09. Atoms, Molecules and Nuclei

9.0 Basic concepts :

Matter appears to be continuous and it is composed of very small independent particles. The ultimate particles of matter are known as atoms. Various atom models were given to explain the structure of atom. A theoretical explanation for the structure of atom is called as an atom model.

Thomson's atom model:

1. The First empirical atom model was proposed by Thomson in 1904.
2. According to this model, an atom is a uniform sphere of positively charged material of radius of about 10^{-10} m in which electrons are embedded.
3. This model explain the thermionic emission, photoelectric emission and the emission and absorption of spectrum of single wavelength.
4. Thomson's model could not explain discrete emission of radiations and large angle scattering of α –particles.
5. The embedding of electrons in the positive charge space is like seeds in water melon or plums in the pudding (food). For this reason Thomson's atom model is also called as plum–pudding model.

9.1 Geiger–Marsden experiment of scattering of α – particles

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9.2 Rutherford's atom model

Rutherford's experiment and atom model:

1. Rutherford's atomic model was proposed by Rutherford in 1906 to explain scattering of α – particles.
2. **Postulates of model:**

i) According to Rutherford atom consist of a very small central core called as nucleus. The nucleus contains positive charge and almost entire mass of the atom is said to be concentrated at the nucleus.

ii) The radius of nucleus (10^{-15} m to 10^{-14} m) is very small compared to the radius of the atom (10^{-10} m). The nucleus is surrounded by electrons which are revolving round the nucleus in different circular orbits under the coulomb's force of attraction between the electrons and the nucleus which provides necessary centripetal force for its circular motion.

iv) The total negative charge of electrons is equal to the total positive charge of nucleus hence atom as a whole is said to be electrically neutral.

3. Density of nucleus $\approx 10^{17}$ kg/m^3 $\approx 10^{14}$ gm/cc
4. Radius of nucleus is given by, r $\propto$ A$^{1/3}$ where A–mass number of nucleus.
5. Rutherford's atomic model could explain radioactivity and scattering of α –particles.
6. **Drawbacks of Rutherford's atom model:**

   i) According to Rutherford atom consist of positively charged nucleus and electrons are revolving round the nucleus in different circular orbits. Hence the motion of electrons is accelerated motion.

   According to classical theory of electromagnetic radiation any accelerated charge radiates energy hence there will be continuous loss of energy of electrons. Hence electron will not revolve along the same circular path but it will revolve along the spiral path and finally it will drop into the nucleus. Therefore atom becomes unstable. But it is found that electron does not exist inside the nucleus

   ii) As the radius of the circular orbit decreases, electron will emit radiation of constantly increasing frequency.

   Hence it gives continuous spectrum of light.

   However infact line spectrum of light is obtained.

7. **Planck's quantum theory:** Quantum theory of light was proposed by Planck in 1900. According to PLANCK'S quantum theory any electromagnetic radiation is emitted or absorbed in the form of discrete units. Each unit is called as photon or quantum.

The energy of each photon = $E = h\nu = \frac{hc}{\lambda}$

9.3 Bohr's atom model

Bohr's theory of H–atom (Bohr's atom model):

1. Niels Bohr in 1913, modified Rutherford's atom model in order to explain the stability of the atom and the emission of the spectral lines. This model is modification of Rutherford's model which is based on Planck's quantum theory.

2. **Postulates of Bohr's model:**

i) Circular orbits: In H–atom, electron is revolving round the nucleus in a circular orbit under the Coulomb's force of attraction between electron and nucleus which provides necessary centripetal force for its circular motion.

Thus, $\frac{1}{4\pi \epsilon_0}\frac{e^2}{r^2} = \frac{mv^2}{r}$

ii) Stationary orbits: The allowed orbits for electron are those in which the electron does not radiate energy. These orbits are stationary orbits or non radiating orbits or Bohr's orbit.

iii) Quantum condition; The stationary orbits are those in which angular momentum of electron is equal to integral multiple of $h/2\pi$

i.e. $I\omega = \frac{nh}{2\pi}$ or $mvr = \frac{nh}{2\pi}$

where n–principle quantum number.

iv) Stationary nucleus : The nucleus is so heavy that its motion may be neglected.

v) Constancy of mass: The mass of electron in motion remains constant.

vi) Transitions : When an electron jumps from one stationary to another stationary orbit, a photon is emitted or absorbed having energy difference equal to the difference of energies between initial and final states and being given by,

$h\nu = E_n - E_p$

3. **Drawbacks of Bohr's model:**

i) It can not explain the spectra of atoms or ions having more than one electron.

ii) When a spectral line is observed under a powerful microscope, it is found to consist of a number of closely spaced lines. Bohr's model does not explain the fine structure of a spectral line.

iii) It does not explain the splitting of a spectral line into a number of spectral lines under the effect of magnetic field (ZEEMAN effect) and electric field (Stark effect).

iv) It does not tell about the relative intensities of spectral lines.

v) It considers electron only as a particle, but the electron exhibits wave nature also.

vi) The researches show that the charge distribution of electron in different orbits is altogether different from one assumed in Bohr's model.

Radius and energy of Bohr's orbit:

1. Radius of nth Bohr's orbit is,

$$r_n = \frac{\epsilon_0 n^2h^2}{\pi me^2} = \frac{\epsilon_0 n^2h^2}{\pi me^2 Z} = \frac{0.53n^2}{Z} \text{ Å}$$

Thus, $r_n \propto n^2$ and $r_n \propto \frac{1}{Z}$ (For H–atom Z = 1)

The graph between r_n and n^2 is a straight line, while graph between r_n and Z is a rectangular hyperbola. The relation between, radius of first orbit and n^{th} orbit is given by, $r_n = r_1 n^2$

The relation between, radius of first orbit and nth orbit for any atom of atomic number Z and nuclear charge +Ze is given by

$$r_n = \frac{r_1 n^2}{Z}$$

The radius of electron in first orbit = r_1 = 0.53 Å

2. **Energy of electron in Bohr's orbit :**

i) K.E. of electron in Bohr's orbit is,

$$K.E. = \frac{1}{8\pi \epsilon_0}\frac{e^2}{r} = \frac{1}{8\pi \epsilon_0}\frac{Ze^2}{r}$$

ii) P.E. of electron in Bohr's orbit is,

$$P.E. = -\frac{1}{4\pi \epsilon_0}\frac{e^2}{r}$$

$$= -\frac{1}{4\pi \epsilon_0}\frac{Ze^2}{r}$$

iii) Total energy of electron in Bohr's orbit is,

$$T.E., \quad E_n = \frac{1}{8\pi \epsilon_0}\frac{e^2}{r}$$

$$= \frac{1}{8\pi \epsilon_0}\frac{Ze^2}{r}$$

$$= -\frac{mZ^2e^4}{8\epsilon_0^2 n^2h^2} = -\frac{me^4}{8\epsilon_0^2 n^2h^2}$$

Thus, $E_n \propto \frac{1}{r}$ and $E_n \propto \frac{1}{n^2}$

The relation between energy of electron in first orbit and nth orbit is given by,

$$E_n = \frac{E_1}{n^2}$$

The relation between, energy of electron of first orbit and nth orbit for any atom of atomic number Z and nuclear charge +Ze is given by,

$$E_n = \frac{E_1 Z^2}{n^2}$$

The energy of electron in first orbit $= E_1$

$= -13.6$ eV

iv) Energy of electron in eV $= \frac{12420}{\lambda(\text{in Å})}$

v) Though energy is inversely proportional to n^2 but because of the presence of negative sign, energy of electrons increases as the number of orbit increases. Thus, energy is minimum in innermost orbits and maximum in outermost orbits. i.e. electrons in the innermost orbit are tightly bound to the nucleus.

vi) P.E. of electron is equal to minus of two times K.E. of electron i.e. P.E. = – 2 K.E.

vii) Negative sign in the equation of total energy indicates that, the electron is bound to the nucleus. Thus, negative sign is a measure of stability of electron in an orbit.

viii) B.E. of electron: The minimum amount of energy supplied to an electron in the ground state of H–atom by which it will escape from H–atom is called as binding energy of electron.

Thus, B.E. of electron $= \frac{me^4}{8\epsilon_0^2 n^2h^2}$

ix) Ground state and excited states: The energy state corresponding to n = 1 or lowest energy state is called as ground state. When energy is supplied to atom, the electron jumps to some higher energy state. The higher energy state of the atom is called as excited state of the atom. These higher states corresponding to n = 2, 3, 4, are called as first, second, third, excited states respectively. The electron can remain in this state 10–8 second.

After the lapse of this time, the electron return to ground state and emits balance of energy in the form of electromagnetic waves.

×) Excitation: The process of absorption of energy by electron, so as to raise it from a lower energy state to higher energy state is called as excitation.

xi) Excitation energy: The amount of energy supplied to an electron in H–atom, so as to take it from ground state to anyone of excited energy state is called as excitation energy.

e.g. first excitation energy $= E_2 - E_1$

$= -3.4 + 13.6$

$= 10.2$ eV

xii) Excitation potential : The potential applied to an electron in H–atom, (i.e. potential difference) so that it will be shifted from its ground state to anyone of the excited state is called as excitation potential. Hence first excitation potential for hydrogen atom = 10.2 volt.

xiii Ionisation : The process of knocking an electron out of the atom is called as ionisation.

xiv) Ionisation energy : The minimum or particular amount of energy supplied to an electron in the ground state of H–atom, so that it will escape from H–atom is called as ionisation energy.

xv) Ionisation potential: The minimum energy required to escape an electron from its lowest energy state to infinity i.e. to an orbit at which energy is zero is called as ionisation potential.

Thus, ionisation potential $= E_\infty - E_1$

$= 0 - (-13.6)$

$= 13.6$ eV

Important formulae :

1. i) Velocity of electron in nth Bohr's orbit is given by,

$$v_n = \frac{e^2}{2\epsilon_0 nh} \quad \text{or} \quad v_n = \frac{Ze^2}{2\epsilon_0 nh}$$

Thus, $v_n \propto 1/n$ i.e. velocity of electron in Bohr's orbit is inversely proportional to principle quantum number.

ii) The relation between velocity of electron in nth and ground state orbit is given by,

$$v_n = \frac{v_1}{n}$$

The relation between, velocity of electron in first orbit and nth orbit for any atom of atomic number Z and nuclear charge +Ze is given by

$$v_n = \frac{v_1 Z}{n}$$

The velocity of electron in first orbit = v_1
= 2.182×10^6 m/s.

iii) The velocity of electron in Bohr's orbit is also given by,

$$v_n = \frac{1}{4\pi\epsilon_0}\frac{2\pi e^2}{nh} = \left(\frac{1}{4\pi\epsilon_0}\frac{2\pi e^2}{ch}\right)\frac{c}{n}$$

The factor, $\frac{1}{4\pi\epsilon_0}\frac{2\pi e^2}{ch}$ is called fine structure constant, having a value $\frac{1}{137}$.

Thus, velocity of electron is,

$v_n = \frac{1}{137}\left(\frac{c}{n}\right)$, where c–velocity of light.

2. Angular speed of electron in nth Bohr's orbit is given by,

i) $$\omega_n = \frac{\pi m e^4}{2\epsilon_0^2 n^3 h^3}$$

ii) $$\omega_n = \frac{\omega_1}{n^3}$$

Also ($\omega_n \propto 1/n^3$ i.e. angular velocity of electron in Bohr's orbit is inversely proportional to cube of principle quantum number.

iii) The relation between, angular speed of electron in first orbit and nth orbit for any atom of atomic number Z and nuclear charge +Ze is given by

$$\omega_n = \frac{\omega_1 Z^2}{n^3}$$

The angular velocity of electron in first orbit
= ω_1
= 4.103×10^{16} rad/s

3. Frequency of revolution of electron in nth Bohr's orbit is given by,

i) $$f_n = \frac{me^4}{4\epsilon_0^2 n^3 h^3}$$

ii) $$f_n = \frac{f_1}{n^3}$$

Thus, $f_n \propto 1/n^3$ i.e. frequency of revolution of electron in Bohr's orbit is inversely proportional to cube of principle quantum number.

iii) The relation between, frequency of revolution of electron in first orbit and nth orbit for any atom of atomic number Z and nuclear charge +Ze is given by

$$f_n = \frac{f_1 Z^2}{n^3}$$

The frequency of revolution of electron in first orbit
= $f_1 = 6.53 \times 10^{15}$ Hz.

4. The period of revolution of electron in nth Bohr's orbit is given by,

i) $$T_n = \frac{4\epsilon_0^2 n^3 h^3}{me^4}$$

ii) $T_n = T_1 n^3$

Thus, $T_n \propto n^3$ i.e. period of revolution of electron in Bohr's orbit is proportional to cube of principle quantum number.

iii) The relation between, period of revolution of electron in first orbit and nth orbit for any atom of atomic number Z and nuclear charge +Ze is given by

$$T_n = \frac{T_1 n^3}{Z^2}$$

The period of revolution of electron in first orbit
= $T_1 = 1.53 \times 10^{-16}$ s.

5. The centripetal acceleration of electron in Bohr's orbit is given by,

$$\text{Centripetal acceleration} = \frac{\pi m e^6}{4\epsilon_0^3 n^4 h^4}$$

Thus, centripetal acceleration of electron in Bohr's orbit is inversely proportional to forth power of its principle quantum number.

The centripetal acceleration of electron in first orbit = $a_1 = 8.983 \times 10^{22}$ m/s².

6. The total energy of electron in terms of Rydberg's

constant is given by,

$$E_n = -\frac{Rch}{n^2}$$

Note:

i) The linerar momentum of electron in first orbit
$= P_1 = 1.985 \times 10^{-24}$ kg m/s.

ii) The angular momentum of electron in first orbit
$= L_1 = 1.055 \times 10^{-34}$ J s.

9.4 Hydrogen spectrum

Origin or emission of spectral lines in H–atom spectrum:

When an electron jumps from outer stationary orbit to inner stationary orbit, then a photon of energy hv or a spectral line of wavelength A or a light radiation of frequency v is emitted. The difference of energies associated with these orbits is the energy of photon.

i.e. $hv = E_n - E_p$

1. The wavelengths of a spectral line is given by,

$$\frac{1}{\lambda} = R\left(\frac{1}{p^2} - \frac{1}{n^2}\right) \text{ and } \frac{1}{\lambda} = Z^2 R\left(\frac{1}{p^2} - \frac{1}{n^2}\right)$$

where $R = \frac{me^4}{8\epsilon_0^2 h^3} = 1.097 \times 10^7 \ m^{-1}$ is called as Rydberg's constant.

2. The frequency of emitted radiation due to the transition of electron is given by,

$$v = \frac{c}{\lambda} = cR\left(\frac{1}{p^2} - \frac{1}{n^2}\right) \text{ and}$$

$$v = Z^2 cR\left(\frac{1}{p^2} - \frac{1}{n^2}\right)$$

3. The reciprocal of wavelength is called as wave number ($\bar{\lambda}$).

Spectrum of H–atom :

According to certain common' characteristics the spectrum of H–atom is divided into following spectral series.

1. Lyman series:

i) If the transition of electrons is on first orbit (p = 1) from different outer orbits like, (n = 2,3,4, ...) then Lyman series of spectral lines is emitted. Lyman series of spectral lines lies in ultraviolet region.

ii) The wavelength of spectral lines in Lyman series is given by

$$\frac{1}{\lambda} = R\left(1 - \frac{1}{n^2}\right)$$

iii) a) For first spectral line p = 1 and n = 2

b) For second spectral line p = 1 and n = 3
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c) Longest wavelength of Lyman series: For longest wavelength of Lyman series, p =1 and n = 2.
The longest wavelength of Lyman series is, 1216 Å.

d) Shortest wavelength (series limit) of Lyman series: For shortest wavelength of Lyman series, p = 1 and n = ∞ .
The shortest wavelength of Lyman series is, 912 Å.

2. Balmer series:

i) If the transition of electron is on second orbit (p = 2) from different outer orbits (n = 3, 4, 5, ...) then Balmer series of spectral lines is emitted. Balmer series of spectral lines lies partly in the visible region of the spectrum.

ii) The wavelength of spectral lines in Balmer series is given by

$$\frac{1}{\lambda} = R\left(\frac{1}{2^2} - \frac{1}{n^2}\right)$$

iii) a) For first spectral line p = 2 and n = 3

b) For second spectral line p = 2 and n = 4.

c) Longest wavelength of Balmer series: For longest wavelength of Balmer series, p = 2 and n = 3.
The longest wavelength of Balmer series is, 6563 Å.

d) Shortest wavelength (series limit) of Balmer series: For shortest wavelength of Balmer series, p = 2 and n = ∞ .
The shortest wavelength of Balmer series is, 3648 Å.

e) In Balmer series, fist spectral line, second spectral line, third spectral line are respectively called as H_α, H_β and H_γ lines.

3. **Paschen series:**

i) If the transition of electron is on third orbit (p = 3) from different outer orbits (n = 4, 5, 6, ...) then Paschen series of spectral lines is emitted.

Paschen series of spectral lines lies in infra red region of the spectrum.

ii) The wavelength of spectral lines in Paschen series is given by,

$$\frac{1}{\lambda} = R\left(\frac{1}{3^2} - \frac{1}{n^2}\right)$$

iii) a) For first spectral line p = 3 and n = 4

b) For second spectral line p = 3 and n = 5.

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c) Longest wavelength of Paschen series: For longest wavelength of Paschen series, p = 3 and n= 4.

The longest wavelength of Paschen series is, 18761.1 Å.

d) Shortest wavelength (series limit) of Paschen series: For shortest wavelength of Paschen series, p = 3 and n = ∞.

The shortest wavelength of Paschen series is, 8208 Å.

4. **Brackett series:**

i) If the transition of electron is on fourth orbit (p = 4) from different outer orbits (n = 5, 6, 7, ...) then Brackett series of spectral lines is emitted. Brackett series of spectral lines lies in infra red and far infra red regions of the spectrum.

ii) The wavelength of spectral lines in Brackett series is given by,

$$\frac{1}{\lambda} = R\left(\frac{1}{4^2} - \frac{1}{n^2}\right)$$

iii) a) For first spectral line p = 4 and n = 5.

b) For second spectral line p = 4 and n = 6.

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c) Longest wavelength of Brackett series: For longest wavelength of Brackett series, p = 4 and n = 5.

The longest wavelength of Brackett series is, 40533.3 Å.

d) Shortest wavelength (series limit) : For shortest wavelength of Brackett series, p = 4 and n = ∞.

The shortest wavelength of Brackett series is, 14592 Å.

5. **Pfund series:**

i) If the transition of electron is on fifth orbit (p = 5) from different outer orbits (n = 6, 7, 8, ...) then Pfund series of spectral lines is emitted.

Pfund series of spectral lines lies in far infra red region of the spectrum.

ii) The wavelength of spectral lines in P.fund series is given by,

$$\frac{1}{\lambda} = R\left(\frac{1}{5^2} - \frac{1}{n^2}\right)$$

iii) a) For first spectral line p = 5 and n = 6.

b) For second spectral line p = 5 and n = 7.

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c) Longest wavelength of Pfund series: For longest wavelength of Pfund series, p = 5 and n = 6. The longest wavelength of Pfund series is, 74618.18 Å.

d) Shortest wavelength (series limit) of Pfund series: For shortest wavelength of Pfund series, p = 5 and n = ∞.

The shortest wavelength of Pfund series is, 22800 Å.

Remark:

1. In the emission spectrum, due to high temperature electron are present in all possible levels, hence in emission spectrum all series are obtained. But in absorption spectrum due to low temperature, almost all electron of all atom are present in lowest energy level, hence in absorption spectrum we get only Lyman series at ordinary temperature.

2. If the electrons are initially to a excited state represented by the principle quantum number n then the total number of spectral lines emitted

are $\frac{n(n-1)}{2}$.

3. As n becomes larger and larger the energy level come closer and closer.

9.5 Composition and size of nucleus

1. Nucleus was first discovered by Rutherford in 1911. According to Rutherford, atom consist of small, central, massive and positive core called as nucleus. Nucleus is surrounded by electrons, which are revolving round the nucleus in different circular orbits.
2. Radius of nucleus is of about to 10^{-14} m and it is 10,000 times smaller than size of the atom.
3. Nucleus consists of positively charged protons (Z) and uncharged neutrons (N). The total number of protons and neutrons are called as nucleons. The total number of protons and neutrons i.e. A = Z + N is also called as atomic mass number. The total number of protons in the nucleus of an atom is called as atomic number. The total number of electrons in nth orbit = $2n^2$.
4. The atomic number gives total number of protons and electrons. However total number of neutrons in the nucleus of an atom is , N = A – Z.
5. Protons: It was discovered by Rutherford in 1919, while positive rays was discovered by Goldstein. The charge of proton is, 1.602×10^{-19} C
   The rest mass of proton is, 1.6726 × 10–27 kg or 1.0073 a.m.u. Further rest mass of proton is 1836.1 times the rest mass of electron. It has got interinsic angular momentum (spin equal to lA. It also possesses a very small magnetic moment as compared to that of electron.
6. Neutron: It was discovered by Chadwick in 1932. Neutron is chargeless and it is present in nucleus. It is unstable during radioactivity. It splits into proton and electron. The rest mass of neutron is 1.6749×10^{-27} kg or 1.0086 a.m.u. Further rest mass of neutron is 1836.6 times mass of electron. Neutron has got intrinsic angular momentum equal to that of proton i.e. $\frac{1}{2}$. The uncharged neutron might be expected to have no magnetic moment since magnetic moment is effect of rotating charge, but it has a very mall magnetic moment compared to electron.
7. Isotopes : The atoms of an element having same atomic number but different mass number (i.e. same number of protons and different number of neutrons) are called as isotopes.
   e.g. $_{82}Pb^{206}$ & $_{82}Pb^{207}$

8. More About Nucleus

i) Size of the Nucleus:

Nuclear size is expressed in 'fermi'

1 fermi is equivalent to 10^{-15} m

The radius of the nucleus is given by $R = R_0A^{1/3}$

where 'R_0' is a constant and is equal to 1.2×10^{-15} m

= 1.2 fermi

'A' is the mass number of the nucleus

Nuclear radius is about 10^{-15} m = 1 fermi

Atomic radius is about 10^{-10} m = 1 AU

ii) Mass of the Nucleus:

The mass of nucleus is equal to the sum of the masses of the neutrons and protons present in it. i.e., Mass of the nucleus = $ZM_P + (A - Z)M$, where "Z' is the atomic number (number of protons), (A – Z) is the number of neutrons. 'M_P' is the mass of the proton, M, is the mass of the neutron.

Nuclear masses are expressed in terms of atomic mass units (a.m.u.).

iii) Nuclear density:

$$\text{Nuclear density } (e) = \frac{\text{Mass of the nucleus}}{\text{Volume of the nucleus}}$$

$$= \frac{Z_{MP} + (A-Z)M_n}{\frac{4}{3}\times\pi(R^3)}$$

$$= 2 \times 10^{17} \text{ kg/m}^3.$$

Remark: The value of nuclear density is same for all nucleus.

9. Isobars : The atoms of an element having same atomic mass number but different atomic numbers are called as isobars.
   e.g. $_6C^{14}$ & $_7N^{14}$.
10. Isotones : The atoms of an element whose nucleus has same number of neutrons but different number of protons are called as isotones of that element.
    e.g. $_6C^{14}$ & $_7N^{15}$.

11. Einstein's mass energy relation:

In Newton's theory, it was assumed that mass of a particle is always constant and it is independent on velocity of a particle.

Einstein assumed that mass is one form of energy. It can be converted into energy and vice versa. Einstein's mass energy equivalence relation is given by, $E = mc^2$

In theory of relativity, Einstein proved that mass of a particle depends on velocity. The mass of a particle is given by

$$m = \frac{m_0}{\sqrt{1-\frac{v^2}{c^2}}} \qquad \text{..... (1)}$$

Where, m_0 = mass of a particle when it is at rest.

m = mass of a particle whenit is moving with velocity v.

v = velocity of a particle.

c = velocity of light

$$E = \left(\frac{m_0}{\sqrt{1-\frac{v^2}{c^2}}}\right)c^2$$

$$= m_0\left(1-\frac{v^2}{c^2}\right)^{-1/2} e^2$$

$$= m_0\left(1-\frac{v^2}{2c^2}\right)e^2$$

(By using binomial theorem)

$${}_0c^2 + \frac{1}{2}\ m_0v^2 \qquad \text{..... (2)}$$

Where $\frac{1}{2}\ m_0\ v^2$ = Kinetic energy of the particle and m_0c^2 is the energy of the particle when it as rest.

According to Planck's quantum theory the energy emitted or absorbed by a particle is given by,

$$E = hv \qquad \text{..... (3)}$$

If a charged particle of charge e is accelerated by a potential difference V then the energy acquired by that particle is given by

$$E = e.V \qquad \text{..... (4)}$$

Thus $E = mc^2 = hV = eV = \frac{1}{2}\ m_0v^2$

This eq^n. is called as Einstein's mass energy equivalence relation. The experimental proof of above eq^n. can be obtained in nuclear phenomenon like fusion, fission, production of X–rays, production of y–rays etc.

Energy of electron,

$$E_e = m_ec^2$$

$$= (9.1 \times 10^{-31}) \times (3 \times 10^8)^2 \text{ joule}$$

$$= \frac{9.1 \times 9 \times 10^{-31} \times 10^{16}}{1.6 \times 10^{-19}} \text{eV}$$

$$= 0.511 \times 10^6 \text{ eV}$$

$$E_e = 0.511 \text{ MeV}$$

Similarly, the energies of proton and neutron are,

$$E_P = 941.1 \text{ MeV and } E_n = 942.2 \text{ MeV}$$

12. Atomic mass unit :

A mass equal to $(1/12)^{th}$ mass of the one carbon atom is called as atomic mass unit.

$$1 \text{ a.m.u.} = \frac{1}{12} \text{ mass of one carbon atom}$$

$$= \frac{1}{12} \times 1.9926 \times 10^{-26}$$

$$= 1.660 \times 10^{-27} \text{ kg.}$$

According to Einstein's mass energy equation, energy equivalent of above mass is given by,

$$E = mc^2$$

$$= 1.660 \times 10^{-27} \times (3 \times 10^8)^2 \text{ J}$$

$$= \frac{9.1 \times 9 \times 10^{-31} \times 10^{16}}{1.6 \times 10^{-19}} \text{ eV}$$

$$= 931.5 \times 10^6 \text{ eV}$$

$$= 931.5 \text{ MeV.}$$

13. Mass defect :

The mass of a stable nucleus is always less than the sum of the masses of its nucleons. The decrease in the measured mass of the nucleons is called the mass defect.

If Z is the atomic number, A is the mass number, the number of neutrons inside the nucleus is A – Z. Let mp be the mass of a proton, mn be the mass of a neutron and m be the measured mass of the nucleus. Then the mass defect Am = Zm_p + (A – Z) mn – m.

14. Binding energy:

When nucleons are formed together into a nucleus, the mass which disappears is converted into energy and this energy is utilized in binding the nucleons together inside the nucleus. Hence this is called Binding energy.

If Δm is the mass defect, the binding energy is given by,

$$BE = \Delta m \times c^2$$
$$= ((Zm_p + (A - Z)m_n) - m) \times c^2.$$

If Δm is expressed in a.m.u. then binding energy is given by,

$$BE = \Delta m \times 931 \text{ MeV}$$

Note: The amount of energy required to break the nucleus into its constituent particles is equal to the binding energy.

15. Binding energy per nucleon:

Binding energy per nucleon

$$= \frac{\text{Binding energy}}{\text{Mass number}}$$

$$= \frac{\Delta m \times c^2}{A} = \left[\frac{Zm_p + (A - Z)m_n - m}{A}\right]c^2$$

$$= \frac{\Delta m \times 931}{A} \text{ MeV / nucleon}$$

Fig. 9.4 shows plot of B.E. per nucleon versus the mass number A for different nuclei. The B.E. curve is an indicator of nuclear stability. The higher the B.E. per nucleon, the greater is the stability of the nucleus.

From B.E. curve we concludes that:

1. The B.E. per nucleon is practically constant and is independent of mass number for nuclei, $30 < A < 170$.
2. It is maximum 8.75 MeV, for A = 56 and is 7.6 MeV, for A = 238.
3. It is low for both light nuclei (A < 30) and heavy nuclei (A > 170). This means that the nucleons of atoms are loosely bound with nucleus.
4. When heavy nucleus (A = 240) breaks into lighter nuclei (A = 120), B.E. increases i.e. nucleons get more tightly bound.
5. When very light nuclei A < 10, join to form a heavier nucleus, B.E. increases, i.e. nucleons get more tightly bound.

In both the cases, there is release of energy because, the new nuclei formed have less mass and are more stable.

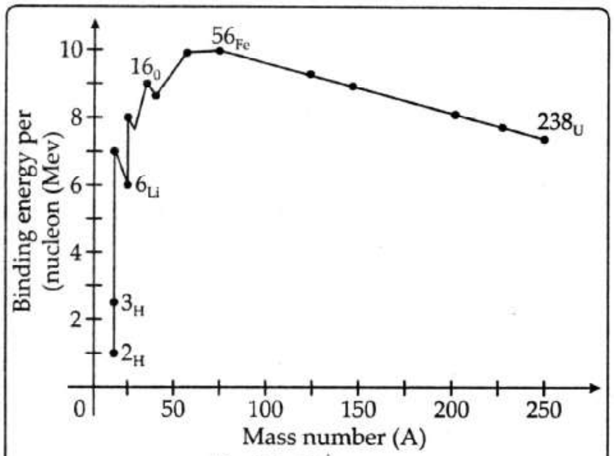

Fig. 9.4 : B.E. curve

16. Packing fraction: The mass defect per nucleon is called packing fraction.

$$\text{Packing fraction} = \frac{\Delta m}{A}$$

Remark: If smaller is the value of packing fraction $\left(\frac{\Delta m}{A}\right)$ greater will be the stability of the nucleus and vice versa.

9.6 Radioactivity

1. The phenomenon of radioactivity was discovered by Henry Becquerel in 1896.
2. The process of spontaneous emission of highly penetrating and invisible radiations from heavy elements is called as radioactivity.
3. The heavy elements whose atomic number is greater than or equal to 80 are called radioacitve elements and radiations emitted by them are called as radioactive rays or Becquerel rays.
4. The process of radioactivity is spontaneous i.e. it can neither be started, stopped, accelerated nor retarded under any physical circum stances.
5. The strong repulsive forces between the protons of the nucleus of heavy elements is the main cause for natural radioactivity.
6. Radioactivity is a nuclear process because origin of radioactivity lie at nucleus. The phenomenon of radioactivity remains unaffected due to physical or chemical charges.

NATURE OF RADIOACTIVE RAYSOR DETECTION OF α, β AND γ RAYS

1. Rutherford studied effect of electric and magnetic

field on the radioactive rays in 1902.

2. Rays which are defected towards the negative plate are called α–rays.
3. Rays which are deflected towards the positive plate are called β–rays.
4. Rays which go undeflected in the electric and magnetic field are called as γ–rays.
5. No radioactive substance emits α and β–particles, simultaneously. Some substances emit α–particles, some other emits β–particles. γ–rays are emitted alongwith both a and y particles.

PROPERTIES OF α, β AND γ RAYS

1. Properties of α–rays:

a) α–rays are positively charged particles. α–particle is nucleus of helium atom ($_2He^4$).
In one α–particle, there are two protons and two neutrons. They come out of nucleus.

b) α–particles carry double the positive charge of proton and are four times as heavy as the proton.

c) When one α–particle is emitted from the radioactive element then its' atomic number decreases by two and mass number decreases by four.

d) The velocity of α–rays (1.45×10^7 m/s to 2.2×10^7 m/s) is less than that of β–rays and γ–rays. The speed of α–rays is about $\frac{1}{10}$ times that of light.

e) They are deflected by electric and magnetic field.

f) Their ionising power is more than β–rays and γ–rays (i.e. 100 times that of β–rays).

g) Their penetrating power is less than β and γ–rays (i.e. 100 times less than β–rays).

h) They affect a photographic plate.

i) They produce fluorescence in substances like zink sulphide and barium platino cyanide.

j) Energy of α–particles emitted form radioactive substances varies from 4.19 to 6.78 MeV.

k) α–particles can produce artificial radioactivity in certain elements and can produce nuclear reaction.

l) α–particles may cause burn on human body.

m) On being stopped, α–particles produce heating effect.

n) The rest mass of α–particle is 6.6×10^{-27} kg

o) The range of α–particles in air varies from 3 to 8 cm.

2. Properties of β–rays:

a) β–rays are negatively charged particles.

β–particleis equivalent with electrons. β–raysare largely deflected towards positive plate.

b) They come out of nuclus. In nucleus, neutron splits up into,

1 neutron = 1 proton + 1 electron + antineutrino.

c) When one β–particle is emitted from the radioactive element then its atomic number increases by one and mass number remains constant.

d) The velocityof β–rays (3×10^7 m/s to 2.96×10^8 m/s) is greater than α–rays but less than γ–rays.

The speed of β–rays is of about $\frac{9}{10}$ times that of light.

e) They are deflected by electric and magnetic fields.

f) Their ionising power is less than that of α–rays (100 times less) and more than γ–rays (100 times more).

g) Their penetrating power is more than α–rays (100 times more) and less than γ–rays (100 times less). They can easily pass through a few mm thick aluminium foil.

h) They affect a photographic plate.

i) They produce fluorescence on fluorescent materials.

j) Energy of β–particles emitted from radioactive substances varies from 2 to 3

MeV.

k) They can produce artificial radioactivity.

l) The rest mass of a β–particles is, 9.1×10^{-31} kg.

m) The range of β–particles in air is several meters.

3. Properties of γ–rays :

a) γ–rays are chargeless. γ–rays are electromagnetic waves.

b) They come out of nucleus when electrons jumps from high energy to low energy state.

c) When γ–rays are emitted from the radioactive element, there is no change in atomic number and atomic mass number.

d) The velocity of γ–rays (3×10^8 m/s) is greater than velocity of α–rays and β–rays.

e) They are not deflected by electric and magnetic fields.

f) Their ionising power is less (minimum) than α–rays and β–rays.

g) Their penetrating power is more than α–rays and β–rays. They can penetrate into 20 cm thickness in steel.

h) They affect photographic plate. They produce photoelectric effect.

i) They produce fluorescence on fluorescence materials like willemite.

j) y–rays produce heating effect in the surface exposed to them.

k) The rest mass of γ–rays is zero.

l) In hospitals, hard γ–rays are used in radiotherapy.

Law of radioactive decay & half life

1. Law of radioactive decay was given by Rutherford– Soddy. Law of radioactivity states that; "The rate of radioactive decay is directly proportional to the number of atoms present at that instant."

i.e. $\frac{dN}{dt} \propto N \qquad \therefore \frac{dN}{dt} = -\lambda N$

Negative sign in the above equation indicates that as time increases, number of atoms decreases.

2. Decay constant (λ) : It is also called as transformation constant. It's value depends on nature of substance and it is independent of all external conditions such as pressure, temperature. It's S.I. unit is per second. It is defined as, "the ratio of radioactive disintegration at any instant to the number of radioactive atoms present at that instant.

3. The rate of radioactive disintegration $\left(\frac{dN}{dt}\right)$ is also called as activity of a radioactive substance. S.I. unit of activity is disintegration/second.

Also,

a) 1 becquerel = 1 disintegration/second.

b) 1 rutherford = 10^6 disintegration/second.

c) 1 curie (Ci) = 3.7×10^{10} disintegrations/sec.

4. Exponential form of law of radioactive decay is given by,

$$N = N_0 e^{-\lambda t}$$

If $t = \frac{1}{\lambda}$ then $N = \frac{N_0}{2.718} = 0.368 N_0$

Hence, radioactive decay constant of a substance may also be defined as the reciprocal of time, after which the number of atoms of a radioactive substance decreases to 0.368 (or 36.8 %) of their number present initially.

5. The time required to disintegrate N_0 atom to N atoms is given by,

$$t = \frac{2.303}{\lambda} \log\left(\frac{N_0}{N}\right)$$

6. The activity of a radioactive element is,

$$\frac{dN}{dt} = A = \lambda N$$

7. The activity of a radioactive element is also given by,

$$A = A_0 e^{-\lambda t}$$

or $t = \frac{2.303}{\lambda} \log\left(\frac{A_0}{A}\right)$

8. Half life :

a) The required to disintegrate half of the original number of atoms of a radioactive element is called as half life.

b) It is given by,

$$T = \frac{0.693}{\lambda}$$

c) Half life period of a radioactive element is inversely proportional to decay constant. It is different for different radioactive elements. For one substance it is constant and con not be changed by any means.

d) Half life depends only on nature of substance and not on mass of substance, temperature of substance and for pressure on the substance.

Note:

The fraction of the radioactive atoms left behind after a time t, (t = nT), is given by,

$$\frac{N}{N_0} = \left(\frac{1}{2}\right)^n = \left(\frac{1}{2}\right)^{t/T}$$

where, N – number of atoms at time t or after n half life periods.

N_0 – original number of atoms.

T – half life period.

9. Mean life or average life (T_a) :

a) The average life of a radioactive substance is defined as the average time for which the nuclei of the atoms of the radioactive substance exist.

b) The average life of a radioactive substance is given by,

$$T_a = \frac{1}{\lambda}$$

Thus, average life is equal to the reciprocal of its decay constant.

c) The relation between half lifeand mean lifeis given by,

$T = 0.693\ T_a$

i.e. half life of a radioactive substance is equal to 0.693 times its average life.

10. Nuclear fission:

1. In 1939 two German scientists Otto Hahn and Strassman discovered that when uranium atom is bombarded with neutrons, it splits up into two separate atoms barium and krypton. The two fragments travel in opposite direction with very high velocity and tremendous energy is released. The original nucleus has a greater mass than the sum of masses of two fragments. The mass defect is converted into energy. This process is called nuclear fission.

2. This is neutron–induced nuclear reaction. When uranium isotope ${}^{235}_{92}U$ is bombarded by neutron, breaks up into two intermediate fragments which emit β–particles to achieve stable end products.

11. Nuclear fusion:

When two lighter nuclei ae fused to form a heavier nucleus, the process is called nuclear fusion. Large energy is released in this process. The newly formed nucleus have smaller mass than the sum of masses of fused nuclei. The mass defect is converted into energy.

9.7 de–Broglie dualistic hypothesis

1. **Dual nature of matter:** Since radiation has dual nature i.e. it possesses properties of both wave and particle and universe is composed of radiation and matter, therefore de Broglie concluded that the moving material particle must also possess dual nature, since nature loves symmetry.

2. **de–Broglie hypothesis:** According to de–Broglie a moving material particle sometimes acts as a wave and sometimes as a particle or a wave is associated with moving material particle which controls the particle in every respect. The wave associated with moving particle is called matter wave or de–Broglie wave whose wavelength called de–Broglie wavelength is given by

9.8 de–Broglie wavelength of an electron

1. The velocity acquired by electron when accelerated from rest through a potential difference of V is

$$v = \sqrt{\frac{2eV}{m}}.$$

2. If A is the de–Broglie wavelength associated with the electron, then,

$$\lambda = \frac{h}{mv} = \frac{h}{m\sqrt{2eV/m}} = \frac{h}{\sqrt{2meV}} = \frac{12.27}{\sqrt{V}}\text{Å}$$

9.9 Davlsecn.and Germer experiment

1. The wave nature of slow moving electron was experimentally proved by Davisson and Germer

in 1927.

2. Electron produces diffraction effect.
3. The intensity maxima and minima produced by a beam of electron can be explained by wave theory only.
4. Electrons are emitted by heating a tungsten filament coated with barium oxide by electric current.
5. The electrons are accelerated to a desired velocity by applying a suitable high potential which can be varied. They are collimated to a fine beam by narrow slits S_1 and S_2.
6. The beam falls on a clean surface of Nickel crystal and the diffracted beam is received in an electron detector which can be rotated on a circular scale. The electrons are scattered by the atoms of the nickel crystal in all possible directions.
7. Electrons are collected by the detector and they pass through a galvanometer which records the current which is proportional to the intensity of the electron beam.
8. The detector is rotated on the scale and intensity of diffracted electron beam is determined for different positions of the detector.
9. A strong peak is obtained for V_a = 54 volt an diffraction angle θ = 50°.

   The equation of first diffraction is

   $$2d \sin \theta = \lambda$$

   where, 2d = interplaner distance of nickel crystal = 2.15 AU.

   $\therefore$ θ = diffraction angle of maximum = 50°

   $\therefore$ λ = 1.65 AU
10. Wavelength varies with the voltage.
11. This experiment helps to developed electron optics.

9.10 Continuous and characteristics X–rays

1. The intensity of X–rays is proportional to the number of electrons emitted per second from the filament. If the number of electrons striking the target is increased, i.e. high–intensity X–rays will be produced.

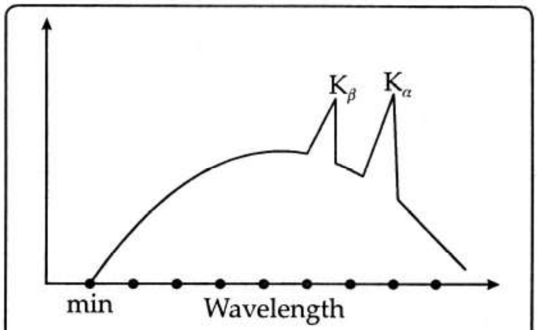

Fig. 9.10

2. Fig. 9.10 shows K_α, K_β wavelengths for which the intensity of X–rays is very large. These X–rays are known as characteristic X–rays. For remaining wavelengths intensity varies gradually and corresponding X–rays are called continuous X–rays.
3. The wavelength depends upon accelerating voltage (V) applied and not on the material of the target on which electrons are incident.
4. The wavelengths for characteristic X–rays may be used to identify the element from which they originate. For a particular material, wavelengths have definite values. These X–rays emitted are called characteristic X–rays. The value of energies are different for different materials.

MULTIPLE CHOICE QUESTIONS

9.1 Geiger–Marsden experiment of scattering of α –particles

&

9.2 Rutherford's atom model

1. The empirical atom model was given by
   a) J. J. Thomson b) Rutherford
   c) Niels Bohr d) Sommerfeld
2. The radius of the atom is of the order of
   a) 10^{-6} m b) 10^{-8} m
   c) 10^{-10} m d) 10^{-12} m
3. Electrons in the atom are held due to
   a) Coulomb's forces b) nuclear forces
   c) gravitational forces d) Vander Wall's forces
4. Atom consists of electrons distributed in a positively charged sphere was proved by
   a) Thomson b) Rutherford
   c) Bohr d) Hertz
5. Which of the following statement is correct in case of Thomson's atom model?
   a) It explains the phenomenon of thermionic emission, photoelectric emission and ionisation
   b) It could not explain emission of line spectra by elements
   c) It could not explain scattering of a–particles
   d) all of these
6. The nuclear model of atom was given by
   a) Avogadro b) Niels Bohr
   c) John Dalton d) Rutherford
7. The existence of a positively charged nucleus in an atom was discovered by
   a) Thomson b) Rutherford
   c) Maxwell d) Bohr
8. According to Rutherford, the positively charged nucleus of the atom has a radius of about
   a) 10^{-14} m b) 10^{-12} m
   c) 10^{-14} cm d) 10^{-10} cm
9. According to Rutherford, electrons revolve in a circular orbit around the nucleus in order to
   a) attract protons
   b) absorb energy
   c) radiate energy
   d) nullify attraction from nucleus
10. According to classical theory, Rutherford's atom model is
   a) stable b) unstable
   c) meta stable d) both a and b
11. Rutherford's atomic model was unstable because
   a) nuclei will break down
   b) electrons do not remain in orbit
   c) orbiting electrons radiate en~rgy
   d) electrons are repelled by the nucleus
12. The electrons of Rutherford's model would be expected to lose energy because, they
   a) move randomly
   b) jump on nucleus
   c) radiate electromagnetic waves
   d) escape from the atom
13. The nuclear structure of the atom was discovered by Rutherford by bombarding metal foil with
   a) X–rays b) γ –rays
   c) β –rays d) α –rays
14. The scattering of α –particles by metal foil can be explained by
   a) Rutherford's model b) Thomson's model
   c) Bohr's model d) all of these
15. Rutherford's experiment of scattering of α –particles shows that atom
   a) is positively charged
   b) is negatively charged
   c) has a large nucleus
   d) has a very small, positively charged nucleus
16. When α –particles are passed through a thin foil, then
   a) they all pass through
   b) they all are deflected
   c) most of them are deflected
   d) most of them pass without deflecting
17. The deflection of α –particles through a thin foil is due to
   a) repulsion by the nucleus
   b) interactions with protons
   c) attraction to nuclei
   d) collision with β –particles
18. As the radius of the orbit goes on decreasing the electrons should emit a radiation of
   a) constant frequency
   b) increasing frequency
   c) decreasing frequency

d) none of these

19. According to Rutherford's atom model, the proposed path of an electron will be
a) circular b) straight line
c) parabolic d) spiral

20. According to Rutherford, electrons revolve round the nucleus in circular orbits due to
a) Coulomb's force b) nuclear force
c) gravitational force d) Vander Wall's force

21. Alpha–particles that come closer to nuclei
a) are deflected more
b) are deflected less
c) make more collisions
d) are solved down more

22. For a given value of n, the number of electrons in an orbit is
a) n b) n^2
c) $2n^2$ d) 2n

9.3 Bohr's atom model

23. Bohr's atom model is the modification of Rutherford's atom model by the application of
a) Newtons theory
b) Huygen's theory
c) Maxwell's theory
d) Planck's quantum theory

24. According to Bohr's atom model, an electron can revolve around a nucleus, if its orbit is a circle of
a) unchanged radius b) permitted radius
c) increasing radius d) decreasing radius

25. According to Bohr's model, angular momentum of electron is equal to integral multiple
a) h b) $\frac{h}{\pi}$
c) $\frac{2h}{\pi}$ d) $\frac{h}{2\pi}$

26. To explain his theory, Bohr used the conservation of
a) energy b) linear momentum
c) angular momentum d) quantum frequency

27. Which of the following model was successful to explain observed hydrogen spectrum?
a) Thomson's model b) Rutherford's model
c) Bohr's model d) none of these

28. In Bohr's model electrons are revolving in a circular orbits around the nucleus called as
a) stationary orbits b) non radiating orbits
c) Bohr's orbits d) all of these

29. According to Bohr's theory of H atom, an electron can revolve around a proton indefinitely, if its path is
a) a perfect circle of any radius
b) a circle of an allowed radius
c) a circle of constantly decreasing radius
d) an ellipse with fixed focus

30. According to Bohr, an electron .radiates energy, when it
a) revolves around the nucleus
b) revolves around the neutrons
c) jumps from lower orbit to higher orbit
d) jumps from higher orbit to lower orbit

31. The concept of an atom with, quantised energy levels, was introduced by
a) E Fermi b) Rutherford
c) Niels Bohr d) M Faraday

32. According to Bohr the difference between the energies of the electron in the two orbits is equal to
a) h v b) hc/λ
c) both 'a' and 'b' d) neither 'a' nor 'b'

33. According to Bohr's atomic model
a) the electron radiates energy only when it jumps to inner orbit
b) an atom has heavy, positively charged nucleus
c) the electron can move in particular orbits
d) all of these

34. According to Bohr's postulates which of the following quantities takes discrete values
a) kinetic energy b) potential energy
c) angular momentum d) momentum

35. The angular momentum of an electron in nth orbit is given by
a) nh b) $\frac{h}{2\pi n}$
c) $\frac{nh}{2\pi}$ d) $\frac{n^2h}{2\pi}$

36. When an electron jumps from the initial orbit nj to the final orbit nf, the energy radiated is given by
a) $hv = E/E_f$ b) $hv = E_1E_f$
c) $hv = E_i + E_f$ d) $hv = E_i - E_f$

37. The angular momentum of electrons in an atom

produces

a) magnetic moment b) ZEEMAN effect

c) light d) nuclear fission

38. According to Bohr's theory of H atom, for the electron in the nth allowed orbit

a) linear momentum is proportional to (1/n)

b) the K. E. is proportional to ($1/n^2$)

c) the angular momentum is proportional to n

d) all of these

39. In the Bohr's theory of Hatom

a) the radius of the nth orbit is proportional to n^2

b) angular momentum is equal to nh/2n

c) the magnitude of the P. E. of the electron in any orbit is greater than its kinetic energy

d) all of these

40. The maximum number of photons emitted when an electron jumps from an energy level n = 4 to n = 1is

a) 1 b) 2

c) 3 d) 4

41. According to Planck's quantum theory any electromagnetic radiation is

a) continuously emitted

b) continuously absorbed

c) emitted or absorbed in discrete units

d) none of these

42. According to PLANCK, energy packets are called as

a) quanta b) photons

c) both 'a' and 'b' d) neither 'a' nor 'b'

43. According to Max Planck energy of photon is

a) E = hv b) E = h

c) E = v d) h/v

Radius and energy of Bohr's orbit

44. The radius of 'n' th Bohr's orbit of Hatom is given by

a) $\dfrac{\epsilon_0 n^2h^2}{\pi me^2}$ b) $\dfrac{n^2h^2}{\epsilon_0 \pi me^2}$

c) $\dfrac{\pi me^2}{\epsilon_0 n^2h^2}$ d) n^2h^2

45. The radii of Bohr's orbit are directly proportional to

a) principle quantum number

b) square of principle quantum number

c) cube of principle quantum number

d) forth power of principle quantum number

46. The linear speed of an electron, in Bohr's orbit is given by

a) $\dfrac{e^2}{h}$ b) $\dfrac{e^2}{2\epsilon_0 nh}$

c) $\dfrac{2\epsilon_0 nh}{e}$ d) $2\epsilon_0 h$

47. According to Bohr's theory speed of an electron in a stationary orbit is related to n as

a) $v_n \propto 1/n^2$ b) $v_n \propto 1/n$

c) $v_n \propto n$ d) $v_n \propto n^2$

48. Angular speed of an electron in a Bohr's orbit is given by

a) $\omega = \dfrac{\pi me^4}{2\epsilon_0^2 n^3h^3}$ b) $\omega = \dfrac{4\epsilon_0^2 n^3h^3}{me^4}$

c) $\omega = \dfrac{me^4}{4\epsilon_0^2 n^3h^3}$ d) all of these

49. According to Bohr's theory, the angular speed (ω) of electron related to n as

a) $\omega \propto \dfrac{1}{n}$ b) $\omega \propto \dfrac{1}{n^2}$

c) $\omega \propto \dfrac{1}{n^3}$ d) $\omega \propto \dfrac{1}{n^4}$

50. Period of revolution of electron in the nth Bohr's orbit is given by

a) $T = \dfrac{4\epsilon_0^2 n^3h^3}{me^4}$ b) $T = 4\epsilon_0^2 n^3h^3$

c) $T = me^4 n$ d) $T = 2\pi$

51. According to Bohr's theory the relation between the period of revolution of electron and principle quantum number is

a) $T \propto 1/n^2$ b) $T \propto 1/n^3$

c) $T \propto n^2$ d) $T \propto n^3$

52. According to Bohr's theory frequency of the revolution of electron in a Bohr's orbit is inversely proportional to

a) principle quantum number

b) square of principle quantum number

c) cube of principle quantum number

d) forth power of principle quantum number

53. Frequency of revolution of electron in the nth

Bohr's orbit is given by

a) $f = \frac{me^4}{4\epsilon_0^2 n^3h^3}$ b) $f = 4\epsilon_0^2 n^3h^3$

c) $f = \frac{me^4}{4\epsilon_0^2 h^2}$ d) $f = \frac{me^4}{\epsilon_0 n}$

54. The total energy of the electron in the Bohr's orbit is given by

a) $E = \frac{me^4}{8\epsilon_0^2 n^3h^3}$ b) $E = -\frac{1}{8\pi\epsilon_0}\frac{e^2}{r}$

c) both 'a' and 'b' d) neither 'a' nor 'b'

55. The energy of the electron in Bohr's orbit related to n as

a) $E \propto 1/n$ b) $E \propto 1/n^2$

c) $E \propto n$ d) $E \propto n^2$

56. The centripetal acceleration of an electron in a Bohr's orbit is inversely proportional to

a) principle quantum number

b) square of quantum number

c) cube of quantum number

d) forth power of its quantum number.

57. Total energy possessed by an electron revolving around nucleus in an orbit of radius r is proportional to

a) r b) r^{-1}

c) r^{-2} d) r^{-3}

58. The radius of the lowest orbit of the hydrogen atom is

a) 1 Å b) 0.53 Å

c) 0.1 Å d) 0.05 Å

59. If 'r' is the radius of the lowest orbit of Bohr's model of H–atom, then the radius of nth orbit is

a) $r\,n^2$ b) 2r

c) n^2/r d) rn

60. When hydrogen atom is in its first excited level, its radius is

a) same b) half

c) twice d) 4 times

61. If the radius of the first Bohr orbit of H atom is 0.5 Å, the radius of third orbit will be

a) 45 Å b) 4.5 Å

c) 1.5 Å d) 0.166 Å

62. The ratio of radii of the first three Bohr orbits is

a) $1 : \frac{1}{2} : \frac{1}{3}$ b) 1 : 2 : 3

c) 1 : 4 : 9 d) 1 : 8 : 27

63. The radius of H atom in its ground state is 0.53 Å. After collision with an electron, its radius is found to be 21.2×10^{-11} m. In this state, the principle quantum number 'n' of the If–atom is

a) 2 b) 3

c) 4 d) 16

64. According to Bohr's theory, the radius of an electron in an orbit described by principal quantum number n and atomic number Z is proportional to

a) $Z^2 n^2$ b) $\frac{Z^2}{n^2}$

c) $\frac{Z^2}{n}$ d) $\frac{n^2}{Z}$

65. The speed of an electron, in the orbit of a H–atom, in the ground state is

a) c b) $\frac{c}{2}$

c) $\frac{c}{10}$ d) $\frac{c}{137}$

66. The speed of electron in first Bohr orbit is c/137. The speed of electron in second Bohr orbit will be

a) $\frac{2c}{137}$ b) $\frac{4c}{137}$

c) $\frac{c}{274}$ d) $\frac{c}{548}$

67. The speed of the electron in the first orbit is 2.182×10^6 m/s, the speed of electron in the third orbit is

a) 2.182×10^6 m/s b) 2.182×10^4 m/s

c) 7.273×10^5 m/s d) 7.273×10^4 m/s

68. The period of revolution of electron in the third orbit in a H–atom is 4.132×10^{-15} s. Hence the period in the fourth orbit is

a) 9.794×10^{-15} s b) 2.794×10^{-14} s

c) 4.974×10^{-15} s d) 6.974×10^{-14} s

69. The change in the angular momentum of the electron when it jumps from the fourth orbit to the first orbit in a H–atom is

a) 3.167×10^{-34} kg m²/s

b) 3.167×10^{-20} kg m²/s

c) 3.167×10^{-32} kg m²/s

d) 3.167×10^{-30} kg m²/s

70. The angular speed of the electron in the first orbit in a H atom is 4.103×10^{16} rad/s, Hence the angular speed of the electron in the third orbit is
a) 1.52×10^{15} rad/s b) 1.25×10^{15} rad/s
c) 1.52×10^{14} rad/s d) 1.25×10^{14} rad/s

71. The linear momentum of the electron in the ground state of H–atom is 2×10^{-24} kg m/s, its linear momentum in the 8th orbit is
a) 2.5×10^{-25} kg m/s b) 5.2×10^{-25} kg m/s
c) 5.2×10^{-15} kg m/s d) 2.5×10^{-15} kg m/s

72. With increasing quantum numbers, the energy difference between adjacent energy level atoms
a) increases b) decreases
c) will be same d) either 'a' or 'b'

73. The difference between atomic energy levels is observed as a measured value of the energy of
a) emitted wave
b) incident wave
c) reflected wave
d) electromagnetic wave

74. When a hydrogen atom is raised from the ground state to an excited state
a) the P. E. decreases and K E. increases
b) the P. E. increases and K E. decreases
c) both P. E. and K E. increases .
d) both KE. and P.E. decreases

75. The energy of the electron in the ground state of H–atom is –13.6 eV. It's energy in the second orbit is
a) –13.6 eV b) –3.4 eV
c) –1.51 eV d) –0.85 eV

76. The energy of the electron in the ground state of H–atom is –13.6 eV. The energy of the first excited state will be
a) –3.4 eV b) –27.2 eV
c) –6.8 eV d) –52.4 eV

77. The ratio of energies of the H–atom, in its first to second excited state is
a) 1 : 4 b) 4 : 9
c) 9 : 4 d) 4 : 1

78. Energy of the lowest level of H–atom is –13.6 eV. The energy of the emitted photons in transition from fourth to second energy state is
a) 2.55 eV b) 3.2 eV
c) 4.5 eV d) 5.4 eV

79. The energy of an excited state of H atom is –0.85 eV. What will be the quantum number of the orbit, if the ground state energy for hydrogen is –13.6 eV?
a) 4 b) 3
c) 2 d) 1

80. The ionisation potential of H–atom is 13.6 eV. The energy required to remove an electron from the second orbit of hydrogen is
a) 27.2 eV b) 13.6 eV
c) 6.8 eV d) 3.4 eV

81. If the ionisation potential of a H–atom is ω, then, its energy in the first excited state is
a) $\frac{\omega}{2}$ b) $\frac{\omega}{3}$
c) $\frac{\omega}{4}$ d) $\frac{\omega}{5}$

82. A hydrogen atom is in an excited state corresponding to an energy level of – 0.85 eV. The frequency of the photon emitted if it comes down to the ground state (–13.6 eV) in a single jump is
a) 3.077×10^{15} Hz b) 30.77×10^{15} Hz
c) 307.7×10^{15} Hz d) 3077×10^{15} Hz

83. The binding energy of the electron in the third orbit is 1.51 eV. Its P. E. in the same orbit is
a) –1.51 eV b) –3.4 eV
c) –3.02 eV d) 3.02 eV

84. Which of the following transition in a hydrogen atom produces a photon of minimum energy?
a) n = 1 to n = 0 b) n = 5 to n = 6
c) n = 6 to n = 8 d) n = 4 to n = 3

85. Normally the time taken in the transition is
a) zero b) 1
c) 10^{-5} s d) 10^{-8} s

86. Of the following transitions in the hydrogen atom, the one which gives on emission line of highest frequency is
a) n = 1 to n = 2 b) n = 3 to n = 10
c) n = 10 to n = 3 d) n = 2 to n = 1

87. The work that must be done to remove an electron from an atom is called its
a) electron infinity b) ionisation energy
c) energy band d) heat of vaporisation

88. Centripetal acceleration of electron in the first Bohr orbit will be
a) 9×10^{22} m/s^2 b) 4×10^{22} m/s^2
c) 6×10^{22} m/s^2 d) 2×10^{22} m/s^2

89. The ratio of magnetic dipole moment of an electron of charge e and mass m in Bohr's orbit in hydrogen to its angular momentum is

a) $\frac{e}{m}$ b) $\frac{e}{2m}$

c) $\frac{m}{e}$ d) $\frac{2m}{e}$

90. As the radius of orbit in Bohr's atom increases, the P. E. of the electron
a) decreases
b) increases
c) remains same
d) may increase or decrease

91. The energy of an electron
a) is greater in outer orbits
b) is greater in inner orbits than in outer orbits
c) is always the same which ever are the orbit
d) decreases as the quantum number increases

92. If the angular momentum of an electron in an orbit is J then the K. E. of the electron in that orbit is

a) $\frac{J^2}{2mr^2}$ b) $\frac{Jv}{r}$

c) $\frac{J^2}{2m}$ d) $\frac{J^2}{2\pi}$

93. If the frequency of revolution of electron in an orbit in H atom is n then the equivalent current is

a) $\frac{2\pi re}{n}$ b) $\frac{en}{2\pi r}$

c) $e^2\pi n$ d) en

94. In an atom, two electrons move round the nucleus in circular orbits of radii R and 4 R. The ratio of the time taken by them to complete one revolution is
a) 1 : 4 b) 4 : 1
c) 1 : 8 d) 8 : 1

95. In an atom, two electrons move around the nucleus in circular orbits taking time 't' and '8t' to complete one revolution. The ratio of their radii is
a) 4 : 1 b) 1 : 4
c) 1 : 8 d) 8 : 1

96. In Bohr model of hydrogen atom, let P.E. represents potential energy and T.E. represents the total energy. In going to a higher, level.
a) P.E. decreases, T.E. increases
b) P.E. increases, T.E. decreases,
c) P.E. decreases, T.E. decreases
d) P.E. increases, T.E. increases

97. The first excitation potential of given atomIs 10.2 eV. Then the ionisation potential must be
a) 20.4 V b) 13.6 V
c) 30.6 V d) 40.8 V

9.4 Hydrogen spectrum

98. Whenever an electron jumps from outer stationary orbit to inner stationary orbit then a
a) photon of energy hv is emitted
b) light radiation of frequency v is emitted
c) spectral line of wave length A. is emitted
d) all of these

99. The wavelength of a spectral line emitted due to the transition of electron from outer stationary orbit to inner stationary orbit is given by

a) $\frac{1}{\lambda}=R\left(\frac{1}{p^2}-\frac{1}{n^2}\right)$ b) $\lambda=R\left(\frac{1}{p^2}-\frac{1}{n^2}\right)$

c) $\lambda=R\left(\frac{1}{p^2}\right)$ d) $\frac{1}{\lambda}=R\frac{1}{n^2}$

100. Which of the following series of hydrogen atoms lies partly in the visible region?
a) Lyman series b) Balmer series
c) Paschen series d) Plund series

101. Each line of Balmer series represents
a) energy level b) low energy level
c) angular momentum d) transition of electrons

102. Information about energy levels. Within the atoms of a gas, comes from the study of
a) spectrum of the gas
b) fermi energy level of gas
c) thermionic emission in gas
d) photoelectric emission in gas

103. An electron makes a transition from outer orbit (n = 4) to the inner orbit (p = 2) of a hydrogen atom. The wave number of the emitted radiations is

a) $\frac{2R}{16}$ b) $\frac{3R}{16}$

c) $\frac{4R}{16}$ d) $\frac{5R}{16}$

104. According to Bohr's theory, when an electron jumps from any higher orbit to the third orbit, spectral lines are emitted. These are called
a) Lyman series b) Balmer series
c) Paschen series d) Plund series

105. Which of the following types of radiation is not emitted by the electronic structure of atoms?
a) Ultraviolet light b) X–rays
c) Visible light d) γ–rays

106. A spectral line is emitted when an electron
a) rotates in the circular orbit
b) rotates in the elliptical orbit
c) jumps from lower orbit to higher orbit
d) jumps from higher orbit to lower orbit

107. Lines of Lyman series are emitted by the hydrogen atom when the electron jumps
a) from higher orbits to first orbit
b) from higher orbit's to second orbit
c) from second orbit to any other orbit
d) from third orbit to higher orbits

108. In the hydrogen atom spectrum, the series which lies in ultraviolet region is
a) Lyman series b) Balmer series
c) Paschen series d) Brackett series

109. Rydberg constant R is equal to
a) $\frac{me^2}{8\epsilon_0^2 ch^3}$ b) $\frac{me^4}{8\epsilon_0^2 ch^3}$
c) $\frac{m^2e^4}{8\epsilon_0^2 ch^3}$ d) $\frac{m^4e^4}{8\epsilon_0^2 ch^3}$

110. Line spectrum is obtained from the substances in
a) atomic state b) molecular state
c) nuclear state d) none of these

111. Infra red spectrum lies between
a) radiowave and microwave regions
b) microwave and visible regions
c) visible and ultraviolet regions
d) ultraviolet and X–rays regions

112. Which of the following are in the ascending order of wavelength?
a) H_α, H_β and H_γ lines of Balmer series
b) Lyman limit, Balmer limit
c) Violet, blue, yellow, red colours in solar spectrum
d) both 'b' and 'c'

113. Rydberg's constant is
a) same for all elements
b) different for different el~ments
c) a universal constants
d) is different for lighter elements but same for heavier elements

114. If the mass of the electron is reduced to half, the Rydbergs constant
a) remains unchanged b) becomes half
c) becomes double d) becomes one fourth

115. The Lyman transitions involve
a) largest changes of energy
b) smallest changes of energy
c) largest changes of potential energy
d) smallest changes in potential energy

116. The ratio of the wavelengths of H_α and H_β lines of Paschen series is of the order of
a) 10 b) 1/10
c) 1.5 d) 100

117. Which series of H_2 atom lie in infrared region?
a) Lyman
b) Balmer
c) Brackett, Paschen, Pfund
d) all of these

118. Which series of Hydrogen atom was first discovered?
a) Lyman b) Balmer
c) Paschen d) All of these

119. Which of the following lines of Balmer series has longest wavelength?
a) H_α b) H_β
c) H_γ d) all of these

120. The series limit wavelength of the Lyman series for the hydrogen atom is given by
a) $\frac{1}{R}$ b) $\frac{4}{R}$
c) $\frac{9}{R}$ d) $\frac{16}{R}$

121. Generally the approximate limits of visible spectrum are
a) 1000 Å to 4000 Å b) 4000 Å to 7000 Å
c) 7000 Å to 10,000 Å d) 10,000 Å to 13,000 Å

122. The frequency of light waves which belongs to the visible range of the spectrum, is of the order of
a) 5000×10^8 c/s b) 3×10^{10} c/s
c) 10^6 c/s d) 5×10^{14} c/s

123. The series limit wavelength of the Balmer series for the hydrogen atom is
a) $\frac{1}{R}$ b) $\frac{4}{R}$
c) $\frac{9}{R}$ d) $\frac{16}{R}$

124. If R is the Rydberg's constant, the energy of an electron in the ground state H atom is
a) $\frac{Rc}{h}$ b) $\frac{-1}{Rhc}$
c) $-$ Rhc d) $\frac{vc}{R}$

125. According to Bohr's theory, the wave number of last line of Balmer series is ($R = 1.1 \times 10^7\ m^{-1}$)
a) $5.5 \times 10^5\ m^{-1}$ b) $4.4 \times 10^7\ m^{-1}$
c) $2.75 \times 10^6\ m^{-1}$ d) $2.75 \times 10^8\ m^{-1}$

126. The wavelength of the first spectral line of the Lyman series of hydrogen spectrum is
a) 912 Å b) 1215 Å
c) 1512 Å d) 6563 Å

127. If the wavelength of the first line of Balmer series of hydrogen atom is 6561 Å, the wavelength of the second line of the series will be
a) 3575 Å b) 3860 Å
c) 4500 Å d) 4860 Å

128. If the series limit wavelength of the Lyman series for the hydrogen atom is 912 Å, then the series limit wavelength for the Balmer series of the hydrogen atom is
a) 912 Å b) 912 × 2 Å
c) 912 × 4 Å d) 912/2 Å

129. An electron jumps from the 4th orbit to the 2nd orbit of hydrogen atom. Given the Rydberg's constant $R = 10^5\ cm^{-1}$. The frequency in Hz of the emitted radiation is
a) $\frac{3}{16} \times 10^5$ b) $\frac{3}{16} \times 10^{15}$
c) $\frac{9}{16} \times 10^{15}$ d) $\frac{3}{4} \times 10^{15}$

130. The longest wavelength of the Balmer series is 6563 Å. The Rydberg's constant is
a) $1.09 \times 10^5\ m^{-1}$ b) $1.09 \times 10^6\ m^{-1}$
c) $1.09 \times 10^7\ m^{-1}$ d) $1.09 \times 10^8\ m^{-1}$

131. According to the Bohr's theory the wave length of shortest wavelength of a spectral line in Brackett series is
($R = 1.1 \times 10^7\ m^{-1}$)
a) 4480 Å b) 8800 Å
c) 40533 Å d) 18450 Å

132. The H_β line of the Balmer series in hydrogen spectrum has a wavelength 4861 Å. The wavelength of the H_α line of the Balmer series is
a) 6563 Å b) 3656 Å
c) 6380 Å d) 3860 Å

133. The shortest wavelength in Lyman series is 912 Å. The shortest wavelength in Paschen series is
a) 8208 Å b) 8082 Å
c) 8820 Å d) 2088 Å

134. The following figure indicates the energy levels of a certain atom. When the system moves from 2E level to E level, a photon of wavelength λ is emitted. The wavelength of photon produced during its transition from level 4E/3 to level E is
a) $\frac{\lambda}{3}$ b) $\frac{3\lambda}{4}$
c) $\frac{4\lambda}{3}$ d) 3λ

135. Energy levels A, B, C of a certain atom correspond to increasing values of energy i.e. $E_A < E_B < E_C$. If λ_1, λ_2, λ_3 are the wavelength of radiations corresponding to the transitions C to B, B to A and C to A respectively. Which of the following statement is correct?
a) $\lambda_3 = \lambda_1 + \lambda_2$ b) $\lambda_3 = \frac{\lambda_1\lambda_2}{\lambda_1 + \lambda_2}$
c) $\lambda_3 + \lambda_2 + \lambda_3 = 0$ d) $\lambda_3^2 = \lambda_1^2 + \lambda_2^2$

9.5 Composition and size of nucleus

136. The nucleus of a hydrogen atom is
a) proton b) electron
c) neutron d) positron

137. Proton was discovered by
a) Rutherford b) Chadwick
c) Goldstein d) Becquerel

138. The expression Ze gives the charge on
a) a proton b) neutron
c) an electron d) a nucleus

139. The mass of a proton is
a) 1.0073 a.m.u. b) 1.6726×10^{-27} kg
c) both a and b d) neither a nor b

140. The charge on a nucleus is
a) positive b) zero
c) negative d) can not be predicted

141. The atomic number of an element is equal to the number of
a) protons b) neutrons
c) electrons d) deutrons

142. Neutron was discovered by
a) Chadwick b) Rutherford
c) Bohr d) Planck

143. Which of the following is a nucleon?
a) meson b) proton
c) neutron d) all of these

144. The mass number of a nucleus is equal to the number of
a) electrons b) protons
c) rleutrons d) nucleons

145. The nucleus of an atom is composed of
a) protons
b) neutrons and protons
c) electrons and protons
d) electrons, protons and neutrons

146. Nuclear forces exists between
a) neutron – neutron b) proton – proton
c) neutron – proton d) all of these

147. The nuclear force acting in the nucleus is stronger than
a) coulomb forces b) cohesive forces
c) gravitational forces d) both a and c

148. Which of the following are short range forces?
a) Nuclear forces b) Cohesive forces
c) Coulomb's forces d) None of these

149. Which of the following has the same mass as a proton, but no charge?
a) Neutron b) Electron
c) Positron d) Neutrino

150. Every nucleus, of a given element, has the same number of
a) mesons b) protons
c) neutrons d) positrons

151. The mass of an atom is
a) equal to zero
b) double of the atomic number
c) concentrated in the orbits
d) concentrated in the nucleus

152. A particle having no charge and no mass is
a) positron b) neutron
c) electron d) neutrino

153. The unit of nuclear radius is
a) metre b) fermi
c) ampere d) coulomb

154. Which one of the following particles can be added to the nucleus of an atom, without changing its chemical properties?
a) Electron b) Proton
c) Positron d) Neutron

155. The number of neutrons is equal to
a) A b) Z
c) A – Z d) A + Z

156. The number of protons, neutrons and electrons in the nucleus of $_{11}Na^{23}$ are respectively
a) 23,12 and 11 b) 11, 12 and 0
c) 23, 11 and 12 d) 12, 11 and 0

157. One atomic mass unit is equal to
a) mass of an atom of $_6C^{12}$
b) mass of hydrogen atom
c) one gram
d) (l/12)th mass of an atom of $_6C^{12}$

158. The mass of an atom depends upon the number of
a) neutrons b) protons
c) electrons d) both a and b

159. The mass of neutron is same as that of
a) a proton b) atomic mass
c) an electron d) atomic number

160. Masses of many atoms are close to integral multiple of the mass of an
a) nitrogen atom b) hydrogen atom
c) carbon atom d) potesium atom

161. The ratio of the mass of the proton to the mass of the electron is
a) 920 b) 1840
c) 3680 d) 4810

162. Energy equivalent to 1 a.m.u. is
a) 900 MeV b) 921 MeV
c) 931 MeV d) 950 MeV

163. The elements having same charge and atomic number, but different mass numbers, are called
a) isobars b) isomers
c) isotones d) isotopes

164. A nuclei having same number of neutron but different number of protons / atomic number are called
a) isobars b) isomers
c) isotones d) isotopes

165. The elements having same mass numbers but different atomic numbers are
a) isobars b) isomers
c) isotones d) isotopes

166. Nuclei of the isotopes have the same number of
a) mesons b) protons
c) neutrons d) nucleons

167. Which one of the following has the identical property for isotopes?
a) Physical property b) Chemical property
c) Nuclear property d) Thermal property

168. The number of electrons in an atom of atomic number Z and mass number A is
a) zero b) Z
c) A–Z d) A

169. The number of protons in an atom of atomic number Z and mass number A is
a) zero b) Z
c) A–Z d) A

170. The number of nucleons in an atom of atomic number Z and mass number A is
a) zero b) Z
c) A–Z d) A

171. When the mass equal to 1 a.m.u. is converted into energy, the energy produced is
a) 1.5×10^{-18} J b) 1.5×10^{-14} J
c) 1.5×10^{-12} J d) 1.5×10^{-10} J

172. In a nuclear reaction, which of the following is conserved?
a) Momentum
b) Charge
c) Sum of mass and energy
d) All of these

173. A pair of isotopes is
a) ${}_6C^{14}$ and ${}_7N^{13}$ b) ${}_7N^{13}$ and ${}_7N^{14}$
c) ${}_6C^{14}$ and ${}_7N^{14}$ d) ${}_6C^{14}$ and ${}_8O^{16}$

Einsteins mass energy relation

174. Mass energy equation was propounded by
a) Newton b) Madam Curie
c) C. V. Raman d) Einstein

175. The mass of an atomic nucleus is less than the sum of the masses of its constituents. This mass defect is converted in to
a) heat energy
b) light energy
c) electrical energy
d) energy which binds nucleons together

176. According to Einsteins theory of relativity, mass of an object moving with velocity v is
a) $m = \dfrac{m_0}{\sqrt{1-\dfrac{v^2}{c^2}}}$ b) $m = \dfrac{m_0}{\left(1-\dfrac{v^2}{c^2}\right)^{\frac{1}{2}}}$
c) $m = m_0 = \left(1-\dfrac{v^2}{c^2}\right)^{-\frac{1}{2}}$ d) all of these

177. According to Einstein, the relation between mass and energy is given by
a) $E = mc^2$ b) $m = Ec^2$
c) $E = mc^{-2}$ d) $E = mc$

178. Which of the following statement is not true regarding Einsteins mass energy relation ?
a) Mass disappears to reappear as energy.
b) Energy disappears to reappear as mass
c) Mass and energy are two different forms of the same entity.
d) Mass and energy can never be related to each other.

179. In nuclear reactions, there is a conservation of
a) mass b) energy
c) momentum d) all of these

180. The energy equivalent to 1 a.m.u. is equal to the energy which an electron would acquire, when accelerated through a potential difference of
a) 931×10^3 V b) 93×10^4 V
c) 931×10^5 V d) 931×10^6 V

181. The mass of an electron at rest is 9.1×10^{-31} kg. The mass of an electron, when it is moving with a speed of 2.4×10^8 m/s is ($c = 3 \times 10^8$ m/s)
a) 1.517×10^{-31} kg b) 15.17×10^{-31} kg

c) 151.7×10^{-31} kg d) 1517×10^{-31} kg

182. The effective mass of photon of frequency 5×10^{14} Hz is
a) 3.683×10^{-32} kg b) 3.683×10^{-36} kg
c) 36.83×10^{-32} kg d) 38.63×10^{-32} kg

183. The rest mass of a proton is 1.67×10^{-27} kg. Its total energy when it moves with a speed of 2.1×10^{8} m/s is
a) 2.105×10^{-10} J b) 20.15×10^{-10} J
c) 2.105×10^{-9} J d) 20.15×10^{-9} J

184. If a particle moves with a speed of 1.5×10^{8} m/s then the ratio of its mass to its rest mass is
a) 1.155 b) 11.55
c) 15.15 d) 1.515

185. The speed of a particle whose kinetic energy is equal to its rest mass energy is
a) 25.98×10^{8} m/s b) 2.598×10^{8} m/s
c) 2.895×10^{8} m/s d) 2.985×10^{8} m/s

186. The rest mass of an electron is 9.1×10^{-31} kg. Its kinetic energy when it moves with a speed of 2.4×10^{8} m/s is
a) 5.45×10^{-14} J b) 54.36×10^{-14} J
c) 56.43×10^{-14} J d) 53.46×10^{-14} J

9.6 Radioactivity

187. The phenomenon of radioactivity was discovered by
a) Becquerel b) M. Curie
c) Rontgen d) Newton

188. Radioactivity is the phenomenon associated with
a) decay of proton
b) decay of nucleus
c) emission of α –particles
d) none of these

189. Radioactivity is due to
a) unstable electronic configuration
b) stable electronic configuration
c) unstable nuclei
d) stable nuclei

190. Which one of the following is not a mode of radioactive decay?
a) Electron emission b) Alpha decay
c) Fusion d) Gamma emission

191. A nucleus which is unstable and tends to breakdown is called
a) radioactive b) fissionable
c) fusbale d) none of these

192. The phenomenon of spontaneous emission of radiations is
a) radioactivity b) electron emission
c) rectification d) none of these

193. Radioactivity is a
a) spontaneous phenomenon
b) production of radio waves
c) transmission of radio waves
d) reception of radiowaves

194. Curie is a unit of
a) half life b) radioactivity
c) energy of γ rays d) intensity of γ rays

195. Heavy radioactive elements eventually turn into
a) lead b) boron
c) carbon d) uranium

196. Which of the following metals was discovered by Madam Curie?
a) Polonium and radium
b) Bismuth and lead
c) Thorium and uranium
d) Cobalt and barium

197. Artificial radioactivity was discovered by
a) Klaproth
b) Rontgen
c) Irene Curie and Joliot
d) P. Curie and M. Curie

198. Radioactive samples are stored in lead boxes because it is
a) heavy b) strong
c) good absorber d) bad conductor

199. The process of radioactive radiations remains unaffected due to
a) physical changes
b) chemical changes
c) electric or magnetic fields
d) all of these

Properties of α, β and γ –rays

200. Which of the following are positively charged particles?
a) α –rays b) β -rays
c) γ –rays d) none of thees

201. The a particle is same as
a) gas atom b) helium nuclei
c) singly ionised atom d) ionised hydrogen atom

202. Which of the following particle is deflected

towards positve plate in an electric field?

a) α b) β

c) γ d) δ

203. The mass of an a particle is

a) equal to mass of four protons

b) equal to mass of four neutrons

c) equal to sum of mass of two protons and two neutrons

d) less than the sum of mass of two protons and two neutrons

204. To produce intense ionization, in air at S.T.P.,we have to use

a) α–rays b) β–rays

c) γ–rays d) X–rays

205. The penetrating power of α–particle is

a) least b) moderate

c) high d) none of these

206. The velocity of α–particles is of the order of

a) 10^6 m/s b) 10^7 m/s

c) 10^8 m/s d) 10^9 m/s

207. Which of the following particle can affect photographic plates?

a) α b) β

c) γ d) all of these

208. Which of the following particle can be deflected by electric and magnetic field?

a) α b) β

c) both a and b c) neither a nor b

209. Which of the following particle can produce fluorescence in substances like zink sulphide?

a) α b) β

c) γ d) all of these

210. If the mass number of an atom of an element decreases by 4 and atomic number decreases by two then it is

a) α b) β

c) γ d) X-rays

211. In an α–decay

a) the parent and daughter nuclei have same number of protons

b) the daughter nucleus has one proton more than parent nucleus

c) the daughter nucleus has two protons less than parent nucleus

d) the daughter nucleus has two neutrons more than parent nucleus.

212. The part of the atom which is not affected by chemical or physical changes is

a) proton b) neutron

c) nucleus d) electron

213. The nature of Becquerel rays was discovered by

a) Rutherford b) Thomson

c) Einstein d) Bohr

214. The β– particle are

a) positvely charged b) negatively charged

c) uncharged d) Done of these

215. Which of the following particle is same as electron?

a) α b) β

c) γ d) X-rays

216. In β–decay, the nuclei emit

a) protons b) electrons

c) neutrinos d) both 'b' and 'c'

217. If an atomic nucleus emits an electron its atomic mass will

a) decrease b) increase

c) becomes zero d) remain the same

218. The penetrating and ionisation power of β–particle is

a) least b) moderate

c) high d) none of these

219. With the emission of β–particle from an atom of an element, its atomic number

a) remains same b) increases

c) increases by one d) decreases by one

220. During radioactive disintegration, β–ray emission is accompanied by the emission of

a) α–rays b) γ–rays

c) nucleons d) neutrons

221. When a nucleus decays by emitting a β–particle, the daughter nucleus has one more

a) meson b) electron

c) proton d) neutrino

222. In a β–decay

a) the parent and daughter nuclei have the same number of protons

b) the daughter nucleus has one proton less than the parent nucleus

c) the daughter nucleus has one proton more than the parent nucleus
d) the daughter nucleus has one neutron more than the parent nucleus

223. Which is the most commonly used particle to produce radio isotopes of elements?
a) α b) β
c) γ d) X-rays

224. A radioactive material undergoes decay by ejecting electorns. The electron ejected in this process is
a) the electron from the decay of a neutron
b) the electron present in the nucleus
c) the resulting from the conversion of y photon
d) an orbital electron

225. The particles of γ radiation are
a) protons b) photons
c) electrons d) none of these

226. The short wavelength electromagnetic wave emitted by nuclei are called
a) α –rays b) β–rays
c) γ –rays d) none of these

227. High energy photons, emitted in nuclear reorganisation, are called
a) α –rays b) β–rays
c) γ –rays d) X–rays

228. The γ –rays are
a) singly ionised gas atom
b) helium nuclei
c) fast moving electrons
d) electromagnetic waves

229. The γ –rays passing through a strong uniform electric field
a) deflects
b) deflects vertically
c) deflects horizontally
d) does not deflect

230. When an atomic nucleus emits γ –rays then
a) mass number decreases
b) atomic number decreases
c) mass of nucleus decreases
d) no change in atomic number and mass number

231. Which of the following has high penetrating power?
a) α –rays b) β–rays
c) γ –rays d) none of these

232. The ionisation power of β–particle is
a) least b) moderate
c) high d) none of these

233. Which of the following rays has same velocity as that of light?
a) α –rays b) β–rays
c) γ –rays d) none of these

234. The same radioactive nucleus may emit
a) all the three α, β and γ one after another
b) all the three α, β and γ radiations simulataneously
c) only α and β simultaneously
d) only one α , β and γ at a time

235. If α, β and γ rays of same energy are aranged in ascending order of their ranges in air the order will be
a) α, β γ b) β, α,γ
c) α,γ, β d) γ, $\beta\alpha$

236. A redioactive element ZXA emits an a particle and changes into
a) ${}_{Z-2}Y^{A}$ b) ${}_{Z}Y^{A-4}$
c) ${}_{Z-2}Y^{A-4}$ d) ${}_{Z+2}Y^{A}$

237. The equation ${}_{Z}X^{A} \rightarrow {}_{Z+1}Y^{A} + {}_{-1}e^{0} + \overline{\nu}$ represents
a) α –decay b) β–decay
c) γ –decay d) fusion

238. A neutron is emitled from a nucleus ${}_{90}X^{233}$. How many β particles must be emitted from it to convert it into ${}_{92}X^{233}$?
a) 1 b) 2
c) 3 d) 4

239. When the radioactive isotope ${}_{88}Ra^{228}$ decays in series by the emission of 3 α and 1 β particle, the isotope finally formed is
a) ${}_{89}X^{229}$ b) ${}_{86}X^{222}$
c) ${}_{83}X^{216}$ d) ${}_{83}X^{215}$

240. What is the respective number of α and β particles emitted in the following radioactive decay?
${}_{90}X^{200} \rightarrow {}_{80}Y^{168}$
a) 6 and 8 b) 6 and 6

c) 8 and 8 d) 8 and 6

241. $_{90}Th^{232}$ emits 6α and 4β particles and gets converted into a lead. The mass number and atomic number of lead is

a) 208, 82 b) 82, 208

c) 210, 82 d) 210, 84

242. In a cloud chamber α,β and γ radiations are sent. The nature of tracks produced by these particles respectively will be

a) thin and long, thick and short thin and very long.

b) thick and short, thin and long, fuzzy

c) thick and long, thin and short, fuzzy

d) thick and short, thin and long, thick and long

Laws of radioactive decay & half life

243. The rate of decay of radioactive element

a) is constant

b) decreases inversely with time

c) increases directly with time

d) decreases exponentially with time.

244. Which of the following of a radioactive material is a measure of its instability?

a) Fuillife b) Mean life

c) Halflife d) None of these

245. The decay constant of a radioactive sample

a) decreases as the atom becomes older

b) increases as the atom becomes older

c) is independent of the age

d) dependes on the nature of activity

246. The rate of disintegration at a given instant, 'is directly proportional to the number of atoms present at that instant. This is the statement of

a) law of radioactive decay

b) half life

c) law of radioactive transformation

d) groop displacement law

247. The time required for the atoms of that element to decrease to half the original value is

a) mean life b) half life

c) period d) full life

248. The half life of a radioactive substance depends upon

a) decay constant

b) mass of substance

c) atomic number of substance

d) all of these

249. The mathematical equation of law of radioactive decay is

a) $N = N_0 e^{-\lambda t}$ b) $N = e^{-\lambda t}$

c) $N = N_0 e\, e^{-\lambda t}$ d) $N_0 = N e^{-\lambda t}$

250. The relation between half life period and decay constant is

a) $T = \dfrac{0.693}{\lambda}$ b) $T = 0.693\ \lambda$

c) $T = \dfrac{\lambda}{0.693}$ d) none of these

251. A radioactive decay rate of 1 curie represents

a) 10^6 disintegrations per second

b) 10^9 disintegrations per second

c) 3.7×10^{10} disintegrations per second

d) 3.7×10^4 disintegrations per second

252. When a nucleus undergoes radioactive decay, its new mass number is

a) always equal to its original mass number

b) always more than its original mass number

c) never more than its original mass number

d) never less than its original mass number

253. The decay constant or a radioactive element is definded as the reciprocal of the time interval after which the number of atoms of the radioactive element falls to nearly

a) 50% of its original number

b) 36.8% of its original number

c) 63.2% of its original number

d) 75% of the original number

254. The half life of a radioactive element is T and its initial activity at t = 0 is Ao and at t = t it is A, than

a) $A = A_0 2^{t/T}$ b) $A = A_0 (2\ t)^T$

c) $A_0 = A\ 2^{t/T}$ d) $A_0 = A\ 2^{-t/T}$

255. The decay constant of end product of any radioactive series is

a) zero b) infinite

c) indefinite d) small and definite

256. Half life period of lead is

a) zero b) infinite

c) 1950 days d) 1590 days

257. The half life of 1gm of a radioactive element of atomic weight M is T. The half life of M gm of the same element will be

a) T b) TM

c) $\dfrac{T}{M}$ d) $\dfrac{TM}{2}$

258. Rate of disintegration per atom is called
a) decay constant b) mean life
c) half life d) none of these

259. The value of decay constant is independent of
a) temperature b) pressure
c) force d) all of these

260. Which of the following is the unit of activity of a radioactive element?
a) curie b) rutherford
c) becquerel d) all of these

261. The half life period of a radioactive sample depends upon
a) temperature
b) pressure
c) nature of substance
d) all of these

262. N atoms of a radioactive substance emit no– particles per second. The half life of the radioactive substance is
a) $\frac{n}{N}$sec b) $\frac{N}{n}$sec
c) $\frac{0.693N}{n}$sec d) $\frac{0.693n}{N}$sec

263. If the half life of radium is 1620 years then its decay constant is
a) 4.2×10^{-4} per year b) 2.4×10^{-4} per year
c) 4.2×10^{-2} per year d) 2.4×10^{-2} per year

264. Activity of a radioactive substance decays to (1/5)th of its orginal value in 56 days. Its decay constant is
a) 0.287 day^{-1} b) 0.0287 per day
c) 2.87 per day d) 28.7 per day

265. The activity of a radioactive substance is readuced by 80% in 100 dyas. Its half life is
a) 40 days b) 41 dyas
c) 42 days d) 43.04 days

266. The half life of radium is 1600 years. The fraction of a sample of radium that would remain after 6400 years is
a) $\frac{1}{4}$ b) $\frac{1}{16}$
c) $\frac{1}{32}$ d) $\frac{1}{64}$

267. A sample contains 10mg of radioactive material of half life 270 days. The mass of remaining radioactive material after 540 days will be
a) 2.5 mg b) 5 mg
c) 10 mg d) 15 mg

268. If a radioactive material has half life of one year, a sample will be reduced to 1/8 of its mass in
a) 2 years b) 3 years
c) 4 years d) 6 years

269. A radioactive substance decays to $\frac{1}{64}$ of its intial quantity in 30 days. The time during which it will decay to $\frac{1}{128}$ of its initial quantity is
a) 30 days b) 35 dyas
c) 40 days d) 45 days

270. Three specimens A, B, C of same radioactive element has activities 1 microcurie, 1 rutherford and and 1 becquerel respectively. Which specimen has maximum mass?
a) A
b) B
c) C
d) all have equal masses

271. Which of the following graphs represents the variation of activity (A) of a radioactive substance with time (t).

9.7 de–Broglie dualistic hypothesis

272. The de Broglie wavelength of a particle having a momentum of 2×10^{-28} kg m/s is
a) 3.3×10^{-5} m b) 6.6×10^{-6} m
c) 3.3×10^{-6} m d) 1.65×10^{-6} m

273. The de–Broglie wavelength λ
a) is proportional to mass
b) is proportional to impulse
c) inversely proportional to impulse
d) does not depend on impulse

274. The de Broglie wavelength (λ) of a particle is related to its kinetic energy E as
a) $\lambda \propto E$ b) $\lambda \propto \sqrt{E}$
d) $\lambda \propto 1/E$ d) $\lambda \propto 1/\sqrt{E}$

275. A proton and an α–particle are accelerated through the same potential difference. The ratio of the de Broglie wavelength of the proton to the de Broglie wavelength of the α–particle will be

a) $2\sqrt{2} : 1$ b) $1 : \sqrt{2}$

c) $\sqrt{2} : 1$ d) $1 : 2\sqrt{2}$

276. A photon, an electron and a uranium nucleus all have the same wavelength. The one with the most energy
   a) is the photon
   b) is the electron
   c) is the uranium nucleus
   d) depends upon the wavelength and the properties of the particle

277. If a photon and an electron propagate in the form of waves, having the same wavelength, it implies that both of them have the same
   a) energy b) velocity
   c) linear momentum d) angular momentum

278. An α–particle and a proton are accelerated in such a way that they get the same kinetic energy. What is the ratio of their de Broglie wavelengths?
   a) 1 : 1 b) 1 : 2
   c) 1 : 3 d) 3 : 2

279. Dual nature of radiation is shown by
   a) diffraction and reflection
   b) refraction and diffraction
   c) photoelectric effect alone
   d) photoelectric effect and diffraction

280. The following particles are moving with the same velocity. Then the maximum de–Broglie wavelength will be for
   a) α–particle b) β–particle
   c) proton d) neutron

281. What is the de Broglie wavelength of a 2 kg mass moving with a velocity of 10 m/s ?
   a) 6.6×10^{-35} m b) 3.3×10^{-35} m
   c) 8×10^{-35} m d) 2.5×10^{-35} m

282. What is the de–Broglie wavelength of the α–particle accelerated through a potential difference V
   a) $\frac{0.287}{\sqrt{V}}$ Å b) $\frac{12.27}{\sqrt{V}}$ Å
   c) $\frac{0.101}{\sqrt{V}}$ Å d) $\frac{0.202}{\sqrt{V}}$ Å

283. For the Bohr's first orbit of circumference $2\pi r$, the de–Broglie wavelength of revolving electron will be
   a) $2\pi r$ b) πr
   c) $1/2\ \pi r$ d) $1/4\ \pi r$

284. Through what potential difference should an electron be accelerated so that its de–Broglie wavelength becomes 0.4 A ?
   a) 999 V b) 242 V
   c) 941 V d) 520 V

285. The de–Broglie wavelength of a particle moving with a velocity 2.25×10^8 m/s is equal to the wavelength of photon. The ratio of kinetic energy of the particle to the energy of the photon is (velocity of light is 3×10^8 m/s)
   a) 1/8 b) 3/8
   c) 5/8 d) 7/8

286. An electron and a proton are accelerated through the same potential difference, The ratio of their de Broglie wavelengths will be
   a) $\left(\frac{m_P}{m_e}\right)^{1/2}$ b) $\frac{m_e}{m_p}$
   c) $\frac{m_P}{m_e}$ d) 1

287. The idea of matter waves was given by
   a) Davisson and Germer
   b) de–Broglie
   c) Einstein
   d) Planck

288. If the kinetic energy associated with an electron is doubled, then its de Broglie wavelength changes by the factor
   a) 2 b) 1/2
   c) $\sqrt{2}$ d) $1/\sqrt{2}$

289. A particle with rest mass m_0 is moving with speed c. The de–Broglie wavelength associated with it will be
   a) zero b) infinity
   c) hv / m_0c d) m_0c / h

290. An electron and a proton have the same de–Broglie wavelength. Then the kinetic energy of the electron is
   a) zero
   b) equal tot he K.E. of proton
   c) less than the K.E. of proton
   d) more than the K.E. of the proton

291. The de–Broglie wavelength associated with a hydrogen molecule moving with thermal velocity of 3 km/s will be

a) 0.66×10^{-10} m b) 0.33×10^{-10} m
c) 10^{-10} m d) 2×10^{-10} m

292. The wavelength of de–Broglie wave is 2 μm, then its momentum is ($h = 6.63 \times 10^{-34}$ J s)
a) 3.315×10^{-28} kg m/s
b) 1.66×10^{-28} kg m/s
c) 4.97×10^{-28} kg m/s
d) 9.9×10^{-28} kg m/s

293. Wave is associated with matter
a) when it is stationary
b) when it is in motion with the velocity of light only
c) when it is in motion with any velocity
d) none of the above

294. Protons and α–particles have the same de Broglie wavelength. What is same for both of them?
a) mass b) linear momentum
c) frequency d) energy

295. The de–Broglie wavelength associated with the particle of mass m moving with velocity v is
a) h/mv b) mv/h
c) mh/v d) m/hv

296. An electron, a proton and an α–particle the moving with the same momentum. Which one of them has the largest de Broglie wavelength?
a) Electron
b) All have the same de Broglie wavelength
c) Proton
d) α–particle

297. de–Broglie wavelength of a body of mass 1 kg moving with velocity of 2000 m/s is
a) 3.32×10^{-27} Å b) 1.5×10^{7} Å
c) 0.55×10^{-22} Å d) none of these

298. A dust particle of mass 2 mg is carried by wind with a velocity of 100 cm/s. What is the de Broglie wavelength associated with the dust particle? ($h = 6.64 \times 10^{-34}$ J s)
a) 3.32×10^{-31} m b) 6.64×10^{-30} m
c) 3.32×10^{-34} m d) 3.32×10^{-28} m

299. The kinetic energy of electron and proton is 10^{-32} J. Then the relation between their de–Broglie wavelengths is
a) $\lambda_p < \lambda_e$ b) $\lambda_p > \lambda_e$
c) $\lambda_p = \lambda_e$, d) $\lambda_p = 2\lambda_e$

300. A particle which has zero rest mass and nonzero energy and momentum must travel with a speed
a) equal to c, the speed of light in vacuum
b) greater than c
c) less than c
d) tending to infinity

301. The relation between the circumference of an electron orbit in a hydrogen atom and the de Broglie wavelength of the electron in the same orbit is given by
a) $2\pi r = n\lambda$ b) $2\pi r = nh/2$
c) $2\pi r = 2n\lambda$ d) $2\pi r = n\lambda/4$

302. An electron of mass m when accelerated through a potential difference V has de–Broglie wavelength λ. The de–Broglie wavelength associated with a proton of mass M accelerated through the same potential difference will be
a) $\lambda\frac{m}{M}$ b) $\lambda\sqrt{\frac{m}{M}}$
c) $\lambda\frac{M}{m}$ d) $\lambda\sqrt{\frac{M}{m}}$

303. The de–Broglie wavelength of a proton and an electron are equal. The it follows that
a) the velocity of the proton is more than that of the electron
b) the velocity of the electron is more than that of the proton
c) the velocities of the proton and electrons are equal
d) the energies of proton and electron are equal

304. What will happen to the de–Broglie wavelength if the velocity of the electron is increased?
a) It will decrease
b) It will increase
c) It will remain the same
d) It will become twice

305. de–Broglie hypothesis treated electrons as
a) particles b) waves
c) both 'a' and 'b' d) none of these

306. What is the wavelength of matter waves associated with a particle of mass 200 gm and moving with a velocity of 100 m/s ? ($h = 6.6 \times 10^{-34}$ J s)
a) 6.6×10^{-33} m b) 3.3×10^{-35} m
c) 2.2×10^{-34} m d) 5.4×10^{-34} m

9.8 de-Broglie wavelength of an electron :

307. The speed of an electron having a wavelength of 10^{-10} m is
a) 7.25×10^6 m/s b) 6.25×10^6 m/s
c) 5.25×10^6 m/s d) 4.24×10^6 m/s

308. The de–Broglie wavelength associated with electrons revolving round the nucleus in a hydrogen atom in the ground state will be
a) 3.3 Å b) 1.3 Å
c) 6.6 Å d) 20 Å

309. If the de–Broglie wavelength for a proton and for a α–particle are equal, then the ratio of their velocities will be
a) 4 : 1 b) 2 : 1
c) 1 : 2 d) 1 : 4

310. The de–Broglie wavelength of an electron, an α–particle and a proton are λ_e, λ_α, λ_p. Which is wrong from the following?
a) $\lambda_e > \lambda_p$ b) $\lambda_e < \lambda_p$
c) $\lambda_p > \lambda_\alpha$ d) $\lambda_e > \lambda_p > \lambda_\alpha$

311. An electron is accelerated from rest between two points at which the potentials are 20 V and 40 V respectively. The de–Broglie wavelength associated with the electron will be
a) 7.5 Å b) 2.75 Å
c) 2.75 m d) 0.75 Å

312. An electron is having a kinetic energy of 50 eV. Its de–Broglie wavelength is
a) 1.732 Å b) 2.5 Å
c) 4.414 Å d) 6.5 Å

313. The de–Broglie wavelength of an electron having 80 eV of energy is nearly
(1 eV = 1.6×10^{-19} J, Mass of electron = 9×10^{-31} kg Plank's constant = 6.6×10^{-34} J s)
a) 140 Å b) 0.14 Å
c) 14 Å d) 1.4 Å

314. The de–Broglie wavelength λ associated with an electron having kinetic energy E is given by the expression
a) $\frac{h}{\sqrt{2mE}}$ b) $\frac{2h}{mE}$
c) 2 mhE d) $\frac{2\sqrt{2mE}}{h}$

315. A potential difference of 15 kV is applied to accelerate the electrons in an electron microscope. The de–Broglie wavelength of the electron waves is
a) 1 Å b) 0.1 Å
c) 0.5 Å d) 0.01 Å

316. The de–Broglie wavelength is proportional to
a) $\lambda \propto 1/v$ b) $\lambda \propto 1/m$
c) $\lambda \propto 1/p$ d) $\lambda \propto p$

317. Electrons kept in an encloser at temperature T have a de–Broglie wavelength λ. If the temperature of the encloser is increased, then the de Broglie wavelength of the electrons will
a) increase b) decrease
c) not change d) none of these

318. When the kinetic energy of an electron is increased, the wavelength of the associated wave will
a) increase
b) decrease
c) wavelength does not depend on the kinetic energy
d) none of the above

319. For an electron, having kinetic energy E and moving at non relativistic speeds (V << C), the de Broglie wavelength is inversely proportional to
a) E b) $E^{1/2}$
c) $E^{-1/2}$ d) E^{-2}

320. If particles are moving with same velocity, then maximum de–Broglie wavelength will be for
a) Neutron b) Proton
c) β–particle d) α–particle

9.9 Davisson and Germer experiment

321. In Davisson and Germer experiment maximum intensity was observed for
a) 54°, 50 V b) 60°, 50 V
c) 50°, 54 V d) 65°, 54 V

322. Davisson and Germer experiment proved
a) wave nature of light
b) particle nature of light
c) both 'a' and 'b'
d) neither 'a' nor 'b'

323. The de Broglie wavelength of an electron revolving in the ground state orbit is
a) πr b) πr^2

c) $2\pi r$ d) $\sqrt{2\pi r}$

324. In Davisson and Germer experiment, a detector with a galvanometer can be rotated on a circular scale. As the detector is rotated the intensity of electronic beam after diffraction
a) remains constant
b) increases continuously
c) decreases continuously
d) increases becomes maximum and decreases

325. In Davisson and Germer experiment, a crystal which diffracts a beam of electrons is of
a) sodium chloride b) nickel
c) silver d) calcium chloride

326. In Davisson and Germer experiment, accelerating potential is kept constant at 54 V. As detector is rotated, the first intensity maximum is obtained 'at an angle of
a) 50° b) 54°
c) 65° d) 45°

327. If the accelerating potential in Davisson and Germer experiment is 54 V, the de–Broglie wavelength of the electron is
a) 0.65 Å b) 1.65 Å
c) 2.65 Å d) 0.165 Å

328. In Davisson and Germer experiment, if the angle of diffraction is 50°, then the angle of glancing will be
a) 65° b) 50°
c) 135° d) 90°

329. The main aim of Davisson and Germer experiment was to verify
a) the wave nature of light
b) the quantum nature of light
c) wave nature of electron
d) negative charge of electron

330. In Davisson and Geremer experiment, an electron beam is incident on a crystal. In the diffracted beam there are
a) α –particles b) protons
c) photons d) electrons

331. In Davisson and Germer experiment; the function of nickel crystal is
a) to absorb the incident beam of electron
b) to diffract the incident beam of electron
c) to interfere the incident beam of electron
d) to refract the incident beam of electron

9.10 Continuous and characteristics

332. X–rays are
a) stream of electrons
b) stream of positively charged particles
c) electromagnetic radiation
d) stream of negatively charged particles

333. The characteristic X–ray radiation is emitted when
a) the electrons are accelerated to a fixed energy
b) the source of electrons emits ~ mono energetic beam
c) the bombarding electrons knock out electrons from the inner shell of the target atoms and one of the outer electrons falls into this vacancy
d) the valence electrons in the target atoms are removed as a result of collision

334. When high speed electrons hit a target
a) only heat is produced
b) only continuous X–rays are emitted
c) only continuous and characteristic X–rays are emitted
d) heat is produced and simultaneously continuous and characteristic X–rays are emitted

335. The continuous X–ray spectrum produced by an X–ray machine at constant voltage has which of the following?
a) a maximum wavelength
b) a minimum wavelength
c) a single wavelength
d) a minimum frequency

336. The characteristic of the electrons striking the target in an X–ray tube that, determines the intensity of X–rays is
a) energy
b) momentum
c) number incident per second
d) mass

337. The characteristic of the electrons striking the target in a Coolidge tube, that determines the upper limit of frequency of continuous X–rays is
a) energy
b) momentum
c) number incident per second
d) mass

338. The target element in an X–ray tube must have a high
a) atomic number only

b) mass number only
c) melting point only
d) both atomic number and melting point

339. The characteristic of the target element that determines the frequency of characteristic X–rays, is
a) its mass number b) its atomic number
c) its melting point d) its conductivity

340. During X–ray formation, if voltage is increased
a) minimum wavelength decreases
b) minimum wavelength increases
c) intensity decreases
d) intensity increases

341. X–rays are produced
a) during electric discharge at low pressure
b) during nuclear explosions
c) when cathode rays are reflected from the target
d) when electrons from higher energy state come back to lower energy state

342. What happens when fast moving electrons are stopped and fall on the metallic target in an evacuated glass bulb?
a) β–particles are produced
b) Metal becomes soft
c) γ–rays are produced
d) X–rays are produced

343. Which of the following types of electromagnetic waves have the longest wavelength ?
a) X–rays b) Infrared
c) Radio waves d) Visible light

344. Intensity of X–rays depends upon the number of
a) neutrons b) positrons
c) protons d) electrons

345. To produce hard X–rays in Coolidge tube, we should increase
a) current in filament
b) potential difference across the filament
c) potential difference across cathode and anticathode
d) none of the above

346. In an X–ray tube, the intensity of the emitted X–ray beam is increased by
a) increasing the filament current
b) decreasing the filament current
c) increasing the target potential
d) decreasing the target potential

347. The wavelength of the characteristic X–ray K_α line emitted by a hydrogen–like element is 0.32 Å. The wavelength of K_β line emitted by the same element will be
a) 0.24 Å b) 0.27 Å
c) 0.32 Å d) 0.48 Å

348. An X–ray tube operated at 30 kV emits a continuous X–ray of short wavelength limit λ = 0.414 Å. The value of Planck's constant is
a) 6.62×10^{-34} J–s b) 6.7×10^{-34} J–s
c) 6.6×10^{-34} J–s d) 6.67×10^{-31} J–s

349. The wavelength of K_α X–rays produced by an X–ray tube is 1.785 Å. Find the atomic number of the anode material of the tube
(R = 109737 cm^{-1})
a) 24 b) 32
c) 48 d) 27

350. Which of the following is accompanied by the characteristic X–ray emission?
a) α–particle emission
b) Electron emission
c) Positron emission
d) K–electron capture

351. The given figure represents the observed intensity of X–rays emitted by an X–ray tube as a function of wavelength. The sharp peaks A and B denote
a) band spectrum Wavelength
b) continuous spectrum
c) white radiation
d) characteristic radiation

352. For continuous X–ray, produced wavelength is
a) inversely proportional to the energy of the electrons hitting the target
b) inversely proportional to the intensity of the electron beam
c) proportional to intensity of the electron beam
d) proportional to target temperature

Examples for practice

353. The speed of the electron in the second orbit in a H–atom is
a) 1.1×10^6 m/s b) 2.1×10^6 m/s
c) 1.5×10^6 m/s d) 2.5×10^6 m/s

354. The velocity of the electron in the first Bohr's orbit is 2.181×10^6 m/s. The linear velocity of

electron in third orbit is

a) 72.7×10^5 m/s b) 2.77×10^5 m/s

c) 7.27×10^5 m/s d) 5.57×10^5 m/s

355. The angular momentum of the electron in the third orbit of H atom is

a) 2.3×10^{-34} Js b) 3.2×10^{-34} Js

c) 5.2×10^{-34} Js d) 4.2×10^{-34} Js

356. The angular speed of the electron in the first orbit in a hydrogen atom is

a) 5.1×10^{16} rad/s b) 1.4×10^{16} rad/s

c) 4.1×10^{16} rad/s d) 1.1×10^{16} rad/s

357. The angular speed of the electron in the first orbit in a H atom is 4.103×10^{16} rad/s. The angular speed of the electron in the third orbit is

a) 2.5×10^{15} rad/s b) 1.5×10^{15} rad/s

c) 5.1×10^{15} rad/s d) 5.5×10^{15} rad/s

358. The radius of the first Bohr orbit of the hydrogen atom is 0.53 Å and angular momentum of the electron in that orbit is 1.055×10^{-34} Js, The linear speed of the electron in the second orbit of the H–atom is

a) 1.1×10^6 m/s b) 1.1×10^{-6} m/s

c) 2.1×10^6 m/s d) 2.1×10^{-6} m/s

259. The radius of first Bohr orbit in H– atom is 0.53 A°. The radius of third orbit is

a) 7.44 A° b) 7.47 A°

c) 47.7 A° d) 4.77 A°

260. The energy of the electron in the third orbit of H–atom is –1.51 eV. The energy of the electron in first orbit is

a) –13.6 eV b) –16.6 eV

c) –1.36 eV d) 13.6 eV

261. Energy of an electron. in second Bohr orbit of H– atom is –3.4 eV. The Rydbergs constant is

a) 2.1×10^{-7} m^{-1} b) 1.1×10^{7} m^{-1}

c) 2.1×10^{7} m^{-1} d) 1.1×10^{-7} m^{-1}

262. In H–atom an electron jumps from third orbit to second orbit. The frequency of emitted light radiation is (E_1 = –13.6 eV)

a) 4.5×10^{14} Hz b) 5.4×10^{14} Hz

c) 4.5×10^{-14} Hz d) 5.5×10^{14} Hz

263. The wavelength of Ha line in Balmer series is

a) 6653A° b) 6365 A°

c) 6563 A° d) 5663 A°

364. The wavelength of the H_α line in Balmer series is 6563 A° . The wavelength of H_γ line in same series is

a) 4143 A° b) 4341 A°

c) 4431 A° d) 1344 A°

365. The shortest wavelength of spectral line in Lyman series is 912 A° . The shortest wavelength of the spectral line of the Paschen series is

a) 8208 A° b) 8028 A°

c) 8828 A° d) 8820 A°

366. The ratio of the longest to the shortest wavelength lines in the Balmer series is

a) 1.1 b) 8.8

c) 1.8 d) 8.1

367. A radioactive substance reduces to $\frac{1}{32}$ of its original value in 300 days. The half life of radioactive substance is

a) 60 days b) 50 days

c) 40 days d) 30 days

368. A radioactive substance decay to $\frac{1}{5}$ of its original value in 56 days. The decay constant is

a) 9.2×10^{-2} per day b) 2.2×10^{-2} per day

c) 2.9×10^{-2} per day d) 9.9×10^{-2} per day

369. A certain mass of radium is reduced by 70% in 2780 years. The decay constant is

a) 4.3×10^{-4} per year b) 3.4×10^{-4} per year

c) 5.4×10^{-4} per year d) 4.8×10^{-4} per year

370. The half life of radium is 1620 years. The fraction decayed out of the original sampleis 3/4. How many years required for it?

a) 3224 years b) 2234 years

c) 3422 years d) 3242 years

371. One gram of a radioactive substance of half life 4 days is sealed in a tube. The quantity left after 5 days is

a) 460 mg b) 240 mg

c) 420 mg d) 402 mg

372. A radioactive substance has a mass of 16 mg and its half life is 25 years. The quantity of substance will remain to be disintegrated in 100 years is

a) 1 mg b) 2 mg

c) 5mg d) 7mg

373. The mass of an electron at rest is 9.1×10^{-31} kg. The energy of electron when it moves with speed of 1.8×10^8 m/s is

a) 2×10^{-13} J b) 1×10^{13} J
c) 1×10^{-13} J d) 1×10^{-3} J

374. A particle moves with a speed of 1.5×10^{8} m/s. The ratio of its mass to its rest mass is
a) 1.1 b) 1.5
c) 2.5 d) 5.2

375. The rest mass of a proton is 1.67×10^{-27} kg. The kinetic energy of proton when it moves with a speed of 2.1×10^{8} m/s is
a) 6×10^{-12} J b) 5×10^{-11} J
c) 6×10^{-11}J d) 7×10^{-11}J

376. The effective mass of a photon of the wavelength of the radiation 3000 A° is
a) 7.4×10^{-36} kg b) 4.7×10^{-36} kg
c) 8.4×10^{-36} kg d) 6.4×10^{-36} kg

377. The percentage increase in the rest mass of an electron when it is moving at a speed of 0.6 c where c is the speed of light, is
a) 52 % b) 75 %
c) 25 % d) 50 %

378. The radius of the nucleus of the atom with A = 216 is (take R_0 = 1.3 fm)
a) 7.2 fm b) 7.8 fm
c) 280 fm d) 19 fm

379. The ratio of the radii of the nuclei $_{13}A^{27}$ and $_{52}Te^{125}$ is approximately
a) 6 : 10 b) 27 : 125
c) 13 : 52 d) 14 : 73

380. A radio active material has a half life of 2.5 hours. In 10 hrs, 1 gm of material is reduced to gm
a) 1/16 b) 1/8
c) 1/4 d) 1/2

381. The half life period of radio active isotope is 5 minutes. The fraction of isotope, that will be remaining after 30 minutes is
a) 1/6 b) 1/36
c) 1/64 d) 1/32

382. The energy of an electron in an excited hydrogen atom is –3.4 eV. Its angular momentum according to Bohr's theory will be
a) 2.11×10^{-34} Js b) $2.11 \times 10^{+34}$ Js
c) 2.11×10^{-34} erg s d) zero

383. The half–life of a certain radioactive element is such that 7/8 of a given quantity decays in 12 days. What fraction remains undecayed after 24 days?
a) 0 b) $\frac{1}{128}$
c) $\frac{1}{64}$ d) $\frac{1}{32}$

384. The ratio of the speed of the electron in the first Bohr orbit of hydrogen and the speed of light is equal to (where e, h and c have their usual meanings)
a) $2nhc/e^2$ b) $e^2h/2nc$
c) $e^2c/2nh$ d) $2ne^2/hc$

385. An electron has a mass of 9.1×10^{-31} kg. It revolves around the nucleus in a circular orbit of radius 0.529×10^{-10} metre at a speed of 2.2×10^{6} ms^{-1}. The magnitude of its linear momentum in this motion is
a) 1.1×10^{-34} kg ms^{-1} b) 2.0×10^{-24} kg ms^{-1}
c) 4.0×10^{-24} kg ms^{-1} d) 4.0×10^{-31} kg ms^{-1}

386. After an interval of one day, (1/16)th initial amount of a radioactive material remains in a sample. Then its half–life is
a) 6 hours b) 12 hours
c) 1.5 hours d) 3 hours

387. The half–life of 215At is 100 μs. The time taken for the radioactivity of a sample of 215At to decay of (1/16)th of its initial value is
a) 400 μs b) 6.3 μs
c) 40 μs d) 300 μs

388. In the figure, energy levels of hydrogen atom have been shown alongwith some transitions marked A, B, C and D. The transitions A, B, C, respectively represent

a) The first member of Lymen series, third member of Balmer series and second member of Paschen series
b) The ionisation potential of H, second member of Balmer series and third member of Paschen series
c) The series limit of Lymen series, second member of Balmer series and third member of Paschen series
d) The series limit of Lymen series, third member of Balmer series and second member of Paschen series

389. The radius of the nucleus $_{8}O^{16}$ is 3×10^{-15} m. The density of this nucleus will be
a) 2.35×10^{-17} kg m^{-3} b) 3.35×10^{17} kg m^{-3}

c) 2.35×10^{17} kg m^{-3} d) 3.35×10^{-17} kg m^{-3}

Questions given in MHT–CET

390. Which of the following is stable?
a) proton b) positron
c) neutron d) electron

391. The radius of a nucleus is]
a) directly proportional to its mass number
b) inversely proportional to its atomic weight
c) directly proportional to the cube root of its mass number
d) none of these

392. Charge on an α –particle is
a) 1.6×10^{-19} C b) 3.2×10^{-19} C
c) 1.6×10^{-20} C d) 4.8×10^{-19} C

393. The radius of hydrogen atom, in its ground state, is of the order of
a) 10^{-8} em b) 10^{-6} cm
c) 10^{-5} cm d) 10^{-4} cm

394. The ionization potential of a hydrogen atom is 13.6 eV. What will be the energy of the atom corresponding to n = 2 ?
a) – 6.8 eV b) – 3.4 eV
c) – 27.2 eV d) – 4.4 eV

395. In a radioactive element is placed in an evacuated chamber, then the rate of radioactive decay will
a) decrease b) remains unchanged
c) increase d) none of these

396. Ratio of velocity in first orbit of H_2 to speed of light is
a) $2e^2/\in_0 hn^2c$ b) $2e^2/\in_0 hc$
c) $e^2/\in_0 hc$ d) $e^2/2\in_0 hc$

397. Unit of 'λ' in radioactivity is
a) m b) (unit of half–lifetl)$^{-1}$
c) (year)$^{-1}$ d) sec

398. The y radiations are
a) electromagnetic radiation with high energy
b) electromagnetic radiation with low energy
c) charged particles emitted by the nucleus
d) electrons orbiting the nucleus

399. What is the amount of energy released, when 3 kg mass is annihilated?
a) 22×10^{16} J b) 18×10^{16} J
c) 27×10^{16} J d) 9×10^{16} J

400. The shortest wavelength for Lyman series is 912 Å. What will be the longest wavelength in Paschen series?
a) 1216 Å b) 3646 Å
c) 18751 Å d) 8208 Å

401. Balmer series lies in which spectrum?
a) visible
b) ultraviolet
c) infrared
d) partially visible, partially infrared

402. Balmer series is obtained in
a) visible region
b) ultraviolet region
c) infrared region
d) visible as well as ultraviolet region

403. Au / Ap in Balmer series is
a) 27 : 20 b) 20 : 27
c) 5 : 36 d) 12 : 64

404. An electron in first orbit of hydrogen moves in circular orbit of radius r with velocity v. Find the current through the loop.
a) 2π ev/r b) ev/2π r
c) 3 ev d) evr

405. The electron in the first orbit of hydrogen has velocity 2.18×10^6 m/s. If radius of first orbit is 0.53 Å then orbital current in the orbit is
a) 0.41 mA b) 1.04 mA
c) 1.84 mA d) 2.4 mA

406. 1.5 kg mass is annihilated. Energy liberated in this process is
a) 1.35×10^{16} J b) 13.5×10^{16} J
c) 23.5×10^{16} J d) 33.5×10^{16} J

407. In Bohr atom, the angular velocity of electron is
a) inversely proportional to n^2
b) inversely proportional to n^3.
c) directly proportional to n
d) independent of n

408. The least energetic wave number in the Paschen series is
a) 5R/16 b) R/4
c) R/9 d) 7R/144

409. Planck's constant has same dimensions as
a) energy b) angular momentum
c) mass d) force

410. Wavelength of first line in Lymen series is A. What is wavelength of first line in Balmer series?
a) $\frac{5\lambda}{27}$ b) $\frac{27\lambda}{5}$

c) $\frac{36\lambda}{5}$ d) $\frac{5\lambda}{36}$

411. 8 gm of radioactive substance decay into 0.5 gm in one hour. Half–life of substance is
a) 45 s b) 10 s
c) 15 s d) 30 s

412. Maximum energy evolved during which of the following transition?
a) n = 1 to n = 2 b) n = 2 to n = 1
c) n = 2 to n = 6 d) n = 6 to n = 2

413. A ground state hydrogen atom has an energy of –13.6 eV. If the electron is excited to the energy state n = 3, its energy becomes
a) –12.09 eV b) – 13.6 eV
c) – 4.5 eV d) – 1.51 eV

414. Which of the following transitions give the highest frequency for electron emission?
a) $n_1 = 1$ to $n_2 = 2$ b) $n_1 = 2$ to $n_2 = 1$
c) $n_1 = 2$ to $n_2 = 5$ d) $n_1 = 5$ to $n_2 = 2$

415. The magnitude of the P.E. of the electron in the first orbit of the Bohr's atom is E. Its K.E. is
a) E b) 2 E
c) E/2 d) E/4

416. The current in the first orbit of Bohr's hydrogen atom is
a) 0.01 mA b) 1 mA
c) 2.63 mA d) 10 mA

417. Radius of nth Bohr's orbit is directly proportional to
a) n b) $\sqrt{n}$
c) n^{-1} d) n^2

418. What is the ratio of orbital magnetic moment and linear momentum of an electron in Bohr's atom?
a) e/2m b) e/m
c) 2e / m d) m / 2e

419. If F is the force between two electrons placed at a distance of 1 m, then Rydberg's constant is
a) $\frac{m\pi F}{h^3C}$ b) $\frac{2m\pi^2F}{h^3C}$
c) $\frac{2m\pi^2F^2}{h^3C}$ d) $\frac{m\pi F^2}{h^3C}$

420. If the velocity of an electron in its first orbit of hydrogen atom is 2.1×10^6 m/s, then it's velocity in the third orbit is
a) 7×10^6 m/s b) 7×10^5 m/s
c) 7×10^4 m/s d) 2×10^4 m/s

421. The de–Broglie wavelength of 1 mg grain of sand blown by a wind at the speed of 20 m/s is [$h = 6.63 \times 10^{-34}$ 5.1. Unit.]
a) 33.15×10^{-36} m b) 33.15×10^{-33} m
c) 33.15×10^{-30} m d) 33.15×10^{30} m

422. For the Bohr's first orbit of circumference $2\pi r$, the de–Broglie wavelength of revolving electron will be
a) πr b) $2\pi r$
c) $\frac{1}{2\pi r}$ d) $\frac{1}{4\pi r}$

423. If an electron is revolving around the hydrogen nucleus at a distance 0.1 mm. What should be its speed
a) 2.188×10^6 m/s b) 1.094×10^6 m/s
c) 4.376×10^6 m/s d) 1.59×10^6 m/s

424. The spectral series of the hydrogen atom that lies in the visible region of the electromagnetic spectrum.
a) Paschen b) Balmer
c) Lyman d) Bracket

425. If the electron in a hydrogen atom jumps from an orbit with level $n_1 = 2$ an orbit with level $n_2 = 1$. The emitted radiation has a wavelength given by
a) $\lambda = \frac{5}{3R}$ b) $\lambda = \frac{4}{3R}$
c) $\lambda = \frac{R}{4}$ d) $\lambda = \frac{3R}{4}$

426. In a hydrogen atom, the electron is making 6.6×10^{15} rps around the nucleus in an orbit of radius 0.528 Å. The magnetic moment will be
a) 1×10^{-15} Am² b) 1×10^{-10} Am²
c) 1×10^{-23} Am² b) 1×10^{-27} Am²

427. If the radius of hydrogen atom in its ground state is 5.3×10^{-11} m. After collision with an electron it is found to have a radius of 21.2×10^{-11} m. The principle quantum number of the final orbit is
a) n = 4 b) n = 3
c) n = 2 d) n = 16

428. The orbital frequency of an electron in the hydrogen atom is proportional to
a) n^3 b) n^{-3}
c) n d) n^0

429. Balmer series of hydrogen atom lies in
a) microwave region b) visible region

c) ultraviolet region d) infrared region

430. The de–Broglie wavelength of an electron in the ground state of hydrogen atom is

a) πr^2 b) $2\pi r$

c) πr d) $\sqrt{2}\ \pi r$

431. The acceleration of electron in Bohr's 1st orbit is given by

a) $\dfrac{h}{4\pi m^2 r^3}$ b) $\dfrac{h}{4\pi m^2 r}$

c) $\dfrac{h^2}{4\pi m^2 r^3}$ d) $\dfrac{h}{4\pi m r}$

432. An electron moves in Bohr's orbit. The magnetic field at the centre is proportional to

a) n^{-5} b) n^{-3}

c) n^{-4} d) n^{-2}

433. The de–Broglie's wavelength in pt Bohr's orbit is

a) πr b) 2 m

c) $3\pi r$ d) $\pi r/2$

434. In Bohr's orbit, angular momentum of an electron is proportional to

a) $\sqrt{r}$ b) $\sqrt{r^2}$

c) r d) $r^{-1/2}$

435. In Bohr's orbit, kinetic energy of an electron in the nth orbit of an atom in terms of angular momentum is

a) $1/L$ b) $1/L^2$

c) L^2 d) $1/L^3$

436. The de–Broglie wavelength λ associated with charged particle of charge q, mass m and potential difference V is

a) $\dfrac{h}{\sqrt{2mqV}}$ b) $\dfrac{h^2}{\sqrt{2mqV}}$

c) $\dfrac{h}{\sqrt{mqV}}$ d) $\dfrac{h}{\sqrt{2qV}}$

437. Ratio of longest wave lengths corresponding to Lyman and Balmer series in hydrogen spectrum is

a) $\dfrac{3}{23}$ b) $\dfrac{7}{29}$

c) $\dfrac{9}{31}$ d) $\dfrac{5}{27}$

438. A certain mass of hydrogen is changed to Helium by the process of fusion. The mass defect in fusion reaction is 0.02866 u. The energy liberated per u is (given 1 u = 931 meV)

a) 26.7 MeV b) 6.675 MeV

c) 13.35 MeV d) 2.67 MeV

439. The half life of a radioactive isotop 'X' is 20 years. If decarys to another element 'Y' which stable. The two elements 'X' and 'Y' were found to be in the ratio 1 : 7 in a sample of a given rock. The age of the rock is estimated to be

a) 60 years b) 80 years

c) 100 years d) 40 years

440. If an electron in hydrogen atom jumps from an orbit of level n = 3 to an orbit of level n = 2, emitted radiation has a frequency (R = Rydberg's constant, c = velocity of light)

a) $\dfrac{3R_C}{27}$ b) $\dfrac{R_C}{25}$

c) $\dfrac{8R_C}{9}$ d) $\dfrac{5R_C}{36}$

441. The de–Broglie wavelength of an electron in 4th orbit is (r = radius of 1^{st} orbit)

a) $2\pi r$ b) $4\pi r$

c) $\dfrac{\pi r}{2}$ d) $16\pi r$

442. For Balmer series, wavelength of first line is λ_1, and for Brackett series, wavelength of first line is 'λ_2' then $\dfrac{\lambda_1}{\lambda_2}$ is

a) 0.081 b) 0.162

c) 0.198 d) 0.238

443. For the hydrogen atom, the energy of radiation emitted in the transition from 4th excited state to 2nd excited state, according to Bohr's theory is

a) 0.567 eV b) 0.667 eV

c) 0.967 eV d) 1.267 eV

444. The de–Broglie wavelength 'λ' of a particle is

a) proportional to mass

b) proportional to impulse

c) inversely proportional to impulse

d) does not depend on impulse .

❍❍❍

Answers

1.	(a)	2.	(c)	3.	(a)	4.	(a)	5.	(d)	6.	(d)	7.	(b)	8.	(a)	9.	(d)	10.	(b)
11.	(c)	12.	(c)	13.	(d)	14.	(a)	15.	(d)	16.	(d)	17.	(a)	18.	(b)	19.	(a)	20.	(a)
21.	(a)	22.	(c)	23.	(d)	24.	(b)	25.	(d)	26.	(c)	27.	(c)	28.	(d)	29.	(b)	30.	(d)
31.	(c)	32.	(c)	33.	(d)	34.	(c)	35.	(c)	36.	(d)	37.	(a)	38.	(d)	39.	(d)	40.	(c)
41.	(c)	42.	(c)	43.	(a)	44.	(a)	45.	(b)	46.	(b)	47.	(b)	48.	(a)	49.	(c)	50.	(a)
51.	(d)	52.	(c)	53.	(a)	54.	(c)	55.	(b)	56.	(d)	57.	(b)	58.	(b)	59.	(a)	60.	(d)
61.	(b)	62.	(c)	63.	(a)	64.	(d)	65.	(d)	66.	(c)	67.	(c)	68.	(a)	69.	(a)	70.	(a)
71.	(a)	72.	(b)	73.	(a)	74.	(b)	75.	(b)	76.	(a)	77.	(c)	78.	(a)	79.	(a)	80.	(d)
81.	(c)	82.	(a)	83.	(c)	84.	(c)	85.	(d)	86.	(d)	87.	(b)	88.	(a)	89.	(b)	90.	(b)
91.	(a)	92.	(a)	93.	(d)	94.	(c)	95.	(b)	96.	(d)	97.	(b)	98.	(d)	99.	(a)	100.	(b)
101.	(c)	102.	(a)	103.	(b)	104.	(c)	105.	(d)	106.	(d)	107.	(a)	108.	(a)	109.	(b)	110.	(a)
111.	(b)	112.	(d)	113.	(b)	114.	(b)	115.	(a)	116.	(b)	117.	(c)	118.	(b)	119.	(a)	120.	(a)
121.	(b)	122.	(d)	123.	(b)	124.	(c)	125.	(c)	126.	(b)	127.	(d)	128.	(c)	129.	(c)	130.	(c)
131.	(c)	132.	(a)	133.	(a)	134.	(d)	135.	(b)	136.	(a)	137.	(c)	138.	(a)	139.	(c)	140.	(a)
141.	(a)	142.	(a)	143.	(d)	144.	(d)	145.	(b)	146.	(d)	147.	(d)	148.	(a)	149.	(a)	150.	(b)
151.	(d)	152.	(d)	153.	(b)	154.	(d)	155.	(c)	156.	(b)	157.	(d)	158.	(d)	159.	(a)	160.	(b)
161.	(b)	162.	(c)	163.	(d)	164.	(c)	165.	(a)	166.	(b)	167.	(b)	168.	(b)	169.	(b)	170.	(d)
171.	(d)	172.	(d)	173.	(b)	174.	(d)	175.	(d)	176.	(d)	177.	(a)	178.	(d)	179.	(d)	180.	(d)
181.	(b)	182.	(b)	183.	(a)	184.	(a)	185.	(b)	186.	(a)	187.	(a)	188.	(b)	189.	(c)	190.	(c)
191.	(a)	192.	(a)	193.	(a)	194.	(b)	195.	(a)	196.	(a)	197.	(c)	198.	(c)	199.	(d)	200.	(a)
201.	(b)	202.	(b)	203.	(d)	204.	(a)	205.	(a)	206.	(b)	207.	(d)	208.	(c)	209.	(d)	210.	(a)
211.	(c)	212.	(c)	213.	(a)	214.	(b)	215.	(b)	216.	(d)	217.	(d)	218.	(b)	219.	(c)	220.	(b)
221.	(c)	222.	(c)	223.	(a)	224.	(a)	225.	(b)	226.	(c)	227.	(c)	228.	(d)	229.	(d)	230.	(d)
231.	(c)	232.	(b)	233.	(c)	234.	(d)	235.	(a)	236.	(c)	237.	(b)	238.	(b)	239.	(c)	240.	(d)
241.	(a)	242.	(b)	243.	(d)	244.	(c)	245.	(c)	246.	(a)	247.	(b)	248.	(a)	249.	(a)	250.	(a)
251.	(c)	252.	(c)	253.	(b)	254.	(c)	255.	(a)	256.	(b)	257.	(a)	258.	(a)	259.	(d)	260.	(d)
261.	(c)	262.	(c)	263.	(a)	264.	(b)	265.	(d)	266.	(b)	267.	(a)	268.	(b)	269.	(b)	270.	(b)
271.	(a)	272.	(c)	273.	(c)	274.	(d)	275.	(a)	276.	(a)	277.	(c)	278.	(b)	279.	(d)	280.	(b)
281.	(b)	282.	(c)	283.	(a)	284.	(c)	285.	(b)	286.	(a)	287.	(b)	288.	(d)	289.	(a)	290.	(d)
291.	(a)	292.	(a)	293.	(c)	294.	(b)	295.	(a)	296.	(b)	297.	(a)	298.	(d)	299.	(a)	300.	(a)
301.	(a)	302.	(b)	303.	(b)	304.	(a)	305.	(b)	306.	(b)	307.	(a)	308.	(a)	309.	(a)	310.	(b)
311.	(b)	312.	(a)	313.	(d)	314.	(a)	315.	(b)	316.	(c)	317.	(b)	318.	(b)	319.	(b)	320.	(c)
321.	(c)	322.	(d)	323.	(c)	324.	(d)	325.	(b)	326.	(a)	327.	(b)	328.	(a)	329.	(c)	330.	(d)
331.	(b)	332.	(c)	333.	(c)	334.	(d)	335.	(b)	336.	(c)	337.	(a)	338.	(d)	339.	(b)	340.	(a)
341.	(d)	342.	(d)	343.	(c)	344.	(d)	345.	(c)	346.	(a)	347.	(b)	348.	(a)	349.	(d)	350.	(d)
351.	(d)	352.	(a)	353.	(a)	354.	(c)	355.	(b)	356.	(c)	357.	(b)	358.	(a)	359.	(c)	360.	(a)
361.	(b)	362.	(a)	363.	(c)	364.	(b)	365.	(a)	366.	(c)	367.	(a)	368.	(c)	369.	(a)	370.	(d)
371.	(c)	372.	(a)	373.	(c)	374.	(a)	375.	(c)	376.	(a)	377.	(c)	378.	(b)	379.	(a)	380.	(a)
381.	(c)	382.	(a)	383.	(c)	384.	(d)	385.	(b)	386.	(a)	387.	(a)	388.	(a)	389.	(c)	390.	(c)
391.	(c)	392.	(b)	393.	(a)	394.	(b)	395.	(b)	396.	(d)	397.	(b)	398.	(a)	399.	(c)	400.	(c)
401.	(a)	402.	(a)	403.	(a)	404.	(b)	405.	(b)	406.	(b)	407.	(b)	408.	(d)	409.	(b)	410.	(b)

Answers

411.	(c)	412.	(b)	413.	(d)	414.	(b)	415.	(c)	416.	(b)	417.	(d)	418.	(a)	419.	(c)	420.	(b)
421.	(c)	422.	(b)	423.	(a)	424.	(b)	425.	(b)	426.	(c)	427.	(c)	428.	(b)	429.	(b)	430.	(b)
431.	(c)	432.	(a)	433.	(b)	434.	(c)	435.	(b)	436.	(c)	437.	(d)	438.	(b)	439.	(a)	440.	(d)
441.	(c)	442.	(b)	443.	(c)	444.	(c)												

Hint / Solutions

40. Possible transitions are

$4 \to 1, 4 \to 2, 4 \to 3.$

Thus, three photons are emitted.

61. $r_n = r_1 n^2 \quad \therefore r_3 = 0.5 \times 3^2 = 4.5\ A^\circ$

62. $r_n = n^2 \quad \therefore r_1 : r_2 : r_3 = 1 : 4 : 9$

63. $r_n = r_1 n^2$

$$\therefore n^2 = \frac{r_n}{r_1} = \frac{21.2 \times 10^{-11}}{0.53 \times 10^{-10}} = 4$$

$$\therefore n = 2$$

66. $v_n = \frac{v_1}{n} \quad \therefore v_2 = \frac{c}{137 \times 2} = \frac{c}{274}$

67. $v_n = \frac{v_1}{n} \quad \therefore v_3 = \frac{2.182 \times 10^6}{3}$

$$= 7.273 \times 10^5 \text{ m/s}$$

68. $T_n = T_1 n^3$

$$\therefore T_4 = \frac{64}{27} \times T_3 = \frac{64 \times 4.132 \times 10^{-15}}{27}$$

$$= 9.794 \times 10^{-15} \text{ sec}$$

69. $I\omega_4 - I\omega_1 = \frac{3h}{2\pi} = \frac{3 \times 6.63 \times 10^{-34}}{2 \times 3.14}$

$$= 3.167 \times 10^{-34} \text{ kg m}^2\text{/s}$$

70. $\omega_n = \frac{\omega_1}{n^3}$

$$\therefore \omega_3 = \frac{\omega_1}{27} = \frac{4.103 \times 10^{16}}{27}$$

$$= 1.52 \times 10^{15} \text{ rad/sec.}$$

71. $P_n = \frac{P_1}{n}$

$$\therefore P_8 = \frac{P_1}{8} = \frac{2 \times 10^{-24}}{8} = 2.5 \times 10^{-25} \text{ kg m/s}$$

75. $E_n = \frac{E_1}{n^2}$

$$\therefore E_2 = \frac{E_1}{4} = \frac{-13.6}{4} = -3.4 \text{ eV.}$$

76. $E_n = \frac{E_1}{n^2}$

Thus, energy of electron in the first excited state is given by,

$$E_2 = \frac{E_1}{4} = \frac{-13.6}{4} = -3.4 \text{ eV}$$

77. $E_n \propto \frac{1}{n^2}$

Thus, $E_1 = \frac{E_0}{4}$ & $E_2 = \frac{E_0}{9} \quad \therefore \frac{E_1}{E_2} = \frac{9}{4}$

78. $E_4 = \frac{E_1}{16} = \frac{-13.6}{16} = -0.85 \text{ eV}$

$$E_2 = \frac{E_1}{4} = \frac{-13.6}{4} = -3.4 \text{ eV}$$

$$\therefore E_4 - E_2 = -0.85 + 3.4 = 2.55 \text{ eV}$$

79. $E_n = \frac{E_1}{n^2} \quad \therefore n^2 = \frac{E_1}{E_n} = \frac{-13.6}{-0.85} = 16$

$$\therefore n = 4$$

80. $E_n = \frac{E_1}{n^2} \quad \therefore E_2 = \frac{E_1}{4} = \frac{13.6}{4} = 3.4 \text{ eV}$

81. $E_n = \frac{E_1}{n^2}$

Thus energy in the first excited state is,

$$E_2 = \frac{E_1}{4} = \frac{\omega}{4}$$

82. Energy of photon $= h\nu = E_n - E_p$

$= -0.85 + 13.6 = 12.75 \text{ eV}$

$$\therefore \nu = \frac{12.75 \times 1.6 \times 10^{-19}}{6.63 \times 10^{-34}}$$

$$= 3.077 \times 10^{15} \text{ Hz}$$

83. T.E. of electron $= -$ B.E. of electron

$= -1.51$ eV

P.E. of electron $=$ 2 times total energy

$= 2 \times (-1.51)$

$= -3.02$ eV

84. Higher the value of the lower quantum number to which electron is jumping, longer will be wavelength i.e. minimum energy. Therefore n = 6 to n = 8 transition produces minimum energy.

86. Lower the value of the lower quantum number to which electron is jumping , higher will be the frequency. Therefore n = 2 to n = 1 transition produces highest frequency.

89. Magnetic dipole moment $= M$

$= IA$

$$= \frac{ev}{2\pi r} \pi r^2 = \frac{evr}{2}$$

Angular momentum $= L$

$= mrv$

$$\text{Thus, } \frac{M}{L} = \frac{evr/2}{mrv} = \frac{e}{2m}$$

92. Angular momentum = mrv = J

$$\therefore \quad v = \frac{J}{mr}$$

$$\text{K.E. of electron} = \frac{1}{2}mv^2 = \frac{1}{2}m\left(\frac{J}{mr}\right)^2$$

$$= \frac{J^2}{2mr^2}$$

93. $I = \frac{q}{t} = qn = en \quad (\because \frac{1}{t} = n \;\&\; q = e)$

94. $T^2 \propto r^3$

$$\therefore \left(\frac{T_1}{T_2}\right)^2 = \left(\frac{r_1}{r_2}\right)^3 = \left(\frac{R}{4R}\right)^3 = \frac{1}{64}$$

$$\therefore \frac{T_1}{T_2} = \frac{1}{8}$$

95. $T^2 \propto r^3$

$$\therefore \left(\frac{r_1}{r_2}\right)^3 = \left(\frac{T_1}{T_2}\right)^2 = \left(\frac{t}{8t}\right)^2 = \frac{1}{64}$$

$$\therefore \frac{r_1}{r_2} = \frac{1}{4}$$

103. $\bar{\lambda} = R\left(\frac{1}{p^2} - \frac{1}{n^2}\right) = R\left(\frac{1}{4} - \frac{1}{16}\right) = \frac{3R}{16}$

123. For series limit of Balmer series,

$p = 2$ and $n = \infty$

$$\frac{1}{\lambda} = R\left(\frac{1}{p^2} - \frac{1}{n^2}\right) = R\left(\frac{1}{4} - \frac{1}{\infty}\right)$$

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

125. For last line of Balmer series,

$p = 2$ and $n = \infty$

$$\bar{\lambda} = R\left(\frac{1}{p^2} - \frac{1}{n^2}\right) = 1.1 \times 10^7 \left(\frac{1}{4} - \frac{1}{\infty}\right)$$

$$= 2.75 \times 10^6 \text{ m}^{-1}$$

126. For first spectral line of Lyman series,

$p = 1$ and $n = 2$

$$\frac{1}{\lambda} = R\left(\frac{1}{p^2} - \frac{1}{n^2}\right) = 1.097 \times 10^7 \left(\frac{1}{1} - \frac{1}{4}\right)$$

$$\therefore \quad \lambda = 1215 \text{ A}^\circ$$

127. For first line of Balmer series,

$p = 2$ and $n = 3$

$$\frac{1}{\lambda_1} = R\left(\frac{1}{p^2} - \frac{1}{n^2}\right) = R\left(\frac{1}{4} - \frac{1}{9}\right)$$

$$\therefore \quad \lambda_1 = \frac{36}{5R} \quad \text{... (1)}$$

For second line of Balmer series,

$p = 2$ and $n = 4$

$$\frac{1}{\lambda_2} = R\left(\frac{1}{p^2} - \frac{1}{n^2}\right) = R\left(\frac{1}{4} - \frac{1}{16}\right)$$

$$\therefore \quad \lambda_2 = \frac{64}{12R} \quad \text{... (2)}$$

Dividing eq. (2) by eq. (1) we have,

$$\lambda_2 = \frac{64 \times 5 \times \lambda_1}{12 \times 36}$$

$$= \frac{64 \times 5 \times 6561}{12 \times 36} = 4860 \text{ A}^\circ$$

128. For series limit wavelength of Lyman series,

$p = 1$ and $n = \infty$

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

$$\therefore \quad \lambda_L = \frac{1}{R} \quad \text{... (1)}$$

For series limit wavelength of Balmer series,

$p = 2$ and $n = \infty$

$$\frac{1}{\lambda_B} = R\left(\frac{1}{p^2} - \frac{1}{n^2}\right) = R\left(\frac{1}{4} - \frac{1}{\infty}\right)$$

$$\therefore \quad \lambda_B = \frac{4}{R} \quad \text{... (2)}$$

From eq. (1) and (2) we have,

$$\lambda_B = 4\lambda_L = 4 \times 912 \text{ A}^\circ$$

129. $\nu = \frac{c}{\lambda} = cR\left(\frac{1}{p^2} - \frac{1}{n^2}\right)$

$$= cR\left(\frac{1}{4} - \frac{1}{16}\right)$$

$$= \frac{3 \times 10^8 \times 10^7 \times 12}{64} = \frac{9}{16} \times 10^{15} \text{ Hz}$$

130. For longest wavelength of Balmer series,

$p = 2$ and $n = 3$

$$\frac{1}{\lambda} = R\left(\frac{1}{p^2} - \frac{1}{n^2}\right) = R\left(\frac{1}{4} - \frac{1}{9}\right) = \frac{5R}{36}$$

$$\therefore \quad R = \frac{36}{5\lambda} = \frac{36}{5 \times 6.563 \times 10^{-7}}$$

$$= 1.09 \times 10^7 \text{m}^{-1}$$

131. For shortest wavelength of Balmer series,

$p = 2$ and $n = \infty$

$$\bar{\lambda} = \frac{1}{\lambda} = R\left(\frac{1}{p^2} - \frac{1}{n^2}\right) = R\left(\frac{1}{4} - \frac{1}{\infty}\right)$$

$$= \frac{1.1 \times 10^7}{4}$$

$$= 2.75 \times 10^6 \text{ m}^{-1}$$

132. For H_β line of Balmer series,

$p = 2$ and $n = 4$

$$\therefore \quad \frac{1}{\lambda_\beta} = R\left(\frac{1}{p^2}-\frac{1}{n^2}\right) = R\left(\frac{1}{4}-\frac{1}{16}\right)$$

$$\therefore \quad \lambda_\beta = \frac{64}{12R} \qquad \text{... (1)}$$

For H_α line of Balmer series,

$p = 2$ and $n = 3$

$$\therefore \quad \frac{1}{\lambda_\alpha} = R\left(\frac{1}{p^2}-\frac{1}{n^2}\right) = R\left(\frac{1}{4}-\frac{1}{9}\right)$$

$$\therefore \quad \lambda_\alpha = \frac{36}{5R} \qquad \text{.... (2)}$$

Dividing eq. (2) by eq. (1) we have,

$$\lambda_\alpha = \frac{36\times 12\times \lambda_\beta}{5\times 64} = \frac{36\times 12\times 4861}{5\times 64}$$

$$= 6563 \text{ A}^\circ$$

133. For shortest wavelength of Lyman series,

$p = 1$ and $n = \infty$

$$\therefore \quad \frac{1}{\lambda_1} = R\left(\frac{1}{p^2}-\frac{1}{n^2}\right) = R\left(\frac{1}{1}-\frac{1}{\infty}\right)$$

$$\therefore \quad \lambda_1 = \frac{1}{R} \qquad \text{.... (1)}$$

For shortest wavelength of Paschen series,

$p = 3$ and $n = \infty$

$$\therefore \quad \frac{1}{\lambda_2} = R\left(\frac{1}{p^2}-\frac{1}{n^2}\right) = R\left(\frac{1}{9}-\frac{1}{\infty}\right)$$

$$\therefore \quad \lambda_2 = \frac{9}{R} \qquad \text{... (2)}$$

From eq. (1) and (2) we have ,

$$\lambda_2 = 9\lambda_1 = 9\times 912 = 8208 \text{ A}^\circ$$

134.

$$2E - E = \frac{hc}{\lambda} \Rightarrow E = \frac{hc}{\lambda} \qquad \text{.....(1)}$$

$$\Rightarrow \frac{4}{3}E - E = \frac{hc}{\lambda_1} \Rightarrow \frac{1}{3}E = \frac{hc}{\lambda_1} \qquad \text{.....(2)}$$

Dividing (1) by (2) we have,

$$3 = \frac{\lambda_1}{\lambda} \Rightarrow \lambda_1 = 3\lambda$$

135.

$$E_{CA} = E_{CB} + E_{BA}$$

$$\frac{hc}{\lambda_3} = \frac{hc}{\lambda_1} + \frac{hc}{\lambda_2} \Rightarrow \frac{1}{\lambda_3} = \frac{1}{\lambda_1} + \frac{1}{\lambda_2}$$

$$\Rightarrow \quad \lambda_3 = \frac{\lambda_1\lambda_2}{\lambda_1+\lambda_2}$$

181.

$$m = \frac{m_0}{\sqrt{1-\frac{v^2}{c^2}}} = \frac{9.1\times 10^{-31}}{\sqrt{1-\left(\frac{2.4\times 10^8}{3\times 10^8}\right)^2}}$$

$$= 15.17\times 10^{-31} \text{ kg}$$

182.

$$E = h\nu = mc^2$$

$$\therefore \quad m = \frac{h\nu}{c^2} = \frac{6.63\times 10^{-34}\times 5\times 10^{14}}{9\times 10^{16}}$$

$$= 3.683\times 10^{-36} \text{ kg}$$

183.

$$m = \frac{m_0}{\sqrt{1-\frac{v^2}{c^2}}} = \frac{1.67\times 10^{-27}}{\sqrt{1-\left(\frac{2.1\times 10^8}{3\times 10^8}\right)^2}}$$

$$m = 2.3386\times 10^{-27} \text{ kg}$$

$$\therefore \quad E = mc^2$$

$$= 2.3386\times 10^{-27}\times 9\times 10^{16}$$

$$= 2.105\times 10^{-10} \text{ J}$$

184.

$$\frac{m}{m_0} = \frac{1}{\sqrt{1-\frac{v^2}{c^2}}} = \frac{1}{\sqrt{1-\left(\frac{1.5\times 10^8}{3\times 10^8}\right)^2}}$$

$$= 1.155$$

185. Given, $m_0c^2 = \frac{1}{2}m_0v^2$

$$\therefore \quad E = mc^2 = 2m_0c^2$$

$$\therefore \quad m = 2m_0$$

Now, $$m = \frac{m_0}{\sqrt{1-\frac{v^2}{c^2}}} \Rightarrow 2m_0 = \frac{m_0}{\sqrt{1-\frac{v^2}{c^2}}}$$

$$\Rightarrow \quad 4 = \frac{1}{1-\frac{v^2}{c^2}} \Rightarrow \frac{1}{4} = 1-\frac{v^2}{c^2}$$

$$\therefore \quad \frac{v}{c} = \frac{\sqrt{3}}{2}$$

$$\therefore \quad v = \frac{1.732\times 9\times 10^8}{2}$$

$$= 2.598\times 10^8 \text{ m/s}$$

186. The mass of electron is given by,

$$m = \frac{m_0}{\sqrt{1-\frac{v^2}{c^2}}} = \frac{9.1\times 10^{-31}}{\sqrt{1-\left(\frac{2.4\times 10^8}{3\times 10^8}\right)^2}}$$

$$= 15.16\times 10^{-31} \text{ kg}$$

The total energy of electron is given by,

$$E = mc^2$$

$$= 15.16\times 10^{-31}\times 9\times 10^{16}$$

$$= 136.44\times 10^{-15} \text{ J}$$

Now, rest mass energy of electron is,

$$m_0c^2 = 9.1 \times 10^{-31} \times 9 \times 10^{16}$$
$$= 81.9 \times 10^{-15}\ J$$

Thus, K.E. of electron is given by,

$$E_k = E - m_0c^2$$
$$= 136.44 \times 10^{-15} - 81.9 \times 10^{-15}$$
$$= 5.454 \times 10^{-14}\ J$$
$$\approx 5.45 \times 10^{-14}\ J$$

241. $${}_{90}Th^{232} \xrightarrow{6\alpha} {}_{78}X^{208} \xrightarrow{4\beta} {}_{82}Pb^{208}$$

262. Number of α-particles emitting

$$\text{per second} = \frac{dN}{dt}$$
$$= \lambda N$$
$$= n$$
$$\therefore \quad \lambda = \frac{n}{N}$$
$$\therefore \quad T = \frac{0.693}{\lambda}$$
$$= \frac{0.693\,N}{n}$$

263. $$\lambda = \frac{0.693}{T} = \frac{0.693}{1620}$$
$$\approx 4.2 \times 10^{-4} \text{ per year}$$

264. $$\lambda = \frac{2.303}{t} \log\left(\frac{N_0}{N}\right)$$
$$= \frac{2.303}{56} \log\left(\frac{5}{1}\right)$$
$$= 0.0287\ \text{day}^{-1}$$

265. $$\lambda = \frac{2.303}{t} \log\left(\frac{N_0}{N}\right)$$
$$= \frac{2.303}{100} \log\left(\frac{100}{20}\right)$$
$$= 0.01609$$
$$T = \frac{0.693}{\lambda} = \frac{0.693}{0.01609}$$
$$= 43.04 \text{ days}$$

266. $$n = \frac{t}{T} = \frac{6400}{1600}$$
$$= 4$$

The fraction of radioactive atom left behind after time t is given by,

$$\frac{N}{N_0} = \left(\frac{1}{2}\right)^n = \left(\frac{1}{2}\right)^4 = \frac{1}{16}$$

267. $$n = \frac{t}{T} = \frac{540}{270} = 2$$

Mass of radioactive element left after time t is given by,

$$\frac{M}{M_0} = \left(\frac{1}{2}\right)^n = \left(\frac{1}{2}\right)^2 = \frac{1}{4}$$
$$\therefore \quad M = \frac{M_0}{4} = \frac{10}{4}$$
$$= 2.5 \text{ mg}$$

268. $$\lambda = \frac{0.693}{T} = \frac{0.693}{1}$$
$$= 0.693 \text{ per year}$$
$$t = \frac{2.303}{\lambda} \log\left(\frac{N_0}{N}\right) = \frac{2.303}{0.693} \log\frac{8}{1}$$
$$t = 3.001 \text{ years}$$
$$\approx 3 \text{ years}$$

269. $$\lambda = \frac{2.303}{t_1} \log\left(\frac{N_0}{N}\right)$$
$$= \frac{2.303}{30} \log\left(\frac{64}{1}\right)$$
$$= 0.1386$$
$$\therefore \quad t_2 = \frac{2.303}{\lambda} \log\left(\frac{N_0}{N}\right)$$
$$= \frac{2.303}{0.1386} \log\left(\frac{128}{1}\right)$$
$$\approx 35 \text{ days}$$

270. Activity is proportional to mass. Activity of specimen B is maximum. Thus, mass of specimen B is also maximum.

272. $$\lambda = \frac{h}{p} = \frac{6.63\times10^{-34}}{2\times10^{-28}} = 3.3 \times 10^{-6}\ \text{m}.$$

275. $$\lambda = \frac{h}{\sqrt{2mqV}}$$
$$\lambda \propto \frac{1}{\sqrt{mq}}$$
$$\frac{\lambda_p}{\lambda_\alpha} = \frac{m_\alpha q_\alpha}{m_p q_p} = \sqrt{\frac{4m_p \times 2q_p}{m_p \times q_p}} = \frac{2\sqrt{2}}{1}$$

278. $$\lambda = \frac{h}{\sqrt{2m E_k}}$$
$$\lambda \propto \frac{1}{\sqrt{m}}$$
$$\frac{\lambda_\alpha}{\lambda_p} = \sqrt{\frac{m_p}{m_\alpha}} = \sqrt{\frac{m_p}{4m_p}} = \frac{1}{2}$$

281. $\lambda = \frac{h}{mv} = \frac{6.63\times10^{-34}}{2\times10} = 3.3\times10^{-35}$ m.

283. $$\lambda = \frac{h}{mv} = \frac{hr}{mv\,r} = \frac{hr}{\frac{nh}{2\pi}}$$

$$\lambda = \frac{2\pi r}{n}$$

$$\therefore\ n\lambda = 2\pi r$$

$$\lambda = 2\pi r \qquad (n = 1)$$

284. $$\lambda = \frac{12.27}{\sqrt{V}}$$

$$\lambda^2 = \frac{12.27\times12.27}{V}$$

$$V = \frac{12.27\times12.27}{0.16} = 941\text{ V.}$$

285. $$\frac{E_K}{E_P} = \frac{\frac{mv^2}{2}}{\frac{hc}{\lambda}} = \frac{mv\cdot v}{2}\times\frac{\lambda}{hc}$$

$$= \frac{h}{\lambda}\cdot\frac{v}{2}\times\frac{\lambda}{hc}$$

$$= \frac{v}{2c} = \frac{2.25\times10^8}{3\times10^8} = \frac{3}{8}$$

286. $$\lambda = \frac{h}{\sqrt{2mqV}}$$

$$\lambda \propto \frac{1}{\sqrt{m}}$$

$$\frac{\lambda_e}{\lambda_p} = \sqrt{\frac{m_p}{m_e}}$$

288. $$\lambda = \frac{h}{\sqrt{2mqV}}$$

$$\lambda \propto \frac{1}{\sqrt{E_K}}$$

$$\frac{\lambda_1}{\lambda_2} = \sqrt{\frac{E_{K_2}}{E_{K_1}}} = \sqrt{\frac{2E_{K_1}}{E_{K_1}}} = \frac{\sqrt{2}}{1}$$

291. $$\lambda = \frac{h}{mv} = \frac{6.63\times10^{-34}}{2\times1.67\times10^{-27}\times3\times10^3}$$

$$= 0.66\times10^{-10}\text{ m.}$$

292. $$\lambda = \frac{h}{p}$$

$$\therefore\ p = \frac{h}{\lambda} = \frac{6.63\times10^{-34}}{2\times10^{-6}} = 3.3\times10^{-28}\text{ kg m/s.}$$

297. $$\lambda = \frac{h}{mv} = \frac{6.63\times10^{-34}}{1\times2\times10^{-3}}$$

$$= 3.3\times10^{-37} = 3.3\times10^{-27}\text{ Å.}$$

298. $\lambda = \frac{h}{mv} = \frac{6.63\times10^{-34}}{2\times10^{-3}\times1} = 3.3\times10^{-28}$ m

299. $$\lambda \propto \frac{1}{\sqrt{E_k}}$$

$$\therefore\ \lambda_p < \lambda_e$$

301. $$\lambda = \frac{h}{mv} = \frac{hr}{mv\,r} = \frac{hr}{\frac{nh}{2\pi}}$$

$$\lambda = \frac{2\pi r}{n}$$

$$\therefore\ n\lambda = 2\pi r$$

$$\lambda = 2\pi r \qquad (n = 1)$$

302. $$\lambda = \frac{h}{\sqrt{2mqV}}$$

$$\lambda \propto \frac{1}{\sqrt{m}}$$

$$\frac{\lambda_p}{\lambda_e} = \sqrt{\frac{m_e}{m_p}}$$

$$\lambda_p = \sqrt{\frac{m}{M}}\,\lambda$$

306. $\lambda = \frac{h}{mv} = \frac{6.63\times10^{-34}}{200\times10^{-3}\times100} = 3.3\times10^{-35}$ m.

307. $$\lambda = \frac{h}{mv}$$

$$\therefore\ v = \frac{h}{m\lambda} = \frac{6.63\times10^{-34}}{9.1\times10^{-31}\times10^{-10}}$$

$$= 7.25\times10^6\text{ m/s.}$$

308. $\lambda = 2\pi r$

$= 2\pi\times0.53 = 3.3$ Å.

309. $$\lambda = \frac{h}{mv} \qquad \therefore\ v = \frac{h}{m\lambda}$$

$$v \propto \frac{1}{m}$$

$$\frac{v_p}{v_\alpha} = \frac{m_\alpha}{m_p} = \frac{4m_p}{m_p} = \frac{4}{1}$$

310. $\lambda \propto \frac{1}{\sqrt{E}} \qquad \therefore\ \lambda_e < \lambda_p.$

311. $\lambda = \frac{12.27}{\sqrt{v}} = \frac{12.27}{\sqrt{20}} = 2.75$ Å.

312. $\lambda = \dfrac{12.27}{\sqrt{V}} = \dfrac{12.27}{\sqrt{50}} = 1.732$ Å.

313. $\lambda = \dfrac{12.27}{\sqrt{V}} = \dfrac{12.27}{\sqrt{80}} = 1.4$ Å.

315. $\lambda = \dfrac{12.27}{\sqrt{V}} = \dfrac{12.27}{15\times10^3} = 0.1$ Å.

319. $\lambda = \dfrac{h}{\sqrt{2mE}}$ i.e., $\lambda \propto \dfrac{1}{\sqrt{E}}$

353. $v_n = \dfrac{e^2}{2\varepsilon_0 nh}$

$v_2 = \dfrac{(1.6\times10^{-19})^2}{2\times8.85\times10^{-12}\times2\times6.63\times10^{-34}}$

$= 1.1\times10^6$ m/s

354. $v_n = \dfrac{v_1}{n}$

$\therefore v_3 = \dfrac{v_1}{3}$

$= \dfrac{2.181\times10^6}{3} = 7.27\times10^5$ m/s

355. $L_n = \dfrac{nh}{2\pi}$

$L_3 = \dfrac{3\times6.63\times10^{-34}}{6.28} = 3.2\times10^{-34}$ J.s

356. $\omega_n = \dfrac{\pi me^4}{2\varepsilon_0^2 n^3 h^3}$

$\therefore \omega_1 = \dfrac{3.14\times9.1\times10^{-31}\times(1.6\times10^{-19})^4}{2\times(8.85\times10^{-12})^2\times1\times(6.63\times10^{-34})^3}$

$= 4.1\times10^{16}$ rad/s

357. $\omega_n = \dfrac{\omega_1}{n^3}$

$\omega_3 = \dfrac{\omega_1}{27}$

$= \dfrac{4.103\times10^{16}}{27} = 1.5\times10^{15}$ rad/s

358. $L_1 = m r_1 v_1$

$\therefore v_1 = \dfrac{L_1}{m r_1} = \dfrac{1.055\times10^{-34}}{9.1\times10^{-31}\times0.53\times10^{-10}}$

$v_2 = \dfrac{v_1}{2}$

$= \dfrac{2.181\times10^6}{2}$

$= 1.1\times10^6$ m/s.

359. $r_n = r_1 n^2$

$r_3 = 9 r_1 = 9\times0.53 = 4.77$ Å.

360. $E_n = \dfrac{E_1}{n^2}$

$E_3 = \dfrac{E_1}{9}$

$\therefore E_1 = 9E_3 = -9\times1.51 = -13.6$ eV.

361. $E_n = \dfrac{E_1}{n^2}$

$E_2 = \dfrac{E_1}{4}$

$E_1 = 4E_2 = -Rhc$

$\therefore R = \dfrac{4\times3.4\times1.6\times10^{-19}}{6.63\times10^{-34}\times3\times10^8}$

$= 1.1\times10^7\ m^{-1}$.

362. $h\nu = E_n - E_p$

$= E_3 - E_2$

$= \dfrac{E_1}{9} - \dfrac{E_1}{4}$

$= -\dfrac{13.6}{9} + \dfrac{13.6}{4}$

$= -1.51 + 3.4$

$= 1.89$ eV

$\therefore \nu = \dfrac{1.89\times1.6\times10^{-19}}{6.63\times10^{-34}} = 4.5\times10^{14}$ Hz

363. For H_α line of Balmer series p = 2 and n = 3

$\therefore \dfrac{1}{\lambda} = R\left[\dfrac{1}{p^2} - \dfrac{1}{n^2}\right]$

$\therefore \lambda = 6563$ Å

364. For H_γ line of Balmer series p = 2 and n = 5

$\therefore \dfrac{1}{\lambda} = R\left[\dfrac{1}{p^2} - \dfrac{1}{n^2}\right]$

$\therefore \lambda = 4341$ Å.

365. For shortest wavelength of Paschen series p = 3 and n = ∞.

$\dfrac{1}{\lambda} = R\left[\dfrac{1}{p^2} - \dfrac{1}{n^2}\right]$

$\dfrac{1}{\lambda} = R\left[\dfrac{1}{9} - \dfrac{1}{\infty}\right]$

$\therefore \lambda = \dfrac{9}{R}$

$= \dfrac{9}{1.093\times10^7} = 8208$ Å.

366. For longest wavelength of Balmer series p = 2 and n = 3

$$\therefore \quad \frac{1}{\lambda_1} = R\left[\frac{1}{4}-\frac{1}{9}\right]$$

$$\therefore \quad \lambda_1 = \frac{36}{5R} \qquad \text{..... (i)}$$

For shortestwavelength of Balmer series p = 2 and n = ∞.

$$\therefore \quad \frac{1}{\lambda_2} = R\left[\frac{1}{4}-\frac{1}{\infty}\right]$$

$$\therefore \quad \lambda_2 = \frac{4}{R} \qquad \text{..... (ii)}$$

$$\frac{\lambda_1}{\lambda_2} = \frac{36}{5R} \times \frac{R}{4}$$

$$= \frac{36}{20} = 1.8.$$

422.

$$\lambda = \frac{h}{mv}$$

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

$$n\lambda = \frac{2\pi r}{n} \qquad (n = 1)$$

$$\therefore \quad \lambda = 2\pi r$$

423.

$$v_n = \frac{e^2}{2\varepsilon_0 nh}$$

$$\therefore \quad v_1 = \frac{(1.6\times10^{-19})^2}{2\times8.85\times10^{-12}\times1\times6.63\times10^{-34}}$$

$$= 2.188 \times 10^6 \text{ m/s.}$$

425.

$$\frac{1}{\lambda} = R\left[\frac{1}{p^2}-\frac{1}{n^2}\right]$$

$$= R\left[\frac{1}{1}-\frac{1}{4}\right] = \frac{3R}{4}$$

$$\therefore \quad \lambda = \frac{4}{3R}$$

426. $M = IA$

$= q f \pi r^2$

$= 1.6\times10^{-19}\times6.6\times10^{15}\times3.14\times(5.28 \times 10^{-11})^2$

$= 1 \times 10^{-23}\ \text{Am}^2.$

427. $r_n = r_1 n^2$

$$\therefore \quad n^2 = \frac{r_n}{r_1} = \frac{21.2\times10^{-11}}{5.3\times10^{-11}} = 4$$

$\therefore \quad n = 2.$

430.

$$\lambda = \frac{h}{mv}$$

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

$$n\lambda = 2\pi r \qquad (n = 1)$$

$$\therefore \quad \lambda = 2\pi r$$

431.

$$a_n = \frac{\pi me^6}{4\varepsilon_0^2 n^4 h^4}$$

$$a_1 = \frac{\pi me^6}{4\varepsilon_0^3 h^4}$$

$$= \frac{\pi me^6}{4\varepsilon_0^3 h^4} \times \frac{\pi^2 m^2 h^2}{\pi^2 m^2 h^2}$$

$$= \frac{\pi^3 m^3 e^6}{\varepsilon_0^3 h^6} \times \frac{h^2}{4\pi^2 m^2}$$

$$= \frac{h^2}{4\pi^2 m^2 r^3} \qquad \left(\because r_1^3 = \frac{\varepsilon_0^3 h^6}{\pi^3 m^3 e^6}\right)$$

432.

$$B = \frac{\mu_0 I}{2a}$$

$$B = \frac{\mu_0 qF}{2a}$$

$$B \propto \frac{F}{a} \quad \text{but } F \propto \frac{1}{n^3} \text{ and } a \propto n^2$$

$$\therefore \quad B \propto \frac{1}{n^5}$$

$$B \propto n^{-5}.$$

434. $L_n = m v_n r_n$

$L_1 \propto r_1$

435.

$$K.E. = \frac{1}{2} mv^2$$

$$= \frac{1}{2} mv^2 \times \frac{m}{m}$$

$$= \frac{1}{2} \frac{m^2 v^2}{m}$$

$$= \frac{p^2}{2m} \qquad (\because p = mv)$$

$$= \frac{L^2}{2mr^2} \qquad \left(\because P = \frac{L}{r}\right)$$

437. For Lyman series

$$\frac{1}{\lambda_L} = R\left[1-\frac{1}{2^2}\right] = \frac{3R}{4}$$

For Balmer series

$$\frac{1}{\lambda_B} = R\left[\frac{1}{4}-\frac{1}{9}\right] = \frac{5R}{36}$$

$$\Rightarrow \frac{\lambda_L}{\lambda_B} = \frac{\frac{4}{3R}}{\frac{36}{5R}} = \frac{4}{36}\left(\frac{5}{3}\right) = \frac{5}{27}$$

438. $\Delta m = 0.02566u$

energy = 0.02866 × 931 = 26.7 MeV

As ${}_1H^2 + {}_1H^2 \rightarrow {}_2He^4$

Energy liberate (MeV) = 13.35 MeV

= 6.675 MeV

439. Value of x is $\frac{1}{8} = \frac{x_0}{8} = \frac{x_0}{2^3} \Rightarrow t = 3T = 3\times 20 = 60$

440. n = 3, p = 2, ν = ?

$$\nu = cR\left[\frac{1}{P^2}-\frac{1}{n^2}\right]$$

$$= cR\left[\frac{1}{4}-\frac{1}{9}\right] = \frac{5\,Rc}{36}.$$

441. n = 4, λ = ?

According to de-Broglie,

$$\lambda = \frac{h}{mv} = \frac{hr}{mvr}$$

$$\lambda = \frac{hr}{\frac{nh}{2\pi}} \qquad \left(\because mvr = \frac{nh}{2\pi}\right)$$

$$\lambda = \frac{2\pi\,r}{n}$$

i.e., $n\lambda = 2\pi r$

For $n = 4$

$$\lambda = \frac{2\pi\,r}{n} = \frac{2\pi\,r}{4}$$

$$\lambda = \frac{\pi\,r}{2}.$$

442. For first line of Balmer series p = 2 and n = 3

$$\therefore \frac{1}{\lambda_1} = R\left[\frac{1}{p_2}-\frac{1}{n^2}\right]$$

$$= R\left[\frac{1}{4}-\frac{1}{9}\right]$$

$$\therefore \lambda_1 = \frac{36}{5\,R}$$

For first line of Brackett series p = 4 and n = 5

$$\therefore \frac{1}{\lambda_2} = R\left[\frac{1}{p_2}-\frac{1}{n^2}\right]$$

$$= R\left[\frac{1}{16}-\frac{1}{25}\right]$$

$$\therefore \lambda_2 = \frac{16\times 25}{9\,R}$$

$$\therefore \frac{\lambda_1}{\lambda_2} = \frac{36}{5R}\times\frac{9R}{16\times 25} = 0.162.$$

443. Given, $E_1 = 13.6$ eV

$$\therefore E_3 = \frac{E_1}{9}$$

$$= \frac{-13.6}{9} = -1.51 \text{ eV}$$

and

$$E_5 = \frac{E_1}{25}$$

$$= \frac{-13.6}{25} = -0.544 \text{ eV}$$

Now

$$h\nu = E_5 - E_3$$

$$= -0.544 + 1.51 = 0:966 \text{ eV}$$