Gas Laws • CHEM 210

1. A tire was filled with 32.0 psi pressure in Death valley where the temperature was 41.0°C. The driver then drove to the Sierras where the temperature was –5.0 °C. What is the pressure in the tire in the Sierras, assuming the volume of the tire is constant?

$P_1 = 32.0$ psi
$T_1 = 314.15$ K
$T_2 = 268.15$ K

$\frac{P_1}{T_1} = \frac{P_2}{T_2}$ → $P_2 = \frac{P_1 \cdot T_2}{T_1} = \frac{(32.0 \text{ psi})(268.15 \text{ K})}{(314.15 \text{ K})}$

$P_2 = 27.3$ psi

2. What volume of liquid ethanol (C_2H_5OH, D = 0.789 g/mL) will burn in 100.0 L of O_2 gas at 50.0°C and 1.80 atm pressure?

$C_2H_5OH_{(l)} + 3O_{2\,(g)} \rightarrow 2CO_{2\,(g)} + 3H_2O_{(g)}$

$M_m = 46.08$ g/mol

100.0 L
$T = 50 + 273 = 323.15$ K
$P = 1.80$ atm

$PV = nRT$

$n = \frac{PV}{RT} = \frac{(1.8)(100)}{(0.08206)(323.15)} = 6.79$ mol O_2

$6.79 \text{ mol } O_2 \left| \frac{1 \text{ mol } C_2H_5OH}{3 \text{ mol } O_2} \right| \frac{46.08 \text{ g } C_2H_5OH}{1 \text{ mol}} \left| \frac{1 \text{ mL}}{0.789 \text{ g}} \right.$

$= 132$ mL

3. A sample of gas expands from 12.8 L at 34°C and 1.5 atm to 15.5 L while the pressure increases to 204.7 kPa. What is the new temperature?

$P_1 = (1.5 \text{ atm})\left(101.3 \frac{\text{kPa}}{\text{atm}}\right) = 152$ kPa
$V_1 = 12.8$ L
$T_1 = 307$ K

$P_2 = 204.7$ kPa
$V_2 = 15.5$ L
$T_2 = ?$

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

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

$= \frac{(204.7)(15.5)}{(152)(12.8)} \cdot 307$ K

$T_2 = 500$ K $= 230$°C

4. What is the density of C_2H_6 gas at STP?

(g/L) $M_m = 2(12.01) + 6(1.01) = 30.08$ g/mol

$D = \frac{1 \text{ mol}}{22.4 \text{ L}} \cdot \frac{30.08 \text{ g}}{1 \text{ mol}} = 1.34$ g/L

or use: $D = \frac{PM_m}{RT}$

5. A 5.00-L fixed volume flask is filled with 10.0-g of nitrogen gas at 22.0°C.

A) What is the pressure of nitrogen in the flask?

$PV = nRT$

$\frac{10.0 \text{ g}}{28.02 \text{ g}} \left| \frac{1 \text{ mol}}{} \right. = 0.3569$ mol N_2

$P = \frac{nRT}{V} = \frac{(0.3569 \text{ mol})\left(0.08206 \frac{\text{L atm}}{\text{K mol}}\right)(295.15 \text{ K})}{(5.00 \text{ L})}$

$P_{N_2} = 1.73$ atm

B) After 2.00-g of helium is injected into the flask, what are the P_{N2}, P_{He}, and P_{total} in the flask?

P_{N_2} is still $= 1.73$ atm

$\frac{2.00 \text{ g He}}{4.00 \text{ g}} \left| \frac{1 \text{ mol}}{} \right. = 0.500$ mol He

$P_{He} = \frac{(0.500 \text{ mol})\left(0.08206 \frac{\text{L atm}}{\text{K mol}}\right)(295.15 \text{ K})}{5.00 \text{ L}}$

$P_{He} = 2.42$ atm

6. Hydrogen gas effuses through an opening at rate of 3.00 mmol/min. If another gas effuses at a rate of 0.15 mmol/min, what is its molar mass?

$M_{H_2} = 2.02$ g/mol
$M_{UNK} = ?$

$\frac{\text{rate}_{H_2}}{\text{rate}_{UNK}} = \sqrt{\frac{M_{UNK}}{M_{H_2}}}$ (squared)

$\left(\frac{3.00 \text{ mmol/min}}{0.15 \text{ mmol/min}}\right)^2 = \frac{M_{UNK}}{2.02}$

$M_{UNK} = 808$ g/mol

(#7) $\frac{1000\text{g CO}_2 \mid 1\text{mol}}{\mid 44.02\text{g}} = 22.72\text{ mol}$

IGL

$$P = \frac{nRT}{V} = \frac{(22.72\text{mol})\left(0.08206\ \frac{\text{L·atm}}{\text{K·mol}}\right)(298.15\text{K})}{25.0\text{L}}$$

$$P_{IGL} = 22.2\text{ atm}$$

VDW

$$P = \frac{nRT}{V-nb} - a\left(\frac{n}{V}\right)^2$$

$a = 3.59\ \frac{\text{atm·L}^2}{\text{mol}^2}$

$b = 0.0427\ \frac{\text{L}}{\text{mol}}$

$$P = \frac{(22.72)(0.08206)(298.15)}{25.0 - (22.72)(0.0427)} - (3.59)\left(\frac{22.72}{25.0}\right)^2$$

$$P_{VDW} = 23.13 - 2.965 = \boxed{20.2\text{ atm} = P_{VDW}}$$

$T = 298.15$ $V_{Tot} = 12.0\text{L}$

(#8) NH_3

a) $\frac{15.2\text{g} \mid 1\text{mol}}{\mid 17.03\text{g}} = 0.8925\text{ mol } NH_3$

$$P_{NH_3} = \frac{nRT}{V} = \frac{(0.8925)(0.08206)(298.15\text{K})}{12.0\text{L}}$$

$P_{NH_3} = 1.82\text{ atm}$

Ne

$\frac{4.55\text{g} \mid 1\text{mol}}{\mid 20.18\text{g}} = 0.2255\text{ mol}$

$$P_{Ne} = \frac{(0.2255)(0.08206)(298.15)}{12.0\text{L}}$$

$P_{Ne} = 0.46\text{ atm}$

$\boxed{P_{Total} = P_{NH_3} + P_{Ne} = 2.28\text{ atm}}$

b) $\frac{9\text{L}}{12\text{L}} = \frac{\text{g Ne (in 9L flask)}}{\text{g Ne (total)}}$ let x = mass Ne in 9L flask

$$\frac{9}{12} = \frac{x}{4.55\text{g}} \Rightarrow \boxed{x = 3.41\text{ g Ne}}$$