Problem Based on Ideal Gas Equation

VERY SHORT ANSWER TYPE QUESTIONS :

VSA.1 How is the pressure of a gas related to its density at a particular temperature ?

Sol. $\rho = \frac{MP}{RT}$

VSA.2 What is the equation of state of an ideal gas for n moles ?

Ans. PV = nRT

VSA.3 What is the value of the gas constants in S.I. units ?

Ans. 8.314 J K^{-1} mol^{-1}

VSA.4 Why is it not possible to cool a gas to 0K.

Ans. This is because all gases condense to liquids or solids before this temperature is reached.

VSA.5 What is the value of molar gas volume (in litres) at NTP for an ideal gas.

Sol. At NTP the molar gas volume for an ideal gas is 22.4 L.

VSA.6 Ideal volume of gas is different from its observed value. Why ?

Ans. The volume of molecule can not be neglected at high P and low T in comparison to total volume of the gas.

VSA.7 Why do gases show high compressibility.

Sol. Due to large empty space between molecules.

VSA.8 Gases occupy whole of the volume, comment.

Sol. Gases do not have appreciable forces of attractions and thus, the molecules can easily diffuse to anywhere in container.

VSA.9 Give various forms of ideal gas equation.

Sol. PV = nRT

$PV = \frac{m}{M}RT$ $\qquad \frac{PV}{T} = R = \text{constant}$

$PM = \frac{m}{V}RT$ $\qquad \frac{P_1V_1}{T_1} = \frac{P_2V_2}{T_2}$

$PM = dRT$ $\qquad d = \frac{PM}{RT}$

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SHORT ANSWER TYPE QUESTIONS :

SA.1 Define the value of gas constant in SI units.

Sol. For expressing R in SI units,

put 10^7 ergs = 1 joule [$R = 8.314 \times 10^7$ ergs $degree^{-1}$ mol^{-1}]

Hence $R = \frac{8.314 \times 10^7}{10^7}$ joules $degree^{-1}$ mol^{-1}

= 8.314 joules $degree^{-1}$ mol^{-1}

= 8.314 J K^{-1} mol^{-1}

Or directly taking

P = 101325 Nm^{-2} or Pa

V = 0.0224 m^3, T = 273 K

We get R = 8.314 J k^{-1} mol^{-1}

or taking

P = 101.325 K Pa,

V = 22.4 dm^3, T = 273 K

We get R = 8.314 K Pa dm^3 k^{-1} mol^{-1}

SA.2 At 27ºC and one atmospheric pressure a gas has volume V. What will be its volume at 177ºC and a pressure of 1.5 atmosphere ?

Sol. Given conditions

$V_1 = V$

$P_1 = 1$ atm.

$T_1 = 273 + 27 = 300$ K.

Final conditions

$V_2 = ?$

$P_2 = 1.5$ atm.

$T_2 = 273 + 177 = 450$ K

Applying gas equation

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

we have,

$$\frac{1 \times V}{300} = \frac{1.5 \times V_2}{450}$$

$$V_2 = \frac{1 \times V \times 450}{300 \times 1.5} = V$$

Volume of gas = V

SA.3 A sealed tube which can withstand a pressure of 3 atmosphere is filled with air at 27ºC and 760 mm pressure. Find the temperature above which it will burst.

Sol. Let the volume of the air in the tube be V ml.

Given conditions

V_1 = V ml.

P_1 = 760 mm = 1 atm.

T_1 = 273 + 27 = 300 K

New conditions

V_2 = V ml.

P_2 = 3 atm.

T_2 = ?

By applying gas equation we have

$$\frac{P_1V_1}{T_1} = \frac{P_2V_2}{T_2}$$

$$\frac{V \times 1}{300} = \frac{V \times 3}{T_2}$$

$\therefore$ $T_2 = 300 \times 3 = 900$ K

Thus the temperature above which the tube will burst.

= 900 – 273 = 627ºC.

SA.4 10 gm of O_2 were introduced in to an evacuated vessel of 5 litres capacity maintained at 27ºC. Calculate the pressure of the gas in atmospheres in the container.

Sol. Since the volume of a gas is equal to the volume of its container, therefore

V = 5 litres

Further molecular mass of O_2 = 32.0, therefore the number of moles of O_2 gas are

$n = \frac{10}{32}$ moles.

We are also given

T = 27ºC = 27 + 273 K = 300 K

Taking R = 0.0821 litres atm K^{-1} mol^{-1} and using the ideal gas equation

$$PV = nRT \Rightarrow P = \frac{nRT}{V}$$

$$= \frac{(10/32)\ (0.0821)\ (300)}{5}$$

P = 1.54 atm.

SA.5 If the density of a gas at the sea level at 0ºC is 1.29 kg m^{-3}. What is its molar mass ? (Assume that pressure is equal to 1 bar)

Sol. $PV_m = RT$ or P M/d = Rt or M = dRT/P

$$= \frac{1.29\text{kg m}^{-3} \times 8.314 \text{ Nm K}^{-1} \text{ mol}^{-1} \times 273.15 \text{ K}}{1.0 \times 10^5 \text{ Nm}^{-2} \text{ (or Pa)}}$$

$$= \frac{1.29 \times 8.314 \times 273.15 \text{ kg mol}^{-1}}{1 \times 10^5}$$

= 0.0293 kg mol^{-1} or molar mass is 29.3 g mol^{-1}.