RADIOPHARMACEUTICALS

- All matters are made up of molecules which are formed by bonding of atoms of different or same element.
- Atom consists of nucleus and electrons distributed around the nucleus in different orbitals.
- The electrons have negligible mass and negative charge
- The nucleus contains positively charged protons, neutral neutrons and other subatomic particles.
- An atom have an equal number of protons and electrons.
- The atomic number of an element is the no. of protons (Z) (or) no. of electrons in a neutral atom.
- The mass number of an element (A) represents the total number of protons (Z) and neutrons (N)
- Therefore $A=Z+N$ or $N=A-Z$

Isotopes

- Atoms having the same atomic number but different mass numbers are called isotopes
- Eg. Hydrogen (1H1) and Deuterium (2H1)
- Iodine 127, iodine 131 both have the atomic number of 54, but the mass numbers are different 127 and 131. This is due to the difference in the number of neutrons.
- 127I contains 73 neutrons (127-54)
- 131I contains 77 neutrons (131-54)
- Therefore 131I54 is an isotope of 127I54

Radio Isotopes

The isotopes which exhibits radio activity is called radio isotopes.

Eg. Uranium 234, Uranium 235

Isobars

- Atoms having the same mass number but different atomic numbers are called isobars.
- Eg. Potassiun 40 and calcium 40 both have the mass number of 40, but the atomic numbers are different 19 and 20.

Isotones

v Atoms having the same number of neutrons but different atomic number

v Eg. Carbon 13 and nitrogen 14 both have the difference atomic number 6 and 7

RADIOACTIVITY

The atoms of heavy elements such as uranium and thorium are unstable. In their nucleus the neutron and proton ratio is high.

Atoms which have almost the same number of neutrons and protons are stable.

But the nucleus of elements like uranium-235 emits some particles such as the alpha or beta particles and also gives out some radiation like the alpha-rays in order to attain stability. This is known as radioactivity.

v It undergoes spontaneous transformation from one kind of atom to another kind until it reaches the stable neutron and proton ratio.

v The spontaneous breaking down of the unstable atom is known as radioactive disintegration or radioactive decay

v Certain substances like polonium and radium emit invisible rays which affect photographic plate, ionize gases, penetrate solid matter and produce flashes in substance like ZnSO4 these rays are called radioactive rays. The phenomenon is called radio activity.

v The substances which possess the property of emit such rays are called radioactive substances on nuclides.

Types of Radiations:

v The radiations emitted due to radioactive are of three types.

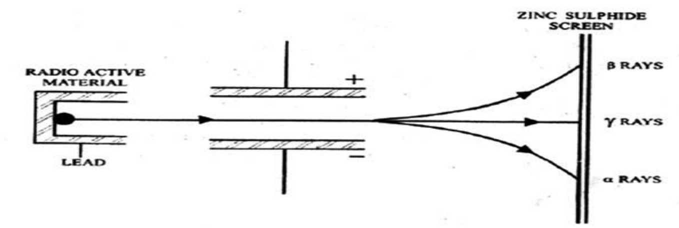
v They can be easily separated by passing them between oppositely charged plates.

v The radiation which bends towards the negatively charged plate must itself be positively charged and is known as alpha rays.

v That which bends towards the positively charged plate is obviously negatively charged itself and is known as beta rays.

v The third one which does not bend towards either the positively charged plate or the negatively charged plate but passes straight through is uncharged and is known as gamma rays.

Alpha Rays:



v Alpha rays consist of streams of alpha particles.

v They have two positive charges. So they are helium nuclei and may be represented as 24He. They are usually emitted having atomic number greater than 82.

v They have very high velocity about one-tenth of light.

v Penetrating power through matter is very low.

v They can be stopped even by a sheet of paper.

v They have capacity to cause intense ionization in gas molecules through which they pass high ionizing power.

v This means that alpha rays, because of their positive charge and relatively high velocity, break off electrons in gas molecules and produce ion-pairs (ie, electrons and positively charged ions).

v They excite more luminosity in Zinc sulphide.

Betarays:

v Beta rays consist of streams of electrons.

v They have very small mass and a negative charge.

v They move with a velocity 9/10 of the speed of light.

v They are more penetrating than alpha rays.

v They can be stopped only by an 1cm thick aluminium sheet.

v They produce weak ionization in gases through which they pass. This is because of their small mass.

v Beta particles produce little luminosity in zinc sulphide

Gamma rays:

v Gamma rays do not consist of particles.

v They are radiation of wave form shorter than x-rays.

v After emission of alpha and beta rays the excited nucleus reaches the ground level with emission of energy. The emission is called gamma emission.

v These rays are electromagnetic radiation similar to light and X-rays but of higher energy.

v They are usually emitted along with alpha or beta rays.

v They have neither mass nor charge and may be represented as Gamma rays also move with equal to the velocity of light.

v It have the highest penetrating power.

v They can be stopped only by a 5 cm thick sheet of lead or concrete of many metres thickness.

v They are very weak ionizers.

Half life period (t1/2)

v It is the time taken for the disintegration of one half of the original amount of the substance.

v Ex-The half life period of 55Fe is 2.7 years and that of 59Fe is 45 days.

DETECTION AND MEASUREMENT OF RADIO ACTIVITY

There are several methods for detecting and measuring radioactive radiation. These are

Geiger Muller Counter

Scintillation counter

Cloud chamber method.

Ionisation chamber

Electroscope

v Since the radiation produced by radio nuclides are dangerous, the radiations should be monitored frequently .

The measurement of radiations is based upon on the following properties of radiations

v To cause ionization of gases

v To cause scintillation (fluorescence)

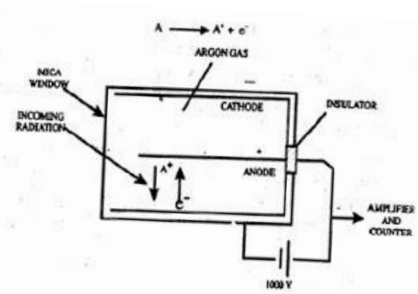
v To effect chemical change

Geiger Muller counter Technique

Principle

v A potential difference of about 1000 volts is applied across the two electrodes.

v The argon gas is ionized whenever any alpha or beta particle enters the tube through the mica window.



v The positively charged argon ions, formed due to the ionization of the gas, positively charged attracted to the cathode and the negatively charged attracted to the anode.

v Thus an electrical pulse flows between the electrodes whenever one alpha or beta particle enters the tube.

v The electrical pulses are counted in an automatic counter.

v The intensity of the radioactivity of any radioactive material can be found out by finding the number of pulses per minute.

Instrument

v Geiger Muller counter consists of a hallow cylinder fitted with tungsten wire at the centre which act as anode.

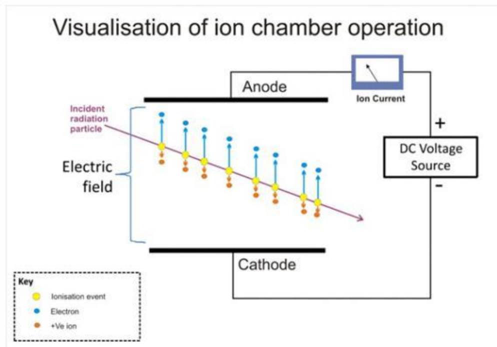
v Inner side of the cylinder is coated with thin silver film which acts as cathode.

v The cylinder is filled with argon and alcohol vapour and closed with a thin mica window at one end.

v When the radiation enters through the mica window the argon gas is ionized and there is flow of current.

v The current is amplified and presented as an analog or digital output and /or audio output

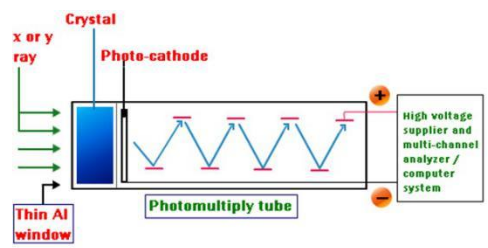
Scintillation Counter



Scintillation means a flash of light.

v In this counter the radioactive substance mounted on a wire emits alpha particles.

v Each alpha partic1e strikes a zinc sulphide screen and gives a flash



v The flashes produced per second can be counted to find out the intensity of radiation.

v In the 'well-type' scintillation counter, instead of the zinc sulphide screen a: crystal of sodium iodide mixed with a little thallium iodide is used.

v The sample of the radioactive substance is kept in a 'well' cut in the crystal.

v The radiation from the radioactive substance strikes the crystal wall and produces flashes.

v These scintillations fall on a photoelectric cell which converts the light energy into electrical energy for each flash.

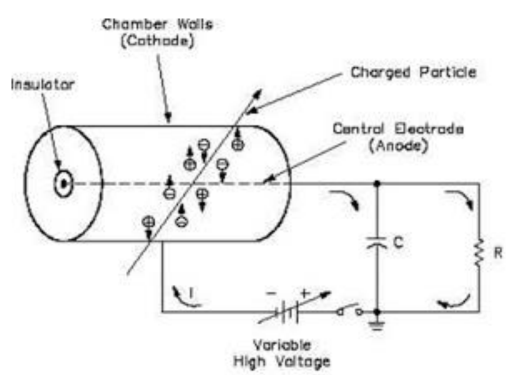
v Then the energy amplified by Photo multiplier tube and count by detector.

v These are counted in a counter, even upto one million scintillations per second.

v This counter can be used for counting either alpha or beta particles.

IONISATION CHAMBERS

v There are available in various shapes and size



v It consist of chambers filled with gas and fitted with two electrodes kept at different electrical potentials 950-1000 volts (for each centimeter of distance between the two electrodes) and a measuring device to indicate the flow of electric current.

Radiation brings about ionization of gas molecules or ions which causes emission of electrons which in turn reveals the changes in electrical current.

PROPORTIONAL CHAMBERS

v These are modified ionization chambers in which an applied potential ionizations of primary electrons causes thunderous bursting or production of more free electrons which get carried to the anode.

v As for each primary electrons liberated much more additional electrons get liberated the current pulse through electrical circuit is greatly amplified.

v The voltage range over which the gas amplification occurs is called the proportional region and the counters working in this region are called proportional counters.

AUTORADIOGRAPHY

v Useful for detecting gamma rays in physiological studies of plant and animals.

v It involves administering of radioactive substance to an animal and after sufficient time, the tissue is removed embedded in paraffin cut into thin section and kept in contact with photographic emulsion in a dark room.

v The radio active atoms are emitting particles which darken photographic emulsion.

v After sufficient time of exposure the emulsions has been developed and fixed.

BIOLOGICAL EFFECTS OF RADIATION

v Humans may be exposed to radiation from various sources such as cosmic rays, x-rays (in diagnostic procedures), monazite (sands of Kerala containing radioactive thorium etc)

v Therefore in this context there is need to study the biological effects of radiation.

v The radiations like alpha particles, beta particles, protons, neutrons, gamma rays and x-rays that can produce biological effect.

The damage caused by radiation may be divided into two types

1. Somatic effects, affecting the various parts of the body.

2. Genetic effects, affecting the reproduction and heredity.

v The initial symptoms in humans are severe nausea, vomiting and prostration (lack of energy or power).

v After a few hours diarrhoea comes on due to ulceration of the gut with bleeding.

Red cells, lymphocytes, blood platelets and granulocytes are found to be reduced in number leading to anemia etc.

Antibody production is decreased the body resistance comes down promoting infection.

Death will follow after 2 to 3 weeks after a heavy dose of radiation.

Delayed Effects of Radiation

Continuous exposure to low level radiation can give rise to delayed effects of radiation.

v The hair greys quickly and other degenerative changes take place leading to premature ageing.

v Several types of cancer are also induced, like skin cancer, lung cancer, leukemia, Hodgkin's disease, etc.

v Large doses of radiation may inactivate the gonads leading to sterility.

v Radiation exposure also produces chromosomal damage giving rise to mutations (permanent transmissible change in the genetic material) and consequent decreased fertility.

Artificial Radioactivity

v Artificial radio activity can be brought about by bombarding a suitable element with neutrons (slow neutrons are very effective).

v This disturbs the nucleus which becomes unstable.

v To retain stability it starts disintegrating and emitting some rays and thus has become radioactive.

v The radioactive isotopes of certain elements have been used as tracers in various types of investigations.

v The stable element and a little of its radioactive isotope are mixed and converted to the required compounds.

v The compounds are now said to be labeled.

v The stable and the radioactive isotopes go through all physical and chemical changes in the same ratio.

v The compound can be estimated by simply measuring the radioactivity of the active isotope.

v Biochemical and physiological properties of certain compounds can be studied like this.

v It may be distributed to different parts of the body or concentrated in one particular part of the body.

v sodium radio iodide is absorbed mainly by the thyroid gland.

v Important artificial radionuclides used in medicine are cobalt-60 (used like radium for the treatment of cancer) phosphorus- 32(used in blood studies) and iodine-131 (used in the diagnosis and treatment of thyroid disease).

MEDICAL USES OF RADIOISOTOPES

Radiation Sterilization:

Ø Thermo labile drugs such as penicillin maybe sterilized by radiation from radionuclide's.

Ø All microorganisms and their spores are killed within seconds and the drug becomes sterile.

Ø Gamma rays from radioisotopes are used for this purpose in addition to high speed electrons.

Radio Therapy:

Ø The aim is to destroy diseased tissue without destroying healthy tissue.

Ø Gamma radiation, being the most penetrating is used for destroying deep seated tumours. Both external and internal therapy are used.

Ø X-radiation can only be used for external therapy. In internal therapy the radionuclide is placed in a natural or surgical cavity of the body or injected into the tissue.

Ø Gamma emitter iodine-131 is given orally and is taken up by the thyroid.

Ø Artificial gamma emitters such as cobalt-60, iridium-192 are now available and they have many advantages.

Ø   Apart from being cheap, they are chemically inert and their disintegration products are harmless.

3.   Radio Diagnosis:

Ø   Many materials which are dense to visible light are transparent to x-rays and gamma rays.

Ø   The function of a particular organ may be studied eg. iodine (given in the form of sodium radioiodide) is taken up by the thyroid gland. This can be easily followed by a radiation detector.

Ø Another use of iodine-131 is in the form of di-iodofluorescein used in brain tumour before surgery.

Storage of Radio Isotopes:

v It is necessary to protect people from the harmful radiations emitted by the radioisotopes since we earlier studied about the harmful biological effects caused by the radiations.

v For this purpose the radioisotopes should be kept in remote places in the general store where people should not be allowed.

v The radioisotopes emitting gamma rays should be kept in lead containers of suitable thickness, as gamma rays are most penetrating.

v Alpha and beta ray emitters should be kept in thick glass containers, as alpha and beta rays are not as penetrating as gamma rays.

v The area where the radioactive materials are kept should be monitored regularly for radioactivity and any untoward increase in radiation should be detected in time and remedial measures taken.

Precautions in the use of radioisotopes:

v The following precautions should be observed while handling the radio isotopes:

v 1. Glass apparatus and other equipment should be tested for Radioactivity before use.

v 2. Rubber gloves should be used while handling radioactive materials.

v 3. Absorbent paper should be used while handling radioactive liquids so that any liquid spilled may be absorbed by the paper and the paper thrown out.

v 4. Pipettes should not be used for withdrawing or transferring radioactive liquids

UNITS OF RADIOACTIVITY

The unit of radioactivity is curie (Ci).

It is the weight of any radioactive substance undergoing the same number of disintegrations as 1 g of radium, which is   3.7 x 1010 disintegrations per second. Each disintegration is also known as a Becquerel (Bq).

Therefore 1 curie is equal to 3.7 x 1010 becquerels.

Curie is a large unit; so in its place smaller units such as milli curies and micro curies are used frequently.

One millicurie is one-thousandth (1/1000) of a curie and therefore represents 3.7 x 107disintegrations per second or becquerels.

One microcurie is one thousandth (1/1000) millicurie and so represents 3.7 x 104 disintegrations per second or becquerels.