Nuclear chemistry and Application of Radioactivity

Nuclear reaction:-

It is a types of reaction, in which nuclei of reacting substances get to transform into the nucleous of another element. It is also called nuclear transformation.

Nuclear chemistry is the study of nuclear reactions ~~involving~~ and their uses.

Radioactivity:-

The phenomenon of spontaneous emission of invisible radiation with transmutation of one element to another is called radioactivity. The term radioactivity was first used by Marie Curie.

+ Radioactive substances.

The substanie which emit invisible radiations α, β and γ are called radioactive substanies and thus emitted radiations are called radioactive rays.

e.g. - Uranium, plutonium, radium. etc

- α, β and γ rays:-

→ Rutherford ~~(Es)~~ classified the raeliation emitted by radioactive substanie ~~Pitchblend~~

e.g. pitchblende (U_3O_8), by doing experiment
In this experiment pitchblende in a lead box with a small hole at top and radiation is given, the radioactive sample was passed through oppositely charged plates. and then,

i) When radiations bent towards the negative plate are positively charged rays are called ∝ alpha (α or ^4_2He) rays.

ii) When radiations bent towards positive plate (anode) are negatively charged rays are ~~gamma~~ Beta (β) rays.

iii) When the third type of radiations remain undeflected but pass straight forward are neutral called gamma (γ) rays.

Types of Radioactivity

There are two types of radioactivity.

(a) Natural radioactivity.
(b) Artificial or induced radioactivity

(a)- Natural radioactivity:

The activity of naturally occurring unstable radioactive isotopes undergo

spontaneous disintegration resulting in the formation of smaller nuclei of another element with emission of radiations are called natural radioactivity. It occurs mostly in isotopes having greater than 83 atomic number. and in some lighter nuclei (~~eg 6 etc~~). heavier nuclei are, uranium throium, radium etc. and smaller nuclei are $^{14}_{6}C$, $^{14}_{7}N$ etc.

~~Radioactive~~ Nuclear reaction is;

For heavier nuclei

$$^{238}_{92}U \longrightarrow {}^{234}_{90}Th + \alpha\text{ particle}\left(^{4}_{2}He^{2+}\right)$$

For lighter nuclei

$$^{14}_{6}C \longrightarrow {}^{14}_{7}N + \beta.$$

⑤ Artificial radioactivity :-

The activity of conversion of stable nuclei into unstable nuclei by bombardment ~~of high~~ of high speed particles like α-particles, β-particles, protons, etc ~~is known as ar~~ artificially is known as artifical radioactivity. The artificial isotopes has a certain limit and has short half life.

$$^{23}_{11}Na + {}^{4}_{2}He \longrightarrow [{}^{27}_{13}Al] \longrightarrow {}^{26}_{12}Mg + {}^{1}_{1}H$$

α-particle — Unstable, short half life — stable.

$\beta-$ 3

Difference between ~~radi~~ Artifical and Natural radioactivity.

Natural radioactivity	Artifical Radioactivity
I) It involves self-disint-egration of unstable nuclei with emission of the radiation.	I) It involves the striking of stable nuclei with high energy particles to produce radioactive elements.
II) It cannot be controlled.	II) It can be controlled by controlling bombarding particle.
III) Heavy elements undergo such process.	III) Lighter particle are carried for such process.
IV) It have long half-life periods	V) It have short-half life periods.

Unit of radioactivity.

The SI unit of radioactivity is Becquerel (Bq). other units are Curie (Ci). One curie (Ci) is defined as the quantity of any substance which produces 3.7×10^{10} disintegration per second (dps)

1 mili Curie (mC) = 3.7×10^{7} dps.

1 Becquerel = 1 disintegration/sec (dps)

Nuclear Reactions (Nuclear Transmutation)

Nuclear reactions are the process of conversion of one element into another elements either spontaneously or as a result of bombardment or a ray.

There are two types of nuclear reactions.

ⓐ Nuclear fission reaction

ⓑ Nuclear fusion reaction.

→ ⓐ Nuclear fission reaction

In the process of breaking (splitting) a heavy nucleus into two or more lighter nuclei of almost equal size (comparable masses) with liberation of large amount of energy is called Nuclear fission reaction. eg.

Splitting of $^{235}_{92}U$ by hitting neutrons ($_0n^1$)

$$^{235}_{92}U + {}_0n^1 \longrightarrow [^{236}_{92}U^*] \rightarrow {}^{141}_{56}Ba + {}^{92}_{36}Kr + 3\,{}_0n^1 + \text{Energy}$$

$^{235}_{92}U$ = isotopes of uranium.

ⓑ ~~Nuclear fusion reaction~~:

The fission of uranium atom may hit

another uranium atom and cause their more fission. Neutrons are produced during the reactions that hit the new uranium atom, to ~~init~~ continue the rxn.

(b) Nuclear fusion reaction.

The process of combining two or more light nuclei to form a stable nucleus with release of large amount of energy is called nuclear fusion reaction.

$$_1^2H + _1^3H \longrightarrow _2^4He + _0^1n + 17.6\ Mev.$$

deuterium tritium. α

deuterium and tritium combine to form Helium nucleus and energy, sub atomic particle such as neutron or protons also produced.

Nuclear fusion reaction requires high ~~energy~~ temperature, so it is also known as thermo nuclear reactions.

some other examples.

$$_1^2H + _1^2H \longrightarrow _2^4He + 23.84\ Mev.$$

$$_1H^2 + _1H^2 \longrightarrow _2^3He + _0n^1 + 3.25\ Mev.$$

~~Nuclear~~

Difference between Nuclear fusion and Nuclear fission reactions:

Nuclear fission	Nuclear fusion
1) A heavy Nucleus splits into two or lighter nuclei	1) Two or lighter nuclei combine to form heavy nucleus.
2). This process is carried out at room temperature.	2). This process is carried out at high temperature.
3). It is a chain reaction.	3). It is not chain reaction.
4). This process can be controlled and energy released can be used	4). fusion process cannot be controlled, and energy released is diffult to use.

Nuclear power and nuclear weapons.

→ Nuclear power:-

Nuclear power is the use of nuclear reactions to produce electricity. It is obtained from nuclear fission ~~and nuclear fusion~~ reactions. of uranium and plutonium atoms. In nuclear power plants. It is efficient way of boiling water to make steam. which turns turbine to produce electricity.

The uranium atoms is fed in a nuclear reactor and allowed to react. A single uranium pellet, slightly larger than a pencil eraser, contains the same energy as a ton of coal, or 17000 cubic feet of natural gas.

- Nuclear explosion can be used for civil engineering such as dam, roads construction etc.

→ # Nuclear weapons:-

- Nuclear weapon is an explosive devices designed to produce energy from nuclear either fission, ~~fission~~ or nuclear fusion or a combination of both. Atomic bomb is a type of nuclear weapons due to nuclear fission reaction (uncontrolled nuclear fission)

Explosion of atomic bomb ~~are~~ explosion are destructive, sudden rise in temperature of air, combustion of materials, intense radiation ~~and~~ etc. It was ~~used on~~ exploded on Japan by ~~US~~ united state.

Hydrogen bomb is a nuclear weapon ~~by~~ based on nuclear fusion reaction. It is also called thermonuclear ~~bomb~~. bomb. because it produces a large temperature.

Industrial Application of radioactivity.

Most industrial application are as follows.

1). ~~power~~ It is used to power generation based on release of the fission energy of uranium.

2). ~~The~~ In industry ~~It is~~ radioisotopes are used to measure the thickness or density of metal/plastic sheets;

3). ~~Radioisotopes~~ It is used to preserve certain kinds of foods by killing microorganism that cause spoilage.

4). It is used to induce mutations in plants to develop hardier species.

Medical uses of radioactivity.

The medical uses of radioisotopes divided mainly into two parts.

(a) ~~Diag~~ Diagnosis:

(b) Medical therapy.

(a) Diagnosis:- Radioisotopes are used in diagnosis.

1). Iron-59 is used to study the deficiency of red blood cells (anemia)

2) Iodine-131 helps to dected disorder of thyroid glands and locate the position of tumors.

(5) Sodium-24 is used in studying blood pumping action of the heart.

(6) In therapy:
radioisotopes are used in therapy in following ways.

1). Iodine-131 (β-emitter) is used to destroy tumor cells on thyroid gland.

2). Cobalt-60 (γ-emitter) used to treating various forms of cancer by radiation therapy.

3). ~~Gold~~ Gold-198 is used to cure blood cancer.

Nuclear isotopes:-

Isotopes of radioactive elements are called nuclear isotopes or radioisotopes. The chemical properties of radioisotopes is same but differ only in their mass number.

Some common isotopes.

- Iodine-131
- phosphorus-32
- carbon-14
- cobalt-60 etc.

Radio carbon dating:-

The determination of the age of the archeological objects like wood plants or animals fossils radio carbon dating is used. $^{14}_{6}C$ - isotope is used for dating.

All plants use CO_2, a portion of the carbon in plants is radioactive therefore plants are slightly radioactive. since C-14 is produced on atmosphere as $^{14}CO_2$. There is one atom of ^{14}C for every 7.69×10^{11} carbon atom in the $^{12}CO_2$ of air in plants and animals. So the ratio of $^{14}C/^{12}C$ remains constant. The age of dead sample is find by

$$\text{dead of sample} = \frac{2.30}{\lambda} \log \frac{\left[{}^{14}_{6}C\right]/\left[{}^{12}_{6}C\right]_{\text{in living body}}}{\left[{}^{14}_{6}C\right]/\left[{}^{12}_{6}C\right]_{\text{in dead body.}}}$$