Chapter from Chemistry 7

States of matter. Gaseous state. General gaseous laws. Dalton´s Law of partial pressure. Liquid state. Vapor pressure .Water as solvent. Noncovalent bonds. Boiling point . Surface tension. Solid state. Melting point. Sublimation.

Illustration : Breathing at High Altitudes. Cooking at High Altitudes. Surfactant Replacement Therapy for Preterm Babies

1. Gaseous State

If we need to define the physical state of any gas we use four properties : pressure, temperature, volume, and amount. All gases follow a small number of laws.

Pressure is defined as force per unit area. Air is matter so it has mass, and like anything with mass it is subject to the earth´s gravitation atmospheric pressure. The force per unit area exerted by any mass is called **pressure**.

The units : 1 atm. = 760 mm Hg=760 torr ; 1 Pa = $N.m^{-2}$; 1 atm= 101.325, 024 Pa tj. 101,325 kPa. Standard pressure is then 101 kPa.

The volume of a gas varies inversely with its pressure at constant temperature. (Boyle´s law). pV = const.

Hypothetical gas is called ideal gas. **Ideal gas** follows the gas laws exactly.

Gas volume varies directly with the Kelvin temperature at constant pressure. (Charles´ law). V/T = const.

Gas pressure varies directly with Kelvin temperature, if the volume is kept constant.

The general gas law : If gases are under conditions in which they obey the gas laws, a remarkable relationship exists. The ratio of pV to T for a given amount of gas is itself a constant :

$$pV/T = \text{constant} \quad .... p_1V_1/T_1 = p_2V_2/T_2$$

This constant is universal gas constant, R.

Under same pressure and temperature, equal volumes of gases contain the same number of moles. **Avogadro´s Principle** :

Equal volumes of gas contain equal numbers of moles when we measured at the same temperature and pressure. At 273 K and 1 atm, one mole of gas occupies **22,4 L - standard molar volume.**

The ratio pV/nT = is same for all gases – **R universal gas constant**.

Universal Gas Law :

$$pV = nRT$$

If you choose the units V=22.4L, n=1, T=273K and P=1.00 atm, then units for R (Universal gas constant) will be

$$R = 0.0821 \text{ L.atm.mol}^{-1} \text{ K}^{-1}$$

Dalton´s Law of Partial Pressure :
The total pressure exerted by a mixture of gases is the sum of their individual partial pressure.
The molecular basis of respiration begins with air, a mixture principally of nitrogen and oxygen but with small traces of another gases. In 100 L of dry air there are 21L of oxygen and 79L of nitrogen. These proportions are true at all altitudes of the earth´s atmosphere. Actually the ratio of oxygen to nitrogen is not changed , but individual pressures - their **partial pressures**. are changed.
The partial pressure of one particular gas in a gas mixture is the contribution that the gas makes to the total pressure. When dry air at 0°C is at a total pressure of 760 mm Hg, the partial pressure of oxygen is 160 mm Hg and nitrogen 600 mm Hg.
Dalton´s law : The total pressure exerted by a mixture of gases is the sum of their individual partial pressures
$P_{total} = P_a + P_b + P_c + \text{etc.}$

Illustration : Breathing at high altitude
At an altitude of 5.5 km, the total pressure is one half as much, 380 mm Hg, and so the partial pressure f oxygen is also one half of its partial pressure, that is 80 mm of Hg. For lung of most people, the partial pressure of oxygen 80 mm Hg in air is not enough to press atmospheric oxygen out of the lungs and into bloodstream for transfer to the peripheral tissue (altitude sickness). Then it is necessary to take oxygen-enriched air or prompt return to low altitude.

The air we exhale includes water vapor and carbon dioxide, too.
The air we inhale is not dry air but it contains small portion of water vapor (5 mm Hg). In the moist environment of alveoli the content of water vapor increases and we exhale about 47 mm Hg partial pressure of water vapor. Carbon dioxide is a gaseous waste product of metabolism and is removed from the blood at the lungs and transferred to the air by exhaling.

Diffusion : A physical process whereby particles, by random motions, pass from the regions of higher concentration to the regions of lower concentration (concentration gradient).

2. Liquid State

Molecules in liquids experience attractions for each other but retain the freedom to move about. The **polar substances** are more likely to be **liquids** than those nonpolar compounds.

Permanent dipoles. Dipole-dipole attraction.

London forces of attraction are between nonpolar molecules. Like charges repel. Temporary polarity. Temporary dipole.

Boiling point is an excellent indication of the attractive forces in molecules. This is the point (temperature) when the atmospheric pressure over the liquid is the same like pressure of vapour in the liquid. A high boiling point indicates relatively large forces of attraction, which must be overcome. Substances with big atoms or molecules have large electron clouds, and therefore have greater London forces, so the higher the formula mass, the higher the boiling point.

Evaporation : the conversion of a substance from its liquid to its vapor state.

Condensation : the physical change of a substance from its gaseous state to its liquid state.

When a dynamic process reaches a steady state in which opposing changes occur at identical rates, no further net change takes place, **dynamic equilibrium** exists for the system:

$$\text{water (l)} \leftrightarrow \text{water (g)}$$

At equilibrium between its liquid and vapor states, each liquid has an equilibrium vapor pressure. These pressures increase for a given liquid with temperature.

Liquids with high vapor pressures even at low temperatures are named **volatile** liquids (ether). Liquids with low vapor pressures at room temperatures are called **nonvolatile** (acetic acid).

Liquid boils when its vapor pressure equals the external pressure. The temperature at which a liquid´s equilibrium vapor pressure equals 760 mm Hg is called **normal boiling point.**

Illustration : Cooking at high altitude

Where the atmospheric pressure is lower then that at the sea level, water boils at a lower temperature. The chemical reactions in cooking are endothermic, therefore they do not occur so fast at a lower temperature (boiling point at high altitude is lower - liquid boils in lower temperature- as a consequence lower pressure) as they do at 100°C. They do need longer time for obtaining of needed heat for cooking.

The physical properties of water are strongly affected by its polarity and the hydrogen bonds between its molecules.