Gas Stoichiometry Problems

- gases occupy a large volume with a small amount of matter (for comparision, one mole of liquid water occupies 18.02 mL, one mole of a gas occupies about 22.414 L, more than one thousand times the volume)

- gases have a variable volume that depends on temperature and pressure – big time

  - temperature increases, volume increases

  - pressure increases, volume decreases

- two types of problems

  - S.T.P. problems (easy)

  - ideal gas law problems (difficult)

S.T.P. Calculations:

- S.T.P. stands for standard temperature and pressure (0 °C and one atmosphere of pressure)

- one atmosphere is the pressure observed at sea level on a average day

1 atm = 101.325 kPa = 760 torr

= 760 mmHg = 29.92 inchHg = 1000 mbar
= 1 bar = 15.6 P.S.I.

- under these conditions, any gas will have a volume of 22.414 L according to Avogadro's Hypothesis (all gas particles occupy the same space regardless of particle size)

- therefore at S.T.P. 22.414 L gas = 1 mol gas

eg: determine the volume of oxygen gas at S.T.P.

required to completely combust 18.0 g of C_2H_5OH

$$\underset{18.0\ \text{g}}{C_2H_5OH} + \underset{?\ \text{L}}{3O_2} \rightarrow 2CO_2 + 3H_2O$$

$$18.0\ \text{g}\ C_2H_5OH \times \frac{1\ \text{mol}\ C_2H_5OH}{46.08\ \text{g}\ C_2H_5OH} \times \frac{3\ \text{mol}\ O_2}{1\ \text{mol}\ C_2H_5OH} \times \frac{22.414\ \text{L}\ O_2}{1\ \text{mol}\ O_2} = 26.3\ \text{L}\ O_2$$

Ideal Gas Law Calculations:

- based on good experimental evidence, most gases follow this relationship

$$PV = nRT$$

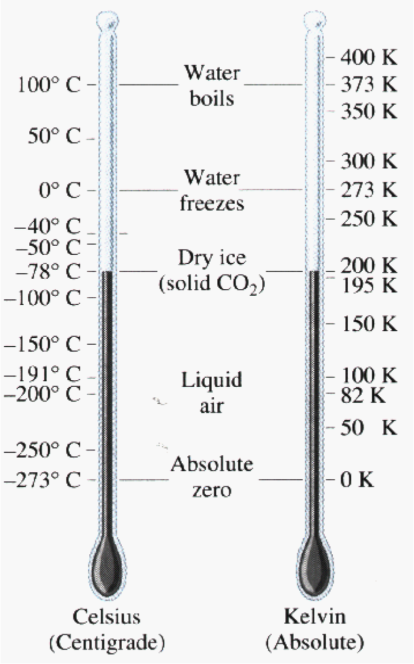
P = pressure (must be in kPa)

V = volume (must be in L)

n = amount (mol)

R = $8.314\ \frac{\text{kPa} \bullet \text{L}}{\text{mol} \bullet \text{K}}$

T = temperature (must be in Kelvin)



to convert between Celsius and Kelvin simply add or subtract 273.15

- Celcius to Kelvin – add 273.15
- Kelvin to Celcius – subtract 273.15

eg Determine the mass of ammonia gas produced from 14.2 L of hydrogen gas at 15.0 atm pressure and 28.0 °C

$$\begin{array}{ccccc} N_2(g) & + & 3H_2(g) & \rightarrow & 2NH_3(g) \\ & & 14.2\text{ L} & & ?\text{ g} \\ & & 15.0\text{ atm} & & \\ & & 28\ ^{\circ}\text{C} & & \end{array}$$

$$P = 15.0\text{ atm} \times \frac{101.325\text{ kPa}}{1\text{ atm}} = 1520\text{ kPa}$$

$V = 14.2$ L

$n = ?$ (mol)

$$R = 8.314\ \frac{\text{kPa} \bullet \text{L}}{\text{mol} \bullet \text{K}}$$

$T = 28\ ^{\circ}\text{C} + 273.15 = 301.15\text{ K}$

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

$$n = \frac{1520\ \text{kPa} \times 14.2\ \text{L}}{8.314\ \frac{\text{kPa} \bullet \text{L}}{\text{mol} \bullet \text{K}} \times 301.15\ \text{K}}$$

$$n = 8.62\ \text{mol}\ H_2$$

$$8.62\ \text{mol}\ H_2 \times \frac{2\ \text{mol}\ NH_3}{3\ \text{mol}\ H_2} \times \frac{17.04\ \text{g}\ NH_3}{1\ \text{mol}\ NH_3} = 97.9\ \text{g}\ NH_3$$