Chemistry

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1 Radioactivity

1.1 Definition

Radioactivity is a set of physical-nuclear processes through which some unstable or radioactive atomic nuclei decay, in a certain period of time called decay time.

An unstable nuclei will keep emitting radiations and transmuting to other nuclei until the atom is stable.

1.2 Decay

The mass of a radioactive material will decrease exponentially.

$$M(t) = M_0 \cdot e^{-kt}$$

$M(t)$ is the mass (or number or particles) after a certain time t. M_0 is the initial mass and k is the rate of decay.

1.3 Half-life

The time of half-life is given by $t_{\frac{1}{2}} = \frac{\ln 2}{k}$.

$$\begin{aligned} \frac{1}{2}M_0 &= M_0 e^{-kt} \\ \frac{1}{2} &= e^{-kt} \\ \ln\left(\frac{1}{2}\right) &= -kt \\ t &= \frac{\ln 2}{k} \end{aligned}$$

1.4 Types of radiations

There are three types of radiations that can be emitted by an unstable nucleai.

α particles An α particle is a helium nuclei. For example

$$^{238}_{92}\mathrm{U} \longrightarrow {}^{4}_{2}\alpha + {}^{234}_{90}\mathrm{Th}$$

β particles There are two types of β particles. β^+ and β^-. A β^+ particle is emitted when the nuclei is unstable due to having too many protons, whist the β^- one is emitted when it has too many neutrons.

$$\begin{cases} \beta^+, & {}^{0}_{+1}\mathrm{e} \text{ (positron)} \\ \beta^-, & {}^{0}_{-1}\mathrm{e} \text{ (electron)} \end{cases}$$

γ particles γ rays are photons of electromagnetic energy. They have 0 mass and 0 charge.

2 Energy levels

An electron is a fundamental particle. It is attracted by protons in the atom nuclei but they repelled by one another. The places where the electrons are found around the nuclei are called *atomic orbitals.* There are two types of orbitals, **s** and **p**. Electrons in **s** orbitals can be measured to be in a spherical region around the nuclei, whilst electrons in **p** orbitals have a dumbell-shaped position region (zero-probability of being measured at the center of the nuclei). An orbital can host up to two electrons. Orbitals are grouped in different zones. Eletrons in zones closer to the center have lower energy and the amount of energy to move an electron from its zone to the next one is constant.

At the lower energy there is a single 1s orbital that can hold two electrons. At the next energy level, there are four orbitals: 2s, 2p1, 2p2 and 2s3 for up to 8 electrons at this level of energy. In larger atoms electrons can be found at the level 3s and 3p

Atoms where the level with most energy is not completly empty or completly full is unstable. The excess electorns are called valence electrons. An atom may share, give or take electrons with other atoms to become stable.

2.1 Ionic bond

An ionic bond is a transfer of valence electrons between metallic atoms and non-metallic atoms. The outcome of this process is a positive ion (more protons than electrons) and a negative ion (more electrons than protons). These ions attract each other often forming a crystal structure.

2.2 Metallic bond

A metallic bond is a transfer of valence electrons between metallic atoms. The valence electrons continually move from one atom to another and are not associated with any specific pair of atoms. This creates a structure of positive ions which conducts electricity (since electrons can freely move).

2.3 Covalent bond

A covalent bond is a sharing of pairs of electrons between non-metallic atoms. A covalent bond happens just between two atoms, it can be simple, double or triple (2, 4, 6 total shared electrons).

2.4 Electronegativity

Electronegativity is a measure of an atom's ability to attract shared electrons to itself. The type of bond if given by the different of electronegativity between two atoms.

- 0 - 0.4: Pure covalent bond
- 0.4 - 1.7: Polar covalent bond
- 1.7 -: Ionic bond

3 Acids

The pH level is a measure of the acidity or alkalinity of a solution. It is a logarithmic scale that ranges from 0 to 14, with 7 being considered neutral. A pH value below 7 indicates acidity, while a pH value above 7 indicates alkalinity.

The pH scale is based on the concentration of hydrogen ions (H^+) in a solution. An acidic solution has a higher concentration of H^+ ions, while an alkaline solution has a lower concentration of H^+ ions. The pH scale is logarithmic..

OH stands for hydroxide ion, which is a negatively charged molecule consisting of one oxygen atom and one hydrogen atom. It is the conjugate base of water (H_2O) and plays a role in determining the pH level of a solution. The concentration of OH^- ions in a solution is directly related to its alkalinity, as the higher the concentration of OH^- ions, the more alkaline the solution is.

$$\begin{aligned} \text{pH} &= -\log_{10}(\text{H}^+) \\ \text{pOH} &= -\log_{10}(\text{OH}^-) \\ \text{pH} + \text{pOH} &= 14 \end{aligned}$$

4 Redox

4.1 Definition

Redox (reduction-oxidation) reactions are a chemical reaction in which electrons are transferred between two reactants participating in it. A redox reaction involves a change in the oxidation state of one or more atoms. Whoever loses electrons is oxidized, whilst whoever gains electrons is reduced.

4.2 Oxidation State

The oxidation state or odixation number of an atom in a molecule represents its ability to lose or gain electrons in a chemical reaction. In a neutral molecule, the sum of the oxidation states of all atoms is always equal to zero. This means that the sum of the electrons lost by some atoms is equal to the sum of the electrons gained by other atoms.

1. Individual elements always have an oxidation number of 0.
2. Monoatomic ions always have an oxidation number of 0.
3. Hydrogen (*almost*) always has an oxidation number of $+1$.
4. Oxygen (*almost*) always has an oxidation number of -2.

If the oxidation state increases, the molecule oxidises (loses electrons).
If the oxidation state decreases, the molecule reduces (gains electrons).

4.3 Spontaneous reactions

A reaction is *spontaneous* if it proceeds spontaneously.