**Combined – Dual/Atom/Nuclei**

**Cathode rays & Positive rays**

**1. Discharge through gases:**

(i) At NTP dry gases are bad conductors of electricity (insulators). But when subjected to low pressure and high voltage, they act as conductors of electricity (conductors).

(ii) The dielectric strength of air at NTP is 3 x 106 V/m. Gases become conducting when pressure is in between I cm and l0-3 cm of mercury.

(iii) A gas becomes a good conductor when it contains free ions. Gases can be ionised by heating or passing ultraviolet rays.

(iv) The potential difference required to start a spark under given conditions is called **sparking potential**. Sparking potential depends on the nature of the gas, pressure of the gas and distance between the electrodes. A potential difference of 30,000 volts is required to produce a spark between two points separated by a distance of I cm in dry air at NTP.

(v) The sparking potential under any condition of pressure and electrode separation is proportional to the product of gas pressure (P) and distance between the electrodes (*l*). Hence V α *l*P. This is called **Paschen's law**.

(vi) The passage of electricity through gases at low pressure and high potential is called **discharge** through gases.

(vii) The discharge phenomena observed at various pressures are as under:

|  |  |  |
| --- | --- | --- |
| S.No. | Pressure | Phenomenon Observed |
|  | Above l0 mm of Hg | No discharge. |
|  | At 10 mm of Hg | Discharge starts with a cracking sound. A steam of glow appears from anode to cathode. |
|  | At 5mm of Hg | The glow becomes steady and extends from anode to cathode called as **positive column**. The colour of the positive column depends on the nature of the gas in the tube. Neon -- Red; Hydrogen --- Blue; Nitrogen --- Red; Air --- Purple red; CO2 ---- Bluish white; Sodium ----- Yellow |
|  | At l mm of Hg | Positive column is separated from the cathode and a glow is observed on the cathode known as negative glow. Between negative glow and positive column a dark space known as **Faraday's dark space** appears. |
|  | At 0.5 mm of Hg | Negative glow detaches from cathode and a narrow dark region called **Crookes dark space** occurs between negative glow and the cathode. |
|  | At 0.1 mm of Hg | Positive column is broken up into pink coloured disk of light called **striations**. |
|  | At 0.01 mm of Hg | Crookes dark space fills the whole tube and cathode rays are produced. |
|  | At 0.001 mm of Hg | No discharge passes through the tube. |

**2. Cathode rays:**

(i) Cathode rays were discovered by Sir William Crookes

(ii) Cathode rays are a stream of fast moving electrons almost in vacuum.

(iii) Mass of electron is 9.1x 10-31 while charge on electron is -1.6 x 10-19 coulomb (or - 4.8 x 10-10 esu).

(iv) The specific charge of electron (e/m) was determined by J.J. Thomson. The specific charge of electron is 1.759 x 1011 coulomb per kg. This value is constant and is independent of the nature of the gas used in the discharge tube and also independent of the material of the cathode.

(v) Mass of the electrons is (l/l837) times that of hydrogen atom. The radius of electron is of the order of 10-15 m.

(vi) **Methods of producing electrons**: (a) discharge of electricity through gases, (b) thermionic emission, (c) photoelectric emission, (d) Fray emission, (e) cold-cathode emission or field emission.

(vii) **Motion of electron in a parallel electric field**: If an electron of charge *e* moves in an uniform electric field of intensity **E** and if m is the mass of the electron, then:

(a) the force on the electron, F = eE

(b) positive charge experiences force in the same direction of the electric field (from high potential to low potential)

(c)negative charge experiences force in the opposite direction of the electric field

(d)when an electron is projected in the direction or in the opposite direction of the electric field, its path is a straight line.

(e)intensity of the electric field, E = V/d = potential difference between the plates/ distance between the plates

(f) the acceleration produced on the electron, a = (F/m) =eE/m

**(viii) Motion of charged particle (electron) perpendicular to the electric field**

If an electron of mass m and charge e is projected at right angles to the electric field of intensity E (in Y-direction), then:

(a) the force experienced by the electron, F = eE ( Y-direction).

(b) intensity of the electric field, E = V/d = potential difference between the plates/ distance between the plates

(c) time taken by the electron to traverse the length *l* of the electric field with constant horizontal velocity vx is

t= *l*/vx

(d) acceleration produced at right angles to the direction of motion is: a = (F/m) =eE/m

(e) the deflection of the electron at right angles to its direction of motion (x-axis) after travelling distance *l* is:



**So, the path of the electron in electric field is a parabola**

(f) beyond the electric field, electron moves along a straight line tangential to its path.

(g)the horizontal component of the velocity vx of the electron remains same throughout the field.

(h) the vertical component of the velocity vy of the electron at the instant of entering the electric field is zero.

(i)the vertical component of the velocity vy, of the electron just after emerging out of the field is

(j) the velocity of the particle at the end of the electric field is:

v = √(vx2 +vy2)

(k) angle θ between v and vx , is:

(ix) **Motion of charged particle (electron) in a magnetic field**

(a) If an electron of charge e enters into a magnetic field of induction B with a velocity v in a direction making an angle θ with the direction of magnetic field, it experiences a force, given by: **F** = e ***v*** x **B**

(b)The direction of force is given by Fleming's left hand rule.

(c) If an electron moves in a direction parallel (θ = 0) or antiparallel (θ = l800 ) to the magnetic field, force experienced F = 0. The path is a straight line

(d)If the electron moves in a direction perpendicular to the magnetic field (θ = 900),then F = Bev = Fmax. and

(I) the path of the electron is circular.

(II) the work done by the force on the charged by the force on the charged Particle W = O

(III) the radius of circular path is given by: r = mv/Be = p/Be ( p = mv = momentum of electron)

(IV) the magnetic field changes only the direction but not the magnitude of the velocity, momentum,

force or acceleration of the particle.

(V) the kinetic energy of a charged particle remains constant in a magnetic field, Kinetic energy = KE = p2/2m = B2e2r2/2m

(VI) if the angle between the direction of motion of charged particle and the direction of magnetic field be different from 00,900,1800 the path is helical (spiral path).

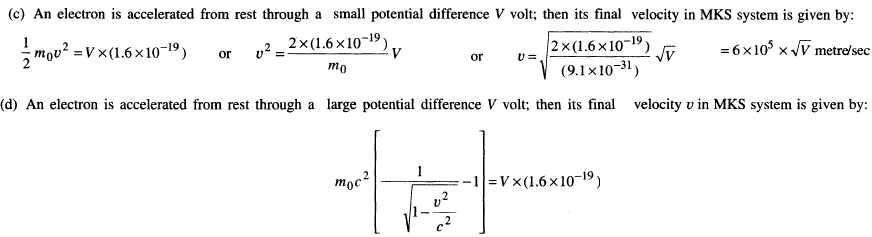
(x) **Motion of electron in perpendicular electric and magnetic fields:** When electric and magnetic fields are applied at right angles to each other and also at right angles to the direction of electron beam and their intensities are adjusted such that the electron goes without deviation, then the forcer exerted by the electric and magnetic fields are equal and opposite to each other, i.e., evB = eE

(I) velocity of electron v =E/B , (II) radius of circular path r =mv/eB or e/m = v/rB

**or e/m = E/rB2**

(xi) **(a) Electron-volt** is the energy gained by an electron when it is accelerated from rest through a potential difference of one volt

(b) One eV = 1.6 x 10-19 joule = 1.6 x 10-12 erg



**3. Positive rays or Canal rays:**

(i) Positive rays were discovered by Goldstein.

(ii) They are produced in a discharged tube with a perforated cathode.

(iii) The positively charged particles are produced at different places in the discharge tube. As they are produced at different places in the discharge tube, they are accelerated to different intervals of time in the electric field; hence they acquire different velocities.

(iv) The presence of isotopes makes the charged panicles in the positive rays to have different velocities.

(v) The lightest positively charged particle was found in hydrogen and is called proton.

(vi) The instrument used for positive ray analysis is called mass spectrograph.

(vii) J.J. Thomson determined the specific charge of positive rays. In this method of determining e/M ,the electric and magnetic fields are applied parallel to each other and at right angles to the direction of positive rays

(viii) Effect of electric field on positive rays: Let M be the mass, e be the charge and u be the velocity of a +ve ion. E is the intensity of electric field.

(a) Force on the charged particle = eE (b) Acceleration, a= eE/M

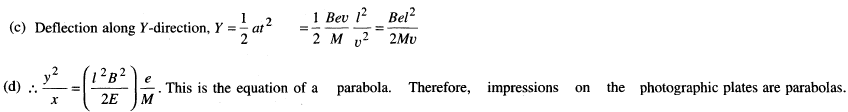
(c) Deflection along x-axis is: *x =½at2 =½eEt2/M*

(d) If *l* is the length of the path of the ion in the electric field and t is the corresponding time taken ( t=*l/v*),then  *x =½at2 =½eEl2/Mv2*

(e) The electric field produces a deviation along x-axis and is inversely proportional to the square of the velocity; so particles of same e/m and moving with the same velocity have same deviation

(ix) **Effect of magnetic field on positive rays:**

(a) The magnetic force on the ions is F = Bev (b) Acceleration, a = (Bev/M)



(e) The magnetic field deviates the positive rays along y-axis. The deviation produced is inversely proportional to the velocity. So, the particle of same e/m and moving with same velocity have same deviation.

(f ) The particles of same e/m and moving with different velocities deviate to different extents.

(g) The presence of hydrogen in the discharge tube forms a parabola with a greater deviation of all the parabolas. This is due to the minimum mass of hydrogen.

(h) When hydrogen is used in the discharge tube, the specific charge is found to be 95,710 coul/kg.

**Photoelectric effect**

**1. Planck's quantum theory: Wave-particle duality:**

(i) Planck gave quantum theory while explaining the radiation spectrum of a black body. According to Planck's theory, energy is always exchanged in integral multiples of a quanta of light or **photon**.

(ii) Each photon has an energy E that depends only on the frequency v of electromagnetic radiation and is given by:

E = hv (l) where h = 6.6 x 10-34 joule-sec, is Planck's constant.

In any interaction, the photon either gives up all of its energy or none of it.

(iii) From Einstein's mass-energy equivalence principle, we have E =mc2 - (2)

Using equations (1) and (2), we get; mc2 = h*v* or **m = h*v*/c2**

where m represents the mass of a photon in The velocity u of a photon is equal to that i.e., u = c.

(iv) According to theory of relativity, the rest mass mo of a photon is given by: mo = m (√[1 –u2/c2] )

where **m = hv/c2** and u ≈ c hence mo = 0

i.e., rest mass of photon is zero, i.e., energy of photon is totally kinetic.

(v)The momentum p of each photon is given by: p=mc = h*v*/c =h/λ

The left hand side of the above equation involves the particle aspect of photons (momentum) while the right hand side involves the wave aspect (wavelength) and the Planck's constant is the bridge between the two sides.

This shows **that electromagnetic radiation exhibits a wave-particle duality**. In certain circumstances, it behaves like a wave, while in other circumstances it behaves like a particle.

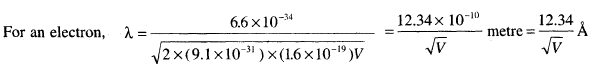
(vi) The wave-particle is not the sole monopoly of e. m. waves. Even a material particle in motion according to de Broglie will have a wavelength. The de Broglie wavelength λ, of the matter waves is also given by

λ =h/mv = h/p = h/√(2mK) where K is the kinetic energy of the particle

(vii) If a particle of mass m kg and charge q coulomb is accelerated from rest through a potential difference

of V volt. Then

mv2/2 = qV or mv = √(2mqV) Hence λ = h/√(2mqV)



2. **Photoelectric effect:**

(i) When light of suitable frequency (electromagnetic radiation) is allowed to fall on a metal surface,electrons are emitted from the surface. These electrons are known as photoelectrons and the effect is known as photoelectric effect.

Photoelectric effect was first discovered by Hertz. In photoelectric effect, light energy is converted into electrical energy.

**Laws of photoelectric effect:**

(a) The kinetic energy of the emitted electron is independent of intensity of incident radiation. But the photoelectric current increases with the increase of intensity of incident radiation.

(b) The kinetic energy of the emitted electron depends on the frequency of the incident radiation. It increases with the increase of frequency of incident radiation.

(c) If the frequency of the incident radiation is less than a certain critical value, then photoelectric emission is not possible. This frequency is known as threshold frequency. This threshold frequency varies from emitter to emitter, i.e., depends on the material.

(d) There is no time lag between the arrival of light and the emission of photoelectrons, i.e., it is an instantaneous Phenomenon.

3. **Failure of wave theory**:

(i) Wave theory of light could not explain the laws of photoelectric effect.

(ii) According to wave theory, the kinetic energy of the emitted electron should increase with the increase of intensity of incident radiation.

(iii) Kinetic energy of the emitted electron does not depend on the frequency of incident radiation according to wave theory.

(iv) Wave theory failed to explain the threshold frequency.

(v) According to wave theory there must between the arrival of light and photoelectrons.

4. **Einstein's theory of photoelectric effect:**

(i) Einstein explained the laws of photoelectric effect on the basis of Planck's quantum theory of radiation.

(ii) Einstein treated photoelectric effect as a collision between a photon and an atom in which photon is absorbed by the atom and an electron is emitted.

(iii) According to law of conservation of energy, h*v* = h*v*o + mv2/2

where h*v* is the energy of the incident photon; h*v*o is the minimum energy required to detach the electron from the atom (work function or ionisation energy) and mv2/2 is the kinetic energy of the emitted electron.

(iv) The above equation is known as Einstein's photoelectric equation.

Kinetic energy of the emitted electron mv2/2= h*v* - h*v*o = h(*v* - *v*o ) = h*v* - W

(v) **Explanation of laws of photoelectric effect:**

(a) The KE of the emitted electron increases with the increase of frequency of incident radiation since W(work function) is constant for a given emitter. KE is directly proportional to (*v* - *v*o).

(b) Keeping the frequency of incident radiation constant if the intensity of incident light is increased, more photons collide with more atoms and more photoelectrons are emitted- The KE of the emitted electron remains constant since the same photon collides with the same atom (i.e., the nature of the collision does not change).With the increase in the intensity of incident light photoelectric current increases.

(c) According to Einstein's equation, if the frequency of incident radiation is less than certain minimum value. the photoelectric emission is not possible. This frequency is known as threshold frequency. Hence, the

frequency of incident radiation below which photoelectric emission is not possible is known as threshold frequency or cut-off frequency. It is given by

*v*o = [mv2/2 - h*v* ]/h

On the other hand, if the wavelength of the incident radiation is more than certain critical value, then photoelectric emission is not possible. This wavelength is known as threshold wavelength or cut-off wavelength. It is given by

* λ*o = hc/ [h*v* - mv2/2]

(d) Since, Einstein treated photoelectric effect as a collision between a photon and an atom, he explained the instantaneous nature of photoelectric effect.

5. **Some other important Points:**

(i) **Stopping potential:** The negative potential applied to the collector in order to prevent the electron from reaching the collector (i.e., to reduce the photoelectric current to zero) is known as stopping potential.

eVo =mvmax2/2 = h*v* -W = h(*v* - *v*o )

(ii) Millikan measured KE of emitted electrons ol stopping potentials for different frequencies of incident radiation for a given emitter. He plotted a graph with the frequency on x-axis and stopping potential on y-axis. The graph so obtained was a straight line as shown in the figure(39.1)

(iii) Millikan measured the slope of the straight line (= h/e) and calculated the value of Planck's constant (fig 39.2)

(iv) The intercept of Vo versus *v* graph on frequency axis is equal to threshold frequency (*v*o). From this, the work function (h*v*o ) can be calculated.



(v) **Graphs in photoelectric effect:**

(a) **Photoelectric current versus potential difference graphs for varying intensity (keeping same metal plate and same frequency of incident light):** These graphs indicate that stopping potential is independent of the intensity of light and saturation current is directly proportional to the intensity of light

(b)**Photoelectric current versus potential difference graphs for varying frequency (keeping same metal plate and same intensity** of incident light): These graphs indicate that the stopping potential is constant for a given frequency. The stopping potential increases with increase of frequency. The KE of the emitted electrons is proportional to the frequency of incident light (fig 39.4).

(c) **Stopping potential versus frequency graphs for different metals**: These graphs indicate that the slope is same for all metals, since they are parallel straight lines. **The slope is a universal constant (= h/e).** Further, the threshold frequency varies with emitter since the intercepts on frequency axis are different for different metals.

**Atomic Structure & Spectrum**

**1.Thomson's atom model:**

(i) J.J. Thomson was the first scientist to propose a model of the atom.

(ii) According to this atom model, the entire positive charge of the atom was uniformly distributed in a sphere and the electrons were embedded in such a manner that their mutual repulsions were balanced by the attractive force towards the centre.

(iii) This atom model is also known as watermelon model of atom.

(iv) This atom model could explain the stability of the atom and emission of electrons from the atom.

(v) This atom model failed to explain the large angle scattering of α-particles by the sheet of matter and line spectra produced by atoms

**2. Rutherford's α-particle scattering experiment:**

**Conclusions:**

(i) Most of the α-particles came out of the gold foil without suffering any deviation from their straight line paths. This shows that that atom is hollow.

(ii) A few α-particles collided with the atoms of the foil which are scattered or deflected through large angles. A very few particles even turned back towards the source itself.

(iii) The entire positive charge and almost the whole mass of the atom is concentrated in a very small region exactly at the centre of the atom, called nucleus.

(iv) Electrons cannot deflect the path of the α particles, i.e., electrons are very light particles.

(v) Electrons revolve round the nucleus in circular orbits.

**(vi) Rutherford’s model of the atom:** According to this model:

(a) the entire positive charge of the atom is concentrated in a small region near the centre of the atom called nucleus.

(b) the electrons revolve round the nucleus just like planets round the sun. The Coulomb force of attraction between the electron and the nucleus is equal to the centripetal force.

(vii) Rutherford's atom model explained the large angle scattering of a-particles.

(viii) According to the classical electromagnetic theory, a revolving electron should radiate energy continuously and the electron should start spiralling and finally fall into the nucleus. This should lead to the destruction of the atom. As the energy decreases continuously the atom should give a continuous spectrum. Thus, the Rutherford atom model failed to explain the formation of spectral lines and also failed to explain the stability of the atom.

(ix) According to Rutherford scattering formula, the number of α-particles scattered at an angle θ by a target are given by:

where No = total number of α-particles that strike the unit area of the scatterer ;n = number of target atoms per m3;t = thickness of target; Ze = charge on the target nucleus; 2e = charge on α-particle;

r = distance of the screen from the target and vo = velocity of α-particle at nearest distance of approach.



(x) The size of the nucleus or the distance of closest approach is given by:

**3. Bohr's atom model:**

Bohr modified Rutherford's atom model on the basis of quantum theory of radiation. His model is based on the following three postulates:

(i) First postulate: Electron revolves round the nucleus just like a planet round the sun. The Coulomb's force of attraction between the electron and the nucleus is equal to the centripetal force. lf m is the mass of the electron, then

(ii) Second postulate: Electrons cannot revolve in all those orbits as suggested by classical theory, but only in those orbits for which the angular momentum is equal to an integral multiple of h/2π, where h is the Planck's constant. Thus,

*Iw* = mvr = nh/2π

(a) Angular momentum and Planck's constant have same units and dimensions.

(b) The SI unit of Planck's constant is joule-sec and its value is equal to 6.63 x 10-34 joule-sec.

(c) The dimensional formula for angular momentum is [M1L2T-1 ].

(d) As long as the electron revolves in these orbits, it neither loses energy nor gains energy. These orbits are known as stationary orbits.

(iii) Third postulate: When an electron jumps from higher energy level to lower energy level, the energy difference is radiated in the form of light of frequency *v*, i.e., E2 –E1 = h*v ;*where E2 is the energy of the outer orbit and E1 is the energy of the inner orbit.

4. **Radius of the orbit:**

(i) rn = radius of the nth orbit of hydrogen-like atom = ∈on2h2/πmZe2 , (hydrogen-like atoms are those which have only one electron and whose atomic number Z >l).

(ii) For the first Bohr orbit, n=l and for hydrogen atom Z =l; hence r1 = radius of the 1st orbit of hydrogen-like atom = ∈oh2/πme2 = 0.53 x 10-10 m

(iii) rn = radius of the nth orbit of hydrogen-like atom = r1n2/Z= = 0.53 x 10-10 n2/Z

(iv) When Z is constant rn α n2 ; i.e., radii of the first,second, third, . . . orbits of hydrogen atom are given by r1 ,4r1,9r1 etc

(v) When n is constant rn α 1/Z i.e., radius of any orbit is inversely proportional to the atomic number

**5. Velocity of the electron in the orbit:**

(i) vn = velocity of the electron in nth orbit of any atom = Ze2/2∈onh

(ii) v1 = velocity of the electron in the first Bohr orbit of hydrogen atom = e2/2∈oh = 2.19 x 106 m/s = c/137

where c is the velocity of light.

(iii) vn = velocity of the electron in nth orbit of any atom =Z v1/n = Z x 2.19 x 106 /n

(iv) When Z is constant, *v* is inversely proportional to the principal quantum number, i.e.. *v* α 1/n

(v) When n is constant then velocity of electron in any orbit is directly proportional to the atomic number.

i.e.. *v* α Z

(vi) Velocity of the electron is inversely proportional to the square root of the radius of the orbit, i.e., *v* α 1/√r

**6. Energy of the electron in the orbit:**

(i) Potential energy of the electron in the orbit = - (1/4π∈o) (Ze2/r) = -2 K.E.

(ii) Kinetic energy of the electron in the orbit =½mv2 = Ze2/8π∈o r

(iii) Total energy of the electron in the orbit P.E. +K.E. = -K.E. = - Ze2/8π∈o r

(iv) En = Total energy of electron in nth orbit of any hydrogen-like atom = -me4Z2/8∈on2h2 = -13.6 Z2/n2 eV

(v) In case of Hydrogen like atoms Z=1 ; so, En = -13.6 /n2 eV = - 217.6 x 10-20/n2 Joule

(vi) When Z is constant En α 1/n2

(vii) When n is constant En α Z2

**7. Dependence of T, f, w, L , v, KE, PE, TE and r on principal quantum number n**

(i) As T2 α r3 ,hence T α r 3/2 i.e., T α (n2) 3/2 or T α n3 ; time period of revolution is directly proportional to

the cube of the principal quantum number

(ii) *f*= frequency of revolution = 1/T hence  *f* α 1/n3 ;i.e frequency of revolution of the electron is inversely

proportional to the cube of the principal quantum number

(iii) *w* = angular velocity or angular frequency = 2π*f* . Hence *w* α 1/n3

(iv) Angular momentum L = nh/2π ; i.e. Angular momentum is directly proportional to the principal quantum number.

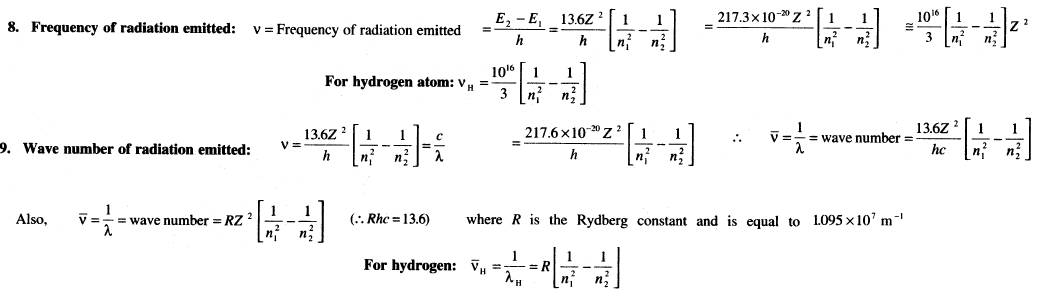
(v) *v* = velocity of the electron in the orbit = Ze2/2∈onh i.e., velocity of electron in an orbit is inversely proportional to the principal quantum number n.

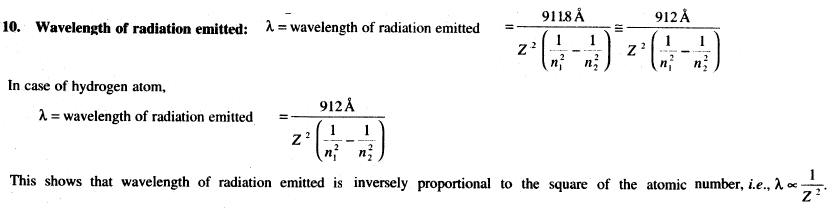
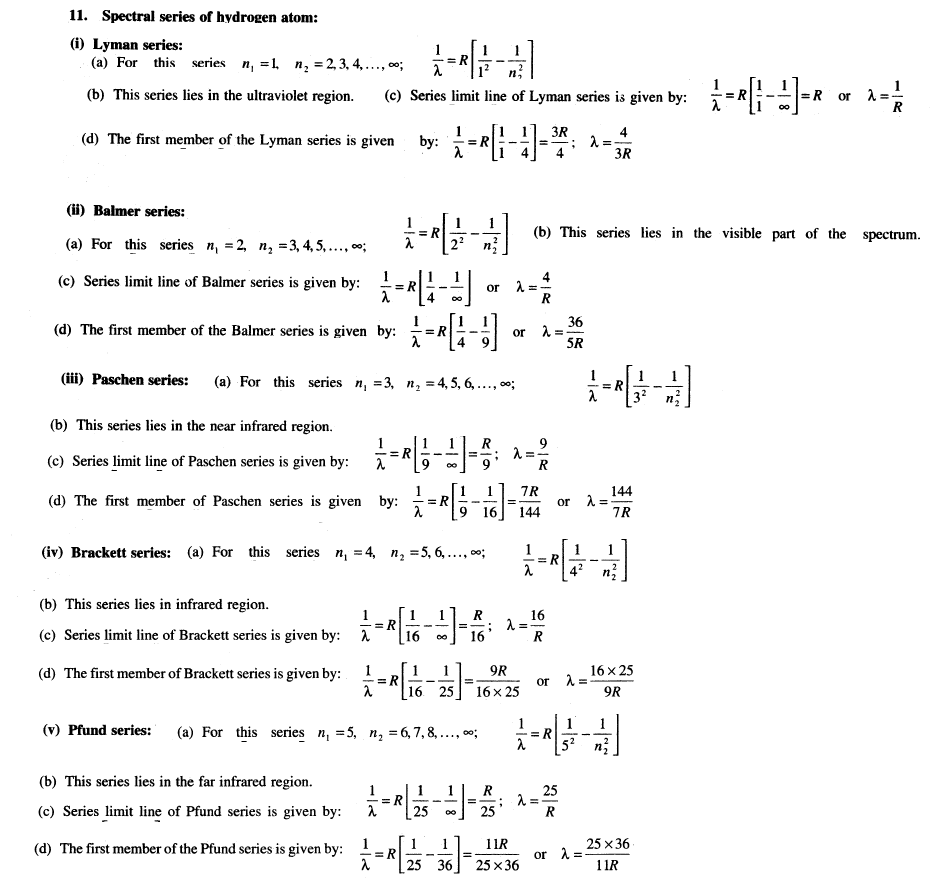
(vi) KE of the electron = -TE of electron = + 13.6/n2 eV i.e. KE of the electron is inversely proportional to the square of the principal quantum number

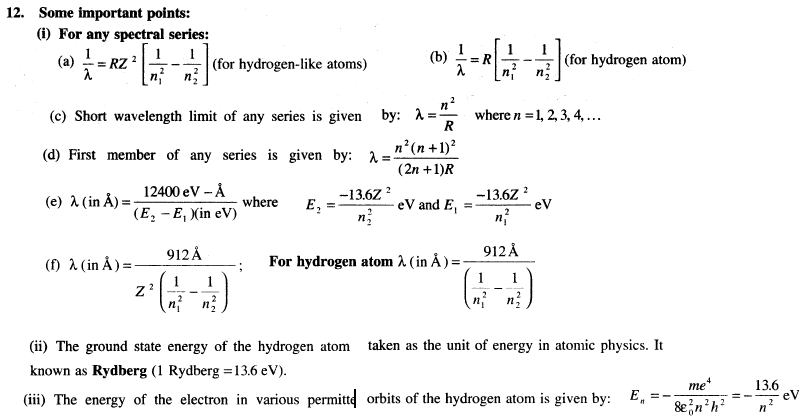
(vii) PE of the electron = -2KE =+2(TE in the orbit) = -2 x 13.6Z2 /n2 eV

(viii) TE of the electro = - KE = - 13.6Z2 /n2 eV

(ix) rn = radius of the nth orbit = r1n2/Z i.e rn α n2 i.e., radius of the orbit is directly proportional to the square of the principal quantum number







(iv) The negative sign appearing in the expression of energy indicates that the electron does not have enough energy to escape from the nucleus. Energy is required to remove the electron from the influence of the nucleus.

(v) As the value of n increases, though the numeric value of energy decreases but its actual value increases because of the negative sign. Thus, the energy of the outer orbit is more than the energy of the inner orbit.

(vi) In the limit n = ∞,E = 0 and the electron is no longer, bound to the nucleus to form an atom.

(vii) The energies specified by the above expression for energy are called energy levels of the hydrogen atom.

(viii) **Excitation:** It is the process of raising an electron within an atom from a lower energy state to a high energy state.

(ix) **Excited state**: The state of an atom when an electron has been raised to a higher orbit is called an excited state.

(x)**Ground state**: The lowest energy state of an atom: when the atom is most stable, is called ground state.

(xi) **Ionisation:** If during the process of excitation an electron is completely removed from the atom, then the atom is said to be ionised. The process of removal of the electron from an atom is called ionisation.

(xii) **Ionisation energy**: The energy required to remove an electron from an atom is called ionisation energy The ionisation energy required to ionise a hydrogen atom is 0 – (-13.6) = 13.6 eV

(xiii) **Ionisation potential**: The potential difference through which an electron is moved to gain ionisation energy is called ionisation potential. The ionisation potential of hydrogen atom is 13.6 volt

**(xiv) Dependence of rn, vn,En and λ on atomic number Z**

(a) rn = r1n2/Z i.e. rn α 1/Z (b) vn = Zv1/n i.e. vn α Z

(c) En = -13.6 Z2/n2  i.e. En α Z2  (b) 1/λ = RZ2[1/n12 - 1/n22 ] i.e. 1/n i.e. λ α 1/Z2

**13. Types of spectra:**

Spectra are mainly of two kinds, emission spectrum and absorption spectrum.

**(i) Emission spectrum**: When light from an incandescent source is made to fall on the slit of a spectrometer, then we see an emission spectrum of the source.

Emission spectrum is of three types:

**(a) Line spectrum**: It is given by incandescent vapours or gases in atomic state. It is on account of the individual behaviour of atoms. Line spectrum is characteristic of the element. No two different elements give identical line spectra.

**(b) Band spectrum**: It is given by incandescent vapours or gases in molecular state. It is on account of the individual behaviour of molecules. Band spectrum is the characteristic of the compound. No two different compounds give identical band spectra.

**(c) Continuous spectrum**: It is given by incandescent solids and liquids. It is on account of the collective behaviour of atoms or molecules.

**(ii) Absorption spectrum**: When white light from an incandescent source passes through transparent gas, liquid or solid at a lower temperature before falling on thg slit of the spectrometer, then we see an absorption spectrum.

Absorption spectrum is also of three types:

(a) For line absorption, the transparent absorbing material must be in the form of atomic vapours or gas.

(b) For band absorption, the absorbing material must be in the form of molecular vapours or gas.

(c) For continuous absorption, the transparent absorbing material must be a solid or a liquid.

(iii) In general, the number of emission lines is larger than the absorption lines.

(iv) For n levels, the number of possible emission lines = n(n-1)/2

and the number of possible absorption lines = (n-1)

(v) **Fraunhofer lines:** These are the dark lines observed in the solar spectrum. These dark lines were discovered by Wolaston. When white light from the photosphere passes through the chromosphere which contains vapours in atomic state, these vapours absorb the light of those wavelengths which they themselves would emit when being incandescent

**X-RAYS**

**1. Introduction:**

(i) X-rays were discovered by Roentgen.

(ii) When fast moving electrons strike a target of suitable material (having high atomic weight and high melting point), X-rays are produced.

(iii) X-ray tubes are mainly of two types, namely

(a) the gas filled or Roentgen X-ray tube. (b) the modern Coolidge tube or hot filament tube.

(iv) X-rays are electromagnetic waves of very small wavelength ranging from 100 A0 to 0.1 A0.

(v) X-rays are not deflected by electric and magnetic fields.

**2. Important properties of X-rays:**

(i) They are invisible. (ii) They travel in straight lines with the speed of light.

(iii) They undergo reflection, refraction, interference, diffraction and polarisation.

(iv) They produce illumination by falling on fluorescent materials.

(v) They show continuous spectrum, hence we conclude that like light rays, X-rays are also electromagnetic waves.

(vi) They ionise the gases through which they pass.

(vii) They penetrate through different depths into different substances, e.g., wood, thin metal sheets, flesh, etc., depending upon their wavelength.

(viii) They do not pass through heavy metals and bones.

(ix) They are very active and may eject photoelectrons from metals (show photoelectric effect).

(x) They affect photographic plates.

(xi) They are not deviated by prisms or lenses.

(xii) They can be used to detect possible cracks, air cavities and other flaws in the interior of metal castings.

**3. Intensity control in X-ray tube:**

(i) Intensity implies the number of X-ray photons produced from the target

(ii) The intensity of X-rays is proportional to the number of electrons emitted per sec from the filament and this can be increased by increasing the filament current in the Coolidge tube.

**4. Quality control in X-ray tube:**

(i) Quality of X-rays implies the penetrating power of X-rays. Penetrating power is proportional to the potential difference between the filament and target.

(ii) The quality of X-rays can be controlled by varying the potential difference between the cathode and the target.

(iii) Depending on the penetrating power, X-rays are of two types:

(a) **Soft X-rays:** X-rays having wavelength of 4 A0 or above are called soft X-rays due to their low penetrating power.

**(b) Hard X-rays:** X-rays having low wavelength of the order of I A0 have high frequency and are Called hard X-rays due to their high penetrating power.

**5. Continuous X-rays:**

(i) Continuous X-rays are produced due to retardation of high speed electrons while passing through the strong electric field of the nucleus.

(ii) When the electron loses whole of its energy in a single collision with the atom, an X-ray photon of maximum energy h*v*max is emitted, i.e., h*v*max = eV

(iii) Minimum wavelength λmin = c/*v*max = hc/eV

This is known as **Duane-Hunt** law. The above equation shows that minimum wavelength λmin is inversely proportional to the accelerating potential (V). With the increase of applied voltage, the minimum wavelength decreases.

(iv) Each spectrum abruptly ends at a certain minimum wavelength or maximum frequency. This minimum wavelength is called the **limiting wavelength.**

(v) The maximum intensity of continuous X-rays increases with the increase of applied voltage.

(vi) If a graph is plotted between accelerating potential (V) and maximum frequency (*v*max) of a continuous X-ray spectrum, a straight line passing through origin is obtained.

(vii) The slope of the straight line is given by e/h from which Planck's constant can be calculated.

(viii) Continuous X-ray spectrum is independent of the material of the target.

(ix) Photoelectric effect is the reverse process of the production of continuous X-ray spectrum.

**6. Characteristic X-ray spectrum:**

(i) Characteristic X-ray spectrum is produced when high energy electrons knock out the electrons from the innermost shells K, L or M of the atoms of the target element.

(ii) Different atoms (elements) emit different characteristic spectra.

(iii) These X-rays have discrete energy or a particular wavelength.

These particular wavelengths are the characteristic nature of the target.

(iv) The number of lines present in the X-ray spectrum depends both on the element and the acceleration potential.

(v) The transition of electron:

(a) from 2nd orbit to lst orbit forms Kα line (b) from 3rd orbit to lst orbit forms Kβ line

(c) from 4th orbit to lst orbit forms Kγ, line

- The above three lines are also known as K -series

(vi) Similarly, the transitions from 3rd,4th, 5th, etc., to 2nd orbit correspond to Lα , Lβ, Lγ ... lines known

as L-series.



(vii) The wavelength of Kα line is,

(viii) The heaviest elements such as uranium, thorium emit a complete spectrum where all the series K, L, M, N are present.

7. Moseley's law:

(i) The square root of the frequency of the characteristic X-ray spectrum line is proportional to the atomic number,√*v* α Z or .. √*v* =a(Z –b)

(ii) The graph plotted between the atomic number (Z) and square root of frequency √*v* is a straight line making a positive intercept on x-axis. The slope of straight line gives the constant a while the intercept on x-axis provides the value of b. For K-series X-rays the value of constant b =1.

(iii) X-ray spectra cannot be obtained with very light elements like hydrogen.

(iv) X-ray spectra are not found in the solar spectrum.

(v) **Important points:** Moseley's law

(a) helps to determine the relative positions of several elements in the periodic table.

(b) helps in the prediction and discovery of new elements.

***RADIOACTIVITY***

1. Introduction:

(i) Radioactivity was discovered by **Henry Becquerel** in the year 1896.

(ii) All the elements with atomic number greater than 82 are naturally radioactive.

(iii) The radioactivity may be defined as the spontaneous disintegration of the atoms of heavy elements with the emission of α-particles, β-particles and γ rays.

(iv) Rate of disintegration of radioactive elements is not affected by the external conditions of temperature, pressure, electric or magnetic fields.

(v) A particular radioactive element can emit either α-particle or β-particles but never both. However, γ-rays can be emitted by a pure γ-emitter or by α-emitter or β-emitter.

(vi) The conversion of lighter elements into radioactive elements by the bombardment of fast moving particles is called **artificial or induced radioactivity**.

(vii) Madame Curie and Pierre Curie discovered two elements **polonium** and **radium**.

(viii) Rutherford demonstrated experimentally that radiations emitted by radioactive elements are of three types, called as α, β and γ-radiations.

**2. Properties of α, β and γ rays:**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **S.no** | **Properties** | **α -rays** | **β -rays** | **γ-rays** |
| 1 | Nature | Helium nucleus | Fast moving electrons | Electromagnetic  radiations or  photons |
| 2 | Nature of charge | Positive | Negative | No charge |
| 3 | Magnitude of charge | 3.2 x 10-19 coulomb | 3.2 x 10-19 coulomb | zero |
| 4 | Mass | 4 x 1.67 x 10-27 kg | 9.1 x 10-31 kg | Rest mass is zero |
| 5 | Velocity | Between 1.4 x 107 – 2.2 x 107 m/s | 1% to 99% of velocity of light | 3 x 108 m/s |
| 6 | Effect of electric and  Magnetic fields | Deflected | Deflected | Not Deflected |
| 7 | Range | 3 to 8cm in air or 1/100 mm of aluminium | 5mm of Al or I mm of lead | 30 cm of iron |
| 8 | Penetrating power | Maximum | 100 times of α-rays | 1000 times of α-rays |
| 9 | Ionising power | Maximum | lesser | minimum |

Important point: The β-particle is the electron ejected from the nucleus but not from the orbits of an atom. The neutron in the nucleus decays into proton and an electron. This electron is emitted out of the nucleus in the form of β-rays.

**3.Radioactive displacement law:**

It was discovered by Soddy and Fajans in the year 1913.

According to this law:

(a) In all radioactive transformations either an α or a β particle (never both or more than one of each kind) is emitted by the atom.

(b) When a radioactive element decays through the emission of an α-particle, a new atom is formed whose mass number is less by four units and atomic number is less by two units than the original atom.



(c) When a radioactive element decays through the emission of a β-particle, a new atom is formed whose mass number remains same but the atomic number increases by one unit than the original atom.



(d) When a radioactive element decays through the emission of a γ-ray, neither atomic number nor the mass number changes. By the emission of α, or β particles the nucleus is left in the excited state. This excited nucleus emits γ-radiations and try to reach the ground state



**5. Law of radioactive disintegration:**

(a) This law was given by Rutherford and Soddy.

(b) If N is the number of atoms present at a given instant t, then the rate of disintegration (-dN/dt) is proportional to N, i.e

dN/dt = - λN ; where λ is called the disintegration constant or decay constant

(c) If N0 is the initial number of atoms present, then N = No e-λt

**6. Activity of a radioactive substance:**

(a) The number of disintegrations in one second is called activity. This is denoted by R

(b) Activity R=λN.

(c) If R0 is the initial activity then R = Ro e-λt

**7. Half-life and average life:**

Half-life

There are two common time measures of how long any given type of radionuclide lasts. One measure is the half-life T 1/2 of a radionuclide, which is the time at which both N and R have been reduced to one-half their initial values.

Mean life τ

The other measure is the mean life τ, which is the time at which both N and R have been reduced to e–1of

their initial values.

Relation between T1/2 , τ and λ T 1/2 = ln 2/λ = 0.693 /λ = τ 0.693

8. Some important points

(i) If N is the number of atoms remained undecayed after n half-lives, then N/No = [ ½]n ; where No is the initial number of atoms

(a) After one half-life or time T, amount of substance remained undisintegrated = half or 50%.

(b) After two half-lives or time 2T, amount of substance remained undisintegrated = (1/4)th or 25%.

(c) After three half-lives or time 3T, amount of substance remained undisintegrated = (1/8)th or 12.5% and so on.

(d) After ten half-lives or time l0T, amount of substance remained undisintegrated is nearly 0.l%.

(ii) If Mo be the initial mass and M is the undecayed mass left after n half-lives, then: M/Mo = [ ½]n

(iii) If Ao be the initial activity and A is the activity after n half-lives, then: A/Ao = [ ½]n

(iv) If n is the number of half-lives and T is the half-life, then total time t = nT.

(v) If N is the number of atoms left undecayed after a time t , then (No/N) = (2) t/T

(vi) **Radioactive equilibrium**: In a radioactive series at the stable equilibrium, the rate of decay of any radioactive product is just equal to its rate of production from the previous member of the series i.e.

N1λ1 =N2λ2 or N1/T1 = N2/T2

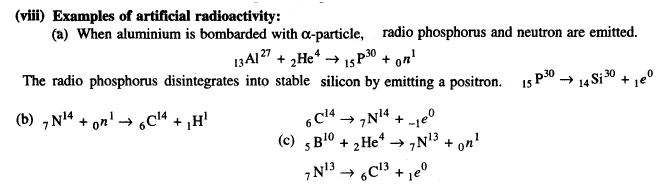
where λ1 & λ2 are the half-life periods of the first and second members of the series; and T1 and T2 are the half-lives of the first and second members of the series.

**(vii) Units of radioactivity:**

(a) The SI unit of radioactivity is Becquerel (bq). : 1 Becquerel = 1 disintegration/sec or 1 dps

(b) 1 Curie or l Ci =3.7 x 1010 dps = 3.7 x1010 bq

(c) 1 Rutherford or 1 Rd =106 dps =106 bq

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**(ix) Uses of radioisotopes:**

(a) Radio phosphorus-32 is used for the treatment of skin diseases, blood cancer, leukaemia.

(b) Radio iodine-l34 is used for the treatment of thyroid gland.

(c) Radio sodium-24 is used for removing defects in blood circulation.

(d) Radio cobalt-60 is used for the treatment of cancer.

(e) Radio carbon-l4 is used for determining the age of fossils and plants

**Nucleus And Nuclear Energy**

**l. Nucleus and its constituents:**

(i) Nucleus of an atom is positively charged. Its radius is about 5 x 10-15 metre.

(ii) Nucleus consists of protons and neutrons which are collectively called nucleons.

(iii) Nucleus was discovered by Rutherford while its constituent’s proton and neutron were discovered by Rutherford and Chadwick respectively.

(iv) Atomic number Z of an atom gives the number of protons in the nucleus while the mass number A provides the total number of nucleons (neutrons + protons) in the nucleus of the atom.

(v) Usually, the nucleus of an element X with atomic number Z and mass number A is denoted as ZXA

(vi) Charge of proton is 1.6 x 10-19 c while mass of proton is =l.67208 x 10-27 kg = 1.00728 amu.

(vii) Neutron has no charge while mass of neutron is =1.67431 x 10-27 kg = 1.008665 amu.

**2. Nuclear size:**

(i) Size of the nucleus is of the order of fermi (l Fermi = 10-15 m).

(ii) The radius of the nucleus is given by: R = Ro A l/3,where Ro =1.3 fermi and A is the mass number.

(iii) The size of the nucleus is of the order of 10-15 m for hydrogen and 7 x 10-14 m for the heaviest nucleus.

(iv) The size of the atom is of the order of 10-10 m.

**3. Density of nuclear matter:**

(i) Density =Mass of the nucleus /Volume of the nucleus

(ii) Density of nuclear matter is of the order of 1017 kg/m3

**(iii) Density of nuclear matter is independent of the mass number.**

**4. Types of nuclei**

**(i) Isotopes**: Isotopes are the nuclei with the same atomic number Z but different mass numbers A. Examples:14Si28 , 14Si29 , 14Si30 and 14Si31. Isotopes are atoms of the same element and have same physical and chemical properties. If the relative abundance of isotopes in an element has a ratio n1:n2 whose atomic masses are m1and m2, then atomic mass of the element is

m = m1n1 +m2n2 / (n1 +n2)

**(ii) Isobars**: Isobars are the nuclei with the same mass number A but different atomic number Z.

(iii) Isotones: Isotones have the same neutron number but different atomic number and mass number

(iv) Isomers: Isomers have the same atomic number and same mass number but their nuclei exist in different energy states. These nuclei are distinguished by their different life times.

(v) Mirror nuclei: Nuclei, having the same mass number A hut with the proton and neutron number interchanged are called mirror nuclei.e.g. 4Be7 & 3Li7

**5. Forces between nucleons:**

**(i) Electrostatic coulombic forces:**

(a) The coulombic forces exist between protons only.

(b) As the atomic number increases, the size of the nucleus increases and therefore the coulombic forces increase.

(c) These forces cause instability of the nucleus.

**(ii) Nuclear forces:**

(a) These forces exist between any two nucleons. (b) These are the strongest known forces in nature.

(c) These are attractive forces and cause stability of the nucleus.

(d) Nuclear forces are short range forces. These do not exist at large distances greater than one fermi.

(e) These forces are charge independent. (0 These are saturable forces.

(g) According to Yukawa, nuclear forces are due to exchange of mesons.

(h) Anderson and Nedder Meyer discovered the meson.

(i) π+ , π- and π0-mesons are the particles which continuously exchange between proton and proton or neutron and neutron or a proton and a neutron.

**(iii) Hard core forces:**

(a) These are repulsive forces.

(b) These forces come into existence when the distance between the nucleons is 0.5 fermi.

(c) Due to these forces the density of the nucleus remains constant.

**(iv) Tensor forces:**

(a) These forces are due to spinning of nucleus.

(b) A spinning nucleus behaves like a magnetic dipole. There exists a force between two dipoles.

This force is called tensor force which prevails upto a distance of 3 fermi

**6. Stability of nucleus:**

(i) The nucleus is more stable when the number of protons is equal to the number of neutrons.

(ii) The nuclei having even number of protons or even number of neutrons are more stable.

(iii) If number of protons or the no. of neutrons in a nucleus is equal to one of the magic numbers, then the nucleus is stable. Magic numbers are 2,8,14,20, 28, 50,82, 126.

**7. Atomic mass unit (amu):** It is equal to (l/12)th of the mass of the carbon nucleus.

1amu =1.67 x 10-27 kg

**8. Mass energy equivalence:**

(i) Einstein established that mass is also a form of energy. The mass m of a particle is equivalent to its energy given by: E = mc2, where c is the velocity of light.

(ii) Energy is released in the form of γ-rays of frequency *v* given by: E = mc2 = h*v*.

(iii) The amount of energy released when 1 g of matter is annihilated = 9 x l0l3 joule = 2.5 x 107 kWh.

(iv) The amount of energy equivalent to 1 amu is 931MeV.

(v) The amount of energy released when an electron is annihilated is 0.51 MeV.

**9. Mass defect:**

(i) The actual mass of the nucleus is always less than the sum of the masses of its constituent particles. This difference in mass is known as mass defect.

(ii) Mass defect, ∆m=[Zmp +(A-Z)mn]-M, where mp =mass of proton, mn =mass of the neutron and M = actual mass of the nucleus.

(iii) Mass defect per nucleon is called packing fraction. Packing fraction =∆m/A ; where A = number of nucleons

**10. Binding energy:**

(i) The energy equivalent of mass defect of a nucleus is called the binding energy of the nucleus.

(ii) If ∆m is the mass defect in amu, then binding energy = ∆m x 931MeV.

(iii) lf ∆m is expressed in kg, then binding energy = ∆mc2 .

(iv) The binding energy is utilised to bind the nucleons in the nucleus.

(v) In order to break the nucleus into its constituent particles, the same amount of energy (= binding energy) is required.

(vi) Binding energy per nucleon = ∆mc2/A joule/nucleon or ∆m x 931/A MeV/nucleon

**11. Variation of binding energy per nucleon with mass number:**

(i) The binding energy per nucleon (except for He4, Cl2 and 016) rises first sharply and reaches a maximum value 8.8 MeV in the neighbourhood of A = 50.

(ii) After A =50 the curve falls very slowly and reaches a value of 8.4 MeV at about A = 140. For higher mass

number, the energy decreases to about 7.6 MeV (for A =240)

(iii) Binding energy per nucleon is a measure of stability of the nucleus. Greater the binding energy greater is the stability of the atom.

(iv) Binding energy per nucleon is more for medium nuclei than for heavy nuclei. Hence, medium nuclei are very highly stable.

(v) The heavier nuclei being unstable split into medium nuclei. This process is called **Fission**.

(vi) The lighter nuclei being unstable fuse into a medium nucleus. This process is called **Fusion**.

(vii) (a) Deuterium : BEN= 1 MeV, A = 2

(b) Neon : BEN=8MeV, A=20

(c) Iron : BEN=8.8MeV, A=56

(d) Bismuth : BEN= 7.8 MeV, A = 209

**12. Fission:**

(i) The splitting of the heavy nucleus into two medium nuclei is known as nuclear fission.

(ii) Nuclear fission was discovered by Otto Hahn and Strassmann in the year 1938.

(iii) The reaction representing the basic fission process of uranium nucleus is written as follows:

92U235 +0n1 ---- 92U236 ----- X +Y + neutrons

Here, 92U236 is a highly unstable isotope and X and Y are the fission fragments.

(iv) The average number of neutrons produced in the fission of uranium is 2.5.

(v) The neutrons released during the fission process are called prompt neutrons.

(vi) Fission fragments while becoming stable emit some neutrons called delayed neutrons. The delayed neutrons are about l% of the prompt neutrons. The velocity of prompt neutrons is more than the velocity of delayed neutrons.

(vii) U235 is more easily fissionable than U238. Fast neutrons are required for the fission of U238 while slow neutrons are needed for the fission of U235.Naturally available uranium has 0.7% of U235 and 99.3% of U238.

(viii) Easily fissionable element is plutonium, 94Pu239, which is an artificially formed element

**13. Energy released in fission:**

(i) The energy released in the fission of one U235 atom is about 200 MeV =3.2 x 10-11 J.

(ii) The energy released in the fission of 1 g of U235 is = ( 6.023 xl023/235) x 200MeV = 5.128 x 1023 MeV

**14. Chain reaction:**

(i) A chain reaction is a self-propagating process in which a number of neutrons multiply rapidly during fission till the whole of the fissile material is disintegrated.

(ii) The chain reaction occurs if loss of neutrons by non-fission capture of neutrons and escape of neutrons without being captured is less than the surplus of neutrons produced by fission.

(iii) To start a chain reaction a minimum mass of the fissile material is required. This mass is called **critical mass or critical size.**

(iv) Uncontrolled chain reaction is the principle of the atom bomb.

(v) The energy released in the explosion of an atom bomb is equal to the energy released by 2000 ton of TNT and the temperature at the place of explosion is of the order of 107 0C.

(vi) Controlled chain reaction is the principle of **nuclear reactor or thermopile**.

**15. Nuclear reactor:**

(i) Nuclear reactor was first devised by Fermi.

(ii) Apsara was the first Indian nuclear reactor.

(iii) A nuclear reactor consists of five main elements:

**(a) Fuel:** The commonly used fuels are isotopes of uranium ,Thorium & Plotonium. U233,U235; Th232. Pu239 ,Pu240 & Pu241

**(b) Moderator:** Moderator slows down the highly energetic neutrons. Examples: Heavy water, graphite, beryllium

**(c) Control rods**: The function of control rods is to absorb the excess of neutrons and thus controls the chain reaction. Examples: cadmium rods, boron rods.

**(d) Neutron reflector**: This prevents the leakage of neutrons. Materials of high scattering cross-section and low absorption cross-section are good reflectors.

**(e) Coolants:** The cooling system removes the heat evolved in the reactor core. e.g. Ordinary water, heavy water, helium, CO2, liquid sodium, potassium, mercury, etc.

**(iv) Breeder reactor**: In a breeder reactor more nuclear fuel would be produced than consumed. In this reactor non-fissionable uranium-238 is converted into fissionable plutonium-239.

**(v) Power of a reactor**: If n atoms undergo fission in a time t second and E be the energy released in each fission, then power P =(nE/t).

**16. Nuclear fusion:**

(i) Fusion is a process in which lighter nuclei combine to form a heavy nucleus. When two deuterium nuclei

are fused together, a single helium nucleus is formed. 1H2 +1H2 ---2He4 +24MeV

(ii) For fusion very high temperature of the order of 107 to 108 K is required and so the reaction is called **thermonuclear** reaction.

(iii) Fusion energy is greater than fission energy.

**17. Stellar energy**:

(i) The source of solar energy or stellar energy is nuclear fusion.

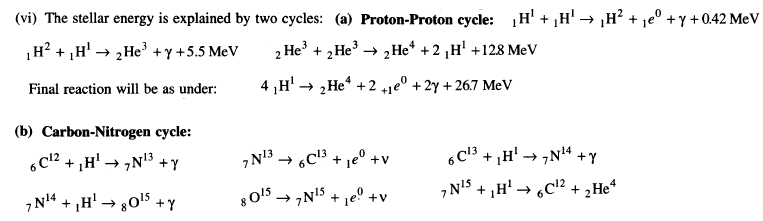
(ii) The solar energy is due to formation of helium by the combination of hydrogen nuclei by fusion reaction.

(iii) The light elements hydrogen and helium together form about 99% by weight of the sun's matter.

(iv) The temperature of the interior of the sun is about 2x107 K and the temperature of some stars is about

108 K.

(v) The sun radiates 3.8 x 1026 joule of energy in each second.



(vii) If the temperature is more than that of the sun, then hydrogen nuclei combine to form helium by carbon-nitrogen cycle.

(viii) More energy is released due to proton-proton cycle than carbon-nitrogen cycle.

(ix) **Hydrogen bomb** is based on the principle of nuclear fission. The very high temperature required for fusion is supplied by an atom bomb. This bomb is more disastrous than atom bomb.

**18. Radiation units:**

**(i) Roentgen (r):** It is the dose of radiation that produces 1.6 x 1012 pairs of ions in one gram of air.

Also, one roentgen (r) =2.58x 104 coulomb/kg.

(ii) Rad is also a unit of radiation. 1 rad = l0-2 J/kg.

**Home Assignment- Dual –Atom-Nuclei**

**Dual Nature**

1. Define *Thermionic emission* , *Field emission and Photo-electric emission*.
2. What do you mean by photoelectric effect?
3. Draw the graph for the variation of photoelectric current with the intensity of light , collector plate potential and frequency of incident light?
4. What are different postulates of Laws of photoelectric effect emission?
5. What do you mean by Einstein’s photoelectric effect equation?
6. Give any 3 points related to the photon theory of EM radiation ?
7. Explain why wave theory of light was not able to explain results of photoelectric effect ?
8. What do you mean by photoelectric cell ?
9. What do you mean by De –Broglie hypothesis ?Find expression for the De-Brogile wavelength ?
10. Derive an expression for De-Brogile wavelength associated with an electron accelerated thru P.D. of V volt?
11. What was the Davisson Germer Experiment ?
12. What is the de Broglie wavelength associated with an electron, accelerated through a potential difference of 100 volts?

**(NCERT Solved)**

1. Monochromatic light of frequency 6.0 ×1014 Hz is produced by a laser. The power emitted is 2.0 ×10–3 W. (a) What is the energy of a photon in the light beam? (b) How many photons per second,on an average, are emitted by the source?
2. The work function of caesium is 2.14 eV. Find (a) the threshold frequency for caesium, and (b) the wavelength of the incident light if the photocurrent is brought to zero by a stopping potential of 0.60 V.
3. What is the de Broglie wavelength associated with (a) an electron moving with a speed of 5.4×106 m/s, and (b) a ball of mass 150 g travelling at 30.0 m/s?
4. An electron, an α-particle, and a proton have the same kinetic energy. Which of these particles has the shortest de Broglie wavelength?
5. A particle is moving three times as fast as an electron.The ratio of the de Broglie wavelength of the particle to that of the electron is 1.813 × 10–4. Calculate the particle’s mass and identify the particle.
6. What is the de Broglie wavelength associated with an electron, accelerated through a potential difference of 100 volts?
7. The wavelength of light in the visible region is about 390 nm for violet colour, about 550 nm (average wavelength) for yellowgreen colour and about 760 nm for red colour.
   1. What are the energies of photons in (eV) at the (i) violet end, (ii)average wavelength, yellow-green colour, and (iii) red end of the visible spectrum?
8. (Take *h* = 6.63×10–34 J s and 1 eV = 1.6×10 –19J.)

**(NCERT Unsolved)**

1. Find the (a) maximum frequency, and (b) minimum wavelength of X-rays produced by 30 kV electrons.
2. 16.The work function of caesium metal is 2.14 eV. When light of frequency 6 ×1014Hz is incident on the metal surface, photoemission of electrons occurs. What is the
   1. maximum kinetic energy of the emitted electrons, (b) Stopping potential, and
   2. maximum speed of the emitted photoelectrons?
3. The photoelectric cut-off voltage in a certain experiment is 1.5 V.What is the maximum kinetic energy of photoelectrons emitted?
4. The energy flux of sunlight reaching the surface of the earth is 1.388 × 103 W/m2. How many photons (nearly) per square metre are incident on the Earth per second? Assume that the photons in the sunlight have an average wavelength of 550 nm.

**Exemplar**

1. There are materials which absorb photons of shorter wavelength and emit photons of longer wavelength. Can there be stable substances which absorb photons of larger wavelength and emit light of shorter wavelength
2. Do all the electrons that absorb a photon come out as photoelectrons?
3. There are two sources of light, each emitting with a power of 100 W. One emits X-rays of wavelength 1nm and the other visible light at 500 nm. Find the ratio of number of photons of X-rays to the photons of visible light of the given wavelength?

**Atoms**

1. Explain Thomson’s model of atom alongwith it’s limitations?
2. Write an expression for distance of closest approach and Impact parameter for Rutherford’s experiment ?
3. Write different postulates of Rutherford’s Model of atom?
4. Calculate the expression for the KE , PE and total energy of the revolving electron ?
5. Write different limitations of Rutherford’s Model of atom?
6. Write 3 different postulates of Bohr’ theory of atom ?
7. Find the expression for the rn, En for Bohr’s model of atom ?
8. Write expressions for different spectral series of hydrogen atom?
9. Explain how De-Broglie’s hypothesis was able to explain quantization of angular momentum?
10. Write limitations of Bohr’s model of atom?
11. What do you mean by excitation and ionisation potential?
12. What do you mean by continuous and characteristic x-ray spectra?

**NCERT Solved**

1. It is found experimentally that 13.6 eV energy is required to separate a hydrogen atom into a proton and an electron. Compute the orbital radius and the velocity of the electron in a hydrogen atom.
2. 2. According to the classical electromagnetic theory, calculate the initial frequency of the light emitted by the electron revolving around a proton in hydrogen atom.
3. 3. A 10 kg satellite circles earth once every 2 h in an orbit having a radius of 8000 km. Assuming that Bohr’s angular momentum postulate applies to satellites just as it does to an electron in the hydrogen atom, find the quantum number of the orbit of the satellite.
4. 4. Using the Rydberg formula, calculate the wavelengths of the first four spectral lines in the Lyman series of the hydrogen spectrum.

**NCERT Unsolved**

1. What is the shortest wavelength present in the Paschen series of spectral lines?
2. A difference of 2.3 eV separates two energy levels in an atom. What is the frequency of radiation emitted when the atom make a transition from the upper level to the lower level?
3. The ground state energy of hydrogen atom is –13.6 eV. What are the kinetic and potential energies of the electron in this state?
4. A hydrogen atom initially in the ground level absorbs a photon, which excites it to the *n* = 4 level. Determine the wavelength and frequency of photon.
5. A 12.5 eV electron beam is used to bombard gaseous hydrogen at room temperature. What series of wavelengths will be emitted?

**Exemplar**

1. The mass of a H-atom is less than the sum of the masses of a proton and electron. Why is this?
2. When an electron falls from a higher energy to a lower energy level, the difference in the energies appears in the form of electromagnetic radiation. Why cannot it be emitted as other forms of energy?
3. Consider two different hydrogen atoms. The electron in each atom is in an excited state. Is it possible for the electrons to have different energies but the same orbital angular momentum according to the Bohr model?
4. Using Bohr model, calculate the electric current created by the electron when the H-atom is in the ground state.

**Nuclei**

1. Write energy equivalent of 1 amu?
2. Derive relation between nuclear radius and mass number?
3. Prove that nuclear density is independent of mass number?
4. What do you mean by Isotopes, Isobars and Isotones , give some examples also?
5. What do you mean by mass defect and binding energy ?
6. Draw graph between “Average binding energy per nucleon” and “mass number” ? Also discuss it’s relevance?
7. Write different properties of Nuclear forces?
8. What do you mean by radioactivity?
9. Tabulate differences between alpha, beta and gamma rays emission?
10. Write different postulates of Laws of radioactivity?
11. Derive Law of Radioactive decay ?
12. What do you mean by Half life and mean life. Derive suitable expressions?
13. Define 1 curie, 1 Becquerel and 1 Rutherford?
14. Explain changes occurring during alpha decay ,beta decay and gamma decay?
15. What do you mean by Nuclear Fission and Fusion?
16. What is the role of Moderators and Control rods in a nuclear reactor ?

**NCERT Solved**

1. Given the mass of iron nucleus as 55.85u and A=56, find the nuclear density?
2. Calculate the energy equivalent of 1 g of substance.
3. Find the energy equivalent of one atomic mass unit, first in Joules and then in MeV. Using this, express the mass defect of 16O8 in MeV/*c*2.
4. Tritium has a half-life of 12.5 y undergoing beta decay. What fraction of a sample of pure tritium will remain undecayed after 25 y.

**NCERT Unsolved**

1. Obtain the binding energy (in MeV) of a nitrogen nucleus 14 N7 , given *m* of 14 N7 =14.00307 u
2. Write nuclear reaction equations for

(i) α-decay of 226 Ra88(ii) α-decay of 242 Pu94 (iii) β*–*- decay of 32 P15 (iv) β–- decay of 210 Bi83

(v) β*+*-decay of 11 C6  (vi) β*+*-decay of 97 Tc43  (vii) Electron capture of 120 Xe54

1. A radioactive isotope has a half-life of *T* years. How long will it take the activity to reduce to a) 3.125%, b) 1% of its original value?
2. The half-life of 90Sr38 is 28 years. What is the disintegration rate of 15 mg of this isotope?
3. From the relation *R* = *R*0*A* 1/3, where *R*0 is a constant and *A* is the mass number of a nucleus, show that the nuclear matter density is nearly constant (i.e. independent of *A*).

**Exemplar**

1. In pair annihilation, an electron and a positron destroy each other to produce gamma radiation. How is the momentum conserved?
2. Why do stable nuclei never have more protons than neutrons?
3. A Piece of wood from the ruins of an ancient building was found to have a 14C activity of 12 disintegrations per minute per gram of its carbon content. The 14C activity of the living wood is 16 disintegrations per minute per gram. How long ago did the tree, from which the wooden sample came, die? Given half-life of 14C is 5760 years.

**Objective Questions**

**Cathode Rays & Positive Rays**

1. The discharge tube in Thomson's experiment contains hydrogen, carbon and oxygen atoms. The order in which parabolas are obtained on the screen is:

(a) oxygen innermost and hydrogen outermost (b) hydrogen innermost and carbon outermost

(c) hydrogen innermost and oxygen outermost (d) carbon innermost and hydrogen outermost

2. The mass of a proton is 1840 times that of an electron. An electron and a proton with equal kinetic energies enter perpendicularly a uniform electric field:

(a) the path of proton shall be more curved than that of electron

(b) the path of proton shall be less curved than that of electron

(c) the paths of both proton and electron will be equally curved (d) the paths of both will be straight

3. When a cathode ray tube is operated at 2912 volt, the velocity of electrons is 3.2 x 107 m/sec. Find the velocity of cathode ray if the tube is operated at 5824 volt

(a) 2.4x 107 m/s (b) 5.2 x 107 m/s (c) 4.525 x 107 m/s (d) 6.2 x 106 m/s

4. A stream of electrons is passing through with a velocity of 2 x107 m/sec in crossed electric and magnetic fields which are also perpendicular to the path of electrons. If the strength of magnetic field is 0.05tesla, calculate the strength of electric field required so that the electron beam will remain undeflected.

(a) 104 V/m (b) 105 V/m (c) 106 V/m (d) 103 V/m

5. In a cathode ray tube, a potential difference of 3000 volts is maintained between the deflector plates whose separation is 2 cm. A magnetic field of 2.5 x 10-3 wb/m2 at right angles to the electric field gives no deflection of the electron beam, which received an initial acceleration by a potential difference of 10,000 volt. Calculate e/m of an electron

(a) 1.8 x l0ll coul/kg (b) 4.2x 1011 coul/kg (c) 1.76 x 1011 coul/kg (d) None of these

6. An electron beam accelerated from rest through a potential difference of 5000 V in vacuum is allowed to impinge on a surface normally. The incident current is 50 μA and if the electrons come to rest on striking the surface, the force on it is: (a) 1.1924x10-8 N (b) 2.1x 10-8 N (c) 1.6x 10-8 N (d) 1.6 x 10-6 N

7. A proton of mass m and charge +e is moving in a circular orbit in a magnetic field with energy 1 MeV. What should be the energy of α-particle (mass 4 m and charge +2e) so that it can revolve in the path of same radius? (a) 1 MeV (b) 4 MeV (c) 2 MeV (d) 0.5 MeV

8. In a positive ray apparatus singly ionised and doubly ionised particles form identical parabola when the magnetic fields are respectively 5 and 7.5 tesla. Compare the masses of particles, assuming the electric field to be same. (a)l:2 (b)2:4 (c)2:9 (d)3:2

9.In an experiment for positive ray analysis with Thomson method, two identical parabola are obtained when applied electric fields are 3000 and 2000 V/m. The particles are singly ionised and doubly ionised. Compare the masses of the particles assuming same magnetic field. (a) 1 :3 (b) 2:4 (c)3:1 (d)4:2

10. If the specific charge of a proton,(e/mp) is 9.6 x 107 coulomb/kg , then that for an alpha particle will be (in coulomb/kg )(a) 2.4 x 107 (b) 4.8 x 107 (c) 19.2 x 107 (d) 38.4 x 107

11. A cathode ray tube contains a pair of parallel metal plates 1.0 cm apart and 3.0 cm long. A narrow horizontal beam of electrons with a velocity of 3 x 107 ms-l is passed down the tube midway between the two plates. When a potential difference of 550 V is maintained across the plates, it is found that the electron beam is so deflected that it just strikes the end of one of the plates. Then the specific charge of an electron (that is, the ratio of its charge to mass(in coulomb/kg )is

(a) 3.6 x 1014 (b) 1.8 x 1011 (c) 3.6 x 1012 (d) 1.8 x 109

12. The current in an electron beam of a cathode ray tube is 4.8 mA. If an accelerating voltage is 2000 V, then the number of electrons striking the screen each second is (take charge on an electron as 1.6 x 10-19 C):

(a) 6 x 1015 (b) 3 x 1016 (c) 3 x 1015 (d) 1.5 x 1016

13. The current in an electron beam of a cathode ray tube is 4.8 mA. If an accelerating voltage is 2000 V, the kinetic energy in joules of each electron as it strikes the screen is:

(a) 1.6 x 10-16 J (b) 3.2 x 10-14 J (c) 3.2 x 10-16 J (d) 1.6 x 10-14 J

14. Cathode rays moving along +X-direction are subjected to a magnetic field along +Y-direction to cause deflection. In order to restore the beam to the original path an electric field must be applied simultaneously along: (a) + Z-direction (b) - Z-direction (c) - Y-direction (d) + Y-direction

15. An electron and a proton are accelerated through a potential V. If pe and pp be, their momenta, then pp/pe is approximately equal to (a) 21 (b) 43 (c) 55 (d) 81

16. Cathode rays are similar to visible light rays, in that:

(a) they both can be deflected by electric and magnetic fields

(b) they both have a definite magnitude of wavelength

(c) they both can ionise the gas through which they pass (d) they both can affect photographic plates

17. A particle A has charge +q and a particle B has charge +4q with each of them having the same mass m. When allowed to fall from rest through the same electric potential difference, the ratio of their speeds vA/vB will become: (a)2:l (b)1:2 (c)l:4 (d)4:1

18. Chlorine has an atomic number 17. It has two naturally occurring isotopes with mass numbers 35 and 37. As occurring in nature, its relative atomic mass is 35.5. Then the relative abundances of the two isotopes in naturally occurring chlorine are: (a)2:1 (b)3:1 (c) 4: 1 (d)1:3

19. In Millikan's oil drop experiment an oil drop of radius r and charge Q is held in equilibrium between the plates of a charged parallel plate capacitor when the potential difference is V. To keep a drop of radius 2r and with a charge 2Q in equilibrium between the plates the potential difference V' required is:

(a) V (b) 2V (c) 4V (d) 8V

20. The mean free path of the electrons in a discharge tube is 15 cm. The length of the tube is 10 cm only. Then, the length of the Crooke's dark space is(a) 15 cm (b) 10 cm (c) 5 cm (d) 25 cm

21. A cylindrical tube of uniform cross-section A is closed at one end. A cathode is fixed in the tube at the closed end. It is fitted with a conducting movable piston at the other end. An anode is fixed to the piston. Now the tube is filled with a gas at a pressure P.*l* denotes the separation between the cathode and the anode. The sparking potential Vs is given by Paschen Law: Vs = *f* (P ,*l*)

Now, if the piston is moved towards inwards decreasing *l*,then the sparking potential: (a) increases

(b) decreases (c) remains unchanged (d) sometimes increases, sometimes decreases

22. A charged oil drop in Millikan's experiment remains suspended in a uniform electric field of 2 xl04 V/m. Find the number of electrons if mass is 8 x 10-15 kg. (a) 25 (b) 35 (c) 50 (d) 60

23. An oil drop having a mass 4.8 x 10-10 g and charge 2.4 x10-18 C stands still between two charged horizontal plates separated by a distance of I cm. If now the polarity of the plates is changed, instantaneous acceleration (in ms-2; of the drop is: (Take g = 10 ms-2); (a) 5 (b) 10 (c) 20 (d) 40

24. An electron is accelerated through a potential difference of V volts. The speed of electron will be

(a) √(eV/m) (b) √(2eV/m) (c) √(eV/2m) (d) √( m/2eV)

25. A charged oil drop is falling freely under gravity in the absence of electric field with a velocity *v*. It is held stationary in a electric field. As it acquires a charge q', it moves up with a velocity of 3*v*. Now, charge q' on the drop is: (a) q (b)2q (c)3q (d)4q

26. If gE & gM are the accelerations due to gravity on the surfaces of the Earth and the Moon respectively and if Millikan's oil drop experiment could be performed on the two surfaces, one will find the ratio electronic charge on the Moon/ electronic charge on the Earth to be: (a)gM/gE (b)1 (c)0 (d) gE/gM

27. Millikan’s oil drop experiment established that:

(a) electric charge depends on velocity (b) specific charge of electron is 1.76 x 1011 C kg-l

(c) electron has wave nature (d) electric charge is quantized (e) electron has particle nature

28. The specific charge of a proton is 9.6x107 C/kg. The specific charge of an alpha particle (in C/kg) will be:

(a) 9.6 x 107 (b) 19.2 x 107 (c) 4.8 x 107 (d) 2.4 x 107

29. A beam of cathode rays is subjected to crossed electric(E) and magnetic fields (B). The fields are adjusted such that the beam is not deflected. The specific charge of the cathode rays is given by:

(a) B2/2VE2 (b) 2V B2/E2 (c) 2VE2/B2 (d) E2/2V B2

(Where V is the potential difference between cathode and anode)

**Photoelectric Effect**

30. When yellow light is incident on a surface no electrons are emitted while green light can emit. If red light is incident on the surface then: (a) no electrons are emitted (b) photons are emitted

(c) electrons of higher energy are emitted (d) electrons of lower energy are emitted

31. Light of two different frequencies whose photons have energies 1 and 2.5 eV respectively, successively illuminate a metal whose work function is 0.5 eV. The ratio of the maximum speeds of the emitted electrons will be: (a) 1 :5 (b) 1 :4 (c) l:2 (d)1:l

32. Radiations of two photon energies twice and five times the work function of metal are incident successively on the metal surface. The ratio of the maximum velocity of the photoelectrons emitted in the two cases will be: (a) l:1 (b)l:2 (c) 1:3 (d) 1:4

33. The human eye can barely detect a yellow light (6000 A0) that delivers 1.7 x10-18 watt to the retina. Nearly how many photons per second does the retina receive?

(a) 50 (b) 5 (c) 500 (d) More than 5 million

34. The graph between the frequency of incident light and the stopping potential is a:

(a) parabola (b) straight line (c) hyperbola (d) circle

35. A proton when accelerated through a potential difference of V volt has a wavelength λ, associated with it. An α-particle in order to have the same λ, must be accelerated through a potential difference of:

(a) V volt (b) 4V volt (c) 2V volt (d) (V/8) volt

36. An electron accelerated under a potential difference V volt has a certain wavelength λ. Mass of proton is some 2000 times of the mass of the electron. If the proton has to have the same wavelength λ, then it will have to be accelerated under a potential difference of:

(a) V volt (b) 2000V volt (c) V/2000 volt (dl V√2000 volt

37. Given that a photon of light of wavelength 10,000 angstrom has an energy equal to 1.23 eV. When light of wavelength 5000 angstrom and intensity Io falls on a photoelectric cell, the saturation current is 0.40 x l0-6 ampere and the stopping potential is 1.36 volt; then the work function is:

(a) 0.43 eV (b) 1.10 eV (c) 1.36 eV (d) 2.47 eV

38. In the Q. 37, if the intensity of light is made 4Io, then the stopping potential will become

(a)l.36 x l volt (b)l.36 x 2 volt (c)1.36 x 3 volt (d) 1.36/2 volt

39. In the Q. 37, if the intensity of light is made 4Io, then the saturation current will become

(a) 0.40 x 1 microampere (b) 0.40 x 2 microampere (c) 0.40 x 4 microampere (d) 0.40 x 8 microampere

40. In the Q. 37, if the cathode and the anode are kept at the same potential, the emitted electrons

(a) all have the same KE equal to 1.36 eV (b) all have the average KE equal to (1.36/2) eV

(c) all have the maximum KE equal to 1.36 eV (d) all have the minimum KE equal to 1.36 eV

41. In the Q. 37, if the wavelength is changed to 4000 A0, then stopping potential will become:

(a) 1.36 volt (b) 3.40 volt (c) 1.60 volt (d) 1.97 volt

42. A caesium photocell with a steady potential difference of 60 V across it, is illuminated by a small bright light placed 1 m away. When the same light is placed 2 m away, the electrons crossing the photocell:

(a) each carry one quarter of their previous momentum (b) each carry one quarter of their previous energy

(c) are one quarter as numerous (d) are half as numerous

43. Light of wavelength 0.6 μm from a sodium lamp falls on a photocell and causes the emission of photoelectrons for which the stopping potential is 0.5 volt. With light of wavelength 0.40 μm from a mercury vapour lamp the stopping potential is 1.5 volt; the work function (in electron volt) of the photocell surface is:

(a) 0.75 (b) l.5 (c) 3 (d) 2.5

44. Silver has a work function of 4.7 eV. When ultraviolet light of wavelength 100 nm is incident upon it, a potential of 7.7 volts is required to stop the photoelectrons from reaching the collector plate. How much potential will be required to stop the photoelectrons when light of wavelength 200 nm is incident upon silver?

(a) 1.5 V (b) 3.85 V (c) 2.35 V (d) 15.4 V

45. The dual nature of light is exhibited by: (a) diffraction and photoelectric effect

(b) diffraction and reflection (c) refraction and interference (d) photoelectric effect



46. The figure(39.6) shows the variation of photo current with anode potential for a photo-sensitive surface for three different radiations. Let Ia, Ib & Ic be the intensities and *fa, fb & fc* be the frequencies for the curves a, b and c respectively: [IIT -2004]

(a) *fa =fb*  & Ia ≠ Ib (b) *fa =fc* & Ia = Ic

(c) *fa =fb* & Ia = Ib (d) *fb =fc*  & Ib = Ic

47. What is the de Broglie wavelength of the α-particle accelerated through a potential difference V (in A0)? (a) 0.287/√V (b) 12.27/√V (c) 0.101/√V (d) 0.202/√V

48.The energy of a photon is equal to the kinetic energy of a proton. The energy of the photon is E. Let λ1 be the de Broglie wavelength of the proton and λ2 be the wavelength of the photon. The ratio λ1/λ2 is proportional to: (a) E0  (b) E1/2 (c) E-1 (d) E-2  **[IIT -2004]**

49. Out of a photon and an electron the equation, E = pc, is valid for

(a) both (b) neither (c) photon only (d) electron only

50. Representing the stopping potential V along y-axis and (1/λ) along x-axis for a given photocathode, the curve is a straight line, the slope of which is equal to:

(a) e/hc (b) hc/e (c) ec/h (d) he/c

51.In the Q. 50, the intercept on the ,y-axis is equal to: (Where W represents the work function of emitter.)

(a) +W/e (b) –W/e (c) -We (d) e/W

52. If nR and nV denote the number of photons emitted by a red bulb and violet bulb of equal power in a given time, then(a) nR = nV  (b) nR > nV  (c) nR < nV (d) nR ≥ nV

53. 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) λm/M (b) λ√(m/M) (c) λM/m (d) λ√(M/m)

54. An image of the sun is formed by a lens of focal length of 30 cm on the metal surface of a photoelectric cell and a photoelectric current I is produced. The lens forming the image is then replaced by another of the same diameter but of focal length l5 cm. The photoelectric current in this case is:

(a) I/2 (b) I (c) 2I (d) 4I

55. In a photo emissive cell, with exciting wavelength λ, the fastest electron has speed *v*. If the exciting wavelength is changed to 3λ/4, the speed of the fastest emitted electron will be

(a) *v*(3/4)1/2 (b) *v*(4/3)1/2 (c) less than *v*(4/3)1/2 (d) greater than *v*(4/3)1/2

56. The cathode of a photoelectric cell is changed such that the work function changes from W1 to W2(W2> W1). If the currents before and after the change are I1 and I2 and all other conditions are unchanged, then: (assuming h*v* > W2): (a) I1= I2 (b) I1< I2 (c) I1> I2 (d) I1< I2 < 2I1

57. If 5% of the energy supplied to a bulb is irradiated as visible light, how many quanta are emitted per sec by a 100 watt lamp? Assume wavelength of visible light as 5.6 x l0-5 cm:

(a) 1.4 x 1019 (b) 2 x 10-4 (c) 1.4 x 10-19 (d) 2 x 104

58. The minimum light intensity that can be perceived by the eye is about10-10 W/m2 .The number of photons of wavelength 5.6 x 10-7 m that must enter the pupil, of area 10-6 m2 per sec for vision is approximately:(use h = 6.6 x 10-34 joule-sec) (a)3x102 (b)3x103 (c)3x104  (d)3x105

59. When 1 centimetre thick surface is illuminated with light of wavelength λ, the stopping potential is V. When the same surface is illuminated by light of wavelength 2λ, the stopping potential is V/3. Threshold wavelength for metallic surface is: (a) 4λ/3 (b) 4λ (c) 6λ (d) 8λ/3

60. The slope of frequency of incident light versus stopping potential for a given surface will be

(a) h/e (b) eh (c) e (d) h

61. The speed of an electron having a wavelength of 10-10 m is (in m/s) :

(a) 7.25 x 106 (b) 6.26 x 106 (c) 5.25 x 106 (d) 4.24 x 106

62. A photon of 1.7 x 10-13 J is absorbed by a material under special circumstances. The correct statement is: (a) photoelectric effect will occur and electrons will be produced

(b) electrons of the atom of absorbed material will go to the higher energy states

(c) electron and positron pair will be created (d) only positron will be produced

63. When light of wavelength 300 nm falls on a photoelectric emitter, photoelectrons are liberated. For another emitter, however, light of 600 nm wavelength is sufficient for creating photoemission. What is the ratio of the work functions of the two emitters : (a)l:4 (b)4:l (c)2:1 (d)l:2

64. A radiation of energy E falls normally on a perfectly reflecting surface. The momentum transferred to the surface is : (a)E/c (b)2E/c (c)Ec (d)E/c2 [AIEEE 2004]

65. According to Einstein's photoelectric equation, the plot of the kinetic energy of the emitted photoelectrons from a metal versus frequency of the incident radiation gives a straight line whose slope [AIEEE 2004]

(a) depends on the nature of metal used (b) depends on the intensity of radiation

(c) depends on both the intensity of radiation and the nature of metal used

(d) is the same for all metals and independent of the intensity of' radiation

66. One milliwatt of light of wavelength 4560 A0 is incident on a caesium surface of work function 1.9 eV. Given that quantum efficiency of photoelectric emission is 0.5%, Planck constant h = 6.62 x 10-34 J-sec, velocity of light c =3 x 108 m/s, the photoelectric current liberated is:

(a) 1.856 x 10-6 amp (b) 1.856 x I0-7 amp (c) 1.856 x l0-5 amp (d) 1.856 x l0-4 amp

67. Light of frequency 1.5 times the threshold frequency is incident on a photosensitive material, photoelectric current is emitted. If the frequency of light is halved and intensity is doubled, the photoelectric current becomes: (a) 4 times the original current (b) 2 times the original current

(c) half the original current (d) zero times the original current

68. Light of wavelength 3500 A0 is incident on two metals A and B. A of work function 4.2eV and B of work function 1.19eV respectively. The photoelectrons will be emitted by:

(a) metal A (b) metal B (c) both A and B (d) neither metal A nor metal B

69. The maximum wavelength of a beam of light that can be used to produce photoelectric effect on a metal is 250 nm. The energy of the electrons (in joule) emitted from the surface of the metal when a beam of light of wavelength 200 m is used:(a) 89.61 x10-22 (b) 69.81 xl0-22 (c) 18.96 x 10-20  (d) 19.86 x 10-20

70. The value of de Broglie wavelength of an electron moving with a speed of 6.6 x 105 m/s, is approximately:

(a)11A0 (b) 111 A0 (c) 211 A0 (d) 311 A0

71. The de Broglie wavelength of an electron in the first Bohr orbit is equal to

(a) circumference of the first orbit (b) half the circumference of first orbit

(c) twice the circumference of first orbit (d) one-fourth circumference of first orbit

72. A photon of wavelength 6630 A0 is incident on a totally reflecting surface. The momentum delivered by the photon is equal to: (a) 6.63x l0-27 kg-m/s (b) 2xl0-27 kg-m/s (c) 10-27 kg-m/s (d) none of these

73. The ratio of de Broglie wavelength of molecules of hydrogen and helium in two gas jars kept separately at temperatures of 270 C and l270 C respectively is: (a) 2/√3 (b) 2/3 (c) √(¾) (d) √(8/3)

74. Which of the following phenomena exhibits particle or quantum nature of light?

(a) Interference (b) Diffraction (c) Polarisation (d) Photoelectric effect

75. Which of the following statements is correct?

(a) The stopping potential increases with increasing intensity of incident light

(b) The photocurrent increases with increasing intensity of light

(c) The photocurrent is proportional to applied voltage

(d) The current in a photocell increases with increasing frequency of light

**Atomic Structure & Spectrum**

76. In an atom, two electrons move around the nucleus in circular orbits of radii R and 4R. The ratio of the time taken by them to complete one revolution is: (a) ¼ (b) 4/l (c) 8/1 (d) 1/8

77. Given mass number of gold =197, density of gold =19.7 gm/cm3, Avogadro's number = 6 x l023.The radius of the gold atom is approximately:

(a) 1.5 x l0-8 m (b) 1.5 x 10-9 m (c) 1.5 x l0-l0 m (d) 1.5 x 10-12 m

78. An a-particle of l0 MeV collides head-on with a copper nucleus (Z =29) and is deflected back. Then, the minimum distance of approach between the centres of the two is:

(a) 8.4 x l0-l5 cm (b) 8.4 x 10-15 m (c) 4.2x 10-15 m (d) 4.2 x 10-15 cm

79. In Rutherford's experiment, the number of α-particles scattered through an angle of 900 is 28 per minute. Then, the number of particles scattered through an angle of 600 per minute by the same nucleus is:

(a) 28 per minute (b) 112 per minute (c) 12.5 per minute (d) 7 per minute

80. In Rutherford's experiment, the number of α-particles scattered through an angle of 600 by a silver foil is 200 per minute. When the silver foil is replaced by a copper foil of the same thickness, the number of α-particles scattered through an angle of 600 per minute is:



81. When the electron jumps from a level n = 4 to n = l, the momentum of the recoiled hydrogen atom will be (in kg-m/s): (a) 6.5 x10-27 (b) 12:75 x 10-19 (c) 13.6 x 10-19 (d) zero

82.The spectrum obtained from the chromosphere of the sun, at the time of total solar eclipse is:

(a) line emission spectrum (b) line absorption spectrum

(c) continuous emission spectrum (d) band absorption spectrum

83. Check the correctness of the following statements about Bohr model of hydrogen atom:

(i) The acceleration of the electron in n= 2 orbit is more than in n=1orbit.

(ii) The angular momentum of the electron in n= 2 orbit is more than in n=1 orbit.

(iii) The KE of the electron in n = 2 orbit is less than in n =1 orbit.

(a) all the statements are correct (b) only (i) and (ii) are correct

(c) only (ii) and (iii) are correct (d) only (iii) and (i) are correct

84. When a hydrogen atom is raised from the ground state to fifth state:

(a) both KE and PE increase (b) both KE and PE decrease

(c) PE increases and KE decreases (d) PE decreases and KE increases

85. As the electron in Bohr orbit of hydrogen atom passes from state ,n= 2 to n =1, the KE (K) and PE (U) change as: (a) K two-fold, U also two-fold (b) K four-fold, U also four-fold

(c) K four-fold, U two-fold (d) K two-fold, U four-fold

86. Consider a spectral line resulting from the transition n = 5 to n =l in the atoms and ions given below. The shortest wavelength is produced by: (a) helium atom (b) deuterium atom

(c) singly ionised helium (d) ten times ionised sodium atom

87. Which state of triply ionised beryllium (Be++) has the same orbital radius as that of the ground state of hydrogen (a) n = l (b) n=2 (c) n=3 (d) n=4

88. Which of the following statements is true regarding Bohr's model of hydrogen atom?

(I) Orbiting sped of electrons decreases as it falls to discrete orbits away from the nucleus.

(II) Radii of allowed orbits of electrons are proportional to the principal quantum number.

(III) Frequency with which electrons orbit around the nucleus in discrete orbits is inversely proportional to the principal quantum number.

(IV) Binding force with which the electron is bound to the nucleus increases as it shifts to outer orbits.

Select the correct answer using the codes given below:

(a) I and III (b) II and IV (c) I, II and II (d) II, III and IV

89. In the Bohr's model of a hydrogen atom, the centripetal force is furnished by the Coulomb attraction between the proton and the electron. If ao is the radius of the ground state orbit, *m* is the mass and *e* is the charge on the electron and ∈o is the permittivity of vacuum, then the speed of the electron is:

(a) 0 (b) e/√(∈o aom) (c) e/√(4π∈o aom) (d)√ [(4π∈o aom)/e ]

90. Hydrogen atoms are excited from ground state to the state of principal quantum number 4. Then the number of spectral lines observed will be: (a) 3 (b) 6 (c) 5 (d) 2

91. The longest wavelength that a single ionised helium atom in its ground state will absorb is :

(a) 912 A0 (b) 304 A0 (c) 606 A0  (d) 1216 A0

92. At the time of total solar eclipse, the spectrum of solar radiation will have:

(a) a large number of dark Fraunhofer lines (b) a smaller number of dark Fraunhofer lines

(c) no lines at all (d) all Fraunhofer lines changed into bright coloured lines

93. The ratio (in SI units) of magnetic dipole moment to that of the angular momentum of electron of mass m kg and charge e coulomb in Bohr's orbit of hydrogen atom is:

(a) e/2m (b) e/m (c) 2e/m (d) none of these

94. Consider an electron in the nth orbit of a hydrogen atom in the Bohr's model. The circumference of the orbit can be expressed in terms of the de Broglie wavelength λ, of that electron as:

(a) 0.529 nλ (b) √(nλ) (c) 13.6λ (d) nλ

95. If the electron in H-atom radiates a photon of wavelength 4860 A0. the KE of the electron:

(a) decreases by 2.0 x l0-l9 J (b) increases by 1x 10-24 J

(c) decreases by 4.1 x 10-l9 J (d) increases by 8.2 x l0-19 J

96. The angular momentum of an electron in a hydrogen atom is proportional to

(a) 1/√r (b) 1/r (c) √r (d) r2

97. The ionisation energy of Li++ ion in ground state is equal to:

(a)13.6 x 9 eV (b) 13.6 J (c) 13.6 erg (d) 13.6 x 10-19 J

98. The radius of hydrogen atom in its ground state is 53 x l0-ll m. After collision with an electron it is found to have a radius of 21.2 x l0-ll m. What is the principal quantum number *n* of the final state of the atom?

(a)n=4 (b)n=2 (c)n=16 (d)n=3

99. The required energy to detach one electron from Balmer series of hydrogen spectrum is:

(a) 13.6 eV (b) 10.2 eV (c) 3.4 eV (d) -1.5 eV

100. Which of the following types of radiation is not emitted by electronic structure of atoms?

(a) ultraviolet light (b) X-rays (c) γ-rays (d) Visible light

101. The angular speed of the electron in the nth orbit of Bohr's hydrogen atom is:

(a) directly proportional to n (b) inversely proportional to √n

(c) inversely proportional to n2 (d) inversely proportional to n3

102. An electron in hydrogen and one in a singly ionised helium atom are excited to the state n=2. A photon is emitted when these electrons jump back to the ground state in each case. Then:

(a) energy of photon is same in both

(b) radiations emitted by the helium atom are shifted towards the red as compared to radiations from the hydrogen atom

(c) radiations emitted by helium are shifted towards the violet as compared to radiations from the hydrogen atom

(d) there is no definite relation between the radiations emitted by the two atoms

103. The first excitation potential of a given atom is 10.2 volt. Then, ionization potential must be:

(a) 20.4 volt (b) 13.6 volt (c) 30.6 volt (d) 40.8 volt

104. In a hypothetical Bohr's hydrogen atom, the mass of the electron is doubled. The energy Eo and radius ro of the first orbit will be:. (ao is the Bohr radius) (a) Eo= -27.2 eV; ro = ao (b) Eo= -13.6 eV; ro = ao/2

(c) Eo= -27.2 eV; ro = ao/2 (d) -13.6 eV; ro = ao

105. The ratio of the frequencies of the long wavelength limits of the Lyman and Balmer series of hydrogen is:

(a)27:5 (b)5:27 (c)4:1 (d)1:4

106. In the hydrogen atom Hα -line arises due to transition of electron from 3rd orbit to 2nd orbit. In the spectrum of singly ionised helium there is a line having almost the same wavelength as that of Hα line; this is due to transition of electron between the orbits: (a)3 to 2 (b)1 to 2 (c)5 to 3 (d)6 to 4

107. The frequency of the first line of Balmer series in hydrogen atom is *v*o Hz. The frequency *v* of the line emitted by a singly ionised He-atom is: (a) 2 *v*o Hz (b) 4 *v*o Hz (c) (*v*o /2) Hz (d) (*v*o /4)Hz

108.If an electron in a hydrogen atom has moved from n = l to n = l0 orbit, the potential energy of the system has: (a) increased (b) decreased (c) remains unchanged (d) become zero

109. The energy of a hydrogen-like atom (or ion) in its ground state is -122.4 eV. It may be

(a) hydrogen atom (b) He+ (c) Li2+ (d) Be3+

110. The radius of the smallest electron orbit in hydrogen-like ion is (0.51 x 10-10 / 4) metre; then it is:

(a) hydrogen atom (b) He+ (c) Li2+ (d) Be3+

111. The transition from the state n = 4 to n =3 in a hydrogen-like atom results in ultraviolet radiation. Infrared radiation will be obtained in the transition: (IIT 2001; AIEEE 2009)

(a)2 to 1 (b)3 to 2 (c)4 to 2 (d)5 to 4

112. In hydrogen spectrum, the shortest wavelength in Balmer series is λ. The shortest wavelength in Brackett series will be: (a) 2λ (b) 4λ (c) 9λ (d) 16λ

113. The energy of an electron is decided by which of the following quantum numbers?

(a) n (b) n and *l* (c) n,*l* and m (d) s, *l*, m and n

114. In the Bohr's model of hydrogen atom, the ratio of the kinetic energy to the total energy of the electron in nth quantum state is : (a)-1 (b)+1 (c) - 2 (d) +2

115. The velocity of an electron in the innermost orbit of an atom is:

(a) zero (b) mean (c) lowest (d) highest

116. In the Bohr's model of the hydrogen atom, the lowest orbit corresponds to:

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

117. In the Bohr's model of the hydrogen atom, let R, *v* and E represent radius of the orbit, speed of electron and total energy of the electron respectively. Which of the following quantities is proportional to the quantum number n? (a) R/E (b) E/*v* (c) RE (d) *v*R

118. Magnetic moment due to the motion of the electron in the nth energy state of hydrogen atom is proportional to (a) n (b) n0 (c)n5 (d) n3

119. The ratio between total acceleration of the electron in singly ionized helium atom and hydrogen atom (both in ground state) is : (a)1 (b) 8 (c) 4 (d) 16

120. The shortest wavelength of the Brackett series of a hydrogen-like atom (atomic number = Z) is the same as the shortest wavelength of the Balmer series of hydrogen atom. The value of Z is:

(a) 2 (b) 3 (c) 4 (d) 6

121. The ratio of the maximum wavelength of the Lyman series in hydrogen spectrum to the maximum wavelength in the Paschen series is: (a) 3/105 (b) 6/15 (c) 52/7 (d) 7/108

122.In which of the following systems will the radius of first orbit be minimum

(a) Hydrogen atom (b) Deuterium atom (c) Singly ionized helium (d) Doubly ionized lithium

123. If the binding energy of the electron in a hydrogen atom is 13.6 eV, the energy required to remove the electron from the first excited state of Li++ is: (a) 122.4 eV (b) 30.6 eV (c) 13.6 eV (d) 3.4 eV

124. The wavelengths involved in the spectrum of deuterium (1D2) are slightly different from that of hydrogen spectrum, because : (AIEEE 2003)

(a) size of the two nuclei are different (b) masses of the two nuclei are different

(c) nuclear forces are different in the two cases

(d) attraction between the electrons and the nucleus is different in two cases

125. The ratio of minimum to maximum wavelength of radiation that an electron in the ground state can cause in a Bohr's hydrogen atom is: (a) ½ (b) zero (c) ¾ (d) 27/32

**X-Rays**

126. On increasing the number of electrons striking the anode of an X-ray tube, which one of the following parameters of the resulting X-rays would increase?

(a) Penetration power (b) Frequency (c) Wavelength (d) Intensity

127. Which of the following statements is true for both X-rays and α-particles?

(a) They cause ionisation of air when they pass through it

(b) They can be deflected in electric and magnetic fields

(c) They can be used to detect flaws in metal castings (d) They travel with speed of light

128. X-rays and gamma rays are both electromagnetic waves. Which of the following statements is true?

(a) In general, X-rays have larger wavelength than that of gamma rays

(b) X-rays have smaller wavelength than that of gamma rays

(c) Gamma rays have smaller frequency than that of X-rays

(d) Wavelength and frequency of X-rays are both larger than those of gamma rays

129.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

130. To produce characteristic X-rays using a tungsten target in an X-ray generator, the accelerating voltage should be greater than . . . . volt. The binding energy of the innermost electron in tungsten is 40 keV:

(a) 20 kV (b) 30 kV (c) 40 kV (d) 6 kV

131.In an X-ray tube, electrons accelerated through a potential difference of 15,000 volt strike a copper target. The speed of the emitted X-rays inside the tube is:

(a) 2.8 x 108 m/s (b) 1.5 x 108 m/s (c) 2 x 108 m/s (d)3 x 108 m/s

132. The wavelength of the characteristic X-ray Kα line emitted by a hydrogen-like element is 0.32 A0. The wavelength of Kβ line emitted by the same element will be( in A0): (a) 0.24 (b) 0.27 (c) 0.32 (d) 0.48

133. An X-ray tube operated at 30 kV emits a continuous X-ray of short wavelength limit λ =0.414 A0. The value of Planck's constant is:

(a) 6.62 x 10-34 J-s (b) 6.7 x 10-34 J-s (c) 6.6 x 10-34 J-s (d) 6.67 x 10-31 J-s

134. The wavelength of Kα X-rays produced by an X-ray tube is 1.785A0.Find the atomic number of the anode material of the tube (R =109737 cm-1): (a) 24 (b) 32 (c) 48 (d) 27

135. Hydrogen atom does not emit X-rays because:

(a) it has single electron (b) it is very small in size

(c) its energy levels are too far apart (d) its energy levels are too close to each other

136. X-rays are not used for radar purpose because:

(a) they are not reflected by the target (b) they are not electromagnetic waves

(c) they are completely absorbed by air (d) they sometimes damage the target

137. When a beam of accelerated electrons hits a target, a continuous X-ray spectrum is emitted from the target. Which one of the following wavelengths is absent in the X-ray spectrum if the X-ray tube is operating at 40,000 volt? (a) 1.5 A0 (b) 0.5 A0 (c) 0.25 A0 (d) 1.0 A0

138. The binding energy of the innermost electron in tungsten is 40 keV. To produce the characteristic X-rays, using a tungsten target in an X-ray tube, the potential difference V between the cathode and the anticathode should be (a) V<40kV (b)V ≤ 40kv (c) V > 40kV (d) V can have any value

139. The wavelength λ of the Kα X-ray line with an anticathode element of atomic number Z is nearly proportional to: (a) Z2 (b) (Z-1)2 (c) 1/(Z-1) (d) 1/(Z-1)2

140. The electronic configuration of zinc in its ground state is 1s2 ,2s2 2p6 , 3s2 3p6 3d10,4s2. Then, the electronic configuration of zinc immediately after the emission of Kα line is:

(a) 1s2 ,2s2 2p6 , 3s2 3p6 3d10,4s2. (b) 1s2 ,2s1 2p6 , 3s2 3p6 3d10,4s2.

(c) 1s2 ,2s2 2p5 , 3s2 3p6 3d10,4s2. (d) 1s2 ,2s2 2p6 , 3s2 3p6 3d10,4s1.

141. If the potential difference across an X-ray tube is 10,000 volt, then the energy of the electrons striking the anticathode is: (a) 1.6 x 10-14 J (b) 1.6 x 10-15 J (c) 1.6 x 10-16 J (d) 1.6 x 10-17 J

142. If the potential difference across an X-ray tube is 10,000 volt, then the maximum frequency of the continuous X-ray radiation is nearly :

(a) 2.42 x 1016 Hz (b) 2.42 x 1018 Hz (c) 2.42 x 1020 Hz (d) 2.42 x 1022 Hz

143. If the potential difference across an X-ray tube is 10,000 volt, then the minimum wavelength of the continuous X-ray radiation is nearly:

(a) 1.23 x 10-8 m (b) 1.23 x 10-10 m (c) 1.23 x 10-12 m (d) 1.23 x 10-14 m

144. The wavelength of the Kα line for an element of atomic number 43 is λ. Then, the wavelength of the Kα line for an element of atomic number 29, is(a) 43λ/29 (b) 42λ/28 (c) 9λ/4 (d) 4λ/9

**Radioactivity**

145. After 2 hours (1/16)th of the initial amount of a certain radioactive isotope remains undecayed. The half-life of the isotope is: (a) 60 minute (b) 45 minute (c) 30 minute (d) 15 minute

146. A certain radioactive substance has a half-life of 5 years. Thus, for a nucleus in a sample of the element , The probability of decay in ten years is: (a) 50% (b) 75% (c) 100% (d) 60%

147. A count rate meter shows a count of 240 per minute from a given radioactive source. One hour later, the meter shows a count rate of 30 per minute. The half-life of the source is:

(a) 20 min (b) 40 min (c) 80 min (d) 120 min

148. During a negative β- decay:

(a) an atomic electron is ejected

(b) an electron which is already present within the nucleus is ejected

(c) a neutron in the nucleus decays emitting an electron

(d) a part of binding energy of nuclei is converted into an electron

149. When a β particle is emitted from a nucleus, the effect on its neutron-proton ratio is

(a) increased (b) decreased (c) remains same (d) first (a) and then (b)

150. The nuclei 6Cl3 and 7N14 can be described as:

(a) isotones (b) isobars (c) isotopes of carbon (d) isotopes of nitrogen

151. The half-value period and the mean value period of a radioactive element are denoted respectively by

TH and TM. Then: (a) TH = TM (b) TH > TM (c) TH < TM (d) TH ≥ TM

152. The activity of a radioactive element decreased to one-third of the original activity Io in a period of nine years. After a further lapse of nine years its activity will be(a) Io (b) 2 Io /3 (c) Io /9 (d) Io /6

153. The half-life of radium is 1600 years. What is the mean life and disintegration constant of radium?

(a) 2309,1/2309 per year (b) 3309,1/3309 per year (c) 1309,1/1309 per year (d) none of these

154. The half-life of radium is 1600 years. The fraction of a sample of radium that would remain after 6400 years is: (a) 2/4 (b) ½ (c) 1/8 (d) 1/16

155. A radioactive substance has a half-life of four months. Three-fourth of the substance will decay in:

(a) three months (b) four months (c) eight months (d) twelve months

156. The half-life of radioactive radon is 3.8 days. The time at the end of which (1/20)th of the radon sample will remain undecayed, is: (a) 3.8 days (b) 16.5 days (c) 33 days (d) 76 days

157. The activity of a radioactive element decreases to one-third of the original activity Io in a period of nine years. After a further lapse of nine years its activity will be(a) Io (b) 2 Io /3 (c) Io /9 (d) Io /6

158. A radioactive element A with a half-value period of 2 hours decays giving a stable element Y. After a time t the ratio of X to Y atoms is 1 : 7. Then, t is: (a) 6 hour (b) 4 hour (c) between 4 and 6 hour (d) 14 hour

159. The half-value period of RaB (82Pb214 ) is 26.8 minute. The mass of one Curie of RaB is:

(a) 3.71 x 1010 gm (b) 3.7 x 10-10 gm (c) 8.61 x 1010 gm (d) 3.06 x 10-8 gm



160. The count rate for 10 gm of radioactive material was measured at different times and this has been shown in the graph(fig 42.1) with scale given. The half-life of the material and the total count in the first half-value period, respectively, are:

(a) 4 hour and 9000 (approximately)

(b) 3 hour and 14100 (approximately)

(c) 3 hour and 235 (approximately)

(d) 10 hour and 150 (approximately)

161. lf l0% of a radioactive material decays in 5 days, then the amount of the original material left after 20 days is approximately: (a) 60% (b) 65% (c) 70% (d) 75%

162. A freshly prepared radioactive source of half-life 2 hours emits radiation of intensity which is 64 times the permissible safe level. The minimum time after which it would be possible to work safely with the source is: (a) 6 hour (b) 12 hour (c) 24 hour (d) 128 hour

163. Uranium ores contain one radium-226 atom for every 28 x 106 uranium-238 atoms. Calculate the half-life of 92U238. (Given that the half-life of 88Ra226 is 1600 years and 88Ra226is a decay product of 92U238)

(a) 1.75 x 103 years (b) 1600 x 238/92 years (c) 4.5 x 109 years (d) 1600 x 92/238 years

164. The radioactivity of a given sample of whisky due to tritium (half-life 12.5 years) was found to be only 3% of that measured in a recently purchased bottle marked "7 years old". The sample must have been prepared about: (a) 220 years back (b) 300 years back (c) 400 years back (d) 70 years back

165. If the end A of a wire is irradiated with α-rays and the other end B is irradiated with β-rays, then:

(a) a current will flow from A to B (b) a current will flow from B to A

(c) there will be no current in the wire (d) a current will flow from each end to the mid-point of the wire

166. There are three lumps of a given radioactive substance their activity is in the ratio of 1: 2 :3 now. What will be the ratio of their activities at any further date? (a) l:2:3 (b) 2: I : 3 (c) 3:2: I (d) 2:3 :1

167. The radioactivity of a sample is A1 at time t1 and A2 at time t2.lf the mean life of the specimen is T, the number of atoms that have disintegrated in the time interval of (t2 - t1) is:

(a) (A1 –A2) (b) (A1 –A2)/T (c) (A1 –A2)T (d) (A1 t1 –A2 t2)

168. The half-life period of a radioactive element is l0 days. Then, how long does it take for 90% of a given mass of this element to disintegrate? (a) 19 days (b) 27 days (c) 33 days (d) 37 days

169.Plutonium has atomic mass 210 and a decay constant equal to 5.8 x 10-8 sec-1. The number of α-particles emitted per second by 1 mg is: (Avogadro's constant = 6.0 x 1023)

(a) 1.75 x 109 (b) 1.75 x 1011 (c) 2.9 x 1011 (d) 3.4 x 109

170. lf 20 gm of a radioactive substance due to radioactive decay reduces to l0 gm in 4 minute, then in what time will 80 gm of the same substance reduce to l0 gm

(a) In 8 minute (b) In 12 minute (c) In 16 minute (d) In 20 minute

171. A radioactive sample with a half-life of 1 month has the label "Activity = 2 microcurie on 1-8-1991". What was its activity two months earlier

(a) 1.0 microcurie (b) 0.5 microcurie (c) 4 microcurie (d) 8 microcurie

172. The activity of a radioactive sample diminishes from l024 to 128 in 2 minutes. In 6 minutes, the activity diminishes to: (a) 16 (b) 8 (c) 4 (d) 2

**Nucleus and Nuclear Energy**

173. The density d of nuclear matter varies with nucleon number A as:

(a) d α A3 (b) d α A2 (c) d α A (d) d α A0

174. An element A decays into an element C by a two step process A---B +2He4 ; B ----- C + 2e- ,Then:

(a) A and C are isobars (b) A and C are isotopes (c) A and B are isotopes (d) A and B are isobars

175. If the matter in proton is completely converted into energy, it will be about (1 amu = 931Mev):

(a) 9310 Mev (b) 100.78 Mev (c) 931 Mev (d) 10078 Mev

176. The nuclear radius of a nucleus with nucleon number 16 is 3 x l0-l5 metre. Then, the nuclear radius of a nucleus with nucleon number 128 is:

(a) 3 x l0-l5 metre (b) 1.5 x l0-l5 metre (c) 6 x l0-l5 metre (d) 4.5 x l0-l5 metre

177. The nuclear radius of 8016 is 3 x l0-l5 metre. If an atomic mass unit is 1.67x10-27 kg, then the nuclear density is approximately:

(a) 2.35x 1017 gm/cm3 (b) 2.35 x 1020 kg/m3 (c) 2.35x 1017 gm/m3 (d) 2.35 x 1017 kg/cm3

178. It Avogadro's number is 6 x1023, then the numbers of protons, neutrons and electrons in 14 g of 6C14 are respectively: (a) 36 x 1023, 48 x l023 ,36 x1023 (b) 36 x 1023, 36 x l023 ,36 x 1023

(c) 48 x 1023, 36 x l023 ,48 x1023  (d) 48 x 1023, 48 x l023 ,36 x 1023

179. In the nuclear decay given below ZXA --- ZXA --- Z+1YA --- Z-1B\*A-4 --- Z-1BA-4

The particles emitted in the sequence are: (a) γ, β, α (b) β, γ, α (c) α, β, γ (d) β, α ,γ

180. How much energy is released when 1 amu of mass is annihilated

(a) 931.5 MeV (b) 1.49 x 10-3 J (c) 4.138 x 10-17 kwH (d) All of these

181. The energy released when 1 g of matter is annihilated is:

(a) 9x1013 J (b) 2.5 x 107 kwh (c) both (a) and (b) (d) none of these

182. Find the binding energy of an α-particle from the following data: Mass of He nucleus = 4.001265 amu

Mass of proton =1.007277 amu ,Mass of neutron = 1.00866 amu, (Take one amu = 931.5 MeV)

(a) 1850 MeV (b) 296 MeV (c) 28.512 MeV (d) none of these

183. The binding energy per nucleon for C12 is 7.68 MeV and that for C13 is 7.47 MeV. What is the energy required to remove a neutron from C13? (a) 0.21 MeV (b) 2.52 MeV (c) 4.95 MeV (d) 2.75 MeV

184. The binding energy of 17Cl35 nucleus is 298 MeV. Find its atomic mass (nearly).

Mass of proton -1.007277 amu , Mass of neutron = 1.00866 amu (Take one amu = 931.5 MeV)

(a) 35.2796 amu (b) 34.9597 amu (c) 34.2796 amu (d) 262.72 amu

185. What would be the energy required to dissociate completely 1 gram of Ca-40 into its constituent particles? Mass of proton =1.007277 amu , Mass of neutron = 1.00866 amu Mass of Ca-40 =39.97545 amu (Take one amu = 931 MeV)

(a) 4.813 x l024 Mev (b) 4813 x l024 ev (c) 4.813 x 1023 MeV (d) None of these

186. The minimum γ-rays energy required to produce an electron-positron pair is:

(a) 1.02 MeV (b) 931.5 MeV (c) 1.04 MeV (d) none of these

187. Nuclear forces are: (a) short range and charge dependent (b) short range and charge independent

(c) long range and charge dependent (d) long range and charge independent

188. A star has 1040 deuterons. It produces energy via the process:

1H2 + 1H2 ---- 1H3 + p and 1H2 + 1H3 ---- 2He4 + on1 ;

(The masses of the nuclei are as follows: M(H2) = 2.014 amu, M(p) = 1.007 amu, M(n) = 1.008 amu and M(He4) =4.001 amu) .If the average power radiated by the star is l016 W, the deuteron supply of the star is exhausted in a time of the order of:

(a) 106 second (b) 108 second (c) l012 second (d) l016 second

189. In fusion the percentage of mass converted into energy is about (a) l0% (b) l% (c) 0.l% (d) 0.01%

190. If per nucleon binding energies for 3Li7 and 2He4 are 5.60 MeV and 7.06 MeV, then the energy released in the nuclear process: 3Li7 + 1p1 ----2 2He4 is : (a) 19.6 MeV (b) 2.4 MeV (c) 8.4 MeV (d)17.3 MeV

191. The binding energies of the atoms of elements A and B are EA and EB respectively. Three atoms of the element B fuse to give one atom of element A. This fusion process is accompanied by release of energy e. Then EA, EB and e are related to each other as:

(a) EA + e = 3EB (b) EA = 3EB  (c) EA - e = 3EB (d) EA + 3EB + e = 0

192. The masses of neutrons and protons are 1.0087 and 1.0073 amu respectively. If the neutrons and protons combine to form helium nucleus of mass 4.0015 amu, the binding energy of the helium nucleus will be: (a) 28.4 MeV (b) 20.8 MeV (c) 27.3 MeV (d) 14.2 MeV

193. In the nuclear reaction, 1H2 + 1H2 ---- 2He3 + on1 ; If the mass of the deuterium atom = 2.014741 amu, mass of 2He3 atom =3.016977 amu and mass of neutron = 1.008987 amu, then the Q value of the reaction is nearly: (a) 0.00352 MeV (b) 3.27 MeV (c) 0.82 MeV (d) 2.45 MeV

194. In the nuclear reaction, 1H2 + 1H2 ---- 2He3 + on1 ; If the mass of the deuterium atom = 2.014741 amu, mass of 2He3 atom =3.016977 amu and mass of neutron = 1.008987 amu, and If the binding energy of deuteron is 2.23 MeV and the Q-value of the reaction is 3.27 MeV, then the binding energy of 2He3 is:

(a) 1.19 MeV (b) 7.73 MeV (c) 4.46 MeV (d) 3.27 MeV

195. Assuming that about 20 MeV of energy is released per fusion reaction 1H2 + 1H3 ---- 2He4 + on1

then the mass of 1H2 consumed per day in a fusion reactor of power I megawatt will approximately be:

(a) 0.001 g (b) 0.1 g (c) 10.0 g (d) 1000 g

196. Assuming that about 200 MeV of energy is released per fission of 92U235 nuclei, then the mass of U235 consumed per day in a fission reactor of power 1 megawatt will be approximately:

(a) 10-2 g (b) 1 g (c) 100 g (d) 10,000 g

197. If mass of U235 = 235.12142 amu, mass of U236 = 236.12305 amu and mass of neutron = 1.008665 amu, then the energy required to remove one neutron from the nucleus of U236 is nearly about:

(a) 75 MeV (b) 6.5 MeV (c) 1 eV (d) zero

198. In the thermonuclear reaction 3 1H2  ---- 2He4 + 1H1  + on1 +21.6MeV , the energy released per nucleon of the reactants is: (a) 21.6 MeV (b) 7.2 MeV (c) 3.6 MeV (d) 1.8 MeV

199. The energy of neutrons in thermal equilibrium at room temperature is approximately:

(a) 5 eV (b) 1 eV (c) 0.1 eV (d) 0.04 eV

200. When 3Li7 nuclei are bombarded by protons and the resultant nuclei are 4Be8, the emitted particles will be: (a) neutrons (b) alpha particles (C) beta particles (d) gamma photons (AIEEE 2006)

201. What is the energy released in process 32He4 --- 6C12 ( mass of 2He4 = 4.002604 amu)

(a) 7.27 MeV (b) 9.38 MeV (c) 6.09 MeV (d) 10.9 MeV

202. An alpha nucleus of energy m*v*2/2 bombards a heavy nuclear target of charge Ze. Then, the distance of closest approach for the alpha nucleus will be proportional to:

(a) 1/Ze (b) *v*2 (c) 1/m (d) 1/*v*4 (AIEEE 2006)

203. Complete the following nuclear reaction : 4Be9 +2He4 ------ 6C12 +......

(a) n (Neutron) (b) *v* (Neutrino) (c) p (Proton) (d) e (Electron)

204. What is the Q-value of the reaction p + 7Li ---- 4He+ 4He ? The atomic masses of lH, 4He and 7Li are 1.007825 u, 4.002603 u and 7.016004u respectively

(a) 17.35 MeV (b) 18.06 MeV (c) 177.35 MeV (d) 170.35 MeV

205. The radius of a nucleus with atomic mass number 7 is 2 fermi. The radius of nucleus with atomic number 189 is: (a) 3 fermi (b) 4 fermi (c) 5 fermi (d) 6 fermi

206. As mass number increases, surface area:

(a) decreases (b) increases (c) remains the same (d) remains the same and increase

207. All the nucleons in an atom are held by:

(a) nuclear forces (b) vander Waals' forces (c) tensor forces (d) Coulomb forces

208.If the nucleus 13Al27 has a nuclear radius of about 3.6 fermi, then 32Te125 would have its radius approximately as: (a) 9.6 fermi (b) 12.0 fermi (c) 4.8 fermi (d) 6.0 fermi

209. Consider the nuclear reaction X200 ---A110 +B80. If the binding energy per nucleon for X, A and B arc 7.4 MeV , 8.2 MeV and 8.1 MeV respectively, then the energy released in the reaction is:

(a) 70 MeV (b) 200 MeV (c) 190 MeV (d) 10 MeV (e) 1480 MeV

210. The volume of a nucleus is directly proportional to: (a) A (b) A3 (c) √A (d) A1/3

(Where A = mass number of the nucleus)

211. ln the options given below, let E denote the rest mass energy of a nucleus and n a neutron. The correct option is: (a) E (92U236) > E (53I137) + E (39Y97) + 2E (n) (b) E (92U236) < E (53I137) + E (39Y97) + 2E (n)

(c) E (92U236) < E (56Ba140) + E (36Kr94) + 2E (n) (d) E (92U236) = E (56Ba140) + E (36Kr94) + 2E (n) (IIT 2007)

212. A nucleus at rest splits into two nuclear parts having same density and radii in the ratio 1:2.Their velocities are in the ratio: (a) 2: I (b)4:1 (c)6:1 (d)8:1

213. The radius of nucleus is:

(a) proportional to its mass number (b) inversely proportional to its mass number

(c) proportional to the cube root of its mass number (d) not related to its mass number

214. lf Mo is the mass of an oxygen isotope 8O17. MP and MN are the masses of a proton and a neutron respectively, the nuclear binding energy of the isotope is:

(a) (Mo -17MN)c2 (b) (Mo -8MP)c2 (c) (Mo -8MP -9MN)c2 (d) (Mo)c2

215. Fig 43.3 is a plot of binding energy per nucleon Eb, against the nuclear mass M.A, B, C, D, E, F correspond to different nuclei. Consider four reactions:

(i) A+B --- C + e (ii) C ---- A + B + e

(iii)D+E---- F + e (iv)F --- D+ E + e

Where e is the energy released. In which reactions is e positive

(a) (i) and (iv) (b) (i) and (iii) (c) (ii) and (iv) (d) (ii) and (iii)

216. Two nuclei have their mass numbers in the ratio of 1:3. The ratio of their nuclear densities would be:

(a) (3)1/3: l (b)1:1 (c)1:3 (d)3:1

217. The ratio of the nuclear radii of elements with mass numbers 216 and 125 is:

(a) 216: 125 (b) √216 : √125 (c)6:5 (d) none of these

218. Two protons are kept at a separation of 40A0. FN is the nuclear force and Fe is the electrostatic force between them. Then: (a) FN>> Fe (b) FN= Fe (c) FN<< Fe (d) FN≈ Fe

219. The energy released in the fission of 1 kg of 92U235 is:(energy per fission = 200MeV)

(a) 5.1 x 1026 eV (b) 5.1 x 1026 J (c) 8.2 x 1013 J (d) 8.2 x 1013 MeV (e) 5.1 x 1023 MeV

220. The nuclear radius of a certain nucleus is 7.2 fm and it has charge of 1.28 x 10-17 C. The number of neutrons inside the nucleus is: (a) 136 (b) 142 (c) 140 (d) 132 (e) 126

221. U234 has 92 protons and 234 total nucleons in its nucleus. It decays by emitting an alpha particle. After the decay it becomes: (a) U232 (b) Pa232 (c) Th230 (d) Ra230

222. A certain radioactive material ZXA starts emitting α and β particles successively such that the end product is Z-3YA-8. The number of α and β particles emitted are:

(a) 4 and 3 respectively (b) 2 and I respectively (c) 3 and 4 respectively (d) 3 and 8 respectively

223. For the stability of any nucleus:

(a) binding energy per nucleon will be more (b) binding energy per nucleon will be less

(c) number of electrons will be more (d) none of the above

224. The mass of a 3Li7 nucleus is 0.042u less than the sum of the masses of all its nucleons. The binding energy per nucleon of 3Li7 nucleus is nearly: (a) 46 MeV (b) 5.6 MeV (c) 3.9 MeV (d) 23 MeV

225. The energy released by the fission of one uranium atom is 200 MeV. The number of fissions per second required to produce 3.2 W of power is: (a) 107 (b) 1010 (c) 1015 (d) 1011

226. The nuclear force:(a) is purely an electrostatic force (b) obeys inverse square law of distance

(c) is equal in strength to gravitational field (d) is short-range force

227. Enriched uranium is used in nuclear reactors because, it contains greater proportion of:

(a) U238 (b) U235 (c) U239  (d) U233

228. The nucleus which has radius one third of the radius of Osl89 is:(a) Be9 (b) Li7 (c) F19  (d)C12 (e)016

229. Pick out the incorrect statement from the following:

(a) β-emission from the nucleus is always accompanied with a neutrino

(b) The energy of the α-particle emitted from a given nucleus is always constant.

(c) γ-ray emission makes the nucleus more stable. (d) Nuclear force is charge independent.

(e) Fusion is the main process by which energy is released from a star.

230. In a nuclear reaction 92U235 decay to 91Pa231, what are the particles emitted

(a) One α-particle and one proton (b) One α-particle and one electron

(c) One deuteron and one positron (d) One electron and one proton

**Answers Objective (Combined – Dual/Atom/Nuclei)**

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| 1. A | 1. D | 1. C | 1. C | 1. A | 1. A |
| 1. A | 1. C | 1. A | 1. B | 1. B | 1. B |
| 1. C | 1. A | 1. B | 1. D | 1. B | 1. B |
| 1. C | 1. B | 1. C | 1. A | 1. C | 1. B |
| 1. D | 1. B | 1. D | 1. C | 1. D | 1. A |
| 1. C | 1. B | 1. B | 1. B | 1. D | 1. C |
| 1. B | 1. A | 1. C | 1. C | 1. D | 1. C |
| 1. B | 1. A | 1. A | 1. A | 1. C | 1. B |
| 1. C | 1. B | 1. B | 1. B | 1. B | 1. B |
| 1. D | 1. A | 1. A | 1. A | 1. B | 1. A |
| 1. A | 1. A | 1. C | 1. B | 1. D | 1. A |
| 1. D | 1. B | 1. D | 1. A | 1. A | 1. B |
| 1. D | 1. D | 1. B | 1. D | 1. C | 1. B |
| 1. B | 1. B | 1. A | 1. A | 1. C | 1. C |
| 1. B | 1. D | 1. B | 1. A | 1. C | 1. B |
| 1. B | 1. D | 1. A | 1. D | 1. C | 1. C |
| 1. A | 1. B | 1. C | 1. C | 1. D | 1. C |
| 1. B | 1. C | 1. B | 1. D | 1. B | 1. A |
| 1. C | 1. D | 1. D | 1. B | 1. B | 1. A |
| 1. D | 1. C | 1. D | 1. A | 1. B | 1. A |
| 1. D | 1. D | 1. B | 1. B | 1. C | 1. D |
| 1. A | 1. A | 1. C | 1. C | 1. D | 1. B |
| 1. A | 1. D | 1. D | 1. A | 1. C | 1. C |
| 1. D | 1. C | 1. B | 1. B | 1. B | 1. C |
| 1. C | 1. B | 1. A | 1. C | 1. B | 1. A |
| 1. C | 1. C | 1. A | 1. D | 1. C | 1. B |
| 1. C | 1. A | 1. D | 1. B | 1. B | 1. B |
| 1. C | 1. D | 1. A | 1. A | 1. C | 1. C |
| 1. B | 1. B | 1. D | 1. D | 1. D | 1. B |
| 1. C | 1. C | 1. B | 1. A | 1. D | 1. C |
| 1. B | 1. C | 1. C | 1. B | 1. A | 1. A |
| 1. B | 1. C | 1. C | 1. D | 1. A | 1. A |
| 1. B | 1. B | 1. B | 1. B | 1. B | 1. C |
| 1. D | 1. D | 1. A | 1. C | 1. A | 1. A |
| 1. D | 1. B | 1. A | 1. D | 1. A | 1. A |
| 1. A | 1. D | 1. C | 1. C | 1. A | 1. B |
| 1. C | 1. C | 1. C | 1. A | 1. D | 1. B |
| 1. A | 1. B | 1. D | 1. D | 1. B | 1. B |
| 1. A | 1. B |  |  |  |  |

**Explanations – Dual/ Atom/Nuclei**

