**ALL SAINTS’ SECONDARY SCHOOL, OYIGBO**

**SS 1 CHEMISTRY**

***LECTURE 5***

**Correction of previous assignment**

1. no of mol of nitrogen =

V = 6500cm3 =

T = 25oC = 25 + 273 = 298K

PV = nRT

1. P = 0.5atm

V = 2dm3

PV = nRT

----------------------- (i)

When 0.01mole of oxygen was added, the number of moles becomes 0.01+n.

The temperature was reduced to 10oC

= 10 + 273 = 283K

That is, the temperature = 283K

The pressure remains constant (0.5atm) and the volume also remains constant (2dm3).

Now PV = nRT

Substitute in (i)

T = 369.1K = 369.1 – 273 = 96.1oC

**TOPIC: GAS DENSITY**

The density of a substance is defined as the mass of that substance per unit volume of the substance.

Mathematically:

From the ideal gas law, we recall:

PV = nRT

Where P is the pressure of the gas, V is the volume of the gas, n is the number of mole of the gas, T is the temperature of the gas while R is the ideal gas constant. Also we recall:

Now, let’s replace **n** with in the ideal gas law:

Divide both sides by V

Make (density) the subject of formula

So,

**Example:**

Let us calculate the density of O2 gas at s.t.p.

Molar mass of O2 = 32g/mol

At s.t.p, P = 1 atm, T = 273K and also the gas constant, R = 0.0821dm3.atm.K-1.mol-1

That is the density of O2 at s.t.p is 1.428Kg/m3.

**RELATIVE VAPOUR DENSITY OF GASES (V.D)**

 The relative vapour density of a gas is the number of times a given volume of that gas is as heavy as the same volume of hydrogen gas at a particular temperature and pressure.

Since the mass of one molecule of hydrogen is 2g/mol

**GRAHAM’S LAW OF DIFFUSION**

Graham’s law of diffusion states that the rate of diffusion of an ideal gas is inversely proportional to the square root of the density at a constant temperature and pressure.

 -------------------- 2.0

 ---------------------- 2.1

Since molecular mass is connected to the density of gases the molar mass can replace the density in the equation.

That is,

 --------------------- 2.2

If the volume of the gases is equal, the time it takes for the first gas to diffuse equals **t1** and the time it takes for the second gas to diffuse equals **t2**

Then; and

Substitute in (2.2)

 ------------------------ 3.0

**WORKED EXAMPLE**

1. 60cm3 of hydrogen diffused through a porous membrane in 10minutes. The same volume of gas **G** diffused through the same membrane in 3.4minutes. Determine the relative molecular mass of **G** (H = 1).

***Solution***

Let the rate of diffusion of hydrogen be R1 and rate of diffusion of gas **G** be R2

Volume of H2 = 60cm3

Volume of **G** = 60cm3

Time of diffusion of H2 = 10min.

Time of diffusion of **G** = 37.4min.

3.74 =

3.742 =

13.9876 =

Therefore, the molecular mass of gas **G** is 27.98g/mol

1. A given volume of oxygen diffuses through a porous plug in 8.0sec. How long will it take the same volume of sulphur (iv) oxide to diffuse through under the same conditions?

(O = 16, S = 32).

***Solution***

Time of diffusion for O2 (**t1)** = 8.0sec

Time of diffusion for SO2 = **t2**

Molar mass of O2 (M1) = 16 2 = 32g/mol

Molar mass of SO2 (M2) = 32 + 16 2

= 64g/mol

Then,

Therefore, it will take 11.3sec. for SO2 to diffuse.

1. A given volume of methane diffuses in 20sec. How long will it take the same volume of sulphur (iv) oxide to diffuse under the same conditions?

(C = 12, H = 1, S = 32, O = 16)

***Solution***

Molar mass of methane (CH4), M1

= 12 + 1 4 = 16g/mol

Molar mass of SO2

(M2) = 32 + 16 2 = 64g/mol

Time of diffusion of methane (t1) = 20sec.

Time of diffusion of SO2 = t2

Therefore, it takes SO2 40sec to diffuse.

Let’s recall that at s.t.p, the volume of 1mole of an ideal gas is 22.4dm3 and this volume is called ***molar volume.*** Also, 1mole of a substance contains particles of that substance. That means that, at s.t.p, 1mole of a gas contains molecules of that gas.

1mol = Vm

**n** mol = V

**DALTON’S LAW OF PARTIAL PRESSURE.**

Dalton’s law of partial pressure states, that at a constant temperature, the total pressure exerted by a mixture of gases in a definite volume is equal to the sum of the partial pressure which each gas would exert if it occupies the same total volume alone provided the gases do not chemically react with each other.

Consider three gases, say **A**, **B** and **C** taken separately in a **V** litre flask at temperature **T**. Let the pressures of the gases be **PA, PB**, and **PC** respectively. If all the three gases are forced into another **V** litre flask at the same temperature, then according to Dalton’s law, total pressure (**PT)** in the flask would be:

 ----------------- 4.0

**PT = PA + PB + PC**

From PV = nRT

 -------------------------- 4.1

 --------------------------- 4.2

and

 ---------------------------- 4.3

Substitute the partial pressure in 4.0

On factorization,

 ----------------------- 4.4

Where nTis the total number of mole of the gases.

Divide (4.1) by (4.4)

------------------------ 4.5

**WORKED EXAMPLE**

1. The total pressure exerted by a mixture of two gases **A** and **B** is 76.2mmHg. The numbers of moles of the two gases are 0.0075 and 0.004 respectively. Calculate the partial pressure of the two gases.

***Solution***

Using:

PA = 49.7mmHg

But PT = PA + PB

 76.2 = 49.7 + PB

PB = 76.2 – 49.7

PB = 26.5mmHg

Therefore, the partial pressure of **A**  is 49.7mmHg while the partial pressure of **B** is 26.5mmHg.

1. If 12.0g of N2, 0.4g of H2 and 9.0g of O2 are put into a 2 litre container at 27oC. what is the total pressure in the container?

(H =1, O = 16, R = 0.0821atm.dm3.mol-1.K-1)

***Solution***

T = 27oC = 27 + 273 = 300K

V = 2dm3

nT = 0.429 + 0.2 + 0.281 = 0.91mol

Using

 Total pressure exerted is 11.2atm

**DEVIATION OF REAL GASES FROM IDEAL BEHAVIOUR**

On studying the actual behaviour of various gases, it was found that few gases obey the ideal gas equation only at low pressure and high temperatures. However, at high pressure and low temperature, large deviations from the ideal behaviour have been observed. To illustrate this, consider the expression: PV = constant, which is Boyle’s low. In words, the product of pressure and volume for a definite quantity of various gases at constant temperature should remain constant at all pressure.

Fore an ideal gas, the plot of PV against P at OoC should be a straight line parallel to the horizontal.



But, this is not true for real gases as should below:



**CAUSES OF DEVIATIONS**

The reason for the deviation of real gases from ideal behaviour lie in the fact that in the discussion of kinetic theory of gases, it was assumed that the volume occupied by the gas molecules is negligibly small as compare to the total volume of the gas and that molecules of gases do not exert any force of attraction on each other. But in reality, these assumptions are wrong as proven below.

1. When the temperature of the gas is decreased and pressure increased, a stage is reached where the molecule of the gas are so close that the liquefaction and finally solidification of the gas take place. Solid cannot be further compressed. This confirms that molecule of the gas occupy some volume.
2. Liquefaction of the gas is possible only if there are forces of attraction between the molecules. Although these forces are much larger in liquids, but nevertheless, they are not negligible in gases.

***ASSIGNMENT***

1. Calculate the density of methane at s.t.p.

 (C = 12, H = 1, R = 0.0821atm.dm3.K-1.mol-1)

1. A mixture of gases contains 4.46moles of Ne, 0.74mple of Ar and 2.15moles of Xe. Calculate the partial pressure of the gases if the total pressure is 2.00atm at a certain temperature.
2. If 100cm3 of oxygen diffusedin 4sec. and 50cm3 of **Y** diffused in 3sec., calculate the relative molecular mass of gas **Y.** (O = 16).
3. Which of the following gases will diffuse faster than air under the same conditions?

Hydrogen, Ammonia, Oxygen, Methane.

Show your working.

(H = 1, C = 12, N = 14, O = 16, relative vapour density of air = 14 4)