Ideal Gas Law Problems

1) **How many molecules are there in 985 mL of nitrogen at 0.0° C and 1.00×10^{-6} mm Hg?**

2) **Calculate the mass of 15.0 L of NH_3 at 27° C and 900. mm Hg.**

3) **An empty flask has a mass of 47.392 g and 47.816 g when filled with acetone vapor at 100.° C and 745 mm Hg. If the volume of the flask is 247.3 mL, what is the molar mass of the acetone?**

4) **Calculate the density in g/L of 478 mL of krypton at 47° C and 671 mm Hg.**

5) **6.3 mg of a boron hydride is contained in a flask of 385 mL at 25.0° C and a pressure of 11 torr.**

(a) **Determine the molar mass of the hydride.**

(b) **Which of the following hydrides is contained in the flask, BH_3, B_2H_6, or B_4H_{10}?**

6) **A volume of 26.5 mL of nitrogen gas was collected in a tube at a temperature of 17° C and a pressure of 737 mm Hg. The next day the volume of the nitrogen was 27.1 mL with the barometer still reading 737 mm Hg. What was the temperature on the second day?**

Solutions

1) **P = 1.00 x 10^{-6} mm Hg** **T = 0.0° C + 273 = 273 K**

V = 985 mL **R = 0.0821 L·atm/mol·K**

PV = nRT

n = PV/RT

n = 1.00 x 10^{-6} ~~mm~~ x 1 ~~atm~~/760 ~~mm~~ x 985 ~~mL~~ x 1 ~~L~~/10^{3} ~~mL~~/

(0.0821 ~~L~~·~~atm~~/mol·~~K~~ x 273 ~~K~~) = 5.78 x 10^{-11} moles N_2

$n_{molecules}$ = 5.78 x 10^{-11} ~~moles N_2~~ x 6.02 x 10^{23} N_2 molecules/1 ~~mol N_2~~

= 3.48 x 10^{13} N_2 molecules

2) **P = 900. mm Hg** **T = 27° C + 273 = 300 K**

V = 15.0 L **R = 0.0821 L·atm/mol·K**

PV = nRT

n = PV/RT

n = 900. ~~mm~~ x 1 ~~atm~~/760 ~~mm~~ x 15.0 ~~L~~/(0.0821 ~~L~~·~~atm~~/mol·~~K~~ x 300 ~~K~~) =

n = 0.721 ~~moles NH_3~~ x 17.04 g NH_3/1 ~~mol NH_3~~ = 12.3 g NH_3

3) **P = 745 mm Hg** **T = 100.° C + 273 = 373 K**

V = 247.3 mL **R = 0.0821 L·atm/mol·K**

m_{vapor} = 47.392 g – 47.816 g = 0.424 g

PV = nRT

n = m/MM

PV = mRT/MM

MM = mRT/PV

MM = 0.424 g x 0.0821 ~~L~~·~~atm~~/mol·~~K~~ x 373 ~~K~~/(745 ~~mm~~ x 1 ~~atm~~/760 ~~mm~~ x 247.3 ~~mL~~ x 1 ~~L~~/10^3 ~~mL~~) = 53.6 g/mol

4) **P = 671 mm Hg** **T = 47° C + 273 = 320. K**

V = 478 mL **R = 0.0821 L·atm/mol·K**

PV = nRT

n = m/MM

D = m/V = P x MM/R x T

D = 671 ~~mm~~ x 1 ~~atm~~/760 ~~mm~~ x 83.80 g/~~mol~~/(0.0821 L·~~atm~~/~~mol~~·~~K~~ x 320. ~~K~~)

= 2.82 g/L

5) **P = 11 torr** **T = 25.0° C + 273 = 298 K**

V = 385 mL **R = 0.0821 L·atm/mol·K**

m = 6.3 mg

PV = nRT

n = m/MM

PV = mRT/MM

MM = 6.3 ~~mg~~ x 1 g/10^3 ~~mg~~ x 0.0821 L·~~atm~~/mol·~~K~~ x 298 ~~K~~)/

(11 ~~torr~~ x 1 ~~mm~~/1 ~~torr~~ x 1 ~~atm~~/760 ~~mm~~ x 385 ~~mL~~ x 1 ~~L~~/10^3 ~~mL~~)

= 27.7 g/mol

B_2H_6 because its molar mass is 27.7 g.

6) **P_1 = 737 mm Hg** **P_2 = 737 mm Hg**

V_1 = 26.5 mL **V_2 = 27.1 mL**

T_1 = 17° C + 273 = 290. K **T_2 = ?**

$P_1V_1 = nRT_1$

$P_2V_2 = nRT_2$

~~P_1~~V_1/ ~~P_2~~V_2 = ~~nR~~T_1/ ~~nR~~T_2

$V_1/V_2 = T_1/T_2$ (Charles's Law)

$T_2 = V_2/V_1 \times T_1$

T_2 = 27.1 ~~mL~~/26.5 ~~mL~~ x 290. K = 297 K = 24° C