Determination of a Molar Mass of a Volatile Liquid

الهدف من التجربة

1.To measure **the physical properties** (pressure, volume, and temperature) for a gaseous substance
2. To determine the molar mass of an unknown volatile liquid

There are many analytical methods to measure the M of an unknown substance based on its nature and state

1. Mass spectrometry : uses to determine the molar mass of compound as well as to identify the structures of high molar mass compounds in the biochemical fields.

2. Dumas method (**John Dumas**, 1800–1884) provides an accurate determination of molar mass of a volatile liquid by the use of ideal gas law, PV = nRT. اسم الطريقة التي تم العمل عليها بالتجربة

من خصائص **liquid** هذه التجربة

1. **Volatile at low boiling point**
2. **Flammable**
3. **Volatile**
4. **Goes under ideal gas path**

Ideal Gas Law

$$PV = nRT$$

P: pressure; V: volume; n: # of gas molecules; R: gas constant; T: temperature (in K)

Variable	Name	Definition	Units	Measured by:
P	Pressure	The force per unit area that the gas exerts on the any surface.	atm, mmHg, kPa	Barometer,
V	Volume	The amount of space occupied.	L	Graduated Cylinder
T	Temperature	The measure of the average kinetic energy in a system	K	Thermometer
R	Ideal Gas Law Constant	$0.0821 \frac{L \cdot atm}{mol \cdot K}$ $8.31 \frac{L \cdot kPa}{mol \cdot K}$		Calculated
N	Moles		Mol	

In this analytical procedure (Dumas method)

تم اختيار liquid بدرجة غليان قليلة لتحويله إلى بخار

*1- The **liquid is converted into a gas** at an E/M flask at a measured temperature and barometric pressure.*

*2- Then use of the **ideal gas law equation (PV = nRT, assuming ideal gas behavior), to calculatet the number of moles of vaporized liquid.***

3-The **mass of the vapor, m_{vapr},** is determined from the mass difference between the empty E/M flask and the vapor-filled vessel.

4-The **molar mass of the compound, M,** is then calculated from the available data:

$$M_{\text{compound}} = \frac{m_{\text{vapor}}}{n_{\text{vapor}}}$$

1.The barometer is an instrument accurately measures atmospheric pressure in mmHg (or torr). لقياس الضغط تم استخدام البارومیتر

2. the temperature of the vaporized liquid is determined in this experiment by measuring the temperature of water bath by using a thermometer لقياس درجة الحرارة تم استخدام الثيرمومیتر

Example. Experimental Data and Calculations:

A 0.252 g of an unknown gas was found to have a volume of 175 mL. The temperature was found to be 27 ^{o}C and the pressure was 0.995 atm. Calculate the molar mass of the unknown gas.

Solution (Answer):

From the ideal gas law

$$n = PV/RT$$

$$= (0.995\ atm)(0.175\ L) / (0.0821\ L\ atm\ mol^{-1}K^{-1})\ (300\ K) = 0.00707\ mol.$$

then, $M_{gas} = mass/n = 0.252\ g/0.0707\ mol = 35.64\ g/mol$

van der Waals' equation un ideal gas

اما الغازات التي لا تسلك سلوك الغاز المثالي فيتم التعامل معها
على قانون او معادلة
Van der Waals Equation

-The ideal behavior of the gas assumes **no intermolecular forces between its molecules in the vapor state**. Also, **assumes zero molar volume of the molecules.**

-Gases and liquids with relatively large intermolecular forces and large molecular volumes deviate from ideal gas law equation.

-therefore, **van der Waals' equation**, a modification of the ideal gas law equation, is used to correct for the intermolecular forces and molecular volumes in determining the moles of gas present in the system:

$$\left(P + \frac{n^2 a}{V^2}\right)(V - nb) = nRT$$

ليست للحفظ 😃

a is an experimental value that is representative of the intermolecular forces of the vapor, and

يتم الحصول عليها عمليا من خلال التجربة بالمختبر

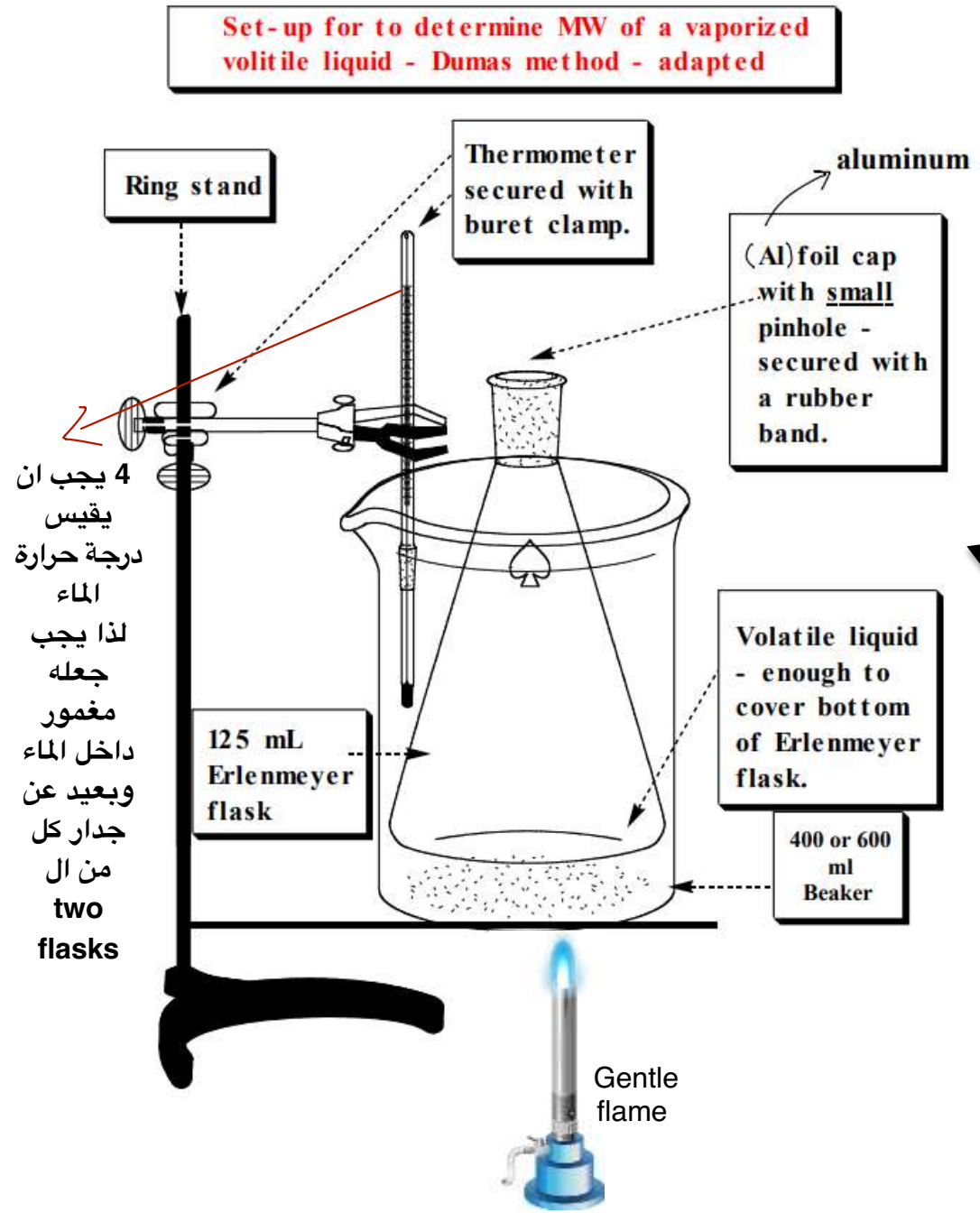
-*b* is an experimental value that is representative of the volume (or size) of the molecules.

Table 3.1 : Van der Wool's Constants for Some Low Boiling-Point Compounds

Name	*a* ($\frac{L^2 \cdot atm}{mol^2}$)	*b* (L/mol)
methanol	9.523	0.06702
ethanol	12.02	0.08407
acetone	13.91	0.0994
propanol	14.92	0.1019
hexane	24.39	0.1735
cyclohexane	22.81	0.1424
n-pentane	19.01	0.1460

a and b قيم
volatile liquids لعدة

Set-up – an "adapted" Dumas method:

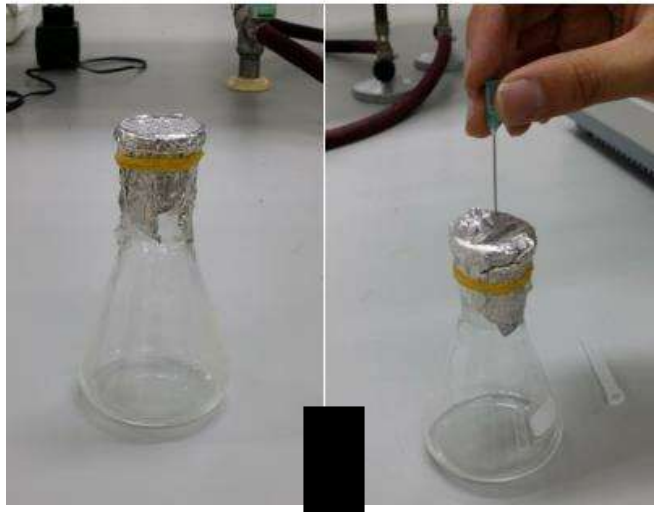


4 يجب ان يقيس درجة حرارة الماء لذا يجب جعله مغمور داخل الماء وبعيد عن جدار كل من ال two flasks

الجانب العملي

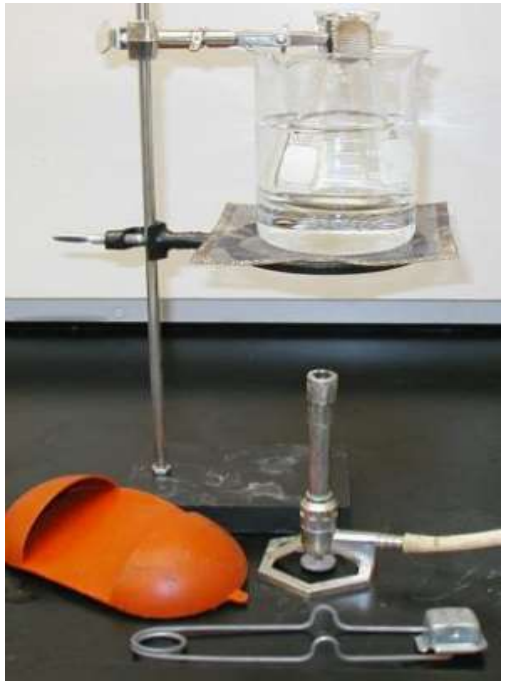
5 الاستمرار بالتجربة إلى ان يتبخر السائل كليا وتسجيل البيانات المطلوبة + نوزن ال Erlenmeyer flask بعد الانتهاء لأخذ ال Mass of vapor

Preparing the Sample



1 جهزنا الأدوات و وزناهم
+
We made a holes n Al foil to allow to liquid to evaporate

2 We take (5-6) ml from volatile liquid



3. Prepare a water bath

We use water bath not direct flame because the liquid flammable

- Put the heat source on again and heat gently to allow the vapors of the unknown liquid to go out through the wholes of the aluminum foil.
- Stop heating when the vapors are no longer visible out of the flask, continue slow and gentle heating for few more minutes.
- Use the thermometer in the laboratory to measure the temperature of the boiling water in the water bath and record it to ±0.01°C.

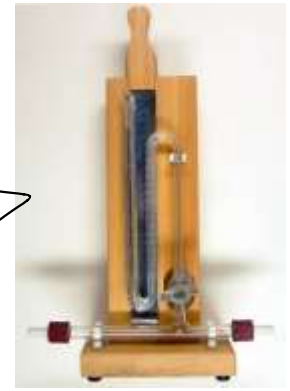
Caution:

hot water bath استخدمنا
بسبب اال volatile liquid قابل للاشتعال
Flammable

1. Do not heat flammable liquids on a direct flame
2. Avoid excessive heat not to allow all of the vapors of the liquid to leave the E. flask, also, the heating should be sufficient not to leave liquid unknown in the E. flask in the liquid form.
3. most unknowns are flammable. Use a moderate flame for heating.

PreLaboratory Questions كيف تم قياس كل من

▸ **1. a.** How is the pressure of the vaporized liquid determined in this experiment?



▸ **b.** How is the volume of the vaporized liquid determined in this experiment?

Erlenmeyer flask تعبئة ال

We take the volume by filling it with water to the neck then using graduated cylinder

▸ **c.** How is the temperature of the vaporized liquid determined in this experiment?

الوزنة بعد نهاية التجربة - الوزنة قبل

▸ **d.** How is the mass of the vaporized liquid determined in this experiment?

Do it

Experiment 6 *Prelaboratory Assignment*

FORMULA MASS OF A VOLATILE LIQUID

Date _____ Lab Sec. _____ Name _____ Desk No. _____

1. A mass of 0.777 grams of an unknown vapor occupies 314 mL at 98.7°C and 740 torr. Assume ideal gas behavior.
   a. How many moles of vapor are present?

   b. What is the formula mass of the vapor?

2. a. If the atmospheric pressure is mistakenly recorded as 760 torr in Question 1, what is the reported formula mass of the vapor?

   b. What is the percent error caused by the error in the pressure reading?

$$\% \text{ error} = \frac{FM_{difference}}{FM_{actual}} \times 100$$

تأكد من تحويل جميع الوحدات إلى الوحدات الاساسيه للقانون ثم أبدا الحل

Experiment 6 *Report Sheet*

FORMULA MASS OF A VOLATILE LIQUID

Date _____ Lab Sec. _____ Name _____ Desk No. ____

Unknown Number	Trial 1	Trial 2
1. Mass of dry flask and stopper (g)	54.26	.....
2. Temperature of boiling water (°C, K)	97°C → K	.....
3. Mass of dry flask, stopper, and vapor (g)	54.42	.....
4. Volume of 125-mL flask (L)	(301 ml) by using cylinder → L	
5. Atmospheric pressure (atm)	650 mm Hg → atm	

Calculations

PV = nRT ⇒

1. Moles of vapor, n_{vapor} (mol)	.....	.....
2. Mass of vapor, m_{vapor} (g)	(54.42 − 54.26)	.....
3. Formula mass of compound (g/mol)	.....	.....
4. Average formula mass	.....	
5. Standard deviation of formula mass	.....	

$$FM = \frac{m_{vapor}}{n_{vapor}}$$

*Calculation of Trial 1. Show work here.