VAPOUR PRESSURE and DALTON'S LAW OF PARTIAL PRESSURES

- John Dalton performed many experiments to analyze the atmosphere. Many of his experiments involved measuring the water content of air- "humidity".

- Dalton found that when water was placed in a closed container, some of the water evaporated to form water vapour, and that the *water vapour exerted a pressure on the container*.

- This pressure is known as the **vapour pressure** of water.

- At any given pressure and temperature, only a certain proportion of liquid will evaporate AND the air above a liquid is said to be saturated when it can no longer hold any more vapour.

- This maximum value of vapour pressure, called the **saturated vapour pressure** changes with temperature.

$$\textbf{Relative humidity} = \frac{\text{actual vapour pressure}}{\text{saturated vapour pressure}} \times 100\%$$

- Solids also exert a vapour pressure: "The case of the vanishing ice cubes".

- in a closed system, liquids evaporate until the air above the liquid is saturated, where as in an open system, liquids continuously evaporate until the liquid is all gone.

Boiling point of a liquid

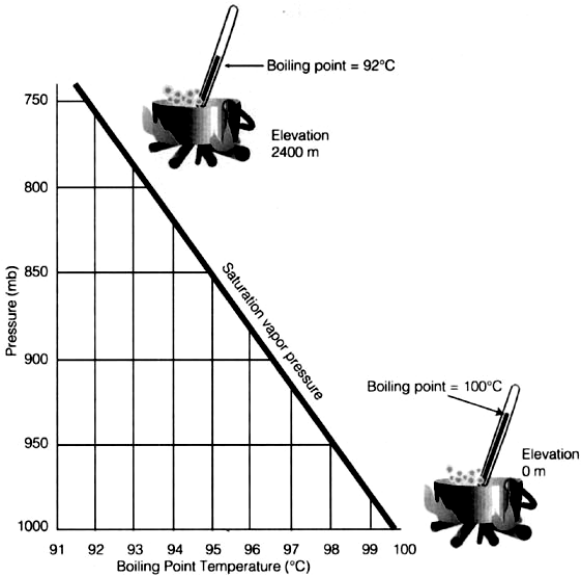
- All liquids exert a vapour pressure which increases with an increase in temperature.

- When vapour pressure reaches external pressure, the liquid begins to boil. The temperature at which this occurs is called the **boiling point** of the liquid.

Boiling point of a liquid is the temperature at which its vapour pressure equals the external pressure (atmospheric pressure).

Note: (atmospheric pressure varies with location).

- Thus, the temperature that water boils at depends on the atmospheric pressure.



►Atop Mount Everest atmospheric pressure is 34 kPa. The vapour pressure of water will reach 34 kPa at about 70°C.

►at sea level atmospheric pressure is 101 kPa. The vapour pressure of water will reach 101 kPa at about 100°C.

DALTON'S LAW OF PARTIAL PRESSURES

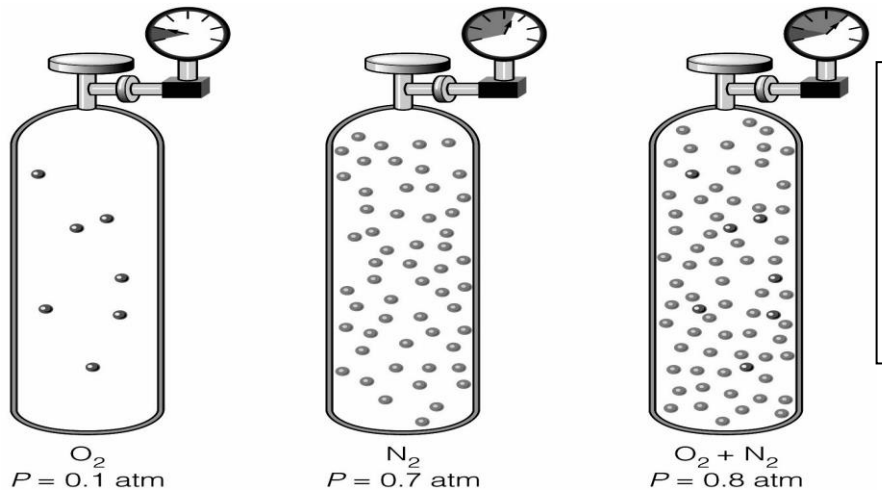
- Dalton measured the pressure of different samples of air varying in humidity.
- Dalton hypothesized that gas particles behaved independently and, that the pressure exerted by a particular gas particle is the same whether it is by itself or is part a mixture of gases(if temperature is constant)
- Dalton's Analysis of Gases in the Atmosphere

Chemical name of the component		Pressure		Composition
Dalton	IUPAC	(mm Hg)	(kPa)	%
azotic gas	nitrogen	593.3	79.11	78.08
oxygenous gas	Oxygen	157	20.9	20.95
aqueous vapour	Water	11	1.5	varies
carbonic acid gas	carbon dioxide	0.5	0.07	0.04

- He concluded that *"the total pressure of a mixture of gases is the sum of the pressures of each of the individual gases".*

Dalton's Law of Partial Pressure-the total pressure of a mixture of non-reacting gases is equal to the sum of the partial pressures of the component gases.

$$P_{total} = P_1 + P_2 + P_3 + \ldots + P_n$$



$P_{total} = P_{O2} + P_{N2}$

P_{total} = 0.1 atm + 0.7 atm

P_{total} = 0.8 atm.

- **<u>Partial pressure</u>** is the pressure (P) that a gas in a mixture would exert if it were the only gas present in the same volume and at the same temperature

- When the law of partial pressures is combined with the ideal gas law, chemists can relate the pressures of a gas mixture to their molar composition.

$$PV = nRT \quad \text{becomes} \quad P_{total}V = n_{total}RT \quad \text{or} \quad P_AV = n_ART$$

Dividing one expression into the other (1), & then simplifying (2) and rearranging (3):

1. $\dfrac{P_AV}{P_{total}V} = \dfrac{n_ART}{n_{total}RT}$ 2. $\dfrac{P_A}{P_{total}} = \dfrac{n_A}{n_{total}}$ 3. $P_A = P_{total}\dfrac{n_A}{n_{total}}$

Sample Problem 1

In a compressed air tank for scuba diving to a depth of 30m, a mixture with an oxygen partial pressure of 28 atm and a nitrogen partial pressure of 110 atm is used. What is the total pressure in the tank?

Given: P_{O2}=28 atm
P_{N2}=110 atm
P_{TOTAL}= ?

Plan: $P_{TOTAL} = P_{O2} + P_{N2}$

Solution: P_{TOTAL} = 28 atm + 110 atm
P_{TOTAL} = 138 atm

Paraphrase: Therefore, the total pressure in the tank is 138 atm.

- Dalton's Law of Partial Pressure can be explained by 2 concepts of KMT;
  1. the pressure of a gas is caused by collisions of molecules with the walls of the container.
  2. gas molecules act independently of each other

Sample Problem 2

A vessel contains 1.25 mol of oxygen gas, O_2, 0.50 mol of nitrogen gas, N_2, and 0.25 mol of carbon dioxide gas, CO_2. The total pressure in the vessel is 300 kPa. What is the partial pressure (in kPa) exerted by the nitrogen gas in the mixture? (A: 75 kPa)