Case –V

Avogadro law states that equal volumesof all gases under the same conditions ofTemperature and pressure contain equalNumber of molecules. This means that asLong as the temperature and pressure remainConstant, the volume depends upon numberOf molecules of the gas or in other wordsAmount of the gas. Mathematically we can write

$V \propto n \Rightarrow V = k_4 n$, where n is the number of molesof the gas. Since volume of a gas is directlyProportional to the number of moles; one moleOf each gas at standard temperature andPressure (STP) will have same volume.Standard temperature and pressure means273.15 K (0°C) temperature and 1 bar (i.e.,Exactly 10^5 Pascal) pressure. TheseValues approximate freezing temperatureOf water and atmospheric pressure at seaLevel. At STP molar volume of an ideal gasOr a combination of ideal gases is22.71098 L mol^{-1}. A gas that follows Boyle's law, Charles' lawAnd Avogadro law strictly is called an idealGas. Such a gas is hypothetical.

The three laws which we have learnt till nowCan be combined together in a single equationWhich is known as ideal gas equation.

At constant T and n; $V \propto \frac{1}{P}$ Boyle's Law

At constant p and n; $V \propto T$ Charles' Law

At constant p and T ; $V \propto n$ Avogadro Law

Thus, $V \propto \frac{nT}{P} \Rightarrow V = R\frac{nT}{P}$

Where R is proportionality constant. OnRearranging the equation

$pV = nRT$(ideal gas Equation) $\Rightarrow R = \frac{pV}{nT}$

R is called gas constant. It is same for all gases. Therefore it is also called Universal GasConstant.

Dalton's Law of Partial PressuresThe law was formulated by John Dalton in1801. It states that the total pressure exertedBy the mixture of non-reactive gases isEqual to the sum of the partial pressuresOf individual gases i.e., the pressures whichThese gases would exert if they were enclosedSeparately in the same volume and under theSame conditions of temperature. In a mixtureOf gases, the pressure exerted by the individualGas is called partial pressure. Mathematically,$p_{Total} = p_1+p_2+p_3+\ldots\ldots$(at constant T, V) . Gases are generally collected over waterAnd therefore are moist. Pressure of dry gasCan be calculated by subtracting vapourPressure of water from the total pressure ofThe moist gas which contains water vapoursAlso. Pressure exerted by saturated waterVapour is called aqueous tension.

Molecules of gases remain in continuousMotion. While moving they collide with eachOther and with the walls of the container. ThisResults in change of their speed andRedistribution of energy. So the speed andEnergy of all the molecules of the gas at anyInstant are not the same. Thus, we can obtainOnly average value of speed of molecules. IfThere are n number of molecules in a sampleAnd their individual speeds are u1, u2, …….un,Then average speed of molecules u_{av} can beCalculated as follows:

$$u_{av} = \frac{u_1 + u_2 + \ldots\ldots\ldots u_n}{n}$$

GasesShow ideal behaviour when the volume Occupied is large so that the volume of theMolecules can be neglected in comparisonTo it. In other words, the behaviour of the gasBecomes more ideal when pressure is very low.Upto what pressure a gas will follow the idealGas law, depends upon nature of the gas andIts temperature. The temperature at which a realGas obeys ideal gas law over an appreciableRange of pressure is called Boyle temperatureOr Boyle point.

[A] MCQ

1) A gas that follows Boyle's law, Charles' law And Avogadro law strictly is called an ...

a) Ideal Gas
b) Real Gas
c) Inert Gas
d) All the above

Ans- a) ideal Gas

2) Which of the following is ideal gas equation ?

a) pR = nVT
b) pV = nRT
c) pT = nRV
d) pn = VRT

Ans - b) pV = nRT

3) Standard Temperature and pressure means

a) 273.15 K (0°C) temperature and 1 bar
b) 300.15 K (27°C) temperature and 10 bar
c) 308.15 K (35°C) temperature and 100 bar
d) 373.15 K (100°C) temperature and 1000 bar

Ans-a) 273.15 K (0°C) temperature and 1 bar

4) At STP molar volume of an ideal gasor a combination of ideal gases is....

a) 22.71098 L
b) 22.71098 L
c) 22.71098 L mol–1
d) 22.71098 L

Ans- c) 22.71098 L

5) Pressure exerted by saturated watervapour is called ....

a) Latitudinal tension
b) longitudinal tension
c) surface tension
d) aqueous tension

Ans- d) aqueous tension

[B]Short Answers

1) Avogadro Law (Volume – AmountRelationship)

Ans- Avogadro law states that equal volumes of all gases under the same conditions of Temperature and pressure contain equal Number of molecules. This means that as Long as the temperature and pressure remain Constant, the volume depends upon number Of molecules of the gas or in other words Amount of the gas. Mathematically ,

$V \propto n \Rightarrow V = k_4 n$,

where n is the number of moles of the gas.

2) State Dalton's law of partial pressure.

Ans- It states that the total pressure exerted By the mixture of non-reactive gases is Equal to the sum of the partial pressures Of individual gases i.e., the pressures which These gases would exert if they were enclosed Separately in the same volume and under the Same conditions of temperature. In a mixture Of gases, the pressure exerted by the individual Gas is called partial pressure. Mathematically, $pTotal = p_1 + p_2 + p_3 + \ldots\ldots$(at constant T, V) .

3)Why is it that the gases show ideal Behaviour when the volume occupied is large? What is Boyle point ?

Ans-Gases Show ideal behaviour when the volume Occupied is large so that the volume of the Molecules can be neglected in comparison To it. In other words, the behaviour of the gas Becomes more ideal when pressure is very low. Upto

what pressure a gas will follow the ideal Gas law, depends upon nature of the gas and Its temperature. The temperature at which a real Gas obeys ideal gas law over an appreciable Range of pressure is called Boyle temperature Or Boyle point.

[C]Long Answers

1) Derive ideal gas equation.

Ans- The three laws can be combined together in a single equation Which is known as ideal gas equation.

At constant T and n; $V \propto \frac{1}{P}$ Boyle's Law

At constant p and n; $V \propto T$ Charles' Law

At constant p and T ; $V \propto n$ Avogadro Law

Thus, $V \propto \frac{nT}{P} \Rightarrow V = R\frac{nT}{P}$

Where R is proportionality constant. On Rearranging the equation

$pV = nRT$(ideal gas Equation) $\Rightarrow R = \frac{pV}{nT}$

R is called gas constant. It is same for all gases. Therefore it is also called Universal Gas Constant.

2) How to calculate the speed of molecules ?

Ans- Molecules of gases remain in continuous Motion. While moving they collide with each Other and with the walls of the container. This Results in change of their speed and Redistribution of energy. So the speed and Energy of all the molecules of the gas at any Instant are not the same. Thus, we can obtain Only average value of speed of molecules. If There are n number of molecules in a sample And their individual speeds are u1 , u2 , …….un , Then average speed

$$u_{av} = \frac{u_1 + u_2 + \ldots\ldots\ldots u_n}{n}$$

of molecules u_{av} can be Calculated as follows: