W-GC General Chemistry Week 26 4/3

## Universal Gas Constant

Jesus & Importance of units

8.314 J/mol·K

$$\boxed{0.0821\ \frac{\text{atm}\cdot\text{L}}{\text{mol}\cdot\text{K}}}$$

$PV \propto nT$

$PV = knT$

$PV = RnT$

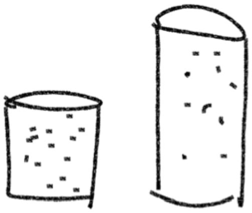
$$PV = nRT$$

## Ideal Gas Relationships

[if all else is held constant]

- As volume increases, pressure ...? $\boxed{\text{decreases}}$

$\downarrow P\overset{\uparrow}{\boxed{V}} = \boxed{nRT}$ —



- As the number of moles decreases, absolute Temperature ...? $\boxed{\text{increases}}$

$-\boxed{PV} = \underset{\downarrow}{n}\boxed{R}T\uparrow$

- As temperature increases, pressure...? $\boxed{\text{increase}}$

$\uparrow P\underline{V} = \underline{n}\,\underline{R}T\uparrow$

$\underbrace{PV}_{\text{inversely}} \overbrace{= nR}^{\text{directly}} T$

What is the pressure of $\boxed{\underset{n}{\text{1.8 moles}}}$ of an ideal gas with a $\boxed{\text{12.7 L}}$ volume at 23 °C?

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

$$P = \frac{\boxed{n}\boxed{R}\boxed{T}}{\boxed{V}}$$

$$R = 0.0821\ \frac{atm \cdot L}{mol \cdot K}$$

$$T = 23^\circ C + 273 = \boxed{296\ K}$$

$$P = \frac{(1.8\ \cancel{mol})\left(0.0821\ \frac{atm \cdot \cancel{L}}{\cancel{mol} \cdot \cancel{K}}\right)(296\ \cancel{K})}{12.7\ \cancel{L}}$$

$$= \boxed{3.4\ atm}$$

What is the temperature of 2.2 mol of an ideal gas with a 1.9 atm pressure and a volume of 6.2 L?

$$\frac{PV}{nR} = \frac{nRT}{nR}$$

$$T = \frac{PV}{nR} = \frac{(1.9\ \cancel{atm})(6.2\ \cancel{L})}{(2.2\ \cancel{mol})\left(0.0821\ \frac{\cancel{atm\,L}}{\cancel{mol}\ K}\right)}$$

$$\boxed{65.2\ K}$$

What volume of carbon dioxide is produced from a reaction at $\boxed{36°C}$ and $\boxed{1.28\ \text{atm}}$ with 16.2g of $C_2H_6$ and a "seemingly infinite supply" of oxygen?

$$\underset{\text{limiting reagent}}{\underset{\uparrow}{C_2H_6}} + \cancel{\tfrac{7}{2}O_2} \longrightarrow 2CO_2 + 3H_2O$$

$$\boxed{P}V = \underset{\text{mol } CO_2}{\underset{\nearrow}{n}}R\boxed{T}$$

$$16.2g\ C_2H_6 * \frac{1\ \text{mol}\ C_2H_6}{30g\ C_2H_6} * \frac{2\ \text{mol}\ CO_2}{1\ \text{mol}\ C_2H_6} *$$

$$= 1.08\ \text{mol}\ CO_2 = n$$

$P = 1.28\ \text{atm}$ $\quad T = 36°C + 273 = 309K$ $\quad n = 1.08\ \text{mol}$ $\quad R = 0.0821\ \frac{\text{atmL}}{\text{molK}}$

$$\frac{PV}{P} = \frac{nRT}{P} \qquad V = \frac{nRT}{P} = \frac{(1.08\ \cancel{\text{mol}})(0.0821\ \frac{\cancel{\text{atm}}L}{\cancel{\text{mol}}\ \cancel{K}})(309\cancel{K})}{1.28\ \cancel{\text{atm}}}$$

$$\boxed{21.4L}$$

What volume of carbon dioxide is produced from a reaction at 38°C and 2.38 atm with 9.83g of $C_4H_{10}$ and a seemingly infinite amount of oxygen?

$$C_4H_{10} + \frac{9}{2}O_2 \longrightarrow 4CO_2 + 5H_2O$$

$$9.83g\ C_4H_{10} * \frac{1\ mol\ C_4H_{10}}{58\ g\ C_4H_{10}} * \frac{4\ mol\ CO_2}{1\ mol\ C_4H_{10}} \qquad \frac{PV}{P} = \frac{nRT}{P}$$

$$= 0.68\ mol\ CO_2 = n \qquad V = \frac{nRT}{P}$$

$$V = \frac{(0.676\ mol)(0.0821)(311k)}{2.38} \qquad \boxed{7.25L}$$

$$\begin{array}{r} 38°C \\ +273 \\ \hline 311K \end{array}$$

A 1.80L container of 3.72 g of an unknown ideal gas is measured at 1.38 atm and 34.0°C. What is the molar mass of the ideal gas?

$$n = \underline{\underline{mol}} = \boxed{\frac{mass}{molar\ mass}}$$

$$PV = nRT$$

$$\boxed{PV} = \frac{mass \cdot R \cdot T}{\boxed{molar\ mass}}$$

$$T = 34°C$$
$$\frac{+273}{307\ K}$$

$$molar\ mass = \frac{mass \cdot R \cdot T}{PV} = \frac{(3.72)(0.0821)(307)}{(1.38)(1.80)}$$

$$\boxed{37.7\ g/mol}$$

# Partial Pressure

1 atm → 760 torr

What is the partial pressure of oxygen if 2.80 mol of oxygen is combined with 1.68 mol of $N_2$ and 0.69 mol of $CO_2$ where the total pressure is 3.78 atm

Oxygen $\approx \frac{100 \text{ torr}}{760}$

$$P_{O_2} = \frac{\text{mol } O_2}{\underset{\text{of all gases}}{\text{tot mol}}} = \frac{2.80 \text{ mol}}{2.80 + 1.68 + 0.69} = \frac{2.8}{5.17} = 0.54$$

$$3.78 \text{ atm} \left(\frac{2.8}{5.17}\right)$$

$$3.78 \text{ atm} \, (0.54) = \boxed{2.05 \text{ atm}}$$

# Kinetic Theory of Gases

$$E = mc^2 \qquad KE = \frac{1}{2} mv^2$$

$$\boxed{\frac{r_1}{r_2} = \sqrt{\frac{mm_2}{mm_1}}}$$

kinetic energy