SELF ASSESSMENT PAPER - 8

SOLUTIONS

I. Multiple Choice Questions **[1 × 4 = 4]**

1. Option (A) is correct.

Explanation: Total energy of two H-atom in ground state = 2(−13.6) = −27.2 eV.

The maximum amount by which their combined kinetic energy is reduced when any one H-atom goes into first excited state after the inelastic collision, that is, the total energy of two H-atom after inelastic collision :

$$E = \frac{13.6}{n^2} + 13.6$$

Putting $n = 2$

$E = 17\ eV$

So that the loss in kinetic energy due to inelastic collision will be,

$$= 27.2 - 17.0 = 10.2\ eV$$

2. Option (A) is correct.

Explanation: The simple Bohr model cannot be directly applied to calculate the energy levels of an atom with many electrons because when we derive the formula for radius/energy levels, etc., we make the assumption that centripetal force is provided only by electrostatic force of attraction by the nucleus.

So that, this will only work for single electron atoms. In multi-electron atoms, there will also be repulsion due to other electrons. The simple Bohr model cannot be directly applied to calculate the energy levels of an atom with many electrons.

3. Option (B) is correct.

Explanation: Electrostatic force between proton-proton is repulsive which causes the instability of nucleus. So neutrons are more than the number of protons.

4. Option (A) is correct.

Explanation: Binding energy is required to hold the protons and neutrons in the nucleus. Hence the mass of a nucleus is less than the total mass of all protons and neutrons present. This difference of mass is converted into energy.

II. Assertion and Reason **[1 × 2 = 2]**

1. Option (B) is correct.

Explanation: Two atoms of different elements having same mass number but different atomic numbers are called isobars. The assertion is true. Atomic number is the number of protons present and atomic mass number is the total number of protons and neutrons present in a nucleus. The reason is also true. But the reason does not explain the assertion.

2. Option (A) is correct.

Explanation: Most of the α-particles pass roughly in a straight line (within 1°) without deviation. This shows that no force is acting on them. So, assertion is true. Most of the space in the atom is empty. Only 0.14% of α-particles are scattered more than 1°.

So, the reason is also true and explains the assertion.

III. Competency Based Questions **[1 × 4 = 4]**

1. (i) Option (B) is correct.

Explanation: The atomic energy programme in India was launched around the time of independence under the leadership of Homi J. Bhabha (1909-1966).

(ii) Option (A) is correct.

Explanation: An early historic achievement was the design and construction of the first nuclear reactor in India named APSARA.

(iii) Option (D) is correct.

Explanation: ARYABHATTA is an Indian artificial satellite.

(iv) Option (B) is correct.

Explanation: The main objectives of the Indian Atomic Energy programme are to provide safe and reliable electric power for the country's social and economic progress and to be self - reliant in all aspects of nuclear technology.

(v) Option (D) is correct.

Explanation: Exploration of atomic minerals in India undertaken in early fifties that has limited reserves of Uranium, but fairly abundant reserves of Thorium just because of limited technical resource.

IV. Very Short Answer Type Question **[1 × 3 = 3]**

1. Anti-neutrino.
2. The difference between the rest mass of a nucleus and the sum of the rest masses of its constituent nucleons is called its mass defect. It is given by

$$\Delta m = Zm_p + (A - Z)\, m_n - M$$

3. 1000 Å; because it belongs to ultraviolet radiations in the electromagnetic spectrum.

V. Short Answer Type Question-I **[2 × 3 = 6]**

1. Energy difference $= E_f - E_i$

$= 3.4\ \text{eV} - 1.51\ \text{eV}$

$= 1.89\ \text{eV}$

Since, $$\lambda = \frac{12375(\text{in Å})}{\text{E(in eV)}}$$

$$= \frac{12375}{1.89\,\text{eV}}\ \text{Å}$$

$$= 6547\ \text{Å}.$$

The given series is Balmer series.

2. (i) According to Rutherford's model, electron orbiting around the nucleus, continuously radiates energy due to the acceleration; hence the atom will not remain stable.

(ii) As electron spirals inwards; its angular velocity and frequency change continuously; therefore it will emit a continuous spectrum.

3. Total BE of P $= 240 \times 7.6 = 1824$ MeV

BE of Q $= 110 \times 8.5 = 935$ MeV

BE of R $= 130 \times 8.4 = 1092$ MeV

Total BE of Q and R = (935 + 1092) = 2027 MeV

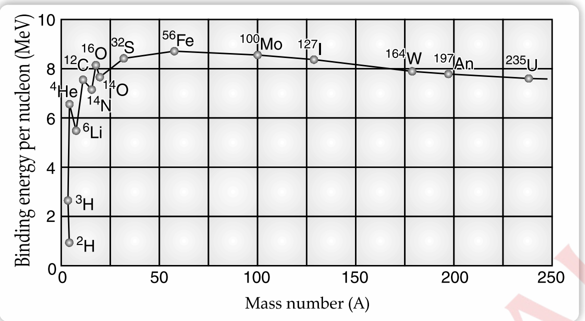
Total energy released in the fission

$= 2027 - 1824$

$= 203$ MeV.

VI. Short Answer Type Question-II [3 × 2 = 6]

1.

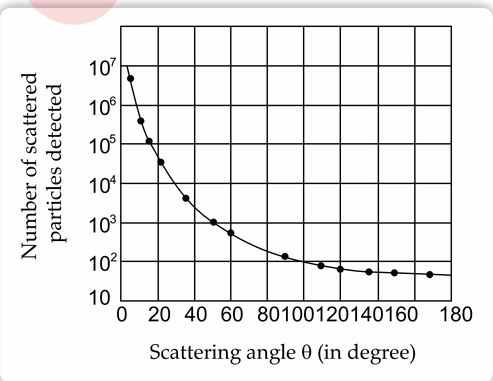


[**Note**: Also accept the diagram that just shows the general shape of the graph]. From the plot we note that:

(i) During nuclear fission: A heavy nucleus in the larger mass region ($A > 200$) breaks into two middle level nuclei resulting in an increase in B.E. per nucleon. This results in a release of energy.

(ii) During nuclear fusion: Lighter nuclei in the lower mass region ($A < 20$) fuse to form a nucleus having higher B.E. per nucleon. Hence energy is released.

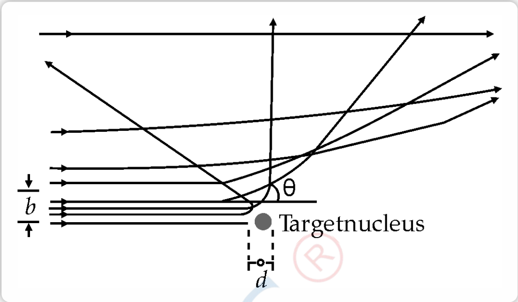
2. Plot of α-particle scattering to show variation of scattering particle.



The graph shown that large number of α-particles do not suffer large scattering but small number suffer greater scattering. It is concluded that:

(i) most of the space in the atom is empty.

(ii) massive positively charged nucleus occupies small region.



From the picture, it is clear that small impact parameter suffers large scattering, thus it shows the upper limit to the size of nucleus.

VII. Long Answer Type Question [1 × 5 = 5]

1. Postulates of Bohr Model of Hydrogen atom:

Postulate I: The electrons revolve in a circular orbit around the nucleus. The electrostatic force of attraction between the positively charged nucleus and negatively charged electrons provide necessary centripetal force for circular motion.

Postulate II: The electrons can revolve only in certain selected orbits in which angular momentum of electrons is equal to the integral multiple of $\frac{h}{2\pi}$, where h is Planck's constant. These orbits are known as stationary or permissible orbits. The electrons do not radiate energy while revolving in theses orbits.

Postulate III: When an electrons jumps from higher energy orbit to lower energy orbit, energy is radiated in the form of a quantum or photon of energy $h\nu$, which is equal to the difference of the energies of the electron in the two orbits.

Expression for Bohr radius:

Let us consider

m = Mass of an electron

r = Radius of the circular orbit in which the electron is revolving

v = Speed of electron

$-e$ = Charge of electron

From 1st postulate

Centripetal force = Electrostatic force

$$\frac{mv^2}{r} = \frac{1}{4\pi\varepsilon_0}\frac{e^2}{r^2}$$

$$\therefore \quad v^2 = \frac{1}{4\pi\varepsilon_0}\frac{e^2}{mr} \quad \text{...(i)}$$

From 2nd postulate

$$mvr = \frac{nh}{2\pi}$$

or,
$$v = \frac{nh}{2\pi mr}$$

or, $$v^2 = \frac{n^2h^2}{4\pi^2m^2r^2} \qquad ...(ii)$$

Comparing eqns (i) and (ii)

$$\frac{1}{4\pi\varepsilon_0}\frac{e^2}{mr} = \frac{n^2h^2}{4\pi^2m^2r^2}$$

$\therefore$ Bohr radius, $$r = \frac{\varepsilon_0 n^2h^2}{\pi m e^2}$$

(b) Shortest wavelength in Balmer series:

$$\frac{1}{\lambda_S} = R\left(\frac{1}{2^2} - \frac{1}{\infty}\right)$$

$$\therefore \quad \lambda_S = \frac{4}{R}$$

Longest wavelength in Balmer series:

$$\therefore \quad \frac{1}{\lambda_L} = R\left(\frac{1}{2^2} - \frac{1}{3^2}\right)$$

$$\therefore \quad \lambda_L = \frac{36}{5R}$$

So, $$\frac{\lambda_L}{\lambda_S} = \frac{\frac{36}{5R}}{\frac{4}{R}} = \frac{9}{5}.$$