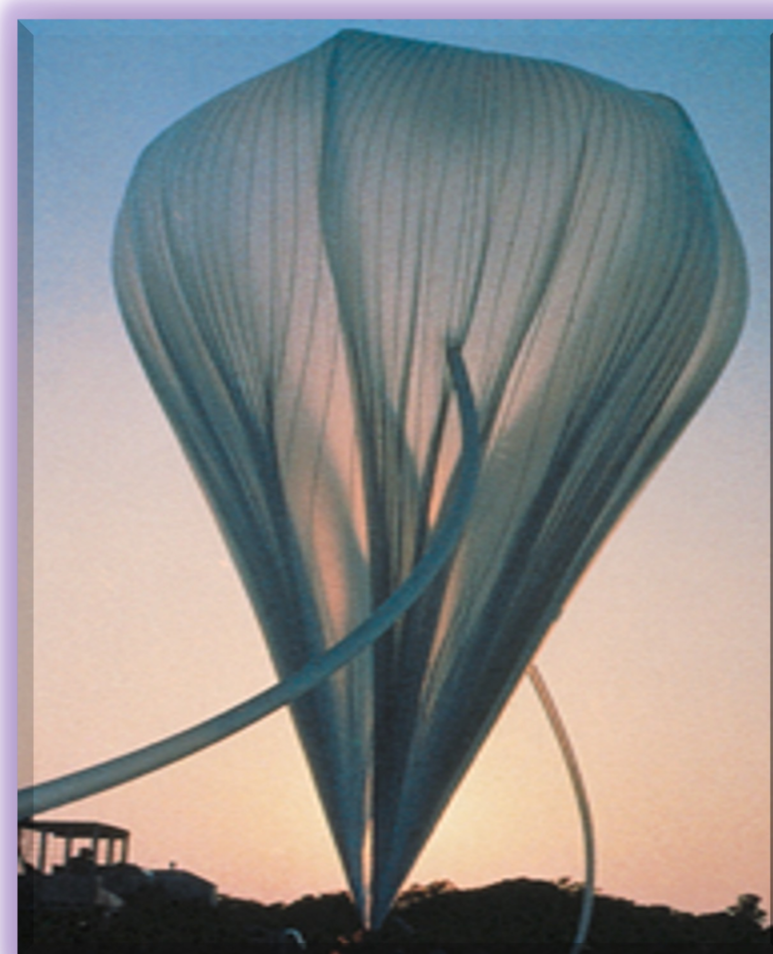
Chapter 4

Gases II

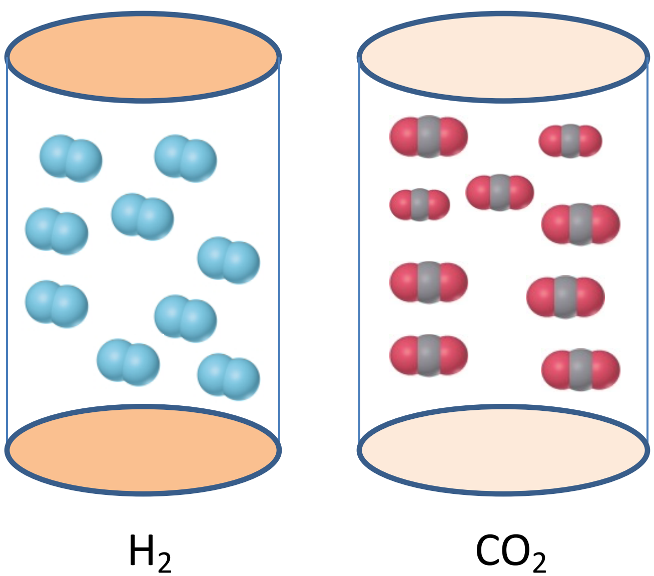
Lecture 7



Gay Lussac's Law
Temperature- Pressure Relationship

- Gay Lussac's law states that "At constant volume, the pressure is directly proportional to the Kelvin temperature

$$\frac{Pressure}{temperature} = constant \quad \text{or} \quad \frac{P_1}{T_1} = \frac{P_2}{T_2}$$



Avogadro's law. Two equal tanks of gas of equal volume at the same temperature and pressure contain the same number of molecules. **V=Cn**

Combined Gas Law

Name	Expression	Constant
Boyle's law	$P_1V_1 = P_2V_2$	T
Charles's law	$\frac{V_1}{T_1} = \frac{V_2}{T_2}$	P
Gay-Lussac's law	$\frac{P_1}{T_1} = \frac{P_2}{T_2}$	V

$$\frac{P_1V_1}{T_1} = \frac{P_2V_2}{T_2}$$

5.4 Ideal Gas Equation

Boyle's law: $V \alpha \frac{1}{P}$ (at constant *n* and *T*)

Charles' law: $V \alpha T$ (at constant *n* and *P*)

Avogadro's law: $V \alpha n$ (at constant *P* and *T*)

$$V \alpha \frac{nT}{P}$$

$$V = \text{constant} \times \frac{nT}{P} = R\frac{nT}{P}$$

R = **gas constant**

$$PV = nRT$$

vii- The Gas Constant

- Repeated experiments show that at standard temperature (273 K) and pressure (1 atm), one mole (n=1) of gas occupies (22.4 L) volume. Using this experimental value, you can evaluate the gas constant R,

$$R = \frac{P\,V}{n\,T} = \frac{1\text{ atm}\;\;22.4\text{ L}}{1\text{ mol}\;\;273\text{ K}}$$

$$= 0.0821\text{ L.atm / (mol.K)}$$

- One mole of CH_4 gas occupies 20.0 L at 1.00 atm pressure. What is the temperature of the gas in Kelvin?
- Solution:

$$PV = nRT$$

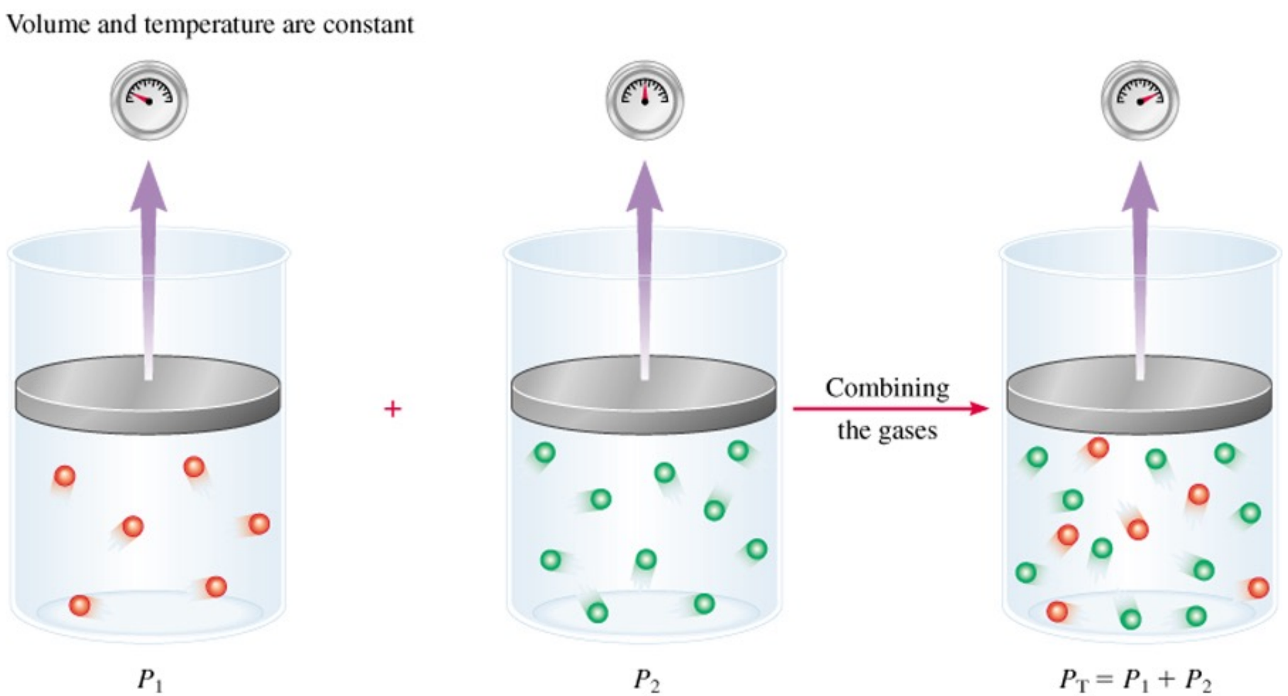
$$T = \frac{PV}{nR} = \frac{(1.00\,atm)(20.0\,L)}{(1.00\,mol)(0.0821\,L.atm.mol^{-1}K^{-1})} = 244\,K$$

- If there is 5.0 g of CO_2 gas in a 10 L cylinder at 350 K, what is the pressure of the gas in atm?

- Solution

$$?\,mol = 5.0\,g\,CO_2 \times \frac{1\,mol\,CO_2}{44\,g\,CO_2} = 0.114\,mol\,CO_2$$

5.5 Dalton's Law

- "The total pressure of a gas mixture is the sum of the partial pressure of each gas
- Partial pressure: $P_{total} = P_1 + P_2 + \ldots$
- "It is the pressure of a single gas in the mixture as if that gas alone occupied the container."
- 

Example: to a tank containing N_2 at 2.0 atm and O_2 at 1.0 atm we add an unknown quantity of CO_2 until the total pressure in the tank is 4.6 atm. What is the partial pressure of CO_2?

Solution:

4.6 atm	=	**2.0 atm**	+	**1.0 atm**	+	**1.6 atm**
Total pressure		**Partial pressure of N_2**		**Partial pressure of O_2**		**Partial pressure of CO_2**

Problem -1 ***Ideal Gas Equation*** H.W

What is the volume of a gas balloon filled with 4.00 moles of He when the atmospheric pressure is 748 torr and the temperature is 30.°C? R= 0.082 L.atm/mol.K

n =4 moles

P= 748 torr /760 = atm

T= 30.°C + 273 K

$$P V = n RT$$

Problem -2

H.W

A helium-filled weather balloon has a volume of 7240 cubic feet. How many grams of helium would be required to inflate this balloon to a pressure of 745 torr at 21°C? (1 ft^3=28.3 L)

Solution

P V = n RT , n = PV/RT , $\frac{m}{M} = \frac{PV}{RT}$, m = $\frac{PVM}{RT}$

R= 0.082 L.atm/mol.K

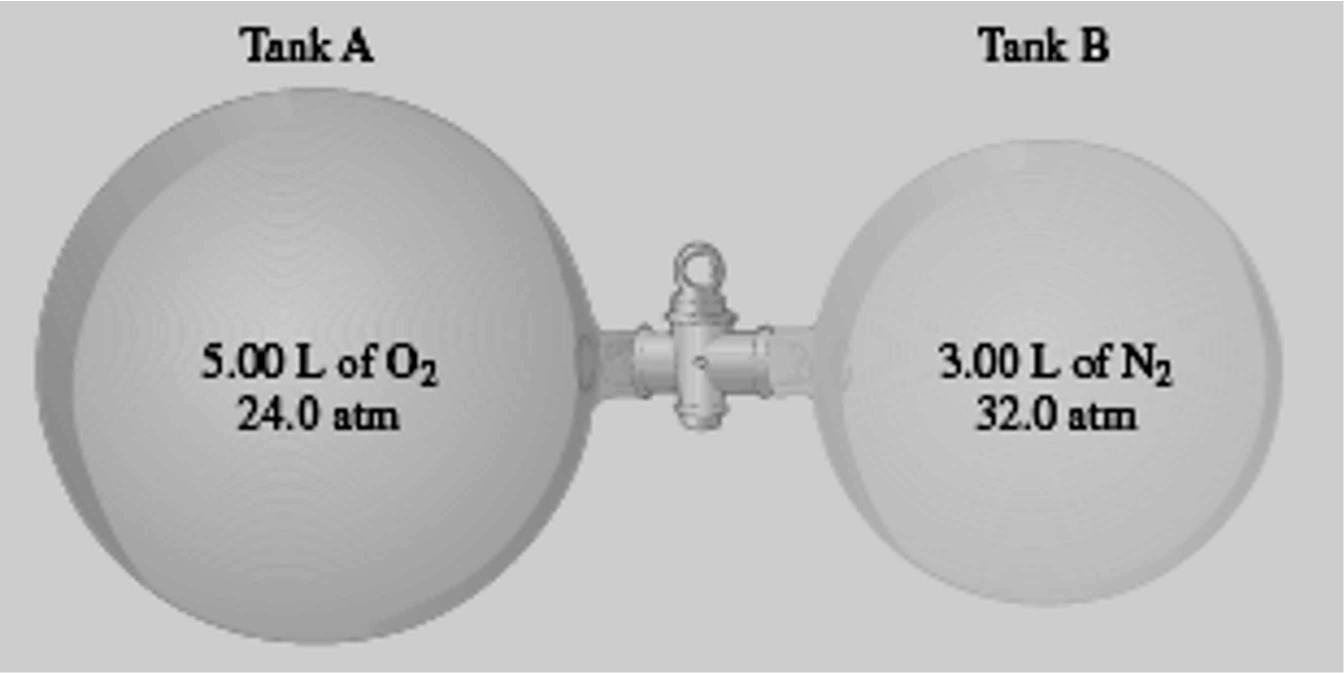
m=$\frac{PVM}{RT}$

$$m = \frac{0.980 \text{ atm} \times 204892 \text{ L} \times 4g/mol}{0.082 \text{ L.atm/mol.K} \times 294K}$$

m= 33315.77 g

Problem -3 H.W

Two tanks are connected by a closed valve. Each tank is filled with gas as shown, and both tanks are held at the same temperature. We open the valve and allow the gases to mix. After the gases mix, what is the partial pressure of each gas, and what is the total pressure?



Solution

(a) For O_2,

$$P_1V_1 = P_2V_2 \quad \text{or} \quad P_{2,O_2} = \frac{P_1V_1}{V_2} = \frac{24.0\text{ atm} \times 5.00\text{ L}}{8.00\text{ L}} = 15.0\text{ atm}$$

For N_2,

$$P_1V_1 = P_2V_2 \quad \text{or} \quad P_{2,N_2} = \frac{P_1V_1}{V_2} = \frac{32.0\text{ atm} \times 3.00\text{ L}}{8.00\text{ L}} = 12.0\text{ atm}$$

The total pressure is the sum of the partial pressures.

$$P_{total} = P_{2,O_2} + P_{2,N_2} = 15.0\text{ atm} + 12.0\text{ atm} = 27.0\text{ atm}$$

Problem -4

A 120.-mL flask contained 0.345 gram of a gaseous compound at 100.°C and 1.00 atm pressure. What is the molecular weight of the compound?

$PV = nRT \qquad n = PV/RT \qquad m/M = PV/RT$

$M/m = RT/PV \qquad M = RTm/PV \qquad R = 0.082$ L.atm/mol.K

$$M = \frac{0.082\ L.atm\ X(100+273.K).345\ g}{mol.K X 1.00 atm\ X 0.120 L} = \qquad \frac{g}{mol}$$