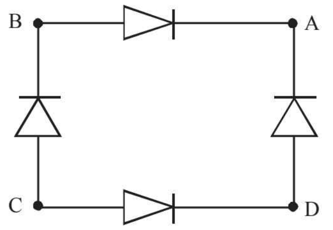
CHAPTER

# 17 Modern Physics

## Section-A JEE Advanced/ IIT-JEE

### A Fill in the Blanks

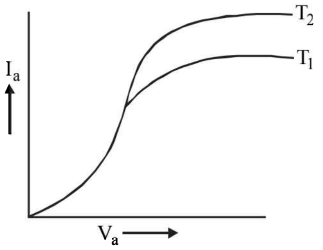
1. To produce characteristic X-rays using a Tungsten target in an X-ray generator, the accelerating voltage should be greater than ___________ volts and the energy of the characteristic radiation is _____eV. (The binding energy of the innermost electron in Tungsten is 40 keV). *(1983 - 2 Marks)*
2. The radioactive decay rate of a radioactive element is found to be $10^3$ disintegration/second at a certain time. If the half life of the element is one second, the decay rate after one second is _______ and after three seconds is _______. *(1983 - 2 Marks)*
3. The maximum kinetic energy of electrons emitted in the photoelectric effect is linearly dependent on the ...... of the incident radiation. *(1984- 2 Marks)*
4. In the Uranium radioactive series the initial nucleus is $_{92}^{238}U$ and the final nucleus is $_{82}^{206}Pb$. When the Uranium nucleus decays to lead, the number of $\alpha$-particles emitted is ......and the number of $\beta$-particles emitted is ..... *(1985 - 2 Marks)*
5. When the number of electrons striking the anode of an X-ray tube is increased, the ........ of the emitted X-rays increases, while when the speeds of the electrons striking the anode are increased, the cut-off wavelength of the emitted X-rays......... *(1986 - 2 Marks)*
6. When Boron nucleus $\left(_{5}^{10}B\right)$ is bombarded by neutrons, $\alpha$-particles are emitted. The resulting nucleus is of the element ........ and has the mass number ......*(1986 - 2 Marks)*
7. Atoms having the same ........... but different ........... are called isotopes. *(1986 - 2 Marks)*
8. The binding energies per nucleon for deuteron ($_1H^2$) and helium ($_2He^4$) are 1.1 MeV and 7.0 MeV respectively. The energy released when two deuterons fuse to form a helium nucleus ($_2He^4$) is .......... *(1988 - 2 Marks)*
9. In the forward bias arrangement of a *p-n* junction rectifier, the *p* end is connected to the ........terminal of the battery and the direction of the current is from ............to ..................in the rectifier. *(1988 - 2 Marks)*
10. ........... biasing of *p-n* junction offers high resistance to current flow across the junction. The biasing is obtained by connecting the *p*- side to the .......... terminal of the battery. *(1990 - 2 Marks)*
11. The wavelength of the characteristic X-ray $K_\alpha$ line emitted by a hydrogen like element is 0.32 Å. The wavelength of the $K_\beta$ line emitted by the same element will be ............ *(1990 - 2 Marks)*
12. The Bohr radius of the fifth electron of phosphorous atom (atomic number = 15) acting as a dopant in silicon (relative dielectric constant = 12) is .................... Å *(1991 - 1 Mark)*
13. For the given circuit shown in fig. to act as full wave rectifier, the a.c. input should be connected across .................... and .................... and the d.c. output would appear across .................... and ................ *(1991 - 1 Mark)*




14. In an X-ray tube, electrons accelerated through a potential difference of 15, 000 volts strike a copper target. The speed of the emitted X-ray inside the tube is .................. m/s *(1992 - 1 Mark)*
15. In the Bohr model of the hydrogen atom, the ratio of the kinetic energy to the total energy of the electron in a quantum state *n* is .................... *(1992 - 1 Mark)*
16. In the nuclear process, $_6C^{11} \longrightarrow {}_5B^{11} + \beta^+ + X$, X stands for ............ *(1992 - 1 Mark)*
17. In a ..... biased p-n junction, the net flow of holes is from the *n* region to the *p* region. *(1993 - 1 Mark)*
18. A potential difference of 20 kV is applied across an X-ray tube. The minimum wavelength of X-rays generated is...........Å. *(1996 - 2 Marks)*
19. The wavelength of $K_\alpha$ X-rays produced by an X-ray tube is 0.76Å. The atomic number of the anode material of the tube is..... *(1996 - 2 Marks)*
20. Consider the following reaction :
$$_1^2H + _1^2H = _2^4He + Q$$
Mass of the deuterium atom = 2.0141 *u*
Mass of helium atom = 4.0024 *u*
This is a nuclear ............ reaction in which the energy *Q* released is ............. MeV. *(1996 - 2 Marks)*

## B True/False

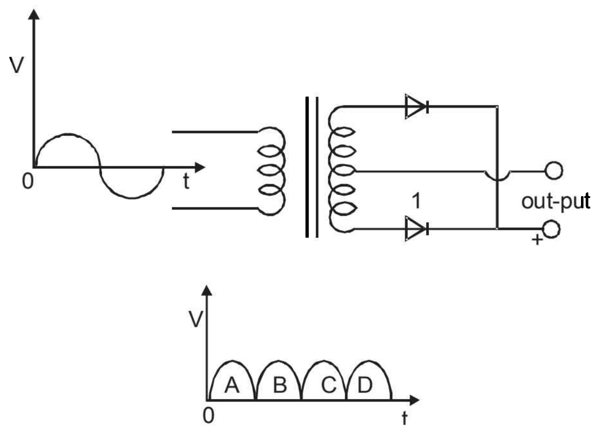
1. The kinetic energy of photoelectrons emitted by a photosensitive surface depends on the intensity of the incident radiation. ***(1981- 2 Marks)***
2. In a photoelectric emission process the maximum energy of the photo-electrons increases with increasing intensity of the incident light. ***(1986 - 3 Marks)***
3. For a diode the variation of its anode current $I_a$ with the anode voltage $V_a$ at two different cathode temperatures $T_1$ and $T_2$ is shown in the figure. The temperature $T_2$ is greater than $T_1$. ***(1986 - 3 Marks)***



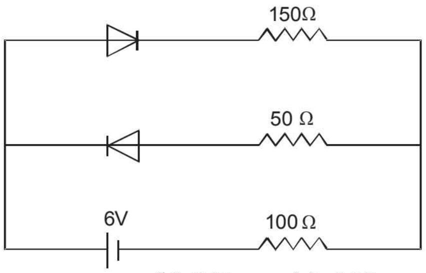

4. The order of magnitude of the density of nuclear matter is $10^4$ kg m$^{-2}$. ***(1989 - 2 Marks)***

## C MCQs with One Correct Answer

1. The plate resistance of a triode is $3 \times 10^3$ ohms and its mutual conductance is $1.5 \times 10^{-3}$ amp/volt. The amplification factor of the triode is ***(1981- 2 - 3 Marks)***
(a) $5 \times 10^{-5}$ (b) 4.5 (c) 45 (d) $2 \times 10^5$
2. The half life of radioactive Radon is 3.8 days. The time at the end of which $\frac{1}{20}$th of the radon sample will remain undecayed is (given $\log_{10} e = 0.4343$) ***(1981- 2 Marks)***
(a) 3.8 days (b) 16.5 days
(c) 33 days (d) 76 days.
3. An alpha particle of energy 5 MeV is scattered through 180° by a fixed uranium nucleus. The distance of closest approach is of the order of ***(1981- 2 Marks)***
(a) 1 Å (b) $10^{-10}$ cm
(c) $10^{-12}$cm (d) $10^{-15}$ cm
4. Beta rays emitted by a radioactive material are ***(1983 - 1 Mark)***
(a) electromagnetic radiations
(b) the electrons orbiting around the nucleus
(c) charged particles emitted by the nucleus
(d) neutral particles
5. If elements with principal quantum number $n > 4$ were not allowed in nature, the number of possible elements would be ***(1983 - 1 Mark)***
(a) 60 (b) 32 (c) 4 (d) 64
6. 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 ***(1983 - 1 Mark)***
(a) Hydrogen atom (b) Deuterium atom
(c) Singly ionized Helium (d) Doubly ionised Lithium
7. The equation
$$4\,{}^1_1\mathrm{H}^+ \longrightarrow {}^4_2\mathrm{He}^{2+} + 2e^- + 26\,\mathrm{MeV}$$ represents ***(1983 - 1 Mark)***
(a) $\beta$-decay (b) $\gamma$-decay
(c) fusion (d) fission
8. Fast neutrons can easily be slowed down by ***(1994 - 1 Mark)***
(a) the use of lead shielding
(b) passing them through water
(c) elastic collisions with heavy nuclei
(d) applying a strong electric field.
9. Consider $\alpha$ particles, $\beta$ particles and $\gamma$ - rays, each having an energy of 0.5 MeV. In increasing order of penetrating powers, the radiations are: ***(1994 - 1 Mark)***
(a) $\alpha, \beta, \gamma$ (b) $\alpha, \gamma, \beta$ (c) $\beta, \gamma, \alpha$ (d) $\gamma, \beta, \alpha$
10. An energy of 24.6 eV is required to remove one of the electrons from a neutral helium atom. The energy in (eV) required to remove both the electrons from a neutral helium atom is ***(1995S)***
(a) 38.2 (b) 49.2 (c) 51.8 (d) 79.0
11. A radioactive material decays by simultaneous emission of two particles with respective half-lives 1620 and 810 years. The time, in years, after which one-fourth of the material remains is ***(1995S)***
(a) 1080 (b) 2430 (c) 3240 (d) 4860
12. The probability of electrons to be found in the conduction band of an intrinsic semiconductor at a finite temperature ***(1995S)***
(a) increases exponentially with increasing band gap
(b) decreases exponentially with increasing band gap
(c) decreases with increasing temperature
(d) is independent of the temperature and the band gap
13. A full-wave rectifier circuit along with the out-put is shown in Figure. The contribution (s) from the diode 1 is (are) ***(1996 - 2 Marks)***




(a) C (b) A,C (c) B, D (d) A,B,C, D.
14. As per Bohr model, the minimum energy (in eV) required to remove an electron from the ground state of doubly ionized Li atom ($Z = 3$) is ***(1997 - 1 Mark)***
(a) 1.51 (b) 13.6 (c) 40.8 (d) 122.4
15. The circuit shown in the figure contains two diodes each with a forward resistance of 50 ohms and with infinite backward resistance. If the battery voltage is 6V, the current through the 100 ohm resistance (in amperes) is ***(1997 - 1 Mark)***




(a) zero (b) 0.02 (c) 0.03 (d) 0.036.

16. Which of the following statements is not true? *(1997 - 1 Mark)*
(a) The resistance of intrinsic semiconductors decrease with increase of temperature
(b) Doping pure Si with trivalent impurities give *p*-type semiconductors
(c) The majority carriers in *n*-type semiconductors are holes
(d) A *p-n* junction can act as a semiconductor diode

17. 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 volt, is *(1997 - 1 Mark)*
(a) 2 (b) 4 (c) 6 (d) 10

18. In hydrogen spectrum the wavelength of $H_\alpha$ line is 656 nm, whereas in the spectrum of a distant galaxy, $H_\alpha$ line wavelength is 706 nm. Estimated speed of the galaxy with respect to earth is, *(1999S - 2 Marks)*
(a) $2 \times 10^8$ m/s (b) $2 \times 10^7$ m/s
(c) $2 \times 10^6$ m/s (d) $2 \times 10^5$ m/s

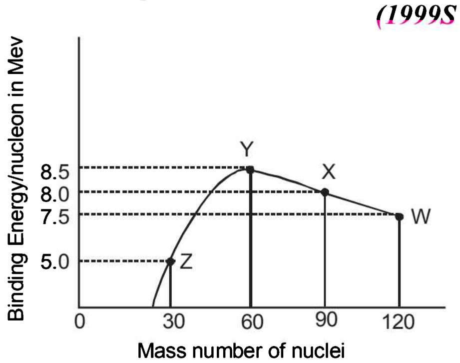
19. A particle of mass $M$ at rest decays into two particles of masses $m_1$ and $m_2$, having non-zero velocities. The ratio of the de Broglie wavelengths of the particles, $\lambda_1/\lambda_2$, is *(1999S - 2 Marks)*
(a) $m_1/m_2$ (b) $m_2/m_1$ (c) 1.0 (d) $\sqrt{m_2}/\sqrt{m_1}$

20. Which of the following is a correct statement? *(1999S - 2 Marks)*
(a) Beta rays are same as cathode rays
(b) Gamma rays are high energy neutrons
(c) Alpha particles are singly ionised helium atoms
(d) Protons and neutrons have exactly the same mass

21. Order of magnitude of density of uranium nucleus is, [$m_p$ = $1.67 \times 10^{-27}$kg] *(1999S - 2 Marks)*
(a) $10^{20}$kg/m$^3$ (b) $10^{17}$kg/m$^3$
(c) $10^{14}$kg/m$^3$ (d) $10^{11}$kg/m$^3$

22. $^{22}$Ne nucleus, after absorbing energy, decays into two α-particles and an unknown nucleus. The unknown nucleus is *(1999S - 2 Marks)*
(a) nitrogen (b) carbon (c) boron (d) oxygen

23. Binding energy per nucleon vs mass number curve for nuclei is shown in the Figure. *W, X, Y* and *Z* are four nuclei indicated on the curve. The process that would release energy is *(1999S - 2 Marks)*




(a) $Y \to 2Z$ (b) $W \to X + Z$
(c) $W \to 2Y$ (d) $X \to Y + Z$

24. 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 to the first excited level. The longest wavelength photon that will be emitted has wavelength $\lambda$ (given in terms of the Rydberg constant $R$ for the hydrogen atom) equal to *(2000S)*
(a) $9/(5R)$ (b) $36/(5R)$ (c) $18/(5R)$ (d) $4/R$

25. The electron in a hydrogen atom makes a transition from an excited state to the ground state. Which of the following statements is true ? *(2000S)*
(a) Its kinetic energy increases and its potential and total energies decreases.
(b) Its kinetic energy decreases, potential energy increases and its total energy remains the same.
(c) Its kinetic and total energies decrease and its potential energy increases.
(d) Its kinetic, potential and total energies decrease.

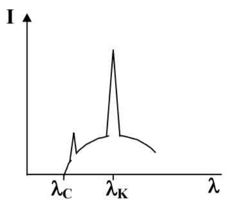
26. Two radioactive materials $X_1$ and $X_2$ have decay constants $10\lambda$ and $\lambda$ respectively. If initially they have the same number of nuclei, then the ratio of the number of nuclei of $X_1$ to that of $X_2$ will be $1/e$ after a time *(2000S)*
(a) $\frac{1}{10\lambda}$ (b) $\frac{1}{11\lambda}$ (c) $\frac{11}{10\lambda}$ (d) $\frac{1}{9\lambda}$

27. Electrons with energy 80 keV are incident on the tungsten target of an X-ray tube. K-shell electrons of tungsten have 72.5 keV energy. X-rays emitted by the tube contain only
(a) a continuous X-ray spectrum (Bremsstrahlung) with a minimum wavelength of 0.155Å *(2000S)*
(b) a continuous X-ray spectrum (Bremsstrahlung) with all wavelengths
(c) the characteristic X-ray spectrum of tungsten
(d) a continuous X-ray spectrum (Bremsstrahlung) with a minimum wavelength of 0.155Å and the characteristic X-ray spectrum of tungsten.

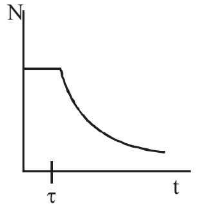
28. The electron emitted in beta radiation originates from
(a) inner orbits of atoms *(2001S)*
(b) free electrons existing in nuclei
(c) decay of a neutron in a nucleus
(d) photon escaping from the nucleus

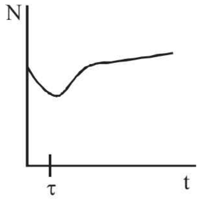
29. The transition from the state $n = 4$ to $n = 3$ in a hydrogen-like atom results in ultraviolet radiation. Infrared radiation will be obtained in the transition *(2001S)*
(a) $2 \to 1$ (b) $3 \to 2$ (c) $4 \to 2$ (d) $5 \to 4$

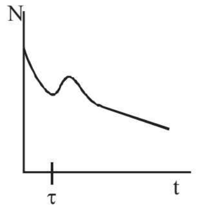
30. The intensity of X-rays from a Coolidge tube is plotted against wavelength $\lambda$ as shown in the figure. The minimum wavelength found is $\lambda_C$ and the wavelength of the $K_\alpha$ line is $\lambda_K$. As the accelerating voltage is increased *(2001S)*
(a) $\lambda_K - \lambda_C$ increases
(b) $\lambda_K - \lambda_C$ decreases
(c) $\lambda_K$ increases
(d) $\lambda_K$ decreases

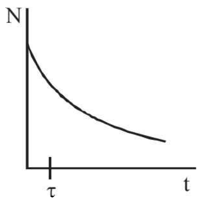


**31.** A radioactive sample consists of two distinct species having equal number of atoms initially. The mean life time of one species is $\tau$ and that of the other is $5\tau$. The decay products in both cases are stable. A plot is made of the total number of radioactive nuclei as a function of time. Which of the following figures best represent the form of this plot? ***(2001S)***

(a)



(b)



(c)



(d)



**32.** The potential difference applied to an X-ray tube is 5kV and the current through it is $3.2mA$. Then the number of electrons striking the target per second is ***(2002S)***

(a) $2\times10^{16}$ (b) $5\times10^{6}$ (c) $1\times10^{17}$ (d) $4\times10^{15}$

**33.** A Hydrogen atom and a $Li^{++}$ ion are both in the second excited state. If $\ell_H$ and $\ell_{Li}$ are their respective electronic angular momenta, and $E_H$ and $E_{Li}$ their respective energies, then ***(2002S)***

(a) $\ell_H > \ell_{Li}$ and $|E_H| > |E_{Li}|$ (b) $\ell_H = \ell_{Li}$ and $|E_H| < |E_{Li}|$

(c) $\ell_H = \ell_{Li}$ and $|E_H| > |E_{Li}|$ (d) $\ell_H < \ell_{Li}$ and $|E_H| < |E_{Li}|$

**34.** The half-life of $^{215}$At is 100 $\mu s$. The time taken for the radioactivity of a sample of $^{215}$At to decay to 1/16$^{th}$ of its initial value is ***(2002S)***

(a) $400\mu s$ (b) $6.3\mu s$ (c) $40\mu s$ (d) $300\mu s$

**35.** Which of the following processes represents a $\gamma$-decay ? ***(2002S)***

(a) $^{A}X_z + \gamma \longrightarrow {}^{A}X_{Z-1} + a + b$

(b) $^{A}X_z + {}^{1}n_o \longrightarrow {}^{A-3}X_{Z-2} + c$

(c) $^{A}X_z \longrightarrow {}^{A}X_Z + f$

(d) $^{A}X_z + e_{-1} \longrightarrow {}^{A}X_{Z-1} + g$

**36.** The electric potential between a proton and an electron is given by $V = V_0 \, ln \, \dfrac{r}{r_0}$, where $r_0$ is a constant. Assuming Bohr's model to be applicable, write variation of $r_n$ with $n$, $n$ being the principal quantum number? ***(2003S)***

(a) $r_n \propto n$ (b) $r_n \propto 1/n$

(c) $r_n \propto n^2$ (d) $r_n \propto 1/n^2$

**37.** If the atom $_{100}Fm^{257}$ follows the Bohr model and the radius of $_{100}Fm^{257}$ is $n$ times the Bohr radius, then find $n$. ***(2003S)***

(a) 100 (b) 200 (c) 4 (d) 1/4

**38.** For uranium nucleus how does its mass vary with volume? ***(2003S)***

(a) $m \propto V$ (b) $m \propto 1/V$

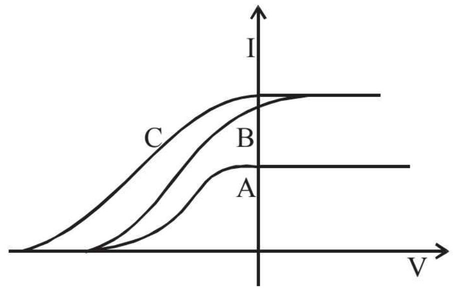
(c) $m \propto \sqrt{V}$ (d) $m \propto V^2$

**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 ***(2003S)***

(a) 4.4 MeV (b) 5.4 MeV

(c) 5.6 MeV (d) 6.5 MeV

**40.** In a photoelectric experiment anode potential is plotted against plate current. ***(2004S)***




(a) $A$ and $B$ will have different intensities while $B$ and $C$ will have different frequencies

(b) $B$ and $C$ will have different intensities while $A$ and $C$ will have different frequencies

(c) $A$ and $B$ will have different intensities while $A$ and $C$ will have equal frequencies

(d) $B$ and $C$ will have equal intensities while $A$ and $B$ will have same frequencies

**41.** A 280 days old radioactive substance shows an activity of 6000 dps, 140 days later its activity becomes 3000 dps. What was its initial activity? ***(2004S)***

(a) 20000 dps (b) 24000 dps

(d) 12000 dps (d) 6000 dps

**42.** A proton has kinetic energy $E = 100$ keV which is equal to that of a photon. The wavelength of photon is $\lambda_2$ and that of proton is $\lambda_1$. The ration of $\lambda_2/\lambda_1$ is proportional to ***(2004S)***

(a) $E^2$ (b) $E^{1/2}$

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

**43.** $K_\alpha$ 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 $4\lambda$. ***(2005S)***

(a) $Z = 6$ (b) $Z = 4$ (c) $Z = 11$ (d) $Z = 44$

**44.** 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 15 eV. What will be observed by the detector? ***(2005S)***

(a) One photon of energy 10.2 eV and an electron of energy 1.4 eV

(b) 2 photon of energy of 1.4 eV

(c) 2 photon of energy 10.2 eV

(d) One photon of energy 10.2 eV and another photon of 1.4 eV

**45.** A beam of electron is used in an YDSE experiment. The slit width is d. When the velocity of electron is increased, then *(2005S)*
(a) no interference is observed
(b) fringe width increases
(c) fringe width decreases
(d) fringe width remains same

**46.** If a star can convert all the He nuclei completely into oxygen nuclei, the energy released per oxygen nuclei is [Mass of He nucleus is 4.0026 amu and mass of Oxygen nucleus is 15.9994 amu] *(2005S)*
(a) 7.6 MeV (b) 56.12 MeV
(c) 10.24 MeV (d) 23.9 MeV

**47.** ${}^{221}_{87}Ra$ is a radioactive substance having half life of 4 days. Find the probability that a nucleus undergoes decay after two half lives *(2006 - 3M, –1)*
(a) 1 (b) $\frac{1}{2}$ (c) $\frac{3}{4}$ (d) $\frac{1}{4}$

**48.** In the options given below, let $E$ denote the rest mass energy of a nucleus and $n$ a neutron. The correct option is *(2007)*
(a) $E\left({}^{236}_{92}U\right) > E\left({}^{137}_{53}I\right) + E\left({}^{97}_{39}Y\right) + 2E(n)$
(b) $E\left({}^{236}_{92}U\right) < E\left({}^{137}_{53}I\right) + E\left({}^{97}_{39}Y\right) + 2E(n)$
(c) $E\left({}^{236}_{92}U\right) < E\left({}^{140}_{56}Ba\right) + E\left({}^{94}_{36}Kr\right) + 2E(n)$
(d) $E\left({}^{236}_{92}U\right) = E\left({}^{140}_{56}Ba\right) + E\left({}^{94}_{36}Kr\right) + 2E(n)$

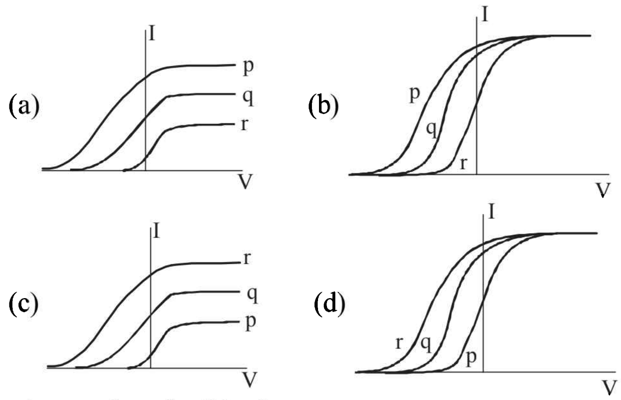
**49.** The largest wavelength in the ultraviolet region of the hydrogen spectrum is 122 nm. The smallest wavelength in the infrared region of the hydrogen spectrum (to the nearest integer) is *(2007)*
(a) 802 nm (b) 823 nm
(c) 1882 nm (d) 1648 nm

**50.** Electrons with de-Broglie wavelength $\lambda$ fall on the target in an X-ray tube. The cut-off wavelength of the emitted X-rays is *(2007)*
(a) $\lambda_0 = \frac{2mc\lambda^2}{h}$ (b) $\lambda_0 = \frac{2h}{mc}$
(c) $\lambda_0 = \frac{2m^2c^2\lambda^3}{h^2}$ (d) $\lambda_0 = \lambda$

**51.** Which one of the following statements is WRONG in the context of X-rays generated from a X-ray tube? *(2008)*
(a) Wavelength of characteristic X-rays decreases when the atomic number of the target increases.
(b) Cut-off wavelength of the continuous X-rays depends on the atomic number of the target
(c) Intensity of the characteristic X-rays depends on the electrical power given to the X-ray tube
(d) Cut-off wavelength of the continuous X-rays depends on the energy of the electrons in the X-ray tube

**52.** A radioactive sample $S_1$ having an activity 5μCi has twice the number of nuclei as another sample $S_2$ which has an activity of 10 μCi. The half lives of $S_1$ and $S_2$ can be *(2008)*
(a) 20 years and 5 years, respectively
(b) 20 years and 10 years, respectively
(c) 10 years each
(d) 5 years each

**53.** Photoelectric effect experiments are performed using three different metal plates p, q and r having work functions $\phi_p$ = 2.0 eV, $\phi_q$ = 2.5 eV and $\phi_r$ = 3.0 eV, respectively. A light beam containing wavelengths of 550 nm, 450 nm and 350 nm with equal intensities illuminates each of the plates. The correct *I-V* graph for the experiment is [Take $hc$ = 1240 eV nm] *(2009)*




**54.** The wavelength of the first spectral line in the Balmer series of hydrogen atom is 6561 A°. The wavelength of the second spectral line in the Balmer series of singly-ionized helium atom is *(2011)*
(a) 1215 A° (b) 1640 A° (c) 2430 A° (d) 4687 A°

**55.** A pulse of light of duration 100 ns is absorbed completely by a small object initially at rest. Power of the pulse is 30 mW and the speed of light is $3 \times 10^8$ ms$^{-1}$. The final momentum of the object is *(JEE Adv. 2013)*
(a) $0.3 \times 10^{-17}$ kg ms$^{-1}$ (c) $3.0 \times 10^{-17}$ kg ms$^{-1}$
(b) $1.0 \times 10^{-17}$ kg ms$^{-1}$ (d) $9.0 \times 10^{-17}$ kg ms$^{-1}$

**56.** If $\lambda_{Cu}$ is the wavelength of $K_\alpha$ X-ray line of 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 $\lambda_{Cu}/\lambda_{Mo}$ is close to *(JEE Adv. 2014)*
(a) 1.99 (b) 2.14 (c) 0.50 (d) 0.48

**57.** 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 eV nm, the work function of the metal is nearly *(JEE Adv. 2014)*
(a) 3.7 eV (b) 3.2 eV (c) 2.8 eV (d) 2.5 eV

**58.** In a historical experiment to determine Planck's constant, a metal surface was irradiated with light of different wavelengths. The emitted photoelectron energies were measured by applying a stopping potential. The relevant data for the wavelength ($\lambda$) of incident light and the corresponding stopping potential ($V_0$) are given below :

| $\lambda$ (μm) | $V_0$ (Volt) |
|---|---|
| 0.3 | 2.0 |
| 0.4 | 1.0 |
| 0.5 | 0.4 |

Given that $c = 3 \times 10^8 m\, s^{-1}$ and $e = 1.6 \times 10^{-19}$ C, Planck's constant (in units of J s) found from such an experiment is *(JEE Adv. 2016)*

(a) $6.0 \times 10^{-34}$ (b) $6.4 \times 10^{-34}$

(c) $6.6 \times 10^{-34}$ (d) $6.8 \times 10^{-34}$

**59.** The electrostatic energy of Z protons uniformly distributed throughout a spherical nucleus of radius R is given by

$$E = \frac{3}{5}\frac{Z(Z-1)e^2}{4\pi\varepsilon_0 R}$$

The measured masses of the neutron $^1_1H$, $^{15}_7N$ and $^{15}_8O$ are 1.008665 u, 1.007825 u, 15.000109 u and 15.003065 u, respectively. Given that the radii of both the $^{15}_7N$ and $^{15}_8O$ nuclei are same, 1 u = 931.5 Me V/c² (c is the speed of light) and $e^2/(4\pi\varepsilon_0) = 1.44$ MeV fm. Assuming that the difference between the binding energies of $^{15}_7N$ and $^{15}_8O$ is purely due to the electrostatic energy, the radius of either of the nuclei is
(1 fm = $10^{-15}$ m) *(JEE Adv. 2016)*

(a) 2.85 fm (b) 3.03 fm

(c) 3.42 fm (d) 3.80 fm

**60.** An accident in a nuclear laboratory resulted in deposition of a certain amount of radioactive material of half-life 18 days inside the laboratory. Tests revealed that the radiation was 64 times more than the permissible level required for safe operation of the laboratory. What is the minimum number of days after which the laboratory can be considered safe for use? *(JEE Adv. 2016)*

(a) 64 (b) 90

(c) 108 (d) 120

## D MCQs with One or More than One Correct

**1.** The shortest wavelength of X-rays emitted from an X-ray tube depends on *(1982 - 3 Marks)*

(a) the current in the tube
(b) the voltage applied to the tube
(c) the nature of the gas in tube
(d) the atomic number of the target material

**2.** The threshold wavelength for photoelectric emission from a material is 5200 Å. Photoelectrons will be emitted when this material is illuminated with monochromatic radiation from a *(1982 - 3 Marks)*

(a) 50 watt infrared lamp (b) 1-watt infra-red lamp
(c) 50 watt ultraviolet lamp (d) 1-watt ultraviolet lamp

**3.** From the following equations pick out the possible nuclear fusion reactions *(1984- 2 Marks)*

(a) ${}_6C^{13} + {}_1H^1 \rightarrow {}_6C^{14} + 4.3\text{MeV}$

(b) ${}_6C^{12} + {}_1H^1 \rightarrow {}_7N^{13} + 2\text{MeV}$

(c) ${}_7N^{14} + {}_1H^1 \rightarrow {}_8O^{15} + 7.3\text{MeV}$

(d) ${}_{92}U^{235} + {}_0n^1 \rightarrow {}_{54}Xe^{140} + {}_{38}Sr^{94} + {}_0n^1 + {}_0n^1 + \gamma + 200\text{MeV}$

**4.** In Bohr's model of the hydrogen atom *(1984- 2 Marks)*

(a) the radius of the nth orbit is proportional to $n^2$
(b) the total energy of the electron in nth orbit is inversely proportional to $n$
(c) the angular momentum of the electron in an orbit is an integral multiple of $\frac{h}{2\pi}$
(d) the magnitude of potential energy of the electron in any orbit is greater than its K.E.

**5.** Select the correct statement from the following *(1984- 2 Marks)*

(a) A diode can be used as a rectifier
(b) A triode cannot be used as a rectifier
(c) The current in a diode is always proportional to the applied voltage
(d) The linear portion of the I–V characteristic of a triode is used for amplification without distortion

**6.** For a given plate voltage, the plate current in a triode valve is maximum when the potential of *(1985 - 2 Marks)*

(a) the grid is positive and plate is negative
(b) the grid is zero and plate is positive
(c) the grid is negative and plate is positive
(d) the grid is positive and plate is positive

**7.** The X-ray beam coming from an X-ray tube will be *(1985 - 2 Marks)*

(a) monochromatic
(b) having all wavelengths smaller than a certain maximum wavelength
(c) having all wavelengths larger than a certain minimum wavelength
(d) having all wavelengths lying between a minimum and a maximum wavelength

**8.** The mass number of a nucleus is *(1986 - 2 Marks)*

(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 and sometimes equal to its atomic number

**9.** Four physical quantities are listed in Column I. Their values are listed in Column II in a random order: *(1987 - 2 Marks)*

| Column I | Column II |
|---|---|
| (a) Thermal energy of air molecules at room temp | (e) 0.02 eV |
| (b) Binding energy of heavy nuclei per nucleon | (f) 2 eV |
| (c) X-ray photon energy | (g) 1k eV |
| (d) Photon energy of visible light | (h) 7 MeV |

The correct matching of Columns I and II is given by

(a) $a-e, b-h, c-g, d-f$
(b) $a-e, b-g, c-f, d-h$
(c) $a-f, b-e, c-g, d-h$
(d) $a-f, b-h, c-e, d-g$.

**10.** Photoelectric effect supports quantum nature of light because *(1987 - 2 Marks)*

(a) there is a minimum frequency of light below which no photoelectrons 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 photoelectrons leave the surface immediately
(d) electric charge of the photoelectrons is quantized

**11.** During a negative beta decay *(1987 - 2 Marks)*
(a) an atomic electron is ejected
(b) an electron which is already present within the nucleus is ejected
(c) a neutron in the nucleus decays emitting an electron
(d) a part of the binding energy of the nucleus is converted into an electron

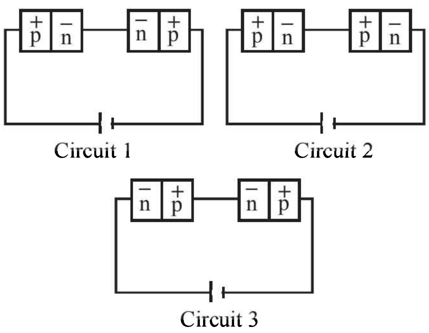
**12.** During a nuclear fusion reaction *(1987 - 2 Marks)*
(a) a heavy nucleus breaks into two fragments by itself
(b) a light nucleus bombarded by thermal neutrons breaks up
(c) a heavy nucleus bombarded by thermal neutrons breaks up
(d) two light nuclei combine to give a heavier nucleus and possibly other products

**13.** The potential difference applied to an X-ray tube is increased. As a result, in the emitted radiation
(a) the intensity increases *(1988 - 2 Marks)*
(b) the minimum wavelength increases
(c) the intensity remain unchanged
(d) the minimum wavelength decreases

**14.** A freshly prepared radioactive source of half life 2 hr emits radiation of intensity which is 64 times the permissibe safe level. The minimum time after which it would be possible to work safely with this source is *(1988 - 2 Marks)*
(a) 6 hr (b) 12 hr
(c) 24 hr (d) 128 hr

**15.** The impurity atoms with which pure silicon should be doped to make a *p*-type semiconductor are those of *(1988 - 2 Marks)*
(a) phosphorus (b) boron
(c) antimony (d) aluminium

**16.** Two identical *p-n* junctions may be connected in series with a battery in three ways, fig. The potential drops across the two $p-n$ junctions are equal in *(1989 - 2 Marks)*




(a) circuit 1 and circuit 2 (b) circuit 2 and circuit 3
(c) circuit 3 and circuit 1 (d) circuit 1 only

**17.** The decay constant of a radioactive sample is $\lambda$. The half-life and mean-life of the sample are respectively given by *(1989 - 2 Marks)*
(a) $1/\lambda$ and $(ln\,2)/\lambda$ (b) $(ln\,2)/\lambda$ and $1/\lambda$
(c) $\lambda\,(ln\,2)$ and $1/\lambda$ (d) $\lambda/(ln\,2)$ and $1/\lambda$

**18.** 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 *(1992 - 2 Marks)*
(a) the stopping potential will be 0.2 volt
(b) the stopping potential will be 0.6 volt
(c) the saturation current will be 6.0 mA
(d) the saturation current will be 2.0 mA

**19.** In an *n-p-n* transistor circuit, the collector current is 10 mA. If 90% of the electrons emitted reach the collector, *(1992 - 2 Marks)*
(a) the emitter current will be 9 mA
(b) the base current will be 1 mA
(c) the emitter current will be 11 mA
(d) the base current will be – 1 mA

**20.** A star initially has $10^{40}$ deuterons. It produces energy via the processes ${}_1H^2 + {}_1H^2 \rightarrow {}_1H^3 + p$, and ${}_1H^2 + {}_1H^3 \rightarrow {}_2He^4 + n$. 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 *(1993-2 Marks)*
(a) $10^6 s$. (b) $10^8 s$.
(c) $10^{12} s$. (d) $10^{16} s$.
The masses of the nuclei are as follows :
$M(H^2) = 2.014$ amu;
$M(p) = 1.007$ amu; $M(n) = 1.008$ amu; $M(He^4) = 4.001$ amu.

**21.** When photons of energy 4.25 eV strike the surface of metal *A*, the ejected photoelectrons have maximum kinetic energy, $T_A$ eV and de Broglie wavelength $\lambda_A$. The maximum kinetic energy of photoelectrons liberated from another metal *B* by photons of energy 4.70 eV is $T_B = (T_A - 1.50)$ eV. If the de Broglie wavelength of these photoelectrons is $\lambda_B = 2\lambda_A$, then *(1994 - 2 Marks)*
(a) The work function of *A* is 2.25 eV
(b) The work function of *B* is 4.20 eV
(c) $T_A = 2.00$ eV
(d) $T_B = 2.75$ eV

**22.** Which of the following statement(s) is (are) correct? *(1994 - 2 Marks)*
(a) The rest mass of a stable nucleus is less than the sum of the rest masses of its separated nucleons
(b) The rest mass of a stable nucleus is greater than the sum of the rest masses of its separated nucleons
(c) In nuclear fission, energy is released by fusing two nuclei of medium mass (approximately 100 amu)
(d) In nuclear fission, energy is released by fragmentation of a very heavy nucleus

**23.** Holes are charge carriers in *(1996 - 2 Marks)*
(a) intrinsic semiconductors (b) ionic solids
(c) *p*-type semiconductors (d) metals

**24.** A transistor is used in the common emitter mode as an amplifier. Then *(1998S - 2 Marks)*
(a) the base-emitter junction is forward-biased
(b) the base-emitter junction is reverse-biased
(c) the input signal is connected in series with the voltage applied to bias the base-emitter junction
(d) the input signal is connected in series with the voltage applied to bias the base-collector junction

**25.** Let $m_p$ be the mass of a proton, $m_n$ the mass of a neutron, $M_1$ the mass of a ${}^{20}_{10}Ne$ nucleus and $M_2$ the mass of a ${}^{40}_{20}Ca$ nucleus. Then *(1998S - 2 Marks)*

(a) $M_2 = 2M_1$ (b) $M_2 > 2M_1$

(c) $M_2 < 2M_1$ (d) $M_1 < 10(m_n + m_p)$

**26.** The electron in a hydrogen atom makes a transition $n_1 \to n_2$ where $n_1$ and $n_2$ are the principal 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 *(1998S - 2 Marks)*

(a) $n_1 = 4, n_2 = 2$ (b) $n_1 = 8, n_2 = 2$

(c) $n_1 = 8, n_2 = 1$ (d) $n_1 = 6, n_2 = 3$

**27.** The half-life of $^{131}I$ is 8 days. Given a sample of $^{131}I$ at time $t = 0$, we can assert that *(1998S - 2 Marks)*

(a) no nucleus will decay before $t = 4$ days
(b) no nucleus will decay before $t = 8$ days
(c) all nuclei will decay before $t = 16$ days
(d) a given nucleus may decay at any time after $t = 0$

**28.** In a *p-n* junction diode not connected to any circuit, *(1998S - 2 Marks)*

(a) the potential is the same everywhere
(b) the *p*-type side is at a higher potential than the *n*-type side
(c) there is an electric field at the junction directed from the *n*-type side to the *p*-type side
(d) there is an electric field at the junction directed from the *p*-type side to the *n*-type side

**29.** X-rays are produced in an X-ray tube operating at a given accelerating voltage. The wavelength of the continuous X-rays has values from *(1998S - 2 Marks)*

(a) 0 to $\infty$

(b) $\lambda_{min}$ to $\infty$ where $\lambda_{min} > 0$

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

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

**30.** The work function of a substance is 4.0 eV. The longest wavelength of light that can cause photoelectron emission from this substance is approximately *(1998S - 2 Marks)*

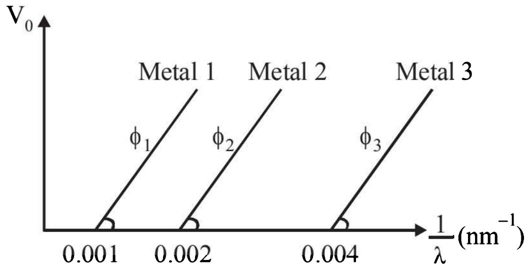
(a) 540 nm (b) 400 nm

(c) 310 nm (d) 220 nm

**31.** 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 *(1999S - 3 Marks)*

(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*

**32.** The graph between the stopping potential ($V_0$) and $\left(\frac{1}{\lambda}\right)$ is shown in the figure. $\phi_1$, $\phi_2$ and $\phi_3$ are work functions, which of the following is/are correct **(2006 - 5M, –1)**



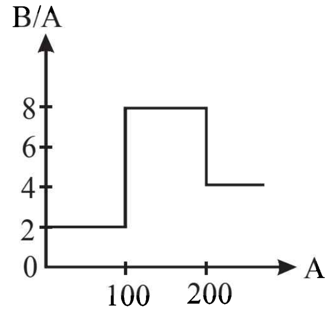

(a) $\phi_1 : \phi_2 : \phi_3 = 1:2:4$

(b) $\phi_1 : \phi_2 : \phi_3 = 4:2:1$

(c) $\tan\theta \propto \frac{hc}{e}$

(d) ultraviolet light can be used to emit photoelectrons from metal 2 and metal 3 only

**33.** Assume that the nuclear binding energy per nucleon (B/A) versus mass number (A) is as shown in the figure. Use this plot to choose the correct choice(s) given below. *(2008)*

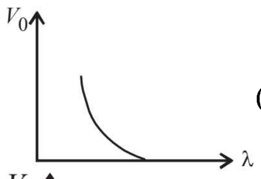


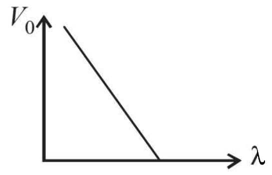

(a) Fusion of two nuclei with mass numbers lying in the range of $1 < A < 50$ will release energy.
(b) Fusion of two nuclei with mass numbers lying in the range of $51 < A < 100$ will release energy
(c) Fission of a nucleus lying in the mass range of $100 < A < 200$ will release energy when broken into 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

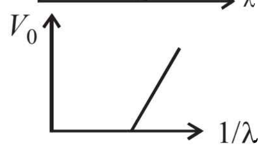
**34.** The radius of the orbit of an electron in a Hydrogen-like atom is $4.5\,a_0$, where $a_0$ is the Bohr radius. Its orbital angular momentum is $\frac{3h}{2\pi}$. It is given that h is Planck constant and R is Rydberg constant. The possible wavelength(s), when the atom de-excites, is (are) *(JEE Adv. 2013)*

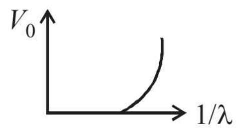
(a) $\frac{9}{32R}$ (b) $\frac{9}{16R}$ (c) $\frac{9}{5R}$ (d) $\frac{4}{3R}$

**35.** For photo-electric effect with incident photon wavelength $\lambda$, the stopping potential is $V_0$. Identify the correct variation(s) of $V_0$ with $\lambda$ and $1/\lambda$. ***(JEE Adv. 2015)***

(a)



(b)



(c)



(d)


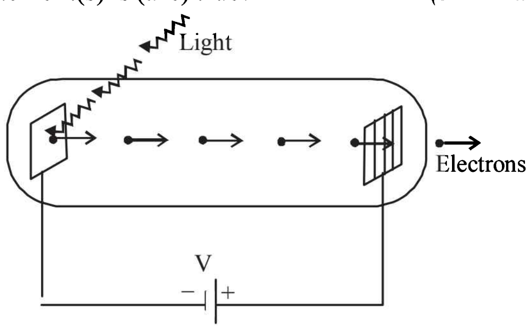

**36.** A fission reaction is given by ${}^{236}_{92}U \rightarrow {}^{140}_{54}Xe + {}^{94}_{38}Sr + x + y$, where $x$ and $y$ are two particles. Considering ${}^{236}_{92}U$ to be at rest, the kinetic energies of the products are denoted by $K_{Xe}$, $K_{Sr}$, $K_x$(2 MeV) and $K_y$(2 MeV), respectively. Let the binding energies per nucleon of ${}^{236}_{92}U$, ${}^{140}_{54}Xe$ and ${}^{94}_{38}Sr$ be 7.5 MeV, 8.5 MeV and 8.5 MeV, respectively. Considering different conservation laws, the correct option(s) is(are) ***(JEE Adv. 2015)***

(a) $x = n, y = n, K_{Sr} = 129$ MeV, $K_{Xe} = 86$ MeV
(b) $x = p, y = e^-, K_{Sr} = 129$ MeV, $K_{Xe} = 86$ MeV
(c) $x = p, y = n, K_{Sr} = 129$ MeV, $K_{Xe} = 86$ MeV
(d) $x = n, y = n, K_{Sr} = 86$ MeV, $K_{Xe} = 129$ MeV

**37.** Highly excited states for hydrogen–like atoms (also called Rydberg states) with nuclear charge Ze are defined by their principal quantum number n, where n>>1. Which of the following statement(s) is(are) true? ***(JEE Adv. 2016)***

(a) Relative change in the radii of two consecutive orbitals does not depend on Z
(b) Relative change in the radii of two consecutive orbitals varies as 1/n
(c) Relative change in the energy of two consecutive orbitals varies as $1/n^3$
(d) Relative change in the angular momenta of two consecutive orbitals varies as 1/n

**38.** Light of wavelength $\lambda_{ph}$ falls on a cathode plate inside a vacuum tube as shown in the figure. The work function of the cathode surface is $\phi$ and the anode is a wire mesh of conducting material kept at a distance d from the cathode. A potential difference V is maintained between the electrodes. If the minimum de Broglie wavelength of the electrons passing through the anode is $\lambda_e$, which of the following statement(s) is (are) true? ***(JEE Adv. 2016)***




(a) $\lambda_e$ decreases with increase in $\phi$ and $\lambda_{ph}$
(b) $\lambda_e$ is approximately halved, if d is doubled
(c) For large potential difference ($V >> \phi/e$), $\lambda_e$ is approximately halved if V is made four times
(d) $\lambda_e$ increases at the same rate as $\lambda_{ph}$ for $\lambda_{ph} < hc/\phi$

## E Subjective Problems

**1.** A single electron orbits around a stationary nucleus of charge $+Ze$. Where $Z$ is a constant and $e$ is the magnitude of the electronic charge. It requires 47.2 eV to excite the electron from the second Bohr orbit to the third Bohr orbit. Find ***(1981- 10 Marks)***

(i) The value of $Z$.
(ii) The energy required to excite the electron from the third to the fourth Bohr orbit.
(iii) The wavelength of the electromagnetic radiation required to remove the electron from the first Bohr orbit to infinity.
(iv) The kinetic energy, potential energy, potential energy and the angular momentum of the electron in the first Bohr orbit.
(v) The radius of the first Bohr orbit.

(The ionization energy of hydrogen atom = 13.6 eV, Bohr radius = $5.3 \times 10^{-11}$ metre, velocity of light = $3 \times 10^8$ m/sec. Planck's constant = $6.6 \times 10^{-34}$ joules - sec).

**2.** Hydrogen atom in its ground state is excited by means of monochromatic radiation of wavelength 975Å. How many different lines are possible in the resulting spectrum ? Calculate the longest wavelength amongst them. You may assume the ionization energy for hydrogen atom as 13.6 eV. ***(1982 - 5 Marks)***

**3.** How many electron, protons and neutrons are there in a nucleus of atomic number 11 and mass number 24 ? ***(1982 - 2 Marks)***

(i) number of electrons = (ii) number of protons =
(iii) number of neutrons =

**4.** The ionization energy of a hydrogen like Bohr atom is 4 Rydbergs. (i) What is the wavelength of the radiation emitted when the electron jumps from the first excited state to the ground state ? (ii) What is the radius of the first orbit for this atom? ***(1984- 4 Marks)***

**5.** A double ionised Lithium atom is hydrogen-like with atomic number 3. ***(1985 - 6 Marks)***

(i) Find the wavelength of the radiation required to excite the electron in $Li^{++}$ from the first to the third Bohr orbit. (Ionisation energy of the hydrogen atom equals 13.6 eV.)
(ii) How many spectral lines are observed in the emission spectrum of the above excited system?

**6.** A triode has plate characteristics in the form of parallel lines in the region of our interest. At a grid voltage of – 1 volt the anode current I (in milli amperes) is given in terms of plate voltage V (in volts) by the algebraic relation :

$$I = 0.125V - 7.5$$

For grid voltage of – 3 volts, the current at anode voltage of 300 volts is 5 milliampere. Determine the plate resistance ($r_p$), transconductance ($g_m$) and the amplification factor ($\mu$) for the triode. ***(1987 - 7 Marks)***

**7.** A particle of charge equal to that of an electron, $-e$, and mass 208 times the mass of the electron (called a mu-meson) moves in a circular orbit around a nucleus of charge $+3e$. (Take the mass of the nucleus to be infinite). Assuming that the Bohr model of the atom is applicable to this system. ***(1988 - 6 Marks)***
(i) Derive an expression for the radius of the nth Bohr orbit.
(ii) Find the value of $n$ for which the radius of the orbit is approximately the same as that of the first Bohr orbit for the hydrogen atom.
(iii) Find the wavelength of the radiation emitted when the mu-meson jumps from the third orbit of the first orbit.

**8.** A gas of identical hydrogen-like atoms has some atoms in the lowest (ground) energy level $A$ and some atoms in a particular upper (excited) energy level $B$ and there are no atoms in any other energy level. The atoms of the gas make transition to a higher energy level by absorbing monochromatic light of photon energy 2.7 eV. Subsequently, the atoms emit radiation of only six different photon energies. Some of the emitted photons have energy 2.7 eV, some have energy more and some have less than 2.7 eV. ***(1989 - 8 Marks)***
(i) Find the principal quantum number of the initially excited level $B$.
(iii) Find the ionization energy for the gas atoms.
(iii) Find the maximum and the minimum energies of the emitted photons.

**9.** Electrons in hydrogen like atom ($Z = 3$) make transitions from the fifth to the fourth orbit and from the fourth to the third orbit. The resulting radiations are incident normally on a metal plate and eject 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 photoelectrons ejected by the longer wavelength. ***(1990 - 7 Marks)***

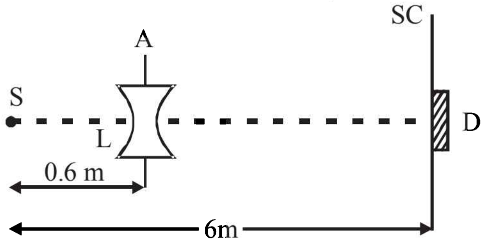
(Rydberg constant = $1.094 \times 10^7 \text{m}^{-1}$)

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

$${}_1^2\text{H} + {}_1^2\text{H} \rightarrow {}_2^4\text{He} \qquad \textit{(1990 - 8 Marks)}$$

in a nuclear reactor of 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)

**11.** A monochromatic point source radiating wavelength 6000 Å, with power 2 watt, an aperture $A$ of diameter 0.1 m and a large screen $SC$ are placed as shown in fig. A photoemissive detector $D$ of surface area 0.5 cm$^2$ is placed at the centre of the screen. The efficiency of the detector for the photoelectron generation per incident photon is 0.9. ***(1991 - 2 + 4 + 2 Marks)***




(a) Calculate the photon flux at the centre of the screen and the photocurrent in the detector.
(b) If the concave lens $L$ of focal length 0.6 m is inserted in the aperture as shown, find the new values of photon flux and photocurrent. Assume a uniform average transmission of 80% from the lens.
(c) If the work function of the photoemissive surface is 1eV, calculate the values of the stopping potential in the two cases (without and with the lens in the aperture).

**12.** A nucleus $X$, initially at rest, undergoes alpha decay according to the equation,

$${}_{92}^{A}X \rightarrow {}_{Z}^{228}Y + \alpha \qquad \textit{(1991 - 4 + 4 Marks)}$$

(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 0.11 m in a uniform magnetic field of 3 Tesla. Find the energy (In MeV) released during the process and the binding energy of the parent nucleus $X$.

Given that : $m(Y) = 228.03\,u$; $m\left({}_0^1 n\right) = 1.009\,u$.

$$m\left({}_2^4\text{He}\right) = 4.003\,u;\ m\left({}_1^1\text{H}\right) = 1.008\,u$$

**13.** 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 ***(1992 - 10 Marks)***
(a) the energy of the photons causing the photoelectric 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)

**14.** A small quantity of solution containing $Na^{24}$ radio nuclide (half life = 15 hour) of activity 1.0 microcurie is injected into the blood of a person. A sample of the blood of volume 1 cm$^3$ taken after 5 hour show an activity of 296 disintegrations per minute. Determine the total volume of the blood in the body of the person. Assume that radioactive solution mixes uniformly in the blood of the person. (1 curie = $3.7 \times 10^{10}$ disintegrations per second) ***(1994 - 6 Marks)***

**15.** 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 and 17.0 eV respectively. Alternately, 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. ***(1994 - 6 Marks)***
Determine the values of $n$ and $Z$. (Ionization energy of H-atom = 13.6 eV)

**16.** An electron, in a hydrogen-like atom, is in an excited state. It has a total energy of –3.4 eV. Calculate (i) the kinetic energy and (ii) the de Broglie wavelength of the electron. *(1996 - 3 Marks)*

**17.** At a given instant there are 25% undecayed radio-active nuclei in a sample. After 10 seconds the number of undecayed nuclei reduces to 12.5%. Calculate (i) mean-life of the nuclei, and (ii) the time in which the number of undecayed nuclei will further reduce to 6.25% of the reduced number. *(1996 - 3 Marks)*

**18.** 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 is formed if the distance d between the atoms of the array is 2Å. A similar standing wave is again formed if d is increased to 2.5 Å but not for any intermediate value of d. Find the energy of the electrons in electron volts and the least value of d for which the standing wave of the type described above can form. *(1997 - 5 Marks)*

**19.** The element Curium $^{248}_{96}$Cm has a mean life of $10^{13}$ seconds. Its pirmary decay modes are spontaneous fission and α-decay, the former with a probability of 8% and the latter with a probability of 92%. Each fission releases 200 MeV of energy. The masses involved in α-decay are as follows: $^{248}_{96}$Cm = 248.072220*u*, $^{244}_{94}$Pu = 244.064100*u* and $^{4}_{2}$He=4.002603 *u*. Calculate the power output from a sample of $10^{20}$ Cm atoms. (1 u = 931 MeV/$c^2$.) *(1997 - 5 Marks)*

**20.** Nuclei of a radioactive element *A* are being produced at a constant rate α. The element has a decay constant λ. At time $t = 0$, there are $N_0$ nuclei of the element. *(1998 - 8 Marks)*
(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 $t \to \infty$.

**21.** Photoelectrons are emitted when 40 nm radiation is incident on a surface of work function 1.9 eV. These photoelectrons pass through a region containing α-particles. A maximum energy electron combines with an α–particle to form a $He^+$ ion, emitting a single photon in this process. $He^+$ 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. [Take $h = 4.14 \times 10^{-15}$ eV.s.] *(1999 - 5 Marks)*

**22.** A hydrogen-like atom of atomic number *Z* is in an excited state of quantum number 2*n*. It can emit a maximum energy photon of 204 eV. If it makes a transition to quantum state *n*, a photon of energy 40.8 eV is emitted. Find *n*, *Z* and the ground state energy (in eV) for this atom. Also calculate the minimum energy (in eV) that can be emitted by this atom during de-excitation. Ground state energy of hydrogen atom is –13.6 eV. *(2000 - 6 Marks)*

**23.** When a beam of 10.6 eV photons of intensity 2.0 W/m² falls on a platinum surface of area $1.0 \times 10^{-4}$ m² 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 energies (in eV). Take 1eV = $1.6 \times 10^{-19}$ J. *(2000 - 4 Marks)*

**24.** In a nuclear reaction $^{235}$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 years, find the total mass of uranium required. *(2001 - 5 Marks)*

**25.** A nucleus at rest undergoes a decay emitting an α particle of de-Broglie wavelength $\lambda = 5.76 \times 10^{-15}$ m. If the mass of the daughter nucleus is 223.610 amu and that of the α particles is 4.002 amu, determine the total kinetic energy in the final state. Hence, obtain the mass of the parent nucleus in amu. (1 amu = 931.470 MeV/$c^2$) *(2001-5 Marks)*

**26.** A radioactive nucleus *X* decays to a nucleus *Y* with a decay constant $\lambda_x = 0.1$ s$^{-1}$. *Y* further decays to a stable nucleus *Z* with a decay constant $\lambda_Y = 1/30$ s$^{-1}$. Initially, there are only *X* nuclei and their number is $N_o = 10^{20}$. 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 $N_Y(t) = (N_o\lambda_X/(\lambda_X - \lambda_Y))\{\exp(-\lambda_Y t) - \exp(-\lambda_X t)\}$. Find the time at which $N_Y$ is maximum and determine the populations *X* and *Z* at that instant. *(2001-5 Marks)*

**27.** A hydrogen-like atom (described by the Bohr model) is observed to emit six wavelengths, originating from all possible transitions between a group of levels. These levels have energies between -0.85 eV and -0.544 eV (**including** both these values). *(2002 - 5 Marks)*
(a) Find the atomic number of the atom.
(b) Calculate the smallest wavelength emitted in these transitions.
(Take $hc$ = 1240 eV-nm, ground state energy of hydrogen atom = –13.6 eV)

**28.** Two metallic plates *A* and *B*, each of area $5 \times 10^{-4}$ m², are placed parallel to each other at a separation of 1 cm. Plate *B* carries a positive charge of $33.7 \times 10^{-12}$ *C*. A monochromatic beam of light, with photons of energy 5 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. Also assume that all the emitted photoelectrons are collected by plate *B* and the work function of plate *A* remains constant at the value 2eV. Determine *(2002 - 5 Marks)*
(a) the number of photoelectrons emitted up to $t = 10$ s,
(b) the magnitude of the electric field between the plates *A* and *B* at $t = 10$ s, and
(c) the kinetic energy of the most energetic photoelectron emitted at $t = 10$ s when it reaches plate *B*.
Neglect the time taken by the photoelectron to reach plate *B*. Take $\varepsilon_0 = 8.85 \times 10^{-12}$ C²/N-m²

**29.** Frequency of a photon emitted due to transition of electron of a certain element from *L* to *K* shell is found to be $4.2 \times 10^{18}$ Hz. Using Moseley's law, find the atomic number of the element, given that the Rydberg's constant $R = 1.1 \times 10^7$ m$^{-1}$. *(2003 - 2 Marks)*

**30.** A radioactive sample emits *n* β-particles in 2 sec. In next 2 sec it emits 0.75 *n* β-particle, what is the mean life of the sample? *(2003 - 2 Marks)*

**31.** In a photoelectric experiment set up, photons of energy 5 eV falls on the cathode having work function 3 eV. (a) If the saturation current is $i_A = 4\mu A$ for intensity $10^{-5}$ W/m², then plot a graph between anode potential and current. (b) Also draw a graph for intensity of incident radiation $2 \times 10^{-5}$ W/m². *(2003 - 2 Marks)*

**32.** A radioactive sample of $^{238}U$ decays to Pb through a process for which the half-life is $4.5\times10^9$ years. Find the ratio of number of nuclei of Pb to $^{238}U$ after a time of $1.5\times10^9$ years. Given $(2)^{1/3} = 1.26$. *(2004 - 2 Marks)*

**33.** The photons from the Balmer series in Hydrogen spectrum having wavelength between 450 nm to 700 nm are incident on a metal surface of work function 2 eV. Find the maximum kinetic energy of ejected electron. (Given $hc = 1242$ eV nm) *(2004 - 4 Marks)*

**34.** The potential energy of a particle of mass $m$ is given by

$$V(x) = \begin{Bmatrix} E_0; & 0 \le x \le 1 \\ 0; & x > 1 \end{Bmatrix}$$

$\lambda_1$ and $\lambda_2$ are the de-Broglie wavelengths of the particle, when $0 \le x \le 1$ and $x > 1$ respectively. If the total energy of particle is $2E_0$, find $\lambda_1 / \lambda_2$. *(2005 - 2 Marks)*

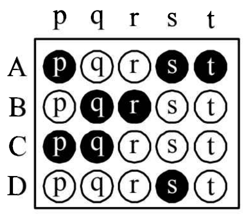
**35.** Highly energetic electrons are bombarded on a target of an element containing 30 neutrons. The ratio of radii of nucleus to that of Helium nucleus is $(14)^{1/3}$. Find (a) atomic number of the nucleus. (b) the frequency of $K_\alpha$ line of the X-ray produced. ($R = 1.1 \times 10^7\ m^{-1}$ and $c = 3 \times 10^8$ m/s) *(2005 - 4 Marks)*

**36.** In hydrogen-like atom ($z = 11$), nth line of Lyman series has wavelength $\lambda$. The de-Broglie's wavelength of electron in the level from which it originated is also $\lambda$. Find the value of $n$? *(2006 - 6M)*

## F Match the Following

**DIRECTIONS (Q. No. 1 to 4 & 6) :** *Each question contains statements given in two columns, which have to be matched. The statements in Column-I are labelled A, B, C and D, while the statements in Column-II are labelled p, q, r and s. Any given statement in Column-I can have correct matching with ONE OR MORE statement(s) in Column-II. The appropriate bubbles corresponding to the answers to these questions have to be darkened as illustrated in the following example :*

*If the correct matches are A-p, s and t; B-q and r; C-p and q; and D-s then the correct darkening of bubbles will look like the given.*




**1.** In the following, column I lists some physical quantities and the column II gives approximate energy values associated with some of them. Choose the appropriate value of energy from column II for each of the physical quantities in column I and write the corresponding letter p, q, r, etc. against the number (A), (B), (C), (D) etc. of the physical quantity in the answer book. In your answer, the sequence of column I should be maintained. *(1997 - 4 Marks)*

| Column I | Column II |
|---|---|
| (A) Energy of thermal neutrons | (p) 0.025 eV |
| (B) Energy of X-rays | (q) 0.5 eV |
| (C) Binding energy per nucleon | (r) 3 eV |
| (D) Photoelectric threshold of a metal | (s) 20 eV |
| | (t) 10 k eV |
| | (u) 8 M eV |

**2.** Given below are certain matching type questions, where two columns (each having 4 items) are given. Immediately after the columns the matching grid is given, where each item of Column I has to be matched with the items of Column II, by encircling the correct match(es). Note that an item of column I can match with more than one item of column II. All the items of column II must be matched. Match the following : *(2006 - 6M)*

| Column I | Column II |
|---|---|
| (A) Nuclear fusion | (p) Converts some matter into energy |
| (B) Nuclear fission | (q) Generally possible for nuclei with low atomic number |
| (C) β-decay | (r) Generally possible for nuclei with higher atomic number |
| (D) Exothermic nuclear reaction | (s) Essentially proceeds by weak nuclear forces |

**3.** Some laws / processes are given in **Column I**. Match these with the physical phenomena given in **Column II** and indicate your answer by darkening appropriate bubbles in the $4 \times 4$ matrix given in the ORS. *(2007)*

| Column I | Column II |
|---|---|
| (A) Transition between two atomic energy levels | (p) Characteristic X-rays |
| (B) Electron emission from a material | (q) Photoelectric effect |
| (C) Mosley's law | (r) Hydrogen spectrum |
| (D) Change of photon energy into kinetic energy of electrons | (s) β-decay |

**4.** **Column-II** gives certain systems undergoing a process. **Column-I** suggests changes in some of the parameters related to the system. Match the statements in **Column-I** to the approapriate process(es) from **Column-II**. *(2009)*

| **Column-I** | | **Column-II** |
|---|---|---|
| (A) The energy of the system is increased | (p) | *System :* A capacitor, initially uncharged<br>*Process :* It is connected to a battery |
| (B) Mechanical energy is provided to the system, which is converted into energy of random motion of its parts | (q) | *System :* A gas in an adiabatic container fitted with an adiabatic piston<br>*Process:* The gas is compressed by pushing the piston |
| (C) Internal energy of the system is converted into its mechanical energy | (r) | *System:* A gas in a rigid container<br>*Process:* The gas gets cooled due to colder atmosphere surrounding it |
| (D) Mass of the system is decreased | (s) | *System:* A heavy nucleus, initially at rest<br>*Process:* The nucleus fissions into two fragments of nearly equal masses and some neutrons are emitted |
| | (t) | *System:* A resistive wire loop<br>*Process:* The loop is placed in a time varying magnetic field perpendicular to its plane |

**DIRECTION (Q.No. 5) :** *Following question has matching list I and II. The codes for the lists have choices (a), (b), (c) and (d) out of which ONLY ONE is correct.*

**5.** Match List I of the nuclear processes with List II containing parent nucleus and one of the end products of each process and then select the correct answer using the codes given below the lists: *(JEE Adv. 2013-II)*

| **List I** | **List II** |
|---|---|
| P. Alpha decay | 1. $^{15}_{8}O \to ^{15}_{7}O + ...$ |
| Q. β+ decay | 2. $^{138}_{92}U \to ^{234}_{90}Th + ...$ |
| R. Fission | 3. $^{185}_{83}Bi \to ^{184}_{82}Pb + ...$ |
| S. Proton emission | 4. $^{239}_{94}Pu \to ^{140}_{57}La + ...$ |

**Codes:**

| | P | Q | R | S |
|---|---|---|---|---|
| (a) | 4 | 2 | 1 | 3 |
| (b) | 1 | 3 | 2 | 4 |
| (c) | 2 | 1 | 4 | 3 |
| (d) | 4 | 3 | 2 | 1 |

**6.** Match the nuclear processes given in column I with the appropriate option(s) in column II. *(JEE Adv. 2015)*

| **Column I** | | **Column II** |
|---|---|---|
| (A) Nuclear fusion | (p) | Absorption of thermal neutrons by $^{235}_{92}U$ |
| (B) Fission in a nuclear reactor | (q) | $^{60}_{27}Co$ nucleus |
| (C) β-decay | (r) | Energy production in stars via hydrogen conversion to helium |
| (D) γ-ray emission | (s) | Heavy water |
| | (t) | Neutrino emission |

## G Comprehension Based Questions

### PASSAGE-I

In a mixture of H-He$^+$ gas (He+ is singly ionized He atom), H atoms and He+ ions are excited to their respective first excited states. Subsequently, H atoms transfer their total excitation energy to He+ ions (by collisions). Assume that the Bohr model of atom is exactly valid. *(2008)*

1. The quantum number n of the state finally populated in He$^+$ ions is –
   (a) 2 (b) 3
   (c) 4 (d) 5
2. The wavelength of light emitted in the visible region by He+ ions after collisions with H atoms is –
   (a) $6.5 \times 10^{-7}$ m
   (b) $5.6 \times 10^{-7}$ m
   (c) $4.8 \times 10^{-7}$ m
   (d) $4.0 \times 10^{-7}$ m
3. The ratio of the kinetic energy of the n = 2 electron for the H atom to that of He$^+$ ion is –
   (a) 1/4 (b) 1/2
   (c) 1 (d) 2

### PASSAGE-2

Scientists are working hard to develop nuclear fusion reactor. Nuclei of heavy hydrogen, $_1^2$H, known as deuteron and denoted by D, can be thought of as a candidate for fusion reactor. The D-D reaction is $_1^2\text{H} + _1^2\text{H} \to _2^3\text{He} + n +$ energy. In the core of fusion reactor, a gas of heavy hydrogen is fully ionized into deuteron nuclei and electrons. This collection of $_1^2H$ nuclei and electrons is known as plasma. The nuclei move randomly in the reactor core and occasionally come close enough for nuclear fusion to take place. Usually, the temperatures in the reactor core are too high and no material wall can be used to confine the plasma. Special techniques are used which confine the plasma for a time $t_0$ before the particles fly away form the core. If $n$ is the density (number/volume) of deuterons, the product $nt_0$ is called Lawson number. In one of the criteria, a reactor is termed successful if Lawson number is greater than $5 \times 10^{14}$ s/cm$^3$.

It may be helpful to use the following: Boltzmann constant

$k = 8.6 \times 10^{-5}$ eV/K; $\dfrac{e^2}{4\pi\varepsilon_0} = 1.44 \times 10^{-9}$ eVm *(2009)*

4. In the core of nuclear fusion reactor, the gas becomes plasma because of
   (a) strong nuclear force acting between the deuterons
   (b) coulomb force acting between the deuterons
   (c) coulomb force acting between deuteron-electron pairs
   (d) the high temperature maintained inside the reactor core
5. Assume that two deuteron nuclei in the core of fusion reactor at temperature $T$ are moving towards each other, each with kinetic energy 1.5 $kT$, when the separation between them is large enough to neglect coulomb potential energy. Also neglect any interaction from other particles in the core. The minimum temperature $T$ required for them to reach a separation of $4 \times 10^{-15}$ m is in the range
   (a) $1.0 \times 10^9\,\text{K} < T < 2.0 \times 10^9\,\text{K}$
   (b) $2.0 \times 10^9\,\text{K} < T < 3.0 \times 10^9\,\text{K}$
   (c) $3.0 \times 10^9\,\text{K} < T < 4.0 \times 10^9\,\text{K}$
   (d) $4.0 \times 10^9\,\text{K} < T < 5.0 \times 10^9\,\text{K}$
6. Results of calculations for four different designs of a fusion reactor using D-D reaction are given below. Which of these is most promising based on Lawson criterion?
   (a) deuteron density = $2.0 \times 10^{12}$ cm$^{-3}$, confinement time = $5.0 \times 10^{-3}$ s
   (b) deuteron density = $8.0 \times 10^{14}$ cm$^{-3}$, confinement time = $9.0 \times 10^{-1}$ s
   (c) deuteron density = $4.0 \times 10^{23}$ cm$^{-3}$, confinement time = $1.0 \times 10^{-11}$ s
   (d) deuteron density = $1.0 \times 10^{24}$ cm$^{-3}$, confinement time = $4.0 \times 10^{-12}$ s

### PASSAGE-3

When a particle is restricted to move along $x$ - axis between $x = 0$ and $x = a$, where $a$ is of nanometer dimension, its energy can take only certain specific values. The allowed energies of the particle moving in such a restricted region, correspond to the formation of standing waves with nodes at its ends $x = 0$ and $x = a$. The wavelength of this standing wave is related to the linear momentum $p$ of the particle according to the de Broglie relation. The energy of the particle of mass $m$ is related to its linear momentum as $E = \dfrac{p^2}{2m}$. Thus, the energy of the particle can be denoted by a quantum number '$n$' taking values 1, 2, 3, ... (n = 1, called the ground state) corresponding to the number of loops in the standing wave. Use the model described above to answer the following three questions for a particle moving in the line $x = 0$ to $x = a$. Take $h = 6.6 \times 10^{-34}$ $Js$ and $e = 1.6 \times 10^{-19}$ $C$.

7. The allowed energy for the particle for a particular value of $n$ is proportional to *(2009)*
   (a) $a^{-2}$ (b) $a^{-3/2}$
   (c) $a^{-1}$ (d) $a^2$
8. If the mass of the particle is $m = 1.0 \times 10^{-30}$ kg and $a = 6.6$ nm, the energy of the particle in its ground state is closest to *(2009)*
   (a) 0.8 meV (b) 8 meV
   (c) 80 meV (d) 800 meV
9. The speed of the particle, that can take discrete values, is proportional to *(2009)*
   (a) $n^{-3/2}$ (b) $n^{-1}$
   (c) $n^{1/2}$ (d) $n$

### PASSAGE-4

The key feature of Bohr's theory of spectrum of hydrogen atom is the quantization of angular momentum when an electron is revolving around a proton. We will extend this to a general rotational motion to find quantized rotational energy of a diatomic molecule assuming it to be rigid. The rule to be applied is Bohr's quantization condition. *(2010)*

10. A diatomic molecule has moment of inertia $I$. By Bohr's quantization condition its rotational energy in the n$^{\text{th}}$ level (n = 0 is not allowed) is
    (a) $\dfrac{1}{n^2}\left(\dfrac{h^2}{8\pi^2 I}\right)$ (b) $\dfrac{1}{n}\left(\dfrac{h^2}{8\pi^2 I}\right)$
    (c) $n\left(\dfrac{h^2}{8\pi^2 I}\right)$ (d) $n^2\left(\dfrac{h^2}{8\pi^2 I}\right)$

11. It is found that the excitation frequency from ground to the first excited state of rotation for the CO molecule is close to $\frac{4}{\pi}\times10^{11}$ Hz. Then the moment of inertia of CO molecule about its center of mass is close to

(Take $h = 2\pi\times10^{-34}$ J s)

(a) $2.76\times10^{-46}$ kg m$^2$ (b) $1.87\times10^{-46}$ kg m$^2$

(c) $4.67\times10^{-47}$ kg m$^2$ (d) $1.17\times10^{-47}$ kg m$^2$

12. In a CO molecule, the distance between C (mass = 12 a.m.u.) and O (mass = 16 a.m.u.), where 1 a.m.u. $=\frac{5}{3}\times10^{-27}$ kg, is close to

(a) $2.4\times10^{-10}$ m (b) $1.9\times10^{-10}$ m

(c) $1.3\times10^{-10}$ m (d) $4.4\times10^{-11}$ m

### PASSAGE-5

The β -decay process, discovered around 1900, is basically the decay of a neutron (*n*). In the laboratory, a proton (*p*) and an electron ($e^-$) are observed as the decay products of the neutron. Therefore, considering the decay of a neutron as a two-body decay process, it was predicted theoretically that the kinetic energy of the electron should be a constant. But experimentally, it was observed that the electron kinetic energy has continuous spectrum. Considering a three-body decay process, i.e. $n \to p + e^- + \bar{\nu}_e$, around 1930, Pauli explained the observed electron energy spectrum. Assuming the anti-neutrino ($\bar{\nu}_e$) to be massless and possessing negligible energy, and the neutron to be at rest, momentum and energy conservation principles are applied. From this calculation, the maximum kinetic energy of the electron is $0.8\times10^6$ eV. The kinetic energy carried by the proton is only the recoil energy.

13. If the anti-neutrino had a mass of 3 eV/c$^2$ (where c is the speed of light) instead of zero mass, what should be the range of the kinetic energy, *K*, of the electron? ***(2012)***

(a) $0 \le K \le 0.8\times10^6\, eV$

(b) $3.0\, eV \le K \le 0.8\times10^6\, eV$

(c) $3.0\, eV \le K < 0.8\times10^6\, eV$

(d) $0 \le K < 0.8\times10^6\, eV$

14. What is the maximum energy of the anti-neutrino? ***(2012)***

(a) Zero

(b) Much less than $0.8\times10^6$ eV.

(c) Nearly $0.8\times10^6$ eV

(d) Much larger than $0.8\times10^6$ eV

### PASSAGE-6

The mass of a nucleus ${}^A_Z X$ is less than the sum of the masses of (A-Z) number of neutrons and Z number of protons in the nucleus. The energy equivalent to the corresponding mass difference is known as the binding energy of the nucleus. A heavy nucleus of mass M can break into two light nuclei of masses $m_1$ and $m_2$ only if $(m_1 + m_2) < M$. Also two light nuclei of masses $m_3$ and $m_4$ can undergo complete fusion and form a heavy nucleus of mass M' only if $(m_3 + m_4) > M'$. The masses of some neutral atoms are given in the table below:

| | | | |
|---|---|---|---|
| ${}^1_1H$ | 1.007825 u | ${}^2_1H$ | 2.014102 u |
| ${}^3_1H$ | 3.016050 u | ${}^4_2He$ | 4.002603 u |
| ${}^6_3Li$ | 6.015123 u | ${}^7_3Li$ | 7.016004 u |
| ${}^{70}_{30}Zn$ | 69.925325 u | ${}^{82}_{34}Se$ | 81.916709 u |
| ${}^{152}_{64}Gd$ | 151.919803 u | ${}^{206}_{82}Pb$ | 205.974455 u |
| ${}^{209}_{83}Bi$ | 208.980388 u | ${}^{210}_{84}Po$ | 209.982876 u |

(1u = 932 MeV/c$^2$)

***(JEE Adv. 2013)***

15. The kinetic energy (in keV) of the alpha particle, when the nucleus ${}^{210}_{84}Po$ at rest undergoes alpha decay, is

(a) 5319 (b) 5422

(c) 5707 (d) 5818

16. The correct statement is

(a) The nucleus ${}^6_3Li$ can emit an alpha particle

(b) The nucleus ${}^{210}_{84}Po$ can emit a proton

(c) Deuteron and alpha particle can undergo complete fusion

(d) The nuclei ${}^{70}_{30}Zn$ and ${}^{82}_{34}Se$ can undergo complete fusion

## H Assertion & Reason Type Questions

1. **STATEMENT-1** ***(2007)***

If the accelerating potential in an X-ray tube is increased, the wavelengths of the characteristic X-rays do not change.

**STATEMENT-2**

When an electron beam strikes the target in an X-ray tube, part of the kinetic energy is converted into X-ray energy.

(a) Statement-1 is True, Statement-2 is True; Statement-2 is a correct explanation for Statement-1

(b) Statement-1 is True, Statement-2 is True; Statement-2 is NOT a correct explanation for Statement-1

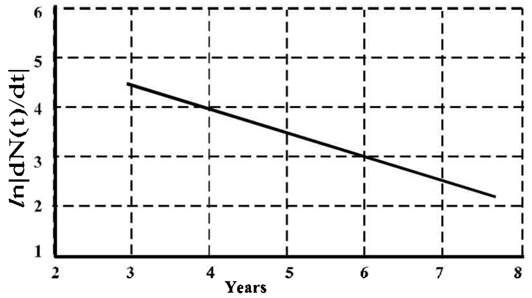
(c) Statement-1 is True, Statement-2 is False

(d) Statement-1 is False, Statement-2 is True

## I Integer Value Correct Type

1. An α-particle and a proton are accelerated from rest by a potential difference of 100 V. After this, their de Broglie wavelengths are $\lambda_\alpha$ and $\lambda_p$ respectively. The ratio $\frac{\lambda_p}{\lambda_\alpha}$, to the nearest integer, is ***(2010)***

2. To determine the half life of a radioactive element, a student plots a graph of $ln\left|\frac{dN(t)}{dt}\right|$ versus $t$. Here $\left|\frac{dN(t)}{dt}\right|$ is the rate of radioactive decay at time $t$. If the number of radioactive nuclei of this element decreases by a factor of $p$ after 4.16 years, the value of $p$ is *(2010)*




3. The activity of a freshly prepared radioactive sample is $10^{10}$ disintegrations per second, whose mean life is $10^9$ s. The mass of an atom of this radioisotope is $10^{-25}$ kg. The mass (in mg) of the radioactive sample is *(2011)*

4. A silver sphere of radius 1 cm and work function 4.7 eV is suspended from an insulating thread in freespace. It is under continuous illumination of 200 nm wavelength light. As photoelectrons are emitted, the sphere gets charged and acquires a potential. The maximum number of photoelectrons emitted from the sphere is $A \times 10^z$ (where $1 < A < 10$). The value of 'z' is *(2011)*

5. 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 fm to the nucleus. The de Broglie wavelength (in units of fm) of the proton at its start is: (take the proton mass, $m_p = (5/3) \times 10^{-27}$ kg; $h/e = 4.2 \times 10^{-15}$ J.s / C;

$\frac{1}{4\pi\varepsilon_0} = 9 \times 10^9$ m/F; 1 fm $= 10^{-15}$ m *(2012- I)*

6. The work functions of Silver and Sodium are 4.6 and 2.3 eV, respectively. The ratio of the slope of the stopping potential versus frequency plot for Silver to that of Sodium is *(JEE Adv. 2013-I)*

7. A freshly prepared sample of a radioisotope of half-life 1386 s has activity $10^3$ disintegrations per second. Given that $ln2 = 0.693$, the fraction of the initial number of nuclei (expressed in nearest integer percentage) that will decay in the first 80 s after preparation of the sample is *(JEE Adv. 2013-I)*

8. A nuclear power plant supplying electrical power to a village uses a radioactive material of half life $T$ years as the fuel. The amount of fuel at the beginning is such that the total power requirement of the village is 12.5% of the electrical power available from the plant at that time. If the plant is able to meet the total power needs of the village for a maximum period of $nT$ years, then the value of $n$ is *(JEE Adv. 2015)*

9. Consider a hydrogen atom with its electron in the $n^{th}$ orbital. An electromagnetic radiation of wavelength 90 nm is used to ionize the atom. If the kinetic energy of the ejected electron is 10.4 eV, then the value of $n$ is ($hc = 1242$ eV $nm$) *(JEE Adv. 2015)*

10. For a radioactive material, its activity $A$ and rate of change of its activity $R$ are defined as $A = -\frac{dN}{dt}$ and $R = -\frac{dA}{dt}$, where N(t) is the number of nuclei at time $t$. Two radioactive sources $P$ (mean life $\tau$) and $Q$ (mean life $2\tau$) have the same activity at $t = 0$. Their rates of change of activities at $t = 2\tau$ are $R_P$ and $R_Q$, respectively. If $\frac{R_P}{R_Q} = \frac{n}{e}$, then the value of n is *(JEE Adv. 2015)*

11. An electron is an excited state of $Li^{2+}$ ion has angular momentum $3h/2\pi$. The de Broglie wavelength of the electron in this state is $p\pi a_0$ (where $a_0$ is the Bohr radius). The value of $p$ is *(JEE Adv. 2015)*

12. The isotope $^{12}_{5}B$ having a mass 12.014 u undergoes β–decay to $^{12}_{6}C$. $^{12}_{6}C$ has an excited state of the nucleus $\left(^{12}_{6}C^*\right)$ at 4.041 MeV above its ground state. If $^{12}_{5}E$ decays to $^{12}_{6}C^*$, the maximum kinetic energy of the β–particle in units of MeV is (1 u = 931.5 MeV/$c^2$, where c is the speed of light in vacuum). *(JEE Adv. 2016)*

13. A hydrogen atom in its ground state is irradiated by light of wavelength 970 Å. Taking hc/e $= 1.237 \times 10^{-6}$ eV m and the ground state energy of hydrogen atom as –13.6 eV, the number of lines present in the emission spectrum is *(JEE Adv. 2016)*

## Section-B JEE Main / AIEEE

1. If 13.6 eV energy is required to ionize the hydrogen atom, then the energy required to remove an electron from $n = 2$ is [2002]
(a) 10.2 eV (b) 0 eV
(c) 3.4 eV (d) 6.8 eV.

2. At absolute zero, Si acts as [2002]
(a) non-metal (b) metal
(c) insulator (d) none of these

3. At a specific instant emission of radioactive compound is deflected in a magnetic field. The compound can emit
(i) electrons (ii) protons
(iii) $He^{2+}$ (iv) neutrons
The emission at instant can be [2002]
(a) i, ii, iii (b) i, ii, iii, iv (c) iv (d) ii, iii

4. Sodium and copper have work functions 2.3 eV and 4.5 eV respectively. Then the ratio of the wavelengths is nearest to [2002]
(a) 1 : 2 (b) 4 : 1 (c) 2 : 1 (d) 1 : 4.

5. Formation of covalent bonds in compounds exhibits [2002]
(a) wave nature of electron
(b) particle nature of electron
(c) both wave and particle nature of electron
(d) none of these

6. If $N_0$ is the original mass of the substance of half-life period $t_{1/2}$ = 5 years, then the amount of substance left after 15 years is [2002]
(a) $N_0/8$ (b) $N_0/16$ (c) $N_0/2$ (d) $N_0/4$
7. By increasing the temperature, the specific resistance of a conductor and a semiconductor [2002]
(a) increases for both (b) decreases for both
(c) increases, decreases (d) decreases, increases
8. The energy band gap is maximum in [2002]
(a) metals (b) superconductors
(c) insulators (d) semiconductors.
9. The part of a transistor which is most heavily doped to produce large number of majority carriers is [2002]
(a) emmiter
(b) base
(c) collector
(d) can be any of the above three.
10. Which of the following are not electromagnetic waves? [2002]
(a) cosmic rays (b) gamma rays
(c) $\beta$-rays (d) X-rays.
11. A strip of copper and another of germanium are cooled from room temperature to 80K. The resistance of [2003]
(a) each of these decreases
(b) copper strip increases and that of germanium decreases
(c) copper strip decreases and that of germanium increases
(d) each of these increases
12. Which of the following radiations has the least wavelength ? [2003]
(a) $\gamma$-rays (b) $\beta$-rays
(c) $\alpha$-rays (d) X-rays
13. When a $U^{238}$ nucleus originally at rest, decays by emitting an alpha particle having a speed '$u$', the recoil speed of the residual nucleus is [2003]
(a) $\frac{4u}{238}$ (b) $-\frac{4u}{234}$ (c) $\frac{4u}{234}$ (d) $-\frac{4u}{238}$
14. The difference in the variation of resistance with temeperature in a metal and a semiconductor arises essentially due to the difference in the *[2003]*
(a) crystal sturcture
(b) variation of the number of charge carriers with temperature
(c) type of bonding
(d) variation of scattering mechanism with temperature
15. A radioactive sample at any instant has its disintegration rate 5000 disintegrations per minute. After 5 minutes, the rate is 1250 disintegrations per minute. Then, the decay constant (per minute) is [2003]
(a) 0.4 ln 2 (b) 0.2 ln 2 (c) 0.1 ln 2 (d) 0.8 ln 2
16. A nucleus with $Z$= 92 emits the following in a sequence:
$\alpha,\beta^-,\beta^-\ \alpha,\alpha,\alpha,\alpha,\alpha,\beta^-,\beta^-,\alpha,\beta^+,\beta^+,\alpha$
Then $Z$ of the resulting nucleus is [2003]
(a) 76 (b) 78 (c) 82 (d) 74
17. Two identical photocathodes receive light of frequencies $f_1$ and $f_2$. If the velocites of the photo electrons (of mass m ) coming out are respectively $v_1$ and $v_2$, then [2003]
(a) $v_1^2 - v_2^2 = \frac{2h}{m}(f_1 - f_2)$
(b) $v_1 + v_2 = \left[\frac{2h}{m}(f_1 + f_2)\right]^{1/2}$
(c) $v_1^2 + v_2^2 = \frac{2h}{m}(f_1 + f_2)$
(d) $v_1 - v_2 = \left[\frac{2h}{m}(f_1 - f_2)\right]^{1/2}$
18. Which of the following **cannot** be emitted by radioactive substances during their decay ? [2003]
(a) Protons (b) Neutrinoes
(c) Helium nuclei (d) Electrons
19. In the nuclear fusion reaction
$${}_1^2\mathrm{H} + {}_1^3\mathrm{H} \rightarrow {}_2^4\mathrm{He} + n$$
given that the repulsive potential energy between the two nuclei is ~ $7.7 \times 10^{-14}$ J , the temperature at which the gases must be heated to initiate the reaction is nearly
[Boltzmann's Constant $k = 1.38 \times 10^{-23}$ J/K] [2003]
(a) $10^7$ K (b) $10^5$ K (c) $10^3$ K (d) $10^9$ K
20. Which of the following atoms has the lowest ionization potential ? [2003]
(a) ${}_7^{14}\mathrm{N}$ (b) ${}_{55}^{133}\mathrm{Cs}$ (c) ${}_{18}^{40}\mathrm{Ar}$ (d) ${}_8^{16}\mathrm{O}$
21. The wavelengths involved in the spectrum of deuterium $\left({}_1^2D\right)$ are slightly different from that of hydrogen spectrum, because [2003]
(a) the size of the two nuclei are different
(b) the nuclear forces are different in the two cases
(c) the masses of the two nuclei are different
(d) the atraction between the electron and the nucleus is differernt in the two cases
22. In the middle of the depletion layer of a reverse- biased $p$-$n$ junction, the [2003]
(a) electric field is zero
(b) potential is maximum
(c) electric field is maximum
(d) potential is zero
23. If the binding energy of the electron in a hydrogen atom is 13.6eV, the energy required to remove the electron from the first excited state of $Li^{++}$ is [2003]
(a) 30.6 eV (b) 13.6 eV
(c) 3.4 eV (d) 122.4 eV
24. A radiation of energy E falls normally on a perfectly reflecting surface. The momentum transferred to the surface is [2004]
(a) $Ec$ (b) $2E/c$ (c) $E/c$ (d) $E/c^2$
25. According to Einstein's photoelectric equation, the plot of the kinetic energy of the emitted photo electrons from a metal **Vs** the frequency, of the incident radiation gives as straight the whose slope [2004]
(a) depends both on the intensity of the radiation and the metal used
(b) depends on the intensity of the radiation
(c) depends on the nature of the metal used
(d) is the same for the all metals and independent of the intensity of the radiation

**26.** The work function of a substance is 4.0 eV. The longest wavelength of light that can cause photoelectron emission from this substance is approximately. [2004]
(a) 310 nm (b) 400 nm (c) 540 nm (d) 220 nm

**27.** A nucleus disintegrated into two nuclear parts which have their velocities in the ratio of 2 : 1. The ratio of their nuclear sizes will be [2004]
(a) $3^{1/2} : 1$ (b) $1 : 2^{1/3}$ (c) $2^{1/3} : 1$ (d) $1 : 3^{1/2}$

**28.** The binding energy per nucleon of deuteron $\left({}_1^2\mathrm{H}\right)$ and helium nucleus $\left({}_2^4\mathrm{He}\right)$ is 1.1 MeV and 7 MeV respectively. If two deuteron nuclei react to form a single helium nucleus, then the energy released is [2004]
(a) 23.6 MeV (b) 26.9 MeV (c) 13.9 MeV (d) 19.2 MeV

**29.** An α-particle of energy 5 MeV is scattered through 180° by a fixed uranium nucleus. The distance of closest approach is of the order of [2004]
(a) $10^{-12}$ cm (b) $10^{-10}$ cm (c) 1A (d) $10^{-15}$ cm

**30.** When npn transistor is used as an amplifier [2004]
(a) electrons move from collector to base
(b) holes move from emitter to base
(c) electrons move from base to collector
(d) holes move from base to emitter

**31.** For a transistor amplifier in common emitter configuration for load impedance of $1\,\mathrm{k}\Omega$ $(h_{fe} = 50$ and $h_{oe} = 25)$ the current gain is [2004]
(a) −24.8 (b) −15.7 (c) −5.2 (d) −48.78

**32.** A piece of copper and another of germanium are cooled from room temperature to 77K, the resistance of
(a) copper increases and germanium decreases
(b) each of them decreases [2004]
(c) each of them increases
(d) copper decreases and germanium increases

**33.** The manifestation of band structure in solids is due to
(a) Bohr's correspondence principle [2004]
(b) Pauli's exclusion principle
(c) Heisenberg's uncertainty principle
(d) Boltzmann's law

**34.** When p-n junction diode is forward biased then [2004]
(a) both the depletion region and barrier height are reduced
(b) the depletion region is widened and barrier height is reduced
(c) the depletion region is reduced and barrier height is increased
(d) Both the depletion region and barrier height are increased

**35.** If radius of the ${}_{13}^{27}\mathrm{Al}$ nucleus is estimated to be 3.6 fermi then the radius of ${}_{52}^{125}\mathrm{Te}$ nucleus be nearly [2005]
(a) 8 fermi (b) 6 fermi (c) 5 fermi (d) 4 fermi

**36.** Starting with a sample of pure ${}^{66}\mathrm{Cu}$, $\frac{7}{8}$ of it decays into Zn in 15 minutes. The corresponding half life is [2005]
(a) 15 minutes (b) 10 minutes
(c) $7\frac{1}{2}$ minutes (d) 5 minutes

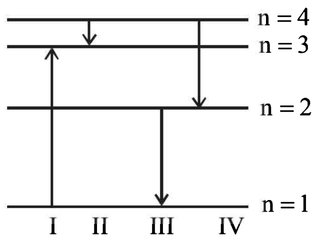
**37.** A photocell is illuminated by a small bright source placed 1 m away. When the same source of light is placed $\frac{1}{2}$ m away, the number of electrons emitted by photocathode would
(a) increase by a factor of 4 [2005]
(b) decrease by a factor of 4
(c) increase by a factor of 2
(d) decrease by a factor of 2

**38.** The electrical conductivity of a semiconductor increases when electromagnetic radiation of wavelength shorter than 2480 nm is incident on it. The band gap in (eV) for the semiconductor is [2005]
(a) 2.5 eV (b) 1.1 eV (c) 0.7 eV (d) 0.5 eV

**39.** The intensity of gamma radiation from a given source is I. On passing through 36 mm of lead, it is reduced to $\frac{I}{8}$. The thickness of lead which will reduce the intensity to $\frac{I}{2}$ will be
(a) 9mm (b) 6mm [2005]
(c) 12mm (d) 18mm

**40.** In a common base amplifier, the phase difference between the input signal voltage and output voltage is [2005]
(a) $\pi$ (b) $\frac{\pi}{4}$ (c) $\frac{\pi}{2}$ (d) 0

**41.** The diagram shows the energy levels for an electron in a certain atom. Which transition shown represents the emission of a photon with the most energy? [2005]




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

**42.** If the kinetic energy of a free electron doubles, it's deBroglie wavelength changes by the factor [2005]
(a) 2 (b) $\frac{1}{2}$ (c) $\sqrt{2}$ (d) $\frac{1}{\sqrt{2}}$

**43.** A nuclear transformation is denoted by $X(n, \alpha)\,{}_3^7\mathrm{Li}$. Which of the following is the nucleus of element $X$?
(a) ${}_5^{10}\mathrm{Be}$ (b) ${}^{12}\mathrm{C}_6$ [2005]
(c) ${}_4^{11}\mathrm{Be}$ (d) ${}_5^{9}\mathrm{B}$

**44.** In a full wave rectifier circuit operating from 50 Hz mains frequency, the fundamental frequency in the ripple would be
(a) 25 Hz (b) 50 Hz [2005]
(c) 70.7 Hz (d) 100 Hz

**45.** In a common base mode of a transistor, the collector current is 5.488 mA for an emitter current of 5.60 mA. The value of the base current amplification factor (β) will be [2006]
(a) 49 (b) 50 (c) 51 (d) 48

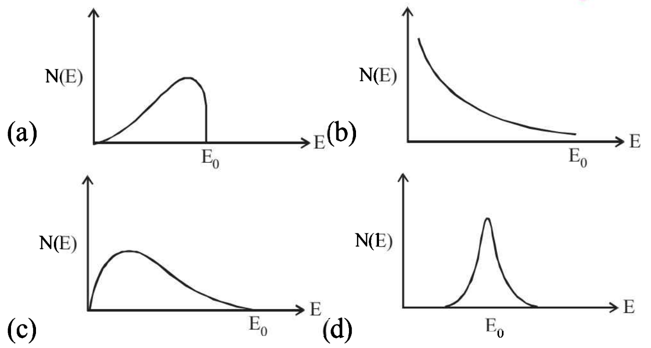
**46.** The threshold frequency for a metallic surface corresponds to an energy of 6.2 eV and the stopping potential for a radiation incident on this surface is 5 V. The incident radiation lies in [2006]
(a) ultra-violet region (b) infra-red region
(c) visible region (d) *X*-ray region

**47.** An alpha nucleus of energy $\frac{1}{2}mv^2$ bombards a heavy nuclear target of charge Ze. Then the distance of closest approach for the alpha nucleus will be proportional to
(a) $v^2$ (b) $\frac{1}{m}$ [2006]
(c) $\frac{1}{v^2}$ (d) $\frac{1}{Ze}$

**48.** The time taken by a photoelectron to come out after the photon strikes is approximately [2006]
(a) $10^{-4}$ s (b) $10^{-10}$ s
(c) $10^{-16}$ s (d) $10^{-1}$ s

**49.** When $_3Li^7$ nuclei are bombarded by protons, and the resultant nuclei are $_4Be^8$, the emitted particles will be
(a) alpha particles (b) beta particles [2006]
(c) gamma photons (d) neutrons

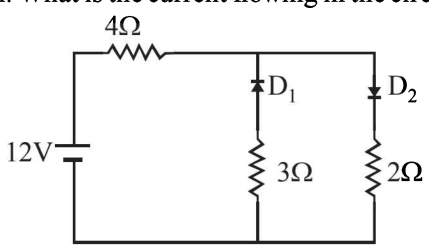
**50.** The energy spectrum of β-particles [number N(E) as a function of β-energy E] emitted from a radioactive source is [2006]




**51.** A solid which is not transparent to visible light and whose conductivity increases with temperature is formed by [2006]
(a) Ionic bonding (b) Covalent bonding
(c) Vander Waals bonding (d) Metallic bonding

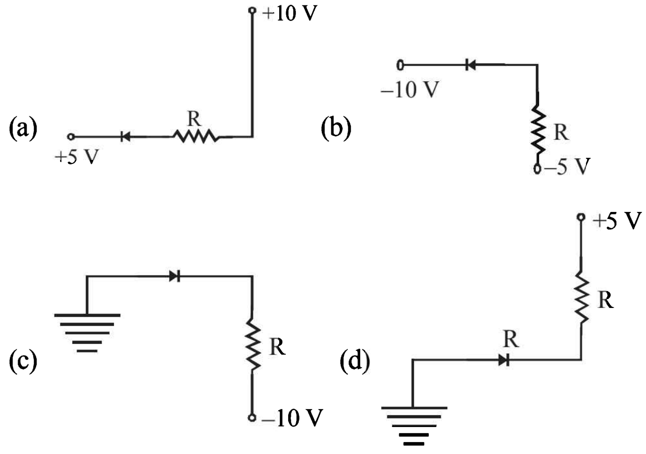
**52.** If the ratio of the concentration of electrons to that of holes in a semiconductor is $\frac{7}{5}$ and the ratio of currents is $\frac{7}{4}$, then what is the ratio of their drift velocities? [2006]
(a) $\frac{5}{8}$ (b) $\frac{4}{5}$ (c) $\frac{5}{4}$ (d) $\frac{4}{7}$

**53.** The circuit has two oppositively connected ideal diodes in parallel. What is the current flowing in the circuit? [2006]

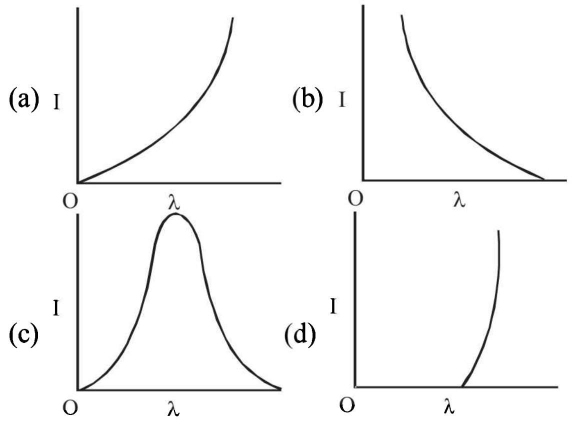



(a) 1.71 A (b) 2.00 A
(c) 2.31 A (d) 1.33 A

**54.** In the following, which one of the diodes reverse biased? [2006]




**55.** The anode voltage of a photocell is kept fixed. The wavelength λ of the light falling on the cathode is gradually changed. The plate current I of the photocell varies as follows [2006]



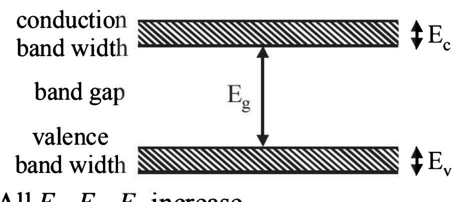

**56.** If the binding energy per nucleon in $^7_3Li$ and $^4_2He$ nuclei are 5.60 MeV and 7.06 MeV respectively, then in the reaction

$$p + {}^7_3Li \longrightarrow 2\,{}^4_2He$$

energy of proton must be [2006]
(a) 28.24 MeV (b) 17.28 MeV
(c) 1.46 MeV (d) 39.2 MeV

**57.** The 'rad' is the correct unit used to report the measurement of
(a) the ability of a beam of gamma ray photons to produce ions in a target [2006]
(b) the energy delivered by radiation to a target
(c) the biological effect of radiation
(d) the rate of decay of a radioactive source

**58.** If the lattice constant of this semiconductor is decreased, then which of the following is correct? [2006]



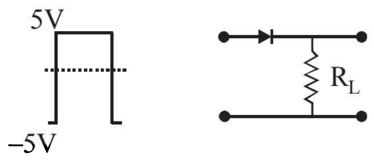

(a) All $E_c$, $E_g$, $E_v$ increase
(b) $E_c$ and $E_v$ increase, but $E_g$ decreases
(c) $E_c$ and $E_v$ decrease, but $E_g$ increases
(d) All $E_c$, $E_g$, $E_v$ decrease

**59.** The rms value of the electric field of the light coming from the Sun is 720 N/C. The average total energy density of the electromagnetic wave is |2006|
(a) $4.58 \times 10^{-6}$ J/m$^3$ (b) $6.37 \times 10^{-9}$ J/m$^3$
(c) $81.35 \times 10^{-12}$ J/m$^3$ (d) $3.3 \times 10^{-3}$ J/m$^3$

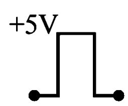
**60.** If $M_O$ is the mass of an oxygen isotope ${}_8O^{17}$, $M_P$ and $M_N$ are the masses of a proton and a neutron respectively, the nuclear binding energy of the isotope is |2007|
(a) $(M_O - 17M_N)c^2$
(b) $(M_O - 8M_P)c^2$
(c) $(M_O - 8M_P - 9M_N)c^2$
(d) $M_O c^2$

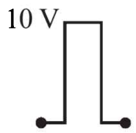
**61.** In gamma ray emission from a nucleus |2007|
(a) only the proton number changes
(b) both the neutron number and the proton number change
(c) there is no change in the proton number and the neutron number
(d) only the neutron number changes

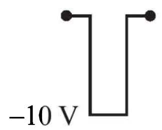
**62.** If in a *p-n* junction diode, a square input signal of 10 V is applied as shown |2007|

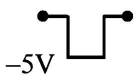



Then the output signal across $R_L$ will be

(a) 

(b) 

(c) 

(d) 


**63.** Photon of frequency $\nu$ has a momentum associated with it. If c is the velocity of light, the momentum is |2007|
(a) $h\nu / c$ (b) $\nu / c$ (c) $h \nu c$ (d) $h\nu / c^2$

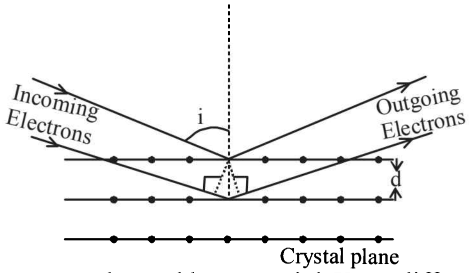
**64.** The half-life period of a radio-active element *X* is same as the mean life time of another radio-active element *Y*. Initially they have the same number of atoms. Then |2007|
(a) *X* and *Y* decay at same rate always
(b) *X* will decay faster than *Y*
(c) *Y* will decay faster than *X*
(d) *X* and *Y* have same decay rate initially

**65.** Carbon, silicon and germanium have four valence electrons each. At room temperature which one of the following statements is most appropriate ? |2007|
(a) The number of free electrons for conduction is significant only in Si and Ge but small in C.
(b) The number of free conduction electrons is significant in C but small in Si and Ge.
(c) The number of free conduction electrons is negligibly small in all the three.
(d) The number of free electrons for conduction is significant in all the three.

**66.** Which of the following transitions in hydrogen atoms emit photons of highest frequency? |2007|
(a) $n = 1$ to $n = 2$ (b) $n = 2$ to $n = 6$
(c) $n = 6$ to $n = 2$ (d) $n = 2$ to $n = 1$

**DIRECTIONS:** *Question No. 67 and 68 are based on the following paragraph.*

Wave property of electrons implies that they will show diffraction effects. Davisson and Germer demonstrated this by diffracting electrons from crystals. The law governing the diffraction from a crystal is obtained by requiring that electron waves reflected from the planes of atoms in a crystal interfere constructively (see figure).




**67.** Electrons accelerated by potential $V$ are diffracted from a crystal. If d = 1Å and i = 30°, $V$ should be about ($h = 6.6 \times 10^{-34}$ Js, $m_e = 9.1 \times 10^{-31}$ kg, $e = 1.6 \times 10^{-19}$ C) |2008|
(a) 2000 V (b) 50 V (c) 500 V (d) 1000 V

**68.** If a strong diffraction peak is observed when electrons are incident at an angle '*i*' from the normal to the crystal planes with distance '*d*' between them (see figure), de Broglie wavelength $\lambda_{dB}$ of electrons can be calculated by the relationship ( n is an integer) |2008|
(a) $d \sin i = n\lambda_{dB}$ (b) $2d \cos i = n\lambda_{dB}$
(c) $2d \sin i = n\lambda_{dB}$ (d) $d \cos i = n\lambda_{dB}$

**69.** This question contains Statement-1 and statement-2. Of the four choices given after the statements, choose the one that best describes the two statements. |2008|
**Statement-1:**
Energy is released when heavy nuclei undergo fission or light nuclei undergo fusion and
**Statement-2 :**
For heavy nuclei, binding energy per nucleon increases with increasing *Z* while for light nuclei it decreases with increasing *Z*.
(a) Statement-1 is false, Statement-2 is true
(b) Statement-1 is true, Statement-2 is true; Statement-2 is a correct explanation for Statement-1
(c) Statement-1 is true, Statement-2 is true; Statement-2 is not a correct explanation for Statement-1
(d) Statement-1 is true, Statement-2 is false

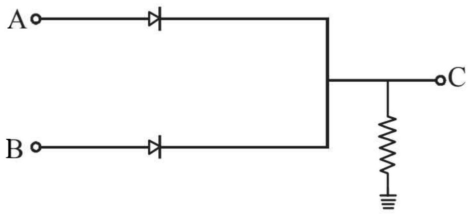
**70.** A working transistor with its three legs marked *P*, *Q* and *R* is tested using a multimeter. No conduction is found between *P* and *Q*. By connecting the common (negative) terminal of the multimeter to *R* and the other (positive) terminal to *P* or *Q*, some resistance is seen on the multimeter. Which of the following is true for the transistor? |2008|
(a) It is an npn transistor with *R* as base
(b) It is a pnp transistor with *R* as collector
(c) It is a pnp transistor with *R* as emitter
(d) It is an npn transistor with *R* as collector

**71.** Suppose an electron is attracted towards the origin by a force $\frac{k}{r}$ where '$k$' is a constant and '$r$' is the distance of the electron from the origin. By applying Bohr model to this system, the radius of the $n^{th}$ orbital of the electron is found to be '$r_n$' and the kinetic energy of the electron to be '$T_n$'. Then which of the following is true? **[2008]**

(a) $T_n \propto \frac{1}{n^2}, r_n \propto n^2$  (b) $T_n$ independent of $n$, $r_n \propto n$

(c) $T_n \propto \frac{1}{n}, r_n \propto n$  (d) $T_n \propto \frac{1}{n}, r_n \propto n^2$

**72.** In the circuit below, $A$ and $B$ represent two inputs and $C$ represents the output. **[2008]**

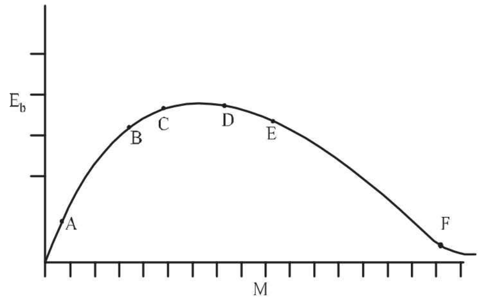



The circuit represents
(a) NOR gate  (b) AND gate
(c) NAND gate  (d) OR gate

**73.** 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 : **[2009]**
(a) $3 \to 2$  (b) $4 \to 2$
(c) $5 \to 4$  (d) $2 \to 1$

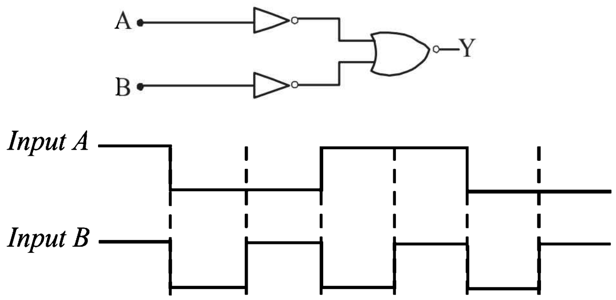
**74.** The surface of a metal is illuminted with the light of 400 nm. The kinetic energy of the ejected photoelectrons was found to be 1.68 eV. The work function of the metal is : **[2009]**
($hc$ = 1240 eV.nm)
(a) 1.41 eV  (b) 1.51 eV
(c) 1.68 eV  (d) 3.09 eV

**75.**



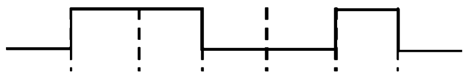

The above is a plot of binding energy per nucleon $E_b$, against the nuclear mass $M$; $A, B, C, D, E, F$ correspond to different nuclei. Consider four reactions : **[2009]**
(i) $A + B \to C + \varepsilon$  (ii) $C \to A + B + \varepsilon$
(iii) $D + E \to F + \varepsilon$ and  (iv) $F \to D + E + \varepsilon$,
where $\varepsilon$ is the energy released? In which reactions is $\varepsilon$ positive?
(a) (i) and (iii)  (b) (ii) and (iv)
(c) (ii) and (iii)  (d) (i) and (iv)

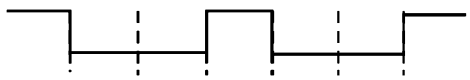
**76.** The logic circuit shown below has the input waveforms '$A$' and '$B$' as shown. Pick out the correct output waveform. **[2009]**

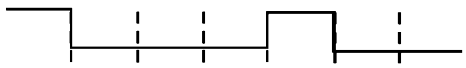



Output is

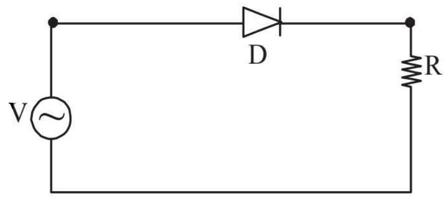
(a) 

(b) 

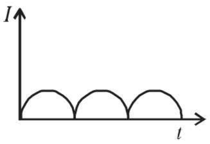
(c) 

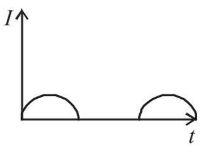
(d) 

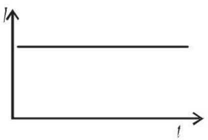
**77.** A $p$-$n$ junction ($D$) shown in the figure can act as a rectifier. An alternating current source ($V$) is connected in the circuit.

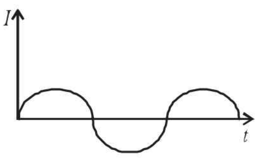



The current ($I$) in the resistor ($R$) can be shown by :

(a) 


(b) 


(c) 


(d) 


**78.** **Statement -1 :** When ultraviolet light is incident on a photocell, its stopping potential is $V_0$ and the maximum kinetic energy of the photoelectrons is $K_{max}$. When the ultraviolet light is replaced by $X$-rays, both $V_0$ and $K_{max}$ increase.
**Statement -2 :** Photoelectrons are emitted with speeds ranging from zero to a maximum value because of the range of frequencies present in the incident light. **[2010]**
(a) Statement -1 is true, Statement -2 is true ; Statement -2 is the correct explanation of Statement -1.
(b) Statement -1 is true, Statement -2 is true; Statement -2 is **not** the correct explanation of Statement -1
(c) Statement -1 is false, Statement -2 is true.
(d) Statement -1 is true, Statement -2 is false.

**DIRECTIONS:** *Questions number 79-80 are based on the following paragraph.*

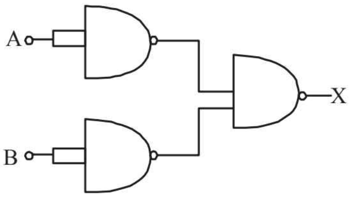
A nucleus of mass $M + \Delta m$ is at rest and decays into two daughter nuclei of equal mass $\frac{M}{2}$ each. Speed of light is $c$.

**79.** The binding energy per nucleon for the parent nucleus is $E_1$ and that for the daughter nuclei is $E_2$. Then **[2010]**
(a) $E_2 = 2E_1$ (b) $E_1 > E_2$
(c) $E_2 > E_1$ (d) $E_1 = 2E_2$

**80.** The speed of daughter nuclei is **[2010]**
(a) $c\frac{\Delta m}{M + \Delta m}$ (b) $c\sqrt{\frac{2\Delta m}{M}}$
(c) $c\sqrt{\frac{\Delta m}{M}}$ (d) $c\sqrt{\frac{\Delta m}{M + \Delta m}}$

**81.** A radioactive nucleus (initial mass number $A$ and atomic number $Z$ emits 3 $\alpha$ - particles and 2 positrons. The ratio of number of neutrons to that of protons in the final nucleus will be **[2010]**
(a) $\frac{A-Z-8}{Z-4}$ (b) $\frac{A-Z-4}{Z-8}$
(c) $\frac{A-Z-12}{Z-4}$ (d) $\frac{A-Z-4}{Z-2}$

**82.** The combination of gates shown below yields **[2010]**
(a) OR gate
(b) NOT gate
(c) XOR gate
(d) NAND gate




**83.** If a source of power 4kW produces $10^{20}$ photons/second, the radiation belongs to a part of the spectrum called **[2010]**
(a) X-rays (b) ultraviolet rays
(c) microwaves (d) $\gamma$ -rays

**84.** This question has Statement – 1 and Statement – 2. Of the four choices given after the statements, choose the one that best describes the two statements. **[2011]**
**Statement – 1 :** Sky wave signals are used for long distance radio communication. These signals are in general, less stable than ground wave signals.
**Statement – 2 :** The state of ionosphere varies from hour to hour, day to day and season to season.
(a) Statement–1 is true, Statement–2 is true, Statement–2 is the correct explanation of Statement–1.
(b) Statement–1 is true, Statement–2 is true, Statement–2 is not the correct explanation of Statement – 1.
(c) Statement – 1 is false, Statement – 2 is true.
(d) Statement – 1 is true, Statement – 2 is false.

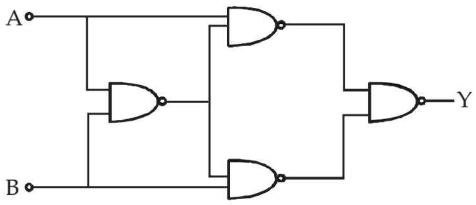
**85.** Energy required for the electron excitation in $Li^{++}$ from the first to the third Bohr orbit is : **[2011]**
(a) 36.3 eV (b) 108.8 eV (c) 122.4 eV (d) 12.1 eV

**86.** The half life of a radioactive substance is 20 minutes. The approximate time interval $(t_2 - t_1)$ between the time $t_2$ when $\frac{2}{3}$ of it had decayed and time $t_1$ when $\frac{1}{3}$ of it had decayed is : **[2011]**
(a) 14 min (b) 20 min
(c) 28 min (d) 7 min

**87.** This question has Statement – 1 and Statement – 2. Of the four choices given after the statements, choose the one that best describes the two statements. **[2011]**
**Statement – 1:** A metallic surface is irradiated by a monochromatic light of frequency $v > v_0$ (the threshold frequency). The maximum kinetic energy and the stopping potential are $K_{max}$ and $V_0$ respectively. If the frequency incident on the surface is doubled, both the $K_{max}$ and $V_0$ are also doubled.
**Statement – 2 :** The maximum kinetic energy and the stopping potential of photoelectrons emitted from a surface are linearly dependent on the frequency of incident light.
(a) Statement–1 is true, Statement–2 is true, Statement – 2 is the correct explanation of Statement – 1.
(b) Statement–1 is true, Statement–2 is true, Statement – 2 is not the correct explanation of Statement – 1.
(c) Statement – 1 is false, Statement – 2 is true.
(d) Statement – 1 is true, Statement – 2 is false.

**88.** Hydrogen atom is excited from ground state to another state with principal quantum number equal to 4. Then the number of spectral lines in the emission spectra will be : **[2012]**
(a) 2 (b) 3 (c) 5 (d) 6

**89.** Truth table for system of four NAND gates as shown in figure is : **[2012]**




(a)

| A | B | Y |
|---|---|---|
| 0 | 0 | 0 |
| 0 | 1 | 1 |
| 1 | 0 | 1 |
| 1 | 1 | 0 |

(b)

| A | B | Y |
|---|---|---|
| 0 | 0 | 0 |
| 0 | 1 | 0 |
| 1 | 0 | 1 |
| 1 | 1 | 1 |

(c)

| A | B | Y |
|---|---|---|
| 0 | 0 | 1 |
| 0 | 1 | 1 |
| 1 | 0 | 0 |
| 1 | 1 | 0 |

(d)

| A | B | Y |
|---|---|---|
| 0 | 0 | 1 |
| 0 | 1 | 0 |
| 1 | 0 | 1 |
| 1 | 1 | 1 |

**90.** A radar has a power of 1kW and is operating at a frequency of 10 GHz. It is located on a mountain top of height 500 m. The maximum distance upto which it can detect object located on the surface of the earth (Radius of earth $= 6.4 \times 10^6$ m) is : **[2012]**
(a) 80 km (b) 16 km (c) 40 km (d) 64 km

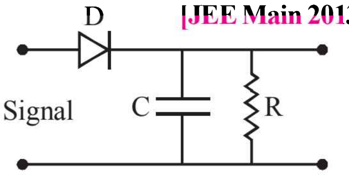
**91.** Assume that a neutron breaks into a proton and an electron. The energy released during this process is : (mass of neutron $= 1.6725 \times 10^{-27}$ kg, mass of proton $= 1.6725 \times 10^{-27}$ kg, mass of electron $= 9 \times 10^{-31}$ kg). **[2012]**
(a) 0.73 MeV (b) 7.10 MeV (c) 6.30 MeV (d) 5.4 MeV

**92.** A diatomic molecule is made of two masses $m_1$ and $m_2$ which are separated by a distance $r$. If we calculate its rotational energy by applying Bohr's rule of angular momentum quantization, its energy will be given by : ($n$ is an integer)

(a) $\dfrac{(m_1+m_2)^2 n^2 h^2}{2m_1^2 m_2^2 r^2}$ (b) $\dfrac{n^2 h^2}{2(m_1+m_2)r^2}$

(c) $\dfrac{2n^2 h^2}{(m_1+m_2)r^2}$ (d) $\dfrac{(m_1+m_2)n^2 \hbar^2}{2m_1 m_2 r^2}$

**93.** A diode detector is used to detect an amplitudemodulated wave of 60% modulation by using a condenser of capacity 250 picofarad in parallel with a load resistance 100 kilo ohm. Find the maximum modulated frequency which could be detected by it. [JEE Main 2013]

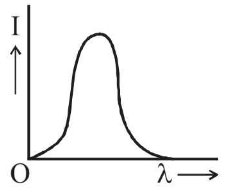


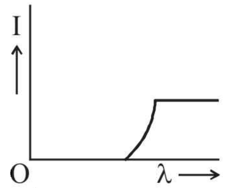

(a) 10.62 MHz
(b) 10.62 kHz
(c) 5.31 MHz
(d) 5.31 kHz

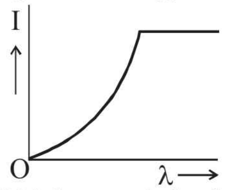
**94.** The magnetic field in a travelling electromagnetic wave has a peak value of 20 nT. The peak value of electric field strength is : [JEE Main 2013]

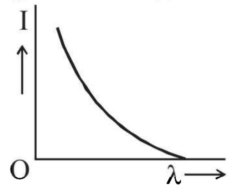
(a) 3 V/m (b) 6 V/m
(c) 9 V/m (d) 12 V/m

**95.** The anode voltage of a photocell is kept fixed. The wavelength $\lambda$ of the light falling on the cathode is gradually changed. The plate current I of the photocell varies as follows : [JEE Main 2013]

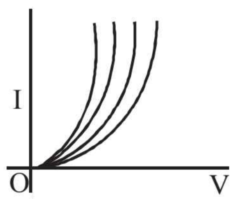
(a)


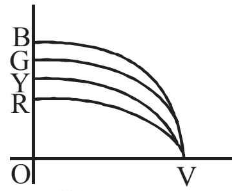

(b)


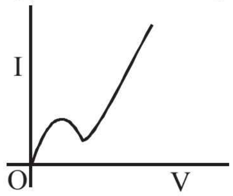

(c)


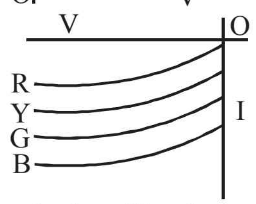

(d)



**96.** The I-V characteristic of an LED is [JEE Main 2013]

(a)



(b)



(c)



(d)



**97.** In a hydrogen like atom electron make transition from an energy level with quantum number n to another with quantum number (n – 1). If n>>1, the frequency of radiation emitted is proportional to : [JEE Main 2013]

(a) $\dfrac{1}{n}$ (b) $\dfrac{1}{n^2}$ (c) $\dfrac{1}{n^{3/2}}$ (d) $\dfrac{1}{n^3}$

**98.** The current voltage relation of a diode is given by $I = \left(e^{1000V/T} - 1\right)$ mA, where the applied voltage V is in volts and the temperature T is in degree kelvin. If a student makes an error measuring $\pm 0.01$ V while measuring the current of 5 mA at 300 K, what will be the error in the value of current in mA? [JEE Main 2014]

(a) 0.2 mA (b) 0.02 mA (c) 0.5 mA (d) 0.05 mA

**99.** During the propagation of electromagnetic waves in a medium: [JEE Main 2014]

(a) Electric energy density is double of the magnetic energy density.
(b) Electric energy density is half of the magnetic energy density.
(c) Electric energy density is equal to the magnetic energy density.
(d) Both electric and magnetic energy densities are zero.

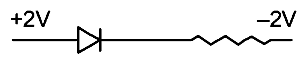
**100.** The radiation corresponding to $3 \to 2$ transition of hydrogen atom falls on a metal surface to produce photoelectrons. These electrons are made to enter a magnetic field of $3 \times 10^{-4}$ T. If the radius of the largest circular path followed by these electrons is 10.0 mm, the work function of the metal is close to: [JEE Main 2014]

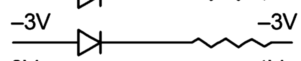
(a) 1.8 eV (b) 1.1 eV (c) 0.8 eV (d) 1.6 eV

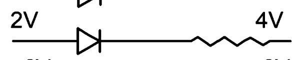
**101.** Hydrogen $\left({}_1H^1\right)$, Deuterium $\left({}_1H^2\right)$, singly ionised Helium $\left({}_2He^4\right)^{+}$ and doubly ionised lithium $\left({}_3Li^6\right)^{++}$ all have one electron around the nucleus. Consider an electron transition from n = 2 to n = 1. If the wavelengths of emitted radiation are $\lambda_1, \lambda_2, \lambda_3$ and $\lambda_4$ respectively then approximately which one of the following is correct? [JEE Main 2014]

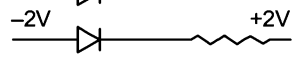
(a) $4\lambda_1 = 2\lambda_2 = 2\lambda_3 = \lambda_4$ (b) $\lambda_1 = 2\lambda_2 = 2\lambda_3 = \lambda_4$
(c) $\lambda_1 = \lambda_2 = 4\lambda_3 = 9\lambda_4$ (d) $\lambda_1 = 2\lambda_2 = 3\lambda_3 = 4\lambda_4$

**102.** The forward biased diode connection is: [JEE Main 2014]

(a)



(b)



(c)



(d)



**103.** Match List - I (Electromagnetic wave type) with List - II (Its association/application) and select the correct option from the choices given below the lists: [JEE Main 2014]

| | List 1 | | List 2 |
|---|---|---|---|
| 1. | Infrared waves | (i) | To treat muscular strain |
| 2. | Radio waves | (ii) | For broadcasting |
| 3. | X-rays | (iii) | To detect fracture of bones |
| 4. | Ultraviolet rays | (iv) | Absorbed by the ozone layer of the atmosphere |

| | 1 | 2 | 3 | 4 |
|---|---|---|---|---|
| (a) | (iv) | (iii) | (ii) | (i) |
| (b) | (i) | (ii) | (iv) | (iii) |
| (c) | (iii) | (ii) | (i) | (iv) |
| (d) | (i) | (ii) | (iii) | (iv) |

**104.** A red LED emits light at 0.1 watt uniformly around it. The amplitude of the electric field of the light at a distance of 1 m from the diode is : **[JEE Main 2015]**

(a) 5.48 V/m (b) 7.75 V/m
(c) 1.73 V/m (d) 2.45 V/m

**105.** A signal of 5 kHz frequency is amplitude modulated on a carrier wave of frequency 2 MHz. The frequencies of the resultant signal is/are : **[JEE Main 2015]**

(a) 2005 kHz, 2000 kHz and 1995 kHz
(b) 2000 kHz and 1995 kHz
(c) 2 MHz only
(d) 2005 kHz and 1995 kHz

**106.** As an electron makes a transition from an excited state to the ground state of a hydrogen - like atom/ion : **[JEE Main 2015]**

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

**107.** Match **List - I** (Fundamental Experiment) with **List - II** (its conclusion) and select the correct option from the choices given below the list: **[JEE Main 2015]**

| List-I | List-II |
|---|---|
| A. Franck-Hertz Experiment | (i) Particle nature of light |
| B. Photo-electric experiment | (ii) Discrete energy levels of atom |
| C. Davison-Germer experiment | (iii) Wave nature of electron |
| | (iv) Structure of atom |

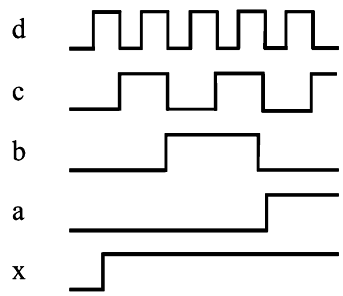
(a) (A)-(ii); (B)-(i); (C)-(iii)
(b) (A)-(iv); (B)-(iii); (C)-(ii)
(c) (A)-(i); (B)-(iv); (C)-(iii)
(d) (A)-(ii); (B)-(iv); (C)-(iii)

**108.** For a common emitter configuration, if $\alpha$ and $\beta$ have their usual meanings, the incorrect relationship between $\alpha$ and $\beta$ is : **[JEE Main 2016]**

(a) $\alpha = \frac{\beta}{1+\beta}$ (b) $\alpha = \frac{\beta^2}{1+\beta^2}$

(c) $\frac{1}{\alpha} = \frac{1}{\beta} + 1$ (d) $\alpha = \frac{\beta}{1-\beta}$

**109.** If a, b, c, d are inputs to a gate and x is its output, then, as per the following time graph, the gate is : **[JEE Main 2016]**




(a) OR (b) NAND
(c) NOT (d) AND

**110.** Choose the correct statement : **[JEE Main 2016]**

(a) In frequency modulation the amplitude of the high frequency carrier wave is made to vary in proportion to the amplitude of the audio signal.
(b) In frequency modulation the amplitude of the high frequency carrier wave is made to vary in proportion to the frequency of the audio signal.
(c) In amplitude modulation the amplitude of the high frequency carrier wave is made to vary in proportion to the amplitude of the audio signal.
(d) In amplitude modulation the frequency of the high frequency carrier wave is made to vary in proportion to the amplitude of the audio signal.

**111.** Radiation of wavelength $\lambda$, is incident on a photocell. The fastest emitted electron has speed v. If the wavelength is changed to $\frac{3\lambda}{4}$, the speed of the fastest emitted electron will be: **[JEE Main 2016]**

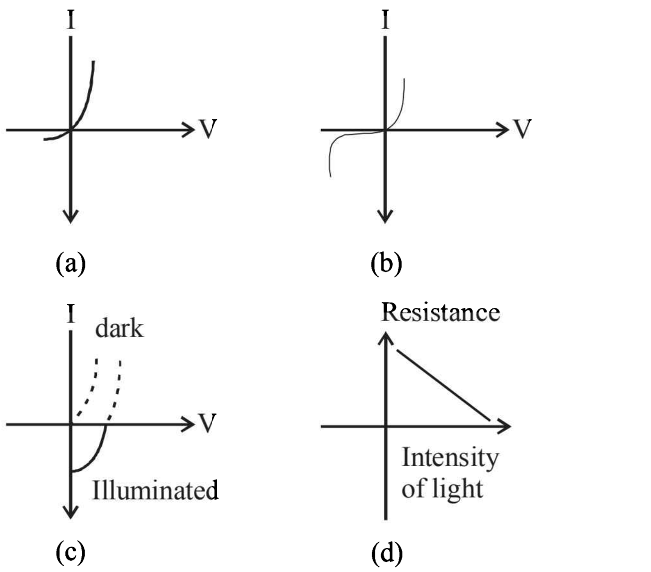
(a) $= v\left(\frac{4}{3}\right)^{\frac{1}{2}}$ (b) $= v\left(\frac{3}{4}\right)^{\frac{1}{2}}$

(c) $> v\left(\frac{4}{3}\right)^{\frac{1}{2}}$ (d) $< v\left(\frac{4}{3}\right)^{\frac{1}{2}}$

**112.** Half-lives of two radioactive elements A and B are 20 minutes and 40 minutes, respectively. Initially, the samples have equal number of nuclei. After 80 minutes, the ratio of decayed number of A and B nuclei will be : **[JEE Main 2016]**

(a) 1 : 4 (b) 5 : 4
(c) 1 : 16 (d) 4 : 1

**113.** Identify the semiconductor devices whose characteristics are given below, in the order (a), (b), (c), (d) : **[JEE Main 2016]**




(a) Solar cell, Light dependent resistance, Zener diode, simple diode
(b) Zener diode, Solar cell, simple diode, Light dependent resistance
(c) Simple diode, Zener diode, Solar cell, Light dependent resistance
(d) Zener diode, Simple diode, Light dependent resistance, Solar cell