$PV=nRT$ $P=\frac{nRT}{V}$ $V=\frac{nRT}{P}$ $T=\frac{PV}{nR}$ $n=\frac{PV}{RT}$

Ideal Gas Problems

1.) 10.0 grams of He, 10.0 grams of N_2, and 10.0 grams of Ar gas are all mixed in a 5.00 liter container at 27.0 °C. Calculate the partial pressure of each gas in the container and then find the total pressure in the container.

$P=\frac{nRT}{V}$ $P=\frac{n(0.0821)(300K)}{5.00L}$

2.50 mol He → $P=12.3$ atm

0.357 mol N_2 → $P=1.76$

0.250 mol Ar → $P=1.23$

$P_{tot}=15.3$ atm

2) A 0.586 g sample of helium is collected by water displacement at 25.0 °C and 1.00 atm total pressure. What volume is occupied by the helium gas? (At 25°C the vapor pressure of water is 23.8 mmHg $\left(\frac{1\text{ atm}}{760\text{ mmHg}}\right)=0.03$ atm

$V=\frac{nRT}{P}$ $P_{tot}-P_{H_2O}=P_{He}$ $1-0.03=0.97$ atm

$0.586\text{ g He}\left(\frac{1\text{ mol}}{4.00\text{ g}}\right)=0.147\text{ mol He}$

$V=\frac{(0.147\text{ mol})(0.0821)(298K)}{0.97\text{ atm}}=3.7L$

3) Quicklime (CaO) is produced by the thermal decomposition of calcium carbonate ($CaCO_3$). Calculate the volume of CO_2 at 25.0 °C and 1.20 atm. from the decomposition of 152 g of $CaCO_3$ according to the reaction (T, P, ⇒ #mols)

$CaCO_3 \rightarrow CaO + CO_2$

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

$152\text{ g }CaCO_3\left(\frac{1\text{ mol }CaCO_3}{100.09\text{ g}}\right)\left(\frac{1\text{ mol }CO_2}{1\text{ mol }CaCO_3}\right)=1.52\text{ mol }CO_2$

$V=\frac{(1.52\text{ mol})(0.0821)(298K)}{1.20\text{ atm}}$

$V=30.9L$

4) A sample of gas was collected near a raging volcano in a 1.5 liter glass vessel. The sample of gas was brought back to the lab where the temperature was 23.0°C and the pressure was 100.6 kPa. The lab technicians weighed the vessel and found that the gas inside had a mass of 4.65 grams. Help the lab guys out and find out what the molecular weight of the gas is. $\left(\frac{1\text{ atm}}{101.3\text{ kPa}}\right)$

$PV=nRT$ $n=\frac{PV}{RT}$ $23+273$

$n=\frac{(0.993\text{ atm})(1.5L)}{(0.0821\frac{L\cdot atm}{mol\cdot K})(296K)}=0.0613\text{ mol}$

$\frac{4.65\text{ g}}{0.0613\text{ mol}}=75.86\text{ g/mol}$

5) Dry ice is solid carbon dioxide (CO_2). It sublimes(turns directly to gas) to give CO_2 gas. If a 386.4 gram sample of dry ice is placed in a tank with a volume of 2.500 dm^3, what is the pressure when all the dry ice has sublimed? The temperature is a constant 32.0 °C. $V=2.5L$ $T=305K$ $n=386.4\text{ g}\left(\frac{1\text{ mol}}{44.01}\right)=8.78\text{ mol }CO_2$

$P=\frac{nRT}{V}=\frac{(8.78\text{ mol})(0.0821)(305K)}{2.5L}=88\text{ atm}$

6) Butane gas (C_4H_{10}) burns by the following reaction: $2C_4H_{10}+13O_2 \rightarrow 8CO_2+10H_2O$. How many liters of O_2 gas would be needed to completely react with 27.6 grams of butane at 25.0 °C and a pressure of 1.05 atm. $V=\frac{nRT}{P}$

$27.6\text{ g }C_4H_{10}\left(\frac{1\text{ mol }C_4H_{10}}{58.14\text{ g}}\right)\left(\frac{13\text{ mol }O_2}{2\text{ mol }C_4H_{10}}\right)=3.09\text{ mol }O_2$

$V=\frac{(3.09)(0.0821)(298)}{1.05}=72.0L$

7) A gas has a molecular mass of 143.0 g/mol. What is the mass of 3.65 liters of this gas at 18.0 °C if it exerts a pressure of 98.6 kPa? $(+273=291)$ $\left(\frac{1\text{ atm}}{101.3\text{ kPa}}\right)=0.973$ atm

$PV=nRT$ $n=\frac{PV}{RT}$

$n=\frac{(0.973\text{ atm})(3.65L)}{(0.0821)(291K)}=0.149\text{ mol}\left(\frac{143.0\text{ g}}{1\text{ mol}}\right)=21.3\text{ g}$