The Ideal Gas Law

- Recall that molar volume is the volume occupied by 1 mole of gas, but is restricted to set conditions for pressure and temperature
- The **Ideal Gas Law** allows us to calculate the amount of gas molecules contained within a certain volume at a certain temperature and pressure
  - The formula for the ideal gas law is as follows:

$$PV = nRT$$ * memorize!

where
- P = pressure in **kPa**
- V = volume in **L**
- n = number of moles in **mol**
- R = universal gas constant (**8.314 kPa•L/mol•K**)
- T = temperature in **K**

} these units are a must!

↑ in data book!

EXAMPLES:

1. A rigid steel vessel with a volume of 2.0L is filled with nitrogen gas to a pressure of 20000kPa at 27.0°C. How many moles of nitrogen gas are in the steel vessel?

$V = 2.0\,L$

$P = 20000\,kPa$

$T = 27.0\,°C + 273.15$

$T = 300.15\,K$

$n = ?$

$PV = nRT$

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

$n = \frac{(20000\,kPa)(2.0\,L)}{(8.314)(300.15\,K)}$

$n = 16.029...\,mol$

$\boxed{n = 16\,mol}$

2. What is the volume of 10.8mol of oxygen gas at 1.30atm and 15.5°C?

$V = ?$

$n = 10.8\,mol$

$P = 1.30\,atm \times \left(\frac{101.325\,kPa}{1\,atm}\right)$

$P = 131.7225\,kPa$

$T = 15.5°C + 273.15$

$T = 288.65\,K$

$PV = nRT$

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

$V = \frac{(10.8\,mol)(8.314)(288.65\,K)}{131.7225\,kPa}$

$V = 196.7638...\,L$

$\boxed{V = 197\,L}$

3. What is the mass of hydrogen (H_2) gas contained in a 4.5L weather balloon at -25°C and 765mmHg?

$m = ?$

$V = 4.5\,L$

$T = -25°C + 273.15$

$T = 248.15\,K$

$P = 765\,mmHg \times \left(\frac{101.325\,kPa}{760\,mmHg}\right)$

$P = 101.9916...\,kPa$

$m = Mn$ (2)

↳ $PV = nRT$ (1)

(1) $PV = nRT \rightarrow n = \frac{PV}{RT}$

$n = \frac{(101.9916...\,kPa)(4.5\,L)}{(8.314)(248.15\,K)}$

$n = 0.2246...\,mol$

(2) $m = Mn = (2.02\,g/mol)(0.2246...\,mol)$

$m = 0.449369...\,g$

$\boxed{m = 0.45\,g}$

4. What is the pressure exerted by 1.55g of methane gas, $CH_{4(g)}$, if it occupies a volume of 200mL at 25.0°C?

$P = ?$

$m = 1.55\,g$

$V = 200\,mL \times \left(\frac{10^{-3}}{1\,mL}\right)$

$V = 0.200\,L$

$T = 25.0°C + 273.15$

$T = 298.15\,K$

$PV = nRT$ ②

$\downarrow$

$m = Mn$ ①

① $m = Mn \rightarrow \frac{m}{M} = n$

$n = \frac{1.55\,g}{16.05\,g/mol} = 0.0965732...\,mol$

② $PV = nRT \rightarrow P = \frac{nRT}{V}$

$P = \frac{(0.0965732...\,mol)(8.314)(298.15\,K)}{(0.200\,L)}$

$P = 1196.9375...\,kPa$

$\boxed{P = 1.20 \times 10^{3}\,kPa}$

Now try Practice Problems

Practice Problems

1. What is the pressure of hydrogen gas when 3.25 mol occupies a volume of 67.5L at a temperature of 295K?

2. What is the volume of 5.65 mol of helium gas at 98kPa and a temperature of 18.0°C?

3. How many moles of ammonia are present in a 250mL container at 25.0°C and 75mmHg?

4. Find the volume of 1.87g of methane gas (CH_4) at 20.0°C and 780mmHg.

5. Find the Celsius temperature of nitrogen gas if a 5.60g samples occupies 2400mL at 3.00atm.

6. A sample of gas with a mass of 0.571g has a volume of 375mL at 99.0kPa and 23.8°C. Find the molar mass of the gas.

Answers:

1. 118 kPa
2. 1.4×10^2 L
3. 1.01×10^{-3} mol
4. 2.73 L
5. 166 °C
6. 38.0g/mol