	INDIAN SCHOOL AL WADI AL KABIR	
Class: XII	**Department: SCIENCE 2022 – 23** **SUBJECT : PHYSICS**	**Date of submission:** **18.02.2022**
Worksheet No:13 **WITH ANSWERS**	**Topic: ATOMS & NUCLEI**	**Note:** **A4 FILE FORMAT**
NAME OF THE STUDENT-	**CLASS & SECTION**	**ROLL NO.**

OBJECTIVE TYPE QUESTIONS

1. Which of the following atoms has the lowest ionization potential?

(a) $^{8}_{8}O$
(b) $^{14}_{7}N$
(c) $^{133}_{55}Cs$
(d) $^{40}_{18}Ar$

Ans. c

2) The Bohr model of atom:
(a) assumes that the angular momentum of electron is quantized
(b) uses Einstein's photoelectric equation
(c) predicts continuous emission spectra for atoms
(d) predicts the same emission spectra for all types of atoms

Ans. (a) assumes that the angular momentum of electron is quantized

3) Nuclear force is:
(a) strong, short range and charge independent force
(b) charge independent, attractive and long-range force
(c) strong, charge dependent and short-range attractive force
(d) long range, change dependent and attractive force

Ans. (a) strong, short range and charge independent force

4) If 13.6 eV energy is required to ionize the hydrogen atom, then energy required to remove an electron from n = 2 is
(a) 10.2 eV
(b) 0 eV
(c) 3.4 eV
(d) 6.8 eV.

Answer: c
Explaination:

(c) $E_n = \frac{-13.6}{n^2}$ eV

$\Delta E_\infty - E_2 = 0 + \frac{13.6}{2^2} = 3.4$ eV

5) In Bohr's model of an atom which of the following is an integral multiple of $h/2\pi$?
(a) Kinetic energy
(b) Radius of an atom
(c) Potential energy
(d) Angular momentum
Answer:

Explaination:

(d) Angular momentum L = mvr = $\frac{nh}{2\pi}$

6) The K.E. of the electron in an orbit of radius r in hydrogen atom is proportional to

(a) $\frac{e^2}{r}$ (b) $\frac{e^2}{2r}$

(c) $\frac{2e^2}{r}$ (d) $\frac{e^2}{3r}$

Answer: b

Explaination:

(b) $\frac{e^2}{2r}$, Scince K.E = $\frac{ke^2}{2r}$

7) The ratio between Bohr radii is
(a) 1 : 2 : 3
(b) 2 : 4 : 6
(c) 1 : 4 : 9
(d) 1 : 3 : 5
Answer: c
8) The longest wavelength in Balmer series of hydrogen spectrum will be
(a) 6557 Å
(b) 1216 Å
(c) 4800 Å

(d) 5600 Å

Answer: a

(a) 6557 Å
For longest wavelength in Balmer series $n_1 = 2$ and $n_2 = 3$

$$\frac{1}{\lambda} = R\left[\frac{1}{n_1^2} - \frac{1}{n_2^2}\right], R = 1.1 \times 10^7 \text{ m}^{-1}$$

9) In terms of Rydberg constant R, the wave number of the first Balmer line is
(a) R
(b) 3R
(c) 5/36R
(d) 8/9R

Answer: c

Explaination:

(c) $\frac{5R}{36}$

For first Balmer line $\frac{1}{\lambda} = R\left(\frac{1}{2^2} - \frac{1}{3^2}\right)$

$= \frac{5R}{36}$

10) The ionization energy of hydrogen atom is 13.6 eV. Following Bohr's theory, the energy corresponding to a transition between 3rd and 4th orbits is
(a) 3.40 eV
(b) 1.51 eV
(c) 0.85 eV
(d) 0.66 eV

Answer: d

Explaination:

(d) 0.66 eV

$$\Delta E = E_4 - E_3 = \frac{-13.6}{4^2} + \frac{13.6}{3^2} = 0.66 \text{ eV}$$

11) The energy of hydrogen atom in the nth orbit is En, then the energy in the nth orbit of single ionised helium atom is

(a) $\frac{E_n}{2}$ (b) $2E_n$

(c) $4E_n$ (d) $\frac{E_n}{4}$

Answer: c
Explanation:
(c) As energy $E \propto Z^2$
For hydrogen atom Z = 1,
for Helium Z = 2
$E_{He} = 4E_n$

2 marks type questions;

1. Write any two characteristic properties of nuclear force.
Answer:
a. Nuclear forces are strongest forces in nature.
b. Nuclear forces are charge independent.

2. Two nuclei have mass numbers in the ratio 1: 8. What is the ratio of their nuclear radii?

Since $R = R_0 A^{1/3}$

$$\Rightarrow \quad R_1 : R_2 = (1^{1/3} : 8^{1/3}) = \left(\frac{1}{8}\right)^{1/3} = \mathbf{1 : 2}$$

3.

A nucleus ${}_Z X^A$ has mass represented by $M(A, Z)$. If M_p and M_n denote the mass of proton and neutron respectively and B.E., the binding energy in MeV, then

Ans.

$$\text{B.E.} = [Z M_p + (A - Z) M_n - M(A, Z)]\, c^2$$

4.

Two nuclei have mass numbers in the ratio 2 : 5. What is the ratio of their nuclear densities ?

Ans. The ratio of their nuclear densities is 1, as nuclear density is constant for all nuclei.

5.

What is the nuclear radius of Fe^{125}, if that of Al^{27} is 3·6 fermi.

Ans. As $\dfrac{R_1}{R_2} = \left(\dfrac{A_1}{A_2}\right)^{1/3} = \left(\dfrac{125}{27}\right)^{1/3} = \dfrac{5}{3}.$

$$R_1 = \frac{5}{3} R_2 = \frac{5}{3} \times 3\cdot6 = \mathbf{6\cdot0\ fermi}$$

6.

What is the effect on neutron to proton ratio in a nucleus when (*i*) an electron, (*ii*) a positron is emitted ?

Ans. In emission of an electron, a neutron is converted into a proton. Therefore, number of neutrons decreases and the number of protons increases. The neutron to proton ratio decreases. In the emission of a positron, a proton is converted into a neutron. Hence the ratio increases.

7.

Why heavy stable nucleus must contain more neutrons than protons ?

Ans. Coulomb forces between protons are repulsive and nuclear forces are ordinarily attractive. For nuclei to be stable nuclear forces must dominate the repulsive forces. Therefore, number of neutrons must be greater than the number of protons.

1. The energy equivalent of 1 amu is............... .
2. One electron volt is the...............when accelerated through a............... .
3. Density of nuclear matter is the...............mass of...............and its............... .
4. Isotopes of an element are the atoms...............which have...............but..............
5. Isobars are atoms of...............which have same...............but different...............
6. Isotones are the nuclides which contain............... .

1. 931 MeV
2. energy acquired by an electron; potential difference of 1 V.
3.ratio of; nucleus; volume
4.of an element; same atomic number; different atomic weights.
5. different elements; atomic weight; atomic numbers.
6. same number of neutrons.

3 MARKS QUESTIONS

1. An electron and alpha particle have the same de-Broglie wavelength associated with them. How are their kinetic energies related to each other?

Answer:

$E_K = \frac{p^2}{2m}$ where $\begin{cases} E_K = \text{Kinetic energy} \\ p = \text{momentum} \\ m = \text{mass of the particle} \end{cases}$

de-Broglie wavelength, $\lambda = \frac{h}{p}$ ...where [h = Planck's constant

$\therefore \lambda = \frac{h}{\sqrt{2mE_K}}$

$\because$ Both the particles have the same de-Broglie wavelength ...[Given

$\therefore \frac{h}{\sqrt{2m_e E_{Ke}}} = \frac{h}{\sqrt{2m_\alpha E_{K\alpha}}}$

or $\frac{m_e}{m_\alpha} = \frac{E_{K\alpha}}{E_{Ke}}$ where $\begin{cases} m_e = \text{mass of electron} \\ m_\alpha = \text{mass of alpha particle} \\ E_{Ke} = \text{K.E. of electron} \\ E_{K\alpha} = \text{K.E. of } \alpha\text{-particle} \end{cases}$

As $m_\alpha > m_e$ $\therefore$ K.$E_{Ke} > E_{K\alpha}$

2. Two nuclei have mass numbers in the ratio 1: 2. What is the ratio of their nuclear densities?

Nuclear density, $f = \frac{\text{Mass of Nucleus}}{\text{Volume of Nucleus}}$

But, $R = R_0 A^{1/3}$

$$\therefore \quad f = \frac{mA}{\frac{4}{3}\pi R_0^3 A}$$

...where {m is mass of proton or neutron and A is number of nucleons

$$\therefore \quad f = \frac{m}{\frac{4}{3}\pi R_0^3}$$

Thus, f is independent of A (mass number)

∴ The ratio of density will be **1 : 1.**

3. Two nuclei have mass numbers in the ratio 8:125. What is the ratio of their nuclear radii?

Answer:

$$A_1 : A_2 = 8 : 125 \quad \Rightarrow \frac{A_1}{A_2} = \frac{8}{125}$$

$$\text{Since } R = R_0\ A^{1/3} \quad \therefore \quad \frac{R_1}{R_2} = \frac{A_1^{1/3}}{A_2^{1/3}} = \frac{8^{1/3}}{125^{1/3}} = \mathbf{\frac{2}{5}}$$

4. A heavy nucleus X of mass number 240 and binding energy per nucleon 7.6 MeV is split into two fragments Y and Z of mass numbers 110 and 130. The binding energy of nucleons in Y and Z is 8.5 MeV per nucleon. Calculate the energy Q released per fission in MeV.

Answer:

Given : $^{240}X = {}^{110}Y + {}^{130}Z$

∴ Gain in binding energy for nucleon = 8.5 − 7.6 = 0.9 MeV

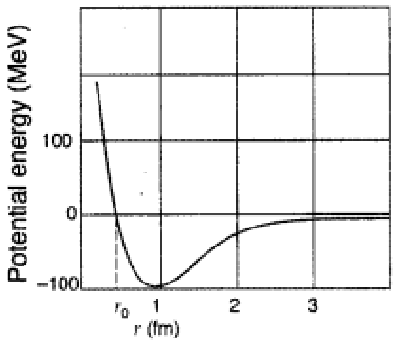
Hence total gain in binding energy per nucleus fission = 240 × 0.9 = 216 MeV

5. Draw a plot of potential energy of a pair of nucleons as a function of their separation. Write two important conclusions which you can draw regarding the nature of nuclear forces.

Answer:

Two important conclusions :

(i) Nuclear force between two nucleons falls rapidly to zero as their distance is more than a few femtometres. This explains constancy of the binding energy per nucleon for large-size nucleus.



(ii) Graph explains that force is attractive for distances larger than 0.8 fin and repulsive for distances less than 0.8 fm.

6.

A nucleus with mass number A = 240 and $\frac{BE}{A}$ = 7.6 MeV breaks into two fragments each of A = 120 with $\frac{BE}{A}$ = 8.5 MeV. Calculate the released energy.

Binding energy of nucleus with mass number 240,

$$(E_{BN})_1 = 240 \times 7.6 \text{ MeV} \quad \ldots(i)$$

Binding energy of two fragments

$$(E_{BN})_2 = 2 \times 120 \times 8.5 \text{ MeV} \quad \ldots(ii)$$

Energy released $= (E_{BN})_2 - (E_{BN})_1$

$= (2 \times 120 \times 8.5) - (240 \times 7.6)$

$= 240(8.5 - 7.6) = 240 \times 0.9$

$= 216$ MeV

7.

Calculate the energy in fusion reaction :

$$^2_1\text{H} + ^2_1\text{H} \longrightarrow ^3_2\text{He} + n,$$

where BE of $^2_1$H = 2.23 MeV and of $^3_2$He = 7.73 MeV

Answer:

Total binding energy of initial system (E_i)

$= {}^2_1\text{H} + {}^2_1\text{H} = (2.23 + 2.23)$ MeV $= 4.46$ MeV

Binding energy of final system

i.e. $^3_2$He (E_f) = 7.73 MeV

Hence, energy released $= E_f - E_i$

$= 7.73$ MeV $- 4.46$ MeV

$= 3.27$ MeV

8) It is found experimentally that,13.6eV energy is required to separate a hydrogen atom into a proton and electron. Compute the orbital radius and the velocity of electron in a hydrogen atom?

Ans. E = - 13.6 eV = $-13.6 \times 1.6 \times 10^{-19}$ J & n=1, e = 1.6 x 10-19C, m = 9.1×10^{-31} kg, k = 9×10^9

T.E of electron = $-K.E = -\frac{e^2}{8\pi\varepsilon o r}$ or $-13.6 \times 1.6 \times 10^{-19} = -\frac{e^2}{2 \times 4\pi\varepsilon o\, r}$ or

r = 5.3×10^{-11} m

K.E = ½ mv^2 = $-\frac{e^2}{8\pi\varepsilon o r}$

v = $\frac{e}{\sqrt{4\pi\varepsilon o m r}}$ = 2.2×10^6m/s

9) Using the Rydberg formula, calculate the wave lengths of the first four spectral lines in the Lyman series of the Hydrogen spectrum. [R = 1.03×10^7/m & c = 3×10^8m/s]

Ans.

$\frac{1}{\lambda}$ = R $[\frac{1}{nf^2} - \frac{1}{ni^2}]$

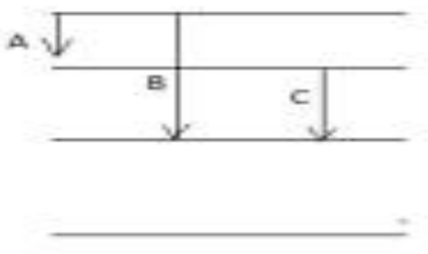
[n_i = 2,3,4 ---] to lower energy level [n_f = 1] , we get

λ_1 = 1218A^0, λ_2 = 1028 A^0, λ_2 = 974.3 A^0, λ_4= 951.4 A^0

10) Obtain the ratio of nuclei radii of gold isotope $_{79}AU^{197}$ & silver isotope $_{47}Ag^{107}$. What is the approximate ratio of the nuclear mass density. R= $R_o A^{1/3}$ [A1= 197,A2 = 107]

$\frac{Rau}{Rag} = \frac{Ro[197]^{1/3}}{Ro[107]^{1/3}}$ = 1.23[ii]1:1,as the mass density does not depend upon the mass no.

11) The energy level diagram of an element is given alongside calculations, which transition corresponds to the emission of a 102.7nm.



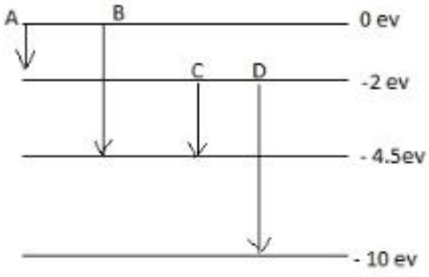
E = $\frac{hc}{\lambda}$ = $\frac{6.6 \times 10^{-34} \times 3 \times 10^8}{102.7 \times 10^{-9}}$ J and in ev ,E = 12.04 ev

E = E2- E1

= -1.51[n =3] - -13.6[n =1] = 12.04 ev

Hence transition is from 3 to 1

12) The energy levels of an atom are shown below. Which of them will result in the transition of a photon of wavelength 275nm? [b] Which transition corresponds to emission of radiation of maximum wave length?



Ans.

a] E = $\frac{hc}{\lambda}$ = $\frac{6.6\, x 10^{-34}\; x 3 x 10^{8}}{275\; x\; 10^{-9}}$ =4.5ev.Hence B

[b] **The radiation of maximum wavelength is emitted when the change in energy is minimum.** Transition A has the minimum change of energy and therefore transition A emits the maximum wave length.

13) Find the wave length of the hydrogen line in the Pfund [n= 4] series that has the largest wavelength.
The largest wavelength corresponds to the smallest frequency. This, in turn, means a transition involving minimum energy. Clearly, the transition from n=5 states to n =4 is what is required [R = 1.097 x $10^7 m^{-1}$]

$\frac{1}{\lambda}$ = R $[\frac{1}{nf^2} - \frac{1}{ni^2}]$ or $\frac{1}{\lambda}$ = R $[\frac{1}{4^2} - \frac{1}{5^2}]$ or λ = 4.05 x 10^{-6} m

LONG ANSWE QUESTIONS

1) Using Rutherford model of the atom, derive the expression to find the total energy of the electron in hydrogen atom. What is the significance of total negative energy possessed by the electron?

2)

(a) State the first two postulates of Bohr's theory of hydrogen atom. Also explain briefly the necessity for invoking these postulates to describe the structure of the atom.

(b) Using Bohr's third postulate, write the Rydberg formula for the spectrum of the hydrogen atom. With the help of this formula, calculate the wavelength of the first member of the spectral line in the Lyman series of the hydrogen spectrum.

(Take the value of Rydberg constant R = 1·03 × 10^7 m^{-1})

ASSERTION REASONING QUESTIONS

Directions: These questions consist of two statements, each printed as Assertion and Reason. While answering these questions, you are required to choose any one of the following four responses.

(a) If both Assertion and Reason are correct and the Reason is a correct

explanation of the Assertion.
(b) If both Assertion and Reason are correct but Reason is not a correct explanation of the Assertion.
(c) If the Assertion is correct but Reason is incorrect.
(d) If both the Assertion and Reason are incorrect.

1) **Assertion:** The force of repulsion between atomic nucleus and α-particle varies with distance according to inverse square law.
Reason: Rutherford did α-particle scattering experiment.

Answer(b) Rutherford confirmed that the repulsive force of α- particle due to nucleus varies with distance according to inverse square law and that the positive charges are concentrated at the centre and not distributed throughout the atom.

2) **Assertion:** In Lyman series, the ratio of minimum and maximum wavelength is 3/4
Reason: Lyman series constitute spectral lines corresponding to transition from higher energy to ground
state of hydrogen atom.
Ans. b

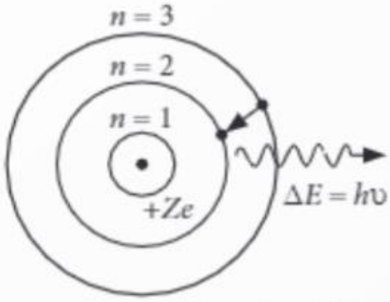
3) **Assertion:** Density of all the nuclei is same.
Reason: Radius of nucleus is directly proportional to the cube root of mass number.
Ans.a

4) **Assertion:** Neutrons penetrate matter more readily as compared to protons.
Reason: Neutrons are slightly more massive than protons.
Ans. b
5) **Assertion:** The mass number of a nucleus is always less than its atomic number.
Reason: Mass number of a nucleus may be equal to its atomic number.
Answer(d) In case of hydrogen atom mass number and atomic number are equal.
CASE BASE STUDY QUESTIONS

1)

Bohr's Model of Hydrogen Atom

Niels Bohr introduced the atomic Hydrogen model in 1913. He described it as a positively charged nucleus, comprised of protons and neutrons, surrounded by a negatively charged electron cloud. In the model, electrons orbit the nucleus in atomic shells. The atom is held together by electrostatic forces between the positive nucleus and negative surroundings.



Bohr correctly proposed that the energy and radii of the orbits of electrons in atoms are quantized, with energy for transitions between orbits given by

$\Delta E = h\upsilon = E_i - E_f$, where ΔE is the change in energy between the initial and final orbits and $h\upsilon$ is the energy of an absorbed or emitted photon.

(i) In the Bohr model of the hydrogen atom, discrete radii and energy states result when an electron circles the atom in an integer number of

(a) de Broglie wavelengths (b) wave frequencies

(c) quantum numbers (d) diffraction patterns.

(ii) The angular speed of the electron in the n^{th} orbit of Bohr's hydrogen atom is

(a) directly proportional to n (b) inversely proportional to $\sqrt{n}$

(c) inversely proportional to n^2 (d) inversely proportional to n^3

(iii) When electron jumps from $n = 4$ level to $n = 1$ level, the angular momentum of electron changes by

(a) $\frac{h}{2\pi}$ (b) $\frac{h}{\pi}$ (c) $\frac{3h}{2\pi}$ (d) $\frac{2h}{\pi}$

(iv) The lowest Bohr orbit in hydrogen atom has

(a) the maximum energy

(b) the least energy

(c) infinite energy

(d) zero energy

(v) Which of the following postulates of the Bohr model led to the quantization of energy of the hydrogen atom?

(a) The electron goes around the nucleus in circular orbits.

(b) The angular momentum of the electron can only be an integral multiple of $h/2\pi$.

(c) The magnitude of the linear momentum of the electron is quantized.

(d) Quantization of energy is itself a postulate of the Bohr model.

Ans.

1. (i) (c)

(ii) (d): $\omega = \frac{v}{r}$. Further $v \propto \frac{1}{n}$ and $r \propto n^2$,
Hence $\omega \propto (1/n^3)$.

(iii) (c)

(iv) (b): The energy of n^{th} Bohr orbit in hydrogen atom is

$$E_n = -\frac{13.6}{n^2} \text{ eV}$$

For lowest orbit, $n = 1$

$\therefore \quad E_1 = -13.6$ eV

Thus, the lowest Bohr orbit in hydrogen atom has the least energy.

(v) (b)

2)

α-particle Scattering Experiment

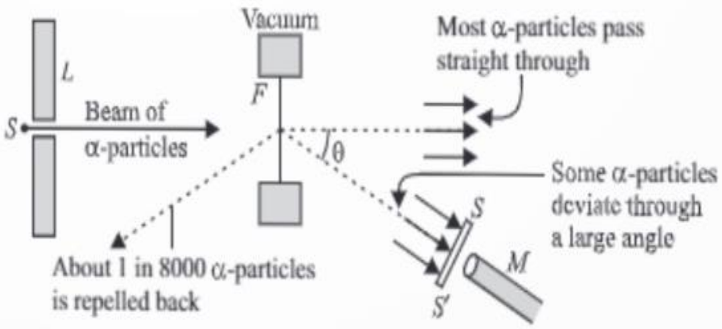
In 1911, Rutherford, along with his assistants, H. Geiger and E. Marsden, performed the alpha particle scattering experiment. H. Geiger and E. Marsden took radioactive source ($^{214}_{83}Bi$) for α-particles. A collimated beam of α-particles of energy 5.5 MeV was allowed to fall on 2.1×10^{-7} m thick gold foil. The α-particles were observed through a rotatable detector consisting of a Zinc sulphide screen and microscope. It was found that α-particles got scattered. These scattered α-particles produced scintillations on the zinc sulphide screen. Observations of this experiment are as follows

(I) Most of the α-particles passed through the foil without deflection.

(II) Only about 0.14% of the incident α-particles scattered by more than 1°.

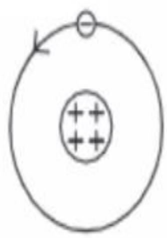
(III) Only about one α-particle in every 8000 α-particles deflected by more than 90°.

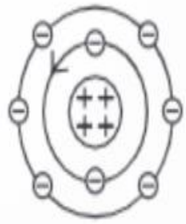
These observations led to many arguments and conclusions which laid down the structure of the nuclear model of an atom.

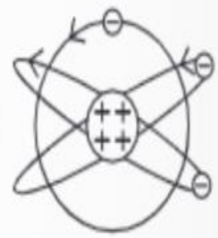


(i) Rutherford's atomic model can be visualised as

(a) 

(b) 

(c) 

(d) 

(ii) Gold foil used in Geiger-Marsden experiment is about 10^{-8} m thick. This ensures

(a) gold foil's gravitational pull is small or possible

(b) gold foil is deflected when α-particle stream is not incident centrally over it

(c) gold foil provides no resistance to passage of α-particles

(d) most α-particle will not suffer more than 1° scattering during passage through gold foil

(iii) In Geiger-Marsden scattering experiment, the trajectory traced by an α-particle depends on

(a) number of collision
(b) number of scattered α- particles
(c) impact parameter
(d) none of these

(iv) In the Geiger-Marsden scattering experiment, in case of head-on collision, the impact parameter should be

(a) maximum
(b) minimum
(c) infinite
(d) zero

(v) The fact only a small fraction of the number of incident particles rebound back in Rutherford scattering indicates that

(a) number of α-particles undergoing head-on-collision is small
(b) mass of the atom is concentrated in a small volume
(c) mass of the atom is concentrated in a large volume
(d) both (a) and (b).

Ans.

2. (i) (d) : Rutherford's atom had a positively charged centre and electrons were revolving outside it. It is also called the planetary model of the atom as in option (d).

(ii) (d): As the gold foil is very thin, it can be assumed that α-particles will suffer not more than one scattering during their passage through it. Therefore, computation of the trajectory of an α-particle scattered by a single nucleus is enough.

(iii) (c) : Trajectory of α-particles depends on impact parameter which is the perpendicular distance of the initial velocity vector of the α particles from the centre of the nucleus. For small impact parameter α particle close to the nucleus suffers larger scattering.

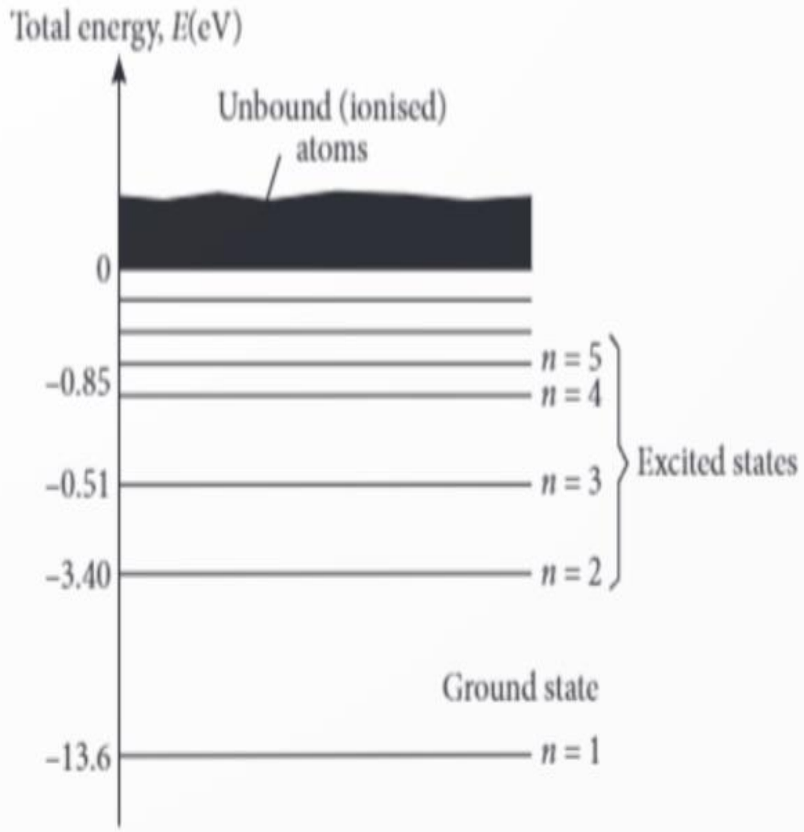
(**iv**) (**b**): At minimum impact parameter, α particles rebound back ($\theta \approx \pi$) and suffers large scattering.

(**v**) (**d**): In case of head-on-collision, the impact parameter is minimum and the α-particle rebounds back. So, the fact that only a small fraction of the number of incident particles rebound back indicates that the number of α-particles undergoing head-on collision is small. This in turn implies that the mass of the atom is concentrated in a small volume. Hence, option (a) and (b) are correct.

3)

Excited State of Atom

At room temperature, most of the H-atoms are in ground state. When an atom receives some energy (*i.e.*, by electron collisions), the atom may acquire sufficient energy to raise electron to higher energy state. In this condition, the atom is said to be in excited state. From the excited state, the electron can fall back to a state of lower energy emitting a photon equal to the energy difference of the orbit.



In a mixture of H—He^+ gas (He^+ is single ionized He atom), H-atoms and He^+ ions are excited to their respective first excited states. Subsequently, H-atoms transfer their total excitation energy to He^+ ions (by collisions).

(i) The quantum number n of the state finally populated in He^+ ions is

(a) 2 (b) 3 (c) 4 (d) 5

(ii) The wavelength of light emitted in the visible region by He^+ ions after collisions with H-atoms is

(a) 6.5×10^{-7} m (b) 5.6×10^{-7} m (c) 4.8×10^{-7} m (d) 4.0×10^{-7} m

(iii) The ratio of kinetic energy of the electrons for the H-atoms to that of He^+ ion for $n = 2$ is

(a) $\frac{1}{4}$ (b) $\frac{1}{2}$ (c) 1 (d) 2

(iv) The radius of the ground state orbit of H-atoms is

(a) $\frac{\varepsilon_0}{h\pi me^2}$ (b) $\frac{h^2\varepsilon_0}{\pi me^2}$ (c) $\frac{\pi me^2}{h}$ (d) $\frac{2\pi h\varepsilon_0}{me^2}$

(v) Angular momentum of an electron in H-atom in first excited state is

(a) $\frac{h}{\pi}$ (b) $\frac{h}{2\pi}$ (c) $\frac{2\pi}{h}$ (d) $\frac{\pi}{h}$

3. (i) (c) : $E_n = \frac{-13.6}{n^2}(Z^2)$

In first excited state, $E_{H_2} = 3.4$ eV and $E_{He} = -13.6$ eV

So, H_2 atom gives excitation energy

(13.6 – 3.4 = 10.2 eV) to helium atom

Now, energy of He ion = –13.6 + 10.2 = –3.4 eV

Again, $E = \frac{-13.6}{n^2} \times Z^2$

$$\Rightarrow \quad -3.4 = \frac{-13.6}{n^2} \times (2)^2 \Rightarrow n = 4$$

(ii) (c) : $\frac{1}{\lambda} = \frac{13.6Z^2}{hc}\left[\frac{1}{n_1^2} - \frac{1}{n_2^2}\right]$

Here, $n_1 = 3$ and $n_2 = 4 \Rightarrow \lambda = 4.8 \times 10^{-7}$ m

(iii) (a) : Kinetic energy, $K \propto \frac{Z^2}{n^2}$

$$\frac{K_{H_2}}{K_{He}} = \left(\frac{Z_{H_2}}{Z_{He}}\right)^2 = \left(\frac{1}{2}\right)^2 = \frac{1}{4}$$

(iv) (b): Radius of the permitted orbit is $r = \frac{n^2h^2\varepsilon_0}{\pi mZe^2}$

For hydrogen atom in ground state, *i.e.*,

$$n = 1, Z = 1 \Rightarrow r = \frac{h^2\varepsilon_0}{\pi me^2}$$

(v) (a): Angular momentum for hydrogen atom is

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

For first excited state, $n = 2$, $L = \frac{h}{\pi}$

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