

Ideal Gas Law

$$PV = nRT$$

P = pressure (in atm)

V = volume (in L)

n = # moles (in mol)

T = temperature (in K)

R is the ideal gas constant

$$R = .08206 \frac{\text{L} \cdot \text{atm}}{\text{mol} \cdot \text{K}}$$

→ this is the unit for R!

Examples

- (1) 1.33 mol of oxygen gas exerts .850 atm of pressure at -11.0°C. Calculate the volume of the container.

$$P = .850 \text{ atm}$$

$$V = ?$$

$$n = 1.33 \text{ mol}$$

$$R = .08206 \frac{\text{L} \cdot \text{atm}}{\text{mol} \cdot \text{K}}$$

$$T = -11.0^\circ\text{C} + 273 = 262 \text{ K}$$

$$PV = nRT$$

$$(.850 \text{ atm}) V = (1.33 \text{ mol}) (.08206 \frac{\text{L} \cdot \text{atm}}{\text{mol} \cdot \text{K}}) (262 \text{ K})$$

$$\frac{(.850 \text{ atm}) V}{.850 \text{ atm}} = \frac{28.5946276 \text{ L} \cdot \text{atm}}{.850 \text{ atm}}$$

$$V = 33.64073835 \text{ L}$$
$$V = 33.6 \text{ L}$$

- (2) .8765 mol of helium gas occupies 2.006 L of space at a pressure of 700.0 torr. What is the temperature of the helium?

must convert to atm

$$P = 700.0 \text{ torr} \frac{700.0 \text{ torr} | 1 \text{ atm}}{760 \text{ torr}} = .9211 \text{ atm}$$

$$V = 2.006 \text{ L}$$

$$n = .8765 \text{ mol}$$

$$R = .08206 \frac{\text{L} \cdot \text{atm}}{\text{mol} \cdot \text{K}}$$

$$T = ?$$

$$PV = nRT$$

$$(.9211 \text{ atm})(2.006 \text{ L}) = (.8765 \text{ mol})(.08206 \frac{\text{L} \cdot \text{atm}}{\text{mol} \cdot \text{K}}) T$$

$$\frac{1.8477266 \text{ atm} \cdot \text{L}}{.071925591 \frac{\text{L} \cdot \text{atm}}{\text{K}}} = \frac{.07192559 \frac{\text{L} \cdot \text{atm}}{\text{K}} T}{.07192559 \frac{\text{L} \cdot \text{atm}}{\text{K}}}$$

$$25.68941875 \text{ K} = T$$

$$25.69 \text{ K} = T$$

(3) What mass of nitrous oxide (N_2O) is contained in a 20.0L balloon at a pressure of 1.09 atm and a temperature of 90.0°C?

1st solve $PV = nRT$ for n (moles). 2nd convert moles to mass.

1st

$$\begin{aligned} P &= 1.09 \text{ atm} \\ V &= 20.0 \text{ L} \\ n &= ? \\ R &= .08206 \frac{\text{L} \cdot \text{atm}}{\text{mol} \cdot \text{K}} \\ T &= 90.0^\circ\text{C} + 273 = 363 \text{ K} \end{aligned}$$

$$\begin{aligned} PV &= nRT \\ (1.09 \text{ atm})(20.0 \text{ L}) &= n(.08206 \frac{\text{L} \cdot \text{atm}}{\text{mol} \cdot \text{K}})(363 \text{ K}) \\ 21.8 \text{ atm} \cdot \text{L} &= n(29.78778 \frac{\text{L} \cdot \text{atm}}{\text{mol}}) \\ \frac{21.8 \text{ atm} \cdot \text{L}}{29.78778 \frac{\text{L} \cdot \text{atm}}{\text{mol}}} &= \frac{29.78778 \frac{\text{L} \cdot \text{atm}}{\text{mol}}}{29.78778 \frac{\text{L} \cdot \text{atm}}{\text{mol}}} \end{aligned}$$

$$.7318437292 \text{ mol} = n$$

$$.732 \text{ mol} = n$$

2nd

$$\frac{.732 \text{ mol } \text{N}_2\text{O} \mid 44.02 \text{ g}}{1 \text{ mol}} = 32.2 \text{ g } \text{N}_2\text{O}$$

MM - N_2O

$$\begin{aligned} 2 \text{ N} \times 14.01 \text{ g} &= 28.02 \text{ g} \\ 1 \text{ O} \times 16.00 \text{ g} &= 16.00 \text{ g} \\ \hline &44.02 \text{ g} \end{aligned}$$

(4) What is the mass of ozone (O_3) in a 5.60L flexible container at a pressure of 200. kPa and a temperature of -40.0°C?

convert to atm

convert to K

$$P = 200. \text{ kPa} \quad \frac{200. \text{ kPa} \mid 1 \text{ atm}}{101.325 \text{ kPa}} = 1.973846533 \text{ atm}$$

$$V = 5.60 \text{ L}$$

$$n = ?$$

$$R = .08206 \frac{\text{L} \cdot \text{atm}}{\text{mol} \cdot \text{K}}$$

$$T = -40.0^\circ\text{C} + 273 = 233 \text{ K}$$

$$PV = nRT$$

$$(1.973846533 \text{ atm})(5.60 \text{ L}) = n(.08206 \frac{\text{L} \cdot \text{atm}}{\text{mol} \cdot \text{K}})(233 \text{ K})$$

$$11.05354059 \text{ atm} \cdot \text{L} = n(19.11998 \frac{\text{L} \cdot \text{atm}}{\text{mol}})$$

$$\frac{11.05354059 \text{ atm} \cdot \text{L}}{19.11998 \frac{\text{L} \cdot \text{atm}}{\text{mol}}} = \frac{19.11998 \frac{\text{L} \cdot \text{atm}}{\text{mol}}}{19.11998 \frac{\text{L} \cdot \text{atm}}{\text{mol}}}$$

$$.5781146523 \text{ mol} = n$$

$$.578 \text{ mol} = n$$

MM - O_3

$$3 \text{ O} \times 16.00 = 48.00 \text{ g}$$

$$\frac{.578 \text{ mol } \text{O}_3 \mid 48.00 \text{ g}}{1 \text{ mol}} = 27.744 \text{ g} = 27.7 \text{ g } \text{O}_3$$