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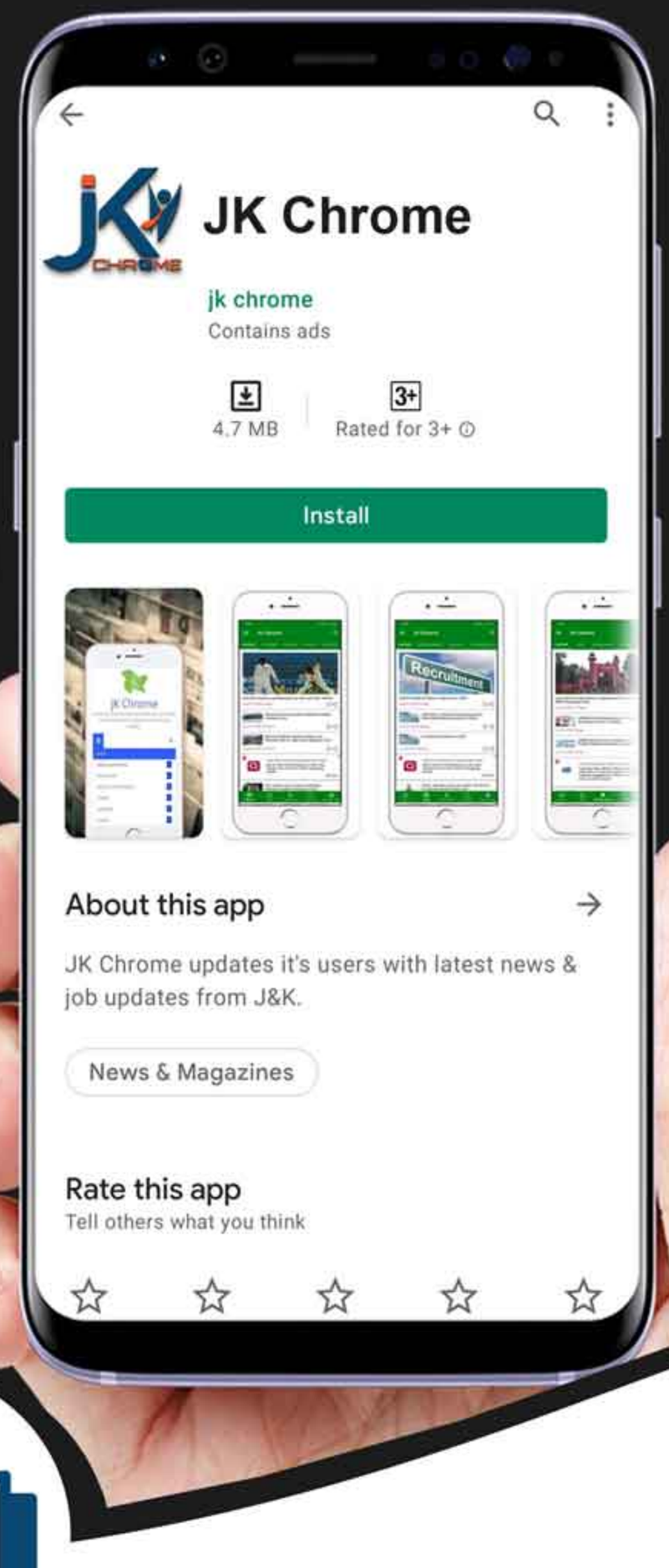

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Atomic & Nuclear Physics

Atomic Physics

1. Atom is the smallest part of matter which takes part in chemical reactions. Atoms of the same element are similar in mass, size and characteristics. Atom consists of three fundamental particles electron, proton and neutron. All the protons and neutrons are present in the central core of atom called nucleus. Electrons revolve around the nucleus.

2. In an atom, electrons and protons are equal in number and have equal and opposite charge. Hence atom is neutral.

Note : Proton was discovered by Golastin and named by Rutherford.

---> Till today, several subatomic particles have been discovered. Some important of them are as follows.

Cathode Rays : If the gas pressure in a discharge tube is 102 to 10-3 mm of Hg and a potential difference of 104 volt is applied between the electrode, then a beam of electrons emerges from the cathode which is called cathode rays. Hence cathode rays are beam of high energy electrons. Cathode is an electrode with a negative charge.

Properties of cathode rays :

(i) Cathode rays are invisible and travel in straight line.

(ii) These rays carry negative charge and travel from cathode to anode.

(iii) These rays emerge perpendicular to the cathode surface and are not affected by the position of anode.

(iv) Cathode rays travel with very high velocity (1 / 10th the velocity of light).

(v) These rays are deflected by electric and magnetic fields.

(vi) These rays can ionise gases.

(vii) These rays heat the material on which they fall.

(viii) They can produce chemical change and thus affect a photographic plate.

(ix) These rays can penetrate through thin metal foils.

(x) The source of emf used in the production of cathode rays is induction coil.

(xi) When they strike a target of heavy metals such as tungsten, they produce x-rays.(xii)The nature of cathode rays is independent of nature of cathode and the gas in the discharge tube.

Positive or Canal rays :

If perforated cathode is used in a discharge tube, it is observed that a new type of rays are produced from anode moving towards the cathode and passed through the holes of cathode. These rays are positively charged and are called positive rays or canal rays or anode rays. These rays were discovered by Goldstein.

Properties of Canal rays :

(i) The positive rays consists of positively charged particles.

(ii) These rays travel in straight line.

(iii) These rays can exert pressure and thus possess kinetic energy.

(iv) These rays are deflected by electric and magnetic fields.

(v) These rays are capable of producing physical and chemical changes.

(vi) These rays can produce ionisation in gases.

Radioactivity

1. Radioactivity is the sending out of harmful radiation or particles, caused when atomic nuclei breakup spontaneously.

2. Radioactivity was discovered by Henry Becquerel, Madame Curie and Pierre Curie for which they jointly win Noble prize.

3. The nucleus having protons 83 or more are unstable. They emit a, ß and ? particles and become stable. The elements of such nucleus are called radioactive elements and the phenomenon of emission of a, ß and ? particles is called radioactivity.

4. ? rays are emitted after the emission of a and ß rays.

5. Robert Pierre and his wife Madame Curie discovered a new radioactive element radium.

6. The rays emitted by radioactivity were first recognised by Rutherford.

7. The end product of all natural radioactive element after emission of radioactive rays is lead.

Properties of a, ß and ? particles

1. With the emission an a-particle, atomic number is decreased by 2 and mass member is decreased by 4.

2. With the emission of a (ß-particle atomic number is increased by one and mass number does not change.

3. The effect on the mass number and atomic number with the emission of a, ß and ? rays is decided by Group-displacement law or Soddy-Fajan Law.

4. Radioactivity is detected by G.M. Counter.

5. The time in which half nuclei of the element is decayed is called half life of the radioactive substance.

6. Cloud chamber : Cloud chamber is used to detect the presence and kinetic energy of radioactive particles. It was discovered by C.R.T. Wilson.

7. Radioactive carbon-14 is used to measure the age of fossils and plants. (Carbon dating) In this method age is decided by measuring the ratio of 6C12 and 6C14.

Nuclear Fission and Fusion

Nuclear Fission : The nuclear reaction in which a heavy nucleus splits into two nuclei of nearly equal mass is nuclear fission. The energy released in the nuclear fission is called nuclear energy.

---> Nuclear fission was first demonstrated by Strassmann and O. Hahn. They found that when U235 nucleus is excited by the capture of a neutron, it splits into two nuclei Ba142 & K92.

Chain Reaction : When uranium atom is bombarded with slow neutrons, fission takes place. With the fission of each uranium nucleus, on the average 3 neutrons and large energy is released. These neutrons cause further fission. Clearly a

chain of fission of uranium nucleus starts which continues till whole of uranium is exhausted. This is called chain reaction.
Chain reaction is of the following two types (i) Uncontrolled chain reaction (ii) Controlled chain reaction.

Uncontrolled Chain Reaction : In each fission reaction, three more neutrons are produced. These three neutrons may cause the fission of three other U235 nuclei producing 9 neutrons and so on. As a result the number of neutron goes on increasing till the whole of fissionable material is consumed. This chain reaction is called uncontrolled or explosive chain reaction. This reaction proceeds very quickly and a huge amount of energy is liberated in a short time.

Atom bomb : Atom bomb is based on nuclear fission. U235 and Pu239 are used as fissionable material. This bomb was first used by USA against Japan in second world war (6th August, 1945 at Hiroshima & 9th August, 1945 at Nagashaki).

Controlled Chain Reaction : A fission chain reaction which proceeds slowly without any explosion and in which the energy released can be controlled is known as controlled reaction. Actually in this situation only one of the neutrons produced in each fission is able to cause further fission. The rate of reaction remains constant.

Nuclear Reactor or Atomic Pile : Nuclear reactor is an arrangement in which controlled nuclear fission reaction takes place.

-----> First nuclear reactor was established in Chicago University under the supervision of Prof. Fermi.

-----> There are several components of nuclear reactor which are as follows :

(i) Fissionable Fuel : U235 or U239 is used.

(ii) Moderator : Moderator decreases the energy of neutrons so that they can be further used for fission reaction. Heavy water and graphite are used as moderator.

(iii) Control rod : Rods of cadmium or boron are used to absorb the excess neutrons produced in fission of uranium nucleus so that the chain reaction continues to be controlled.

(iv) Coolant : A large amount of heat is produced during fission. Coolant absorbs that heat and prevents excessive rise in the temperature. The coolant may be water, heavy water, or a gas like He or C02.

Uses of nuclear reactor

(i) To produce electrical energy from the energy released during fission.

(ii) To produce different isotopes which can be used in medical, physical and agriculture science.

Fast Breeder Reactor : A nuclear reactor which can produce more missile fuel than it consumes is called a fast breeder reactor.

Nuclear Fusion : When two or more light nuclei combined together to form a heavier nucleus, tremendous energy is released. This phenomenon is called nuclear fusion. A typical example of nuclear fission is 1H2 + 1H3 2He4 + 0n1 + 17.6 Mev.

-----> The energy released by sun and other stars is by nuclear fusion.

-----> For the nuclear fusion, a temperature of the order of 108 K is required.

Hydrogen bomb : Hydrogen bomb was made by American scientists in 1952. This is based on nuclear fusion. It is 1000 times more powerful than atom bomb.

Mass Energy Relation : In 1905 Einstein established a relation between mass and energy on the basis of special theory of relativity. According to this relation, mass can be converted into energy and vice versa, according to the relation E = me2 where c is the velocity of light and E is the energy equivalent of mass m.

-----> Albert Einstein was an American scientist. He was born in Germany. He was given Nobel Prize of Physics in 1921.

-----> Sun is continuously emitting energy. Earth is continuously receiving 4 x 1026 joule of energy per second from sun. As a result mass of sun is decreasing at the rate of approximately 4 x 109 kg per second. But mass of sun is so large that it is estimated that the sun will continuously supply energy for next 109 years.