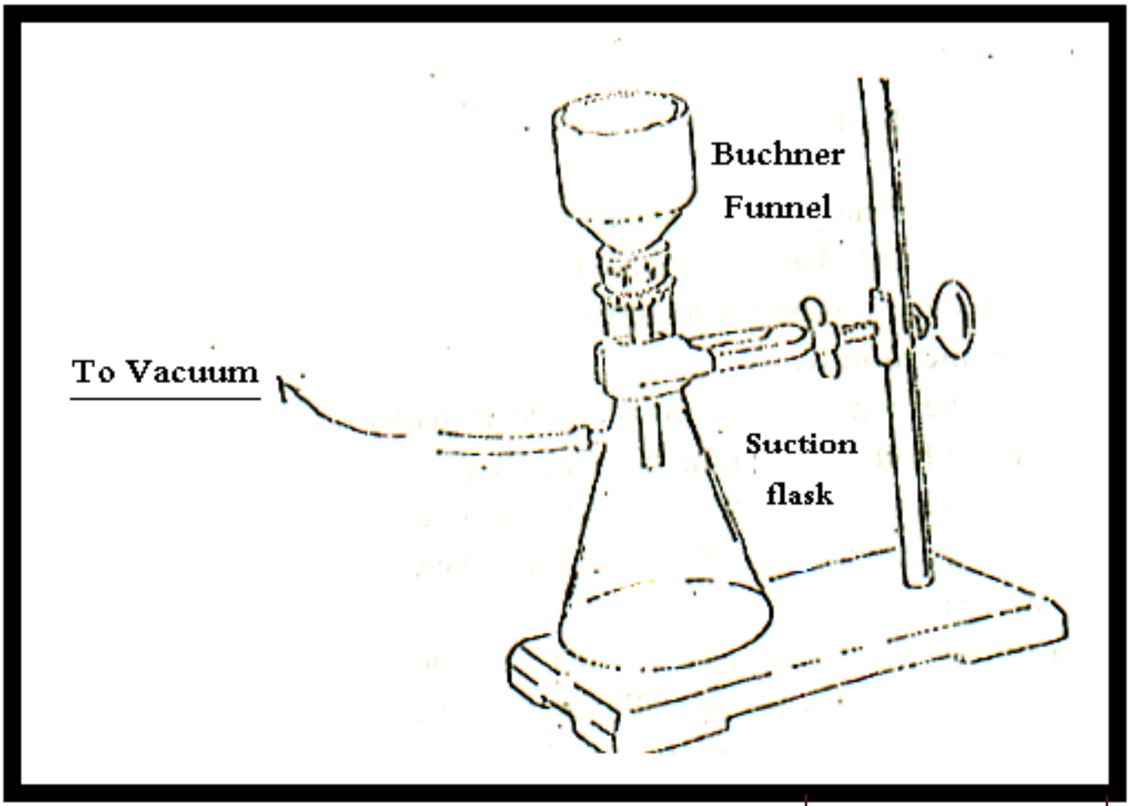


Fig. (1): Setup for vacuum filtration

The purpose of this exp:
1) determine the L.R of the exp rxns
2) determine the (Act.Yield , Theo. Yield , % yield) of the rxns

1) نضع ماء مقطر في Beaker
100-200ml

2) نضع من المادة غير المعلومة
0.1-0.2g

3) ثم نضيف المادة على 1

4) ثم نشغل النار على 1
لمدة 10-15 min

5) نضع Beaker على الطاولة
حتى يصفى و يتكون راسب

[اسم الراسب الذي
يتكون ولا يذوب في
الماء]

Sitt down of products

*Supernatant
↳ Clear solu. over

6) لما يصير المحلول صافي
نضع القليل من المحلول في
2 Small Beaker

7) نضع قليل من المواد
الموجودة في القطرات

[المادة التي تتكون هي
limiting reactant]

1) 25g sample of Na3Po4.12H2O react with excess BaCl2.H2O ... If the mass of Ba3(Po4)2 obtained is 17.56g . Calculate the % yield of Ba3(Po4j2 ?

$L.R = Na_3PO_4 = 25\,g$

$excess = BaCl_2$

mass of product → $Ba(PO_4)_2 = 17.56\,g$

*كتلة الناتج تتأثر ب L.R *

*كتلة الناتج = Act. yield *

$$\text{mole } Na_3PO_4 = \frac{25}{380.2} = 0.065 \text{ mole}$$

$$2 \text{ mole } PO_4^{-3} \longrightarrow 1 \text{ mole } Ba_3(PO_4)_2$$

$$0.065 \text{ mole} \longrightarrow x$$

$$\boxed{x = 0.0328 \text{ mole}}$$

mass of $Ba_3(PO_4)_2 = 19.79\,g$ ⇐ Theo. yield

$$\%\text{ yield} = \frac{17.56}{19.79} = 88.68\,\%$$

---

2)mixture containing 40g of Na3Po4.12H2O & 30g of BaCl2.2H2O is dissolved in water. A ppt of Ba3(Po4)2 weighing 22.65g is produced. Calculate % yield of Ba3(Po4)2 ?

Act. yield $= Ba_3(PO_4)_2 = 22.65\,g$

mass $Na_3PO_4 = 40\,g$

mass $BaCl_2 = 30\,g$

* لتحديد L.R و excess ← نجد mole

$$Na_3PO_4 = \frac{40}{380.2} = 0.105 \text{ mole} \Longrightarrow \frac{0.105}{2} = 0.0525$$

$$BaCl_2 = \frac{30}{244.2} = 0.122 \text{ mole} \Longrightarrow \frac{0.122}{3} = 0.0409$$

* The smallest number is $L.R = BaCl_2$

$$3 \text{ mole } BaCl_2 \longrightarrow 1 \text{ mole } Ba_3(PO_4)_2$$

$$0.123 \text{ mole } BaCl_2 \longrightarrow x$$

$$\boxed{x = 0.041 \text{ mole}}$$

mass of $Ba_3(PO_4)_2 = 24.69\,g$

$$\%\text{ yield} = \frac{\text{Act. yield}}{\text{Theo. yield}}$$

$$= \frac{22.65}{24.69} * 100\,\% = 91.7\,\%$$

---

3) 10g of a unborn mixture containing Na3Po4.12H2O & BaCl2.2H2O is distilled water , mass of Ba3(Po4)2 ppt is 3.5g . Calculate % yield of each salt present in mixture. If BaCl2 is L.R ?

Theo. yield = 10 g

$L.R = BaCl_2$

$$\text{Mole } Ba_3(PO_4)_2 = \frac{3.5}{602.2} = 5.8 \times 10^{-3} \text{ mole}$$

$$3 \text{ mole of } BaCl_2 \longrightarrow 1 \text{ mole of } Ba_3(PO_4)_2$$

$$x \longleftarrow 5.8 \times 10^{-3} \text{ mole}$$

$$\boxed{x = 0.0174 \text{ mole}}$$

Mass of $BaCl_2 = 4.25\,g$ ← Act. yield

$$\%\,Ba^{+2} = \frac{4.25}{10} * 100\,\% = 42.5\,\% \quad // \quad \%\,PO_4^{-3} = (100 - 42.5)\,\%$$

$$= 57.5\,\%$$

1) Don’t boil the solution?
To minimize the lost of the mass

2) Using distilled water?
To avoid the reaction of the unknown

3)Test for excess $(Po4)^{-3}$ OR limiting $(Ba)^{+2}$:
-Add 2 drops of 0.5 mole $BaCl2$ to the solution … If a ppt is formed then $(Po4)^{-3}$ is the excess & $(Ba)^{+2}$ is the L.R
- If a ppt is not formed the $(Po4)^{-3}$ is the L.R & $(Ba)^{+2}$ is the excess

---

1) given the equation A+3B~~C+D … y reaction 1 mole of A with 2 moles of B . Which of the following is true:
— A is L.R because it’s higher molar mass
— B is L.R because of its higher molar mass
— A is L.R because you have fewer moles of A than B
— B is L.R because you have fewer moles of B than A
— B is L.R because you need 3 moles of B & you have 2 moles

find L.R

$A \longrightarrow \frac{n}{\text{المعامل}} = \frac{1}{1} = 1$

$B \longrightarrow \frac{n}{\text{المعامل}} = \frac{2}{3} = 0.66$

⑤

2) In the L.R of salt mixture exp. to test for limiting $(Ba)^{+2}$ ion:
— Add few drops of (Barium ion) 0.5 moles to the ppt will appear
— Add a few drops of (Phosphate ion) 0.5 mole to the ppt will appear
— Add a few drops of (Barium ion) 0.5 mole to the ppt will not appear
— heat the mixture solution in the water both for 30 minutes
— non of these

①

3)If 3.28g unknown mixture containing $Na3Po4.12H2O$ & $BaCl2.2H2O$ is dissolved in distilled water, mass $Ba3(Po4)2$ ppt is 1.75g . Calculate % of $Na3Po4.12H2O$ in the mixture if $BaCl2$ is L.R ?

Act. yield = 1.75 g

L.R = $BaCl_2$

moles of Products $= \frac{1.75}{602.2} = 2.9 \times 10^{-3}$ mole

3 mole of $BaCl_2 \longrightarrow 1$ mole $Ba_3(Po_4)_2$

$x \longrightarrow 2.9 \times 10^{-3}$ of $Ba_3(Po_4)_2$

$x = 8.7 \times 10^{-3}$ mole

mass of $BaCl_2$ = 2.128 g

$\boxed{\text{mass of } Na_3Po_4 \ne \text{Theo. yield}}$

mass of $Na_3Po_4 = 3.28 - 2.128 = 1.15$ g

% yaild $= \frac{\text{Act}}{\text{Theo}} * 100\%$

$= \frac{1.15}{3.28} * 100\%$

$= 35.09\%$

??

4)True OR False: ④

— The rxn in the L.R exp isn't endothermic

— is exothermic

5) The purpose of L.R exp : ⑤

— determine actual yield

— determine theoretical yield

— determine % yield (percentage)

— determine L.R of the exp rxn

— all of these

6) a mixture containing equal masses (X) of Na3Po4.12H2O & BaCl2.2H2O is dissolved in water. A ppt of Ba3(Po4)2 was produced with a mass (0.2X) of the starting material. Then the % yield of Ba3(Po4)2 is :

mass $BaCl_2$ = mass $Na_3PO_4 = x$ g

mass $Ba_3(PO_4)_2 = 0.2x$ g

Act. yield = $0.2x$ g

mole of $BaCl_2 = \frac{x}{244.2 * \underline{\underline{3}}} = \frac{x}{732.6}$ أقل

المعامل

mole of $Na_3PO_4 = \frac{x}{380.2 * \underline{\underline{2}}} = \frac{x}{760.4}$ أكبر

كلما قل المقام زادت النتيجة

$$\boxed{L.R \rightarrow Na_3PO_4}$$

2 mole of $Na_3PO_4 \longrightarrow$ 1 mole $Ba_3(PO_4)_2$

$\frac{x}{380.2}$ mole $Na_3PO_4 \longrightarrow Y$

$$\boxed{\underset{\text{ناتج}}{Y} = \frac{x}{760.4} \text{ mole}}$$

mass of products (Y) $= 0.791x$ g

Thero. Yeild

% yeild $= \frac{Act}{Theo} * 100\%$

$= \frac{0.2x}{0.791x} * 100\%$

$= 25.3\%$

Student Name: ______________________________ Section No.: _____________________
ID Number: _____________________________ Date : _____________________
Partner Name: _____________________________ Group No.: _____________________

Experiment (3)

Limiting Reactant

Report Sheet

Part (1):- Preparation **of $Ba_3(PO_4)_2$**

Unknown number _________________

Data:	**Trial 1**	**Trial 2**
1. Mass of mixture (g)		
2. Mass of filter Paper (g)		
3. Mass of Filter paper + $Ba_3(PO_4)_2$ (g)		
4. Mass of $Ba_3(PO_4)_2$ (g)		

Part (2): - Determination of the Limiting reactant

Data:	**Trial 1**	**Trial 2**
1. Limiting reactant in salt mixture		
2. Excess reactant in salt mixture		
Calculations:		
1. Mass of $Ba_3(PO_4)_2$ (g)		
2. Moles $Ba_3(PO_4)_2$: (FM = 602.2 g/mole)		
3. Moles $BaCl_2.2H_2O$; (FM = 244.2g/mole)		
4. Mass of $BaCl_2.2H_2O$ reacted (g)		
5. Moles $Na_3PO_4.12H_2O$ reacted; (FM = 380.2 g/mole)		
6. Mass of $Na_3PO_4.12H_2O$ reacted (g)		
7. Mass of salt mixture (g)		
8. Mass of excess reactant (g)		
9. % Of $BaCl_2.2H_2O$ in the mixture		
10. % Of $Na_3PO_4.12H_2O$ in the mixture		

Show your calculation on a separate paper.

Experiment (3)

Limiting Reactant

PostLab

1. What is the effect of heating the solution on the particle size of $Ba_3(PO_4)_2$ precipitate?

to prevent accougulation

2. Describe the effect of each of the following factors (whether increase, decrease, or has no effect) on the actual yield of $Ba_3(PO_4)_2$

استعال فلتر مساماتها واسعة

a. Using a coarse filter paper instead of one with fine porosity.

product lost Act. yield dec↓ % dec↓

b. Insufficient washing of the precipitate. عدم التخلص من المادة الفائضة

product + excess , Act. yield ↑ % inc↑

c. If the precipitate is washed with an acidic solution. تفاعل العض مع الناتج

Act. yield dec↓ product ↓ % ↓

d. If the precipitate was not dried completely. لم تنشف المادة في الفرن

Act. yield ↑ % ↑

Student Name: ______________________________ Section No.: ____________________
ID Number: ______________________________ Date : ____________________
Partner Name: ______________________________ Group No.: ____________________

Experiment (4)

Identification of a Compound: Physical Properties

Prelab

1. Define:-

A. Solubility:

like dissolves in like
polar in polar // nonpolar in nonpolar
polar + non ⇒ Insoluble [immiscible]

B. Boiling point:

Temprefure at which (V.P) = atmospheric pressure

Normal B.P → temp. at which (V.P) = 1 atm = atm pressure (at sea level)

2. A students liquid unknown boils at approximately 69°C, is insoluble in water but soluble in cyclohexane. Its density is 0.65g / ml. Which chemical in table (1) is the unknown?

3. What physical property, measurable in this experiment, distinguishes *cyclohexane* from *cyclohexene*?

4. Using the apparatus described in this experiment, when should the boiling point of a liquid be recorded?

Experiment (4)

Identification of a Compound: Physical Properties

Objective:

- To identify a compound based on its physical properties
- To learn how to properly assemble a boiling point apparatus

Introduction:

Gold is yellow, roses are red, salt is white and crystalline, lead is "heavy" and water is a colorless clear liquid. These are all physical properties of chemical substances. Physical properties are often used for the identification of a chemical substance .The more common physical properties include color, odor, density ,solubility ,melting point, boiling point ,and whether the substance is a solid, liquid ,or gas. These properties can be observed without any knowledge of the reactivity of the compound. Additional tests, tests that reveal more information about its chemical or physical properties, may be necessary, however, to confirm its purity.

The purpose of this experiment to identify a chemical compound from the data collected on its solubility, density, and boiling point.

polar + Salt → Soluble [Miscible]
non polar + Salt → insoluble [immiscible]
polar + polar → Soluble
non + nop → Soluble

Solubility:

The solubility of a compound is the maximum mass (usually in grams) of the substance that dissolves in a fixed mass (usually 100g) of solvent at a given temperature. A chemical has different solubilities in different solvents, reflecting the differences in the molecular composition of the solute from that of the solvent. For instance, some substances such as table salt, are soluble in water but insoluble in gasoline. In this experiment we will examine the solubility of a substance in three different solvents: water, cyclohexane, (C_6H_{12}) and ethanol (C_2H_5OH). Qualitatively each substance is recorded as being soluble (complete dissolution), slightly soluble (partial dissolution), or insoluble.

غير ذائب

ذوبان كامل

ذوبان جزئي

1L = 1000 mL

Density:

The density is the mass per unit volume. Substances with a large density have a large mass in a small volume. While we commonly say that Lead is"heavy" we really mean that lead has a high density-it doesn't require much volume in order to have a large mass of lead.

* أي المواد تصلح للتجربه : ماده درجه غليانها < درجه غليان الماء 100C

* أي ماده لا تصلح للتجربه : ماده درجه غليانها > درجه غليان الماء 100C

Boiling point:

1) at which the liquid starts to boil
2) where the vapor pressure is equal to the atmosphere pressure

When a liquid is gradually heated, there is a temperature at which bubbles form spontaneously and continue to form until the entire volume of the liquid has been converted to a gas. This "constant" temperature is called the boiling point of the liquid. At the boiling point the temperature of the escaping vapor equals that of the liquid; this temperature depends upon the prevailing atmospheric pressure. The boiling point values listed in Table (1) are measured at normal atmospheric pressure (called one atmosphere of pressure).

The boiling point of a substance is characteristic of the magnitude of the forces acting between molecules, called ***intermolecular forces***. The greater the magnitude of the intermolecular forces, the higher will be boiling point. Since the magnitude of the intermolecular forces is different for each compound, each has a characteristic boiling point.

Apparatus and Chemicals:

Normal B.P : if (vapor pressure = pressure atmosphere = 1 atm)

75 mm test tube (4), dropper, 150 ml-beaker, pipette, thermometers 110°C, rubber band, and capillary tube. Beaker 250 ml, Burner, wire gauze, O-ring. Stirring rod, Ethanol, Cyclohexane, Acetone, and about 15ml of an unknown liquid.

* When air bubbles escape rapidly :
(V.P) > atm. Pressure (high B.P)

* After Liq. enters the capillary tube:
(V.P) < atm. Pressure. (low B.P)

* While Liq. enters capillary tube: Tomp = B.P
(V.P) = atm. Pressure

1) نضع في unknown
test tube + ماء مقطر
2) نحرك tube لمعرفة
هل المحلول non / polar
3) p ← one lyer
n ← two lyer

1) نضع Beaker
على الميزان
2) نضع من محلول
0.1mL ← unknown
في Cylinder لمعرفة
الحجم V=1.8
3) نضع الحجم في Beaker
لمعرفة الكتلة على
الميزان m=1.27

$d = \frac{1.27}{1.8} = 0.705$

1) نضع على Beaker
stande وفي داخله
tube يحتوي على
unknowns +
Copillary tube
[الفتحة داخل المحلول]
2) نضع tube داخل
Beaker بواسطة حمالة
بحيث مستوى الماء
أعلى من tube + نضع
ميزان الحرارة داخل
tube

B.P = 78°C

Experimental Procedure:

Note: (Ask your instructor for an unknown listed in Table 1)

A. Solubility:

1. **Solubility in Cyclohexane**:

Into a 75-mm test tube add 3 drops of your liquid unknown to 1 ml of cyclohexane. Agitate the contents (Figure 1) Does each drop dissolve? Partially dissolve? Record your observations.

P: Polar ═

n: nonpolar

2. **Solubility in water and Ethanol**:

Repeat the test with water and ethanol as solvents. Describe the solubility of your unknown as soluble, slightly soluble, or insoluble in each solvent.

Table (1) physical properties of some common laboratory chemicals

Symbols used: i = insoluble, sls = slightly soluble, s = soluble

	Compound	Density(g/ml)	Boiling Point(C)	Solubility		
				H_2O	C_6H_{12}	C_2H_5OH
═	Acetone	P 0.79	56	s	s	s
═	2-butanone	P 0.805	80	s	s	s
C_6H_{12}	Cyclohexane	n 0.79	80.74	i	-	s
	Cyclohexene	n 0.81	83	i	s	s
═	Ethanol	P 0.79	79	sls	s	-
C_2H_5OH ═	Ethylacetate	P 0.90	77	s	s	s
	Heptane	n 0.684	98	i	s	s
	n-hexane	n 0.66	68	i	s	s
	1-hexene	n 0.67	63	i	s	s
═	Isopropanol	P 0.79	83	s	s	s
═	Methanol	P 0.79	65	s	s	s
═	n-propanol	P 0.805	97	s	s	s
H_2O ═	Water	P 1.00	100	-	i	s

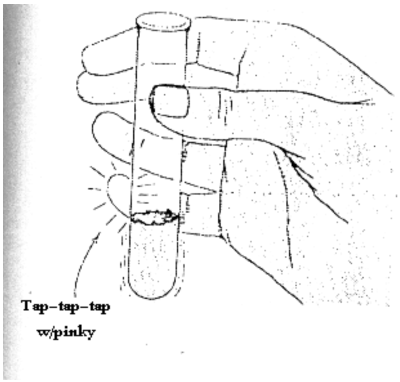


Figure (1) shake contents of the test tube

B. Density:

Complete two trials to determine the density of your unknown.

Determine Mass and Volume of Unknown. Pipette 2ml of the liquid into a beaker and weigh. Calculate the density of the liquid.

C. Boiling point:

Check out a 110^{o}C thermometer. Assemble the apparatus in Figure 2. Complete two measurements for the boiling point of your unknown.

1. Assemble the Boiling Point Apparatus. Place 10 drops of the unknown liquid into a 75-mm test tube. Position it beside the thermometer bulb using a rubber band. Invert (open end down) a 10-cm capillary tube in the liquid. Place the apparatus into the water bath.

2. Measure the Boiling Point. Slowly heat the water in the water bath while stirring with the stirring rod . When a rapid and continuous stream of bubbles escapes the capillary tube, discontinue heating the water bath. The stream of bubbles slows as the bath cools. When the bubbles cease to escape and before the liquid re-enters the capillary tube, record the temperature. This is the boiling point of the liquid.

3. Repeat the Measurement. Determine the boiling point a second time. The same (volume of) liquid may be used. However, the capillary tube must be removed and re-inserted before heating resumes.

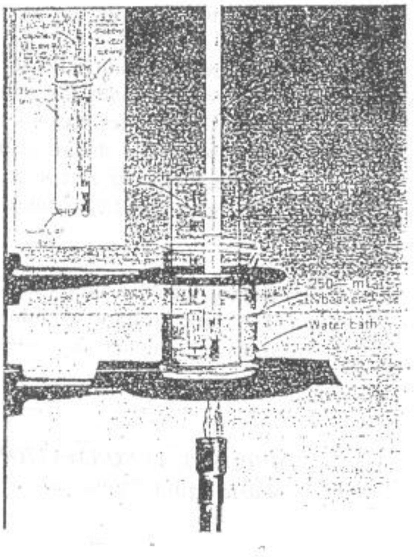


Figure (2) apparatus for determining the boiling point of a liquid

1) what physical property, measurable , in this , exp. distinguishes cyclohexane from cyclohexene ?
- Boiling point

2) using apparatuse described in this exp. , when should the boiling point of a liquid be recorded?
- when the bubbles cease to escape and before the liquid re-enters the capillary tube

3) why B.P solution > B.P solvent?
-because it has stronger intermolecular forces

4) how does Atmospheric pressure affect the B.P of the liquid?
- directly

5) how does Intermolecular force affect the B.P of a liquid?
- directly

6) can you predict when the V.P = atmosphere pressure, theoretically?
- no , by experience

7) if several drops of liquid unknown cling to the pipette wall after delivery will the density of the unknown be reported too high OR too low?
- $D = \frac{m}{v} \Longrightarrow$ mass dec. $\Rightarrow$ because some of Liquid cling of pipette
Too low , because mass will decrease because some liquid cling to pipette then the density will decrease

8) when air bubbles escape rapidly from the capillary tube: (& heat is removed)
- V.P>V.atmosphere. , temperature > B.P true

9) when the liquid enters the capillary tube: (& after heat is removed)
- V.atmosphere > V.P , temperature < B.P true

10) the temperature is taken while (not before or after) the liquid enters the capillary:
V.atmospheric =V.P , temperature = B.P true

11) a student liquid unknown boil at approximately 69C , is insoluble in water but soluble in cyclohexane . Its density is 0.65g/ml . Which chemical in table is the unknown?

من الجدول مباشرة

* Qualitative : color, odor ... نوعيه
* Quantitative : Boiling point, density, solubility ... كميه

* V.P & Inter molecules forces : inverse (dec)
* V.P & Temperature: direct (inc)
* V.P & Boiling point: inverse (dec)

1) which of the following pair of liquids are miscible?
- polar + salt. - non + polar
- non + non. - non + salt
- 1 + 2 will be miscible

③

2) if you need 10ml pipette to weight 10 ml of three unknown liquid substances A,B&C . You find that the wight of the 10ml of each substance is the following: A=9.2g , B=9g , C=8.9g . The order of density decreasing of these liquids is :

$d_A = \frac{m}{v} = \frac{9.2}{10} = 0.92$ / $d_B = \frac{9}{10} = 0.9$ / $d_C = \frac{8.9}{10} = 0.89$

3) which of the following is qualitative :
- density. - boiling point
- solubility. - non of these

④

4) True OR False:

- the B.P is the temperature at which at which the V.P of the liquid is higher than the atmosphere pressure

F

- if the B.P is recorded while the bubble escaping from the capillary tube (and the heat is removed) , the recorded boiling point will be too low

F

- as the temperature increases the vapor pressure of the liquid increases

T

- if the B.P is recorded after the liquid enters the capillary tube (after the heat is removed) , the recoded B.P will be too high

F

- the B.P of the substance increases as the intermolecular forces between molecules decrease

F

5) which can I use in exp.4 :
- X , B.P = 90
- y , B.P = 101
- Z, B.P = 160

①

6) which can not I use in exp.4 :
-A , B.P= 107
-B, B.P = 90
- C, B.P = 92

①

Student Name: ____________________________ Section No.: _____________________

ID Number: ____________________________ Date : _____________________

Partner Name: ____________________________ Group No.: _____________________

Experiment (4)

Identification of a Compound: Physical Properties

Report Sheet

Solubility:

Unknown Number________

	Soluble	Slightly Soluble	Insoluble
1. Solubility in cyclohexane	______	______	______
2. Solubility in ethanol	______	______	______
3. Solubility in water	______	______	______

Density:

	Trial 1	Trial 2
1. Volume of liquid (ml)	________	________
2. Mass of liquid (g)	________	________
3. Density of liquid (g/ml)	________	________
4. Average density of liquid (g/m)	________	

Boiling point:

1. Observed boiling point (c) ________ ______

Name of unknown: _____________________

Experiment (4)

Identification of a Compound: Physical Properties

Post Lab

1. How does atmospheric pressure affect the boiling point of a liquid? Ask your instructor.

B.P = temp. at which (V.P) = atm. pressure

2. If several drops of liquid unknown (Part B) cling to the pipette wall after delivery will the density of the unknown be reported too high or too low? Explain

$d = \frac{m}{V}$

$d\downarrow$ due to $m\downarrow$

3. (**A**). In part C.2 if the boiling point is recorded when bubbles are rapidly escaping the capillary tube, will it be recorded too high or too low? Explain.

(V.P) > atm pressure (high B.P the true B.P)

(**B**). If the boiling point is recorded after the liquid enters the capillary tube (after the heat is removed), will it be recorded too high or too low? Explain

lower due to (V.P) Liq < atm pressure

Exp.5 / Cation and anions tests

Cations

1- Calcium ion Ca^{+2}

		كاشف		الناتج		
$Ca(NO_3)_{2(aq)}$	+	$Na_2C_2O_{4(aq)}$	→	$CaC_2O_{4(s)}$	+	$2NaNO_{3(aq)}$
		Sodium oxalate		White ppt.		
				الراسب		

2- Iron (III) ion Fe^{+3}

Ferric Test

					الناتج		
$Fe(NO_3)_{3\ (aq)}$	+	$3\ KSCN_{(aq)}$	كاشف	→	$Fe(SCN)_{3(aq)}$	+	$3\ KNO_{3(aq)}$
Iron Sulfate		Potassium thiocyanate			Red solution الراسب		

3- Ammonium iron NH_4^+

$NH_4NO_{3\ (aq)}$	+	$NaOH_{(aq)}$	كاشف	→	$NH_{3(g)}$ الناتج	+	$H_2O_{(l)}$
Ammonium Nitrade		Sodium hydroxide (Basic)			Gas (with heating changes the litmus paper red to blue)		

Anions

1- Hydrogen carbonate ion HCO_3^-

					الناتج		
$NaHCO_{3(aq)}$	+	$HCl_{(aq)}$	الكاشف	→	$H_2CO_{3(aq)}$	+	$NaCl_{(aq)}$
Sodium hydrogen carbonate		Hydrochloric acid (Acidic)			$(H_2O + CO_2)$		
					Bubble of carbon dioxide		

2- Sulfate ion SO_4^{+2}

		الكاشف		HCl وسط حمضي		الناتج		
$Na_2SO_{4(aq)}$	+	$BaCl_{2\ (aq)}$	+	$H^+_{(aq)}$	→	$BaSO_{4(s)}$	+	$2\ NaCl_{(aq)}$
Sodium Sulfate		Barium chloride		Shaking Gently		White ppt.		
						الراسب		

3- Chloride and Bromide ion Cl^- and Br^-

$NaCl_{(aq)}$	+	$AgNO_{3\ (aq)}$	+	$HNO_{3(aq)}$	→	$AgCl_{(s)}$	+ $NaNO_{3(aq)}$
		Silver nitrate		وسط حمضي		White ppt.	
Or						or	
NaBr						AgBr	
						Pale yellow ppt.	

1) the sulfate ion can be detected by:
— adding BaCl2 solution in Acidic media & a white ppt will appear
— adding BaCl2 solution in Basic media & a white ppt will appear
— adding HCl solution, a gas will change the wet red litmus to blue
— adding NaOH solution, a gas will change the wet blue litmus to red
— adding NaOH solution, Ammonia smell can be detected

①

2)the Cl- can be detected by:
— sodium Oxalate ③
— potassium thiocyanate
— silver nitrate + acid
—barium chloride + acid
— hydrophobic acid

3)the iron (|||) ion can be detected by:
— adding BaCl2 solution, in acidic media & a white ppt will appear
— adding KSCN solution & a red color will appear
— adding KSCN solution & a white color will appear ②

4)an unknown salt give a gas that convert the litmus paper from red to blue when detected with sodium hydroxide & a pale yellow precipitate when reacted with silver nitrate in acidic media . The formula of the salt is :
— CaBr2. — Fe2(So4)3. — NH4Br — NH4HCO3

③

5)four unknown salt have the formula: AB , XY , ZW , AY . The following results were obtained by testing the ions in the sample : According to the previous table , the salt AY is : ④

— Fe2(So4)3. —CaCl2. —NH4Br. — FeCl3

6)when an unknown react with sodium hydroxide solution, it evolved a gas which convert the wet red litmus paper to blue. The resulted aqueous layer from the previous rxn was treated with hydrochloride acid solution & carbon dioxide evolved immediately as a result of rxn , the unknown is :

— CaCl2. — Ca(HCO3)2. — NH4Cl. — NH4HCO3

④

1) …… + NaoH → تحول المحلول من الأحمر إلى الأزرق

↳ NH_4^+

2) …… + HCl → $\underline{H_2CO_3}$

↳ HCO_3^-

CO_2 H_2O

Experiment (6)

Molar Mass of a Volatile Liquid

Objective:

To determine the molar mass of an unknown volatile liquid.

Introduction:

According to Avogadro's principle, equal volumes of gases at the same temperature and pressure contain equal number of particles (molecules). Dumas used this principle in 1826 to determine atomic and molar masses. Dumas measured the densities of volatile liquids (easily vaporized), and from these densities he determined the atomic and molar masses of many gases. In this experiment the molar mass of a volatile liquid is determined using the modified Dumas apparatus and procedure. A volatile liquid is transferred to a weighed Erlenmeyer flask. The flask is then heated to the boiling point of water to vaporize the liquid and expel air and excess liquid. Finally the flask is cooled to room temperature. The flask with contents is weighed again and the mass of the condensed vapor is calculated. The molar mass is determined using the ideal gas law:

$$PV = nRT \qquad (1)$$

The number of moles, n, is given by $M_r = \frac{mRT}{PV}$

$$n = (m/M) \qquad (2)$$

The ideal gas equation becomes: $\hookrightarrow M_r = \frac{dRT}{P}$

$$PV = (m/M)\ RT \qquad (3)$$

Where:

P = atmospheric pressure (atm) = 1 atm = 760 mmHg = 760 torr = 101325 pa

V = volume of vapor (L) 1 L = 1000 mL = $1 c^3$ = $1 dm^3$

$V \rightarrow H_2O$

m = mass of vapor (g)

$m \rightarrow$ gas

M = molar mass of volatile liquid (g/mol)

R = gas constant = 0.0821 atm L K^{-1} mol^{-1} = atm L / K mol

T = temperature of boiling water (K).

$T(C°) + 273 = T(K°)$

$d = \frac{m}{V}$ (g/mL)

↲ لازم تتحول (g/L)

$n = \frac{m}{M_r}$ $\frac{\text{of vapor}}{\text{of vol. liq}}$

$\frac{g}{g/mol}$ ↲

Experimental Procedure:

1. Weigh together a clean and **dry** 125 ml Erlenmeyer flask, a copper wire and an aluminum foil (8 x 8 cm) on a Top-loading balance and record the weight as accurately as possible.

2. Using a graduated cylinder, pour about 10 ml sample of the volatile liquid (supplied by your instructor) into the Erlenmeyer flask.

3. Center the aluminum foil (8 x 8 cm) over the mouth of the flask and secure it in place with the copper wire.

4. Place a larger piece of aluminum foil (10 x 10 cm) over the first foil, cover and secure it in place with a rubber band.

5. Make a small hole through the aluminum foils with a sharp pin.

6. Place the Erlenmeyer flask into a 400 ml beaker and clamp it to a stand.

7. Place some water in the beaker, to cover up the liquid level in the flask, along with few boiling stones.

8. Place the beaker, with the flask over Bunsen burner as shown in the following figure.

9. Heat the beaker slowly till the water boils (this step should take about 10 minutes).

10. Allow the water to boil gently, till all the volatile liquid has vaporized. Continue gentle heating of water for another 5 minutes.

11. Measure the temperature of the boiling water and record it.

12. Turn off the Bunsen burner.

13. Using a towel, immediately remove the **Erlenmeyer** flask from the beaker.

14. Dry the outside of the flask and the aluminum foil **completely.**

15. Remove the outer aluminum foil **and rubber band** only.

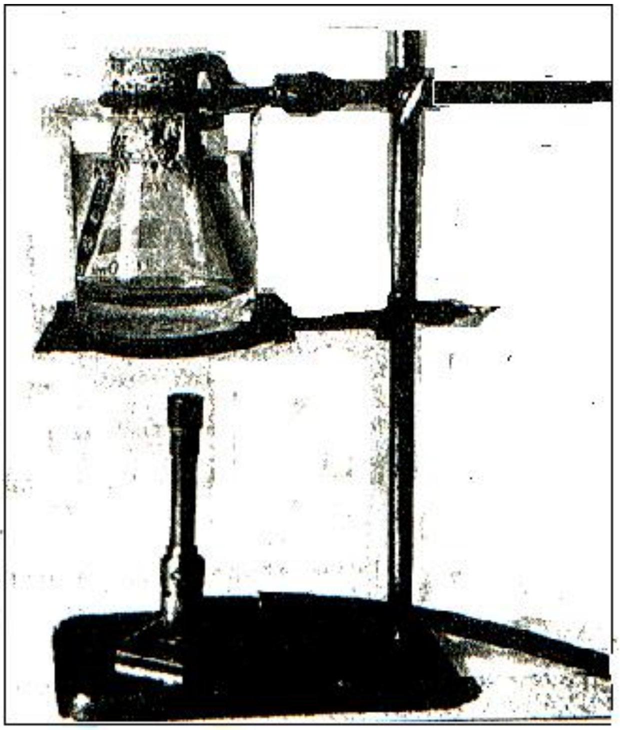
16. Allow the Erlenmeyer flask to sit for 15 minutes to cool to room temperature.

17. While waiting for the Erlenmeyer flask to cool, read the atmospheric pressure on the laboratory barometer.

18. Weigh the Erlenmeyer flask, with aluminum cover and wire still on, accurately and record the mass.

19. Determine the volume of the flask by filling it to the rim with water and measuring the volume of the water with a graduated cylinder. Record the volume.

20. Repeat the above steps for a second trial.



في هذه
التجربه
نختار
الماده التي
درجه
غليانها اقل
من الماء

B.P < B.P
sabustant water

.

1) what’s the mass of vapour volatile liquid (Mm= 85 g/mol) which completely fill a 184 ml flask at 94C & 675.05 torr ?

$T = 94\,C^{\circ} \longrightarrow 94 + 273 = \boxed{367\ K}$

$P = 675.05\ torr \longrightarrow \frac{675.05}{760} = \boxed{0.888\ atm}$

$V = 184\ mL \longrightarrow \boxed{0.184\ L}$

$$M_m = \frac{mRT}{PV} \Longrightarrow 85 = \frac{m * 0.0821 * 376}{0.184 * 0.888} \Longrightarrow m = 0.449\,g$$

---

2)a cylinder contain compressed hydrogen gas & the mass of the hydrogen is 20g , what mass of oxygen would be contained in an identical cylinder at the same temperature & pressure?

Identical cylinder $\longrightarrow V_H = V_O \longrightarrow T_H = T_O \longrightarrow P_H = P_O$ [Avogadro's] $\longrightarrow n_H = n_O$

$n_H = \frac{m}{M_r} = \boxed{20\ mole} \longrightarrow n_H = n_O$

$m_O = n_O * M_{r_O} = 20 * 16 = \boxed{320\ g}$

---

3)for which of the following components can we determine. It’s Mm using the method described in this exp, give reasons ...

A) Benzene (B.P 78C). B) Glycerol (B.P 180C)

نختار A

A) why should the Earl. flask be dry?

-to avoid changing the mass of the substance

B) why we should make a small hole through the aluminium foil?

- to avoid the explosion of the flask

C) does it affect if we change the quantity of the water?

-No, Mm is independent on the quantity of the water

D) why we are putting a few boiling stones in the liquid?

- to decrease the bubbles of the boiling , so we can avoid explosions

E) why should we heat the beaker slowly

- to avoid fast evaporation

F) why should we dry the outside of the aluminium foil completely, after finish heating?

- to have an accurate reading of the mass

Student Name: ______________________ Section No.: ________________
ID Number: ______________________ Date : ________________
Partner Name: ______________________ Group No.: ________________

Experiment (6)

Molar Mass of a Volatile Liquid

Report Sheet

Unknown No. ____________

Data:

		Trial I	Trial II
1.	Mass of empty Erlenmeyer flask + Aluminum foil + Wire (g)	73.70	
2.	Temperature of boiling water (K)	95°C = 368 K	
3.	Atmospheric pressure (atm)	749 torr	
4.	Mass of Erlenmeyer flask + Condensed vapor + aluminum foil + wire (g)	73.11	
5.	Mass of condensed vapor (g)	0.41	
6.	Volume of Erlenmeyer flask	196 mL = 0.196 L	
7.	Molar mass of the liquid, calculated		
8.	Average molar mass		

$R = 0.0821$

$$\mathcal{M} = \frac{mRT}{PV} = \frac{0.41 * 0.0821 * 368}{0.98 * 0.196} = \frac{12.387}{0.192}$$

$$\frac{749}{760} \rightarrow 0.98$$

$= 64.515$ g/

Note: *A more accurate calculation of the molar mass uses a corrected mass for the vapor which takes into consideration the mass of air displaced by vapor at room temperature.*

Experiment (6)

Molar Mass of a Volatile Liquid

PostLab

1. A flask weighs 40.1305g when clean, dry, evacuated, 138.2410g when filled with water (density = 0.9970 g/ml) and 40.2487g when filled with a gaseous substance at 470.4 torr and 96ºC. What is the molar mass (g/mol) of the gas? [R = 0.082 L.atm/mol. K]

$* \ P = \frac{470.4}{760} = 0.62 \text{ atm}$

$* \ m_{H_2O} = 138.241 - 40.1305 = 98.1105 \text{ g}$

$* \ V_{H_2O} = \frac{m}{d} = \frac{98.1105}{0.997} = 98.4057 \text{ mL} = 0.0984 \text{ L}$

$* \ m_{gas} = 40.2487 - 40.1305 = 0.1182 \text{ g}$

$* \ T = 96 + 273 = 369 \text{ K}$

$Mr = \frac{mRT}{PV}$

$= \frac{0.1182 * 0.0821 * 369}{0.69 * 0.0984}$

$= 58.7 \text{ g/mol}$

1) if flask isn't dried completely from outside before weighing ?

- $m \uparrow \implies M_m \uparrow$ inc

2) if the density of the volatile liquid was mistakenly greater than the true value?

- increase

3) if the temperature of the boiling water was mistakenly less then the true value?

- decrease

4) if balance reads lower than the true value?

- No effect

5) if the volume of the flask than the recorded volume ?

- increase

6) if amount of volatile liquid isn't enough the flask ?

- V will be considered as filled

Mr of vapor will be lower [decrease]

7) if 50 ml rather then 20ml of vol. liquid is used exp?

- No effect → due to mass of vapor not vol. liquid is considerd

Student Name: ______________________________ Section No.: _____________________
ID Number: ______________________________ Date : _____________________
Partner Name: ______________________________ Group No.: _____________________

Experiment (7)

Determination of the Molar Volume of Hydrogen Gas

PreLab

A student at The Hashemite University wants to determine experimentally the volume occupied by one mole of H_2 gas at STP. She reacts 0.1471 g of Zn with excess HCl*(aq)* and collects 56.09 ml of gas over water at 22 °C and 757.8 torr. The vapor pressure of water at 22 °C is 19.8 torr.

1. Use the data given above to calculate:
   (i) The volume occupied by one mole of dry H_2 at 22 °C and 760 torr.
   (ii) The volume occupied by one mole of dry H_2 at STP.

Note: do NOT simply use the ideal gas law equation!

Molar volume $= \bar{V} = \frac{\text{Vol. of gas (L)}}{\text{moles of gas (mol}} = \frac{V_2}{\text{moles}}$ $\boxed{\text{L/mol}}$

*** one mole of an ideal gas at STP will occupy a volume = 22.4L**
Molar Volume at STP = 22.4 L/mole

STP : standard Temperature &pressure
T= 0C =32 °C= 273K
P= 1 atm = 760 torr

2. Name the gas laws which you used in your calculations.

$1\,Mg + 2\,HCl \longrightarrow MgCl_2 + 1\,H_2$ $n_{Mg} = n_{H_2}$

$P_{tot} = P_{gas} + P_{H_2O}$ → Atmospheric prssure (P_{atm})

لم يتم حسابها
(H_2) بالتجربة

Experiment (7)

Determination of the Molar Volume of Hydrogen Gas

Objectives:

- To determine the volume, in liters, of one mole of dry hydrogen (H_2) gas at STP

Introduction:

Hydrogen gas, or dihydrogen, (H_2) can be produced from the reaction of active metals with acids. In this experiment you will generate H_2 by reacting magnesium metal with hydrochloric acid. You will collect the H_2 in an inverted burette by water displacement and measure the volume of the gas. You can then calculate the volume of dry gas at STP if you know the room temperature, the barometric pressure, and the vapor pressure of water. We know that the ideal gas law predicts a volume of 22.4 L mol^{-1}, but in this experiment we want to *measure* this for ourselves.

Apparatus and Chemicals:

50 mL burette, one- or two-hole stopper to fit burette, ring stand with clamp, 600 mL beaker, 10 mL and 1000 mL graduated cylinders, fine copper wire, 6 M HCl, 5-6 cm piece of magnesium ribbon.

Experimental Procedure:

1. The first step is to record the volume contained in your burette between the 50 mL mark and the sealed end. It is written on your burette
2. Weigh a piece of magnesium ribbon with a mass of approximately 0.035–0.04 g on an analytical balance. Record its mass to four decimal places.
3. Fold the magnesium ribbon into a small pellet. Wrap it tightly all around with copper wire so that no small pieces can escape as it dissolves. Leave about 5 cm of copper wire to serve as a handle. See Figure 1.
4. Clamp your burette in an upright position in the ring stand. Fill a 600 mL beaker about two-thirds full of tap water and place near the ring stand.
5. Measure about 10 mL of 6 M HCl in a graduated cylinder. Tilt the burette at an angle from the upright position and pour in the HCl.
6. With the burette in the same position, SLOWLY fill it with tap water from the beaker. While pouring, rinse any acid that may be on the sides of the tube so that the liquid in the top of the tube will contain very little acid. TRY TO AVOID STIRRING UP THE ACID LAYER IN THE BOTTOM OF THE TUBE.
7. While holding the copper coil by the handle, insert the metal about 3 cm down into the burette. Hook the copper wire over the edge of the tube and hold it there by inserting the stopper. Fill

the burette completely so that the stopper displaces a little water when put in place. See the left of Figure 1.

8. Cover the hole in the stopper with your finger and invert the burette in the 600 mL beaker of water, as shown in the middle of Figure 1. Clamp the burette in place. The acid being more dense than water will flow down to the bottom and eventually react with the metal.
9. After the reaction stops, wait for about 5 minutes to allow the burette to come to room temperature. If any bubbles stick to the sides of the burette, tap them gently.
10. Cover the hole in the stopper with your finger and transfer the burette to a large graduated cylinder almost full of room temperature water. See Figure 2. Raise or lower the burette until the level of the liquid inside the burette is the same as the level outside the burette. This permits you to measure the volume of the gases in the burette (H_2 and water vapor) at room pressure.
11. Read the burette. The calibrations are upside down, so make sure you read it correctly. Ask for help if you are not sure of the reading. Record this reading on your data sheet.
12. Remove the burette from the water and pour the acid solution it contains down the sink. Rinse the burette with tap water and then with distilled water.
13. Record the temperature of the water in the large graduated cylinder, the room temperature, and the room pressure as given by your instructor.
14. Do the experiment a second time.

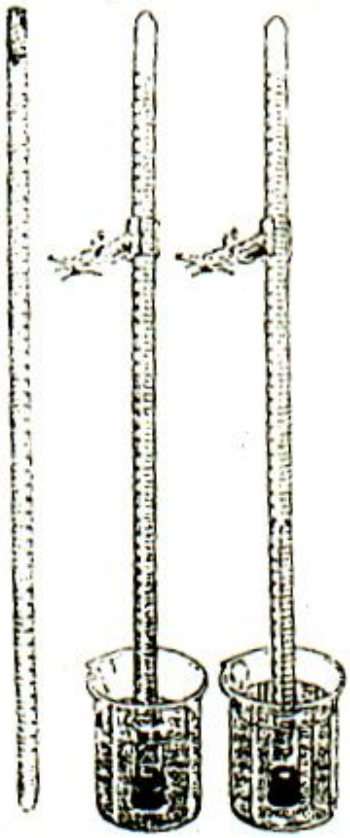


Figure 1 Manipulating the burette.

Figure 2 Measuring the volume of gas.

1) one mole of an ideal gas at STP will occupy volume equal? 22.4 L

2) a student wants to determine exp. The volume occupied by one mole of H_2 gas at STP . She reacts 0.1471g of Zn with excess HCl & collects 56.09ml of gas over water at 22C & 757.8 torr . The V.P of water at 22C is 19.8 torr

- $mass_{Zn} = 0.1471 g$ $\quad P_{H_2O} = \frac{19.8}{760} = 0.026 atm$

$V = 0.05609 L$

$T = 22 + 273 = 295 K$ $\quad P_{tot} = \frac{757.8}{760} = 0.997 atm$

—) the vol. occupied by one mole of dry H_2 at 22C , 760 torr $\rightarrow$ $T_2 = 295K$, $P_2 = 1 atm$

$P_{tot} = P_{gas} + P_{H_2O}$

$0.997 = P + 0,026 \Longrightarrow P_1 = 0.971 atm$

$n_{H_2} = n_{Zn} = \frac{0.1471}{65.4} = 2.25 * 10^{-3}$

$\bar{V}_2 = \frac{V_2}{mole_{H_2}} = \frac{0.054}{2.25*10^{-3}} = 24 L/mole$

$\frac{P_1 V_1}{T_1} = \frac{P_2 V_2}{T_2}$

$\frac{0.971 * 0.056}{295} = \frac{1 * V_2}{295} \Longrightarrow V_2 = 0.054 L$

—) the vol. occupied by one mole of dry H_2 at STP ?

$T_2 = 273 K$

$P_2 = 1 atm$

$\frac{P_1 V_1}{T_1} = \frac{P_2 V_2}{T_2} \Longrightarrow \frac{0.971 * 0.056}{295} = \frac{1 * V_2}{273} \Longrightarrow V_2 = 0.0504 L$

$\bar{V} = \frac{V_2}{mole_{H_2}} = \frac{0.0504}{2.24*10^{-3}} = 22.4 L/mol$ $\Longleftarrow$ حفظ السؤال + الجواب

Student Name: ______________________________ Section No.: _____________________
ID Number: ______________________________ Date : _____________________
Partner Name: ______________________________ Group No.: _____________________

Experiment (7)

Determination of the Molar Volume of Hydrogen Gas

Report Sheet

	Trial 1	Trial 2
Volume of burette from 50 mL mark to the sealed end	5.3 mL	
Mass of piece of magnesium ribbon	0.05g	
Burette reading from Step 11	34.1mL	
Temperature of the water in the graduated cylinder (Step 13)	23.0 C°	
Room temperature	27.2C°	
Room pressure	754 torr	
Vapor pressure of water—use the water temperature from Step 13 and the Table below.		

Vapor Pressure of Water at Various Temperatures

Temperature ºC	Pressure torr	Temperature ºC	Pressure torr
16	13.6	21	18.6
17	14.5	22	19.8
18	15.5	23	21.0
19	16.5	24	22.4
20	17.5	25	23.8

Calculations:

Set up each problem completely and **SHOW UNITS.** Cancel the units when you do the calculation. Use the correct number of significant figures in your answers.

1. Write the balanced equation for the reaction.

2. Determine the number of moles of magnesium used. Find the average for the 2 trials.

3. Determine the volume of gas produced. Find this by the following equation:
   Volume of gas = (Volume of burette from 50 mL to sealed end) + (50.0 mL – burette reading). Find the average for the 2 trials.

Use the average of your data from the previous page for these calculations.

4. Determine the partial pressure of the H_2 gas. Since the H_2 is collected over water, the gas in the burette consists of a mixture of H_2 and water vapor. The total pressure is $P_{\text{room}} = P_{H_2} + P_{H_2O}$.

5. Using the results of your calculations in the previous steps, determine the volume (in liters) of the H_2 at one atmosphere pressure (760 torr) if no water were present.

6. Using the results of your calculations in the previous steps, calculate the molar volume (in liters/mol) of dry H_2 at room temperature and 1 atmosphere pressure. (*Don't* simply use the ideal gas law, use your own results!)

7. Using the results of your calculations in the previous step, calculate the molar volume (in liters/mol) of dry H_2 at STP.

Section No.: ____________________

Student Name: ____________________________

ID Number: ____________________________

Date : ____________________

Partner Name: ____________________________

Group No.: ____________________

Experiment (8)

Colligative Properties: Molar Mass Determination

PreLab

1. Students prepared two cyclohexane solutions having the same mass of solute. However Student 1 used 13 g of cyclohexane, Student 2 used 15 g. Which student will observe the larger freezing point change? Explain.

2. A 0.597 g sample of a non-electrolyte dissolves in 20.0g of cyclohexane. The freezing point depression is 3.62 °C. What is the molar mass of the non-electrolyte? (K_f for Cyclohexane is 20.0 °C Kg/mol).

Experiment (8)

Colligative Properties: Molar Mass Determination

Objective:

To determine the molar mass of a non-volatile, non-electrolyte by observing the difference between the freezing points of a solvent and a solution.

Introduction:

The addition of a non-volatile solute to a solvent produces characteristic changes in a solvent's physical properties. These changes are: **vapor pressure lowering**, **boiling point elevation** and **freezing point depression**. For example when antifreeze (ethylene glycol) is added to an automobile's cooling system it will prevent freeze-up in the winter and boiling in the summer because the antifreeze-water solution has a lower freezing point and a higher boiling point than pure water.

Vapor pressure lowering, boiling point elevation, and freezing point depression are called **colligative properties** of solutions. These properties are governed by the number, rather than the type, of solute particles dissolved in the solvent.

The change in colligative properties of a solution is directly proportional to the amount of solute dissolved in the solvent. The freezing point depression, ΔT_f, and the boiling point elevation, ΔT_b, are proportional to the molality, m, of the solute in the solution:

Freezing point : dec [depression]
Boiling point : inc [elevation]
Vapor pressure : dec [lowering]

Quantitave

$$\Delta T_f = K_f m \qquad (1)$$

$$\Delta T_b = K_b m \qquad (2)$$

Where

K_f and K_b are the molar freezing point and boiling point constants for the solvent.

$$m = \frac{mol\ \ solute}{Kg\ solvent} = \frac{(g/mol.wt.)solute}{Kg\ solvent} \qquad (3)$$

In this experiment you will determine the molar mass of a non-volatile, non-electrolyte (solute) in cyclohexane by measuring the freezing points for the pure cyclohexane and the solution, as well as the mass of solute and solvent. From K_f and equations (1) and (3), you will calculate the formula weight of the solute.

Cyclohexane's freezing point and that for the solutions are obtained from a cooling curve; a graph representing a decreasing temperature as a function of time (Figure 1). Cyclohexane's cooling curve reaches a plateau at its freezing point; extrapolation of the plateau to the temperature axis determines its freezing point. The solution's cooling curve does not reach a plateau, but continues to decrease slowly as the cyclohexane freezes. Its freezing point is determined at the intersection of two lines drawn tangent to the curves above and below the freezing point (See Figure 1).

* Amount of Solute in Solvent inc↑ :-   كمية Solute (inc) في Solvent

* f.p.d inc↑   * f.p dec↓

الفرق في درجة التجمد ΔT_f درجة التجمد العادية

$\Delta T_f \propto m$ ⇐ molality $\Delta T_f = K_f\, m$ → $m = \frac{\text{moles Solute}}{\text{mass Solvent (kg)}}$ mole/kg

Kf : f.p.d constant foe solvent: C/m = C kg/mol

* if we have an (electrolyte solute)
We will have van’t hoff factor (i) معامل التفكك

non-electrolyte solute [مادة غير متفككة] ⇒ $i = 1$ $\Delta T_f = T_{solvent} - T_{solution}$

electrolyte solute [مادة متفككة] ⇒ $\Delta T_f = i\, K_f\, m$ $\Delta T_f \uparrow$ = f.p.d↑

---

1) students prepared two cyclohexane solutions. Having the same mass of solute , however students 1 used 13g of cyclohexane . students 2 used 15g . Which student will observe the larger freezing changes?

Student 1

$$\Delta T_f = \frac{\cancel{Kf}\ \cancel{mass}_{solute}}{\cancel{Mr}_{\cancel{solute}}\ mass_{solvent}} = \rightarrow \Delta T_f = \frac{1}{13}$$

=0,0769

Student 2

$$\Delta T_f = \frac{\cancel{Kf}\ \cancel{mass}_{solute}}{\cancel{Mr}_{\cancel{solute}}\ mass_{solvent}} = \rightarrow \Delta T_f = \frac{1}{15}$$

=0,066

Student 1

- - - - - - - - - - - - - - - - - - - -

2) a 0.597g sample of a non-electrolyte dissolves in 20g of cyclohexane. The f.p.d is 3.62C .
What’s the Mm of the non-electrolyte?   Kf=20C kg/mol

$$\Delta T_f = \frac{Kf\ mass_{solute}}{Mr_{solute}\ mass_{solvent}} \Rightarrow 3.62 = \frac{20 * 0.597}{Mr_{solute} * 0{,}02} \Rightarrow Mr_{solute} = 164.92\ g/mol$$

- - - - - - - - - - - - - - - - - - - -

*) why should we keep moving the solution when it freezing?
- to avoid super cooling
*) temperature remains constant at f.p until the freezing is almost complete
*) cooling curve: freezing point as function of time
*) if thermometer reads 0.2C lower than true value
- no effect

$f.p_{Solvent} > f.p_{Solution}$

$\Delta T_f = T_{Solvent} - T_{Solution}$

ثابتة ← $T_{Solvent}$

3) if the solution f.p is erroneously read 0.2C lower than it should be, will the unknown calculated molar mass be too low or too high?

$\uparrow \Delta T_f = T_{solvent} - T_{solution} \downarrow \Longrightarrow \Delta T_f \uparrow$

ثابتة ←

$\uparrow \Delta T_f = \frac{K_f * mass_{solute}}{\downarrow Mr_{solute} * mass_{solven}}$

Mr solute ⇒ decrease

---

*) how will the f.p change of cyclohexane be effected (compared the f.p change by a non-volatile, non-associating & non-dissociating solute) by :

-) a non-volatile solute that dissociates? متفككة

يوجد i

$\Delta T_f = i K_f m$ $\Delta T_f \propto i$ $\Delta T_f \uparrow$

-)two solutes that react according to the equation.   A+B~~~C

$A + B \rightsquigarrow C$

$i \quad i \qquad i$

$2i \rightsquigarrow i \longrightarrow$ dec $i \downarrow \propto \Delta T$ dec $\downarrow$

$\Delta T \downarrow$

-) if equation C~~~A+B

$C \rightsquigarrow A + B$

$i \qquad 2i$

inc $i \uparrow \propto$ inc $\Delta T_f \uparrow$

---

4) if some solute adheres to the test tube wall in part B.1 , is the f.p change greater or less than it should be ?

$\downarrow \Delta T_f = \frac{K_f * mass_{solute} \downarrow}{Mr_{solute} * mass_{solvent}}$

$\Delta T_f \downarrow$ dec

less than

---

4) a solution of 3.33g of unknown in 50g of water freezing at -0.773C. What's the molecular weight of the unknown?

mass solute = 3.33g

mass solvent = 50

Temp. solution = -0.7773°C

Temp. solvent = Zero°C

$\Delta T_f = T_{solvent} - T_{solution}$

$= Zero - -0.773$

$\Delta T_f = 0.773°C$

$\Delta T_f = \frac{K_f * mass_{solute}}{Mr_{solute} * mass_{solvent}}$

$0.773 = \frac{1.86 * 3.33}{Mr * 0.05}$

$Mr = 160.25\ g/mol$

Experimental Procedure:

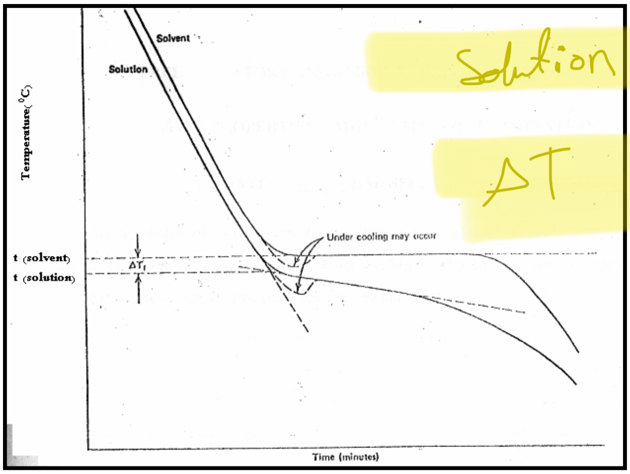
A. Freezing Point of Solvent:

1. Assemble the apparatus shown in Figure (2). Weigh (±0.01 g) a clean, dry 200 mm test tube. Add approximately 10 g of cyclohexane to the test tube and reweigh (±0.01 g) the tube and contents. Prepare about 300 mL of an ice-water slurry in a 400-mL beaker. Place the test tube and cyclohexane in the ice-water bath (Figure 2). Insert a thermometer, through one hole of a two-hole stopper, into the solvent to measure the temperature.
2. While stirring with the wire stirrer inserted through the stopper's other hole, record temperature (± 0.1°C) readings at timed intervals (30 sec) on the Report Sheet. The temperature remains virtually constant at the freezing point until solidification is almost complete. Continue recording until the temperature begins to drop again. On a linear graph paper (provided by your laboratory technician), plot the temperature (°C, vertical axis) versus time (t, horizontal axis) to obtain cyclohexane's "cooling curve". The temperature corresponding to the plateau of the cooling curve is cyclohexane's freezing point.

B. Freezing Point of Solvent-Unknown Solute:

Two freezing point trials for the solution are to be completed. The same unknown solute-cyclohexane solution can be used to repeat Parts B.1 and B.2.

1. Dry the outside of the test tube containing the cyclohexane and reweigh (±0.01 g). Ask the instructor for a solid unknown sample. Record your unknown number on your data sheet. Weigh (± 0.01 g) approximately 0.2g of the unknown on weighing boat. Transfer the unknown to the cyclohexane in the 200-mm test tube. In the transfer be certain that **none** of the solid solute remains in the boat or adheres to the test tube's side. If some does, roll the test tube until the solute dissolves. If an unknown is a liquid, weigh (±0.01 g) about 3 mL of it in a 10-mL graduated cylinder, pour this into the cyclohexane; then reweigh the empty cylinder. The difference is the weight of the unknown liquid added to the cyclohexane.
2. Determine the solution's freezing point in the same way as the solvent's was found in Part A. When the solution is near the freezing point, record the temperature (±0.1°C) at more frequent intervals (20 sec). Plot the temperature vs. time (on the same graph as in Part A) to get the solution's cooling curve. It will show a "break" at the temperature where freezing began. The break may not be as sharp as that for the pure solvent. Draw lines tangent to the curves above and below the freezing point; the lines' intersection is the solution's freezing point. Repeat the freezing point determination one more time (warm the tube and the solution to a temperature higher than the freezing point of the solution then cool again as before.) Have your instructor approve your graphs. After completing the collection of the experimental data, discard the solution into a bottle marked "waste solvent."



Solution ← f.p كلما قلت

ΔT → تزداد

K_f : for Solvent

K_f = ☐ C°/m

= ☐ C kg/mol

FIGURE 1. Cooling curves for solvent and solution

i للمركبات العضوية = 1

$i(C_{10}H_8) = 1$

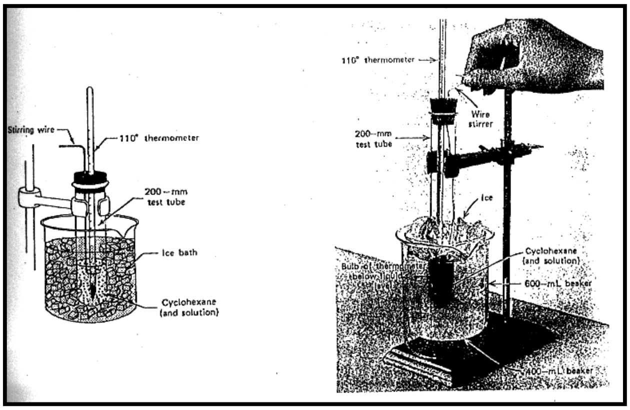


FIGURE 2. Freezing point apparatus

*True OR False:

1) if the test tube contains an insoluble impurity, then the calculated molar mass will be no effected ...... True (T)

2) if the thermometer reading is always 1.5C higher than the correct temperature, the calculated molar mass will be not effected ...... True (T)

3) the f.p of solution had been incorrectly read 0.6 higher than the true f.p , the calculated molar mass will be lower than the actual......False (F)

4) the f.p.d of 0.2 mole of NaCl in 10 g of water is lower than the f.p.d of 0.2 mole C10H8 in 10g of water ...... False (F)

Student Name:	____________________________	Section No.:	____________________
ID Number:	___________________________	Date :	____________________
Partner Name:	___________________________	Group No.:	____________________

Experiment (8)

Colligative Properties: Molar Mass Determination

Report Sheet

Unknown Number ________________

Data:

A. Freezing Point of Cyclohexane

1. Mass of test tube (g)	__________
2. Mass of cyclohexane (g)	__________
3. Freezing point, from cooling curve (°C)	__________

B. Freezing Point of a Solvent-Unknown Solute	**Trial I**	**Trial II**
1. Mass of test tube + cyclohexane (g)	________	_______
2. Mass of cyclohexane (g)	________	_______
3. Mass of solute (g)	________	_______
4. Freezing point, from cooling curve (°C)	________	_______

Calculations:

1. Freezing point constant, Kf, of cyclohexane	20.0° C.kg/mol	
2. Freezing point change, ΔT_f (C°)	________	_______
3. Mass of solute in solution (g)	________	_______
4. Mass of cyclohexane in solution (kg)	________	_______
5. Molar mass (g/mol)	________	_______
6. Average molar mass (g/mol)	_________	

DATA FOR COOLING CURVES					
PART A (SOLVENT)		PART B (SOLUTION)			
Trial 1		Trial 1		Trial 2	
Time(second	Temp.	Time	Temp.	Time	Temp.
0		0		0	
30		20		20	
60		40		40	
90		60		60	
120		80		80	
150		100		100	
180		120		120	
210		140		140	
240		160		160	
270		180		180	
300		200		200	
330		220		220	
360		240		240	
390		260		260	
420		280		280	
450		300		300	
480		320		320	
510		340		340	
540		360		360	
570		380		380	
600		400		400	
630		420		420	
660		440		440	

Experiment (8)

Colligative Properties: Molar Mass Determination

PostLab

1. If the solution's freezing point is erroneously read 0.2°C lower than it should be, will the unknown's calculated molar mass be too high or too low ? Explain!

2. How will the freezing point change of cyclohexane be affected (compared with the freezing point change by a non-volatile, non-associating and non-dissociating solute) by:

(a) A non-volatile solute that dissociates? Explain.

(b) Two solutes that react according to the equation,

$A + B \rightarrow C$? Explain!

3. If some solute adheres to the test tube's wall in Part B.1, is the freezing point change greater or less than it should be? Explain!

Experiment (9)

Calorimetry

Objective :

To measure heat of reaction

Introduction :

This experiment is designed to measure the HEATS OF REACTION of a series of chemical reactions. There are several knids of "heats of reactions", such as heat of solution, heat of neutralization, heat of combustion, heat of formation, etc. However, we shall study only the first two of these.

1. ***Heat of solution***: it is the heat flow during the process of solution; as an example when NaOH dissolves in water, hydrated ions are formed and heat is released. The solution absorbs this heat and, therefore increases in temperature.

Solution $\Longrightarrow$ $NaOH_{(s)} \xrightarrow{H2O} H_2O \quad Na^+_{(aq)} + OH^-_{(aq)} + Heat \quad \boxed{\Delta H_1}$

Where the heat of solution in kJ is ΔH_1

becouse H_2O

2. ***Combined heat of solution and heat of neutralization***: in a second reaction, solid sodium hydroxide is reacted with an aqueous solution of hydrogen chloride. During this reaction, water and a dilute aqueous solution of sodium ions and chloride ions are formed. This time both the heat of solution and the heat of neutralization are released:

reaction $\Longrightarrow$ $NaOH_{(s)} + H^+_{(aq)} + Cl^-_{(aq)} \rightarrow H_2O + Na^+_{(aq)} + Cl^-_{(aq)} + Heat \quad \boxed{\Delta H_2}$

becouse HCl

Where the combined heat of solution and heat of neutralization in kJ is ΔH_2.

3. ***Heat of neutralization***: It is the heat evolved, at constant pressure, when acids are neutralized with bases. **It** can be obtained from the two steps above. The difference between the **heat of reactoin** obtained by dissolving solid NaOH in aquesous HCl solution (step 2) and the **heat of solution** obtained by dissolving solid NaOH in water (step1).

4. The final experiment of this laboratory class will be to determine the heat of solution of an unknown salt, as in (step 1) above.

Example 1

A 2.00 g sample of solid CsOH is dissolved in 200.0 mL of water in a calorimeter. The temperature of the water was raised from 22.3 to 23.4 ºC. Calculate the heat of solution in kJ/mol. (assume the specific heat of the solution to be 4.184 J/g ºC and the density of the solution to be 1.00 g/mL).

a. Temperature change, ΔT= 23.4- 22.3 = 1.1 ºC
b. Total mass of solution, m, (200.0 mL water) (1.00 g/mL) + 2.00 g CsOH =202.0 g
c. Heat absorbed by the solution = heat evolved by CsOH =

   Mass of solutin x specific heat of solution x ΔT =

   202.0 g x 4.184 J/g ºC x 1.1ºC = 930 J
d. Moles of CsOH = mass/Molar mass = 2.00 g / 149.9 g /mol = 0.01334 mol
e. Heat evolved per mole of CsOH = 930 J/0.01334 mol = -7.0×10^4 J/mol
f. Heat of solution in KJ/mole = (-7.0×10^4 J/mol) x (1 kJ/10^3 J) = -70 kJ/mol

Note: the minus sign shows that the reaction is exothermic; i.e heat is given off (evolved) by the system.

Example 2

A 2.00 g sample of solid CsOH reacted with 200.0 mL of an aqueous solution of hydrogen chloride (HCl) in a calorimeter, the temperature of the solution increased from 22.3 to 24.3 ºC. Calculate the heat of reaction in kJ/mol? (Assume the specific heat of the solution to be 4.184 J/g ºC and the density of the solution to be 1.00 g/mL)

a. Temperature change, ΔT = 2.0 ºC
b. Total mass of solution = 202.0g
c. Heat absorbed by the solution = 202.0 X 4.184 X 2.0

   = 1.7×10^3 J
d. Moles of CsOH = 0.01334 mol
e. Heat evolved per mole of CsOH = 1.3×10^5 J/mol
f. Heat of reaction in kJ /mol = 1.3×10^2 kJ /mol

Note: The difference in the heat of reaction (Example 2) and the heat of solution (Example1) is the **heat of neutralization**. So the heat of neutralization of CsOH with HCl is 60 KJ /mol

Experimental Procedure:

Assume that the **density** of all solutions is 1.00 g/mL and their **specific heat** is 4.184 J/g ºC .

A. Determination of the heat of solution for NaOH (ΔH_1)

1. Add 100.0 mL of water to the calorimeter.
2. Close the calorimeter and stir the water until a constant temperature is reached.

   Record the temperature of water.
3. Weigh accurately about 2.0 g of NaOH. You should weigh the NaOH fast, since it is very HYGROSCOPIC.
4. Add the solid NaOH to the water in the calorimeter. Stir gently. Read the temperature every 30 seconds. Record the maximum temperature reached.

B. Determination of the heat of reaction (ΔH_2)

1. Add 100.0 mL of 0.500 M HCl solution to the calorimeter.
2. Stir the solution as in procedure 1 above, and record the initial temperature.
3. Weigh accurately about 2.0 g of NaOH. You should weigh the NaOH fast, since it is very HYGROSCOPIC.
4. Add the solid NaOH to the HCl solution in the calorimeter and stir gently until the maximum temperature is reached. Record the maximum (final) temperature.

C. Determination of the heat of solution of an unknown salt:

1. Pick up an unknown salt from the instructor and record the unknown number on the report sheet. You will be given the molar mass of the salt.
2. Repeat the procedure in part A, using 3.0 g of the unknown salt in place of NaOH.

$\Delta H_{rxn} + \Delta H_{solution} \Rightarrow$ Can be determined experimently

$\Delta H_{neut} \Rightarrow$ Can't be determined experimently

$\hookrightarrow \Delta H_{neut} = \Delta H_{rxn} - \Delta H_{solution}$

$\Delta H_{rxn} = \Delta H_{solution} + \Delta H_{nutr}$

$$\begin{tikzcd} & \Delta H_{nutr} \\ \Delta H_{rxn} \arrow[ur] \arrow[dr] & \\ & \Delta H_{solution} \end{tikzcd}$$

إضافة إشارة (-)

$\Delta H = \text{Mass}_{\text{Solution}} * \text{S.p Heat} * \Delta T$

mass (solvent + solute) — g

$\frac{J}{g \cdot C^\circ}$

C°

$\Delta H\ (J) \swarrow\nearrow$ + / −

$\Delta T = T_f - T_i$

ΔH هي التي تحدد إشارة

---

* Specific Heat: Amount of Heat required to rais Temp of 1 g of sample by 1 C°

Tf > Ti : increasing in Temp. ...... Exothermic طارد الحرارة
flows out of the system
$\Delta T (+)$
(-ve) sing should be added to the value of ΔH that is calculated

Ti > Tf : decreasing in the Temp. ...... Endothermic ماص للحرارة
flows into the system
$\Delta T (-)$
(+ve) sing should be added to the value of ΔH that is calculated

$\Delta T (\pm) \rightleftharpoons \Delta H (\mp)$

The heat of the solution should be calculated while the calorimeter is closed tightly مغلقة بإحكام

NaOH : that used in the exp. is hygroscopic so that it should be weighed & use it fast

Heat per mole of A ...... $\frac{\Delta H}{\text{mole of } A} = J/mol$

Heat per gram of A ...... $\frac{\Delta H}{\text{mass of } A} = J/g$

Heat in KJ/mol OR KJ/g ...... $\Delta H * 10^{-3} \Rightarrow$ $\left.\begin{matrix} J/mol \\ J/g \end{matrix}\right] \rightarrow * 10^{-3}$

ΔH is quantitave property
↳ depends on Amount not Nature

---

1) a 2g sample of solid CsOH dissolved in 200ml of water in a calorimeter . The temp. of the water was raised from 22.3 to 23.4 C, calculated the heat of the solution in KJ/mol . Assume the S.P.H of the solution to be 4.184J/gC & the density of the solution to be 1g/mol ?

$mass_{Solute} = 2g$ $\quad T_1 = 22.3$

$V = 200 \text{ mL}$ $\quad T_2 = 23.4$

$d_{water} = 1$ $\quad S.P.H = 4.184$

$d = \frac{m_{Solvent}}{V}$

$1 = \frac{m}{200} \Rightarrow m = 200g$

$m_{Solution} = 200 + 2 = 202 g$

$\Delta T = 23.4 - 22.3 = 1.1 C^{\circ}$

$\Delta H = - mass * S.P.H * \Delta T$

$= -202 * 4.184 * 1.1$

$\Delta H = -929.7 J$

$n = \frac{2}{149.9} = 0.0133$ mole

$\Delta H = \frac{-929.7}{0.0133} * 10^{-3} = -69.9 KJ/mol$

2) a 2g sample of CsOH reaction with 200ml of aqueous solution of HCl in a calorimeter , the temp of the solution in creased from 22.3 to 24.3C calculated the heat of the reaction in KJ/mol? Assume the S.P.H of solution to be 4.184 J/gC & the density of the solution to be 1g/ml

$m_{solute} = 2g$

$V_{water} = 200ml$

$d_{water} = 1$

$T_1 = 22.3$

$T_2 = 24.3$

$S.P.H = 4.184$

$mass_{Solvent} = d * V_{water}$

$= 1 * 200 = 200g$

$Mass_{Solution} = 2 + 200 = 202g$

$\Delta T = 24.3 - 22.3 = 2C°$

$\Delta H_{rxn} = - mass * S.P.H * \Delta T$

$= -202 * 4.184 * 2$

$\Delta H_{rxn} = -1690,336 \text{ J}$

$n = \frac{2}{149.9} = 0.0133$

$\Delta H = \frac{-1690,336}{0,0133} * 10^{-3} = 127,09 \text{ KJ/mol}$

-) calculated ΔH_n?

$\Delta H_n = \Delta H_{rxn} - \Delta H_{Solution}$

$= -12.09 - (-69.9) = -57.2 \text{ KJ/mol}$

Student Name: ______________________________ Section No.: _____________________
ID Number: ______________________________ Date : _____________________
Partner Name: ______________________________ Group No.: _____________________

Experiment (9)

Calorimetry

Report Sheet

Part A: Determination of the heat of solution of NaOH (ΔH_1)

Data:

		Trial I	Trial II
1.	Volume of water	____________	____________
2.	Mass of water	____________	____________
3.	Mass of NaOH	____________	____________
4.	Molar mass of NaOH	40.0g/mol	
5.	Moles of NaOH	____________	____________
6.	Mass of solution	____________	____________
7.	Initial temperature	____________	____________
8.	Final temperature	____________	____________
9.	ΔH_1 of solution	____________	____________
10.	Average ΔH_1	____________	____________

Part B: Determination of the heat of reaction of NaOH with HCl (ΔH_2) and the heat of neutralization (ΔH_n)

Data:

		Trial I	Trial II
1.	Volume of HCl solution		
2.	Mass of HCl solution		
3.	Mass of NaOH		
4.	Molar mass of NaOH	40.0 g/mol	
5.	Moles of NaOH reacted		
6.	Mass of solution		
7.	Initial temperature		
8.	Final temperature		
9.	ΔH_2 of solution		
10.	Heat of neutralization ($\Delta H_2 - \Delta H_1$)		
11.	Average heat of neutralization		

Part C: Determination of the heat of solution of an unknown salt:

Data:

		Trial I	Trial II
1.	Volume of water		
2.	Mass of water		
3.	Mass of unknown salt		
4.	Initial temperature		
5.	Final temperature		
6.	ΔH of solution		
7.	Average ΔH		

Show your calculation for Trial I:

Exp. 10/ Electrochemistry :

- Oxidation : loss of e^-'s.
- Reduction : gain of e^-'s.
- Substance that is oxidized is called Reducing Agent.
- 〃 〃 〃 reduced 〃 〃 Oxidizing Agent.

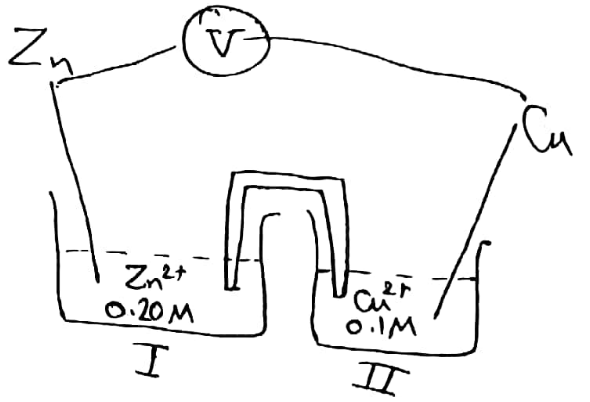
- The redox rxns (oxidation-reduction) cause the transfer of e^-'s which can be detected by Voltmeter.

- The redox of substances & transfer of e^-'s can be represented by Galvanic Cell:

* The Components of Galvanic Cell:

① Substances to be oxidized & reduced.

- The Reduction occurs for the half cell that has higher (+ve) value of $\mathcal{E}^\circ$, then oxidation will be for the other half cell.



$Cu^{2+} + 2e^- \rightleftharpoons Cu_{(s)}$, $\mathcal{E}^\circ = 0.34V$

$Zn^{2+} + 2e^- \rightleftharpoons Zn_{(s)}$, $\mathcal{E}^\circ = -0.76V$

$Cu^{2+} + 2e^- \longrightarrow Cu \quad \mathcal{E}^\circ = 0.34V$

$Zn \longrightarrow Zn^{2+} + 2e^- \quad \mathcal{E}^\circ = 0.76V$

$\mathcal{E}^\circ$: Voltage of the half cell at the standard conditions which are: 1 atm, 25°C & 1.0M.

- In the fig. above, e^-'s flow from beaker (I) to beaker (II)
- The oxidizing agent is Cu^{2+}, & the reducing agent is $Zn_{(s)}$.
- $2H^+ + 2e^- \rightleftharpoons H_{2(g)}$ $\mathcal{E}^\circ$ = Zero. This half cell is used to measure the Voltage of the other half cell of ions, which are ordered in a table.

✓ According to the Values of $\mathcal{E}^0$ for every half cell, one can detect the strength of reduction.

- According to the previous galvanic Cell, the order of decr. of ability to be reduced; $Cu^{2+} > H^+ > Zn^{2+}$.

② Electrodes:

Cathod: Electrode at which reduction occurs.

Anode: " " " Oxidation occurs.

- Always in galvanic cell $\bar{e}$'s flow from Anode to Cathod.

③ Salt Bridge: U-tube that is filled with saturated electrolyte soln. Such as KNO_3 or KCl.

- The purpose of Salt Bridge: compensation the transfer of ions.

- In the previous Galvanic Cell:

Cathode: $Cu^{2+} \cancel{+2e^-} \longrightarrow Cu \quad \mathcal{E}^0 = 0.34\,V$

Anode: $Zn \longrightarrow Zn^{2+} \cancel{+2e^-} \quad \mathcal{E}^0 = 0.76\,V$

Cell rxn.: $Cu^{2+} + Zn \longrightarrow Cu + Zn^{2+} \quad \mathcal{E}_{cell} = 1.10\,V$

But According to the Previous galvanic cell; The conditions are not standard due to concs are not 1.0 M, So that;

$$\boxed{\mathcal{E}_{cell} = \mathcal{E}^0_{cell} - \frac{0.0592}{n}\log Q} \text{ Nernst Eq.}$$

$$n = 2 \;;\; Q = \frac{[Zn^{2+}]/[Cu^{2+}]}{} \Rightarrow \mathcal{E}_{cell} = 1.10 - \frac{0.0592}{2}\log\frac{0.20}{0.10} = \text{---}\,V$$

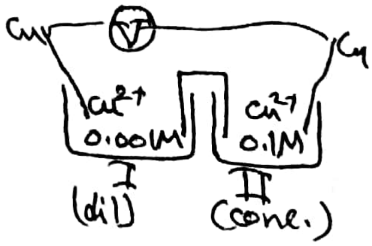
$\Rightarrow n =$ moles of $\bar{e}$'s.

- This Galvanic Cell can be represented by line Cell:

$$\underbrace{Zn\,|\,Zn^{2+}(0.20M)}_{\text{Anode}}\,||\,\underbrace{Cu^{2+}(0.10M)\,|\,Cu}_{\text{Cathode}} \qquad \mathcal{E}^0_{Cu^{2+}/Cu} = 0.34\,V \;;\; \mathcal{E}^0_{Zn^{2+}/Zn} = -0.76\,V$$

---

*Concentration Cell: the two half cells contain the same soln. but with different concs.



- $\bar{e}$'s flow from dil. to conc.

* dil: diluted

* conc: Concentrated

- $\mathcal{E}^0_{cell} = $ Zero.

- $\mathcal{E}_{cell} = \underset{\text{Zero}}{\mathcal{E}^0_{cell}} - \frac{0.0592}{n}\log\frac{[dil]}{[conc.]}$