10/22/2018

The ideal gas law: $pV = nRT$

$R = 0.08206 \ \text{atm·L/mol·K}$

ex: What's the vol. of $0.845 \ \text{mol} \ N_2(g)$ @ a pressure of $1.37 \ \text{atm}$ and a temp of 42°C?

$T = 42 + 273.15 = 315.15 \ \text{K}$

$pV = nRT$

$V = \frac{nRT}{p} = \frac{0.845 \ \text{mol} \times 0.08206 \ \frac{\text{atm·L}}{\text{mol·K}} \times 315.15 \ \text{K}}{1.37 \ \text{atm}}$

$= 16.0 \ \text{L}$ (3 s.f.)

Q: What's pressure of $1.75 \ \text{mol}$ of helium gas @ -28°C w/ a vol. of $23.8 \ \text{L}$?

$T = -28 + 273.15 = 245.15 \ \text{K}$

$pV = nRT$

$p = \frac{nRT}{V} = \frac{1.75 \ \text{mol} \times 0.08206 \ \frac{\text{atm·L}}{\text{mol·K}} \times 245.15 \ \text{K}}{23.8 \ \text{L}}$

$= 1.48 \ \text{atm}$

Molar Volume

- vol. occupied by 1 mol gas.
- often speak of: Standard Temperature + Pressure (STP)

0°C = 273.15K

1 atm

$$pV = nRT, \quad V = \frac{nRT}{P} = \frac{(1\,\text{mol})(0.08206\,\frac{\text{atm}\cdot\text{L}}{\text{mol}\cdot\text{K}})(273.15\,\text{K})}{(1\,\text{atm})}$$

$n = 1\,\text{mol}$ (exact)

$T = 273.15\,\text{K}$ (exact)

$p = 1\,\text{atm}$ (exact)

$= 22.41\,\text{L}$

$\approx 22.4\,\text{L}$

~ vol of 1 mol ideal gas @ STP

Density + Molar-Mass

Ch 1: $d = \frac{m}{V}$ — intensive, extensive

Molar Mass $= \mathcal{M}$ $(g/mol) = \frac{m}{n}$

$\Rightarrow m = \mathcal{M} \cdot n$ $\quad d = m/V$?

V? $pV = nRT \Rightarrow V = \frac{nRT}{p}$

$\Rightarrow d = \frac{m}{V} = \frac{\mathcal{M} \cdot n}{nRT/p} = \mathcal{M} \times \frac{p}{RT}$

$\Rightarrow \boxed{d = \frac{\mathcal{M} \cdot p}{RT}}$ $\quad d \propto \mathcal{M}$, $\propto 1/T$

ex: $N_2(g)$, $H_2(g)$ @ STP — d?

$T = 273.15K$, $p = 1\,atm$ (exact)

$R = 0.08206 \frac{atm \cdot L}{mol \cdot K}$

N_2: $2 \times N = 2 \times 14.01$ $\quad 28.029\,g/mol$ $\quad \mathcal{M}$

H_2: $2 \times H = 2 \times 1.008$ $\quad 2.016\,g/mol$ $\quad \mathcal{M}$

N_2 H_2

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

$$d = \frac{(1\,\text{atm})(28.029\,\text{g/mol})}{(0.08206\,\frac{\text{atm}\cdot\text{L}}{\text{mol}\cdot\text{K}})(273.15\,\text{K})} \qquad d = \frac{(1\,\text{atm})(2.016\,\text{g/mol})}{\ldots}$$

$= 1.250$ g/L (4 s.f.) $= 0.08994$ g/L (4 s.f.)