



## PHYSICS

### BOOKS - DC PANDEY ENGLISH

#### MODERN PHYSICS

#### Example

1. The intensity of direct sunlight before it passes through the earth's atmosphere is  $1.4 \text{ kW/m}^2$ . If it is completely absorbed, find the corresponding radiation pressure.

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2. An electron is accelerated by a potential difference of 25 V. Find the de Broglie wavelength associated with it.



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3. A partical of mass  $M$  at rest decays into two Particles of masses  $m_1$  and  $m_2$  having non-zero velocities. The ratio of the de - Broglie wavelengths of the particles  $\lambda_1$  |  $\lambda_2$  is

(a)  $m_1 / m_2$  (b)  $m_2 / m_1$  (c ) 1 (d)  $\sqrt{m_2} / \sqrt{m_1}$



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4. The energy of a photon is equal to the kinetic energy of a proton. The energy of the photon is  $E$ . Let  $\lambda_1$  be the de-Broglie wavelength of the proton and  $\lambda_2$  be the wavelength of the photon. The ratio  $\frac{\lambda_1}{\lambda_2}$  is proportional to

(a)  $E^0$  (b)  $E^{1/2}$  (c )  $E^{-1}$  (d)  $E^{-2}$



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5. An  $\alpha$ -particle and a proton are accelerated from rest by a potential difference of 100V. After this, their de-Broglie wavelengths are  $\lambda_a$  and  $\lambda_p$  respectively. The ratio  $\frac{\lambda_p}{\lambda_a}$ , to the nearest integer, is.



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6. The potential energy of a particle varies as

$$U(x) = E_0 f \text{ or } 0 \leq x \leq 1 = 0 \text{ or } x > 1 \quad f \text{ or } 0 \leq x \leq 1, \text{ de-}$$

Broglie wavelength is  $\lambda_1$  and for  $x > 1$  the de-Broglie wavelength is  $\lambda_2$ .

Total energy of the particle is  $2E_0$ . find  $\frac{\lambda_1}{\lambda_2}$ .



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7. Using the known values for hydrogen atom, calculate

(a) radius of third orbit for  $\text{Li}^{+2}$

(b) speed of electron in fourth orbit for  $\text{He}^+$

(c) angular momentum of electron in 3rd orbit of  $\text{He}^+$ .



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8. A doubly ionized lithium atom is hydrogen like with atomic number 3. Find the wavelength of the radiation to excite the electron in  $Li^{++}$  from the first to the third Bohr orbit. The ionization energy of the hydrogen atom is 13.6V.



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9. Find variation of angular speed and time period of single electron of hydrogen like atoms with  $n$  and  $Z$ .



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10. find kinetic energy, electrostatic potential energy and total energy of single electron in 2nd excited state of  $Li^{+2}$  atom.



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**11.** Find the kinetic energy, potential energy and total energy in first and second orbit of hydrogen atom if potential energy in first orbit is taken to be zero.



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**12.** A small particle of mass  $m$  moves in such a way that the potential energy  $U = ar^2$ , where  $a$  is constant and  $r$  is the distance of the particle from the origin. Assuming Bhor model of quantization of angular momentum and circular orbits, find the radius of  $n$ th allowed orbit.



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**13.** Calculate (a) the wavelength and (b) the frequency of the  $H\beta$  line of the Balmer series for hydrogen.



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**14.** Find the largest and shortest wavelengths in the Lyman series for hydrogen. In what region of the electromagnetic spectrum does each series lie?



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**15.** In a hypothetical atom, mass of electron is doubled, value of atomic number is  $Z = 4$ . Find wavelength of photon when this electron jumps from 3rd excited state to 2nd orbit.



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**16.** Find the cut off wavelength for the continuous X - rays coming from an X-ray tube operating at 40 kv.

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17. Use Moseley's law with  $b = 1$  to find the frequency of the  $K_{\alpha}$  X-ray of  $La(Z = 57)$  if the frequency of the  $K_{\alpha}$  X-ray of  $Cu(Z = 29)$  is known to be  $1.88 \times 10^{18}$  Hz.

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18. Electrons with de - Brogli wavelength  $\lambda$  fall on the target in an X-ray tube. The cut off wavelength of the emitted X-rays is

$$(a) \lambda_0 = \frac{2mc\lambda^2}{h} \quad (b) \lambda_0 = \frac{2h}{mc}$$

$$(c) \lambda_0 = \frac{2m^2c^2\lambda^3}{h^2} \quad (d) \lambda_0 = \lambda$$

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19. Electrons with energy  $80\text{keV}$  are incident on the tungsten target of an X - rays tube , k - shell electrons of tungsten have  $72.5\text{keV}$  energy X-

rays emitted by the tube contain only



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**20.** A metal plate is placed 5m from a monochromatic light source whose power output is  $10^{-3}\text{W}$ . Consider that a given ejected photoelectron may collect its energy from a circular area of the plate as large as ten atomic diameters ( $10^{-9}\text{m}$  in radius). The energy required to remove an electron through the metal surface is about 5.0 eV. Assuming light to be a wave, how long would it take for such a 'target' to soak up this much energy from such a light source.



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**21.** The photoelectric work - function of potassium is 2.3 eV. If light having a wavelength of  $2800\text{\AA}$  falls on potassium, find

- (a) the kinetic energy in electron volts of the most energetic electrons ejected.
- (b) the stopping potential in volts.



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**22.** When a beam of 10.6 eV photons of intensity  $2.0 \text{ W/m}^2$  falls on a platinum surface of area  $1.0 \times 10^{-4} \text{ m}^2$  and work function 5.6 eV, 0.53% of the incident photons eject photoelectrons. Find the number of photoelectrons emitted per second and their minimum and maximum energy (in eV). Take  $1 \text{ eV} = 1.6 \times 10^{-19} \text{ J}$ .



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**23.** Maximum kinetic energy of photoelectrons from a metal surface is  $K_0$  when wavelength of incident light is  $\lambda$ . If wavelength is decreased

to  $\lambda \mid 2$ , the maximum kinetic energy of photoelectrons becomes

$$(a) = 2K_0 \quad (b) > 2K_0 \quad (c) < 2K_0$$



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**24.** Intensity and frequency of incident light both are doubled.

Then, what is the effect on stopping potential and saturation current.



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**25.** When a monochromatic point source of light is at a distance

of 0.2 m from a photoelectric cell, the cut off voltage and the saturation current

are respectively 0.6 V and 18.0 mA. If the same source is placed 0.6 m away from the photoelectric cell, then

(a) the stopping potential will be 0.2 V

(b) the stopping potential will be 0.6 V

(c) the saturation current will be 6.0 mA

(d) the saturation current will be 2.0 mA

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26. The threshold wavelength for photoelectric emission for a material is  $5200\text{\AA}$ . Will the photoelectrons be emitted when this material is illuminated with monochromatic radiation from 1 watt ultra violet lamp?

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27. Mass number of a nucleus X is A and atomic number is Z. Find mass number and atomic number of the new nucleus (say Y) after the emission of m-alpha particles and n-beta particles.

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28. At time  $t = 0$ , number of nuclei of a radioactive substance are 100. At  $t = 1\text{ s}$  these numbers become 90. Find the number of nuclei at  $t = 2\text{ s}$ .

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**29.** At time  $t = 0$ , activity of a radioactive substance is 1600 Bq, at  $t=8$  s activity remains 100 Bq. Find the activity at  $t=2$  s.



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**30.** From a radioactive substance  $n_1$  nuclei decay per second at an instant when total number of nuclei are  $n_2$ . Find half-life of the radioactive substance.



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**31.** Half-life of a radioactive substance is  $T$ . At time  $t_1$  activity of a radioactive substance is  $R_1$  and at time  $t_2$  it is  $R_2$ . Find the number of nuclei decayed in this interval of time.



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**32.** Two radioactive  $X_1$  and  $X_2$  have decay constants  $10\lambda$  and  $\lambda$  respectively. If initially they have the same number of nuclei, then the ratio of the number of nuclei of  $X_1$  to that of  $X_2$  will be  $1/e$  after a time.



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**33.** The half-life period of a radioactive element  $x$  is same as the mean life time of another radioactive element  $y$ . Initially, both of them have the same number of atoms. Then,

(a)  $x$  and  $y$  have the same decay rate initially

(b)  $x$  and  $y$  decay at the same rate always

(c)  $y$  will decay at a faster rate than  $x$

(d)  $x$  will decay at a faster rate than  $y$



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**34.** A radioactive sample consists of two distinct species having equal number of atoms initially. The mean life of one species is  $\tau$  and that of

the other is  $5\tau$ . The decay products in both cases are stable. A plot is made of the total number of radioactive nuclei as a function of time. Which of the following figure best represents the form of this plot?

(a), (b), (c), (d)



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**35.** A radio nuclide X is produced at constant rate  $\alpha$ . At time  $t = 0$ , number of nuclei of X are zero. Find

(a) the maximum number of nuclei of X.

the number of nuclei at time t.

Decay constant of X is  $\lambda$ .



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**36.** In the above problem if each decay produces  $E_0$  energy, then find

(a) power produced at time t

(b) total energy produced upto time t

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37. Find the increase in mass of water when  $1.0\text{ kg}$  of water absorbs  $4.2 \times 10^3 \text{ J}$  of energy to produce a temperature rise of  $1\text{ K}$ .

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38. In the fusion reaction  ${}_1^2\text{H} + {}_1^2\text{H} \rightarrow {}_2^3\text{He} + {}_0^1\text{n}$ , the masses of deuteron, helium and neutron expressed in amu are 2.015, 3.017 and 1.009 respectively. If 1 kg of deuterium undergoes complete fusion, find the amount of total energy released.  $1 \text{ amu} = 931.5 \text{ MeV}/c^2$ .

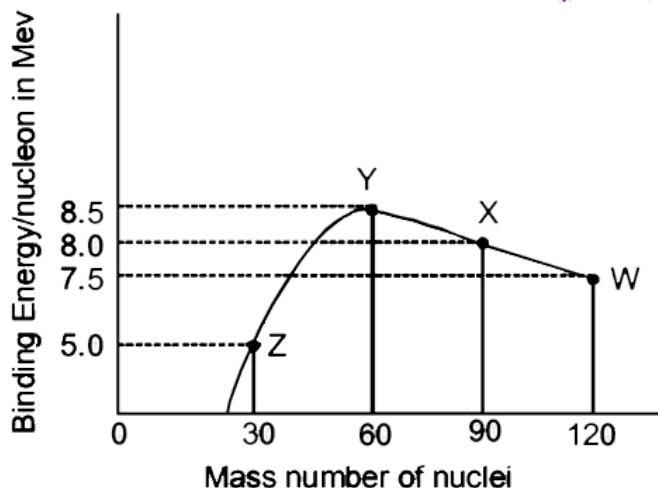
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39. A nucleus with mass number 220 initially at rest emits an  $\alpha$ -particle. If the Q-value of the reaction is 5.5 MeV, calculate the kinetic energy of the  $\alpha$ -particle.

(a) 4.4 MeV (b) 5.4 MeV (c) 5.6 MeV (d) 6.5 MeV

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40. Binding energy per nucleons vs mass curve for nucleus is shown in the figure  $W$ ,  $X$ ,  $Y$  and  $Z$  are four nuclei indicated on the curve. The process that would release energy is

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41. A star initially has  $10^{40}$  deuterons. It produces energy via the processes  ${}_1^1\text{H} + {}_1^2\text{H} \rightarrow {}_1^3\text{H} + p$  and  ${}_1^2\text{H} + {}_1^3\text{H} \rightarrow {}_2^4\text{He} + n$ . If the average power radiated by the star is  $10^{16}$  W, the deuteron supply

of the star is exhausted in a time of the order of

(a)  $10^6 s$  (b)  $10^8 s$  (c)  $10^{12} s$

The masses of the nuclei are as follows

$$M(H^2) = 2.014 \text{ amu}, M(n) = 1.008 \text{ amu},$$

$$M(p) = 1.007 \text{ amu}, M(He^4) = 4.001 \text{ amu}$$



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**42.** Assume that the nuclear binding energy per nucleon ( $B/A$ ) versus mass number ( $A$ ) is as shown in figure. Use this plot to choose the correct choice(s) given below.

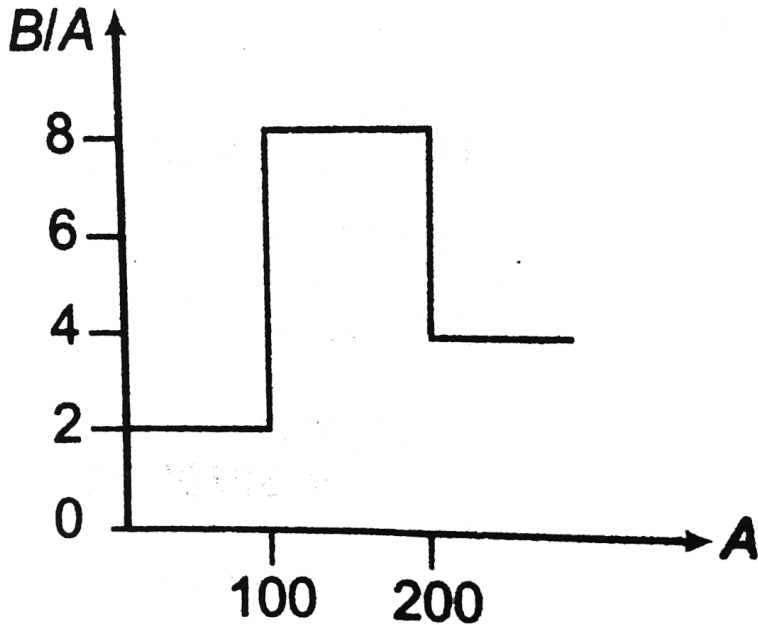
(a) Fusion of two nuclei with mass numbers, lying in the range of  $1 < A < 50$  will release energy.

Fusion of two nuclei with mass numbers lying in the range of  $51 < A < 100$  will release energy.

(c) Fission of a nucleus lying in the mass range of  $100 < A < 200$  will release energy when broken into two equal fragments.

(d) Fission of a nucleus lying in the mass range of  $200 < A < 260$  will

release energy when broken into two equal fragments.



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### Example Type 1

1. A proton is fired from very far away towards a nucleus with charge  $Q = 120 e$ , where  $e$  is the electronic charge. It makes a closest approach of  $10\text{fm}$  to the nucleus. The de - Broglie wavelength (in units of  $\text{fm}$ ) of the

proton at its start is [ take the proton mass,

$$m_p = (5/3 \times 10^{-27} \text{ kg}, h \leq 4.2 \times 10^{-15} \text{ J} - \text{s} / C,$$

$$\frac{1}{4\pi\epsilon_0} = 9 \times 10^9 \text{ m} / F, 1 \text{ fm} = 10^{-15} \Big]$$



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2. Find de-Broglie wavelength of single electron in 2 nd orbit of hydrogen atom by two methods.



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3. At a given instant there are 25% undecayed radioactive nuclei in a sample. After 10 s the number of undecayed nuclei reduces to 12.5%.

Calculate

(a) mean life of the nuclei,

(b) the time in which the number of undecayed nuclei will further reduce to 6.25% of the reduced number.



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4. A radioactive element decays by  $\beta - \text{emission}$ . A detector records  $n$  beta particles in 2 s and in next 2 s it records 0.75  $n$  beta particles. Find mean life correct to nearest whole number. Given  $\ln |2| = 0.6931$ ,  $\ln |3| = 1.0986$ .



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5. A small quantity of solution containing  $\text{Na}^{24}$  radio nuclide of activity 1 microcurie is injected into the blood of a person. A sample of the blood of volume  $1\text{cm}^3$  taken after 5 h shows an activity of 296 disintegration per minute. What will be the total value of the blood in the person? Assume that the radioactive solution mixes uniformly in the blood of the person. (Take, 1 curie =  $3.7 \times 10^{10}$  disintegration per second and  $e^{-\lambda t} = 0.7927$ , where  $\lambda$  = disintegration constant)



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6. A radioactive nucleus X decays to a nucleus Y with a decay constant  $\lambda_X = 0.1s^{-1}$ , Y further decays to a stable nucleus Z with a decay constant

$\lambda_Y = 1/30s^{-1}$ . Initially, there are only X nuclei and their number is  $N_0 = 10^{20}$ . Set up the rate equations for the populations of X, Y and Z.

The population of Y nucleus as a function of time is given by

$$N_Y(t) = \{N_0\lambda_X / (\lambda_X - \lambda_Y)\}[\exp(-\lambda_Y t) - \exp(-\lambda_X t)].$$

Find the time at which  $N_Y$  is maximum and determine the population X and Z at that instant.



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## Example Type 2

1. The electric potential between a proton and an electron is given by

$V = V_0 \ln\left(\frac{r}{r_0}\right)$ , where  $r_0$  is a constant. Assuming Bohr model to be applicable, write variation of  $r_n$  with  $n$ , being the principal quantum number. (a)  $r_n \propto n$  (b)  $r_n \propto \frac{1}{n}$  (c)  $r_n^2$  (d)  $r_n \propto \frac{1}{n^2}$



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2. Imagine an atom made up of a proton and a hypothetical particle of double the mass of the electron but having the same charge as the electron . Apply the Bohr atom model and consider all possible transitions of this hypothetical particle that will be emitted level . The longest wavelength photon that will be emitted has longest wavelength  $\lambda$  (given in terms of the Rydberg constant  $R$  for the hydrogen atom) equal to



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3. When a hydrogen atom emits a photon during the transition  $n=5$  to  $n=1$  , its recoil speed is approximately



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4. A hydrogen like atom (described by the Borh model) is observed to emit six wavelength, originating from all possible transitions between a group of levels. These levels have energies between  $-0.85\text{ eV}$  and  $0.544\text{ eV}$  (including both these values). (a) Find the atomic number of the atom. (b) Calculate the smallest wavelength emitted in these transitions. ( Take,  $hc = 1240\text{ eV} \cdot \text{nm}$ , ground state energy of hydrogen atom  $= -13.6\text{ eV}$ )



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5. A hydrogen like atom of atomic number  $Z$  is in an excited state of quantum number  $2n$ . It can emit a maximum energy photon of  $204\text{ eV}$ . If it makes a transition to quantum state  $n$ , a photon of energy  $40.8\text{ eV}$  is emitted. Find  $n$ ,  $Z$  and the ground state energy (in  $\text{eV}$ ) of this atom. Also calculate the minimum energy( $\text{eV}$ ) that can be emitted by this atom during de - excitation. Ground state energy of hydrogen atom is  $-13.6\text{ eV}$



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6. A hydrogen like atom (atomic number  $Z$ ) is in a higher excited state of quantum number  $n$ . The excited atom can make a transition to the first excited state by successively emitting two photons of energy 10.2 eV and 17.0 eV, respectively. Alternatively, the atom from the same excited state can make a transition to the second excited state by successively emitting two photons of energies 4.25 eV and 5.95 eV, respectively. Determine the values of  $n$  and  $Z$ . (Ionization energy of H-atom = 13.6 eV)



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7. In a nuclear reactor  $^{235}\text{U}$  undergoes fission liberating 200 MeV of energy. The reactor has a 10% efficiency and produces 1000 MW power. If the reactor is to function for 10 yr, find the total mass of uranium required.



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8. The element curium  ${}_{96}^{248}\text{Cm}$  has a mean life of  $10^{13}\text{s}$ . Its primary decay modes are spontaneous fission and  $\alpha$ -decay, the former with a probability of 8% and the later with a probability of 92%, each fission releases 200 MeV of energy. The masses involved in decay are as follows

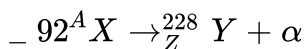
$${}_{96}^{248}\text{Cm} = 248.072220u,$$

${}_{94}^{244}\text{Pu} = 244.064100u$  and  ${}_2^4\text{He} = 4.002603u$ . Calculate the power output from a sample of  $10^{20}$  Cm atoms. ( $1u = 931\text{MeV}/c^2$ )



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9. A nucleus X, initially at rest, undergoes alpha-decay according to the equation.



(a) Find the values of A and Z in the above process.

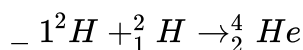
(b) The alpha particle produced in the above process is found to move in a circular track of radius  $r$  during the process and the binding energy of the parent nucleus X.

Given that  $m({}_0^1\text{n}) = 1.009\text{u}$ ,  $m({}_2^4\text{He}) = 4.003\text{u}$ ,  $m({}_1^1\text{H}) = 1.008\text{u}$



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10. It is proposed to use the nuclear fusion reaction,



in a nuclear reactor 200 MW rating. If the energy from the above reaction is used with a 25 per cent efficiency in the reactor, how many grams of deuterium fuel will be needed per day? (The masses of  ${}_1^2\text{H}$  and  ${}_2^4\text{He}$  are 2.0141 atomic mass units and 4.0026 atomic mass units respectively.)



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### Example Type 3

1. Determine the energy of the characteristic X-ray ( $K_\beta$ ) emitted from a tungsten ( $Z = 74$ ) target when an electron drops from the M-shell ( $n=3$ ) to a vacancy in the K-shell ( $n=1$ )



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2. The potential difference applied to an X-ray tube is 5k V and the current through it is 3.2 mA. Then, the number of electrons striking the target per second is \_\_\_\_\_.



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3. Highly energetic electron are bombarded in a target of an element containing 30 neutrons The ratio of nucleus to that of Helium nucleus is  $(14)^{1/3}$ . Find (a) atomic number of the nucleus (b) the frequency of  $k_\alpha$  line of the X-rays produced ( $R = 1.1 \times 10^7 m^{-1}$  and  $c = 3 \times 10^8 m/s$ )



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4. Stopping potential of 24, 100, 110 and 115 k V are measured for photoelectrons emitted from a certain element when it is radiated with monochromatic X-ray . If this element is used as a target in an X-ray tube, what will be the wavelength of  $K_{\alpha}$  - line?



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### Example Type 4

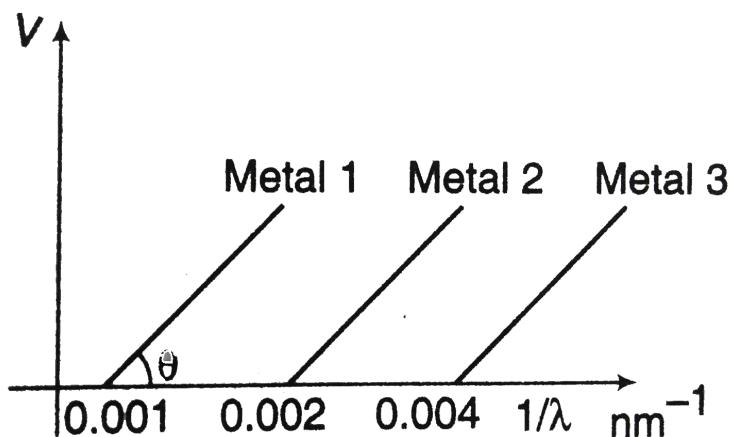
1. A monochromatic light source of frequency  $f$  illuminates a metallic surface and ejects photoelectrons. The photoelectrons having maximum energy are just able to ionize the hydrogen atoms in ground state. When the whole experiment is repeated with an incident radiation of frequency  $\frac{5}{6}f$ , the photoelectrons so emitted are able to excite the hydrogen atom beam which then emits a radiation of wavelength  $1215\text{\AA}$ . (a) What is the frequency of radiation? (b) Find the work-function of the metal.



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2. The graph between  $1/\lambda$  and stopping potential ( $V$ ) of three metals having work- functions  $\Phi_1$ ,  $\Phi_2$  and  $\Phi_3$  in an experiment of photoelectric effect is plotted as shown in the figure. Which of the following statement(s) is/are correct? (Here,  $\lambda$  is the wavelength of the incident ray).



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3. A beam of light has three wavelengths  $4144\text{\AA}$ ,  $4972\text{\AA}$ , and  $6216\text{\AA}$  with a total intensity of  $3.6 \times 10^{-3} \text{ W m}^{-2}$  equally distributed among the three

wavelengths. The beams fall normally on an area  $1.0\text{cm}^2$  of a clean metallic surface of work function  $2.3\text{eV}$ . Assume that there is no loss of light by reflection and that each energetically capable photon ejects one electron. Calculate the number of photoelectrons liberated in 2 s.



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## Miscellaneous Examples

1. Two metallic plate  $A$  and  $B$ , each of area  $5 \times 10^{-4}\text{m}^2$ , are placed parallel to each at a separation of  $1\text{cm}$  plate  $B$  carries a positive charge of  $33.7 \times 10^{-12}\text{C}$  A monocharomatic beam of light, with photoes of energy  $5\text{eV}$  each, starts falling on plate  $A$  at  $t = 0$  so that  $10^{16}$  photons fall on it per square meter per second. Assume that one photoelectron is emitted for every  $10^6$  incident photons fall on it per square meter per second. Also assume that all the emitted photoelectrons are collected by plate  $B$  and the work function of plate  $A$  remain constant at the value  $2\text{eV}$  Determine

(a) the number of photoelectrons emitted up to  $i = 10\text{s}$ ,

- (b) the magnitude of the electric field between the plate  $A$  and  $B$  at  $t = 10\text{ s}$ , and
- (c) the kinetic energy of the most energetic photoelectrons emitted at  $t = 10\text{ s}$  when it reaches plate  $B$

Neglect the time taken by the photoelectrons to reach plate  $B$ . Take

$$\epsilon_0 = 8.85 \times 10^{-12} \text{ C}^2 \text{ N}^{-1} \text{ m}^{-2}$$



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2. Photoelectrons are emitted when 400 nm radiation is incident on a surface of work - function 1.9 eV. These photoelectrons pass through a region containing  $\alpha$ -particles. A maximum energy electron combines with an  $\alpha$ -particle to form a  $\text{He}^+$  ion, emitting a single photon in this process.  $\text{He}^+$  ions thus formed are in their fourth excited state. Find the energies in eV of the photons lying in the 2 to 4 eV range, that are likely to be emitted during and after the combination.

$$[ \text{Take, } h = 4.14 \times 10^{-15} \text{ eV} \cdot \text{s} ]$$



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3. Light from a discharge tube containing hydrogen atoms falls on the surface of a piece of sodium. The kinetic energy of the fastest photoelectrons emitted from sodium is 0.73 eV. The work function for sodium is 1.82 eV. Find (a) the energy of the photons causing the photoelectrons emission.

(b) the quantum numbers of the two levels involved in the emission of these photons.

(c) the change in the angular momentum of the electron in the hydrogen atom, in the above transition, and

(d) the recoil speed of the emitting atom assuming it to be at rest before the transition. (Ionization potential of hydrogen is 13.6 eV.)



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4. If an X-ray tube operates at the voltage of 10kV, find the ratio of the de-broglie wavelength of the incident electrons to the shortest wavelength of X-ray produced. The specific charge of electron is  $1.8 \times 10^{11} \frac{C}{kg}$ .



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5. The wavelength of the first line of Lyman series for hydrogen is identical to that of the second line of Balmer series for some hydrogen like ion x. Calculate energies of the first four levels of x.



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6. A moving hydrogen atom makes a head on collision with a stationary hydrogen atom. Before collision both atoms are in ground state and after collision they move together. What is the minimum value of the kinetic energy of the moving hydrogen atom, such that one of the atoms reaches one of the excited state?



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7. An imaginary particle has a charge equal to that of an electron and mass 100 times the mass of the electron. It moves in a circular orbit around a nucleus of charge  $+4e$ . Take the mass of the nucleus to be

infinite. Assuming that the Bhor model is applicable to this system.

(a) Derive an expression for the radius of  $n$ th Bhor orbit. (b) Find the wavelength of the radiation emitted when the particle jumps from fourth orbit to the second orbit.



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8. The energy levels of a hypothetical one electron atom are given by

$$E_n = - \frac{18.0}{n^2} eV$$

where  $n = 1, 2, 3, \dots$  (a) Compute the four lowest energy levels and construct the energy levels diagram. (b) What is the first excitation potential (c) What wavelength ( $\text{\AA}$ ) can be emitted when these atoms in the ground state are bombarded by electrons that have been accelerated through a potential difference of 16.2 V? (e) what is the photoelectric threshold wavelength of this atom?



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9. In a photocell the plates P and Q have a separation of 5 cm, which are connected through a galvanometer without any cell. Bichromatic light of wavelengths  $4000\text{\AA}$  and  $6000\text{\AA}$  are incident on plate Q whose work-function is 2.39 eV. If a uniform magnetic field B exists parallel to the plates, find the minimum value of B for which the galvanometer shows zero deflection.



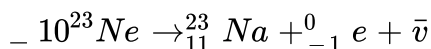
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10. Find the minimum kinetic energy of an  $\alpha$ -particle to cause the reaction  ${}^{14}\text{N}(\alpha, p){}^{17}\text{O}$ . The masses of  ${}^{14}\text{N}$ ,  ${}^4\text{He}$ ,  ${}^1\text{H}$  and  ${}^{17}\text{O}$  are respectively 14.00307u, 4.00260u, 1.00783u and 16.99913u.



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11. Neon-23 decays in the following way,



Find the minimum and maximum kinetic energy that the beta particle

$\left( - ( - 1)^0 e \right)$  can have. The atomic masses of  $^{23}\text{Ne}$  and  $^{23}\text{Na}$  are  $22.9945u$  and  $22.9898u$ , respectively.



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**12.** The mean lives of an unstable nucleus in two different decay processes are 1620 yr and 405 yr, respectively. Find out the time during which three-fourth of a sample will decay.



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**13.** In the chemical analysis of a rock the mass ratio of two radioactive isotopes is found to be 100:1. The mean lives of the two isotopes are  $4 \times 10^9$  years and  $2 \times 10^9$  years, respectively. If it is assumed that at the time of formation the atoms of both the isotopes were in equal proportion, calculate the age of the rock. Ratio of the atomic weights of the two isotopes is 1.02:1.



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14. A proton is bombarded on a stationary lithium nucleus. As a result of the collision, two  $\alpha$ -particles are produced. If the direction of motion of the  $\alpha$ -particles with the initial direction of motion makes an angle  $\cos^{-1}(1/4)$ , find the kinetic energy of the striking proton. Given, binding energies per nucleon of  $Li^7$  and  $He^4$  are 5.60 and 7.06 MeV, respectively. (Assume mass of proton  $\approx$  mass of neutron).



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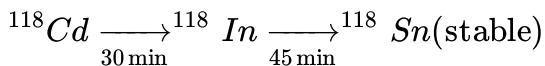
15. A  ${}^7Li$  target is bombarded with a proton beam current of  $10^{-4}$  A for 1 hour to produce  ${}^7Be$  of activity  $1.8 \times 10^8$  disintegrations per second.

Assuming that  ${}^7Be$  radioactive nucleus is produced by bombarding 1000 protons, determine its half-life.



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16. A  $^{118}\text{Cd}$  radio nuclide goes through the transformation chain.



The half-lives are written below the respective arrows. At time  $t = 0$  only Cd was present. Find the fraction of nuclei transformed into stable over 60 minutes.



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17. Natural uranium is a mixture of three isotopes  $_{92}^{234}\text{U}$ ,  $_{92}^{235}\text{U}$ ,  $_{92}^{238}\text{U}$  and  $_{92}^{235}\text{U}$  with mass percentage 0.01%, 0.71% and 99.28% respectively. The half-life of three isotopes are  $2.5 \times 10^5 \text{ yr}$ ,  $7.1 \times 10^8 \text{ yr}$  and  $4.5 \times 10^9 \text{ yr}$  respectively.

Determine the share of radioactivity of each isotope into the total activity of the natural uranium.



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18. Uranium ores on the earth at the present time typically have a composition consisting of 99.3% of the isotope  ${}_{92}\text{U}^{238}$  and 0.7% of the isotope  ${}_{92}\text{U}^{235}$ . The half-lives of these isotopes are  $4.47 \times 10^9 \text{ yr}$  and  $7.04 \times 10^8 \text{ yr}$ , respectively. If these isotopes were equally abundant when the earth was formed, estimate the age of the earth.



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### Exercise 33.1

1. Find the energy and mometum of a photon of ultraviolet radiation of 280 nm wavelength.



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2. A small plate of a metal is placed at a distance of 2m from a monochromatic light source of wavelenght  $4.8 \times 10^{-7} \text{ m}$  and power 1.0

Watt. The light falls normally on the plate. Find the number of photons striking the metal plate per square metre per second.



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3. An  $\alpha$ -particle and a proton are accelerated from rest by the same potential . Find the ratio of their de Broglie wavelengths .



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4. A deuteron and an  $\alpha$  - partical have same kinetic energy. Find the ratio of their de-Broglie wavelengths.



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5. Two electrons are moving with same speed  $v$ . One electron enters a region of uniform electric field while the other enters a region of uniform

magnetic field, then after some time de Broglie wavelength of two are  $\lambda_1$  and  $\lambda_2$ , respectively. Now,



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6. Find the de-Broglie wavelengths of (a) a 46 g golf ball with a velocity of 30 m/s (b) an electron with a velocity of  $10^7 \text{ m/s}$ .



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### Exercise 33.2

1. Find the ionisation energy of a doubly ionized lithium atom.



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2. A hydrogen atom is in a state with energy  $-1.51 \text{ eV}$ . In the Bohr model, what is the angular momentum of the electron in the atom with

respect to an axis at the nucleus?



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**3.** As an electron makes a transition from an excited state to the ground state of a hydrogen like atom/ion

- (a) kinetic energy, potential energy and total energy decrease
- (b) kinetic energy decreases, potential energy increases but total energy remains same
- (c ) kinetic energy and total energy decrease but potential energy increases
- (d) its kinetic energy increases but potential energy and total energy decrease



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**4.** The wavelength of the ultraviolet region of the hydrogen spectrum is 122 nm. The wavelength of the second spectral line in the Balmer series of singly ionized helium atom is (a) 1215Å (b) 1640Å (c ) 2430Å (d) 4687Å



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5. The largest wavelength in the ultraviolet region of the hydrogen spectrum is 122nm. The smallest wavelength in the infrared region of the hydrogen spectrum (to the nearest interger) is (a) 802 nm (b) 823 nm (c ) 1882 nm (d) 1648 nm.



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6. A photon collides with a stationary hydrogen atom in ground state inelastically. Energy of the colliding photon is 10.2 eV. After a time interval of the order of micro second another photon collides with same hydrogen atom inelastically with an energy of 15eV. What will be observed by the detector?

- (a) 2 photons of energy 10.2 eV
- (b) 2 photons of energy 1.4 eV
- (c ) One photon of energy 10.2 eV and an electron of energy 1.4 eV
- (d) One photon of energy 10.2 eV and another photon of energy 1.4 eV



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7. A hydrogen atom and a  $Li^{2+}$  ion are both in the second excited state.

If  $l_H$  and  $l_{Li}$  are their respective electronic angular momenta, and

$E_H$  and  $E_{Li}$  their respective energies, then (a)

$l_H > l_{Li}$  and  $|E_H| > |E_{Li}|$  (b)  $l_H = l_{Li}$  and  $|E_H| < |E_{Li}|$

(c)  $l_H = l_{Li}$  and  $|E_H| > |E_{Li}|$  (d)  $l_H < l_{Li}$  and  $|E_H| < |E_{Li}|$



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8. 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 from



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9. As per the Bohr model, the minimum energy (in eV) required to remove an electron from ground state of doubly ionized Li atom ( $Z = 3$ ) is



A. -122.4 eV

B. 122.4 eV

C. -13.6 eV

D. 13.6 eV

**Answer: B**



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**10.** Consider the spectral line resulting from the transition  $n = 2 \rightarrow n = 1$  in the atoms and ions given below. The shortest wavelength is produced by



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**11.** The energy levels of a certain atom are shown in figure. If a photon of frequency  $f$  is emitted when there is an electron transition from  $5E$  to  $E$  what frequencies of photons could be produced by other energy level

transitions?



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12. Find the longest wavelength present in the Balmer series of hydrogen.



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### Exercise 33.3

1. if  $\lambda_{Cu}$  is the wavelength of  $K_{\alpha}$ , X-ray line fo copper (atomic number 29) and  $\lambda_{Mo}$  is the wavelength of the  $K_{\alpha}$  X-ray line of molybdenum (atomic number 42), then the ratio  $\frac{\lambda_{Cu}}{\lambda_{Mo}}$  is close to

(a) 1.99 (b) 2.14

(c ) 0.50 (d) 0.48



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2. Which one of the following statement is wrong in the context of X-rays generated from an X-ray tube ?



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3.  $K_{\alpha}$  wavelength emitted by an atom of atomic number  $Z=11$  is  $\lambda$ . Find the atomic number for an atom that emits  $K_{\alpha}$  radiation with wavelength  $4\lambda$ .

A.  $Z=6$

B.  $Z=4$

C.  $Z=11$

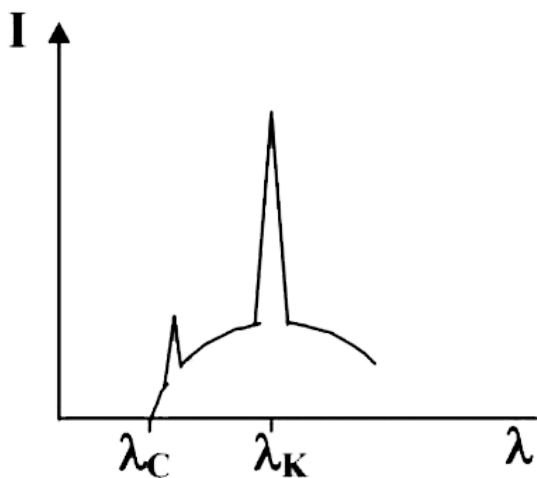
D.  $Z=44$

**Answer: A**



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4. The intensity of X- ray from a coolidge tube is plotted against wavelength  $\lambda$  as shown in the figure . The minimum wavelength found  $\lambda_c$  and the wavelength of the  $k_\alpha$  line is  $\lambda_k$ , As the accelerating voliage is increase



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5. X-ray are produced in an X-ray tube operating at a given accelerating voltage. The wavelength of the continuous X-ray has values from. (a)

$$0 \rightarrow \infty$$

$$(b) \lambda_{\min} \rightarrow \infty, \text{ where } \lambda_{\min} > 0$$

(c)  $0$  to  $\lambda_{\max}$ , where  $\lambda_{\max} < \infty$

(d)  $\lambda_{\min}$  to  $\lambda_{\max}$ , where  $0 < \lambda_{\min} < \lambda_{\max} < \infty$

A. (a)  $0 \rightarrow \infty$

B.

C.

D.

**Answer: B**



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6. Characteristic X-rays of frequency  $4.2 \times 10^{18}$  Hz are produced when transitions from L-shell to K-shell take place in a certain target material. Use Mosley's law to determine the atomic number of the target material. Given Rydberg constant  $R = 1.1 \times 10^7 m^{-1}$ .



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## Exercise 33.4

1. Light of wavelength  $2000\text{\AA}$  is incident on a metal surface of work function  $3.0\text{ eV}$ . Find the minimum and maximum kinetic energy of the photoelectrons.



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2. Is it correct to say that  $K_{\text{max}}$  is proportional to  $f$ ? If not what would a correct statement of the relationship between  $K_{\text{max}}$  and  $f$ ?



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3. When a metal is illuminated with light of frequency  $f$ , the maximum kinetic energy of the photoelectrons is  $1.2\text{ eV}$ . When the frequency is increased by  $50\%$  the maximum kinetic energy increases to  $4.2\text{ eV}$ . What is the threshold frequency for this metal?



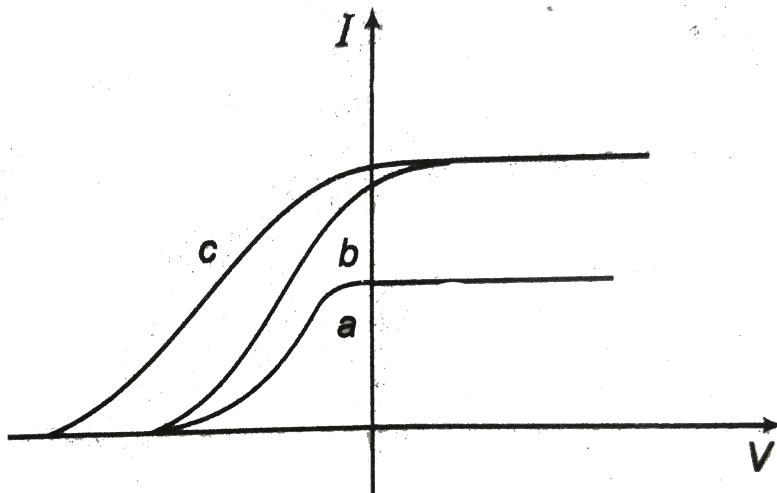
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4. A metal surface is illuminated by light of two different wavelengths 248 nm and 310 nm. The maximum speeds of the photoelectrons corresponding to these wavelengths are  $u_1$  and  $u_2$  respectively. If the ratio  $u_1 : u_2 = 2 : 1$  and  $hc = 1240 \text{ eV nm}$ , the work function of the metal is nearly. (a) 3.7 eV (b) 3.2 eV (c) 2.8 eV (d) 2.5 eV.



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5. The figure shows the variation of photocurrent with anode potential for a photosensitive surface for three different radiations. Let  $\lambda_a$ ,  $\lambda_b$  and  $\lambda_c$  be the curves a, b and c, respectively



(a)  $f_a = f_b$  and  $l_a \neq l_b$  (b)  $f_a = f_c$  and  $l_a = l_c$

(c)  $f_a = f_b$  and  $l_a = l_b$  (d)  $f_b = f_c$  and  $l_b = l_c$



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6. The work function of substance is 4.0 eV. The longest wavelength of light that can cause photoelectron emission from this substance is approximately



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7. The maximum kinetic energy of photoelectrons emitted from a surface when photons of energy 6 eV fall on it is 4 eV. The stopping potential in volts is



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8. Photoelectric effect supports quantum nature of light because



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### Level -1 Assertion And Reason

1. Assertion: X-rays cannot be deflected by electric or magnetic fields

. Reason: These are electromagnetic waves.

A. If both Assertion and Reason are true and the Reason is correct explanation of the Assertion.

B. If both Assertion and Reason are true but Reason is not the correct explanation of Assertion.

C. If Assertion is true, but the Reason is false.

D. If Assertion is false but the Reason is true.

**Answer: A**



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2. Assertion: if wavelength of light is doubled, energy and momentum of photons are reduced to half.

Reason: By increasing the wavelength, speed of photons will decrease.

A. If both Assertion and Reason are true and the Reason is correct explanation of the Assertion.

B. If both Assertion and Reason are true but Reason is not the correct explanation of Assertion.

C. If Assertion is true, but the Reason is false.

D. If Assertion is false but the Reason is true.

**Answer: C**



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3. Assertion: we can increase the saturation current in photoelectric experiment without increasing the intensity of light.

Reason: Intensity can be increased by increasing the frequency of incident photons.

A. If both Assertion and Reason are true and the Reason is correct explanation of the Assertion.

B. If both Assertion and Reason are true but Reason is not the correct explanation of Assertion.

C. If Assertion is true, but the Reason is false.

D. If Assertion is false but the Reason is true.

**Answer: A::B**



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**4. Assertion:** Photoelectric effect proves the particle nature of light.

**Reason:** Photoemission starts as soon as light is incident on the metal surface, provided frequency of incident light is greater than or equal to the threshold frequency.

- A. If both Assertion and Reason are true and the Reason is correct explanation of the Assertion.
- B. If both Assertion and Reason are true but Reason is not the correct explanation of Assertion.
- C. If Assertion is true, but the Reason is false.
- D. If Assertion is false but the Reason is true.

**Answer: A**



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5. Assertion: During de-excitation from  $n=6$  to  $n=3$ , total six emission lines may be obtained.

Reason: From  $n = n \rightarrow n = 1 \rightarrow \text{total} \left( n \frac{n-1}{2} \right)$  emission lines are obtained.

A. If both Assertion and Reason are true and the Reason is correct explanation of the Assertion.

B. If both Assertion and Reason are true but Reason is not the correct explanation of Assertion.

C. If Assertion is true, but the Reason is false.

D. If Assertion is false but the Reason is true.

**Answer: A::B**



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6. Assertion: If frequency of incident light is doubled, the stopping potential will also become two times

Reason: Stopping potential is given by  $V_0 = \frac{h}{e}(v - v_0)$

- A. If both Assertion and Reason are true and the Reason is correct explanation of the Assertion.
- B. If both Assertion and Reason are true but Reason is not the correct explanation of Assertion.
- C. If Assertion is true, but the Reason is false.
- D. If Assertion is false but the Reason is true.

**Answer: D**



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7. Assertion: X-rays cannot be obtained in the emission spectrum of hydrogen atom.

Reason: Maximum energy of photons emitted from hydrogen spectrum is 13.6 eV.

- A. If both Assertion and Reason are true and the Reason is correct explanation of the Assertion.
- B. If both Assertion and Reason are true but Reason is not the correct explanation of Assertion.
- C. If Assertion is true, but the Reason is false.
- D. If Assertion is false but the Reason is true.

**Answer: A**



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8. Assertion: If applied potential difference in Coolidge tube is increased, then difference in Coolidge tube.

- A. If both Assertion and Reason are true and the Reason is correct explanation of the Assertion.
- B. If both Assertion and Reason are true but Reason is not the correct explanation of Assertion.
- C. If Assertion is true, but the Reason is false.
- D. If Assertion is false but the Reason is true.

**Answer: B**



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**9. Assertion:** In  $n=2$ , energy of electron in hydrogen like atoms is more compared to  $n=1$

**.Reason:** Electrostatic potential energy in  $n=2$  is more.

- A. If both Assertion and Reason are true and the Reason is correct explanation of the Assertion.



B. If both Assertion and Reason are true but Reason is not the correct explanation of Assertion.

C. If Assertion is true, but the Reason is false.

D. If Assertion is false but the Reason is true.

**Answer: B**



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**10.** Assertion: In continuous X-ray spectrum, all wavelength can be obtained

. Reason: Accelerated (or retarded) charged particles radiate energy. This is the cause of production of continuous X-rays.

A. If both Assertion and Reason are true and the Reason is correct explanation of the Assertion.

B. If both Assertion and Reason are true but Reason is not the correct explanation of Assertion.

C. If Assertion is true, but the Reason is false.

D. If Assertion is false but the Reason is true.

**Answer: D**



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### Level 1 Objective

1. According to Einstein's photoelectric equation, the graph of kinetic energy of the photoelectron emitted from the metal versus the frequency of the incident radiation gives a straight line graph, whose slope

A. depends on the nature of metal used

B. depends on the intensity of radiation

C. depends on both intensity of radiation and the nature of metal used

D. is the same for all metals and independent of the intensity of radiation

**Answer: D**



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2. The ratio of the speed of the electron in the first Bohr orbit of hydrogen and the speed of light is equal to (where  $e$ ,  $h$  and  $c$  have their usual meaning in cgs system)

A.  $1/300$

B.  $1/500$

C.  $1/137$

D.  $1/187$

**Answer: C**



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3.  ${}_{86}^{222}\text{A} \rightarrow {}_{84}^{210}\text{B}$ . In this reaction, how many  $\alpha$  and  $\beta$  particles are emitted?

A.  $6\alpha, 3\beta$

B.  $3\alpha, 4\beta$

C.  $4\alpha, 3\beta$

D.  $3\alpha, 6\beta$

**Answer: B**



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4. An X-ray tube is operated at 20 kV. The cut off wavelength is

A.  $0.89\text{\AA}$

B.  $0.75\text{\AA}$

C.  $0.62\text{\AA}$

D. None of these

**Answer: C**



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5. An X-ray tube is operated at 18 kV. The maximum velocity of electron striking the target is

A.  $8 \times 10^7 \text{ m/s}$

B.  $6 \times 10^7 \text{ m/s}$

C.  $5 \times 10^7 \text{ m/s}$

D. None of these

**Answer: A**



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6. what is the ratio of de-Broglie wavelength of electron in the second and third Bohr orbits in the hydrogen atoms?

A.  $2/3$

B.  $3/2$

C.  $4/3$

D.  $3/4$

**Answer: A**



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7. 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.  $Li^{2+}$

D.  $Be^{3+}$

**Answer: C**



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8. The operating potential in an x-ray tube is increased by 2%. The percentage change in the cut off wavelength is

- A. 1% increase
- B. 2% increase
- C. 2% decrease
- D. 1% decrease

**Answer: C**



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9. The energy of an atom or ion in the first excited state is  $-13.6 \text{ eV}$ . It may be

A.  $\text{He}^+$

B.  $\text{Li}^{++}$

C. Hydrogen

D. Deuterium

**Answer: A**



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10. in order that the short wavelength limit of the continuous X-ray spectrum be  $1\text{\AA}$ , the potential difference through which an electron must be accelerated is

A.  $124 \text{ kV}$

B.  $1.24 \text{ kV}$



C. 12.4 kV

D. 1240 kV

**Answer: C**



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**11.** The momentum of an x-ray photon with  $\lambda = 0.5\text{\AA}$  is

A.  $13.26 \times 10^{-26} \text{ kg} - \text{m} / \text{s}$

B.  $1.326 \times 10^{-26} \text{ kg} - \text{m} / \text{g}$

C.  $13.26 \times 10^{-24} \text{ kg} - \text{m} / \text{s}$

D.  $13.26 \times 10^{-22} \text{ kg} - \text{m} / \text{s}$

**Answer: C**



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12. The work function of a substance is 1.6 eV. The longest wavelength of light that can produce photoemission from the substance is

A. 7750 Å

B. 3875 Å

C. 5800 Å

D. 2900 Å

**Answer: A**



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13. Find the binding energy of an electron in the ground state of a hydrogen like atom in whose spectrum the third Balmer line is equal to 108.5 nm.

A. 54.4 eV

B. 13.6 eV

C.  $112.4\text{eV}$

D. None of these

**Answer: A**



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**14.** What is the energy of a hydrogen atom in the first excited state if the potential energy is taken to be zero in the ground state?

A.  $10.2\text{ eV}$

B.  $13.6\text{ eV}$

C.  $23.8\text{ eV}$

D.  $27.2\text{ eV}$

**Answer: C**



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15. Light of wavelength 330nm falling on a piece of metal ejects electrons with sufficient energy with required voltage  $V_0$  to prevent them reaching a collector. In the same set up, light of wavelength 220 nm ejects electrons which require twice the voltage  $V_0$  to stop them in reaching a collector. the numerical value of voltage  $V_0$  is

A.  $\frac{16}{15}V$

B.  $\frac{15}{16}V$

C.  $\frac{15}{8}V$

D.  $\frac{8}{15}V$

**Answer: C**



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16. Maximum kinetic energy of a photoelectron is E when the wavelength of incident light is  $\lambda$ . If energy becomes four times when wavelength is reduced to one third, then work function of the metal is

A.  $\frac{3hc}{\lambda}$

B.  $\frac{hc}{3\lambda}$

C.  $\frac{hc}{\lambda}$

D.  $\frac{hc}{2\lambda}$

**Answer: B**



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17. if the frequency fo  $K_a$  X-ray emitted from the element with atomic number 31 is  $f$ , then the frequency of  $K_a$  x-ray emitted from the elemet with atomic number 51 would be

A.  $\frac{5f}{3}$

B.  $\frac{51f}{31}$

C.  $\frac{9f}{25}$

D.  $\frac{25f}{9}$

**Answer: D**



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**18.** According to Moseley's law the ratio of the slope of graph between  $\sqrt{f}$  and  $Z$  for  $K_\beta$  and  $K_\alpha$  is

- A.  $\left( \frac{\sqrt{32}}{27} \right)$
- B.  $\left( \frac{\sqrt{27}}{32} \right)$
- C.  $\left( \frac{\sqrt{5}}{36} \right)$
- D.  $\left( \frac{\sqrt{36}}{5} \right)$

**Answer: A**



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**19.** If the electron in an hydrogen atom jumps from an orbit with level  $n_f = 3$  to an orbit with level  $n_f = 2$ , the emitted radiation has a

wavelength given by

A.  $\lambda = \frac{R}{6}$

B.  $\lambda = \frac{R}{6}$

C.  $\lambda = \frac{36}{5R}$

D.  $\lambda = \frac{5R}{36}$

**Answer: C**



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**20.** A potential of 10000 V is applied across an x-ray tube. Find the ratio of de-Broglie wavelength associated with incident electrons to the minimum wavelength associated with x-rays.

A. 10

B. 20

C.  $1/10$

**Answer: C**



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21. When a metallic surface is illuminated with monochromatic light of wavelength  $\lambda$ , the stopping potential is  $5V_0$ . When the same surface is illuminated with the light of wavelength  $3\lambda$ , the stopping potential is  $V_0$ . Then, the work function of the metallic surface is

A.  $hc/6\lambda$

B.  $hc/5\lambda$

C.  $hc/4\lambda$

D.  $2hc/4\lambda$

**Answer: A**



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22. The threshold frequency for a certain photosensitive metal is  $\nu_0$ . When it is illuminated by light of frequency  $\nu = 2\nu_0$ , the stopping potential for photoelectric current is  $V_0$ . What will be the stopping potential when the same metal is illuminated by light of frequency  $\nu = 3\nu_0$ ?

A.  $1.5V_0$

B.  $2V_0$

C.  $2.5V_0$

D.  $3V_0$

**Answer: B**



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23. The frequency of the first line in Lyman series in the hydrogen spectrum is  $\nu$ . What is the frequency of the corresponding line in the spectrum of doubly ionized Lithium?

A.  $v$

B.  $3v$

C.  $9v$

D.  $2v$

**Answer: C**



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**24.** Which energy state of doubly ionized lithium ( $Li^{++}$ ) has the same energy as that of the ground state of hydrogen?

A.  $n=1$

B.  $n=2$

C.  $n=3$

D.  $n=4$

**Answer: C**

25. Two identical photo-cathodes receive light of frequencies  $\nu_1$  and  $\nu_2$ . If the velocities of the photoelectrons (of mass  $m$ ) coming out are  $v_1$  and  $v_2$  respectively, then

A.  $v_1 - v_2 = \left[ \left( \frac{2h}{m} \right) (\nu_1 - \nu_2) \right]^{1/2}$

B.  $v_1^2 - v_2^2 = \frac{2h}{m} (\nu_1 - \nu_2)$

C.  $v_1 - v_2 = \left[ \left( \frac{2h}{m} \right) (\nu_1 - \nu_2) \right]^{1/2}$

D.  $v_1^2 - v_2^2 = \frac{2h}{m} (\nu_1 - \nu_2)$

**Answer: B**

26. The longest wavelength of the Lyman series for hydrogen atom is the same as the wavelength of a certain line in the spectrum of  $He^+$  when the electron makes a transition from  $n \rightarrow 2$ . The value of  $n$  is

A. 3

B. 4

C. 5

D. 6

**Answer: B**



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27. The wavelength of the  $K_\alpha$  line for the uranium is

$$(Z = 92)(R = 1.0973 \times 10^7 m^{-1})$$

A.  $1.5\text{\AA}$

B.  $0.5\text{\AA}$

C.  $0.15\text{\AA}$

D.  $2.0\text{\AA}$

**Answer: C**

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28. The frequencies of  $K_\alpha$ ,  $K_\beta$  and  $L_\alpha$  X-rays of a material are  $\gamma_1$ ,  $\gamma_2$  and  $\gamma_3$  respectively. Which of the following relation holds good?

A.  $\gamma_2 = \sqrt{\gamma_1 + \gamma_3}$

B.  $\gamma_2 = \gamma_1 + \gamma_3$

C.  $\gamma_2 = \frac{\gamma_1 + \gamma_3}{2}$

D.  $\gamma_3 = \sqrt{\gamma_1 \gamma_2}$

**Answer: B**

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29. A proton and an alpha - particle are accelerated through same potential difference. Then, the ratio of de-Broglie wavelength of proton and alpha-particle is

A.  $\sqrt{2}$

B.  $\frac{1}{\sqrt{2}}$

C.  $2\sqrt{2}$

D. None of these

**Answer: C**



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**30.** If  $E_1$ ,  $E_2$  and  $E_3$  represent respectively the kinetic energies of an electron, an  $\alpha$  - *partic*  $\leq$  and a proton each having same de-Broglie wavelength, then

A.  $E_1 > E_3 > E_2$

B.  $E_2 > E_3 > E_1$

C.  $E_1 > E_2 > E_3$

D.  $E_1 = E_2 = E_3$

**Answer: A**



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31. if the potential energy of a hydrogen atom in the ground state is assumed to be zero, then total energy of  $n = \infty$  is equal to

A.  $13.6\text{eV}$

B.  $27.2\text{eV}$

C. zero

D. None of these

**Answer: B**



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32. A 1000 W transmitter works at a frequency of 880kHz. The number of photons emitted per second is

A.  $1.7 \times 10^{28}$

B.  $1.7 \times 10^{30}$

C.  $1.7 \times 10^{23}$

D.  $1 \times 10^{25}$

**Answer: B**



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**33.** Electromagnetic radiation of wavelength  $3000\text{\AA}$  is incident on an isolated platinum surface of work- function  $6.30\text{ eV}$ . Due to the radiation, the

A. sphere becomes positively charged

B. sphere becomes negatively charged

C. sphere remains neutral

D. maximum kinetic energy of the ejected photoelectrons would be

$2.03\text{ eV}$



**Answer: C**



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**34.** The energy of a hydrogen atom in its ground state is  $-13.6\text{eV}$ . The energy of the level corresponding to the quantum number  $n=5$  is

A.  $-0.54\text{eV}$

B.  $-5.40\text{eV}$

C.  $-0.85\text{eV}$

D.  $-2.72\text{eV}$

**Answer: A**



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**35.** Ultraviolet radiation of  $6.2\text{ eV}$  falls on an aluminium surface (work - function =  $4.2\text{ eV}$ ). The kinetic energy in joule of the fastest electrons

mitted is

A.  $3.2 \times 10^{-21}$

B.  $3.2 \times 10^{-19}$

C.  $3.2 \times 10^{-17}$

D.  $3.2 \times 10^{-15}$

**Answer: B**



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**36.** What should be the velocity of an electron so that its momentum becomes equal to that of a photon of wavelength  $5200 \text{ \AA}$  ?

A. (A)  $700 \text{ m/s}$

B. (B)  $1000 \text{ m/s}$

C. (C)  $1400 \text{ m/s}$

D. (D)  $2800 \text{ m/s}$

**Answer: C**



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**37.** Photoelectric work- function of a metal is 1 eV. Light of wavelength  $\lambda = 3000\text{\AA}$  falls on it. The photoelectrons come out with maximum velocity

- A. 10 m/s
- B.  $10^3 \text{ m/s}$
- C.  $10^4 \text{ m/s}$
- D.  $10^6 \text{ m/s}$

**Answer: D**



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**38.** For uranium nucleus how does its mass vary with volume?

A. (a)  $m \propto V$

B. (b)  $m \propto 1/V$

C. (c)  $m \propto \sqrt{V}$

D. (d)  $m \propto V^2$

**Answer: A**



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**39.** Order of magnitude of density of uranium nucleus is , [m = 1.67 xx 10<sup>^-27</sup> kg]

A. (a)  $10^{20} \text{ kg/m}^3$

B. (b)  $10^{17} \text{ kg/m}^3$

C. (c)  $10^{14} \text{ kg/m}^3$

D. (d)  $10^{11} \text{ kg/m}^3$

**Answer: B**



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40. During a beta decay

- A. (a) an atomic electron is ejected
- B. (b) an electron present inside the nucleus is ejected
- C. (c) a neutron in the nucleus decays emitting an electron
- D. (d) a part of the binding energy is converted into electron

Answer: C



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41. In the nucleus of helium if

$F_1$  is the force between two protons,  $F_2$

is the force between two neutrons and  $F_3$  is the net force

between a proton and a neutron. Then,

A. (a)  $F_1 = F_2 = F_3$

B. (b)  $F_1 > F_2 > F_3$

C. (c)  $F_2 > F_3 > F_1$

D. (d)  $F_2 = F_3 > F_1$

**Answer: A**



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**42.** What are the respective number of  $\alpha$  and  $\beta$ -particles emitted in the following radioactive decay?

A. (a) 6 and 8

B. (b) 6 and 6

C. (c) 8 and 8

D. (d) 8 and 6

**Answer: D**

43. If an atom of  $_{92}^{235}\text{U}$ , after absorbing a slow neutron, undergoes fission to form an atom of  $_{54}^{138}\text{Xe}$  and an atom of  $_{38}^{94}\text{Sr}$ , the other particles produced are

- A. (a) one proton and two neutrons
- B. (b) three neutrons
- C. (c) two neutrons
- D. (d) one proton and one neutron

**Answer: B**

44. Nucleus A is converted into C through the following reactions,

$$A \rightarrow B + \alpha$$

$$B \rightarrow C + 2\beta$$

then,

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

**Answer: D**



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**45.** The binding energy of  $\alpha$ -particle is

( if  $m_p = 1.00785u$ ,  $m_n = 1.00866u$  and  $m_\alpha = 4.00274u$ )

- A. (a) 56.42 MeV
- B. (b) 2.821 MeV
- C. (c) 28.21 MeV



D. (d) 32.4 MeV

**Answer: C**



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46.  $\frac{7}{8}th$  of the active nuclei present in a radioactive sample has decayed in 8 s. The half-life of the sample is

A. (a) 2s

B. (b) 1s

C. (c) 7s

D. (d)  $\frac{8}{3}$  s

**Answer: D**



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47. A radioactive element disintegrates for a time interval equal to its mean life. The fraction that has disintegrated is

A. (a)  $\frac{1}{e}$

B. (b)  $1 - \frac{1}{e}$

C. (c)  $\frac{0.693}{e}$

D. (d)  $0.693 \left(1 - \frac{1}{e}\right)$

**Answer: B**



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48. Starting with a sample of pure  $^{66}\text{Cu}$ ,  $\frac{3}{4}$  of it decays into Zn in 15 minutes. The corresponding half-life is

A. (a) 5 minutes

B. (b) 7.5 minutes

C. (c) 10 minutes

D. (d) 3.5 minutes

**Answer: B**



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**49.** A sample of radioactive substance loses half of its activity in 4 days.

The time in which its activity is reduced to 5% is

A. (a) 12 days

B. (b) 8.3 days

C. (c) 17.3 days

D. (d) None of these

**Answer: C**



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50. On bombardment of  $U^{235}$  by slow neutrons, 200 MeV energy is released. If the power output of atomic reactor is 1.6 MW, then the rate of fission will be

- A. (a)  $5 \times 10^{16}$  per second
- B. (b)  $10 \times 10^{16}$  per second
- C. (c)  $15 \times 10^{16}$  per second
- D. (d)  $20 \times 10^{16}$  per second

**Answer: A**



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51. Atomic masses of two heavy atoms are  $A_1$  and  $A_2$ . Ratio of their respective nuclear densities will be approximately

- A. (a)  $\frac{A_1}{A_2}$
- B. (b)  $\left(\frac{A_1}{A_2}\right)^{\frac{1}{3}}$

C. (c)  $\left(\frac{A_2}{A_1}\right)^{\frac{1}{3}}$

D. (d) 1

**Answer: D**



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52. A radioactive element is disintegrating having half-life 6.93 s. The fractional change in number of nuclei of the radioactive element during 10 s is

A. (a) 0.37

B. (b) 0.63

C. (c) 0.25

D. (d) 0.50

**Answer: B**



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53. The activity of a radioactive sample goes down to about 6% in a time of 2 hour. The half-life of the sample in minute is about

- A. (a) 30
- B. (b) 15
- C. (c) 60
- D. (d) 120

**Answer: A**



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54. What is the probability of a radioactive nucleus to survive one mean life?

- A. (a)  $\frac{1}{e}$
- B. (b)  $\frac{1}{e + 1}$

C. (c)  $1 - \frac{1}{e}$

D. (d)  $\frac{1}{e} - 1$

**Answer: A**



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### Level 1 Subjective

1. For a given element the wavelength of the  $K_\alpha$ - line is 0.71 nm and of the  $K_\beta$ - line it is 0.63 nm. Use this information to find wavelength of the  $L_\alpha$  line.



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2. The energy of the  $n=2$  state in a given element is  $E_2 = -2870\text{eV}$ . Given that the wavelengths of the  $K_\alpha$  and  $K_\beta$  lines are 0.71 nm and 0.63 nm respectively, determine the energies  $E_1$  and  $E_3$ .

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3. 1.5 mW of 400 nm light is directed at a photoelectric cell. If 0.1% of the incident photons produce photoelectrons, find the current in the cell.

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4. A photon has momentum of magnitude  $8.24 \times 10^{-28} \text{ kg} \cdot \text{m/s}$ . (a)

What is the energy of this photon? Given your answer in joules and in electron volts

(b) What is the wavelength of this photon? In what region of the electromagnetic spectrum does lie?

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5. A 75 W light source emits light of wavelength 600 nm. (a) Calculate the frequency of the emitted light.

(b) How many photons per second does the source emit?





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6. An excited nucleus emits a gamma-ray photon with energy of 2.45 MeV.

(a) What is the photon frequency?

(b) what is the photon wavelength?



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7. (a) A proton is moving at a speed much less than the speed of light. It has kinetic energy  $K_1$  and momentum  $p_1$ . If the momentum of the proton is doubled, so  $p_2 = 2p_1$ , how is its new kinetic energy  $K_2$  related to  $K - 1$ ?

(b) A photon with energy  $E_1$  has momentum  $p_1$ . If another photon has momentum  $p_2$  that is twice  $p_1$ , how is the energy  $E_2$  of the second photon related to  $E_1$ ?



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8. A parallel beam of monochromatic light of wavelength 500 nm is incident normally on a perfectly absorbing surface. The power through any cross section of the beam is 10 W. Find

(a) the number of photons absorbed per second by the surface and

(b) the force exerted by the light beam on the surface.



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9. A beam of white light is incident normally on a plane surface absorbing 70% of the light and reflecting the rest. If the incident beam carries 10 W of power, find the force exerted by it on the surface.



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10. A parallel beam of monochromatic light of wavelength 663 nm is incident on a totally reflection plane mirror. The angle of incidence is  $60^\circ$  and the number of photons striking the mirror per second is  $1.0 \times 10^{19}$ . Calculate the force exerted by the light beam on the mirror.



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11. wavelength of Bullet. Calculate the de-Broglie wavelength of a 5.00 g bullet that is moving at 340 m/s will it exhibit wave like particle?



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12. (a) An electron moves with a speed of  $4.70 \times 10^6$  m/s. What is its de-Broglie wavelength?

(b) A proton moves with the same speed. Determine its de - Broglie wavelength.



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13. An electron has a de Broglie wavelength of  $2.80 \times 10^{-10}$  m. Determine

(a) the magnitude of its momentum,

(b) its kinetic energy (in joule and in electron volt).



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14. Find de-Broglie wavelength corresponding to the root-mean square velocity of hydrogen molecules at room temperature ( $20^{\circ}C$ ).

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15. An electron, in a hydrogen like atom, is in excited state. It has a total energy of  $-3.4\text{ eV}$ , find the de-Broglie wavelength of the electron.

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16. In the Bohr model of the hydrogen atom, what is the de-Broglie wavelength for the electron when it is in (a) the  $n=1$  level?  
(b) Then  $n=4$  level? In each case, compare the de-Broglie wavelength to the circumference  $2\pi r_n$  of the orbit.

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17. The binding energy of an electron in the ground state of He atom is equal to  $E_0 = 24.6\text{eV}$ . Find the energy required to remove both electrons from the atom.



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18. Hydrogen atom in its ground state is excited by means of monochromatic radiation of wavelength  $1023\text{\AA}$ . How many different lines are possible in the resulting spectrum? Calculate the longest wavelength among them. You may assume the ionization energy of hydrogen atom as  $13.6\text{ eV}$ .



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19. A doubly ionized lithium atom is hydrogen like with atomic number 3. Find the wavelength of the radiation required to excite the electron in  $\text{Li}^{++}$  from the first to the third Bohr orbit (ionization energy of the hydrogen atom equals  $13.6\text{ eV}$ ).

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20. Find the quantum number  $n$  corresponding to  $n$ th excited state of  $He^{++}$  ion if on transition to the ground state the ion emits two photons in succession with wavelength 108.5 nm and 30.4 nm. The ionization energy of the hydrogen atom is 13.6 eV.

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21. A hydrogen like atom (described by the Bohr model) is observed to emit ten wavelengths, originating from all possible transition between a group of levels. These levels have energies between - 0.85 eV and -0.544 eV (including both these values). (a) Find the atomic number of the atom. (b) Calculate the smallest wavelength emitted in these transitions. (Take ground state energy of hydrogen atom = - 13.6 eV)

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**22.** The energy levels of a hypothetical one electron atom are shown in the figure. (a) Find the ionization potential of this atom.

(b) Find the short wavelength limit of the series terminating at  $n=2$

(c) Find the excitation potential for the state  $n=3$ .

(d) find wave number of the photon emitted for the transition  $n=3$  to  $n=1$

$$\infty \quad \quad \quad 0 \text{ eV}$$

$$n = 5 \quad \quad \quad -0.80 \text{ eV}$$

$$n=4 \quad \quad \quad -1.45 \text{ eV} \quad n = 3 \quad \quad \quad -3.08 \text{ eV}$$

$$n=2 \quad \quad \quad -5.30 \text{ eV} \quad n=1 \quad \quad \quad -15.6 \text{ eV}.$$



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**23.** (a) An atom initially in an energy level with  $E = -6.52 \text{ eV}$  absorbs a photon that has wavelength  $860 \text{ nm}$ . What is the internal energy of the atom after it absorbs the photon?

(b) An atom initially in an energy level with  $E = -2.68 \text{ eV}$  emits a photon that has wavelength  $420 \text{ nm}$ . What is the internal energy of the atom after it emits the photon?

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24. A silver ball is suspended by a string in a vacuum chamber and ultraviolet light of wavelength  $2000\text{\AA}$  is directed at it. What electrical potential will the ball acquire as a result? Work function of silver is  $4.3\text{ eV}$ .

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25. A small particle of mass  $m$  move in such a way the potential energy  $\left( U = \frac{1}{2} m^2 \omega^2 r^2 \right)$  when  $a$  is a constant and  $r$  is the distance of the particle from the origin. Assuming Bohr's model of quantization of angular momentum and circular orbits, show that radius of the  $n$ th allowed orbit is proportional to  $n$ .

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26. Wavelength of  $K_{\alpha}$  line of an element is  $\lambda_0$ . Find wavelength of  $K_{\beta}$  line for the same element.



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27. x-rays are produced in an X-ray tube by electrons accelerated through an electric potential difference of 50.0 kV. An electron makes three collisions in the target coming to rest and loses half its remaining kinetic energy in each of the first two collisions. Determine the wavelength of the resulting photons. (Neglecting the recoil of the heavy target atoms).

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28. From what material is the anode of an X-ray tube made if the  $K_{\alpha}$  line wavelength of the characteristic spectrum is  $0.76\text{\AA}$ ?

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29. The short-wavelength limit shifts by 26 pm when the operating voltage in an X-ray tube is increased to 1.5 times the original value. What was the original value of the operating voltage?

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**30.** The  $k_{\alpha}$  X-rays of aluminium ( $Z = 13$ ) and zinc ( $Z = 30$ ) have wavelengths 887 pm and 146 pm respectively. Use Moseley's law  $\sqrt{\nu} = a(Z - b)$  to find the wavelength of the  $K_{\alpha}$  X-ray of iron ( $Z = 26$ ).

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**31.** Characteristic X-rays of frequency  $4.2 \times 10^{18}$  Hz are produced when transitions from L-shell to K-shell take place in a certain target material. Use Mosley's law to determine the atomic number of the target material. Given Rydberg constant  $R = 1.1 \times 10^7 m^{-1}$ .

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**32.** The electric current in an X-ray tube (from the target to the filament) operating at 40kV is 10mA. Assume that on an average, 1% of the total kinetic energy of the electrons hitting the target are converted into X-

rays (a) what is the total power emitted as X-rays and (b) how much heat is produced in the target every second?



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**33.** The stopping potential for the photoelectrons emitted from a metal surface of work function 1.7 eV is 10.4 V. Find the wavelength of the radiation used. Also, identify the energy levels in hydrogen atom which will emit this wavelength.



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**34.** What will be the maximum kinetic energy of the photoelectrons ejected from magnesium (for which the work -function  $W=3.7$  eV) when irradiated by ultraviolet light of frequency  $1.5 \times 10^{15} s^{-1}$ .



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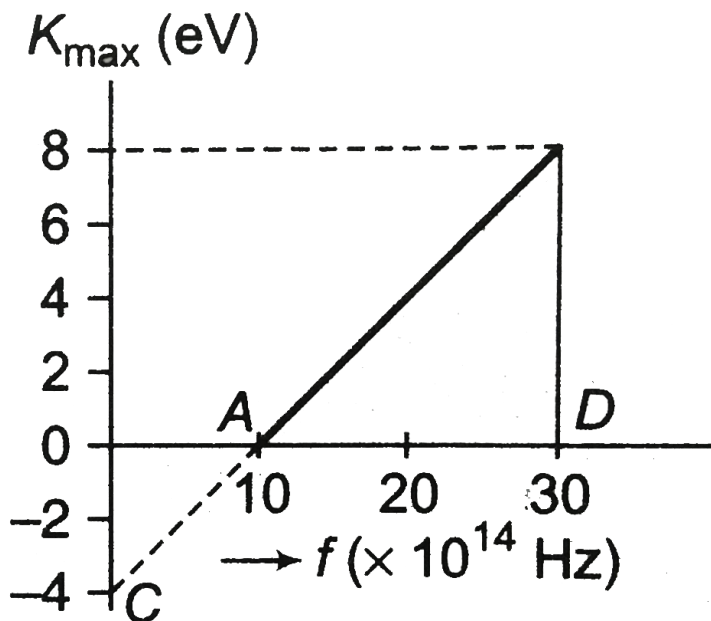
**35.** A metallic surface is irradiated with monochromatic light of variable wavelength. Above a wavelength of  $5000\text{\AA}$  no photoelectrons are emitted from the surface. With an unknown wavelength, stopping potential of  $3\text{V}$  is necessary to eliminate the photocurrent. Find the unknown wavelength.



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**36.** A graph regarding photoelectric effect is shown between the maximum kinetic energy of electrons and the frequency of the incident light. On the basis of data as shown in the graph, calculate (a) threshold

frequency , (b) work- function, (c ) planck constant



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37. A metallic surface is illuminated alternatively with light of wavelengths  $3000\text{\AA}$  and  $6000\text{\AA}$ . It is observed that the maximum speeds of the photoelectrons under these illuminations are in the ratio  $3 : 1$ . Calculate the work function of the metal and the maximum speed of the photoelectrons in two cases.



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**38.** Light of wavelength 180 nm ejects photoelectrons from a plate of metal whose work - function is 2 eV. If a uniform magnetic field of  $5 \times 10^{-5}$  T be applied parallel to the palte, what would be the radius of the path followed by electrons ejected normally from the plate with maximum energy.



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**39.** Light described at a palce by te equation  $E = \left(100 \frac{V}{m}\right) [\sin \times 10^{15} s^{-1} t + \sin(8 \times 10^{15} s^{-1} t)]$  falls on a metal surface having work function 2.0 eV. Calcualte the maximum kinetic energy of the photoelectrons.



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**40.** The electric field associated with a light wave is given by  $E = E_0 \sin[(1.57 \times 10^7 m^{-1}(x - ct)]$ . Find the stopping potential when

this light is used in an experiment on photoelectric affect with a metal having work - function 1.9 eV.



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**41.** The disintegration rate of a certain radioactive sample at any instant is 4750 disintegrations per minute. Five minutes later the rate becomes 2700 per minute. Calculate

(a) decay constant and (b) half-life of the sample



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**42.** A radioactive sample contains  $1.00 \times 10^{15}$  atoms and has an activity of  $6.00 \times 10^{11}$  Bq. What is its half-life?



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43. Obtain the amount of  $^{60}\text{Co}$  necessary to provide a radioactive source of 8.0 Ci strength. The half-life of  $^{60}\text{Co}$  is 5.3 years?



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44. The half-life of  $^{238}\text{U}_{92}$  against alpha decay is  $4.5 \times 10^9$  year. How much disintegration per second occurs in 1 g of  $^{238}\text{U}_{92}$ ?



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45. What is the probability that a radioactive atom having a mean life of 10 days decays during the fifth day?



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46. In an ore containing uranium, the ratio of  $^{238}\text{U} \rightarrow ^{206}\text{Pb}$

$\nu c \leq iis3$ . Calcatethea  $\geq$  ofthe or e, as  $\sum \in gt\hat{a}llthe \leq adpresent \in t$

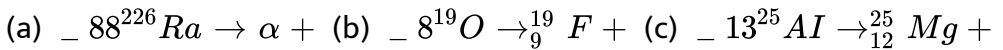


<sup>238</sup>U. Take the half-life of <sup>238</sup>U → <sup>4</sup>He + <sup>234</sup>Th as 4.5 × 10<sup>9</sup> years.



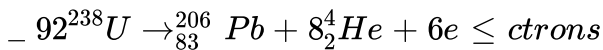
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47. Complete the following reactions.



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48. Consider two decay reactions.



Are both the reactions possible?



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49. Obtain the binding energy of a nitrogen nucleus from the following data:

$$m_H = 1.00783u, m_N = 1.00867u, m(^{14}_7\text{N}) = 14.00307u$$

Give your answer in units of MeV. [Remember  $1u = 931.5 \text{ MeV}/c^2$ ]



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50. 8 protons and 8 neutrons are separately at rest. How much energy will be released if we form  $^{16}_8\text{O}$  nucleus?

Given:

Mass of  $^{16}_8\text{O}$  atom = 15.994915u

Mass of neutron = 1.008665u

Mass of hydrogen atom = 1.007825u



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51. Assuming the splitting of  $^{235}_{92}\text{U}$  nucleus liberates 200 MeV energy, find

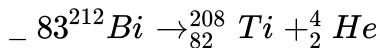
(a) the energy liberated in the fission of 1 kg of  $^{235}_{92}\text{U}$  and

(b) the mass of the coal with calorific value of  $30 \text{ kJ/g}$  which is equivalent to 1 kg of  $^{235}_{92}\text{U}$ .



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52.  $_{83}^{212}\text{Bi}$  decays as per following equation.



The kinetic energy of  $\alpha$ -particle emitted is 6.802 MeV. Calculate the kinetic energy of Ti recoil atoms.



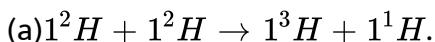
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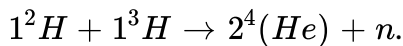
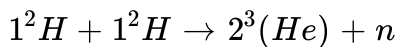
53. In a neutron induced fission of  $_{92}^{235}\text{U}$  nucleus, usable energy of 185 MeV is released. If  $_{92}^{235}\text{U}$  reactor is continuously operating it at a power level of 100 MW power, how long will it take for 1 kg of uranium to be consumed in this reactor?



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54. Calculate the  $Q$ -values of the following fusion reactions:





Atomic masses are  $m(1^2H) = 2.014102u$ ,  $m(1^3H) = 3.016049u$ ,  
 $m(2^3(He)) = 3.016029u$ ,  $m(2^4(He)) = 4.002603u$ .



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**55.** Calculate the Q-values of the fusion reaction



In such a fusion energetically favourable? Atomic mass of  $Be^8$  is 8.0053u and that of  $He^4$  is 4.0026 u.



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**56.** When fission occurs, several neutrons are released and the fission fragments are beta radioactive, why?



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1. if we assume only gravitational attraction between proton and electron in hydrogen atom and the Bohr quantization rule to be followed, then the expression for the ground state energy of the atom will be (the mass of proton is  $M$  and that of electron is  $m$ .)

- A. increases 4 times
- B. decreases 4 times
- C. increases 8 times
- D. decreases 8 times

**Answer: B**



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2. An electron in a hydrogen atom makes a transition from first excited state to ground state. The magnetic moment due to circulating electron

A. 21

B. 10

C. 15

D. None of these

**Answer: B**



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3. The excitation energy of a hydrogen -like ion in its first excited state is  $40.8\text{ eV}$  Find the energy needed to remain the electron from the ion



**Watch Video Solution**

4. An electron in a hydrogen in a hydrogen atom makes a transition from first excited state to ground state. The equivalent current due to circulating electron

A. decreases 16 times

B. decreases 8 times

C. increases 8 times

D. increases 32 times

**Answer: C**



**Watch Video Solution**

5. In a sample of hydrogen like atoms all of which are in ground state, a photon beam containing photos of various energies is passed. In absorption spectrum, five dark line are observed. The number of bright lines in the emission spectrum will be (assume that all transitions take place)

A. 21

B. 10

C. 15

D. none of these

**Answer: C**



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6. Let  $A_0$  be the area enclosed by the orbit in a hydrogen atom. The graph of  $\ln(A_0/A_1)$  against  $\ln(n)$

- A. Will not pass through origin
- B. Will be a straight line with slope 4
- C. will be rectangular hyperbola
- D. Will be parabola

**Answer: B**



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7. In a hydrogen atom, the electron atom makes a transition from  $n = 2 \rightarrow n = 1$ . The magnetic field produced by the circulating electron at the nucleus

- A. Decreases 16 times
- B. Increases 4 times
- C. Decreases 4 times
- D. Increases 32 times

**Answer: D**



**Watch Video Solution**

8. A stationary hydrogen atom emits photon corresponding to the first line of Lyman series. If  $R$  is the Rydberg constant and  $M$  is the mass of the atom, then the velocity acquired by the atom is

A.  $\frac{3RH}{4M}$

B.  $\frac{4M}{3RH}$

C.  $\frac{RH}{4M}$

D.  $\frac{4M}{RH}$

**Answer: A**



**Watch Video Solution**

9. Light wave described by the equation  $200V/m \sin(1.5 \times 10^{15} s^{-1}t) \cos(0.5 \times 10^{15} s^{-1}t)$  falls metal surface having work function 2.0 eV. Then, the maximum kinetic energy photoelectrons is

A.  $3.27eV$

B.  $2.2eV$

C.  $2.85eV$

D. none of these

**Answer: D**



**Watch Video Solution**

10. A hydrogen like atom is excited using a radiation . Consequently, six spectral lines are observed in the spectrum. The wavelength of emission radiation is found to be equal or smaller than the radiation used for excitation. This concludes that the gas was initially at

- A. Ground state
- B. First excited state
- C. Second excited state
- D. Third excited state

**Answer: C**



**Watch Video Solution**

11. The time period of the electron in the ground state of hydrogen atom is two times the times period of the electron in the first excited state of a certain hydrongen like atom (Atomic number  $Z$ ). The value of  $Z$  is

- A. 2
- B. 3
- C. 4
- D. None of these

**Answer: C**



**Watch Video Solution**

12. The wavelengths of  $K_{\alpha}$  X-rays from lead isotopes  $Pb^{204}$ ,  $Pb^{206}$  and  $Pb^{208}$  are  $\lambda_1$ ,  $\lambda_2$  and  $\lambda_3$  respectively. Choose the correct alternative.

- A.  $\lambda_1 < \lambda_2 < \lambda_3$

B.  $\lambda_1 > \lambda_2 > \lambda_3$

C.  $\lambda_1 = \lambda_2 = \lambda_3$

D. None of these

**Answer: C**



**Watch Video Solution**

13. in cases of hydrogen atom, whenever a photon is emitted in the Balmer series, (a) there is a probability emitting another photon in the Lyman series

(b) there is a probability of emitting another photon of wavelength  $1213\text{\AA}$

(c) the wavelength of radiation emitted in Lyman series is always shorter than the wavelength emitted in the Balmer series

(d) All of the above.

A. there is a probability emitting another photon in the Lyman series

- B. there is a probability of emitting another photon of wavelength  $1213 \text{ \AA}$
- C. the wavelength of radiation emitted in Lyman series is always shorter than the wavelength emitted in the Balmer series
- D. All of the above.

**Answer: D**



**Watch Video Solution**

**14.** An electron of kinetic energy  $K$  collides elastically with a stationary hydrogen atom in the ground state. Then,

- A.  $K > 13.6 \text{ eV}$
- B.  $K > 10.2 \text{ eV}$
- C.  $K < 10.2 \text{ eV}$
- D. data insufficient

**Answer: C**



**Watch Video Solution**

**15.** In a stationary hydrogen atom, an electron jumps from  $n = 3$  to  $n = 1$ .

The recoil speed of the hydrogen atom is about

A.  $4m/s$

B.  $4cm/s$

C.  $4mm/s$

D.  $4 \times 10^{-4}m/s$

**Answer: A**



**Watch Video Solution**

**16.** An X-ray tube is operating at 150 kV and 10 mA. If only 1% of the electric power supplied is converted into X-rays, the rate at which the

target is heated in calories per second is

A. 3.55

B. 35.5

C. 355

D. 3550

**Answer: C**



**Watch Video Solution**

**17.** An electron revolves round a nucleus of atomic number  $Z$ . if 32.4 eV of energy is required to excite an electron from the  $n=3$  state to  $n=4$  state, then the value of  $Z$  is

A. 5

B. 6

C. 4



D. 7

**Answer: D**



**Watch Video Solution**

**18.** If the de-Broglie wavelength of a proton is  $10^{-13}$  m, the electric potential through which it must have been accelerated is

A.  $4.07 \times 10^4 V$

B.  $8.15 \times 10^4 V$

C.  $8.15 \times 10^3 V$

D.  $4.07 \times 10^5 V$

**Answer: B**



**Watch Video Solution**

19. If  $E_n$  and  $L_n$  denote the total energy and the angular momentum of an electron in the  $n$ th orbit of Bohr atom, then

A.  $E_n \propto L_n$

B.  $E_n \propto \frac{1}{L_n}$

C.  $E_n \propto L_n^2$

D.  $E_n \propto \frac{1}{L_n^2}$

**Answer: D**



**Watch Video Solution**

20. An orbital electron in the ground state of hydrogen has the magnetic moment  $\mu_1$ . This orbital electron is excited to 3rd excited state by some energy transfer to the hydrogen atom. The new magnetic moment for the electron is  $\mu_2$  then

A.  $\mu_1 = 4\mu_2$

B.  $2\mu_1 = \mu_2$

C.  $16\mu_1 = \mu_2$

D.  $4\mu_1 = \mu_2$

**Answer: D**



**Watch Video Solution**

**21.** A moving hydrogen atom makes a head on collision with a stationary hydrogen atom. Before collision both atoms are in in ground state and after collision they move together. What is the minimum value of the kinetic energy of the moving hydrogen atom, such that one of the atoms reaches one of the excited state?

A.  $20.4eV$

B.  $10.2eV$

C.  $54.4eV$

D.  $13.6eV$

**Answer: A**



**Watch Video Solution**

22. In an excited state of hydrogen like atom an electron has total energy of  $-3.4\text{eV}$ . If the kinetic energy of the electron is  $E$  and its de-Broglie wavelength is  $\lambda$ , then

A.  $\lambda = 6.6\text{\AA}$

B.  $E = 3.4\text{eV}$

C. Both are correct

D. Both are wrong

**Answer: C**



**Watch Video Solution**

23. The count rate observed from a radioactive source at  $t$  second was  $N_0$  and at  $4t$  second it was  $\frac{N_0}{16}$ . The count rate observed at  $\left(\frac{11}{2}\right)t$  second will be

A. (a)  $\frac{N_0}{128}$

B. (b)  $\frac{N_0}{64}$

C. (c)  $\frac{N_0}{32}$

D. (d) None of these

**Answer: B**



**Watch Video Solution**

24. The half-lives of radioactive sample are 30 years and 60 years for two decay processes. If the sample decays by both the processes simultaneously. The time after which, only one-fourth of the sample will remain is

A. (a) 10 years

B. (b) 20 years

C. (c) 40 years

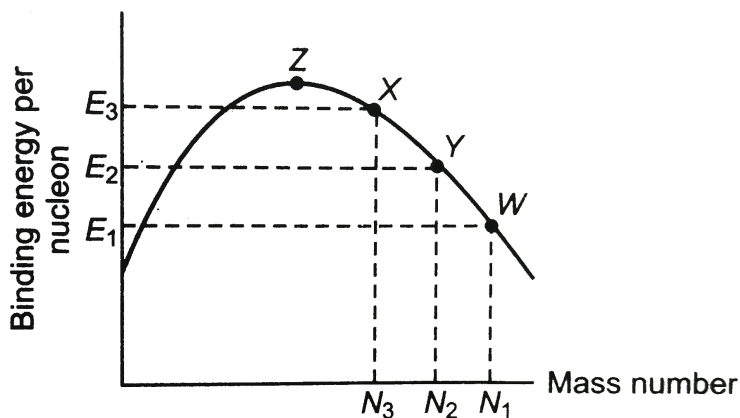
D. (d) 60 years

Answer: C



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25. Consider the nuclear fission reaction  $W \rightarrow X + Y$ . What is the Q-value (energy released) of the reaction?



A. (a)  $E_1N_1 - (E_2N_2 + E_3N_3)$

B. (b)  $(E_2N_2 + E_3N_3 - E_1N_1)$

C. (c)  $E_2N_2 + E_1N_1 - E_3N_3$

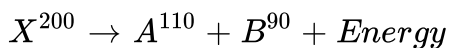
D. (d)  $E_1N_1 + E_3N_3 - E_2N_2$

**Answer: B**



**Watch Video Solution**

**26.** Consider the following nuclear reaction,



If the binding energy per nucleon for X, A and B are 7.4 MeV, 8.2 MeV and 8.2 MeV respectively, the energy released will be

A. (a) 900 MeV

B. (b) 110 MeV

C. (c) 200 MeV

D. (d) 160 MeV

**Answer: D**



**Watch Video Solution**

27. The energy released by the fission of a single uranium nucleus is 200 MeV. The number of fission of uranium nucleus per second required to produce 16 MW of power is (Assume efficiency of the reactor is 50%)

A. (a)  $2 \times 10^6$

B. (b)  $2.5 \times 10^6$

C. (c)  $5 \times 10^6$

D. (d) None of these

**Answer: D**



**Watch Video Solution**



28. A radioactive isotope is being produced at a constant rate  $dN/dt = R$  in an experiment. The isotope has a half-life  $t_{1/2}$ . Show that after a time  $t \gg t_{1/2}$ , the number of active nuclei will become constant. Find the value of this constant.

A. (a)  $AT$

B. (b)  $\frac{A}{T} \ln 2$

C. (c)  $AT \ln 2$

D. (d)  $\frac{AT}{\ln 2}$

**Answer: D**



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29. A bone containing 200 g carbon-14 has  $\beta$ -decay rate of 375 decay/min. Calculate the time that has elapsed since the death of the living one. Given the rate of decay for the living organism is equal to 15 decay per min per gram of carbon and half-life of carbon-14 is 5730 years.

- A. (a) 27190 years
- B. (b) 1190 years
- C. (c) 17190 years
- D. (d) None of these

**Answer: C**



**Watch Video Solution**

**30.** Two identical samples (same material and same amount) P and Q of a radioactive substance having mean life  $T$  are observed to have activities  $A_P$  and  $A_Q$  respectively at the time of observation. If P is older than Q, then the difference in their age is

- A. (a)  $T \ln \left( \frac{A_P}{A_Q} \right)$
- B. (b)  $T \ln \left( \frac{A_Q}{A_P} \right)$
- C. (c)  $T \left( \frac{A_P}{A_Q} \right)$
- D. (d)  $T \left( \frac{A_Q}{A_P} \right)$

**Answer: B**



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31. A star initially has  $10^{40}$  deuterons. It produces energy via the processes  ${}_1^2\text{H} + {}_1^2\text{H} \rightarrow {}_1^3\text{H} + p$  and  ${}_1^2\text{H} + {}_1^3\text{H} \rightarrow {}_2^4\text{He} + n$ .

Where the masses of the nuclei are

$m({}_1^2\text{H}) = 2.014a\mu$ ,  $m(p) = 1.007a\mu$ ,  $m(n) = 1.008a\mu$  and  $m({}_2^4\text{He}) = 4.001$

amu. If the average power radiated by the star is  $10^{16}W$ , the deuteron supply of the star is exhausted in a time of the order of

A. (a)  $10^6s$

B. (b)  $10^8s$

C. (c)  $10^{12}s$

D. (d)  $10^{16}s$

**Answer: C**



**Watch Video Solution**

32. Two radioactive samples of different elements (half-lives  $t_1$  and  $t_2$  respectively) have same number of nuclei at  $t = 0$ . The time after which their activities are same is

A. (a)  $\frac{t_1 t_2}{0.693(t_2 - t_1)} \ln \frac{t_2}{t_1}$

B. (b)  $\frac{t_1 t_2}{0.693} \ln \frac{t_2}{t_1}$

C. (c)  $\frac{t_1 t_2}{0.693(t_1 + t_2)} \ln \frac{t_2}{t_1}$

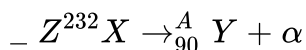
D. (d) None of these

**Answer: A**



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33. A nucleus X initially at rest, undergoes alpha decay according to the equation



What fraction of the total energy released in the decay will be the kinetic energy of the alpha particle?

A. (a)  $\frac{90}{92}$

B. (b)  $\frac{228}{232}$

C. (c)  $\sqrt{\frac{228}{232}}$

D. (d)  $\frac{1}{2}$

**Answer: B**



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**34.** A stationary nucleus of mass 24 amu emits a gamma photon. The energy of the emitted photon is 7 MeV. The recoil energy of the nucleus is

A. (a)  $2.2keV$

B. (b)  $1.1keV$

C. (c)  $3.1keV$

D. (d)  $2.2keV$

**Answer: B**



**Watch Video Solution**

**35.** A radioactive material of half-life  $T$  was kept in a nuclear reactor at two different instants. The quantity kept second time was twice of the kept first time. If now their present activities are  $A_1$  and  $A_2$  respectively, then their age difference equals

A. (a)  $\frac{T}{\ln 2} \ln \frac{2A_1}{A_2}$

B. (b)  $T \ln \frac{A_1}{A_2}$

C. (c)  $\frac{T}{\ln 2} \ln \frac{A_2}{2A_1}$

D. (d)  $T \ln \frac{A_2}{2A_1}$

**Answer: C**



**Watch Video Solution**

1. If the potential difference of coolidge tube producing X-ray is increased, then choose the correct option (s).

Here,  $\lambda_0$  is cut off wavelength and  $\lambda_{K\alpha}$  and  $\lambda_{K\beta}$  are wavelengths of  $K_\alpha$  and  $K_\beta$  characteristic X-rays.

- A. the interval between  $\lambda_{K\alpha}$  and  $\lambda_{K\beta}$  increases
- B. the interval between  $\lambda_{K\alpha}$  and  $\lambda_0$  increases
- C. the interval between  $\lambda_{K\beta}$  and  $\lambda_0$  increases
- D.  $\lambda_0$  does not change

**Answer: B::C**



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2. In Bohr model of the hydrogen atom, let  $R$ ,  $v$  and  $E$  represent the radius of the orbit, speed of the electron and the total energy respectively.

Which of the following quantities are directly proportional to the quantum number  $n$ ?

A.  $vR$

B.  $RE$

C.  $v/E$

D.  $R/E$

**Answer: A::C**



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3. The magnitude of angular momentum, orbital radius and time period of revolution of an electron in a hydrogen atom corresponding to the quantum number  $n$  are  $L$ ,  $r$  and  $T$  respectively. Which of the following statement (s) is/are correct?

A.  $\frac{rL}{T}$  is independent of  $n$

B.  $\frac{L}{T} \propto \frac{1}{n^2}$



C.  $\frac{T}{r} \propto n$

D.  $Lr \propto \frac{1}{n^3}$

**Answer: A::B::C**



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4. In which of the following cases the heavier of the two particles has a smaller de-Broglie wavelength ? The two particles

A. move with the same speed

B. move with the same linear momentum

C. move with the same kinetic energy

D. have the same change of potential energy in a conservative field

**Answer: A::C**



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5. Hydrogen atom absorbs radiations of wavelength  $\lambda_0$  and consequently emit radiations of 6 different wavelengths, of which two wavelengths are longer than  $\lambda_0$ . Chosses the correct alternative(s).

- A. The final excited staate of the atoms is  $n=4$
- B. The initial state of the atoms is  $n=2$
- C. The initial state of the atoms is  $n=3$
- D. There ae three transitions belonging to Lyman series

**Answer: A::B::D**



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6. In coolidge tube, if  $f$  and  $\lambda$  represent the frequency and wavelength of  $K_\alpha$  -line for a metal of atomic number  $Z$ , then identify the statement which represents a straight line

- A.  $\sqrt{f}$  versus  $Z$

B.  $\frac{1}{\sqrt{\lambda}}$  versus  $Z$

C.  $f$  versus  $Z$

D.  $\lambda$  versus  $Z$

**Answer: A::B**



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7. At  $t = 0$ , number of radioactive nuclei of a radioactive substance are  $x$  and its radioactivity is  $y$ . Half-life of radioactive substance is  $T$ . Then,

A. (a)  $\frac{x}{y}$  is constant throughout

B. (b)  $\frac{x}{y} > T$

C. (c) value of  $xy$  remains half after one half-life

D. (d) value of  $xy$  remains one fourth after one half-life

**Answer: A::B::D**



**Watch Video Solution**

8. Choose the correct options.

- A. (a) Isotopes have same number of atomic number
- B. (b) Isobars have same atomic weight
- C. (c) Isotones have same number of neutrons
- D. (d) In neutral isotope atoms number of electrons are same

**Answer: A::B::C::D**



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9. Choose the correct options.

- A. (a) By gamma radiations atomic number is not changed
- B. (b) By gamma radiations mass number is not changed
- C. (c) By the emission of one  $\alpha$  and two  $\beta$  particles isotopes are produced

D. (d) By the emission of one  $\alpha$  and four  $\beta$  particles isobars are produced

**Answer: A::B::C**



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10. Two radioactive substances have half-lives  $T$  and  $2T$ . Initially, they have equal number of nuclei. After time  $t = 4T$ , the ratio of their number of nuclei is  $x$  and the ratio of their activity is  $y$ . Then,

A. (a)  $x = 1/8$

B. (b)  $x = 1/4$

C. (c)  $y = 1/2$

D. (d)  $y = 1/4$

**Answer: B::C**



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11. Regarding the nuclear forces, choose the correct options.

- A. (a) They are short range forces
- B. (b) They are charge independent forces
- C. (c) They are not electromagnetic forces
- D. (d) They are exchange forces

**Answer: A::B::C::D**



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12. Regarding a nucleus choose the correct options.

- A. (a) Density of a nucleus is directly proportional to mass number A
- B. (b) Density of all the nuclei is almost constant of the order of  $10^{17} \text{ kg/m}^3$
- C. (c) Nucleus radius is of the order of  $10^{-15} \text{ m}$

D. (d) Nucleus radius  $\propto A$

Answer: B::C



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## Level 2 Comprehension Based

1. When a surface is irradiated with light of wavelength  $4950\text{\AA}$ , a photocurrent appears which vanishes if a retarding potential greater than  $0.6\text{ volt}$  is applied across the phototube. When a second source of light is used, it is found that the critical potential is changed to  $1.1\text{ volt}$ .

The work- function of the emitting surface is i

A.  $2.2\text{eV}$

B.  $1.5\text{eV}$

C.  $1.9\text{eV}$

D.  $1.1\text{eV}$

**Answer: C**



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2. When a surface is irradiated with light of wavelength  $4950\text{\AA}$ , a photocurrent appears which vanishes if a retarding potential greater than 0.6 volt is applied across the phototube. When a second source of light is used, it is found that the critical potential is changed to 1.1 volt. The wavelength of the second source is

A.  $6150\text{\AA}$

B.  $5150\text{\AA}$

C.  $4150\text{\AA}$

D.  $4500\text{\AA}$

**Answer: C**



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3. When a surface is irradiated with light of wavelength  $4950\text{\AA}$ , a photocurrent appears which vanishes if a retarding potential greater than  $0.6V$  is applied across the phototube. When a second source of light is used, it is found that the critical potential is changed to  $1.1V$ .

If the photoelectrons (after emission from the source) are subjected to a magnetic field of  $10T$ , the two retarding potentials would

- A. Uniformly increase
- B. Uniformly decrease
- C. remain the same
- D. none of these

**Answer: C**



**Watch Video Solution**

4. The atomic masses of the hydrogen isotopes are

Hydrogen  $m_1 H^1 = 1.007825$  amu

Deuterium  $m_1 H^2 = 2.014102$  amu

Tritium  $m_1 H^3 = 3.016049$  amu

The energy released in the reaction,

$_1H^2 + _1H^2 \rightarrow _1H^3 + _1H^1$  is nearly

A. (a) 1MeV

B. (b) 2MeV

C. (c) 4MeV

D. (d) 8 MeV

**Answer: C**



**Watch Video Solution**

5. The atomic masses of the hydrogen isotopes are

Hydrogen  $m_1 H^1 = 1.007825$  amu

Deuterium  $m_1H^2 = 2.014102$  amu

Tritium  $m_1H^3 = 3.016049$  amu

The number of fusion reactions required to generate 1kWh is nearly

- A. (a)  $10^8$
- B. (b)  $10^{18}$
- C. (c)  $10^{28}$
- D. (d)  $10^{38}$

**Answer: B**



**Watch Video Solution**

**6.** The atomic masses of the hydrogen isotopes are

Hydrogen  $m_1H^1 = 1.007825$  amu

Deuterium  $m_1H^2 = 2.014102$  amu

Tritium  $m_1H^3 = 3.016049$  amu

The mass of deuterium,  $_1H^2$  that would be needed to generate 1 kWh.

(energy released by 1 fusion is 4MeV)

A. (a)  $3.7kg$

B. (b)  $3.7g$

C. (c)  $3.7 \times 10^{-5}kg$

D. (d)  $3.7 \times 10^{-8}kg$

**Answer: D**



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## Level 2 Passage 2

1. in an experimental set up to study the photoelectric effect a point source of light of power  $3.2 \times 10^{-3} \text{ W}$  was taken. The source can emit monoenergetic photons of energy  $5\text{eV}$  and is located at a distance of  $0.8 \text{ m}$  from the centre of a stationary metallic sphere of work-function  $3.0 \text{ eV}$ . The radius of the sphere is  $r = 8. \cdot 10^{-3} \text{ m}$ . The efficiency of photoelectric emission is one for every  $10^6$  incident photons. Based on the information given above answer the questions given below. (Assume that the sphere

is isolated and photoelectrons are instantly swept away after the emission).

de-Broglie wavelength of the fastest moving photoelectron is

A.  $6.63\text{\AA}$

B.  $8.69\text{\AA}$

C.  $2\text{\AA}$

D.  $5.26\text{\AA}$

**Answer: B**



**Watch Video Solution**

## Level 2 Passage 3

1. in an experimental set up to study the photoelectric effect a point source of light of power  $3.2 \times 10^{-3}$  W was taken. The source can emit monoenergetic photons of energy 5eV and is located at a distance of 0.8 m from the centre of a stationary metallic sphere of work-function 3.0 eV.

The radius of the sphere is  $r = 8 \times 10^{-3}$  m. The efficiency of photoelectric emission is one for every  $10^6$  incident photons. Based on the information given above answer the questions given below. (Assume that the sphere is isolated and photoelectrons are instantly swept away after the emission).

It was observed that after some time emission of photoelectrons from the sphere stopped. Charge on the sphere when the photon emission stops is

A.  $16\pi\epsilon_0^r$  coulomb

B.  $8\pi\epsilon_0^r$  coulomb

C.  $15\pi\epsilon_0^r$  coulomb

D.  $20\pi\epsilon_0^r$  coulomb

**Answer: B**



**Watch Video Solution**

1. in an experimental set up to study the photoelectric effect a point source of light of power  $3.2 \times 10^{-3}$  W was taken. The source can emit monoenergetic photons of energy 5eV and is located at a distance of 0.8 m from the centre of a stationary metallic sphere of work-function 3.0 eV. The radius of the sphere is  $r = 8. \cdot 10^{-3}$  m. The efficiency of photoelectric emission is one for every  $10^6$  incident photons. Based on the information given above answer the questions given below. (Assume that the sphere is isolated and photoelectrons are instantly swept away after the emission).

Time after which photoelectric emission stops is

A. 100s

B. 121s

C. 111s

D. 141s

**Answer: C**



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## Level 2 Subjective

1. The wavelength for  $n=3$  to  $n=2$  transition of the hydrogen atom is 656.3 nm. What are the wavelength for this same transition in (a) positronium, which consists of an electron and a positron (b) singly ionized helium



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2. (a) Find the frequencies of revolution of electrons in  $n = 1$  and  $n=2$  Bohr orbits.

(b) What is the frequency of the photon emitted when an electron in an  $n=2$  orbit drops to an  $n=1$  hydrogen orbit?

(c) An electron typically spends about

$10^{-8} \text{ s}$  in an excited state before it drops to a lower state by emitting a photon.  $100 \times 10^{-8} \text{ s}$ ?



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3. A muon is an unstable elementary particle whose mass ( $\mu^-$ ) can be captured by a hydrogen nucleus (or proton) to form a muonic atom.

a Find the radius of the first Bohr orbit of this atom.

b Find the ionization energy of the atom.



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4. (a) A gas of hydrogen atoms in their ground state is bombarded by electrons with kinetic energy 12.5 eV. What emitted wavelengths would you expect to see?

(b) What if the electrons were replaced by photons of same energy?



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5. A source emits monochromatic light of frequency  $5.5 \times 10^{14}$  Hz at a rate of 0.1 W. Of the photons given out, 0.15% fall on the cathode of a photocell which gives a current of  $6\mu\text{A}$  in an external circuit.

(a) Find the energy of a photon.

(b) Find the number of photons leaving the source per second.

(C) Find the percentage of the photons falling on the cathode which produce photoelectrons.



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6. The hydrogen atom in its ground state is excited by means of monochromatic radiation. Its resulting spectrum has six different lines. These radiations are incident on a metal plate. It is observed that only two of them are responsible for photoelectric effect. If the ratio of maximum kinetic energy of photoelectrons in the two cases is 5 then find the work function of the metal.



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7. Electrons in hydrogen like atom ( $Z = 3$ ) make transition from the fifth to the fourth orbit and from the third orbit. The resulting radiation is incident normally on a metal plate and ejects photoelectrons. The stopping potential for the photoelectrons ejected by the shorter

wavelength is 3.95 volts. Calculate the work function of the metal and the stopping potential for the photoelectron ejected by longer wavelength (Rydberg constant =  $1.094 \times 10^7 m^{-1}$ )



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8. Find an expression for the magnetic dipole moment and magnetic field induction at the centre of Bohr's hypothetical hydrogen atom in the  $n$ th orbit of the electron in terms of universal constant.



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9. An electron and a proton are separated by a large distance and the electron approaches the proton with a kinetic energy of 2 eV. If the electron is captured by the proton to form a hydrogen atom in the ground state, what wavelength photon would be given off?



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10. Hydrogen gas in the atomic state is excited to an energy level such that the electrostatic potential energy of H-atom becomes  $-1.7\text{eV}$ . Now, a photoelectric plate having work function  $w=2.3\text{ eV}$  is exposed to the emission spectra of this gas. Assuming all the transitions to be possible, find the minimum de-Broglie wavelength of the ejected photoelectrons.



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11. A gas of hydrogen-like atoms can absorb radiations of  $698\text{eV}$ . Consequently, the atoms emit radiation of only three different wavelengths. All the wavelengths are equal to or smaller than that of the absorbed photon.

a Determine the initial state of the gas atoms.

b Identify the gas atoms

c Find the minimum wavelength of the emitted radiation,

d Find the ionization energy and the respective wavelength for the gas atoms.



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12. A photon with energy of 4.9 eV ejects photoelectrons from tungsten. When the ejected photoelectrons from tungsten. When the ejected electron enters a constant magnetic field of strength  $B=2.5$  mT at an angle of  $60^\circ$  with the field direction, the maximum pitch of the helix described by the electron is found to be 2.7 mm. Find the work function of the metal in electron volt. Given that specific charge of electron is  $1.76 \times 10^{11}$  C/kg.



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13. For a certain hypothetical one electron atom, the wavelength ( $\in \text{\AA}$ ) for the spectral lines for transitions originating at  $n=p$  and terminating at

$n=1$  are given by  $\lambda = \frac{1500p^2}{p^2 - 1}$ , where  $p = 2, 3, 4$

(a) Find the wavelength of the least energetic and the most energetic photons in this series.

(b) Construct an energy level diagram for this element showing the energies of the lowest three levels.

(c) What is the ionization potential for this element?

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14. A photocell is operating in saturation mode with a photocurrent  $4.8 \text{ mA}$  when a monochromatic radiation of wavelength  $3000 \text{ \AA}$  and power of  $1 \text{ W}$  is incident. When another monochromatic radiation of wavelength  $1650 \text{ \AA}$  and power  $5 \text{ W}$  is incident, it is observed that maximum velocity of photoelectron increases to two times. Assuming efficiency of photoelectron generation per incident photon to be same for both the cases, calculate.

(a) the threshold wavelength for the cell

(b) the saturation current in second case

(c) the efficiency of photoelectron generation per incident photon.

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15. The photons from the Balmer series in Hydrogen spectrum having wavelength between  $450 \text{ nm}$  to  $700 \text{ nm}$  are incident on a metal surface of

work function  $2eV$  Find the maximum kinetic energy of ejected electron  
(Given  $hc = 1242 \text{ eV nm}$ )`



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**16.** Assume that the de Broglie wave associated with an electron can form a standing wave between the atoms arranged in a one-dimensional array with nodes at each of the atomic sites. It is found that one such standing wave exists if the distance  $d$  between the atoms of the array is  $2\text{\AA}$ . A similar standing wave is again formed if  $d$  is increased to  $2.5\text{\AA}$ . Find the energy of the electrons in electron volts and the least value of  $d$  for which the standing wave type described above can form.



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**17.** The negative muon has charge equal to that of an electron but a mass that is 207 times as great. Consider hydrogen-like atom consisting of a proton and a muon.

(a) What is the reduced mass of the atom?

(b) What is the ground-level energy (in eV)?

(c) What is the wavelength of the radiation emitted in the transition from the  $n=2$  level to the  $n=1$  level?



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**18.** Assume a hypothetical hydrogen atom in which the potential energy between electron and proton at separation  $r$  is given by  $U = \left[ k \ln r - \left( \frac{k}{2} \right) \right]$ , where  $k$  is a constant. For such a hypothetical hydrogen atom, calculate the radius of  $n$ th Bohr orbit and energy levels.



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**19.** An electron is orbiting in a circular orbit of radius  $r$  under the influence of a constant magnetic field of strength  $B$ . Assuming that Bohr postulate regarding the quantisation of angular momentum holds good for this electron, find

(a) the allowed values of the radius  $r$  of the orbit.



- (b) the kinetic energy of the electron in orbit
- (c) the potential energy of interaction between the magnetic moment of the orbital current due to the electron moving in its orbit and the magnetic field  $B$ .
- (d) the total energy of the allowed energy levels.
- (e) the total magnetic flux due to the magnetic field  $B$  passing through the  $n$ th orbit. (Assume that the charge on the electron is  $-e$  and the mass of the electron is  $m$ ).



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**20.** A mixture of hydrogen atoms (in their ground state) and hydrogen like ions (in their first excited state) are being excited by electrons which have been accelerated by same potential of emitted light are found in the ratio 5:1. Then, find

- (a) the minimum value of  $V$  for which both the atoms get excited after collision with electrons.
- (b) atomic number of other ion.
- (c) the energy of emitted light.

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21. When a surface is irradiated with light of wavelength  $4950\text{\AA}$ , a photocurrent appears which vanishes if a retarding potential greater than 0.6 volt is applied across the phototube. When a second source of light is used, it is found that the critical potential is changed to 1.1 volt. The wavelength of the second source is

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22. In an experiment on photoelectric effect of light wavelength 400 nm is incident on a metal plate at rate of 5W. The potential of the collector plate is made sufficiently positive with respect to emitter so that the current reaches the saturation value. Assuming that on the average one out of every  $10^6$  photons is able to eject a photoelectron, find the photocurrent in the circuit.

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**23.** A light beam of wavelength 400 nm is incident on a metal of work-function 2.2 eV. A particular electron absorbs a photon and makes 2 collisions before coming out of the metal

(a) Assuming that 10% of existing energy is lost to the metal in each collision find the final kinetic energy of this electron as it comes out of the metal.

(b) Under the same assumptions find the maximum number of collisions, the electron should suffer before it becomes unable to come out of the metal.



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**24.** A  $F^{32}$  radio nuclide with half-life  $T = 14.3$  days is produced in a reactor at a constant rate  $q = 2 \times 10^9$  nuclei per second. How soon after the beginning of production of that radio nuclide will its activity be equal to  $R = 10^9$  disintegration per second?



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**25.** Consider a radioactive disintegration according to the equation  $A \rightarrow B \rightarrow C$ . Decay constant of A and B is same and equal to  $\lambda$ . Number of nuclei of A, B and C are  $N_0$ , 0, 0 respectively at  $t = 0$ . Find

(a) number of nuclei of B as function of time  $t$ .

(b) time  $t$  at which the activity of B is maximum and the value of maximum activity of B.



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**26.** Nuclei of a radioactive element A are being produced at a constant rate  $\alpha$ . The element has a decay constant  $\lambda$ . At time  $t = 0$ , there are  $N_0$  nuclei of the element.

(a) Calculate the number  $N$  of nuclei of A at time  $t$ .

(b) If  $\alpha = 2N_0\lambda$ , calculate the number of nuclei of A after one half-life of A, and also the limiting value of  $N$  as  $t \rightarrow \infty$ .



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27. A solution contains a mixture of two isotopes A (half-life=10days) and B (half-life=5days). Total activity of the mixture is  $10^{10}$  disintegration per second at time  $t = 0$ . The activity reduces to 20% in 20 days. Find (a) the initial activities of A and B, (b) the ratio of initial number of their nuclei.



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28. A radio nuclide with disintegration constant  $\lambda$  is produced in a reactor at a constant rate  $\alpha$  nuclei per second. During each decay energy  $E_0$  is released. 20% of this energy is utilized in increasing the temperature of water. Find the increase in temperature of  $m$  mass of water in time  $t$ . Specific heat of water is  $s$ . Assume that there is no loss of energy through water surface.



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29. A stable nuclei C is formed from two radioactive nuclei A and B with decay constant of  $\lambda_1$  and  $\lambda_2$  respectively. Initially, the number of nuclei of

A is  $N_0$  and that of B is zero. Nuclei B are produced at a constant rate of

P. Find the number of the nuclei of C after time  $t$ .



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30. Polonium ( $_{84}^{210}\text{Po}$ ) emits  $_{2}^4\text{He}$

particles and is converted into  $_{82}^{206}\text{Pb}$ . This reaction is used for the production of space mission.

$_{84}^{210}\text{Po}$

has a half-life of 138.6 days. As the efficiency of 10% for the

$_{84}^{210}\text{Po}$  is required  $\rightarrow$   $_{82}^{206}\text{Pb}$   $1.2 \times 10^7$

of the  $_{82}^{206}\text{Pb}$  is required at the end of 693 days. Also find the initial activity

$_{84}^{210}\text{Po} = 209.98264 \text{ amu}$ ,  $_{82}^{206}\text{Pb} = 205.97440 \text{ amu}$ ,  $_{2}^4\text{He} = 4.00260 \text{ amu}$ ,  $1 \text{ amu} = 931 \text{ MeV}/c^2$  and Avogadro's number  $= 6 \times 10^{23} \text{ mol}^{-1}$



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**31.** A radio nuclide consists of two isotopes. One of the isotopes decays by  $\alpha$ -emission and other by  $\beta$ -emission with half-lives  $T_1 = 405s$  and  $T_2 = 1620s$ , respectively. At  $t = 0$ , probabilities of getting  $\alpha$  and  $\beta$ -particles from the radio nuclide are equal. Calculate their respective probabilities at  $t = 1620s$ . If at  $t = 0$ , total number of nuclei in the radio nuclide are  $N_0$ . Calculate the time  $t$  when total number of nuclei remained undecayed becomes equal to  $N_0/2$ .

$$\log_{10} 2 = 0.3010, \log_{10} 5.94 = 0.7742 \text{ and } x^4 + 4x - 2.5 = 0, x=0.594$$



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**32.** Find the amount of heat generated by 1 mg of  $Po^{210}$  preparation during the mean life period of these nuclei if the emitted alpha particles are known to possess kinetic energy 5.3 MeV and practically all daughter nuclei are formed directly in the ground state.



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33. In an agriculture experiment, a solution containing 1 mole of a radioactive material ( $t_{1/2} = 14.3 \text{ days}$ ) was injected into the roots of a plant. The plant was allowed 70 hours to settle down and then activity was measured in its fruit. If the activity measured was  $1 \mu\text{Ci}$  what per cent of activity is transmitted from the root to the fruit in steady state?



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### Exercise 34.1

1. The decay constant of a radioactive sample is  $\lambda$ . The half-life and the average-life of the sample are respectively

A. (a)  $1/\lambda$  and  $(\ln 2)/\lambda$

B. (b)  $(\ln 2)/\lambda$  and  $1/\lambda$

C. (c)  $\lambda(\ln 2)$  and  $1/\lambda$

D.  $\lambda/(\ln 2)$  and  $1/\lambda$



**Answer: B**



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2. Consider alpha particle ,  $\beta$  particle and  $\gamma$  - rays , each having an energy of  $0.5\text{MeV}$  . In increase order of penetrating power , the radiation are .

A. (a)  $\alpha, \beta, \gamma$

B. (b)  $\alpha, \gamma, \beta$

C. (c)  $\beta, \gamma, \alpha$

D. (d)  $\gamma, \beta, \alpha$

**Answer: A**



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3. Which of the following is a correct statement?

- A. (a) Beta rays are same as cathode rays
- B. (b) Gamma rays are high energy neutrons
- C. (c) Alpha particles are singly ionized helium atoms
- D. (d) Protons and neutrons have exactly the same mass

**Answer: A**



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**4. The electron emitted in beta radiation originates from**

- A. (a) inner orbits of atom
- B. (b) free electrons existing in nuclei
- C. (c) decay of a neutron in a nucleus
- D. (d) photon escaping from the nucleus

**Answer: C**



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5. During a negative beta decay,

- A. (a) an atomic electron is ejected
- B. (b) an electron which is already present within the nucleus is ejected
- C. (c) a neutron in the nucleus decays emitting an electron
- D. (d) a part of the binding energy of the nucleus is converted into a electron

**Answer: C**



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6. A freshly prepared radioactive source of half-life  $2h$  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 this source is

- A. (a) 6h
- B. (b) 12h
- C. (c) 24h
- D. (d) 128 h

**Answer: B**



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7. A radioactive sample  $S_1$  having an activity of  $5\mu Ci$  has twice the number of nuclei as another sample  $S_2$  which has an activity of  $10\mu Ci$ . The half-lives of  $S_1$  and  $S_2$  can be

- A. (a) 20 yr and 5 yr, respectively
- B. (b) 20 yr and 10 yr, respectively
- C. (c) 10 yr each
- D. (d) 5 yr each

**Answer: A**



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8. Half-life of a radioactive substance A is 4 days. The probability that a nuclear will decay in two half-lives is

A. (a)  $1/4$

B. (b)  $3/4$

C. (c)  $1/2$

D. (d) 1

**Answer: B**



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9. After 280 days, the activity of a radioactive sample is 6000 dps. The activity reduces to 3000 dps after another 140 days. The initial activity of

the sample in dps is

- A. (a) 6000
- B. (b) 9000
- C. (c) 3000
- D. (d) 24000

**Answer: D**



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**10.** The half-life of  $^{215}\text{At}$  is  $100\mu\text{s}$ . The time taken for the activity of a sample of  $^{215}\text{At}$  to decay to  $\frac{1}{16}$ th of its initial value is

- A. (a)  $400\mu\text{s}$
- B. (b)  $63\mu\text{s}$
- C. (c)  $40\mu\text{s}$
- D. (d)  $300\mu\text{s}$

**Answer: A**



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11. The half life of radioactive Radon is  $3.8\text{days}$  . The time at the end of which  $\frac{1}{20}th$  of the radon sample will remain undecayed is  
(*given*  $\log e = 0.4343$ )

A. (a) 3.8 days

B. (b) 16.5 days

C. (c) 33 days

D. (d) 76 days

**Answer: B**



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**12.** Activity of a radioactive substance decreases from 8000 Bq to 1000 Bq in 9 days. What is the half-life and average life of the radioactive substance?



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**13.** A radioactive substance has a half-life of 64.8 h. A sample containing this isotope has an initial activity ( $t = 0$ ) of  $40\mu Ci$ . Calculate the number of nuclei that decay in the time interval between  $t_1 = 10.0h$  and  $t_2 = 12.0h$ .



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**14.** A freshly prepared sample of a certain radioactive isotope has an activity of 10mCi. After 4.0h its activity is 8.00 mCi.

(a) Find the decay constant and half-life

How many atoms of the isotope were contained in the freshly prepared



sample?

(c) What is the sample's activity 30.0 h after it is prepared?



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**15.** A radioactive substance contains  $10^{15}$  atoms and has an activity of  $6.0 \times 10^{11}$  Bq. What is its half-life?



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**16.** Two radioactive elements X and Y have half-life periods of 50 minutes and 100 minutes, respectively. Initially, both of them contain equal number of atoms. Find the ratio of atoms left  $\frac{N_X}{N_Y}$  after 200 minutes.



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## Exercise 34.2

1. If a star can convert all the He nuclei completely into oxygen nuclei. The energy released per oxygen nuclei is (Mass of the helium nucleus is 4.0026 amu and mass of oxygen nucleus is 15.9994 amu)

- A. (a) 7.6 MeV
- B. (b) 56.12 MeV
- C. (c) 10.24 MeV
- D. (d) 23.4 MeV

**Answer: C**



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2. Fast neutrons can easily be slowed down by

- A. (a) the use of lead shielding
- B. (b) passing them through heavy water
- C. (c) elastic collisions with heavy nuclei

D. (d) applying a strong electric field

**Answer: B**



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**3.** During a nuclear fusion reaction,

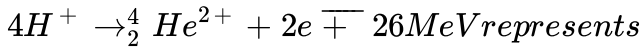
- A. (a) a heavy nucleus breaks into two fragments by itself
- B. (b) a light nucleus bombarded by thermal neutrons breaks up
- C. (c) a heavy nucleus bombarded by thermal neutrons breaks up
- D. (d) two light nuclei combine to give a heavier nucleus and possibly other products

**Answer: D**



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4. The equation



- A. (a)  $\beta$ -decay
- B. (b)  $\gamma$ -decay
- C. (c) fusion
- D. (d) fission

**Answer: C**



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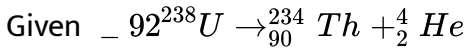
5. (a) How much mass is lost per day by a nuclear reactor operated at a  $10^9$  watt power level?

(b) If each fission releases 200 MeV, how many fissions occur per second to yield this power level?



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6. Find energy released in the alpha decay,



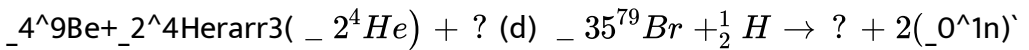
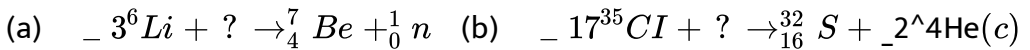
$$M({}_{92}^{238}\text{U}) = 238.050784\text{u}, M({}_{90}^{234}\text{Th}) = 234.043593\text{u}$$

$$M({}_2^4\text{He}) = 4.002602\text{u}$$



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7. Complete the nuclear reactions.



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8. Consider the reaction  ${}_1^2\text{H} + {}_1^2\text{H} \rightarrow {}_2^4\text{He} + Q$ . Mass of the deuterium atom =  $2.0141\text{u}$ . Mass of helium atom =  $4.0024\text{u}$ . This is a nuclear.....reaction in which the energy  $Q$  released is.....MeV.



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9. The binding energies per nucleon for deuteron ( ${}_1^2\text{H}$ ) and helium ( ${}_2^4\text{He}$ ) are  $1.1\text{ MeV}$  and  $7.0\text{ MeV}$  respectively. The ratio of the binding energy per nucleon of  ${}_2^4\text{He}$  to that of  ${}_1^2\text{H}$  is



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## Assertion And Reason

1. Assertion : Rate of radioactivity cannot be increased or decreased by increasing or decreasing pressure or temperature.

Reason : Rate depends on the number of nuclei present in the radioactive sample.

- A. (a) If both Assertion and Reason are true and Reason is correct explanation of the Assertion.
- B. (b) If both Assertion and Reason are true but Reason is not the correct explanation of Assertion.

C. (c) If Assertion is true, but the Reason is false.

D. (d) If Assertion is false but the Reason is true.

**Answer: B**



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2. Assertion : Only those nuclei which are heavier than lead are radioactive.

Reason : Nuclei of elements heavier than lead are unstable.

A. (a) If both Assertion and Reason are true and Reason is correct explanation of the Assertion.

B. (b) If both Assertion and Reason are true but Reason is not the correct explanation of Assertion.

C. (c) If Assertion is true, but the Reason is false.

D. (d) If Assertion is false but the Reason is true.

**Answer: D**



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**3. Assertion :** After emission of one  $\alpha$ -particle and two  $\beta$ -particles, atomic number remains unchanged.

**Reason :** Mass number changes by four.

- A. (a) If both Assertion and Reason are true and Reason is correct explanation of the Assertion.
- B. (b) If both Assertion and Reason are true but Reason is not the correct explanation of Assertion.
- C. (c) If Assertion is true, but the Reason is false.
- D. (d) If Assertion is false but the Reason is true.

**Answer: B**



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4. Assertion :  $\gamma$ -rays are produced by the transition of a nucleus from some higher energy state to some lower energy state.

Reason : Electromagnetic waves are always produced by the transition process.

A. (a) If both Assertion and Reason are true and Reason is correct explanation of the Assertion.

B. (b) If both Assertion and Reason are true but Reason is not the correct explanation of Assertion.

C. (c) If Assertion is true, but the Reason is false.

D. (d) If Assertion is false but the Reason is true.

**Answer: C**



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5. Assertion : During  $\beta$ -decay a proton converts into a neutron and an electron. No other particle is emitted.

Reason: During  $\beta$ -decay linear momentum of system should remain constant.

A. (a) If both Assertion and Reason are true and Reason is correct explanation of the Assertion.

B. (b) If both Assertion and Reason are true but Reason is not the correct explanation of Assertion.

C. (c) If Assertion is true, but the Reason is false.

D. (d) If Assertion is false but the Reason is true.

**Answer: D**



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**6. Assertion :** If we compare the stability of two nuclei, then that nucleus is more stable whose total binding energy is more.

**Reason:** More the mass defect during formation of a nucleus more will be the binding energy.

A. (a) If both Assertion and Reason are true and Reason is correct explanation of the Assertion.

B. (b) If both Assertion and Reason are true but Reason is not the correct explanation of Assertion.

C. (c) If Assertion is true, but the Reason is false.

D. (d) If Assertion is false but the Reason is true.

**Answer: D**



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7. Assertion : In a nuclear process energy is released if total binding energy of daughter nuclei is more than the total binding energy of parent nuclei.

Reason: If energy is released then total mass of daughter nuclei is less than the total mass of parent nuclei.

A. (a) If both Assertion and Reason are true and Reason is correct explanation of the Assertion.

B. (b) If both Assertion and Reason are true but Reason is not the correct explanation of Assertion.

C. (c) If Assertion is true, but the Reason is false.

D. (d) If Assertion is false but the Reason is true.

**Answer: A::B**



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8. Assertion : Binding energy per nucleon is of the order of MeV.

Reason:  $1\text{MeV} = 1.6 \times 10^{-13}\text{J}$ .

- A. (a) If both Assertion and Reason are true and Reason is correct explanation of the Assertion.
- B. (b) If both Assertion and Reason are true but Reason is not the correct explanation of Assertion.
- C. (c) If Assertion is true, but the Reason is false.
- D. (d) If Assertion is false but the Reason is true.

**Answer: B**



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9. Assertion : 1 amu is equal to 931.48 MeV.

Reason: 1 amu is equal to 1/12th the mass of  $C^{12}$  atom.

- A. (a) If both Assertion and Reason are true and Reason is correct explanation of the Assertion.
- B. (b) If both Assertion and Reason are true but Reason is not the correct explanation of Assertion.
- C. (c) If Assertion is true, but the Reason is false.
- D. (d) If Assertion is false but the Reason is true.

**Answer: D**



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**10.** Assertion: Between  $\alpha$ ,  $\beta$  and  $\gamma$  radiations, penetrating power of  $\gamma$ -rays is maximum.

Reason : Ionising power of  $\gamma$ -rays is least.

- A. (a) If both Assertion and Reason are true and Reason is correct explanation of the Assertion.

B. (b) If both Assertion and Reason are true but Reason is not the correct explanation of Assertion.

C. (c) If Assertion is true, but the Reason is false.

D. (d) If Assertion is false but the Reason is true.

**Answer: B**



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**11. Assertion:** The nuclear energy can be obtained by the nuclear fission of heavier nuclei as well as by fusion of lighter nuclei.

**Reason:** As the mass number increases, the binding energy per nucleon, first increases and then decreases.

A. (a) If both Assertion and Reason are true and Reason is correct explanation of the Assertion.

B. (b) If both Assertion and Reason are true but Reason is not the correct explanation of Assertion.

C. (c) If Assertion is true, but the Reason is false.

D. (d) If Assertion is false but the Reason is true.

**Answer: A::B**



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### Level 1 Subjective Questions

1. The half-lives of radio isotopes  $P^{32}$  and  $P^{33}$  are 14 days and 28 days respectively. These radioisotopes are mixed in the ratio of 4:1 of their atoms. If the initial activity of the mixed sample is 3.0 mCi, find the activity of the mixed isotopes after 60 years.



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**for JEE MAIN**



1. When a metallic surface is illuminated with light of wavelength  $\lambda$ , the stopping potential is  $V$ . the same surface is illuminated by light of wavelength  $2\lambda$  the stopping potential is  $\frac{V}{3}$  The threshold wavelength for the surface is

A.  $\frac{4\lambda}{3}$

B.  $4\lambda$

C.  $6\lambda$

D.  $\frac{8\lambda}{3}$

**Answer: B**



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2. The de Broglie wavelength of an electron moving with a velocity of  $1.5 \times 10^8 \text{ ms}^{-1}$  is equal to that of a photon find the ratio of the kinetic energy of the photon to that of the electron.

A. 2

B. 4

C.  $\frac{1}{2}$

D.  $\frac{1}{4}$

**Answer: D**



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3. Let  $p$  and  $E$  denote the linear momentum and energy of a photon. If the wavelength is decreased,

A. both  $p$  and  $E$  increase

B.  $p$  increase and  $E$  decreases

C.  $p$  decrease and  $E$  increases

D. both  $p$  and  $E$  decreases

**Answer: A**

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4. The de Broglie wavelength of a neutron corresponding to root mean square speed at  $927^{\circ}$  is  $\lambda$ . What will be the de Broglie wavelength of the neutron corresponding to root mean square speed at  $27^{\circ}C$ ?

A.  $\frac{\lambda}{2}$

B.  $\lambda$

C.  $2\lambda$

D.  $4\lambda$

**Answer: C**

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5. If an orbital electron of the hydrogen atom jumps from the ground state to a higher energy state, its orbital value where its velocity is reduced to

half its initial value.. If the radius of the electron orbit in the ground state is  $r$ , then the radius of the new orbit would be:

A.  $2r$

B.  $4r$

C.  $8r$

D.  $16r$

**Answer: B**



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6. If a hydrogen atom at rest, emits a photon of wavelength  $\lambda$ , the recoil speed of the atom of mass  $m$  is given by :

A.  $\frac{h}{\lambda}$

B.  $\frac{mh}{\lambda}$

C.  $mh\lambda$

D.  $\frac{h\lambda}{m}$

**Answer: A**



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7. Two particles of masses  $m$  and  $2m$  have equal kinetic energies. Their de Broglie wavelengths are in the ratio of:

A.  $1:1$

B.  $1:2$

C.  $1:\sqrt{2}$

D.  $\sqrt{2}:1$

**Answer: D**



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8. The binding energy of nuclei X and Y are  $E_1$  and  $E_2$ , respectively. Two atoms of X fuse to give one atom of Y and an energy  $Q$  is released. Then,

A.  $Q = 2E_1 - E_2$

B.  $Q = E_2 - 2E_1$

C.  $Q < 2E_1 - E_2$

D.  $Q > E_2 - 2E_1$

**Answer: B**



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9.  $A \xrightarrow{\lambda} B \xrightarrow{2\lambda} C$

$T = 0N_0, 0, 0$

$T = N_1 N_2 N_3$

The ratio of  $N_1$  to  $N_2$  is maximum if

A.  $\frac{2}{\ln 2}$

B. 2

C. 0.5

D.  $\frac{\ln 2}{2}$

**Answer: B**



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10. The graph of  $\ln\left(\frac{R}{R_0}\right)$  versus  $\ln A$  ( $R = \text{radius}$  of a nucleus and  $A = \text{its mass number}$ ) is

A. a straight line

B. a parabola

C. and ellipse

D. a circle

**Answer: A**



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11. When a  $\beta^-$  particle is emitted from a nucleus, the neutrons-proton ratio:

- A. is decreased
- B. is increased
- C. remains the same
- D. may increase or decrease

**Answer: A**



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12. Radiation of two photons having energies twice and five times the work function of a metal are incident successively on the metal surface. The ratio of the maximum velocity of photoelectrons emitted in the two cases will be



A. 1:2

B. 2:1

C. 1:4

D. 4:1

**Answer: A**



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**13.** Cut off potential for a metal in photoelectric effect for light of wavelength  $\lambda_1$ ,  $\lambda_2$  and  $\lambda_3$  is found to be  $V_1$ ,  $V_2$  and  $V_3$  volts, If  $V_1$ ,  $V_2$  and  $V_3$  are in Arithmetic progression then  $\lambda_1$ ,  $\lambda_2$  and  $\lambda_3$  will be in

A. Arithmetic progression

B. Geometric progression

C. Harmonic progression

D. None of these

**Answer: C**



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14. Photons with energy  $5eV$  are incident on a cathode  $C$  in a photoelectric cell . The maximum energy of emitted photoelectrons is  $2eV$ . When photons of energy  $6eV$  are incident on  $C$  , no photoelectrons will reach the anode  $A$  , if the stopping potential of  $A$  relative to  $C$  is

A. 5

B. 3 V

C. 1 V

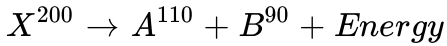
D. 4 V

**Answer: B**



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15. Consider the following nuclear reaction,



If the binding energy per nucleon for X, A and B are  $7.4\text{MeV}$ ,  $8.2\text{MeV}$  and  $8.2\text{MeV}$  respectively, the energy released will be

A. 200 MeV

B. 160 MeV

C. 110 MeV

D. 90 MeV

**Answer: B**



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16. The activity of a sample reduces from  $A_0$  to  $\frac{A_0}{\sqrt{3}}$  in one hour. The activity after 3 hours more will be

A.  $\frac{A_0}{3\sqrt{3}}$

B.  $\frac{A_0}{9}$

C.  $\frac{A_0}{9\sqrt{3}}$

D.  $\frac{A_0}{27}$

**Answer: B**



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17. The number of  $\alpha$  and  $\beta^-$  emitted during the radioactive decay chain starting from  ${}^{88}_{226}\text{Ra}$  and ending at  ${}^{82}_{206}\text{Pb}$  is

A.  $3\alpha$  and  $6\beta^-$

B.  $4\alpha$  and  $5\beta^-$

C.  $5\alpha$  and  $4\beta^-$

D.  $6\alpha$  and  $6\beta^-$

**Answer: C**



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18. The wavelength of the  $K_{\alpha}$  line for an element of atomic number 57 is  $\lambda$ . What is the wavelength of the  $K_{\alpha}$  line for the element of atomic number 29?

- A.  $\lambda$
- B.  $2\lambda$
- C.  $4\lambda$
- D.  $8\lambda$

**Answer: C**



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19. There are two radioactive substances  $A$  and  $B$ . Decay constant of  $B$  is two times that of  $A$ . Initially, both have equal number of nuclei. After  $n$  half-lives of  $A$ , rates of disintegration of both are equal. The value of  $n$  is

.

A. 1

B. 2

C. 4

D. None of these

**Answer: A**



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**20.** A radioactive nucleus A finally transforms into a stable nucleus. B Then A and B can be

A. isobars

B. isotones

C. isotopes

D. None of these

**Answer: C**

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21. If  ${}_{92}U^{238}$  changes to  ${}_{85}At^{210}$  by a series of  $\alpha$ -and  $\beta$  -decays, the number of  $\alpha$  and  $\beta$ -decays undergone is .

A. 7 and 5

B. 7 and 7

C. 5 and 7

D. 7 and 9

**Answer: B**

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22. Number of nuclei of a radioactive substance are 1000 and 900 at times  $t = 0$  and time  $t = 2s$ . Then, number of nuclei at time  $t = 4s$  will be

A. 8000

B. 810

C. 790

D. 700

**Answer: B**



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**23.** In a sample of a radioactive substance, what fraction of the initial nuclei will remain undecayed after a time  $t = T/2$ , where  $T$ =half-life of radioactive substance?

A.  $\frac{1}{\sqrt{2}}$

B.  $\frac{1}{2\sqrt{2}}$

C.  $\frac{1}{4}$

D.  $\frac{1}{\sqrt{2}-1}$

**Answer: A**



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24. Magnetic moment of an electron in  $n$ th orbit of hydrogen atom is

A.  $n$

B.  $n^0$

C.  $n^5$

D.  $n^3$

**Answer: A**

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25. An electron in  $n$ th excited state in a hydrogen atom comes down to first excited state by emitting ten different wavelengths. Find value of  $n$  (an integer).

A. 6

B. 7

C. 8

D. 9

**Answer: A**



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**26.** The angular momentum of an electron in an orbit is quantized because it is a necessary condition for the compatibility with

A. the wave nature of electron

B. particle nature of electron

C. Pauli exclusion behaviour

D. None of these

**Answer: A**



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27. Find the maximum angular speed of the electron of a hydrogen atoms in a statoonary orbit

A.  $6.2 \times 10^5 \text{ rad/s}$

B.  $4.1 \times 10^{16} \text{ rad/s}$

C.  $2.4 \times 10^{10} \text{ rad/s}$

D.  $9.2 \times 10^{10} \text{ rad/s}$

**Answer: B**



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28. In hydrogen and hydrogen-like atom , the ratio of  $E_{4n} - E_{2n}$  and  $E_{2n} - E_n$  varies with atomic nimber  $z$  and principal quantum number  $n$  as

A.  $\frac{Z^2}{N^2}$

B.  $\frac{Z^4}{n^4}$

C.  $\frac{Z}{n}$

D. None of these

**Answer: D**



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**29.** The ratio of the maximum wavelength of the Lyman series in hydrogen spectrum to the maximum wavelength in the Panchen series is

A.  $\frac{3}{105}$

B.  $(6)(15)$

C.  $\frac{52}{7}$

D.  $\frac{7}{108}$

**Answer: D**



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30. When an electron in the hydrogen atom in ground state absorb a photon of energy  $12.1\text{eV}$ , its angular momentum

- A. decreases by  $2.11 \times 10^{-34} \text{J} - \text{s}$
- B. decreases by  $1.055 \times 10^{-34} \text{J} - \text{s}$
- C. increase by  $2.11 \times 10^{-34} \text{J} - \text{s}$
- D. increase by  $1.055 \times 10^{-34} \text{J} - \text{s}$

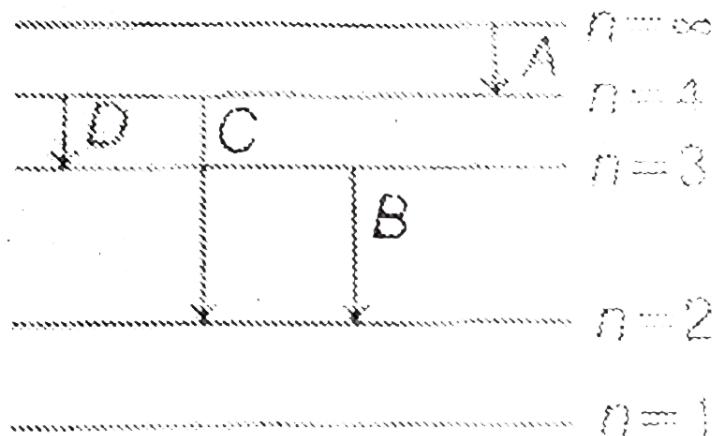
**Answer: C**



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31. Consider the electron energy level diagram of H-atom Photons associated with shortes and longest wavelength would be emitted from

the atom by the transitions labeled



A. D and C respectively

B. C and A respectively

C. C and D respectively

D. A and C respectively

**Answer: C**



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32. In a characteristic X-ray spectra of some atom superimposed on continuous X-ray spectra :



- A. P represents  $K_{\alpha}$  line
- B. Q represents  $K_{\beta}$  line
- C. Q and P represent  $K_{\alpha}$  and  $K_{\beta}$  lines respectively
- D. Q and P represent  $K_{\alpha}$  and  $K_{\beta}$  lines respectively

**Answer: C**



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33. What is the probability of a radioactive nucleus to survive one mean life?

A.  $\frac{1}{e}$

B.  $1 - \frac{1}{e}$

C.  $\frac{\ln 2}{e}$

D.  $1 - \frac{\ln 2}{e}$

**Answer: A**



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**34.** The activity of a radioactive substance is  $R_1$  at time  $t_1$  and  $R_2$  at time  $t_2$  ( $t_2 > t_1$ ). Its decay constant is  $\lambda$ . Then .

A.  $R_1 t_1 = R_2 t_2$

B.  $R_1 = R_2 e^{-(\lambda t_1 - t_2)}$

C.  $\frac{R_1 - R_2}{t_2 - t_1} = \text{constant}$

D.  $R_2 = R_1 e^{\lambda(t_2 - t_1)}$

**Answer: B**



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35. The activity of a radioactive substance is  $R_1$  at time  $t_1$  and  $R_2$  at time  $t_2 (> t_1)$ . its decay constant is  $\lambda$ . Then, number of atoms decayed between time interval  $t_1$  and  $t_2$  are

A.  $\frac{\ln(2)}{\lambda}(R_1 - R_2)$

B.  $R_1 e^{-\lambda t_1} - R_2 e^{-\lambda t_2}$

C.  $\lambda(R_1 - R_2)$

D.  $\left( \frac{R_1 - R_2}{\lambda} \right)$

**Answer: D**



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36.  $N_1$  atoms of a radioactive element emit  $N_2$  beta particles per second.

The decay constant of the element is (in  $s^{-1}$ )

A.  $\frac{N_1}{N_2}$

B.  $\frac{N_2}{N_1}$

C.  $N_1 \ln(2)$

D.  $N_2 \ln(2)$

**Answer: B**



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**37.** According to Bohr's theory, the time averaged magnetic field at the centre (i.e. nucleus) of a hydrogen atom due to the motion of electrons in the  $n$ th orbit is proportional to : ( $n$  = principal quantum number)



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**38.** The binding energy of an electron in the ground state of He is equal to 24.6eV. The energy required to remove both the electron is

A.  $24.6\text{eV}$

B.  $49.2\text{eV}$

C.  $79eV$

D.  $38.2eV$

**Answer: C**



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**39.** A  $\gamma$ -ray photon is emitted

A. (a) after ionization of an atom

B. (b) due to conversion of a neutron into a neutron in the nucleus

C. (c) after de-excitation of a nucleus

D. (d) due to conversion of a proton into a neutron in the nucleus

**Answer: C**



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40. Angular momentum ( $L$ ) and radius ( $r$ ) of a hydrogen atom are related as

A.  $Lr = \text{constant}$

B.  $Lr^2 = \text{constant}$

C.  $L^4 = \text{constant}$

D. None of these

**Answer: D**



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41.  ${}_{92}^{235}\text{U}$  nucleus absorbs a slow neutron and undergoes fission into  ${}_{54}^{139}\text{X}$  and  ${}_{38}^{94}\text{Sr}$  nuclei. The other particles produced in this fission process are

A.  $1\beta$  and  $1\alpha$

B.  $2\beta$  and 1 neutron

C. 2 neutrons

D. 3 neutrons

**Answer: B**



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**42.** The ratio of de-Broglie wavelength of molecules of hydrogen and helium gas moving at rms speed in two gas jars kept separately at temperature  $37^\circ \text{C}$  and  $127^\circ \text{C}$  respectively is :

A.  $\frac{2}{\sqrt{3}}$

B.  $\sqrt{\frac{2}{3}}$

C.  $\frac{\sqrt{3}}{2}$

D.  $\sqrt{\frac{8}{3}}$

**Answer: D**



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43. The rest mass of a deuteron is equivalent to an energy of  $1876\text{MeV}$ , that of a proton to  $939\text{MeV}$ , and that of a neutron to  $940\text{MeV}$ . A deuteron may disintegrate to a proton and neutron if

- A. emits a X-ray photon of energy  $2\text{MeV}$
- B. captures a X-ray photon of energy  $2\text{MeV}$
- C. emits a X-ray photon of energy  $3\text{MeV}$
- D. captures a X-ray photon energy  $3\text{MeV}$

**Answer: D**



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44. Consider a hydrogen-like atom whose energy in  $n$ th excited state is given by

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

When this excited makes a transition from excited state to ground state ,

most energetic photons have energy

$E_{\max} = 52.224\text{eV}$ . and least energetic photons have energy

$E_{\min} = 1.224\text{eV}$

Find the atomic number of atom and the initial state or excitation.



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**45.** An electron in a Bohr orbit of hydrogen atom with quantum number  $n$  has an angular momentum  $4.2176 \times 10^{-34} \text{ kg} - \text{m}^2 / \text{sec}$ . If the electron drops from this level to the next lower level, the wavelength of this line is

A.  $5.86\text{\AA}$

B.  $3.26\text{\AA}$

C.  $4.66\text{\AA}$

D.  $4.77\text{\AA}$

**Answer: D**



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46. Two identical photocathode receive light of frequencies  $f_1$  and  $f_2$ . If the maximum velocities of the photoelectrons (of mass  $m$ ) coming out are respectively  $v_1$  and  $v_2$  then:

A.  $v_1 - v_2 = \left[ \frac{2h}{m}(f_1 - f_2) \right]^{1/2}$

B.  $v_1^2 - v_2^2 = \frac{2h}{m}(f_1 - f_2)$

C.  $v_1 + v_2 = \left[ \frac{2h}{m}(f_1 - f_2) \right]^{1/2}$

D.  $v_1^2 + v_2^2 = \frac{2h}{m}(f_1 - f_2)$

**Answer: B**



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47. Assuming that about  $20MeV$  of energy is released per fusion reaction

${}_1^2H + {}_1^3H \rightarrow {}_0^1n + {}_2^4He$ , the mass of  ${}_1^2H$  consumed per day in

a future fusion reactor of power  $1MW$  would be approximately



A.  $0.001g$

B.  $0.2g$

C.  $10.0g$

D.  $2g$

**Answer: B**



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**48.** In a Coolidge tube, the potential difference used to accelerate the electrons is increased from  $12.4kV$  to  $24.8kV$ . As a result, the difference between the wavelengths of  $K_{\alpha}$ -line and minimum wavelength becomes thrice. The wavelength of the  $K_{\alpha}$  line is  $0.25 \times KA^{\circ}$ . Find the value of  $K$ .

$$\frac{hc}{e} = (12.4KVA^{\circ})$$



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49. The half-life of  $^{238}_{92}\text{U}$  undergoing  $\alpha$ -decay is  $4.5 \times 10^9$  years. What is the activity of 1g sample of  $^{238}_{92}\text{U}$

A.  $3.89 \times 10^{11} \text{ Bq}$

B.  $3.89 \times 10^8 \text{ Bq}$

C.  $1.23 \times 10^4 \text{ Bq}$

D.  $1.23 \times 10^5 \text{ Bq}$

**Answer: C**



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50. Positron is the antiparticle of an electron .It has the same mass as an electron but the opposite charge An electron and a positron moving towards each other with equal and opposite velocities.

A. can annihilate into one photon. Conserving both energy and momentum

B. cannot annihilate into one photon because energy cannot be conserved

C. cannot annihilate into one photon because momentum cannot be conserved

D. cannot annihilate into one photon because charge cannot be conserved

**Answer: C**



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51. Ratio of the de Broglie wavelength of molecules of helium and hydrogen at temperature  $27^{\circ}\text{C}$  and  $327^{\circ}\text{C}$  respectively is

A. (a) 2

B. (b) 1

C. (c) 3

D. (d) 4

**Answer: B**



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52. An element A decays into an element C by a two step process

$A \rightarrow B + {}_2\text{He}^4$  and  $B \rightarrow C + 2e^-$ . Then,

A. A and C are isotopes

B. A and C are isobars

C. B and C are isotopes

D. A and B are isobars

**Answer: A**



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53. Consider the following energies

(1) The minimum energy needed to excite a hydrogen atom from its ground state  $= E_1$

(2) Energy needed to ionize a hydrogen atom from ground state  $= E_2$

(3) Energy released in  $^{235}\text{U}$  - fission  $= E_3$

(4) Energy needed to remove a neutron from a  $^{12}\text{C}_{\text{nucleus}} = E_4$

A.  $E_1 < E_2 < E_3 < E_4$

B.  $E_1 < E_3 < E_2 < E_4$

C.  $E_1 < E_2 < E_4 < E_3$

D.  $E_2 < E_1 < E_4 < E_3$

**Answer: C**



**Watch Video Solution**

54. Suppose the potential energy between electron and proton at a distance

$r$  is given by  $U = -\frac{Ke^2}{3r^3}$  Assuming Bohr's Model to be valid for this

atom if the speed of electron in  $n^{th}$  orbit depends on the principal quantum number  $n$  as  $v \propto n^x$  then find the value of  $x$ .

A. 1

B. 2

C. 3

D. 4

**Answer: C**



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**55.** Half lives of two isotopes X and Y of a material are known to be  $2 \times 10^9$  years and  $4 \times 10^9$  years respectively if a planet was formed with equal number of these isotopes, then the current age of planet, given that currently the material has 20 % of X and 80 % of Y by number, will be:

A.  $8 \times 10^9$  years

B.  $6 \times 10^9$  years

C.  $4 \times 10^9$  years

D.  $2 \times 10^9$  years

**Answer: A**



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**for JEE Advanced (only one option is Correct)**

1. A radioactive substance is being consumed at a constant of  $1s^{-1}$ . After what time will the number of radioactive nuclei become 100. Initially, there were 200 nuclei present.

A. 1 s

B.  $\frac{1}{\ln(2)}s$

C.  $\ln(2)s$

D. 2 s

**Answer: C**



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2. A radioactive isotope is being produced at a constant rate  $X$ . Half-life of the radioactive substance is  $Y$ . After some time, the number of radioactive nuclei become constant. The value of this constant is .

A.  $\frac{XY}{\ln(2)}$

B.  $XY$

C.  $(XY) \ln(2)$

D.  $\frac{X}{Y}$

**Answer: A**



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3. A radioactive substance  $X$  decays into another radioactive substance  $Y$ . Initially, only  $X$  was present.  $\lambda_x$  and  $\lambda_y$  are the disintegration constant of  $X$  and  $Y$ .  $N_y$  will be maximum when.

A.  $\frac{N_y}{N_x - N_y} = \frac{\lambda_y}{\lambda_x - \lambda_y}$

B.  $\frac{N_x}{N_x - N_y} = \frac{\lambda_x}{\lambda_x - \lambda_y}$

C.  $\lambda_y N_y = \lambda_x \lambda_x$

D.  $\lambda_y N_x = \lambda_y \lambda_x$

**Answer: C**



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4. Half-life of a radioactive substance  $A$  is two times the half-life of another radioactive substance  $B$ . Initially, the number of  $A$  and  $B$  are  $N_A$  and  $N_B$ , respectively. After three half-lives of  $A$ , number of nuclei of both are equal. Then, the ratio  $N_A / N_B$  is .

A.  $1/4$

B.  $1/8$

C.  $1/3$

D.  $1/6$

**Answer: B**



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5. The kinetic energy of an electron is  $E$  when the incident wavelength is  $\lambda$

To increase the KE of the electron to  $2E$ , the incident wavelength must be

A.  $2\lambda$

B.  $\lambda/2$

C.  $\frac{(hc\lambda)}{(E\lambda + hc)}$

D.  $\frac{(hc\lambda)}{(E\lambda - hc)}$

**Answer: C**

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6. 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

**Answer: B**

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7. The shortest wavelength of the Brackett series of a hydrogen-like atom (atomic number of  $Z$  ) 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

**Answer: A**



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8. According to Bohr's theory of hydrogen atom , the product of the binding energy of the electron in the  $n$ th orbit and its radius in the  $n$ th orbit

A. is proportional to  $n^2$

B. is inversely proportional to  $n^3$

C. has a constant value of  $10.2 \text{ eV-}\text{\AA}$

D. has a constant value of  $7.2 \text{ eV} - \text{\AA}$

**Answer: D**



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9. An electron and a photon have same wavelength . If  $p$  is the moment of electron and  $E$  the energy of photons, the magnitude of  $p/E$  in S I unit is

A.  $3.0 \times 10^8$

B.  $3.33 \times 10^{-9}$

C.  $9.1 \times 10^{-31}$

D.  $6.64 \times 10^{-34}$

**Answer: B**



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10. In X-ray tube , when the accelerating voltage  $V$  is halved, the difference between the wavelength of  $K_{\alpha}$  line and minimum wavelength of continuous X-ray spectrum

- A. remains constant
- B. becomes more than two times
- C. becomes half
- D. becomes less than two times

**Answer: D**



**Watch Video Solution**

11. If  $K_1$  and  $K_2$  are maximum kinetic energies of photoelectrons emitted when light of wavelength  $\lambda_1$  and  $\lambda_2$  respectively are incident on a metallic surface. If  $\lambda_1 = 3\lambda_2$  then

- A.  $2K_1 = K_2$

B.  $K_1 = 2K_2$

C.  $K_1 < \frac{K_2}{3}$

D.  $K_1 < 2K_2$

**Answer: C**



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**12.** The binding energy per nucleon number for deuteron  $H_1^2$  and helium  $He_2^4$  are  $1.1MeV$  and  $7.0MeV$  respectively . The energy released when two deuterons fuse to form a helium nucleus  $He_2^4$  is .....

A.  $20.8MeV$

B.  $16.6MeV$

C.  $25.2MeV$

D.  $23.6MeV$

**Answer: D**

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13. A particle of mass  $3m$  at rest decays into two particles of masses  $m$  and  $2m$  having non-zero velocities. The ratio of the de Broglie wavelengths of the particles  $\left(\frac{\lambda_1}{\lambda_2}\right)$  is

A.  $\frac{1}{2}$

B.  $\frac{1}{4}$

C. 2

D. None of these

**Answer: D**

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14. A potential difference of  $10^3$  V is applied across an X-ray tube. The ratio of the de-Broglie wavelength of X-rays produced is



A.  $\frac{1}{20}$

B.  $1/100$

C. 1

D.  $1/10^4$

**Answer: C**



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**15.** de-Broglie wavelength of an electron in the  $n$ th Bohr orbit is  $\lambda_n$  and the angular momentum is  $J_n$  then

A.  $J_n \propto \lambda_n$

B.  $\lambda_n \propto \frac{1}{J_n}$

C.  $\lambda_n \propto J_n^2$

D. None of these

**Answer: A**

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16. The angular momentum of an electron in the hydrogen atom is  $\frac{3h}{2\pi}$

Here,  $h$  is Planck's constant. The kinetic energy of this electron is

A.  $4.35eV$

B.  $1.51eV$

C.  $3.4eV$

D.  $6.8eV$

**Answer: B**

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17. In a hydrogen atom, the binding energy of the electron in the ground state is  $E_1$  then the frequency of revolution of the electron in the  $n$ th orbit is

A.  $2E_1 / nh$

B.  $2E_1 n / h$

C.  $E_1 / nh$

D.  $E_1 n / h$

**Answer: A**



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**18.** A radioactive material of half-life  $T$  was kept in a nuclear reactor at two different instants. The quantity kept second time was twice of the kept first time. If now their present activities are  $A_1$  and  $A_2$  respectively, then their age difference equals

A.  $\lambda_1 = \lambda_2$

B.  $\lambda_1 > \lambda_2$

C.  $\lambda_1 < \lambda_2$

D.  $\lambda_1 > \lambda_2$  or  $\lambda_1 < \lambda_2$

**Answer: D**



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**19.** A radioactive material of half-life  $T$  was kept in a nuclear reactor at two different instants. The quantity kept second time was twice of the kept first time. If now their present activities are  $A_1$  and  $A_2$  respectively, then their age difference equals

A.  $\frac{T}{\ln 2} \left| \ln. \frac{2A_1}{A_2} \right|$

B.  $T \left| \ln. \frac{2A_1}{A_2} \right|$

C.  $\frac{T}{\ln 2} \left| \ln. \frac{A_1}{2A_2} \right|$

D.  $T \left| \ln. \frac{A_2}{2A_1} \right|$

**Answer: C**



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20. One of the lines in the emission spectrum of  $Li^{2+}$  has the same wavelength as that of the second line of Balmer series in hydrogen spectrum. The electronic transition corresponding to this line is.

A.  $12 \rightarrow 9$

B.  $12 \rightarrow 6$

C.  $4 \rightarrow 3$

D.  $6 \rightarrow 3$

**Answer: B**



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21. different between  $n$ th and  $(n + 1)$ th Bohr's radius of hydrogen atom is equal to  $(n = 1)$ th Bohr's radius. The value of  $n$  is

A. 1

B. 2

C. 3

D. 4

**Answer: D**



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**22.** When a hydrogen atom emits a photon in going from  $n=5$  to  $n=1$ , its recoil speed is almost

A. 4 m/s

B. 800 m/s

C. 3mm/s

D. 01.  $mm/s$

**Answer: A**



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23. There are two radio nuclei  $A$  and  $B$ .  $A$  is an  $\alpha$  emitter and  $B$  a  $\beta$  emitter. Their disintegration constants are in the ratio of 1:2. What should be the ratio of number of atoms of  $A$  and  $B$  at any time  $t$  so that probabilities of getting alpha and beta particles are same at that instant?

A. 2:1

B. 1:2

C.  $e$

D.  $e^{-1}$

**Answer: A**



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24. A radioactive element  $X$  converts into another stable element  $Y$ . Half-life of  $X$  is  $2h$ . Initially, only  $X$  is present. After time  $t$ , the ratio of atoms of  $X$  and  $Y$  is found to be 1:4. Then  $t$  in hours is .

A. 2

B. 4

C. between 4 and 6

D. 4

**Answer: C**



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25. A radioactive nucleus is being produced at a constant rate  $\alpha$  per second. Its decay constant is  $\lambda$ . If  $N_0$  are the number of nuclei at time  $t = 0$ , then maximum number of nuclei possible are .

A.  $\frac{\alpha}{\lambda}$

B.  $N_0 + \frac{\alpha}{\lambda}$

C.  $N_0$

D.  $\frac{\lambda}{\alpha} + N_0$

**Answer: A**



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26. The ratio of molecular mass of two radioactive substances is  $3/2$  and the ratio of their decay constant is  $4/3$ . Then, the ratio of their initial activity per mole will be

A. 2

B.  $\frac{8}{9}$

C.  $\frac{4}{3}$

D.  $\frac{9}{8}$

**Answer: C**

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27. A radioactive source in the form of a metal sphere of diameter  $3.2 \times 10^{-3}$  m emits  $\beta$ -particle at a constant rate of  $6.25 \times 10^{10}$  particle/sec. The

source is electrically insulated and all the  $\beta$ -particle are emitted from the surface. The potential of the sphere will rise to 1 V in time

A.  $180\mu s$

B.  $90\mu s$

C.  $18\mu s$

D.  $9\mu s$

**Answer: C**



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**28.** A hydrogen atom is in excited state of principal quantum number  $n$ .

It emits a photon of wavelength  $\lambda$  when it returns to the ground state.

The value of  $n$  is

A.  $\sqrt{\lambda R(\lambda R - 1)}$

B.  $\sqrt{\frac{\lambda R - 1}{\lambda}}$

C.  $\sqrt{\frac{\lambda}{\lambda R - 1}}$

D.  $\sqrt{\lambda(R - 1)}$

**Answer: C**



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**29.** A neutron moving with a speed  $v$  makes a head-on collision with a hydrogen in ground state kept at rest which inelastic collision will take place is (assume that mass of photon is nearly equal to the mass of neutron)

A.  $10.2\text{eV}$

B.  $20.4\text{eV}$

C.  $12.1\text{eV}$

D.  $16.8\text{eV}$

**Answer: B**



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30. At  $t=0$ , light of intensity  $10^{12}$  photons/ $s - m^2$  of energy  $6\text{eV}$  per photon starts falling on a plate with work function  $2.5\text{eV}$ . If area of the plate is  $2 \times 10^{-4}\text{m}^2$  and for every  $10^5$  photons one photoelectron is emitted, charge on the plate at  $t=25\text{ s}$  is

A.  $8 \times 10^{-15}\text{C}$

B.  $4 \times 10^{-14}\text{C}$

C.  $12 \times 10^{-10}\text{C}$

D.  $16 \times 10^{-12}\text{C}$

**Answer: A**



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31. The radius of the second orbit of an electron in hydrogen atom is  $2.116\text{\AA}$ . The de Broglie wavelength associated with this electron in this orbit would be

A.  $6.64\text{\AA}$

B.  $1.058\text{\AA}$

C.  $2.116\text{\AA}$

D.  $13.28\text{\AA}$

**Answer: A**



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**32.** The de-Broglie wavelength of electron in ground state of an hydrogen atom is

A.  $1.06\text{\AA}$

B.  $1.52\text{\AA}$

C.  $0.53\text{\AA}$

D.  $3.33\text{\AA}$

**Answer: D**

33. Radius of an electron moving in a circle in constant magnetic field is two times that of an  $\alpha$  particle in the same field. Then de-Broglie wavelength of electrons is x-times of the  $\alpha$ -particle Here x is

A. 2

B.  $\frac{1}{2}$

C. 1

D. 4

**Answer: C**

34. An electrons of a stationary hydrogen aton passes form the fifth enegy level to the ground level. The velocity that the atom acquired as a result of photon emission will be

( $m$  is the mass of the electron,  $R$ , Rydberg constant and  $h$ , Planck's constant)

A.  $\frac{25m}{24hR}$

B.  $\frac{24}{25hR}$

C.  $\frac{24hR}{25m}$

D.  $\frac{25hR}{24m}$

**Answer: C**



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**35.** An electron and a proton are separated by a large distance and the electron approaches the proton with a kinetic energy of 2 eV. If the electron is captured by the proton to form a hydrogen atom in the ground state, what wavelength photon would be given off?

A.  $1262.2\text{\AA}$

B.  $793.3\text{\AA}$

C.  $1204.6\text{\AA}$

D.  $942.6\text{\AA}$

**Answer: B**



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**36.** Two separate monochromatic light beams  $A$  and  $B$  of the same intensity (energy per unit area per unit time) are falling normally on a unit area of a metallic surface. Their wavelength are  $\lambda_A$  and  $\lambda_B$  respectively. Assuming that all the the incident light is used in ejecting the photoelectrons, the ratio of the number of photoelectrons from beam  $A$  to that from  $B$  is

A.  $\left(\frac{\lambda_A}{\lambda_B}\right)$

B.  $\left(\frac{\lambda_B}{\lambda_A}\right)$

C.  $\left(\frac{\lambda_B}{\lambda_A}\right)^2$

D.  $\left(\frac{\lambda_A}{\lambda_B}\right)^2$



**Answer: A**



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37. In the Bohr model of a hydrogen atom, the centripetal force is furnished by the Coulomb attraction between the proton and the electrons. If  $a_0$  is the radius of the ground state orbit,  $m$  is the mass and  $e$  is the charge on the electron and  $\epsilon_0$  is the vacuum permittivity, the speed of the electron is

A. zero

B.  $\frac{e}{\sqrt{\epsilon_0 a_0 m}}$

C.  $\frac{e}{\sqrt{4\pi\epsilon_0 a_0 m}}$

D.  $\frac{\sqrt{4\pi\epsilon_0 a_0 m}}{e}$

**Answer: C**



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38. Average life of a radioactive sample is 4 ms. Initially the total number of nuclei is  $N_0$ . A charged capacitor of capacity  $20\mu\text{f}$  is connected across a resistor  $R$ . The value of  $R$  such that ratio of number of nuclei remaining to the charge on capacitor remains constant with time is

A.  $100\Omega$

B.  $200\Omega$

C.  $300\Omega$

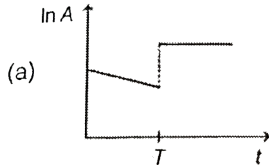
D.  $400\Omega$

**Answer: B**

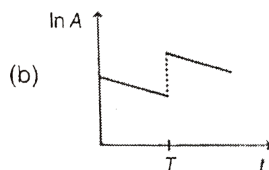


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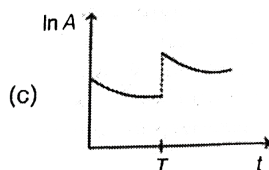
39. At time  $t = 0$ , some radioactive gas is injected into a sealed vessel. At time  $T$ , some more of the same gas is injected into the same vessel. Which one of the following graphs best represents the variation of the logarithm of the activity  $A$  of the gas with time  $t$ ?



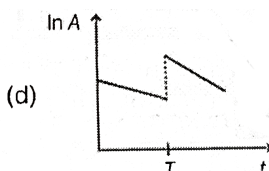
A.



B.



C.



D.

**Answer: B**



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**40.** A sample of radioactive material has mass  $m$ , decay constant  $\lambda$ , and molecular weight  $M$ . Avogadro constant  $= N_A$ . The initial activity of the sample is:

A.  $\lambda m$

B.  $\frac{\lambda m}{M}$

C.  $\frac{\lambda m N_A}{M}$

D.  $\frac{\lambda m}{M N_A}$

**Answer: C**



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**41.** Binding energy per nucleon for  $C^{12}$  is  $7.68 MeV$  and for  $C^{13}$  is  $7.74 MeV$ . The energy required to remove a neutron from  $C^{13}$  is .

A.  $5.34 MeV$

B.  $5.5 MeV$

C.  $9.5 MeV$

D.  $9.34 MeV$

**Answer: A**

42. Light coming from a discharge tube filled with hydrogen falls on the cathode of the photoelectric cell. The work function of the surface of cathode is  $4\text{eV}$  Which one of the following values of the anode voltage (in volts ) with respect to the cathode will likely to make the photo current zero.

- A. (a)  $-4$
- B. (b)  $-4$
- C. (c)  $-8$
- D. (d)  $-10$

**Answer: D**

43. In a hypothetical system , a partical of mass  $m$  and charge  $-3q$  is moving around a very heavy partical chaRGE  $q$ . Assume that Bohr's model is applicable to this system , then velocuity of mass  $m$  in the first orbit is

A.  $\frac{3q^2}{2\varepsilon_0 h}$

B.  $\frac{3q^2}{4\varepsilon_0 h}$

C.  $\frac{3q}{2\varepsilon_0 h}$

D.  $\frac{3q}{4\varepsilon_0 h}$

**Answer: A**



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44. In a certain nuclear reactor, a radioactive nucleus is bieng produced at a constant rate  $=1000/\text{s}$  The mean life of the radionuclide is 40 minutes. At steady state, the number of radionuclide will be

A.  $4 \times 10^4$

B.  $24 \times 10^4$

C.  $24 \times 10^5$

D.  $24 \times 10^6$

**Answer: C**



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**45.** In a hypothetical atom, potential energy between electron and proton at distance  $r$  is given by  $\left(\frac{-ke^2}{4r^2}\right)$  where  $k$  is a constant. Suppose Bohr theory of atomic structures is valid and  $n$  is principle quantum number, then total energy  $E$  is proportional to

- 1)  $n^5$
- 2)  $n^2$
- 3)  $n^6$
- 4)  $n^4$

A.  $n^5$

B.  $n^2$

C.  $n^6$

D.  $n^4$

**Answer: C**



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**46.** A freshly prepared sample contains  $16 \times 10^{20}$  radioactive nuclei, whose mean life is  $10^{10}$  seconds. The activity of the sample just after 4 half-lives time is

A.  $\frac{\ln 2}{16} \times 10^{10} \text{ dps}$

B.  $1 \times 10^{10} \text{ dps}$

C.  $\frac{1}{\ln 2} \times 10^{10} \text{ dps}$

D.  $\ln 2 \times 10^{10} \text{ dps}$

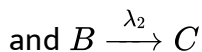
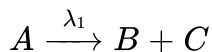
**Answer: B**



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47. Consider a nuclear reaction :



A converts into B and to C with decay with decay constant  $\lambda_1$  B is also stable nucleus which further decays into stable nucleus C with decay constant  $\lambda_2$ . Mark the correct statement(s)

A.  $\frac{dN_C}{dt} = -(\lambda_1 N_A + \lambda_2 N_B)$

B.  $\frac{dN_A}{dt} = -\lambda_1 N_A$

C.  $\frac{dN_A}{dt} = (\lambda_1 N_A + \lambda_2 N_B)$

D.  $\frac{dN_B}{dt} = \lambda_1 N_A + \lambda_2 N_B$

**Answer: B**



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48. Two particles A and B have de-Broglie's wavelength  $30\text{\AA}$  combined to form a single particle C. Momentum is conserved in this process. The

possible de-Broglie's wavelength of C is (the motion in one dimensional)

A.  $10\text{\AA}$

B.  $20\text{\AA}$

C.  $60\text{\AA}$

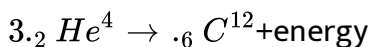
D.  $80\text{\AA}$

**Answer: C**



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**49.** The only source of energy in a particular star is the fusion reaction given by -



Masses of  ${}_2\text{He}^4$  and  ${}_6\text{C}^{12}$  are given

$$(m.{}_2\text{He}^4) = 4.0025u, m({}_6\text{C}^{12}) = 12.0000u$$

Speed of light in vaccume is  $3 \times 10^8 m/s$ . power output of star is  $4.5 \times 10^{27}$  watt. The rate at which the star burns helium is

A.  $8 \times 10^{13}$

B.  $4 \times 10^{12}$

C.  $12 \times 10^{13}$

D.  $9 \times 10^{13}$

**Answer: A**



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**50.** The de-Broglie wavelength of an electron emitted from the ground state of an H-atom after the absorption of a photon equals  $\frac{1}{2}$  of the de-Broglie wavelength when it was in orbit. The energy of the photon absorbed is

A.  $66\text{eV}$

B.  $13.6\text{eV}$

C.  $20.4\text{eV}$

D.  $136\text{eV}$

**Answer: A**



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51. An electron and a proton are separated by a large distance and the electron approaches the proton with a kinetic energy of 2 eV. If the electron is captured by the proton to form a hydrogen atom in the ground state, what wavelength photon would be given off?

A.  $2.4\text{eV}$

B.  $2.7\text{eV}$

C.  $2.9\text{eV}$

D.  $5.4\text{eV}$

**Answer: B**



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52. If light of wavelength of maximum intensity emitted from surface at temperature  $T_1$  is used to cause photoelectric emission from a metallic surface, the maximum kinetic energy of the emitted electron is 6 eV, which is 3 times the work function of the metallic surface. If light of wavelength of maximum intensity emitted from a surface at temperature  $T_2$  ( $T_2 = 2T_1$ ) is used, the maximum kinetic energy of the photoelectrons emitted is

A. 10 eV

B. 8 eV

C. 14 eV

D. 12 eV

**Answer: C**



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53. When photon of wavelength  $\lambda_1$  are incident on an isolated sphere suspended by an insulated support, the corresponding stopping potential is found to be  $V$ . When photon of wavelength  $\lambda_2$  are used, the corresponding stopping potential was thrice the above value. If light of wavelength  $\lambda_3$  is used, calculate the stopping potential for this case.

A.  $\frac{hc}{e} \left( \frac{1}{\lambda_3} + \frac{1}{2\lambda_2} - \frac{1}{\lambda_1} \right)$

B.  $\frac{hc}{e} \left( \frac{1}{\lambda_3} + \frac{1}{2\lambda_2} - \frac{1}{2\lambda_1} \right)$

C.  $\frac{hc}{e} \left( \frac{1}{\lambda_3} + \frac{1}{\lambda_2} + \frac{1}{\lambda_1} \right)$

D.  $\frac{hc}{e} \left( \frac{1}{\lambda_3} - \frac{1}{\lambda_2} - \frac{1}{\lambda_1} \right)$

**Answer: B**



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54. The ground state and first excited state energies of hydrogen atom are  $-13.6\text{eV}$  and  $-3.4\text{eV}$  respectively. If potential energy in ground state is taken to be zero. Then:

A. potential energy in the first excited state would be  $20.4eV$

B. total energy in the first excited state would be  $23.8eV$

C. kinetic energy in the first excited state would be  $3.4eV$

D. total energy in the ground state would be  $13.6eV$

**Answer: A::B::C::D**



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**55.** An electron is excited from a lower energy state to a higher energy state in a hydrogen atom. Which of the following quantity/quantities decreases/decrease in the excitation ?

A. potential energy

B. Angular speed

C. Kinetic energy

D. Angular momentum

**Answer: B::C**



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**56.** The electron in a hydrogen atom makes a transition  $n_1 \rightarrow n_2$ , where  $n_1$  and  $n_2$  are the principle quantum numbers of the two states. Assume the Bohr model to be valid. The time period of the electron in the initial state is eight times that in the final state. the possible values of  $n_1$  and  $n_2$  are

A.  $n_1 = 4, n_2 = 2$

B.  $n_1 = 8, n_2 = 2$

C.  $n_1 = 8, n_2 = 1$

D.  $n_1 = 6, n_2 = 3$

**Answer: A::D**



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57. An electron in hydrogen atom first jumps from second excited state to first excited state and then from first excited state to ground state. Let the ratio of wavelength, momentum and energy of photons emitted in these two cases be  $a$ ,  $b$  and  $c$  respectively, Then

A.  $c=1/a$

B.  $a=9/4$

C.  $b=5/27$

D.  $c=5/27$

**Answer: A::C::D**



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58. The magnitude of energy, the magnitude of linear momentum and orbital radius of an electron in a hydrogen atom corresponding to the quantum number  $n$  are  $E$ ,  $P$  and  $r$  respectively. Then according to Bohr's theory of hydrogen atom:

A.  $E_p$  is proportional to  $\frac{1}{n}$

B.  $P/E$  is proportional to  $n$

C.  $E_r$  is constant for all orbits

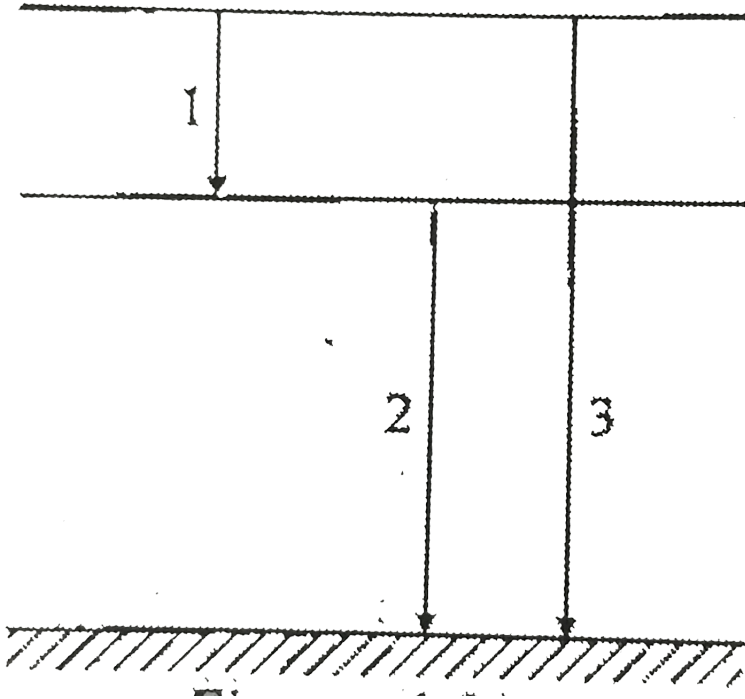
D.  $P_r$  is proportional to  $n$

**Answer: A::B::C::D**



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**59.** The wavelengths and frequencies of photons in transition 1,2 and 3 for hydrogen like atom are  $\lambda_1, \lambda_2, \lambda_3, v_1, v_2$  and  $v_3$  respectively. Then:



A.  $v_3 = v_1 + v_2$

B.  $v_3 = \frac{v_1 v_2}{v_1 + v_2}$

C.  $\lambda_3 = \lambda_1 + \lambda_2$

D.  $\lambda_3 = \frac{\lambda_1 \lambda_2}{\lambda_1 + \lambda_2}$

**Answer: A::D**



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60. Which of the following transitions in  $He^+$  ion will give rise to a spectral line which has the same wavelength as some spectral line in the hydrogen atom ?

- A.  $n=4$  to  $n=2$
- B.  $n=6$  to  $n=5$
- C.  $n=6$  to  $n=3$
- D. none of these

**Answer: A**



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61. Suppose the potential energy between an electron and a proton at a distance  $r$  is given by  $Ke^2/3r^3$ . Application of Bohr's theory to hydrogen atom in this case shows that

- A. kinetic energy in the  $n$ th atom in this orbit is proportional to  $n^6$

B. kinetic energy is proportional to  $m^{-3}$  (m=mass of electron)

C. kinetic energy in the  $n^{\text{th}}$  orbit is proportional to  $n^{-2}$

D. kinetic energy is proportional to  $m^3$  (m=mass of electron)

**Answer: A::B**



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62. Let  $A_n$  be the area enclosed by the  $n^{\text{th}}$  orbit in a hydrogen atom. The graph of  $\ln(A_n / A_t)$  against  $\ln(n)$

A. will pass through origin

B. will be a straight line with slope 4

C. will be a parabola

D. will be a circle

**Answer: A::B**



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63. Hydrogen atom absorbs radiations of wavelength  $\lambda_0$  and consequently emit radiations of 6 different wavelengths, of which two wavelengths are longer than  $\lambda_0$ . Chosses the correct alternative(s).

- A. The final excited state of atoms is  $n=4$
- B. The fina state of the atoms is  $n=4$
- C. The initial state of the atoms is  $n=3$
- D. There are three transitions belonging to Lyman series

**Answer: A::B::D**



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64. The threshold wavelength for photoelectric emission for a material is  $5200\text{\AA}$ . Will the photoelectrons be emitted when this material is illuminated with monochromatic radiation from 1 watt ultra violet lamp?

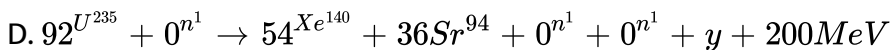
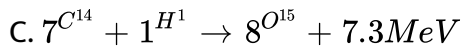
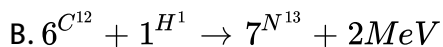
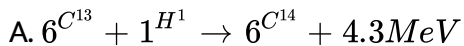
- A. 50 watt infrared lamp
- B. 1 watt infrared lamp
- C. 50 watt ultraviolet lamp
- D. 10 watt infrared lamp

**Answer: C::D**



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**65.** From the following equation pick out the possible nuclear fusion reactions



**Answer: B::C**



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66. In the Bohr model of the hydrogen atom

- A. a) the radius of the  $n$ th orbit is proportional to  $n^2$
- B. b) the total energy of the electron in the  $n$ th orbit is inversely proportional to  $n$
- C. c) the angular momentum of the electron in an the orbit is an integral multiple of  $h/2\pi$
- D. d) the magnitude of the potential energy of the electron in any orbit is greater than its kinetic energy

Answer: A::C::D



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67. The mass number of a nucleus is.



- A. always less than its atomic number
- B. always more than its atomic number
- C. sometimes equal to its atomic number
- D. sometimes more than its atomic number

**Answer: C::D**



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**68.** Photoelectric effect supports quantum nature of light because

- (a) there is a minimum frequency of light below which no photo electrons are emitted
- (b) the maximum kinetic energy of photo electrons depends only on the frequency of light and not on its intensity
- (c ) even when the metal surface is faintly illuminated, the photo electrons leave the surface immediately
- (d) electric charge of the photo electrons is quantised

- A. there is minimum frequency of light below which no photoelectrons are emitted
- B. the maximum kinetic energy of photoelectrons depends only on the frequency of light and not on its intensity
- C. even when the metal surface energy is faintly illuminated (with frequency more than the threshold frequency ) the photoelectrons leave the surface immediately
- D. electric charge of the photoelectrons is quantized

**Answer: A::B::C**



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**69.** If a nucleus  ${}^A_Z X$  emits one  $\alpha$ -particle and one  $\beta$  (negative  $\beta$ ) particle in succession, then the daughter nucleus will have which of the following configurations?

- A.  $A-4$  nucleons

B.  $A-3$  nucleons

C.  $A-Z-3$  neutrons

D.  $A-Z$  protons

**Answer: A::C**



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70. Find the half life of  $U^{238}$ , if one gram of it emits  $1.24 \times 10^4$   $\alpha$ -particle per second. Avogadro's Number =  $6.023 \times 10^{23}$ .

A. a The half life of this nuclide is  $4.5 \times 10^9$  years

B. b The half-life of this nuclide is  $9 \times 10^9$  years

C. c The activity of the prepared sample is  $2.48 \times 10^4$  particles/sec

D. d The activity of the prepared sample is  $1.24 \times 10^4$  particles/sec

**Answer: A::D**



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71. A nitrogen nucleus  ${}^{14}_{7}\text{N}$  absorbs a neutron and can transform into lithium nucleus  ${}^7_3\text{Li}$  under suitable conditions, after emitting :

- A. 4 protons and 5 neutrons
- B. 1 alpha particles and 2 gamma particles
- C. 1 alpha particle 3 protons and 1 negative beta particle
- D. 4 protons and 4 neutrons

**Answer: C::D**



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72. Nucleus  $A$  decays to  $B$  with decay constant  $\lambda_1$  and  $B$  decays to  $C$  with decay constant  $\lambda_2$ . Initially at  $t = 0$  number of nuclei of  $A$  and  $B$  are  $2N_0$  and  $N_0$  respectively. At  $t = t_0$ , no. of nuclei of  $B$  is  $\frac{3N_0}{2}$  and nuclei of  $B$  stop changing. Find  $t_0$ ?

A. the value of  $t_0$  is  $\frac{1}{\lambda_1} \ln. \frac{4}{3} \frac{\lambda_1}{\lambda_2}$

B. the value of  $t_0$  is  $\frac{1}{\lambda_2} \ln. \frac{4}{3} \frac{\lambda_1}{\lambda_2}$

C. the value of  $N_A$  at  $t_0$  is  $\frac{3N_0}{2} \frac{\lambda_2}{\lambda_1}$

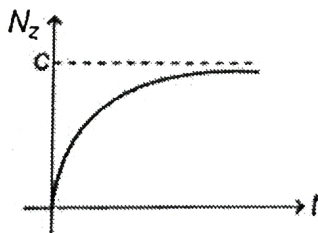
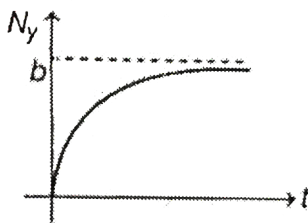
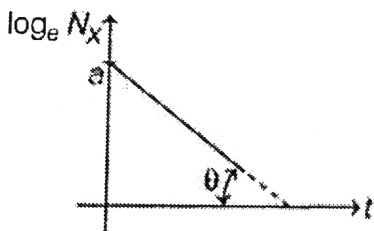
D. the value of  $N_A$  at  $t_0$  is  $\frac{2N_0}{3} \frac{\lambda_2}{\lambda_1}$

**Answer: A::C**



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**73.** An unstable nucleus X can decay into two stable nuclei Y and Z. A sample containing only X is taken at  $t=0$ . Three graphs  $\log_e(N_x \text{ vs } t, N_y \text{ vs } t \text{ and } N_z \text{ vs } t)$  are drawn as shown below. Here  $N_x, N_y$  and  $N_z$  represent number of nuclei of X, Y and Z respectively at any instant.  $t$



Choose the correct choice (s) from the following :

- A. Decay constant for decay of X into Y is  $\frac{b \tan \theta}{e^a}$
- B. Decay constant for decay of X into Z is  $\frac{c \tan \theta}{e^a}$
- C. Number of nuclei of X at  $t=0$  is  $e^a$
- D. Half-life of nuclei X is  $\frac{1}{\tan \theta}$

**Answer: A::B::C**



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74. An electron, initially at rest, is released from a large distance from a proton (fixed in space). The de-Broglie wavelength of the electron when it is at distance  $r$  from the proton is  $\lambda$ . The ratio of its kinetic energy at this distance with the kinetic energy of the electron in the ground state of hydrogen atom (Bohr model) with the radius of its orbit being  $r$ , is  $\alpha$ . Pick the correct options (s)

A.  $\lambda \propto \sqrt{r}$

B.  $\lambda \propto \frac{1}{r}$

C.  $\alpha = \frac{1}{2}$

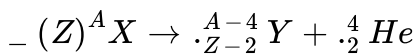
D.  $\alpha = 2$

**Answer: A::D**



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75. A nucleus  $X$  of mass  $M$ , initially at rest, undergoes alpha decay according to the equation



The alpha particle emitted in the above process is found to move in a circular track of radius  $r$  in a uniform magnetic field  $B$ . Then (mass and charge of  $\alpha$  particle are  $m$  and  $q$  respectively)

A. The ratio of kinetic energies of the alpha particle and (daughter nucleus Y approximately equals

$$\frac{M - m}{m}$$

B. the ratio of kinetic energies of the alpha particle and the daughter nucleus Y approximately

$$\frac{m}{M}$$

C. The energy released in the process approximately equals

$$\frac{M}{M - m} \frac{r^2 q^2 B^2}{2m}$$

D. The energy released in the process approximately equals

$$\frac{M}{M - m} \left( \frac{r^2 q^2 B^2}{2m} \right)$$

**Answer: A::C**



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76. Consider an atom made up of a protons and a hypothetical particle of triple the mass of electron but having same charge as electron. Apply bohr model and consider all possible transition of this hypothetical from second excited state to lower states. The possible wavelengths emitted is (are) (given in term of the Rydberg constant  $R$  for the hydrogen atom)

A.  $\frac{8}{5R}$

B.  $\frac{3}{8R}$

C.  $\frac{4}{9R}$

D.  $\frac{12}{5R}$

**Answer: B::C::D**



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**for JEE Advanced (More than One Options is Correct )**

1. The wavelengths of  $K_{\alpha}$  X-rays from lead isotopes  $Pb^{204}$ ,  $Pb^{206}$  and  $Pb^{208}$  are  $\lambda_1$ ,  $\lambda_2$  and  $\lambda_3$  respectively. Choose the correct alternative.

A.  $\lambda_1 = \lambda_2 = \lambda_3$

B.  $\lambda_1 > \lambda_2 > \lambda_3$

C.  $\lambda_1 < \lambda_2 < \lambda_3$

D.  $\lambda_2 = \sqrt{\lambda_1 \lambda_3}$

**Answer: A::D**



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## Match the column

1.  $\sqrt{v}$  versus  $Z$  graph for dcharacteristic X-rays is as shown in figure.

Match

the

following

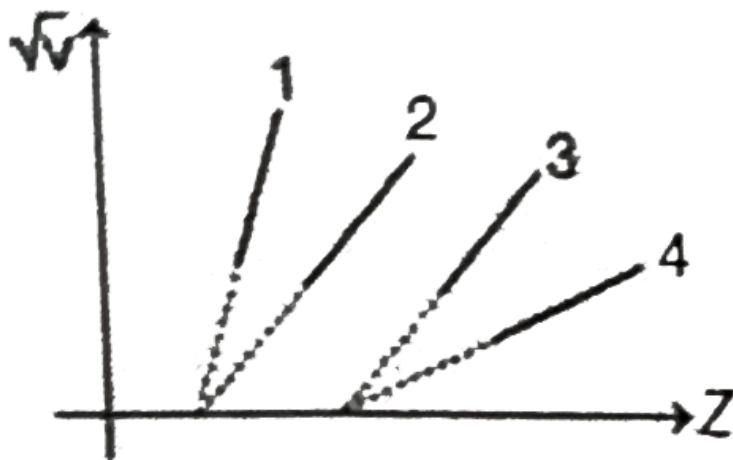


Table-1	Table-2
(A) Line-1	(P) $L_{\alpha}$
(B) Line-2	(Q) $L_{\beta}$
(C) Line-3	(R) $K_{\alpha}$
(D) Line-4	(S) $K_{\beta}$

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2. Regarding transition of electrons match the following table

Table-1	Table-2
(A) $n = 5$ to $n = 2$	(P) Lyman series
(B) $n = 8$ to $n = 4$	(Q) Brackett series
(C) $n = 3$ to $n = 1$	(R) Paschen series
(D) $n = 4$ to $n = 3$	(S) Balmer series

3. Match the following table.

Table-1	Table-2
(A) Sun	(P) Nuclear fission
(B) Nuclear reactors	(Q) Nuclear fusion
(C) Total binding energy in a process is increased	(R) Energy is released
(D) Total binding energy in a process is decreased	(S) Energy is absorbed

4. Excitations energy of hydrogen atom is  $13.6\text{eV}$  match the following

Table-1	Table-2
(A) Energy of second excited state of hydrogen	(P) $-3.4\text{eV}$
(B) Energy of fourth state of $\text{He}^+$	(Q) $-13.6\text{eV}$
(C) Energy of first excited state of $\text{Li}^{+2}$	(R) $-1.5\text{eV}$
	(S) None

5. In a nuclear reactor match the following .

Table-1	Table-2
(A) Cadmium rods	(P) Moderator
(B) Boron rods	(Q) Control rods
(C) Graphite core	(R) Neutron absorbing rods
(D) Carbon rods	

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6. In each situation of Table-1 a physical quantity related to orbiting electron in a hydrogen like atom is given. The terms  $Z$  and  $n$  given in Table-2 have usual meaning in Bohr's theory. Match the quantities in Table-1 with the terms those depend on quantity given in Table-2

Table-1	Table-2
(A) Frequency of orbiting electron	(P) is directly proportional to $Z^2$
(B) Angular momentum of orbiting electron	(Q) is directly proportional to $n$
(C) Magnetic moment of orbiting electron	(R) is inversely proportional to $n^3$
(D) The average current due to orbiting of electron	(S) is independent of $Z$



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## Integer Type Questions

1. The ratio between acceleration of the electron in singly ionized helium atom and doubly ionized lithium atom (both in ground state) is  $(x/27)$ . Find value of  $x$ .



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2. If the radius of first Bohr's orbit is  $x$ , then de-Broglie wavelength of electron in 3rd orbit is nearly  $(n\pi x)$ . Find value of  $n$ .



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3. A H-atom moving with speed  $v$  makes a head on collision with a H-atom at rest. Both atoms are in ground state. The minimum value of

velocity  $v$  for which one of the atom may excite is  $(1.25n \times 10^4)$  m/s Find value of  $x$ .



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4. The magnetic field at the centre of a hydrogen atom due to the motion of the electron in the first Bohr orbit is  $B$ . The magnetic field at the centre due to the motion of the electron in the second Bohr orbit will be  $\frac{B}{2^x}$  Find value of  $x$ .



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5. when the voltage applied to an X-ray tube increases from  $V_1 = 10kV$  to  $V_2 = 20kV$ , the wavelength interval between  $K_\alpha$  line and cut-off wavelength of continuous spectrum increases by a factor of 3. Atomic number of the metallic target is



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6. Light of wavelength  $330\text{nm}$  falling on a piece of metal ejects electrons with sufficient energy with required voltage  $V_0$  to prevent them reaching a collector. In the same set up, light of wavelength  $220\text{nm}$  ejects electrons which require twice the voltage  $V_0$  to stop them in reaching a collector. the numerical value of voltage  $V_0$  is



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7. Light of wavelength  $0.6\mu\text{m}$  from a sodium lamp falls on a photocell and causes the emission of photoelectrons for which the stopping potential is  $0.5\text{V}$ . With light of wavelength  $0.4\mu\text{m}$  from a mercury vapor lamp, the stopping potential is  $1.5\text{V}$ . Then, the work function [in electron volts] of the photocell surface is



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8. An  $\alpha$ -particle accelerated through  $V$  volt is fired towards a nucleus . Its distance of closest approach is  $r$ . If a proton acceleration through the



same potential is fired towards the same nucleus, the distance of closest approach of proton will be  $xr$ . Find value of  $x$ .



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9. The kinetic energies of the photoelectrons ejected from a metal surface by light of wavelength  $2000\text{\AA}$  range from zero to  $3.2 \times 10^{-19}$  Joule. Then find the stopping potential (in V).



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10. In a hydrogen atom following the Bohr's postulates the product of linear momentum and angular momentum is proportional to  $(n)^x$  where 'n' is the orbit number. Find the value of  $x$ .



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11. A target element A is bombarded with electrons and the wavelengths of the characteristic spectrum are measured. A second characteristic spectrum is also obtained, because of an impurity in the target. The wavelengths of the  $K_{\alpha}$  lines are 196 pm (element A) and 169 pm (impurity). If the atomic number of impurity is  $z = (10\lambda - 1)$ . Find the value of  $\lambda$ . (atomic number of element A is 27).



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12. A moving hydrogen atom makes a head on collision with a stationary hydrogen atom. Before collision both atoms are in ground state and after collision they move together. What is the minimum value of the kinetic energy of the moving hydrogen atom, such that one of the atoms reaches one of the excited state?

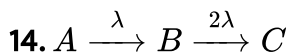


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13. A radioactive sample contains two different types of radioactive nuclei. A-with half-time 5 days and B-type with half life 30 days. Initially the decay rate of A-type nuclei is 64 times that of B type of nuclei . Their decay rates will be equal when time is  $9n$  days. Find the value of  $n$ .



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$$T = 0, N_0, 0,$$

$$TN_1N_2N_3$$

The ratio of  $N_1$  to  $N_2$  is maximum l s



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15. In a photelectric experiment , when electromegnetic wave given by  $E = E_0\sin\omega t$  is incident , electron just ejects. When  $E = E_0\sin2\omega t$  is incident  $K_{\max} = K_1$  and when  $E = E_0\sin6\omega t$  is incident  $K_{\max} = k_2$ .  
When  $k_2 / k_1$

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16. Nuclei X and Y convert into a stable nucleus Z. At  $t=0$ , the number of nuclei of X is 8 times that of Y. Half life of X is 1 hour and half life of Y is 2 hour. Find the time (in hour) at which rate of disintegration of X and Y are equal.

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17. Single electron is orbiting in  $n^{th}$  orbit of hydrogen atom. The magnetic field produced by the electron at the nucleus will be proportional to  $n^{-k}$ . Find the value of k.

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