**SS 1 CHEMISTRY**

***Lecture 3***

**TPIC: GAS LAWS**

1. ***Boyle’s Law***

Boyle’s law states, that at a constant temperature, the volume of a given mass of an ideal gas is inversely proportional to the pressure of the gas.

PV = K

Where ‘K’ is the constant of proportionality.

**Using Kinetic theory to explain Boyle’s law**

Considering a given mass of a gas enclosed in a vessel with a movable piston. At first a suitable load is placed on the piston to keep it stationary. At a constant temperature, the gas exerts a certain constant pressure by iits molecule colliding with the wall of the vessel.

If8 the load on the piston is reduced so the piston moves up and the volume of the gas increases by 2, the molecules of the gas will be spread out so that the collision of the gas molecules with the wall is halved thereby exerting half of the original pressure. Hence, at constant temperature, the pressure of a gas decreases as the volume increases.

On the other hand, if the load is increased so that the piston moves down and the volume of the gas decreases to half of the original volume, the collision of the gas molecules increases by 2 due to the fact that the gas molecules are now packed more closely. As a result of that, the pressure of the gas increases by 2. Hence, at a constant temperature, the pressure of a gas increases as the volume decreases.



If the initial volume = V1

Final volume = V2

Initial pressure = P1

Final pressure = P2

And PV = constant

P1V1 = P2V2

Then

**Graphical representation of Boyle’s law**



1. ***Charles’ Law***

Charles’ law states that at a constant pressure, the volume of a given mass of an ideal gas is directly proportional to the temperature in Kelvin.

V = KT

**Using Kinetic theory to explain Charles’ law**

A given mass of a gas enclosed in a vessel with a movable piston having a particular temperature, pressure and volume is heated so that the temperature of the gas is increased. At that increase in temperature, the number of collision per unit area also increases. To maintain a constant pressure (i.e. number of collision per unit area), the piston is moved up to increase the volume.

Hence, at a constant pressure, the temperature of an ideal gas increases with the volume and vice versa.



If the initial Volume = V1

Final Volume = V2

Initial Temperature = T1

Final Temperature = T2

And

Then,

**Graphical representation of Charles’ law**



**STANDARD TEMPERATURE AND PRESSURE (s. t. p)**

Since the volume of gases is a function of temperature and pressure, a particular experiment carried out on a gas at different places with different atmospheric temperature will show different pressure. Because of this observation, scientists decided to choose 0OC or -273K as the standard temperature and 760mmHg or or 1atm as the standard pressure.

At s.t.p, 22.4dm3 volume of a ideal gas contains 1mole of the gas. Therefore, 22.4dm3 is called the molar volume of gases.

**GENERAL GAS EQUATION**

The general gas equation is derived from the combination of Boyle’s law and Charles’ law.

That is,

 (Boyle’s law)

 (Charles’ law)

Since

Then,

***Worked Example***

1. A given mass of nitrogen is 0.12dm3 at 60oC and . Find its pressure at the same temperature if the volume is changed to 0.24dm3.
2. If 60cm3 of a gas is heated from 27oC to 50oC, what is the new volume of the gas at constant pressure?
3. 15dm3 of a gas at s.t.p in a tube was pressed by a piston whose pressure was increased to twice its original value at the same temperature. What is the volume of the gas in dm3 at this new pressure?
4. A give mass of a gas occupies 500cm3 at 30oC and . Calculate the volume of the gas at s.t.p (standard pressure = )
5. A sample of nitrogen occupies a volume of 1dm3 at 500K and . What will be its volume at and 400K.
6. 130cm3 of a gas at 20oC exerts a pressure of 750mmHg. Calculate its pressure if its volume is increased to 150cm3 at 15oC.

***Solutions***

***Note:***

1. When the temperature is given in oC, you must convert it to K (Kelvin scale)
2. The unit of the initial and final volume must be the same; if not convert the unit of the initial to that of the final or final to initial before solving. The same thing holds fore pressure.
3. To determine which formula you will use to solve a particular question, observe which of the variables is constant. If you see ***“the same temperature”, or “constant temperature”*** then it is Boyle’s law. If you see ***“the same pressure or constant pressure”,*** then it is Charles’ law. If none of the variable is constant, then it is general gas equation.

***Solution 1***

V1 = 0.12dm3

V2 = 0.24dm3

P1 =

P2 = ?

Temperature is the same (constant)

That is Boyle’s law

Using P1V1 = P2V2

 when the volume changes to 0.24dm3, the pressure was .

***Solution 2***

V1 = 60cm3
T1 = 27oC = 27 + 273 = 300K

T2 = 50oC = 50 + 273 = 323K

V2 = ?

In this question, pressure is constant, so we use Charles’ law formula.

 The new volume when the temperature of the gas changed from 27oC to 50OC is 64.6cm3.

***Solution 3***

V1 = 15dm3

T1 = standard temperature = 273K

P1 = standard pressure = 1atm

P2 = twice the initial pressure

T2 = 273K (constant)

V2 = ?

Temperature is constant, so the question is from Boyle’s law.

Using P1V1 = P2V2

 The final volume of the gas is 7.5dm3

***Solution 4***

V1 = 500cm3

T1 = 30oC = 30 + 273 = 303K

P1 =

P2 =

T2 = 273K

V2 = ?

No variable is constant, so the question is from general gas equation.

Using

V2 = 289.92cm3

That is the volume at s.t.p is 289.92cm3

***Solution 5***

V1 = 1dm3

V2 = ?

T1 = 500K

T2 = 400K

P1 =

P2 =

Using

That is the final volume is 0.4dm3

***Solution 6***

V1 = 130cm3

V2 = 150cm3

P1 = 750mmHg

P2 = ?

T1 = 20oC = 20 + 273 = 293K

T2 = 15oC = 15 + 273 = 288K

Using

The final pressure is 638.91mmHg.

***Assignment***

1. A certain gas completely filled a 0.15dm3 vessel at 25oC. if the gas is carefully transferred to a 100cm3 vessel, what temperature is required to keep the pressure constant assuming there is no loss of any gas molecule?
2. A given mass of a certain gas occupy 20dm3 at s.t.p. calculate the temperature that is capable of keeping the pressure constant when the volume is increased to 65dm3.
3. A given mass of an ideal gas occupies 1.16dm3 at 40oC and 2.05atm. Calculate the volume at 35oC and 1.52atm.