

## CHAPTER - III

PROPERTIES,  
APPLICATIONS  
AND  
DETECTION OF ALPHA  
RADIATIONS.

(A) GENERAL ASPECTS OF IONIZING RADIATIONS

- (1) The radiations emitted by radioactive substances found to possess a high penetrating power, affect photographic plates, ionize gases, cause scintillations on fluorescent screens, develop heat and produce chemical effects.
- (2) As the radiations are given out, new elements are formed in an irreversible process, each element having its own characteristic radiations.
- (3) Emission of radiations is spontaneous, unaffected by any external agent.
- (4) The emission is not instantaneous but prolonged i.e. delayed action, extended over a certain period of time, otherwise it can not have been discovered at all.
- (5) There is nothing abnormal about the radioactive elements as regards their physical and chemical properties, of all them have their places in periodic table. Thus for instance, radium, except for a special feature of activity fits in at the ends of the second group of periodic table having chemical and spectral properties similar to calcium, strontium and barium, the other members of the same group.
- (6) The process of separation of radioactive substances from the original mineral ores is an exceedingly difficult task, a ton of Uranium ore, for instance, yielding a few decigrams of radium - hence the high cost of radium.

(B) CHARACTERISTICS OF ALPHA-RAYS

(1) Ionizing Power

They produce intense ionization in the gases through which they pass. Their ionizing power is hundred time greater than that of beta rays and ten thousand times greater than that of gamma rays. Hence, they produce very dense cloud chamber tracks that resemble the vapour trails of high flying aircraft. These traces are short and thick.

(2) Penetrating Power

Out of the three radioactive radiations, they have the shortest penetrating power. It is so because alpha particles produce greatest number of ions in a given path, hence they penetrate shortest distance. In fact, their penetrating power is inversely proportional to their ionizing power.

(3) Range

The range of alpha particles is given by the distance which it travel in air at N.T.P. before losing its ionizing power. Its value varies from 2.7 cm for the alpha particles emitted by Uranium to 8.6 cm for those emitted from Thorium-C'.

The range of alpha particles depends on the following factors :

- (i) The radioactive substance giving out the alpha particles.
- (ii) Nature of absorbing material and
- (iii) The initial value of emission - the range being proportional to  $V^3$  as given by Geiger's rule.

(4) Velocity

Alpha particles are emitted from the nuclei of radioactive elements with the velocities ranging from  $\frac{1}{10}$ th to  $\frac{1}{100}$ th of the velocity of light. Since

alpha particles even from a single source have different velocities, it means that they occupy discrete quantized energy levels inside the nucleus.

(5) **Effect on Photographic Plate**

They affect a photographic plate although the effect is very feeble.

(6) **Fluorescence**

They produce fluorescence in substances like Zinc and barium plationo-cyanide. On observing the fluorescence through a spinthariscopes, it is found to consist of successive scintillations produced by the impact of the individual particles.

(7) **Deflection**

Being charged particles, they are deflected by both electric and magnetic fields.

(8) **Scattering**

The alpha rays are scattered when they pass through thin sheets of mica, gold foil etc.. The divergence of alpha particle from its straight line path is 2 to 3 degrees. Geiger and Marsden found that a few particles, sometimes, were deflected more than  $90^\circ$ . This was explained by Rutherford to be due to the repulsion between the alpha particle and the nucleus of the atom scattering it.

(9) **Alpha Disintegration**

Before the emission they probably exist in some form or other, though not as individual units, in the nucleus. Moreover the alpha particles inside the nucleus are not lying in any confused and idle manner, but are arranged in discrete energy levels.

(C) APPLICATIONS OF ALPHA RAYS

- (1) For studying the phenomenon of artificial transmutation.
- (2) Self-luminous paints for use on instrument and watch dials have been made by adding a natural alpha emitting radioactive substance to phosphor.
- (3) Radioactive nuclides emitting alpha rays have been used for the generation of electric power which is used in space vehicles.
- (4) By bombarding the alpha-particles radioactive isotopes can be prepared which are used in industries, geological dating and diagnosis. Some of the examples are given below.
  - (i) Radioisotopes are used to locate and detect the presence of tumours, which are difficult to detect and especially to locate. e.g. brain tumour.
  - (ii) By using iron-59, many diseases caused by deficiency of red blood cells in the human body can be distinguished from each other.
  - (iii) The functioning of various organs like liver, kidney and spleen etc. under normal and diseased conditions has been studied with the help of labelled iodine-131.
  - (iv) Radiosodium can be used to study the cases of restricted circulation of blood.
  - (v) Pumping action of heart has been studied by using radiosodium or radioiodine.
  - (vi) Alloys are frequently subjected to different treatments such as age-hardening, annealing, quenching and cold rolling. Radioisotopes can be used to find the effect of such treatments.
  - (vii) The phenomenon of self-diffusion in metals i.e. the movement of the atoms of a metal within the crystal lattice can be studied with

the help of radioisotopes.

- (viii) The wear of piston rings and of gears in engines and its prevention by means of suitable lubricants can be studied with the help of radioactivity.
- (ix) Uniformity of mixing during the blending of petrols, lubricating oils and greases etc. can be achieved by labelling one of the constituents with a radioactive tracer.
- (x) The age of rock or mineral containing uranium can be determined by its radioactive decay.
- (xi) Radioisotopes are used in tracer elements and research places.

#### (D) DETECTION OF ALPHA RAYS

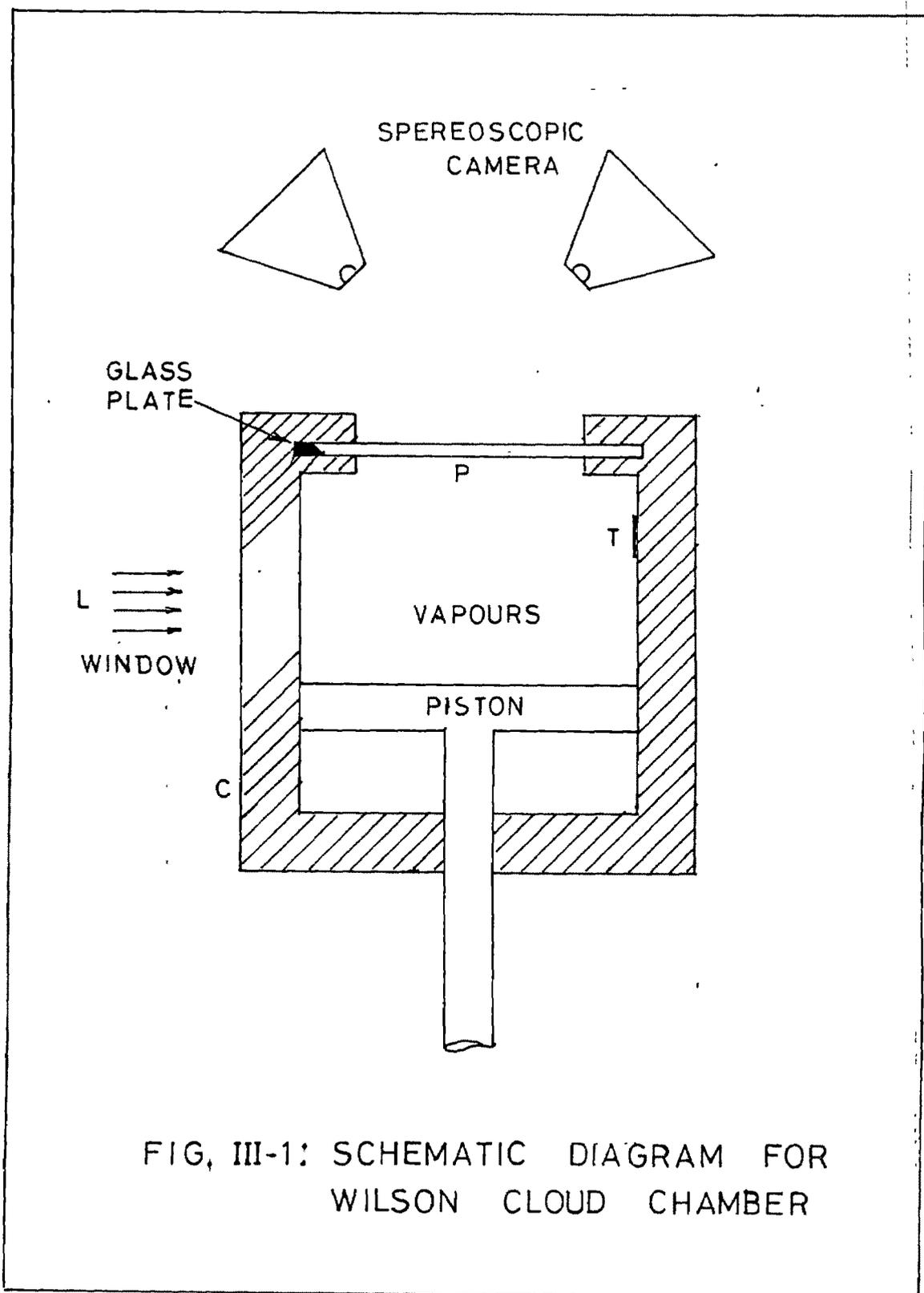
There are number of instruments for the detection of alpha rays like Scintillation counter, Wilson-Cloud chamber, nuclear emulsion, Cherenkov counter etc.. The best method is cloud chamber.

##### WILSON - CLOUD CHAMBER

This detector is one of the most important detector for measuring moving charged particles, photographing the actual paths of ionizing radiations and analysing the complicated interactions which takes place between charged particles and individual atoms.

##### (a) Principle

The working of cloud chamber is based on the fact that supercooled vapour needs the flow of nuclei to initiate its condensation, without the flow of nuclei vapour does not condense. For example, consider a volume of air saturated with water vapour. If the temperature is lowered its saturated limit decreases. Hence, air contains more water vapour than is necessary



FIG, III-1: SCHEMATIC DIAGRAM FOR WILSON CLOUD CHAMBER

for saturation at lower temperature. If dust particles are present, they will act as condensation nuclei and excess of water vapour will separate out as droplets in the form of cloud. If dust particles are absent, condensation is not possible and air will remain supersaturated with water vapour. Similarly in Wilson-Cloud chamber alpha particles will act as condensation nuclei and these ions will produce a passage of high energy particles like alpha particles through the chamber leading ionization of air or gas present in the chamber.

(b) Construction

A schematic diagram of Wilson-Cloud chamber is shown in Fig. III-1. It consists of an air-tight cylinder C whose one end is closed by a gas plate P and other by a movable metal piston. The air chamber formed between the two contains a saturated vapour from an excess amount of some liquid, usually a mixture of alcohol and water. A small amount of this mixture is kept in trough T inside the chamber which keeps the air saturated. The chamber is strongly illuminated by a mercury vapour lamp L whose light passes through a window in the side of cylinder.

(c) Working

If the volume of chamber is increased suddenly by moving the piston downward, adiabatic expansion causes cooling which renders the vapour supersaturated, unstable and likely to condense. If ions are present within the chamber condensation occurs preferentially on them.

If an ionizing particle enters the chamber either immediately before, during or immediately after the expansion, the ions left in its path will act as condensation nuclei so that a close array of fine droplets i.e. a kind of linear cloud called a cloud track will be formed. When illuminated

the track appears like a white line on the black background. The tracks can be photographed by a stereoscopic camera, whose pictures can be used for studying track orientations in three dimensions. The chamber is then cleared off the ions by means of a sweep field applied across the chamber and the piston is returned to its original position so that the chamber is ready for another burst of radiations.

Instead of operating the chamber regularly, many methods have been decided to make the chamber function automatically at the critical moment. Geiger counters are placed at the top and bottom of the chamber and when an ionizing particle passes through both of them and hence through the chamber, a relay is operated which causes adiabatic expansion of the gas and condensation takes place on the ions left by the particles. At the same time cameras are triggered to photograph the track immediately. From the nature of the track particles can be detected.

The detection of alpha radiations does not give complete informations regarding alpha radiations. The professional workers need the knowledge of exact alpha radiation dose received by the material, which help them to use alpha rays for different applications and to take precautionary measures against its adverse effects on human body. In spite of variety of techniques presently available for the estimation of radiation dose, the Thermoluminescence Radiation Dosimetry (TLD) is the most practicable and popular one. The present thesis discusses TLD in detail and an attempt has been made to apply it for determination of alpha dose. The radiation units used for practical applications by radiation users are described in the following section of the chapter.

### (E) RADIATION UNITS

Certain quantities and units are particularly used in the area of ionizing radiations. The units such as Curie, Rontgen, Rad and Rem which are adopted previously are not coherent with the S.I. Units, but their temporary use with the S.I. Units takes place. The International Commission of Radiation Units (ICRU) and International Commission Radiological Protection (ICRP) have adopted the special names; Bacquerel (Bq), Gray (Gy) and Sievert (Sv) for the S.I. derived units of activated energy, absorbed dose or dose equivalent.

#### (i) Activity Units

The Bacquerel (Bq) is the S.I. Unit of activity (radioactivity disintegration rate). The Curie (Ci), the special unit of activity is equal to  $3.7 \times 10^{10}$  Bq.

#### (ii) Exposure Unit

The unit of exposure is Rontgen (R). It is defined as that of X- or gamma radiation which produces 1 esu of charge in 1 ml of dry air at N.T.P. The energy absorbed in 1 g of air due to 1 R exposure is 87.5 ergs.

#### (iii) Absorbed dose

The energy absorbed per unit mass of the material is measured in RAD (Radiation Absorbed Dose). 100 ergs of energy absorbed in 1 g of material is defined as 1 RAD. The Gray (Gy), the S.I. Unit of absorbed dose, is the mass imparted to the matter by ionizing radiation is 1 Joule/Kg

The relation between RAD and Gy is  $1 \text{ Rad} = 10^{-2} \text{ Gy}$ .

The unit Kerma is related to absorbed dose. The term kerma is acronym for kinetic energy released per unit mass.

(iv) Dose equivalent units

The same dose of different types of radiations produces different effects in a material. Therefore, if a person is exposed to radiation, another unit of measuring quantity of dose equivalent must be used. This is obtained by multiplying the absorbed dose with a factor which depends on the biological effectiveness of radiation. The unit is called Rem (Rontgen equivalent man) and defined as absorbed dose of any radiation which produces the same biological effect as that of 1 RAD of X- or gamma rays. The population dose therefore is measured in Rem.

The Sievert (Sv), the S.I. unit of dose equivalent is the dose equivalent when the absorbed dose of ionizing radiation multiplied by the stipulated dimensionless factor is 1 J/Kg and  $1 \text{ Rem} = 10^{-2} \text{ Sv}$ .