General Chemistry Standard 9.7

DEFINITIONS

- **Ideal Gas Law:** The equation of state for a gaseous situation
  - It can be used to solve for one unknown variable when three of the following four variables are known:
    - Pressure
    - Volume
    - Temperature
    - Amount (moles)

$PV = nRT$

P = Pressure (Pa)
V = Volume (m^3)
n = Number of moles (mol)
R = Universal Gas Constant (8.31 J/mol K)
T = Temperature (K)

R is a constant – never changes

OTHER VERSION OF THE IDEAL GAS LAW

- Consider the number of moles n equal to the mass of a substance m divided by its molar mass M:

$$n = m / M$$

Now use substitution for n:

$$PV = (m/M)RT$$

Now divide by V and consider that Density d = m / v:

$$P = d (R / M) T$$

EXAMPLE

- How many moles of gas will a 1250 mL flask hold at 35.0°C and a pressure of 95.4 kPa?
  - First, convert the given units to the required units:
    - Pressure in Pa

95.4 kPa	1000 Pa	= 95400 kPa
	1 kPa	

    - Volume in m^3

1250 mL	1 L	1 m_3	= 0.00125 m^3
	1000 mL	1000 L	

    - Temperature in K

      35.0°C + 273 = 308 K

    - Amount (moles)

      Unknown

EXAMPLE CONTINUED

- Now use the five step problem solving method:

Step 1

n = ?
$V = 0.00125 m^3$
P = 95400 Pa
R = 8.31 J/mol K
T = 308 K

Step 2

PV = nRT

Step 3

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

Step 4

$$\frac{95400 \text{ Pa} \times 0.00125 \text{ m}^3}{8.31 \text{ J/mol K} \times 308 \text{ K}} = n$$

Step 5

n = 0.0466 mol

ANOTHER EXAMPLE

- A flask has a volume of 258 mL. A gas with mass 1.475 g is introduced into the flask at a temperature of 302.0 K and a pressure of 9.86×10^4 Pa. Calculate the molecular mass of the gas using the ideal gas equation.
  - First, convert the given units to the required units:
    - Pressure in Pa – 9.86×10^4 Pa
    - Volume in m^3

258 mL	1 L	1 m_3
	1000 mL	1000 L

$= 0.000258\ m^3$

    - Temperature in K – 302.0 K
    - Amount (moles)
      Unknown – but have mass, so use $n = m / M$ and solve for M

ANOTHER EXAMPLE CONTINUED

- Now use the five step problem solving method:

Step 1

M = ?
m = 1.475 g
V = $0.000258 m^3$
P = 9.86×10^4 Pa
R = 8.31 J/mol K
T = 302.0 K

Step 2

PV = (m/M)RT

Step 3

$$\frac{mRT}{PV} = M$$

Step 4

$$\frac{1.475 \times 8.31 \times 302.0}{9.86 \times 10^4 \times 0.000258} = M$$

Step 5

n = 146.0 g/mol

TRY IT YOURSELF

- Hydrogen has a volume of 8.56 L at 0°C and 1.5 atm. Calculate the moles of hydrogen present.

- A gaseous compound has an empirical formula of CH_2. When the gas is at 23°C and 0.990 atm it has a volume of 0.783 L and a mass of 2.23 g. What is the molecular formula of the gas?

TRY IT YOURSELF SOLUTIONS

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  0.57 moles

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  C_5H_{10}