EXERCISE–01 CHECK YOUR GRASP

Select the correct alternative (only one correct answer)

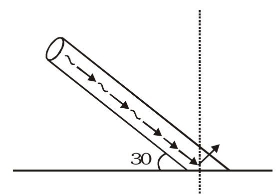
1. The probability of nucleus to decay in two mean lives is

(A) $\frac{1}{4}$ (B) $\frac{e^2-1}{e^2}$ (C) $\frac{3}{4}$ (D) $\frac{1}{e^2}$

2. A sample of radioactive material decays simultaneously by two processes A and B with half lives $\frac{1}{2}$ and $\frac{1}{4}$ hr respectively. For first half hr it decays with the process A, next one hr with the process B and for further half an hour with both A and B. If originally there were N_0 nuclei, find the number of nuclei after 2 hr of such decay.

(A) $\frac{N_0}{(2)^8}$ (B) $\frac{N_0}{(2)^4}$ (C) $\frac{N_0}{(2)^6}$ (D) $\frac{N_0}{(2)^5}$

3. The number of photons (λ=6630Å) that strike per second on a totally reflecting screen (as shown in figure), so that a force of 1N is exerted on the screen, is approximately.



(A) 10^{23} (B) 10^{27}
(C) 10^{25} (D) 10^{26}

4. Photo electric effect is the phenomenon in which
(A) Photons come out of a metal when it is hit by a beam of electrons
(B) Photons come out of the nucleus of an atom under the action of an electric field
(C) Electrons come out of metal with a constant velocity depending on frequency and intensity of incident light
(D) Electrons come out of a metal with different velocity not greater than a certain value which depends only on the frequency of the incident light wave and not on its intensity.

5. When an electro–magnetic radiation is incident on the surface of metal, maximum kinetic energy of photoelectron depends on–
(A) Frequency of radiation (B) Intensity of radiation
(C) Both the frequency and intensity (D) Polarization of radiation

6. Which one of the following is true in photoelectric emission
(A) Photoelectric current is directly proportional to the amplitude of light of a given frequency
(B) Photoelectric current is directly proportional to the intensity of light of a given frequency above threshold value
(C) Above the threshold frequency, the maximum K.E. of photoelectrons is inversely proportional to the frequency of incident light
(D) The threshold frequency depends upon the wavelength of incident light

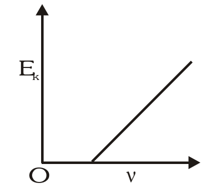
7. The maximum kinetic energy of photoelectrons emitted from a surface when photons of energy 6 eV fall on it is 4 eV. The stopping potential in volts is :
(A) 2 (B) 4 (C) 6 (D) 10

8. Light of two different frequencies whose photons have energies of 1 eV and 2.5 eV are incident one by one on a metal surface of work function 0.5 eV. The ratio of maximum energies of emitted electrons will be
(A) 1 : 4 (B) 4 : 1 (C) 1 : 2 (D) 2 : 1

9. The work functions of tungsten and sodium are 5.06 eV and 2.53 eV respectively. If the threshold wavelength for sodium is 5896 Å, then the threshold wavelength for the tungsten will be
(A) 11792 Å (B) 5896 Å (C) 4312 Å (D) 2948 Å

10. The stopping potential necessary to reduce the photoelectric current to zero–
(A) is directly proportional to wavelength of incident light.
(B) uniformly increases with the wavelength of incident light.
(C) directly proportional to frequency of incident light.
(D) uniformly increases with the frequency of incident light.

11. Graph is plotted between maximum kinetic energy (E_K) of electron with frequency of incident photon (ν) in Photo electric effect. The slope of curve will be–



(A) Charge of electron (B) Work function of metal

(C) Planck's constant (D) Ratio of Planck constant and charge of electron

12. The maximum energy of the electrons released in photocell is independent of–

(A) Frequency of incident light. (B) Intensity of incident light.

(C) Nature of cathode surface. (D) None of these.

13 Photoelectric effect takes place in element A. Its work function is 2.5 eV and threshold wavelength is λ. An other element B is having work function of 5 eV. Then find out the wavelength that can produce photoelectric effect in B.

(A) $\lambda/2$ (B) 2λ (C) λ (D) 3λ

14. When a certain metallic surface is illuminated with monochromatic light of wavelength λ, the stopping potential for photo electric current is 6 V_0. When the same surface is illuminated with light of wavelength 2λ, the stopping potential is $2V_0$. The threshold wavelength of this surface for photoelectric effect is–

(A) 6λ (B) $4\lambda/3$ (C) 4λ (D) 8λ

15. A photoelectric cell is illuminated by a point source of light 1 m away. When the source is shifted to 2m then–

(A) each emitted electron carries one quarter of the initial energy

(B) number of electrons emitted is half the initial number

(C) each emitted electron carries half the initial energy

(D) number of electrons emitted is a quarter of the initial number

16. A photo sensitive metallic surface has work function $h\nu_0$. If photons of energy $2h\nu_0$ fall on this surface, the electrons come out with a maximum velocity of 4 10^6 m/s. When the photon energy is increased to 5 $h\nu_0$, then maximum velocity of photo electrons will be–

(A) 2 10^6 m/s (B) 2 10^7 m/s (C) 8 10^5 m/s (D) 8 10^6 m/s

17. The half–life of the radioactive radon is 3.8 days. The time, at the end of which 1/20th of the radon sample will remain undecayed, is (given $\log_{10} e = 0.4343$) :

(A) 3.8 day (B) 16.5 day (C) 33 day (D) 76 day

18. In a photoelectric experiment, with light of wavelength λ, the fastest electron has speed v. If the wavelength is changed to $\frac{3\lambda}{4}$, the speed of the fastest emitted electron will becomes

(A) $v\sqrt{\frac{3}{4}}$ (B) $v\sqrt{\frac{4}{3}}$ (C) less than $v\sqrt{\frac{3}{4}}$ (D) greater than $v\sqrt{\frac{4}{3}}$

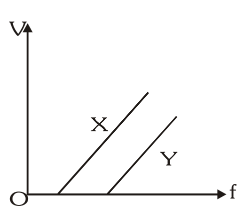
19. 1.5 mW of 400 nm light is directed at a photoelectric cell. If 0.10% of the incident photons produce photoelectrons, the current in the cell is:

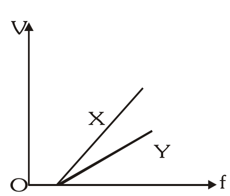
(A) 0.36 μA (B) 0.48 μA (C) 0.42 mA (D) 0.32 mA

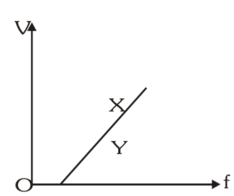
20. Let K_1 be the maximum kinetic energy of photoelectrons emitted by a light of wavelength λ_1 and K_2 corresponding to λ_2. If $\lambda_1 = 2\lambda_2$, then

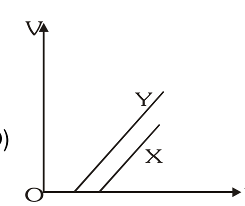
(A) $2K_1 = K_2$ (B) $K_1 = 2K_2$ (C) $K_1 < \frac{K_2}{2}$ (D) $K_1 > 2K_2$

21. In a photoelectric experiment, electrons are ejected from metals X and Y by light of intensity I and frequency f. The potential difference V required to stop the electrons is measured for various frequencies. If Y has a greater work function than X; which one of the following graphs best illustrates the expected results?

(A)


(B)


(C)


(D)


22. The de Broglie waves are associated with moving particles. These particle may be–
(A) electrons (B) He^{+}, Li^{2+} ions (C) Cricket ball (D) All of the above

23. Which of the following statements is wrong ?
(A) De–Broglie waves are probability waves and there is no physical existence of these.
(B) De–Broglie wavelength of a moving particle is inversely proportional to its momentum.
(C) Wave nature is associated with atomic particles only.
(D) In general wave nature of matter is not observed.

24. Two particles have identical charges. If they are accelerated through identical potential differences, then the ratio of their deBroglie wavelength would be
(A) $\lambda_1 : \lambda_2 = 1 : 1$ (B) $\lambda_1 : \lambda_2 = m_2 : m_1$ (C) $\lambda_1 : \lambda_2 = \sqrt{m_2} : \sqrt{m_1}$ (D) $\lambda_1 : \lambda_2 = \sqrt{m_1} : \sqrt{m_2}$

25. Linear momenta of a proton and an electron are equal. Relative to an electron–
(A) Kinetic energy of proton is more (B) De–Broglie wavelength of proton is more.
(C) De–Broglie wavelength of proton is less (D) De–Broglie wavelengths of proton and electron are equal

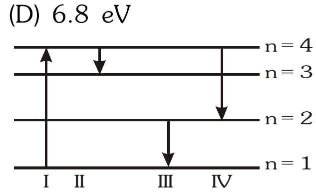
26. The wavelength of de–Broglie waves associated with neutrons at room temperature T K is
(A) $\frac{1.82}{T}$Å (B) $\frac{1.82}{\sqrt{T}}$Å (C) $\frac{25.15}{\sqrt{T}}$Å (D) $\frac{30.7}{T}$Å

27. Light coming from a discharge tube filled with hydrogen falls on the cathode of the photoelectric cell. The work function of the surface of cathode is 4eV. Which one of the following values of the anode voltage (in volts) with respect to the cathode will likely to make the photo current zero ?
(A) –4 (B) –6 (C) –8 (D) –10

28. If elements with principal quantum number n > 4 were not allowed in nature, the number of possible elements would be :
(A) 60 (B) 32 (C) 4 (D) 64

29. If 13.6 eV energy is required to ionize the hydrogen atom, then the energy required to remove an electron from n = 2 is–
(A) 10.2 eV (B) 0 eV (C) 3.4 eV (D) 6.8 eV

30. The diagram shown the energy levels for an electron in a certain atom. Which transition shown represents the emission of a photon with the most energy ?
(A) III (B) IV
(C) I (D) II



31. Which of the following transitions in hydrogen atoms emit photons of highest frequency ?
(A) n = 2 to n = 6 (B) n = 6 to n = 2 (C) n = 2 to n = 1 (D) n = 1 to n = 2

32. The wave number of the series limit of Lyman series is–
(A) 1.097 10^{7} m^{-1} (B) 2.74 10^{6} m^{-1} (C) 1.22 10^{6} m^{-1} (D) 6.86 10^{5} m^{-1}

33. 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 form a neutral helium atom is
(A) 38.2 (B) 49.2 (C) 51.8 (D) 79.0

34. A photon was absorbed by a hydrogen atom in its ground state, and the electron was prompted to the fifth orbit. When the excited atom returned to its ground state, visible and other quanta were emitted. In this process, how many maximum spectral lines could be obtained –
(A) 1 (B) 2 (C) 5 (D) 10

35. In Bohr's atom the number of de Broglie waves associated with an electron moving in n^{th} permitted orbit is–
(A) n (B) 2n (C) n/2 (D) n^2

36. The K_α X–ray emission line of tungsten occurs at λ = 0.021 nm. The energy difference between K and L levels in this atoms is about :
(A) 0.51 MeV (B) 1.2 MeV (C) 59 keV (D) 13.6 eV

37. Which of the following are the characteristics required for the target to produce X–rays

	(A)	(B)	(C)	(D)
Atomic number	Low	High	Low	High
Melting point	High	High	Low	Low

38. The wavelength of K_α line for an element of atomic number 43 is λ. Then the wavelength of K_α line for an element of atomic number 29 is :–

(A) (43/29) λ (B) (42/28) λ (C) (9/4) λ (D) (4/9) λ

39. The wavelengths of K_α X–rays of two metals 'A' and 'B' are $\frac{4}{1875R}$ and $\frac{1}{675R}$ respectively, where 'R' is Rydberg constant. The number of elements lying between 'A' and 'B' according to their atomic numbers is :

(A) 3 (B) 6 (C) 5 (D) 4

40. On operating an X–ray tube at 1 kV. X–rays of minimum wavelength 6.22 Å are produced. If the tube is operated at 10 kV, then the minimum wavelength of X–rays produced will be

(A) 0.622 Å (B) 6.22 Å (C) 3.11 Å (D) 62.2 Å

41. The production of characteristic X–rays is due to–

(A) transfer of momentum in collision of electrons with the target atom
(B) transfer of energy in collision of electrons with the target atom
(C) the transition of electrons in heavy target atoms from high to low energy level
(D) none of these

42. Characteristic X–rays are not obtained in the spectrum of H–atom because–

(A) hydrogen is a gas
(B) hydrogen is very light
(C) energy difference in energy levels of hydrogen is much less
(D) energy difference in energy levels of hydrogen is much high

43. Assuming that 200 MeV of energy is released per fission of $_{92}U^{235}$ atom. Find the number of fission per second required to release 1 kW power :–

(A) 3.125 10^{13} (B) 3.125 10^{14} (C) 3.125 10^{15} (D) 3.125 10^{16}

44. Per nucleon energy of $_3Li^7$ and $_2He^4$ nucleus is 5.60 MeV and 7.06 MeV, then in $_3Li^7 + {}_1P^1 \rightarrow 2\,{}_2He^4$ energy released is :–

(A) 29.6 MeV (B) 2.4 MeV (C) 8.4 MeV (D) 17.3 MeV

45. The mass of proton is 1.0073 u and that of neutron is 1.0087 u (u = atomic mass unit). The binding energy of ${}_2^4He$ is :– [Given helium nucleus mass $\approx 4.0015u$]

(A) 0.0305 J (B) 0.0305 erg (C) 28.4 MeV (D) 0.061 u

46. The binding energy of deuteron is 2.2 MeV and that of ${}_2^4He$ is 28 MeV. If two deuterons are fused to form one ${}_2^4He$ then the energy released is :–

(A) 23.6 MeV (B) 19.2 MeV (C) 30.2 MeV (D) 25.8 MeV

47. In an α–decay the Kinetic energy of α–particle is 48 MeV and Q–value of the reaction is 50 MeV. The mass number of the mother nucleus is :– (Assume that daughter nucleus is in ground state)

(A) 96 (B) 100 (C) 104 (D) None of these

48. When a neutron is disintegrated, it gives :–

(A) one proton, one electron and one anti neutrino
(B) one positron, one electron and one neutrino
(C) one proton, one positron and one neutrino
(D) one proton, γ – rays and one neutrino

49. If $N_t = N_o e^{-\lambda t}$ then number of disintegrated atoms between t_1 to t_2 ($t_2 > t_1$) will be :–

(A) $N_o\,[e^{\lambda t_2} - e^{\lambda t_1}]$ (B) $N_o[-e^{\lambda t_2} - e^{-\lambda t_1}]$ (C) $N_o\,[e^{-\lambda t_1} - e^{-\lambda t_2}]$ (D) None of these

50. The half life of a radioactive element is 30 days, in 90 days the percentage of disintegrated part is :–

(A) 13.5 % (B) 46.5 % (C) 87.5% (D) 90.15%

51. The half life of a radioactive element is 10 days. If the mass of the specimen reduces to $1/10^{th}$ then the time taken is :–

(A) 100 days (B) 50 days (C) 33 days (D) 16 days

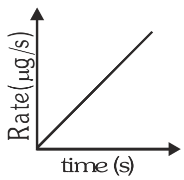
52. In a mean life of a radioactive sample :–

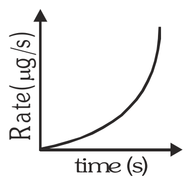
(A) about 1/3 of substance disintegrates
(B) about 2/3 of substance disintegrates
(C) about 90% of the substance disintegrates
(D) almost all the substance disintegrates

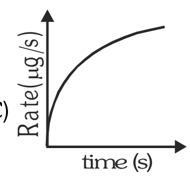
53. Atomic weight of a radioactive element is M_w gm. Radioactivity of m gm. of its mass is :–
(N_A = Avogadro number, λ = decay constant)

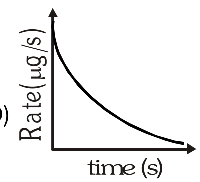
(A) $N_A\,\lambda$ (B) $\left[\frac{N_A}{M_w}m\right]\lambda$ (C) $\left[\frac{N_A}{m}\right]\lambda$ (D) $\left[\frac{N_A}{m}M_w\right]\lambda$

54. The radioactive nuclide of an element X decays to a stable nuclide of element Y. Then, in a given sample of X, the rate of formation of Y is given by the graph –

(A)


(B)


(C)


(D)


CHECK YOUR GRASP — **ANSWER KEY** — EXERCISE –1

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
B	A	B	D	A	B	B	A	D	D	C	B	A	C	D	D	B	D	B	C
21	**22**	**23**	**24**	**25**	**26**	**27**	**28**	**29**	**30**	**31**	**32**	**33**	**34**	**35**	**36**	**37**	**38**	**39**	**40**
A	D	C	C	D	C	D	A	C	A	C	A	D	D	A	C	B	C	D	A
41	**42**	**43**	**44**	**45**	**46**	**47**	**48**	**49**	**50**	**51**	**52**	**53**	**54**						
C	C	A	D	C	A	B	A	C	C	C	B	B	D						

EXERCISE–02 BRAIN TEASURES

Select the correct alternatives (one or more than one correct answers)

1. For a doubly ionised Li–atom

(A) Angular momentum of an electron in 3rd orbit is $\frac{3h}{2\pi}$

(B) Energy of electron in 2nd excited state is –13.6 eV

(C) Speed of electron in 3rd orbit is $\frac{c}{137}$, where c is speed of light

(D) Kinetic energy of electron is 2nd excited state is half of the magnitude of the potential energy

2. The electron in a hydrogen atom jumps back from an excited state to ground state, by emitting a photon of wavelength $\lambda_0=\frac{16}{15R}$, where R is Rydberg's constant. In place of emitting one photon, the electron could come back to ground state by

(A) Emitting 3 photons of wavelengths λ_1, λ_2 and λ_3 such that $\frac{1}{\lambda_1}+\frac{1}{\lambda_2}+\frac{1}{\lambda_3}=\frac{15R}{16}$

(B) Emitting 2 photons of wavelength $\lambda_1$and λ_2 such that $\frac{1}{\lambda_1}+\frac{1}{\lambda_2}=\frac{15R}{16}$

(C) Emitting 2 photons of wavelength λ_1 and λ_2 such that $\lambda_1 + \lambda_2 = \frac{16}{15R}$

(D) Emitting 3 photons of wavelength λ_1, λ_2 and λ_3 such that $\lambda_1+\lambda_2+\lambda_3=\frac{16}{15R}$

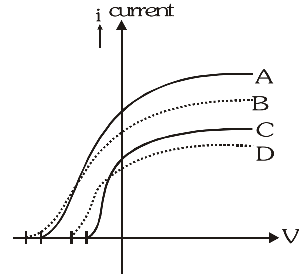
3. The photon radiated from hydrogen corresponding to 2nd line of Lyman series is absorbed by a hydrogen like atom 'X' in 2nd excited state. As a result the hydrogen like atom 'X' makes a transition to n^{th} orbit. Then:
(A) X = He^+, n = 4 (B) X = Li^{++}, n = 6 (C) X = He^+, n = 6 (D) X = Li^{++}, n = 9

4. When a hydrogen atom is excited from ground state to first excited state then :
(A) its kinetic energy increases by 10.2 eV (B) its kinetic energy decreases by 10.2 eV
(C) its potential energy increases by 20.4 eV (D) its angular momentum increases by 1.05 10^{-34} J–s

5. Suppose the potential energy between electron and proton at a distance r is given by $-\frac{Ke^2}{3r^3}$.
Application of Bohr's theory to hydrogen atom in this case shows that
(A) energy in the n^{th} orbit is proportional to n^6 (B) energy is proportional to m^{-3} (m = mass of electron)
(C) energy in the nth orbit is proportional to n^{-2} (D) energy is proportional to m^3 (m = mass of electron)

6. The stopping potential for photo electron emitted from a metal surface of work function 1.7 eV is 10.4V. Select correct choice
(A) The wavelength of light used is 1022 Å
(B) The wavelength of light used is 970.6 Å
(C) The light used is emitted by hydrogen gas sample which de–excites from n=3 to n=1
(D) The light used is emitted by hydrogen gas sample which de–excites from n=4 to n=1

7. The figure shows the results of an experiment involving photoelectric effect. The graphs A, B, C and D relate to a light beam having different wavelengths. Select the correct alternative



(A) Beam B has highest frequency

(B) Beam C has longest wavelength

(C) Beam A has highest rate of photoelectric emission

(D) Photoelectrons emitted by B have highest momentum

8. When photons of energy 4.25 eV strike the surface of a metal A, the ejected photoelectrons have maximum kinetic energy T_A eV and de–Broglie wavelength λ_A. The maximum kinetic energy of photoelectrons liberated from another metal B by photons of energy 4.70 eV is $T_B = (T_A - 1.5 \text{ eV})$. If the de–Broglie wavelength of these electrons are related as $\lambda_B = 2\lambda_A$, then

(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

9. In a photoelectric experiment, the collector plate is at 2.0V with respect to the emitter plate made of copper (ϕ= 4.5 eV). The emitter is illuminated by a source of monochromatic light of wavelength 200 nm.

(A) The minimum kinetic energy of the photoelectrons reaching the collector is 0.
(B) The maximum kinetic energy of the photoelectrons reaching the collector is 3.7 eV.
(C) If the polarity of the battery is reversed then answer to part A will be 0
(D) If the polarity of the battery is reversed then answer to part B will be 1.7 eV

10. Disintegration constant of a radioactive material is λ

(A) Its half life equal to $\frac{\log_e 2}{\lambda}$
(B) Its mean life equals to $\frac{1}{\lambda}$
(C) At time equal to mean life, 63% of the initial radioactive material is left undecayed
(D) After 3–half lives, $\frac{1}{3}$rd of the initial radioactive material is left undecayed.

11. A nucleus undergoes a series of decay according to the scheme $A \xrightarrow{\alpha} B \xrightarrow{\beta} C \xrightarrow{\alpha} D \xrightarrow{\gamma} E$

Atomic number and mass numbers of E are 69 and 172

(A) Atomic number of A is 72
(B) Mass number of B is 176
(C) Atomic number of D is 69
(D) Atomic number of C is 69

12. The half life of a radioactive substance is T_0. At t=0, the number of active nuclei are N_0. Select the correct alternative.

(A) The number of nuclei decayed in time internal 0–t is $N_0 e^{-\lambda t}$
(B) The number of nuclei decayed in time interval 0–t is $N_0 (1-e^{-\lambda t})$
(C) The probability that a radioactive nuclei does not decay in interval 0–t is $e^{-\lambda t}$
(D) The probability that a radioactive nuclei does not decay in interval $1-e^{-\lambda t}$

13. 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 :

(A) 10^6 s
(B) 10^8 s
(C) 10^{12} s
(D) 10^{16} s

The mass of the nuclei are as follows :

$M(H^2) = 2.014$ amu ; $M(n) = 1.008$ amu ; $M(p) = 1.0087$ amu ; $M(He^4) = 4.001$ amu.

14. Which of the following is correct for a nuclear reaction?

(A) A typical fission represented by $_{92}U^{235} + {_0n^1} \rightarrow {_{56}Ba^{143}} + {_{36}Kr^{93}}$+energy
(B) Heavy water is used as moderator in preference to ordinary water because H may capture neutrons, while D would not
(C) Cadmium rods increase the reactor power when they go in, decrease when they go outward
(D) Slower neutrons are more effective in causing fission than faster neutrons in case of U^{235}

15. In photoelectric effect, stopping potential depends on

(A) frequency of the incident light
(B) intensity of the incident light by varies source distance
(C) emitter's properties
(D) frequency and intensity of the incident light

16. An electron in hydrogen atom first jumps from second excited state to first excited state and then, from first excited state to ground state. Let the ratio of wavelength, momentum and energy of photons in the two cases be x, y and z, then select the wrong answer/(s)

(A) z= 1/x (B) x = 9/4 (C) y = 5/27 (D) z = 5/27

17. An electron is in an excited state in hydrogen–like atom. It has a total energy of –3.4 eV. If the kinetic energy of the electron is E and its de–Broglie wavelength is λ, then

(A) E = 6.8 eV, λ = 6.6 10^{-10} m (B) E = 3.4 eV, λ = 6.6 10^{-10}m
(C) E = 3.4 eV, λ = 6.6 10^{-11}m (D) E = 6.8 eV, λ = 6.6 10^{-11}m

18. A particular hydrogen like atom has its ground state binding energy 122. 4 eV. It is in ground state. Then
(A) Its atomic number is 3
(B) An electron of 90 eV can excite it
(C) An electron of kinetic energy nearly 91.8 eV can be brought to almost rest by this atom
(D) An electron of kinetic energy 2.6 eV may emerge from the atom when electron of kinetic energy 125 eV collides with this atom

19. A beam of ultraviolet light of all wavelengths passes through hydrogen gas at room temperature, in the x–direction. Assume that all photons emitted due to electron transition inside the gas emerge in the y–direction. Let A and B denote the lights emerging from the gas in the x and y directions respectively.
(A) Some of the incident wavelengths will be absent in A
(B) Only those wavelengths will be present in B which are absent in A
(C) B will contain some visible light
(D) B will contain some infrared light

20. If radiations of allowed wavelengths from ultraviolet to infrared are passed through hydrogen gas at room temperature, absorption lines will be observed in the

(A) Lyman series (B) Balmer series (C) Both (A) and (B) (D) Neither (A) nor (B)

21. In the hydrogen atom, if the reference level of potential energy is assumed to be zero at the ground state level. Choose the incorrect statement.
(A) The total energy of the shell increases with increase in the value of n
(B) The total energy of the shell decrease with increase in the value of n
(C) The difference in total energy of any two shells remains the same
(D) The total energy at the ground state becomes 13.6 eV

22. Choose the correct statement(s) for hydrogen and deuterium atoms (considering the motion of nucleus)
(A) The radius of first Bohr orbit of deuterium is less than that of hydrogen
(B) The speed of electron in first Balmer line of deuterium is more than that of hydrogen
(C) The wavelength of first Balmer line of deuterium is more than that of hydrogen
(D) The angular momentum of electron in the first Bohr orbit of deuterium is more than that of hydrogen

23. A neutron collides head–on with a stationary hydrogen atom in ground state. Which of the following statements are correct (Assume that the hydrogen atom and neutron has same mass)
(A) If kinetic energy of the neutron is less than 20.4 eV collision must be elastic
(B) If kinetic energy of the neutron is less than 20.4 eV collision may be inelastic
(C) Inelastic collision may be take place only when initial kinetic energy of neutron is greater than 20.4 eV
(D) Perfectly inelastic collision can not take place

24. When a nucleus with atomic number Z and mass number A undergoes a radioactive decayed process
(A) both Z and A will decrease, if the process is α decay
(B) Z will decrease but A will not change, if the process is β^+ decay
(C) Z will decrease but A will not change, if the process is β^- decay
(D) Z and A will remain unchanged, if the process is γ decay

25. In a Coolidge tube experiment, the minimum wavelength of the continuous X–ray spectrum is equal to 66.3 pm, then
(A) electrons accelerate through a potential difference of 12.75 kV in the Coolidge tube
(B) electrons accelerate through a potential difference of 18.75 kV in the Coolidge tube
(C) de–Broglie wavelength of the electrons reaching the anticathode is of the order of 10 μm
(D) de–Brgolie wavelength of the electrons reaching the anticathode is 0.01 Å

26. The potential difference applied to an X–ray tube is increase. As a result, in the emitted radiation
(A) the intensity increases (B) the minimum wavelength increases
(C) the intensity decreases (D) the minimum wavelength decreases

27. When the atomic number Z of the nucleus increases
(A) initially the neutron– proton ratio is constant =1
(B) initially neutron–proton ratio increases and later decreases
(C) initially binding energy per nucleon increases and later decreases
(D) the binding energy per nucleon increases when the neutron–proton ratio increases

28. The decay constant of a radio active substance is 0.173 $(\text{years})^{-1}$. Therefore
(A) Nearly 63% of the radioactive substance will decay in (1/0.173) year
(B) Half life of the radio active substance is (1/0.173) years.
(C) One–fourth of the radioactive substance will be left after nearly 8 years
(D) All the above statements are true

29. Let n_r and n_b be respectively the number of photons emitted by a red bulb and a blue bulb of equal power in a given time
(A) $n_r = n_b$ (B) $n_r < n_b$ (C) $n_r > n_b$ (D) Data insufficient

30. 10^{-3}W of 5000 Å light is directed on a photoelectric cell. If the current in the cell is 0.16 μ, the percentage of incident photons which produce photoelectrons, is
(A) 0.4% (B) .04% (C) 20% (D) 10%

31. Two electrons are moving with the same speed v. One electron enters a region of uniform electric field while the other enters a region of uniform magnetic field, then after sometime if the de–Broglie wavelengths of the two are λ_1 and λ_2, then
(A) $\lambda_1 = \lambda_2$ (B) $\lambda_1 > \lambda_2$ (C) $\lambda_2 > \lambda_1$ (D) None of these

32. An electron with initial kinetic energy of 100 eV is accelerated through a potential difference of 50 V. Now the de–Broglie wavelength of electron becomes
(A) 1Å (B) $\sqrt{1.5}$ Å (C) $\sqrt{3}$ Å (D) 12.27 Å

33. When a photon of light collides with a metal surface, number of electrons, (if any) coming out is
(A) only one (B) only two (C) infinite (D) depends upon factors

34. Two radioactive material A_1 and A_2 have decay constants of 10 λ_0 and λ_0. If initially they have same number of nuclei, the ratio of number of their undecayed nuclei will be (1/e) after a time
(A) $\frac{1}{\lambda_0}$ (B) $\frac{1}{9\lambda_0}$ (C) $\frac{1}{10\lambda_0}$ (D) 1

35. Cut off potential for a metal in photoelectric effect for light of wavelength λ_1, λ_2 and λ_3 is found to be V_1, V_2 and V_3 volts if V_1, V_2 and V_3 are in Arithmetic Progression and λ_1, λ_2 and λ_3 will be
(A) Arithmetic Progression (B) Geometric progression (C) Harmonic Progression (D) None

36. Photons with energy 5 eV are incident on a cathode C, on a photoelectric cell. The maximum energy of the emitted photoelectrons is 2 eV. When photons of energy 6 eV are incident on C, no photoelectrons will reach the anode A if the stopping potential of A relative to C is
(A) 3 V (B) – 3V (C) –1 V (D) 4 V

37. de–Broglie wavelength of an electron in the n^{th} Bohr orbit is λ_n and the angular momentum is J_n, then
(A) $J_n \propto \lambda_n$ (B) $\lambda_n \propto \frac{1}{J_n}$ (C) $\lambda_n \propto J_n^2$ (D) None of these

38. In Hydrogen and Hydrogen like atoms, the ratio of difference of energies $E_{2n} - E_n$ and E_{2n} E_n varies with its atomic number z and n as-
(A) z^2 / n^2 (B) z^4 / n^4 (C) z /n (D) (n^2/z^2)

39. In a hydrogen atom, the electron is in n^{th} excited state. It may come down to second excited state by emitting ten different wavelengths. What is the value of n ?
(A) 6 (B) 7 (C) 8 (D) 5

40. An electron in hydrogen atom after absorbing energy photons can jump between energy states n_1 and n_2 ($n_2 > n_1$). Then it may return to ground state after emitting six difference wavelengths in emission spectrum. The energy of emitted photons is either equal to, less than or greater than the absorbed photons. Then n_1 and n_2 are :–

(A) $n_2 = 4$, $n_1 = 3$ (B) $n_2 = 5$, $n_1 = 3$ (C) $n_2 = 4$, $n_1 = 2$ (D) $n_2 = 4$, $n_1 = 1$

41. The electron in a hydrogen atom makes transition from M shell to L. The ratio of magnitudes of initial to final centripetal acceleration of the electron is :–

(A) 9:4 (B) 81:16 (C) 4:9 (D) 16:81

42. The electron in a hydrogen atom makes a transition $n_1 \rightarrow n_2$ where n_1 and n_2 are the principal quantum numbers of the two states. Assume the Bohr model to be valid. The frequency of orbital motion of the electron in the initial state is 1/27 of that in the final state. The possible values of n_1 and n_2 are

(A) $n_1 = 4$, $n_2 = 2$ (B) $n_1 = 3$, $n_2 = 1$ (C) $n_1 = 8$, $n_2 = 1$ (D) $n_1 = 6$, $n_2 = 3$

43. Monochromatic radiation of wavelength λ is incident on a hydrogen sample containing in ground state. Hydrogen atoms absorb the light and subsequently emit radiations of ten different wavelengths. The value of λ is

(A) 95 nm (B) 103 nm (C) 273 nm (D) 88 nm

44. When a hydrogen atom, initially at rest emits a photon resulting in transition $n=5 \rightarrow n=1$, its recoil speed is about

(A) 10^{-4} m/s (B) 2 10^{-2} m/s (C) 4.2 m/s (D) 3.8 10^{-2} m/s

45. An electron collides with a fixed hydrogen atom in its ground state. Hydrogen atom gets excited and the colliding electron loses all its kinetic energy. Consequently the hydrogen atom may emit a photon corresponding to the largest wavelength of the Balmer series. The min. K.E. of colliding electron will be :–

(A) 10.2 eV (B) 1.9 eV (C) 12.1 eV (D) 13.6 eV

46. In an atom, two electrons move around the nucleus in circular orbits of radii R and 4R. The ratio of the time taken by them to complete one revolution is (neglect electric interaction) :–

(A) 1:4 (B) 4:1 (C) 1:8 (D) 8:1

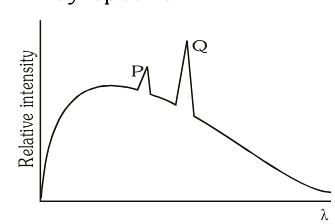
47. The electron in hydrogen atom in a sample is in n^{th} excited state, then the number of different spectrum lines obtained in its emission spectrum will be

(A) $1+2+3+......+(n-1)$ (B) $1+2+3+......+(n)$
(C) $1+2+3+......+(n+1)$ (D) $1 \quad 2 \quad 3 \quad ...... \quad (n-1)$

48. The magnitude of angular momentum, orbit radius and frequency of revolution of electron in hydrogen atom corresponding to quantum number n are L, r and f respectively. Then according to Bohr's theory of hydrogen atom

(A) fr^2L is constant for all orbits (B) frL is constant for all orbits
(C) f^2rL is constant for all orbits (D) frL^2 is constant for all orbits

49. In a characteristic X–ray spectra of some atom superimposed on continuous X–ray spectra



(A) P represents K_α line

(B) Q represents K_β line

(C) Q and P represents K_α and K_β lines respectively

(D) Relative positions of K_α and K_β depends on the particular atom

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

(A) $Q=2E_1 - E_2$ (B) $Q=E_2-2E_1$ (C) $Q=2E_1 + E_2$ (D) $Q=2E_2 + E_1$

51. A radioactive material of half–life T was produced in a nuclear reactor at different instants. The quantity produced second time was twice of that produced first time. If now their present activities are A_1 and A_2 respectively then their age difference equals

(A) $\frac{T}{\ell n2}\left|\ell n\frac{A_1}{A_2}\right|$ (B) $T\left|\ell n\frac{A_1}{A_2}\right|$ (C) $\frac{T}{\ell n2}\left|\ell n\frac{A_2}{2A_1}\right|$ (D) $T\left|\ell n\frac{A_2}{2A_1}\right|$

52. Half life for certain radioactive element is 5 min. Four nuclei of that element are observed at a certain instant of time. After five minutes

Assertion (A) : It can be definitely said that two nuclei will be left undecayed

Reasoning (R) : After half life i.e. 5 minutes, half of total nuclei will disintegrate. So only two nuclei will be left undecayed. Then

(A) A is correct & R is correct explanation of A
(B) Both are correct. But R is not correct explanation of A
(C) A is incorrect & R is correct
(D) Both are incorrect

53. The radioactivity of a sample is R_1 at time T_1 and R_2 at time T_2. If the half life of the specimen is T then number of atoms that have disintegrated in time (T_2-T_1) is proportional to

(A) $(R_1T_1-R_2T_2)$ (B) $(R_1-R_2)T$ (C) $(R_1-R_2)/T$ (D) $(R_1-R_2)(T_1-T_2)$

54. The decay constant of the end product of a radioactive series is

(A) zero (B) infinite (C) finite (non zero) (D) depends on the end product

55. At time t=0, N_1 nuclei of decay constant λ_1 & N_2 nuclei of decay constant λ_2 are mixed. The decay rate of the mixture is

(A) $N_1N_2e^{-(\lambda_1+\lambda_2)t}$ (B) $+\left(\frac{N_1}{N_2}\right)e^{-(\lambda_1-\lambda_2)t}$ (C) $+\left(N_1\lambda_1e^{-\lambda_1t}+N_2\lambda_2e^{-\lambda_2t}\right)$ (D) $+N_1\lambda_1N_2\lambda_2e^{-(\lambda_1+\lambda_2)t}$

BRAIN TEASERS — **ANSWER KEY** — EXERCISE -2

Que.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
Ans.	ABCD	AB	D	BCD	AB	AC	ABCD	ABC	B	AB	BC	BC	C	ABD	AC	B	B	ACD	ACD	A
Que.	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40
Ans.	B	A	AC	ABD	B	AD	AC	AC	C	B	D	A	A	B	C	B	A	D	A	C
Que.	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55					
Ans.	D	B	A	C	C	C	B	B	C	B	C	D	B	A	C					

EXERCISE–03

MISCELLANEOUS TYPE QUESTIONS

True/False

1. The different lines in the Lyman series have their wavelengths lying between 911 Å and 1215Å.

2. The kinetic energy of photoelectrons emitted by a photosensitive surface depends on the intensity of the incident radiation.

3. In artificial radioactivity, we sometimes observe decay by 'K–electron capture'. In this process, the nucleus captures one of its own orbital electrons. The atomic number change in this process is different from that in the decay process that involves the emission of a positron.

4. When two deuterium nuclei fuse together, they give rise to a tritium nucleus accompanied by a release of energy.

Fill in the blanks

1. 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 ....

2. A potential difference of 20 kV is applied across an X–ray tube. The minimum wavelength of X–rays generated is.........Å.

3. The wavelength of K_α X–rays produced by an X–ray tube is 0.76 Å. The atomic number of the anode material of the tube is ....

4. 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 ....

5. The maximum kinetic energy of electrons emitted in the photoelectric effect is linearly dependent on the ....of the incident radiation.

6. 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 ....

7. In the uranium radioactive series the initial nucleus is ${}^{238}_{92}U$ and the final nucleus is ${}_{82}Pb^{206}$ when the uranium nucleus decays to lead, the number of α–particles emitted is ... and the number of β–particle emitted is ....

8. The binding energies per nucleon for deuteron (${}_1H^2$) and helium (${}_2He^4$) are 1.1 MeV and 7.0 MeV respectively. Then energy released when two deuterons fuse to form a helium nucleus (${}_2He^4$) is ....

9. Consider the following reaction : ${}^2_1H + {}^2_1H = {}^4_2He + Q$. Mass of the deuterium atom = 2.0141u. Mass of helium atom = 4.0024 u. This is a nuclear .... reaction in which the energy Q released is .... MeV.

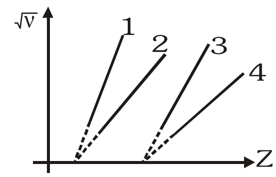
Match the Column

1. In Bohr's atomic model for hydrogen like atoms match the following column :

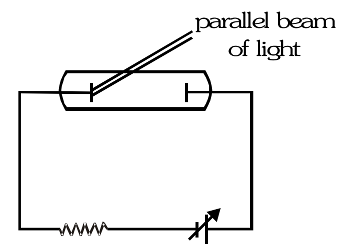
	Column I		Column II
(A)	If electron jumps from n = 2 to n = 1	(p)	Speed of electron will become 2 times
(B)	If electron jumps from n = 1 to n = 4	(q)	Kinetic energy of electron will become 4 times
(C)	If electron jumps from n = 4 to n = 1	(r)	Angular momentum of electron will become 2 times
		(s)	Angular velocity of electron will become 4 times
		(t)	None

2. $\sqrt{\nu}$ versus Z graph for characteristic X–rays is as shown in figure. Match the following :

	Column I		Column II
(A)	Line – 1	(p)	L_α
(B)	Line – 2	(q)	L_β
(C)	Line – 3	(r)	K_α
(D)	Line – 4	(s)	K_β



3. In the shown experimental setup to study photoelectric effect, two conducting electrodes are enclosed in an evacuated glass–tube as shown. A parallel beam of monochromatic light, falls on photosensitive electrodes. The emf of battery shown is high enough such that all photoelectrons ejected from left electrode will reach the right electrode. Under initial conditions photoelectrons are emitted. As changes are made in each situation of column–I; Match the statements in column–I with results in column–II.



	Column I		Column II
(A)	If frequency of incident light is increased keeping its intensity constant	(p)	magnitude of stopping potential will increase
(B)	If frequency of incident light is increased and its intensity is decreased.	(q)	current through circuit may stop
(C)	If work function of photo sensitive electrode is increased	(r)	maximum kinetic energy of ejected photoelectrons will increase
(D)	If intensity of incident light is increased keeping its frequency constant	(s)	saturation current will increase

4. Let R_t represents activity of a sample at an instant and N_t represent number of active nuclei in the sample at the instant. $T_{1/2}$ represents the half life

	Column I		Column II
(A)	$t = T_{1/2}$	(p)	$R_t = \dfrac{R_0}{2}$
(B)	$t = \dfrac{T_{1/2}}{\ell n 2}$	(q)	$N_0 - N_t = \dfrac{N_0}{2}$
(C)	$t = \dfrac{3}{2}T_{1/2}$	(r)	$\dfrac{R_t - R_0}{R_0} = \dfrac{1-e}{e}$
		(s)	$N_t = \dfrac{N_0}{2\sqrt{2}}$

5. Four physical quantities are listed in column–I. Their values are listed in column–II in a random order.

	Column I		Column II
(A)	Thermal energy of air molecules at room temperature.	(p)	0.02 eV
(B)	Binding energy of heavy nuclei per nucleon.	(q)	2 eV
(C)	X–ray photon energy.	(r)	10 keV
(D)	Photon energy of visible light.	(s)	7 MeV

6. Some laws /processes are given in column–I. Match these with the physical phenomena given in column–II.

	Column I		Column II
(A)	Nuclear fusion	(p)	Converts some matter in energy
(B)	Nuclear fission	(q)	Generally possible for nuclei with low atomic number.
(C)	β–decay	(r)	Generally possible for nuclei with high. atomic no.
(D)	Exothermic nuclear reaction	(s)	Essentially proceeds by weak nuclear forces.

ASSERTION–REASON

1. **Statement–1** : Between any two given energy levels, the number of absorption transitions is always less than the number of emission transitions.
and
Statement–2 : Absorption transitions starts from the lowest energy level only and may end at any higher energy level. But emission transitions may start from any higher energy level and end at any energy level below it.
(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.

2. **Statement–1** : Hydrogen atom consists of only one electron but its sample's emission spectrum has many lines.
and
Statement–2 : Only Lyman series is found in the absorption spectrum of hydrogen atom (at room temperature) whereas in the emission spectrum, all the series are found.
(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.

3. **Statement–1** : The Bohr's model cannot differentiate between the spectra of hydrogen and deuterium.
and
Statement–2 : The Bohr's model considers the nucleus as infinitely massive in comparison to the orbiting electrons.
(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.

4. **Statement–1** : The Bohr model of the hydrogen atom does not explain the fine structure of spectral lines.
and
Statement–2 : The Bohr model does not take into account the spin of the electron
(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.

5. **Statement–1** : The frequency of K_α X–radiation is greater than K_β for a given target material.
and
Statement–2 : K_α radiation is produced when an electron from n = 2 jumps into the vacancy in n = 1 orbit; whereas in K_β radiation the transition takes place from n = 3 to n = 1.
(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.

6. **Statement–1** : Work function of a metal is 8 eV. Two photons each having energy 5 eV can't eject the electron from the metal.
and
Statement–2 : More than one photon can't collide simultaneously with an electron.
(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.

7. **Statement–1** : Light described at a place by the equation $E = E_0$ (sin ωt + sin $7\omega t$) falls on a metal surface having work function ϕ_0. The maximum kinetic energy of the photoelectrons is $KE_{max} = \frac{7h\omega}{2\pi} - \phi_0$
and
Statement–2 : Maximum kinetic energy of photoelectron depends on the maximum frequency present in the incident light according to Einstein's photoelectric effect equation.
(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.

8. **Statement–1** : Though light of a single frequency (monochromatic) is incident on a metal, the energies of emitted photoelectrons are different.
and
Statement–2 : The energy of electrons emitted from inside the metal surface, is lost in collision with the other atoms in the metal.
(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.

9. **Statement–1** : In a photoelectric effect experiment different photoelectrons have different kinetic energy.
and
Statement–2 : In the incident radiation different photons must have different 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.

10. **Statement–1** : In photoelectric effect, the number of photoelectrons emitted is always equal to number of photons incident.

and

Statement–2 : All the photons falling on the surface will eject photoelectrons, is not necessary.

(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.

11. **Statement–1** : Among the particles of same kinetic energy; lighter particle has greater de broglie wavelength.

and

Statement–2 : The de–Broglie wavelength of a particle depends only on the charge of the particle.

(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.

12. **Statement–1:** The de–Broglie wavelength of a molecule (in a sample of ideal gas) varies inversely as the square root of absolute temperature.

and

Statement–2 : The rms velocity of a molecule (in a sample of ideal gas) depends on temperature.

(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.

13. **Statement–1** : The ionising power of β–particle is less compared to α–particles but their penetrating power is more.

and

Statement–2 : The mass of β–particle is less than the mass of α–particle.

(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.

14. **Statement–1** : Electron capture occurs more often than positron emission in heavy elements.

and

Statement–2 : Heavy elements generally exhibit radioactivity.

(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.

15. **Statement–1** : In α–emission, the α–particle carries the major share of the energy.

and

Statement–2 : In α–decay, the α–particle being lighter has more velocity.

(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

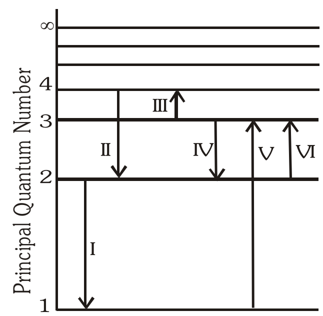
(C) Statement–1 is True, Statement–2 is False.

(D) Statement–1 is False, Statement–2 is True.

Comprehensions Type Questions

Comprehension#1

The figure shows an energy level diagram for the hydrogen atom. Several transitions are marked as I, II, III,__ ______, the diagram is only indicative and not to scale.



1. In which transition is a Balmer series photon absorbed ?

(A) II (B) III (C) IV (D) VI

2. The wavelength of the radiation involved in transition II is

(A) 291 nm (B) 364 nm (C) 487 nm (D) 652 nm

3. Which transition will occur when a hydrogen atom is irradiated with radiation of wavelength 103nm ?

(A) I (B) II (C) IV (D) V

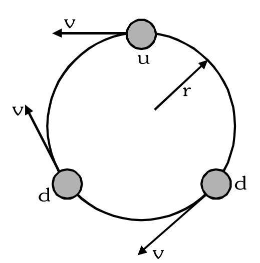
4. Which transition involves the longest wavelength line in the visible portion of the hydrogen spectrum

(A) I (B) III (C) VI (D) IV

Comprehension#2

Quark Model of the Neutron

The neutron is a particle with zero charge still it has a non–zero magnetic moment with z–component 9.66 10^{-27} A–m^2. This can be explained by the internal structure of the neutron. The evidence indicates that a neutron is composed of three fundamental particles called quarks : an "up" (u) quark, of charge $+\frac{2e}{3}$, and two "down" (d) quarks, each of charge $-\frac{e}{3}$. The combinations of the three quarks produces a net charge of $\frac{2e}{3}-\frac{e}{3}-\frac{e}{3}=0$.



If the quarks are in motion they can produce a non–zero magnetic moment. As a very simple model, suppose the u quark moves in a counter clockwise circular path and the d quarks move in a clockwise circular path, all of the radius r and all with the same speed v see figure.

1. The current due to the circular motion of the u quark :–

(A) $\frac{ev}{6\pi r}$ (B) $\frac{ev}{3\pi r}$ (C) $\frac{ev}{\pi r}$ (D) $\frac{2ev}{\pi r}$

2. Determine the magnitude of the magnetic moment due to the circular u quark :–

(A) $\frac{evr}{3}$ (B) $\frac{2evr}{3}$ (C) $\frac{4evr}{3}$ (D) evr

3. Determine the magnitude of the magnetic moment of the three–quark system :–

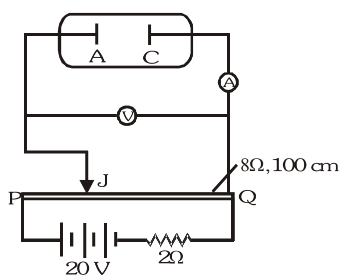
(A) $\frac{evr}{3}$ (B) $\frac{2evr}{3}$ (C) evr (D) 2evr

4. If all Quarks start moving in the same direction then what will be the magnetic moment of the neutron:–

(A) $\frac{evr}{3}$ (B) $\frac{2evr}{3}$ (C) evr (D) None of these

Comprehension# 3

An experimental setup of verification of photoelectric effect is shown in the diagram. The voltage across the electrodes is measured with the help of an ideal voltmeter, and which can be varied by moving jockey 'J' on the potentiometer wire. The battery used in potentiometer circuit is of 20 V and its internal resistance is 2Ω . The resistance of 100 cm long potentiometer wire is 8Ω. The photo current is measured with the help of an ideal ammeter. Two plates of potassium oxide of area 50 cm^2 at separation 0.5 mm are used in the vacuum tube. Photo current in the circuit is very small so we can treat potentiometer circuit an independent circuit. The wavelength of various colours is as follows :



Light	1 Violet	2 Blue	3 Green	4 Yellow	5 Orange	6 Red
λ in Å →	4000 – 4500	4500 – 5000	5000 – 5500	5500 – 6000	6000 – 6500	6500 – 7000

1. The number of electrons appeared on the surface of the cathode plate, when the jockey is connected at the end 'P' of the potentiometer wire. Assume that no radiation is falling on the plates.

(A) 8.85 10^6 (B) 11.0625 10^9 (C) 8.85 10^9 (D) 0

2. When radiation falls on the cathode plate a current of 2μA is recorded in the ammeter. Assuming that the vacuum tube setup follows ohm's law, the equivalent resistance of vacuum tube operating in this case when jockey is at end P.

(A) 8 10^8 Ω (B) 16 10^6 Ω (C) 8 10^6 Ω (D) 10 10^6 Ω

3. It is found that ammeter current remains unchanged (2μA) even when the jockey is moved from the 'P' to the middle point of the potentiometer wire. Assuming all the incident photons eject electron and the power of the light incident is 4 10^{-6} W. Then colour of the incident light is:

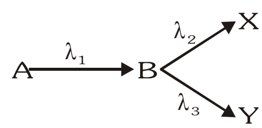
(A) Green (B) Violet (C) Red (D) Orange

4. When other light falls on the anode plate the ammeter reading remains zero till, jockey is moved from the end P to the middle point of the wire PQ. Thereafter the deflection is recorded in the ammeter. The maximum kinetic energy of the emitted electron is :

(A) 16 eV (B) 8 eV (C) 4 eV (D) 10 eV

Comprehension#4

The rate at which a particular decay process occurs in a radio active sample, is proportional to the number of radio active nuclei present. If N is the number of radio active nuclei present at some instant, the rate of change of N is $\frac{dN}{dt} = -\lambda N$.



Consider radioactive decay of A to B which may further decay either to X or to Y, λ_1, λ_2 and λ_3 are decay constants for A to B decay, B to X decay and B of Y decay respectively. If at t = 0 number of nuclei of A, B, X and Y are N_0, N_0, zero and zero respectively and N_1, N_2, N_3, N_4 are number of nuclei A,B,X and Y at any instant.

1. Rate of accumulation of B of any instant will be –

(A) $N_1\lambda_1 + N_2\lambda_2 + N_3\lambda_3$ (B) $N_1\lambda_1 - N_3\lambda_2 - N_4\lambda_3$

(C) $N_1\lambda_1 - N_2\lambda_2 - N_2\lambda_3$ (D) $N_1\lambda_1 + N_2\lambda_2 - N_3\lambda_3$

2. The number of nuclei of B will first increase then after a maximum value, it will decreases, if–

(A) $\lambda_1 > \lambda_2 + \lambda_3$ (B) $\lambda_1 = \lambda_2 = \lambda_3$

(C) $\lambda_1 = \lambda_2 + \lambda_3$ (D) For any values of λ_1, λ_2 and λ_3

3. At t = ∞, which of the following is incorrect ?

(A) $N_2 = 0$ (B) $N_3 = \frac{N_0\lambda_2}{\lambda_2 + \lambda_3}$ (C) $N_4 = \frac{2N_0\lambda_3}{\lambda_2 + \lambda_3}$ (D) $N_3+N_4+N_1+N_2=2N_0$

MISCELLANEOUS TYPE QUESTION **ANSWER KEY** EXERCISE -3

- ***True / False*** 1. T 2. F 3. F 4. F
- ***Fill in the blanks :*** 1. –1 2. 0.62Å 3. 41
  4. Intensity, decrease 5. frequency 6. 500 dps, 125 dps
  7. eight, six 8. 23.6 MeV 9. fusion, 24
- ***Match the Column:*** 1. (A) p,q (B) t (C) t 2. (A) s (B) r (C) q (D) p
  3. (A) p,r (B) p,r (C) q (D) s 4. (A) p,q (B) r (C) s
  5.(A) p (B) s (C) r (D) q 6. (A) p,q (B) p,r (C) p,s (D)p,q,r
- ***Assertion – Reason Questions*** 1. D 2. B 3. A 4. A 5. D 6. A 7. A 8. A
  9. C 10. D 11. C 12. B 13. B 14. B 15. A
- ***Comprehension Based Questions***

Comprehension #1 : 1. D 2. C 3. D 4. D

Comprehension #2 : 1. B 2. A 3. B 4. D

Comprehension #3 : 1. C 2. C 3. D 4. B

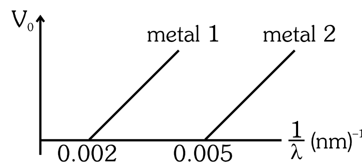
Comprehension #4 : 1. C 2. A 3. B

EXERCISE–04 [A] CONCEPTUAL SUBJECTIVE EXERCISE

1. 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 volt and 18.0 mA. If the same source is placed 0.6 m away from the photoelectric cell, then find (i) the stopping potential (ii) the saturation current.

2. Light of wavelength 330 nm falling on a piece of metal ejects electrons with sufficient energy which requires voltage V_0 to prevent a collector. In the same setup; light of wavelength 220 nm, ejects electrons which require twice the voltage V_0 to stop them in reaching a collector. Find the numerical value of voltage V_0. (Take plank's constant, h = 6.6 10^{-34} Js and 1 eV = 1.6 10^{-19}J)

3. The graph between $\frac{1}{\lambda}$ and stopping potential V_0 of two metals having work functions ϕ_1 and ϕ_2 in an experiment of photoelectric effect is obtained as shown in the figure. Find out –

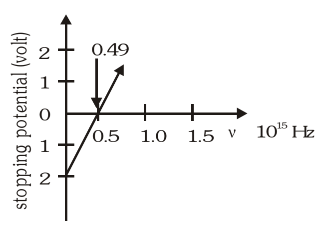


(i) Threshold wavelength of both metals

(ii) $\phi_1 : \phi_2$

(iii) Which metal can emit photoelectrons with visible light ?

4. The surface of cesium is illuminated with monochromatic light of various wavelengths and the stopping potential for the wavelengths are measured. The results of this experiment is plotted as shown in the figure. Estimate the value of work function of the cesium and Planck's constant.



5. A metallic surface is illuminated alternatively with light of wavelength 3000Å and 6000Å respectively. It is observed that the maximum speeds of the photoelectrons under these illuminations are in the ratio 3 : 1. Calculate the work function of the surface in eV. (h = 6.62 10^{-34} J–s, c = 3 10^{8} m/s)

6. What is the effect on the maximum kinetic energy and the number of photoelectrons when (i) The intensity of incident light decreases. (ii) The emitting surface is charged. (iii) Wavelength of incident light increase.

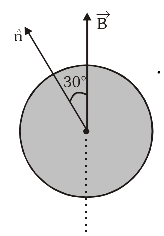
7. A small 10 W source of ultraviolet light of wavelength 99 nm is held at a distance 0.1 m from a metal surface. The radius of an atom of the metal is approximately 0.05 nm. Find (i) the average number of photons striking an atom per second. (ii) the number of photoelectrons emitted per unit area per second if the efficiency of liberation of photoelectrons is 1%.

8. An electron of mass "m" and charge "e" initially at rest gets accelerated by a constant electric field E. Find the rate of change of de-Broglie wavelength of this electron at time t.

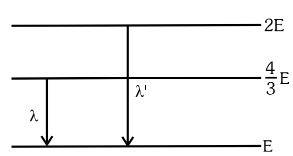
9. Assume that the de–Broglie wave associated with an electron can form a standing wave between the atoms arranged in a one dimensional array with nodes at each of the atomic sites. It is found that one such standing wave is formed if the distance 'd' between the atoms of the array is 2Å. A similar standing 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.

10. 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 & (ii) The de–Broglie wavelength of the electron.

11. An electron in the ground state of hydrogen atoms is revolving in anti–clockwise direction in a circular orbit of radius R. (i) Obtain an expression for the orbital magnetic dipole moment of the electron. (ii) The atom is placed in a uniform magnetic induction, such that the plane normal to the electron orbit make an angle of 30^0 with the magnetic induction. Find the torque experienced by the orbiting electron



12. The adjacent diagram shows the energy level of a certain atom. When the electron jumps from 4E/3 level to E level, a photon of wavelength λ is emitted. Calculate the wavelength of the radiation produced during the electronic transition from 2E level to E level.



13. A hydrogen like atom (atomic number Z) is in a higher excited state of quantum number n. This excited atom can make a transition to the first excited state by successively emitting two photons of energies 10.20 eV & 17.00 eV respectively. Alternatively, the atom from the same excited state can make a transition to the second excited state by successively emitting two photons of energies 4.25 eV & 5.95 eV respectively. Determine the values of n & Z. (Ionisation energy of hydrogen atom = 13.6 eV)

14. Find the ratio of series limit wavelength of Balmer series to wavelength of first line of paschen series.

15. An electron joins a helium nucleus to form a He^+ ion. Find the wavelength of the photon emitted in this process (in nm) if the electron is assumed to have no kinetic energy when it combines with nucleus. Assume Bohr's model to be applicable.

16. An X–ray tube, operated at a potential difference of 40 kV, produces heat at the rate of 720 W. Assuming 0.5% of the energy of incident electrons is converted into X–rays, calculate

(i) the number of electron per second striking the target. (ii) the velocity of the incident electrons

17. The K_α X–ray of molybdenum has wavelength 71pm. If the energy of a molybdenum atom with a K electron knocked out is 23 32 keV, What will be the energy of this atom when an L–electron is knocked out?

18. The positron is a fundamental particle with the same mass as that of the electron and with a charge equal to that of an electron but of opposite sign. When a positron and an electron collide, they may annihilate each other. The energy corresponding to their mass appears in two photons of equal energy. Find the wavelength of the radiation emitted. [Take : mass of electron = $(0.5/c^2)$MeV and hc = 1.2 10^{-12} MeV-m, where h is the Planck's constant and c is the velocity of light in air.

19. The binding energies per nucleon for deuteron ($_1H^2$) and helium ($_2He^4$) are 1.1 MeV and 7.0 MeV respectively. Find the energy released when two deuterons fuse to form a helium nucleus ($_2He^4$).

20. If three times of λ_{min} of continuous X–ray spectrum of target metal at 40 kV is same as the wavelength of K_α line of this metal at 30 kV, then determine the atomic number of the target metal .

21. Decay constant of two radioactive samples is λ and 3λ respectively. At t = 0, they have equal number of active nuclei. Calculate when will be the ratio of active nuclei becomes e : 1.

22. The half lives of radioactive elements X and Y are 3 minute and 27 minute respectively. If the activities of both are same, then calculate the ratio of number of atoms of X and Y.

23. 36% amount of a radioactive sample disintegrates in t time. Calculate how much percentage fraction will decay in t/2 time.

24. By using the following atomic masses : $^{238}_{92}U$ = 238.05079u, $^{4}_{2}He$ = 4.00260u, $^{234}_{90}Th$ = 234.04363u, $^{1}_{1}H$ = 1.007834, $^{237}_{91}Pa$ = 237.065121u (i) Calculate the energy released during the α–decay of $^{238}_{92}U$.

(ii) Show that $^{238}_{92}U$ cannot spontaneously emit a proton.

25. A radioactive sample decays with an average – life of 20ms. A capacitor of capacitance 100μF is charged to a potential V and then a resistance R is connected across the capacitor. What should be value of R so that the ratio of charge on the capacitor to the activity of the radioactive sample remains constant in time.

CONCEPTUAL SUBJECTIVE EXERCISE — **ANSWER KEY** — EXERCISE–4(A)

1. (i) 0.6 volt, (ii) 2.0 mA

2. 15/8 V

3. (i) 5000 Å, 2000 Å, (ii) 2 : 5 (ii) Metal–1

4. 2eV, 6.53 10^{-34} J-s

5. 1.81 eV

6. (i) Number of electrons ejected from the surface will decrease and no effect on kinetic energy of electron.
(ii) No effect on number of electrons but kinetic energy will change.
(iii) Kinetic energy will decrease and no effect on number of photo electrons.

7. $\frac{5}{16}, \frac{10^{20}}{80\pi}$

8. $\frac{-h}{eEt^2}$

9. (i) 150.8eV (ii) 0.5 Å

10. (i) 3.4 eV (ii) 6.63 Å

11. (i) $\frac{he}{4\pi m}$ (ii) $\frac{ehB}{8\pi m}$

12. $\frac{\lambda}{3}$

13. 6,3

14. 7 : 36

15. 22.8 nm

16. (i) 1.1 10^{17} (ii) 1.2 10^{8} m/s

17. 5.86 keV

18. 2.48 10^{-12} m

19. 23.6 MeV

20. 37

21. $1/2\lambda$

22. 1/9

23. 20

24. (i) Q = 4.25 MeV
(ii) Q = (–0.022165) uC^2 (impossible)

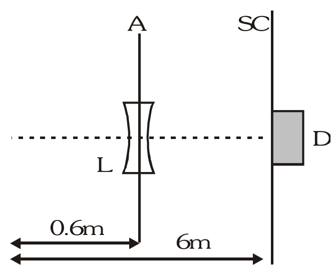
25. 200 Ω

EXERCISE–04 [B] BRAIN STORMING SUBJECTIVE EXERCISE

1 A monochromatic light of frequency f is incident on two identical metal spheres of threshold frequency $\frac{f}{2}$ and $\frac{f}{3}$ respectively. After some time, emission of photoelectron will stop on both spheres. Now both metal spheres are connected through wire. (Radius of spheres is R)

(i) What will be potential of spheres now? (ii) How many electron will flow through wire?

2. A monochromatic point source S radiating wavelength 6000 Å with power 2 watt, an aperture A of diameter 0.1 m & a large screen SC are placed as shown in figure. 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.



(i) Calculate the photon flux density at the centre of the screen and the photo current in the detector.

(ii) If a concave lens L of focal length 0.6 m is inserted in the aperture as shown, find the new values of photon flux density & photocurrent. Assume a uniform average transmission of 80% for the lens.

(iii) If the work–function of the photoemissive surface is 1 eV, calculate the values of the stopping potential in the two cases (without & with the lens in the aperture).

3. Monochromatic radiation of wavelength λ_1 = 3000 Å falls on a photocell operating in saturating mode. The corresponding spectral sensitivity of photocell is J = 4.8×10^{-3} A/W. When another monochromatic radiation of wavelength λ_2 = 1650 Å and power P = 5×10^{-3} W is incident, it is found that maximum velocity of photoelectrons increases n=2 times. Assuming efficiency of photoelectron generation per incident photon to be same for both the cases, calculate (i) threshold wavelength for the cell. (ii) saturation current in second case.

4. A beam of light has three wavelengths 4000 Å, 5000Å, 6000Å with a total intensity 3×10^{-3} W/m^2 equally distributed amongst the three wavelength. The beam falls normally on an area 2 cm^2 of clean metallic surface of work function 2.4 eV. Calculate photo current. (Assume each energetically suitable photon emits one electron)

5. Two identical non–relativistic particles move at right angles to each other, possessing De Broglie wavelengths, λ_1 & λ_2. Find the De Broglie wavelength of each particle in the frame of their centre of mass.

6. A single electron orbits a stationary nucleus of charge Ze where Z is a constant and e is the electronic charge. It requires 47.2 eV to excite the electron from the 2nd Bohr orbit to 3rd Bohr orbit. Find (i) the value of Z, (ii) energy required to excite the electron from the third to the fourth orbit. (iii) the wavelength of radiation required to remove the electron from the first orbit to infinity (iv) the kinetic energy, potential energy and angular momentum in the first Bohr orbit. (v) the radius of the first Bohr orbit.

7. A gas of identical hydrogen like atoms has some atoms in the lowest (ground) energy level A & some atoms in a particular upper (excited) energy level B & there are no atoms in any other energy level. The atoms of the gas make transition to a higher energy level by the 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. (i) Find the principal quantum number of the initially excited level B. (ii) Find the ionisation energy for the gas atoms. (iii) Find the maximum and the minimum energies of the emitted photons.

8. A classical model for the hydrogen atom consists of a single electron of mass m_e in circular motion of radius r around the nucleus (proton). Since the electron is accelerated, the atom continuously radiates electromagnetic waves. The total power P radiated by the atom is given by $P = P_0/r^4$ where $P_0 = \frac{e^6}{96\pi^3\varepsilon_0^3c^3m_e^2}$ (c = velocity of light) (i) Find the total energy of the atom. (ii) Calculate an expression for the radius r(t) as a function of time. Assume that at t=0, the radius is $r_0 = 10^{-10}$m. (iii) Hence or otherwise find the time t_0 when the atom collapses in a classical model of the hydrogen atom. Take: $\left[\frac{2}{\sqrt{3}}\frac{e^2}{4\pi\varepsilon_0}\frac{1}{m_ec^2} = r_e \approx 3\times10^{-15}\,m\right]$

9. An imaginary particle has charge equal to that of an electron and mass hundred times the mass of the electron. It moves in a circular orbit around a nucleus of charge +4e. Take the mass of nucleus to be very large. Applying Bohr's model. (i) Find radius of n^{th} Bohr's orbit. (ii) Energy of photon emitted when the particle makes a transition from fourth orbit to second orbit.

10. U^{238} and U^{235} occur in nature in an atomic ratio 140:1. Assuming that at the time of earth's formation the two isotopes were present in equal amounts. Calculate the age of the Earth. (Half life of U^{238} =4.5 10^9 yrs & that of U^{235} = 7.13 10^8 yrs)

11. A radioactive nuclide is produced at a constant rate x nuclei per second. During each decay, E_0 energy is released 50% of this energy is utilised in melting ice at 0^0C. Find mass of ice that will melt in one mean life. (λ= decay constant, L_f = Latent heat of fusion.)

12. In a fusion reactor the reaction occurs in two stages (i) Two deuterium $\left({}_1^2D\right)$ nuclei fuse to form a tritium $\left({}_1^3T\right)$ nucleus with a proton as product. The reaction may be represented as D (D,p)T. (ii) A tritium nucleus fuses with another deuterium nucleus to form a helium $\left({}_2^4He\right)$ nucleus with neutron as another product. The reaction is represented as T(D,n) α. Find: (i) the energy release in each stage. (ii) The energy release in the combined reaction per deuterium & (iii) What% of the mass of the initial deuterium is released in the form of energy. Given: $\left({}_1^2D\right)$= 2.014102 u; $\left({}_1^3T\right)$ = 3.016049 u; $\left({}_2^4He\right)$ = 4.002603 u; $\left({}_1^1P\right)$ = 1.00785 u; $\left({}_0^1n\right)$ = 1.008665u

13. The element curium ${}_{96}^{248}Cm$ has a mean life of 10^{13} second. Its primary 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 decay are as follows : ${}_{96}^{248}Cm$ =248.072220 u, ${}_{94}^{244}Pu$ =244.064100 u and ${}_2^4He$ = 4.002603 u. Calculate the total power produced. Assume a sample of 10^{20} Cm atom.

14. A small bottle contains powdered beryllium Be & gaseous radon which is used as a source of α–particles. Neutrons are produced when α–particles of the radon react with beryllium. The yield of this reaction is (1/4000) i.e. only one α–particle out of 4000 induced the reaction. Find the amount of radon (Rn^{222}) originally introduced into the source, if it produces 1.2 10^6 neutrons per second after 7.6 days. [$T_{1/2}$ of R_n = 3.8 days]

15. A body of mass m_0 is placed on a smooth horizontal surface. The mass of the body is decreasing exponentially with disintegration constant λ. Assuming that the mass is ejected backward with a relative velocity v_0. Initially the body was at rest. Find the velocity of body after time t.

16. A radionuclide with disintegration constant λ is produced in a reactor at a constant rate α nuclei per sec. During each decay energy E_0 is released. 20% of this energy is utilised in increasing the temperature of water. Find the increase in temperature of m mass of water in time t. Specific heat of water is S. Assume that there is no loss of energy through water surface.

BRAIN STORMING SUBJECTIVE EXERCISE **ANSWER KEY** EXERCISE–4(B)

1. (i) $V' = \frac{7hf}{12}$ (ii) $\Delta n = \frac{hfR}{12eK}$

2. (i) 1.1462 10^{14} Photons/m^2 –s, 2.063 10^{-10}A
(ii) 2.0574 10^{13} Photons/m^2–s, 1.4813 10^{-10} A (iii) 1.06 volt

3. (i) 4125 Å, (ii) 13.3 μA

4. 0.14 μÅ

5. $\lambda = \frac{2\lambda_1\lambda_2}{\sqrt{\lambda_1^2 + \lambda_2^2}}$

6. (i) 5 (ii) 16.5 eV (iii) 36.4 Å (iv) 340 eV, –680 eV, $\frac{h}{2\pi}$ (v) 1.06 10^{-11} m

7. (i) 4 (ii) 23.04 10^{-19} J
(iii) E_{max} = 13.5 eV, E_{min} = 0.7eV

8. (i) $-\frac{1}{8\pi\varepsilon_0}\frac{e^2}{r}$ (ii) $r_0\left(1 - \frac{3cr_e^2 t}{r_0^3}\right)^{1/3}$ (iii) $10^{-10} \times \frac{100}{81}$ sec

9. (i) $\frac{n^2h^2\varepsilon_0}{400\pi me^2}$ (ii) 408 eV

10. 6.04 10^9 yrs

11. $\frac{xE_0}{2\lambda eL_f}$

12. (a) 4 MeV, 17.6,
(b) 7.2 MeV
(c) 0.384%

13. 3.32 10^{-5} watt

14. 3.3 10^{-6} g

15. $v = v_0\lambda t$

16. $\Delta T = \frac{0.2E_0\left[\alpha t - \frac{\alpha}{\lambda}\left(1 - e^{-\lambda t}\right)\right]}{mS}$

EXERCISE–05(A) PREVIOUS YEARS QUESTIONS

ATOMIC STRUCTURE & X-RAY

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- [AIEEE - 2002]

(1) 10.2 eV (2) 0 eV (3) 3.4 eV (4) 6.8 eV

2. If the binding energy of the electron in a hydrogen atom is 13.6 eV, the energy required to remove the electron from the first excited state of Li^{2+} is- [AIEEE - 2003]

(1) 30.6 eV (2) 13.6 eV (3) 3.4 eV (4) 122.4 eV

3. Which of the following atoms has the lowest ionization potential ? [AIEEE - 2003]

(1) ${}^{14}_{7}N$ (2) ${}^{133}_{55}Cs$ (3) ${}^{40}_{18}Ar$ (4) ${}^{16}_{8}O$

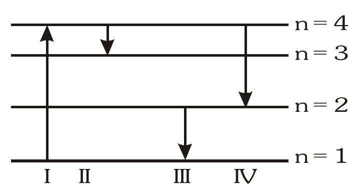
4. The wavelengths involved in the spectrum of deuterium $\left({}^{2}_{1}D\right)$ are slightly different from that of hydrogen spectrum, because- [AIEEE - 2003]

(1) sizes of the two nuclei are different
(2) nuclear forces are different in the two cases
(3) masses of the two nuclei are different
(4) attraction between the electron and the nucleus is different in the two cases

5. The manifestation of band structure in solids is due to- [AIEEE - 2004]

(1) Heisenberg's uncertainty principle (2) Pauli's exclusion principle
(3) Bohr's correspondence principle (4) Boltzmann's law

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



(1) III (2) IV (3) I (4) II

7. Which of the following transitions in hydrogen atoms emit photons of highest frequency ?[AIEEE - 2007]

(1) n = 2 to n = 6 (2) n = 6 to n = 2 (3) n = 2 to n = 1 (4) n = 1 to n = 2

8. Suppose an electron is attracted towards the origin by a force $\frac{k}{r}$ where 'k' is a cosntant and 'r' is the distance of the electron from the origin. By applying Bohr model to this sytem, 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? [AIEEE - 2008]

(1) $T_n \propto \frac{1}{n^2}, r_n \propto n^2$ (2) T_n independent of n, $r_n \propto n$ (3) $T_n \propto \frac{1}{n}, r_n \propto n$ (4) $T_n \propto \frac{1}{n}, r_n \propto n^2$

9. The transistion 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 :- [AIEEE - 2009]

(1) $4 \to 2$ (2) $5 \to 4$ (3) $2 \to 1$ (4) $3 \to 2$

10. Energy required for the electron excitation in Li^{++} from the first to the third Bohr orbit is:- [AIEEE-2011]

(1) 108.8 eV (2) 122.4 eV (3) 12.1 eV (4) 36.3 eV

11. 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 :- [AIEEE - 2012]

(1) 6 (2) 2 (3) 3 (4) 5

12. 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) [AIEEE - 2012]

(1) $\frac{(m_1+m_2)n^2h^2}{2m_1m_2r^2}$ (2) $\frac{(m_1+m_2)^2n^2h^2}{2m_1^2m_2^2r^2}$ (3) $\frac{n^2h^2}{2(m_1+m_2)r^2}$ (4) $\frac{2n^2h^2}{(m_1+m_2)r^2}$

13. In a hydrogen like atom electron makes 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 Mains 2013]

(1) $\frac{1}{n}$ (2) $\frac{1}{n^2}$ (3) $\frac{1}{n^{3/2}}$ (4) $\frac{1}{n^3}$

PHOTO ELECTRIC EFFECT & MATTER WAVES

14. Sodium and copper have work functions 2.3 eV and 4.5 eV respectively. Then the ratio of the wavelengths is nearest to- [AIEEE - 2002]

(1) 1 : 2 (2) 4 : 1 (3) 2 : 1 (4) 1 : 4

15. Formation of covalent bonds in compounds exhibits- [AIEEE - 2002]

(1) wave nature of electron (2) particle nature of electron
(3) both wave and particle nature of electron (4) none of the above

16. Two identical, photocathodes receive light of frequencies f_1 and f_2. If the velocities of the photoelectrons (of mass m) coming out are respectively v_1 and v_2, then- [AIEEE - 2003]

(1) $v_1^2 - v_2^2 = \frac{2h}{m}(f_1 - f_2)$ (2) $v_1 + v_2 = \left[\frac{2h}{m}(f_1+f_2)\right]^{1/2}$

(3) $v_1^2 + v_2^2 = \frac{2h}{m}(f_1 + f_2)$ (4) $v_1 + v_2 = \frac{2h}{m}\left[\frac{2h}{m}(f_1-f_2)\right]^{1/2}$

17. A radiation of energy E falls normally on a perfectly reflecting surface. The momentum transferred to the surface is- [AIEEE - 2004]

(1) E/c (2) 2E/c (3) Ec (4) E/c^2

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

(1) depends on the nature of the metal used
(2) depends on the intensity of the radiation
(3) depends both on the intensity of the radiation and the metal used
(4) is the same for all metals and independent of the intensity of the radiation

19. 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- **[AIEEE - 2004]**

(1) 540 nm (2) 400 nm (3) 310 nm (4) 220 nm

20. A photocell is illuminated by a small bright source placed 1 m away. When the same source of light is place $\frac{1}{2}$ m away, the number of electrons emitted by photocathode would- **[AIEEE - 2005]**

(1) decrease by a factor of 4 (2) increase by a factor of 4

(3) decrease by a factor of 2 (4) increase by a factor of 2

21. If the kinetic energy of a free electron doubles, its de-Broglie wavelength changes by the factor- **[AIEEE - 2005]**

(1) $\frac{1}{2}$ (2) 2 (3) $\frac{1}{\sqrt{2}}$ (4) $\sqrt{2}$

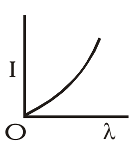
22. The threshold frequency for a metallic surface corresponds to an energy of 6.2 eV and the stopping potential for a radiation incident on this surface is 5V. The incident radiation lies in- **[AIEEE - 2006]**

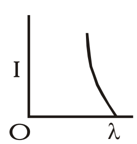
(1) ultra-violet region (2) infra-red region (3) visible region (4) X-ray region

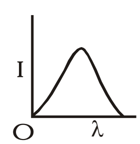
23. The time taken by a photoelectron to come out after the photon strikes is approximately-**[AIEEE - 2006]**

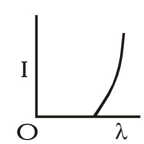
(1) 10^{-4} s (2) 10^{-10} s (3) 10^{-16} (4) 10^{-1} s

24. 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 : **[AIEEE - 2006]**

(1) 

(2) 

(3) 

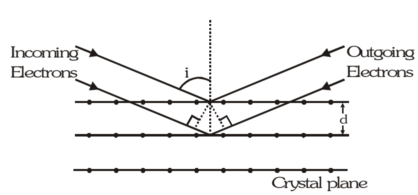
(4) 

25. Photon of frequency ν has a momentum associated with it. If c is the velocity of light, the momentum is-

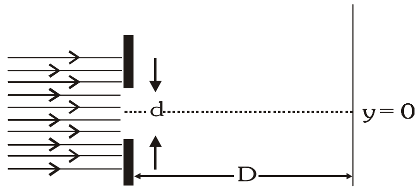
(1) ν/c (2) $h\nu c$ (3) $h\nu/c^2$ (4) $h\nu/c$ **[AIEEE - 2007]**

Directions :Questions are based on the following paragraph.

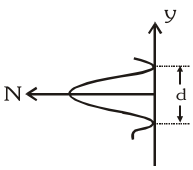
Wave property of electrons implies that they will show diffraction effects. Davission and Germer demonstrated this by diffracting electrons from crystals. The law governing the diffraction from a crystal is obtained by requiring that electron waves reflected from the planes of atoms in a crystal interfere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

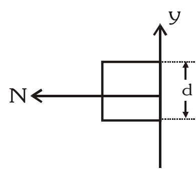


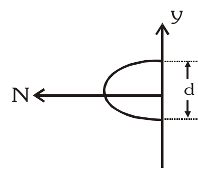
26. In an experiment, electrons are made to pass through a narrow slit of width 'd' comparable to their de-Broglie wavelength. They are detected on a screen at a distance 'D' from the slit (see figure).

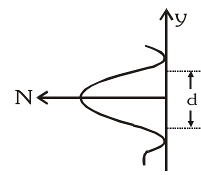


Which of the following graphs can be expected to represent the number of electrons 'N' detected as a function of the detector position 'y' (y = 0 corresponds to the middle of the slit) ? [AIEEE - 2008]

(1) 

(2) 

(3) 

(4) 

27. Electrons accelerated by potential V are diffracted from a crystal. If d = 1Å and i = 30 V should be about ($h = 6.6 \quad 10^{-34}$ Js, $m_e = 9.1 \quad 10^{-31}$ kg, $e = 1.6 \quad 10^{-19}$ C) : [AIEEE - 2008]

(1) 2000 V (2) 50 V (3) 500 V (4) 1000 V

28. 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 λ_{dB} of electrons can be calculated by the relationship (n is an integer): [AIEEE - 2008]

(1) $d \sin i = n \lambda_{dB}$ (2) $2d \cos i = n \lambda_{dB}$ (3) $2d \sin i = n \lambda_{dB}$ (4) $d \cos i = n \lambda_{dB}$

29. The surface of a metal is illuminated 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 : (hc = 1240 eV-nm) [AIEEE - 2009]

(1) 1.51 eV (2) 1.68 eV (3) 3.09 eV (4) 1.42 eV

Directions : Question contain Statement-1 and Statement-2. Of the four choices given after the statements, choose the one that best discribes the two statements.

30. **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. [AIEEE - 2010]

(1) Statement–1 is true, Statement–2 is false

(2) Statement–1 is true, Statement–2 is true; Statement–2 is the correct explanation of Statement–1

(3) Statement–1 is true, Statement–2 is true; Statement–2 is not the correct explanation of Statement–1

(4) Statement–1 is false, Statement–2 is true

31. If a source of power 4kW produces 10^{20} photons/second, the radiation belongs to apart of the spectrum called:- [AIEEE - 2010]

(1) γ-rays (2) X-rays (3) ultraviolet rays (4) microwaves

32. This question has Statememtn-1 and Statement-2. Of the four choices given after the statements, choose the one that best describes the two statements.

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 boubled.

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. [AIEEE-2011]

(1) Statement–1 is true, Statement–2 is true, Statement–2 is not the correct explanationof Statement–1

(2) Statement–1 is false, Statement–2 is true

(3) Statement–1 is true, Statement–2 is false

(3) Statement–1 is true, Statement–2 is true, Statement–2 is the correct explanation of Statement–1

33. **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.**

Statement-1: Davisson-Germer experiment established the wave nature of electrons.

Statement-2 : If electrons have wave nature, they can interfere and show diffraction. [AIEEE-2012]

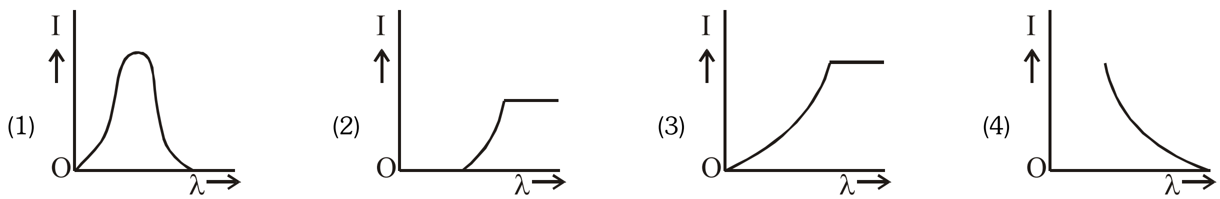
(1) Statement-1 is true, Statement-2 is true and Statement-2 is not the correct explanation of Statement-1.

(2) Statement-1 is false, Statement-2 is true

(3) Statement-1 is true, Statement-2 is false

(4) Statement-1 is true, Statement-2 is true and Statement-2 is the correct explanation of statement-1.

34. The anode voltage of 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 : [JEE Mains 2013]



RADIOACTIVITY, NUCLEAR PHYSICS

35. 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- [AIEEE - 2002]

(1) $\frac{N_0}{8}$ (2) $\frac{N_0}{16}$ (3) $\frac{N_0}{2}$ (4) $\frac{N_0}{4}$

36. At a specific instant emission of radioactive compound is deflected in a magnetic field. The compound can emit- [AIEEE - 2002]

(i) electrons (ii) protons (iii) He^{2+} (iv) neutrons

The emission at the instant can be-

(1) i, ii, iii (2) i, ii, iii, iv (3) iv (4) ii, iii

37. Which of the following radiations has the least wavelength ? [AIEEE - 2003]

(1) γ-rays (2) β-rays (3) α-rays (4) X-rays

38. When U^{238} nucleus originally at rest, decays by emitting an alpha particle having a speed u, the recoil speed of the residual nucleus is- [AIEEE - 2003]

(1) $\frac{4u}{238}$ (2) $-\frac{4u}{234}$ (3) $\frac{4u}{234}$ (4) $-\frac{4u}{238}$

39. A radioactive sample at any instant has its disintegration rate 5000 disintegration per minute. After 5 minutes, the rate is 1250 disintegrations per minute. Then, the decay constant (per minute) is- [AIEEE - 2003]

(1) 0.4 ln 2 (2) 0.2 ln 2 (3) 0.1 ln 2 (4) 0.8 ln 2

40. A nucleus with Z = 92 emits the following in a sequence : α, α, β^-, β^-, α, α, α, α, β^-, β^-, α, β^+, β^+, α. The Z of the resulting nucleus is- **[AIEEE - 2003]**

(1) 76 (2) 78 (3) 82 (4) 74

41. Which of the following cannot be emitted by radioactive substances during their decay ? **[AIEEE - 2003]**

(1) Protons (2) Neutrinos (3) Helium nuclei (4) Electrons

42. In the nuclear fusion reaction, ${}_1^2H + {}_1^3H \rightarrow {}_2^4He + n$ given that the repulsive potential energy between the two nuclei is 7.7 10^{-14} J, the temperature at which the gases must be heated to initiate the reaction is nearly [Boltzmann's constant k = 1.38 10^{-23} J/K]- **[AIEEE - 2003]**

(1) 10^7 K (2) 10^5 K (3) 10^3 K (4) 10^9 K

43. A nucleus disintegrates into two nuclear parts which have their velocities in the ratio 2 : 1 The ratio of their nuclear sizes will be- **[AIEEE - 2004]**

(1) $2^{1/3}$: 1 (2) 1 : $3^{1/2}$ (3) $3^{1/2}$: 1 (4) 1 : $2^{1/3}$

44. The binding energy per nucleon of deuteron $({}_1^2H)$ and helium nucleus $({}_2^4He)$ is 1.1 MeV and 7 MeV respectively. If two deuteron nuclei react to form a single helium nucleus, then the energy released is- **[AIEEE - 2004]**

(1) 13.9 MeV (2) 26.9 MeV (3) 23.6 MeV (4) 19.2 MeV

45. An α-particle of energy 5 MeV is scattered through 180 by a fixed uranium nucleus. The distance of the closest approach is of the order of- **[AIEEE - 2004]**

(1) 1 Å (2) 10^{-10} cm (3) 10^{-12} cm (4) 10^{-15} cm

46. The intensity of gamma radiation from a given source is I. On passing through 36 mm of lead, it is reduced to I/8. The thickness of lead, which will reduce the intensity to I/2 will be- **[AIEEE-2005]**

(1) 6 mm (2) 9 mm (3) 18 mm (4) 12 mm

47. Starting with a sample of pure ${}^{66}Cu$, 7/8 of it decays into Zn in 15 min. The corresponding half-life is- **[AIEEE - 2005]**

(1) 10 min (2) 15 min (3) 5 min (4) $7\frac{1}{2}$ min

48. If radius of the ${}_{13}^{27}Al$ nucleus is estimated to be 3.6 fermi, then the radius of ${}_{52}^{125}Te$ nucleus be nearly- **[AIEEE - 2005]**

(1) 6 fermi (2) 8 fermi (3) 4 fermi (4) 5 fermi

49. A nuclear transformation is denoted by X(n, α) $\rightarrow {}_3^7Li$. Which of the following is the nucleus of element X ? **[AIEEE - 2005]**

(1) ${}_6^{12}C$ (2) ${}_5^{10}B$ (3) ${}_5^9B$ (4) ${}_4^{11}Be$

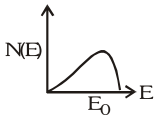
50. An alpha nucleus of energy $\frac{1}{2}mv^2$ bombards a heavy nuclear target of charge Ze. Then the distance of closest approach for the alpha nucleus will be proportional to- **[AIEEE - 2006]**

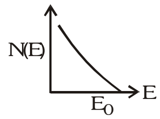
(1) v^2 (2) 1/m (3) $1/v^4$ (4) 1/Ze

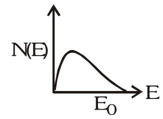
51. When ${}_3Li^7$ nuclei are bombarded by protons and the resultant nuclei are ${}_4Be^8$, the emitted particles will be **[AIEEE - 2006]**

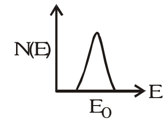
(1) alpha particles (2) beta particles (3) gamma photons (4) neutrons

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

(1) 

(2) 

(3) 

(4) 

53. If the binding energy per nucleon in ${}_3^7Li$ and ${}_2^4He$ nuclei are 5.60 MeV and 7.06 MeV respectively, then in the reaction : $p + {}_3^7Li \rightarrow 2\,{}_2^4He$ energy of proton must be- **[AIEEE - 2006]**

(1) 28.24 MeV (2) 17.28 MeV (3) 1.46 MeV (4) 39.2 MeV

54. If M_0 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- **[AIEEE - 2007]**

(1) $(M_o - 8M_p)c^2$ (2) $(M_o - 8Mp - 9M_n)c^2$ (3) M_oc^2 (4) $(M_o - 17M_n)c^2$

55. In gamma ray emission from a nucleus **[AIEEE-2007]**

(1) both the neutron number and the proton number change
(2) there is no change in the proton number and the neutron number
(3) only the neutron number changes
(4) only the proton number changes

56. The half-life period of a radioactive element X is same as the mean life time of another radioactive element Y. Initially they have the same number of atoms. Then- **[AIEEE - 2007]**

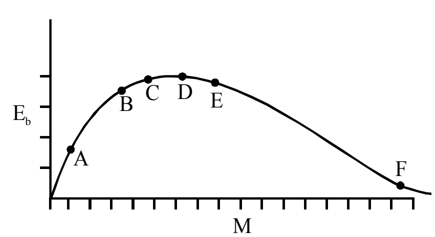
(1) X will decay faster than Y (2) Y will decay faster than X
(3) Y and X have same decay rate initially (4) X and Y decay at same rate always

57. This question contains Statement-1 and Statement-2. Out of the four choices given after the statements, choose the one that best describes the two statements.

Statement-1 : Energy is released when heavy nuclei undergo fission or light nuclei undergo fusion.
Statement-2 : For heavy nuclei, binding energy per nucleon increases with increasing Z while for light nuclei it decreases with increasing Z. **[AIEEE - 2008]**

(1) Statement-1 is false, Statement-2 is true.
(2) Statement-1 is true, Statement-2 is true; Statement-2 is a correct explanation for Statement-1.
(3) Statement-1 is true, Statement-2 is true; Statement-2 is not a correct explanation for Statement-1.
(4) Statement-1 is true, Statement-2 is false.

58. 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 : **[AIEEE - 2009]**



(i) $A + B \rightarrow C + \varepsilon$ (ii) $C \rightarrow A + B + \varepsilon$ (iii) $D + E \rightarrow F + \varepsilon$ (iv) $F \rightarrow D + E + \varepsilon$

where ε is the energy released ? In which reactions is ε positive ?

(1) (ii) and (iv) (2) (ii) and (iii) (3) (i) and (iv) (4) (i) and (iii)

Directions : Paragraph 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.

59. The speed of daughter nuclei is :- [AIEEE-2010]

(1) $c\sqrt{\frac{\Delta m}{M+\Delta m}}$ (2) $c\frac{\Delta m}{M+\Delta m}$ (3) $c\sqrt{\frac{2\Delta m}{M}}$ (4) $c\sqrt{\frac{\Delta m}{M}}$

60. The binding energy per nucleon for the parent nucleus is E_1 an that for the daughter nuclei is E_2. Then :- [AIEEE - 2010]

(1) $E_1 = 2E_2$ (2) $E_2 = 2E_1$ (3) $E_1 > E_2$ (4) $E_2 > E_1$

61. A radioactive nucleus (initial mass number A and atomic number Z) emits 3 α-particles and 2 positrons. The ratio of number of neutrons to that of protons in the final nucleus will be:- [AIEEE - 2010]

(1) $\frac{A-Z-4}{Z-2}$ (2) $\frac{A-Z-8}{Z-4}$ (3) $\frac{A-Z-4}{Z-8}$ (4) $\frac{A-Z-12}{Z-4}$

62. 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 has decayed and time t_1 when $\frac{1}{3}$ of it had decayed is :- [AIEEE - 2011]

(1) 20 min (2) 28 min (3) 7 min (4) 14 min

63. After absorbing a slowly moving neutron of mass m_N (momentum ~0) a nucleus of mass M breaks into two nuclei of masses m_1 and $5m_1(6m_1 = M + m_N)$, respectively. If the de Broglie wavelength of the nucleus with mass m_1 is λ, then de Broglie wavelength of the other nucleus will be:- [AIEEE - 2011]

(1) 25λ (2) 5λ (3) $\frac{\lambda}{5}$ (4) λ

64. **Statement-1**: A nucleus having energy E_1 decays be β^- emission to daughter nucleus having energy E_2, but the β^- rays are emitted with a continuous energy spectrum having end point energy $E_1 - E_2$.

Statement-2 : To conserve energy and momentum in β-decay at least three particles must take part in the transformation. [AIEEE - 2011]

(1) Statement-1 is incorrect, statement-2 is correct

(2) Statement-1 is correct, statement-2 is incorrect

(3) Statement-1 is correct, statement-2 correct; statement-2 is the correct explanation of statement-1

(4) Statement-1 is correct, statement-2 is correct; statement -2 is not the correct explanation of statement-1.

65. Assume that a neutron breaks into a proton and an electron. The energy released during this process is :

(Mass of neutron = $1.6747 \quad 10^{-27}$ kg [AIEEE - 2012]

Mass of proton = $1.6725 \quad 10^{-27}$ kg

Mass of electron = $9 \quad 10^{-31}$ kg)

(1) 5.4 MeV (2) 0.73 MeV (3) 7.10 MeV (4) 6.30 MeV

PREVIOUS YEARS QUESTIONS **ANSWER KEY** EXERCISE –5(A)

Que.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
Ans.	3	1	2	3	2	1	3	2	2	1	1	1	4	3	1	1	2	4	3	2
Que.	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40
Ans.	3	1	2	2	4	4	2	2	4	1	2	2	4	4	1	1	1	3	1	2
Que.	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60
Ans.	1	4	4	3	3	4	3	1	2	2	3	3	2	2	2	2	4	3	3	4
Que.	61	62	63	64	65															
Ans.	3	1	4	3	2															

EXERCISE–05(B) PREVIOUS YEARS QUESTIONS

MCQ'S WITH ONE CORRECT ANSWER

1. 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 : [IIT-JEE 1998]

(A) 0 to ∞
(B) λ_{min} to ∞ where $\lambda_{min} > 0$
(C) 0 to λ_{max} where $\lambda_{max} < \infty$
(D) λ_{min} to λ_{max} where $0 < \lambda_{min} < \lambda_{max} < \infty$

2. 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 : [IIT-JEE 1998]

(A) 540 nm
(B) 400 nm
(C) 310 nm
(D) 220 nm

3. The half–life of ^{131}I is 8 days. Given a sample of ^{131}I at time t = 0, we can assert that : [IIT-JEE 1998]

(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

4. In hydrogen spectrum the wavelength of H_α line is 656 nm ; whereas in the spectrum of a distant galaxy H_α line wavelength is 706 nm. Estimated speed of galaxy with respect to earth is : [IIT-JEE 1999]

(A) $2 \quad 10^8$ m/s
(B) $2 \quad 10^7$ m/s
(C) $2 \quad 10^6$ m/s
(D) $2 \quad 10^5$ m/s

5. ^{22}Ne nucleus, after absorbing energy, decay into two α–particles and an unknown nucleus. The unknown nucleus is [IIT-JEE 1999]

(A) nitrogen
(B) carbon
(C) boron
(D) oxygen

6. 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 λ_1/λ_2 is : [IIT-JEE 1999]

(A) m_1/m_2
(B) m_2/m_1
(C) 1
(D) $\sqrt{m_2}/\sqrt{m_1}$

7. Which of the following is a correct statement ? [IIT-JEE 1999]

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

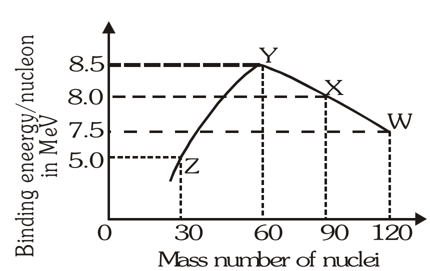
8. The half–life period of a radioactive element x is same as the mean life time of another radioactive element y. Initially both of them have the same number of atoms. Then : [IIT-JEE 1999]

(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 faster rate than y

9. Order of magnitude of density of uranium nucleus is ($m_p = 1.67 \quad 10^{-27}$ kg) : [IIT-JEE 1999]

(A) 10^{20} kg/m^3
(B) 10^{17} kg/m^3
(C) 10^{14} kg/m^3
(D) 10^{11} kg/m^3

10. Binding energy per nucleon versus mass number curve for nuclei is shown in figure. W, X, Y and Z are four nuclei indicated on the curve. The process that would release energy is : [IIT-JEE 1999]



(A) Y $\rightarrow$ 2Z
(B) W $\rightarrow$ X + Z
(C) W $\rightarrow$ 2Y
(D) X $\rightarrow$ Y + Z

11. Imagine an atom made up of 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 λ (given in terms of the Rydberg constant R for hydrogen atom) equal to : **[IIT-JEE 2000]**

(A) 9/5 R (B) 36/5R (C) 18/5R (D) 4/R

12. The electron in a hydrogen atom makes a transition from an excited state to the ground state. Which of the following statement is true? **[IIT-JEE 2000]**

(A) Its kinetic energy increases and its potential and total energy decreases

(B) Its kinetic energy decreases, potential energy increases and its total energy remains the same

(C) Its kinetic and total energy decreases and its potential energy increases

(D) Its kinetic, potential and total energy decrease

13. 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 : **[IIT-JEE 2000]**

(A) a continuous X–ray spectrum (Bremsstrahlung) with a minimum wavelength of ≈ 0.155 Å

(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.

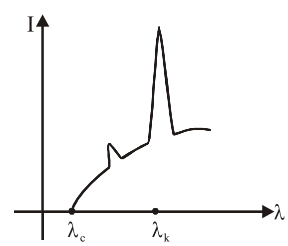
14. Two radioactive materials X_1 and X_2 have decay constant 10 λ and λ respectively. If initially they have the same number of nuclei, then the ratio of the number of nuclei of X_1 to that of X_2 will be 1/e after a time :

(A) $1/10\lambda$ (B) $1/11\lambda$ (C) $11/10\lambda$ (D) $1/9\lambda$ **[IIT-JEE 2000]**

15. The transition from the state n = 4 to n = 3 in a hydrogen like atom results in ultraviolet radiation. Infrared radiation will be obtained in the transition : **[IIT-JEE 2001]**

(A) $2 \rightarrow 1$ (B) $3 \rightarrow 2$ (C) $4 \rightarrow 2$ (D) $5 \rightarrow 4$

16. The intensity of X–rays from a Coolidge tube is plotted against wavelength λ as shown in the figure. The minimum wavelength found is λ_c and the wavelength of the K_α line is λ_k. As the accelerating voltage is increased: **[IIT-JEE 2001]**



(A) $\lambda_k - \lambda_c$ increases

(B) $\lambda_k - \lambda_c$ decreases

(C) λ_k increases

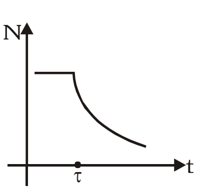
(D) λ_k decreases

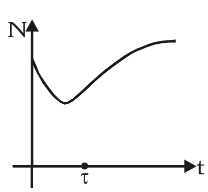
17. The electron emitted in beta radiation originates from : **[IIT-JEE 2001]**

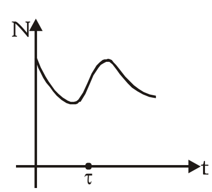
(A) inner orbits of atom (B) free electrons existing in nuclei

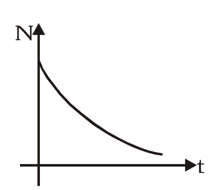
(C) decay of a neutron in a nucleus (D) photon escaping from the nucleus

18. A radioactive sample consists of two distinct species having equal number of atoms initially. The mean life of one species is τ and that of the other is 5τ. The decay products in both cases are stable. A plot is made of the total number of radioactive nuclei as a function of time. Which of the following figure best represent the form of this plot ? **[IIT-JEE 2001]**

(A)


(B)


(C)


(D)


19. A hydrogen atom and a Li^{2+} ion are both in the second excited state. If ℓ_H and ℓ_{Li} are their respective electronic angular momenta, and E_H and E_{Li} their respective energies, then : **[IIT-JEE 2002]**

(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 $|E_H| < |E_{Li}|$

20. The potential difference applied to an X–ray tube is 5 kV and the current through it is 3.2 mA. Then the number of electrons striking the target per second is : **[IIT-JEE 2002]**

(A) 2 10^{16} (B) 5 10^{6} (C) 1 10^{17} (D) 4 10^{15}

21. The half–life of ^{215}At is 100 μs. The time taken for the radioactivity of a sample of ^{215}At to decay to $1/16^{th}$ of its initial value is : **[IIT-JEE 2002]**

(A) 400μs (B) 63μs (C) 40μs (D) 300μs

22. Which of the following process represent a γ–decay ? **[IIT-JEE 2002]**

(A) $^{A}X_{Z} + \gamma \rightarrow {}^{A}X_{Z-1} + a + b$
(B) $^{A}X_{Z} + {}^{1}n_{0} \rightarrow {}^{A-3}X_{Z-2} + c$
(C) $^{A}X_{Z} \rightarrow {}^{A}X_{Z} + f$
(D) $^{A}X_{Z} + e_{-1} \rightarrow {}^{A}X_{A-1} + g$

23. The electric potential between a proton and an electron is given by $V = V_0 \,\ell n \frac{r}{r_0}$, 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 :– **[IIT-JEE 2003]**

(A) $r_n \propto n$ (B) $r_n \propto \frac{1}{n}$ (C) $r_n \propto n^2$ (D) $r_n \propto \frac{1}{n^2}$

24. 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.

(A) 100 (B) 200 (C) 4 (D) 1/4 **[IIT-JEE 2003]**

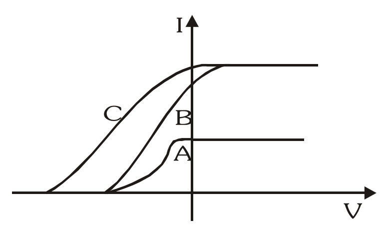
25. For uranium nucleus how does its mass vary with volume ? **[IIT-JEE 2003]**

(A) $m \propto V$ (B) $m \propto 1/V$ (C) $m \propto \sqrt{V}$ (D) $m \propto V^2$

26. A nucleus with mass number 220 initially at rest emits an α–particle. If the Q value of the reaction is 5.5 MeV, calculate the kinetic energy of the α–particle. **[IIT-JEE 2003]**

(A) 4.4 MeV (B) 5.4 MeV (C) 5.6 MeV (D) 6.5 MeV

27. The figure shows the variation of photocurrent with anode potential for a photosensitive surface for three different radiations. Let I_a, I_b and I_c be the intensities and f_a, f_b and f_c be the frequencies for the curves a, b and c respectively : **[IIT-JEE 2004]**



(A) $f_a = f_b$ and $I_a \neq I_b$
(B) $f_a = f_c$ and $I_a = I_c$
(C) $f_a = f_b$ and $I_a = I_b$
(D) $f_b = f_c$ and $I_b = I_c$

28. The energy of a photon is equal to the kinetic energy of a proton. The energy of the photon is E. Let λ_1 be the de–Broglie wavelength of the proton and λ_2 be the wavelength of the photon. The ratio λ_1/λ_2 is proportional to :– **[IIT-JEE 2004]**

(A) E (B) $E^{1/2}$ (C) E^{-1} (D) E^{-2}

29. After 280 days, the activity of a radioactive sample is 6000 dps. The activity reduces to 3000 dps after another 140 days. The initial activity of the sample in dps is : **[IIT-JEE 2004]**

(A) 6000 (B) 9000 (C) 3000 (D) 24000

30. 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? [IIT-JEE 2005]

(A) 2 photon of energy 10.2 eV

(B) 2 photon of energy of 1.4 eV

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

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

31. K_α wavelength emitted by an atom of atomic number Z = 11 is λ. Find the atomic number for an atom that emits K_α radiation with wavelength 4λ. [IIT-JEE 2005]

(A) Z = 6 (B) Z = 4 (C) Z = 11 (D) Z = 44

32. If a star can convert all the He nuclei completely into oxygen nuclei. The energy released per oxygen nuclei is : [Mass of the nucleus is 4.0026 amu and mass of oxygen nucleus is 15.9994] [IIT-JEE 2005]

(A) 7.6 MeV (B) 56.12 MeV (C) 10.24 MeV (D) 23.4 MeV

33. Half–life of a radioactive substance A is 4 days. The probability that a nucleus will decay in two half–lives is : [IIT-JEE 2006]

(A) 1/4 (B) 3/4 (C) 1/2 (D) 1

34. 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 : [IIT-JEE 2007]

(A) 802 nm (B) 823 nm (C) 1882 nm (D) 1648 nm

35. Electrons with de–Broglie wavelength λ fall on the target in an X–ray tube. The cut–off wavelength of the emitted X–rays is : [IIT-JEE 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) $\lambda_0 = \lambda$

36. In the options given below, let E denote the rest mass energy of a nucleus and n a neutron. The correct option is : [IIT-JEE 2007]

(A) $E({}^{236}_{92}U) > E({}^{137}_{53}I) + E({}^{97}_{39}Y) + 2E(n)$ (B) $E({}^{236}_{92}U) < E({}^{137}_{53}I) + E({}^{97}_{39}Y) + 2E(n)$

(C) $E({}^{236}_{92}U) < E({}^{140}_{56}Ba) + E({}^{94}_{36}Kr) + 2E(n)$ (D) $E({}^{236}_{92}U) < E({}^{140}_{56}Ba) + E({}^{94}_{36}Kr) + 2E(n)$

37. Which one of the following statements is wrong in the context of X–rays generated from a X–ray tube? [IIT-JEE 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

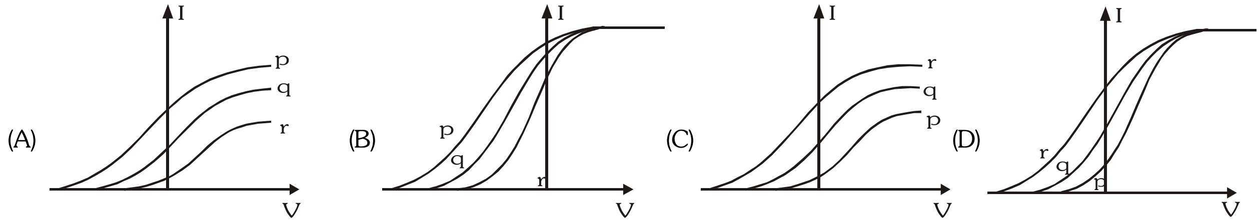
(D) Cut–off wavelength of the continuous X–rays depends on the energy of the electrons in the X–rays tube

38. A radioactive sample S1 having an activity of 5μCi has twice the number of nuclei as another sample S2 which has an activity of 10μCi. The half lives of S1 and S2 can be :– [IIT-JEE 2008]

(A) 20 years and 5 years, respectively (B) 20 years and 10 years, respectively

(C) 10 years each (D) 5 years each

39. Photoelectric effect experiments are performed using three different metal plates p, q and r having work functions ϕ_p = 2.0 eV, ϕ_q = 2.5 eV and ϕ_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] [IIT-JEE 2009]



40. 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 3×10^{8} ms^{-1}. The final momentum of the object is :- [JEE Advanced 2013]

(A) 0.3×10^{-17} kg ms^{-1} (B) 1.0×10^{-17} kg ms^{-1}
(C) 3.0×10^{-17} kg ms^{-1} (D) 9.0×10^{-17} kg ms^{-1}

MCQ's (one or more than one correct)

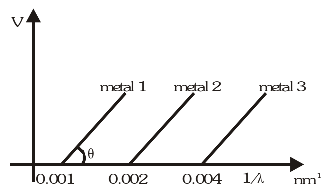
1. Let m_p be the mass of proton, m_n the mass of neutron. M_1 the mass of ${}^{20}_{10}Ne$ nucleus and M_2 the mass of ${}^{40}_{20}Ca$ nucleus. Then : [IIT-JEE 1998]

(A) $M_2 = 2M_1$ (B) $M_2 > 2M_1$ (C) $M_2 < 2M_1$ (D) $M_1 < 10(m_n + m_p)$

2. 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 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 : [IIT-JEE 1998]

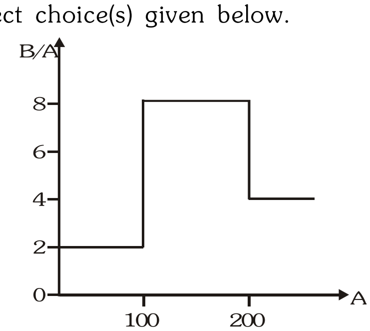
(A) $n_1=4$, $n_2=2$ (B) $n_1=8$, $n_2=2$ (C) $n_1=8$, $n_2=1$ (D) $n_1=6$, $n_2=3$

3. The graph between $1/\lambda$ and stopping potential (V) of three metals having work function ϕ_1, ϕ_2 and ϕ_3 in an experiment of photoelectric effect is plotted as shown in the figure. Which of the following statement (s) is / are correct? [Here λ is the wavelength of the incident ray]: [IIT-JEE 2006]



(A) Ratio of work functions $\phi_1 : \phi_2 : \phi_3 = 1 : 2 : 4$
(B) Ratio of work functions $\phi_1 : \phi_2 : \phi_3 = 4 : 2 : 1$
(C) $\tan\theta$ is directly proportional to hc/e, where h is Planck's constant and c is the speed of light
(D) The violet colour light can eject photoelectrons from metals 2 and 3.

4. 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. [IIT-JEE 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

5. 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 Advanced 2013]

(A) $\frac{9}{32R}$ (B) $\frac{9}{16R}$ (C) $\frac{9}{5R}$ (D) $\frac{4}{3R}$

Match the column

1. Some laws / processes are given in Column–I. Match these with the physical phenomena given in Column II. [IIT-JEE 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

2. 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 appropriate process(es) from Column II. [IIT-JEE 2009]

	Column-I		Column-II
(A)	The energy of the system is increased	(p)	System: A capacitor, initially uncharged 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 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 Process :The gas gets cooled due to colder atmo sphere surrounding it
(D)	Mass of the system is decrease	(s)	System: A heavy nucleus, initially at rest Process :The nucleus fissions into two fragments of nearly equal masses and some neutrons are emitted
		(t)	System : A resistive wire loop Process :The loop is placed in a time varying magnetic field perpendicular to its plane

Matching List

1. 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 Advanced 2013]

	List I		List II
P.	Alpha decay	1.	${}^{15}_{8}O \rightarrow {}^{15}_{7}N + ...$
Q.	β^+ decay	2.	${}^{238}_{92}U \rightarrow {}^{234}_{90}Th + ...$
R.	Fission	3.	${}^{185}_{83}Bi \rightarrow {}^{184}_{82}Pb + ...$
S.	Proton emission	4.	${}^{239}_{94}Pu \rightarrow {}^{140}_{57}La + ...$

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

COMPREHENSION BASED QUESTIONS

Comprehension # 1

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 Bohr model of atom is exactly valid. **[IIT-JEE 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) $6.5 \quad 10^{-7}$ m (B) $5.6 \quad 10^{-7}$ m (C) $4.8 \quad 10^{-7}$ m (D) $4.0 \quad 10^{-7}$ m

3. The ratio of the kinetic energy of the n = 2 electron for the H atoms to that of He^{+} ion is :–

(A) 1/4 (B) 1/2 (C) 1 (D) 2

Comprehension # 2

Scientists are working hard to develop nuclear fusion reactor. Nuclei of heavy hydrogen $^{2}_{1}H$, known as deuteron and denoted by D, can be thought of as a candidate for fusion reactor, The D-D reaction is $^{2}_{1}H + ^{2}_{1}H \rightarrow ^{3}_{2}H + n + \text{energy}$. In the core of fusion reactor, a gas of heavy hydrogen is fully ionized into deuteron nuclei and electrons. This collection of $^{2}_{1}H$ 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, temperatures in the reaction core are two 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 from 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 $5 \quad 10^{14}$ s/cm^3.It may be helpful to use the following :

Boltzmann constant k = $8.6 \quad 10^{-5}$ eV/K; $\dfrac{e^2}{4\pi\varepsilon_0} = 1.44 \times 10^{-9}$ eVm **[IIT-JEE 2009]**

1. 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

2. Assume that two deuteron nuclei in the core of fusion rector 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 $4 \quad 10^{-15}$ m is in the range

(A) $1.0 \quad 10^{9}$ K < T < $2.0 \quad 10^{9}$ K (B) $2.0 \quad 10^{9}$ K < T < $3.0 \quad 10^{9}$ K

(C) $3.0 \quad 10^{9}$ K < T < $4.0 \quad 10^{9}$ K (D) $4.0 \quad 10^{9}$ K < T < $5.0 \quad 10^{9}$ K

3. Results of calculations for four different designs of a fusion reactor using D-D reaction are given below. Which of these is promising based on Lawson criterion ?

(A) deuteron density = 2.0 10^{12} cm^{-3}, confinement time = 5.0 10^{-3} s

(B) deuteron density = 8.0 10^{14} cm^{-3}, confinement time = 9.0 10^{-1} s

(C) deuteron density = 4.0 10^{23} cm^{-3}, confinement time = 1.0 10^{11} s

(D) deuteron density = 1.0 10^{24} cm^{-3} , confinement time = 4.0 10^{12} s

Comprehension # 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 Breoglie relation. The energy of the particle of mass m is related to its linear momentum as $E = \frac{p^2}{2m}$. 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 10^{-34} J s and e = 1.6 10^{-19} C. **[IIT-JEE 2009]**

1. The allowed energy for the particle for a particular value of n is proportional to

(A) a^{-2} (B) $a^{-3/2}$ (C) a^{-1} (D) a^{2}

2. If the mass of the particle is m = 1.0 10^{-30} kg and a = 6.6 nm, the energy of the particle in its ground state is closest to

(A) 0.8 meV (B) 8 meV (C) 80 meV (D) 800 meV

3. The speed of the particle, that can take discrete values, is proportional to

(A) $n^{-3/2}$ (B) n^{-1} (C) $n^{1/2}$ (D) n

Comprehension # 4

[IIT-JEE 2010]

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.

1. A diatomic molecule has moment of inertia I. By Bohr's quantization condition its rotational energy in the n^{th} level (n =0 is not allowed) is

(A) $\frac{1}{n^2}\left(\frac{h^2}{8\pi^2 I}\right)$ (B) $\frac{1}{n}\left(\frac{h^2}{8\pi^2 I}\right)$ (C) $n\left(\frac{h^2}{8\pi^2 I}\right)$ (D) $n^2\left(\frac{h^2}{8\pi^2 I}\right)$

2. It is found that the excitation frequency from ground to the first excited state of rotation for the CO molecule is close to $\frac{4}{\pi} \times 10^{11}$ Hz. Then the moment of inertia of CO molecule about its center of mass is close to

[Take h = 2π × 10^{-34} Js)

(A) 2.76 × 10^{-46} kg m^2 (B) 1.87 × 10^{-46} kg m^2 (C) 4.67 × 10^{-47} kg m^2 (D) 1.17 × 10^{-47} kg m^2

3. 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) 2.4×10^{-10}m (B) 1.9×10^{-10}m (C) 1.3×10^{-10}m (D) 4.4×10^{-11}m

Comprehension # 5

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 :-

[JEE Advanced 2013]

$^{1}_{1}H$	1.007825 u	$^{2}_{1}H$	2.014102 u	$^{3}_{1}H$	3.016050 u	$^{4}_{2}He$	4.002603 u
$^{6}_{3}Li$	6.015123 u	$^{7}_{3}Li$	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)

1. 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

2. The correct statement is :-

(A) The nucleus $^{6}_{3}Li$ 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

Assertion– Reason This question contains, Statement I (assertion) and Statement II (reason).

1. **Statement–I** : If the accelerating potential in an X–ray tube is increased, the wavelengths of the characteristic X–rays do not change. [IIT-JEE 2007]

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

Subjective Questions

1. 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. [IIT-JEE 1998]

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

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

2. Photoelectrons are emitted when 400 nm radiation is incident on a surface of work function 1.9 eV. These photoelectrons pass through a region containing α–particle. A maximum energy electron combines with 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. [Taken $h = 4.14 \quad 10^{-15}$ eV–s] **[IIT-JEE 1999]**

3. A hydrogen like atom of atomic number Z is in an excited state of quantum number 2n. It can emit a max. 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) of 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. **[IIT-JEE 2000]**

4. When a beam of 10.6 eV photons of intensity 2.0 W/m^2 falls on a platinum surface of area $1.0 \quad 10^{-4}$ m^2 and work function 5.6 eV then 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 1 eV = $1.6 \quad 10^{-19}$J. **[IIT-JEE 2000]**

5. 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 $N_0 = 10^{20}$. Set–up the rate equations for the populations of X, Y and Z. The population of Y nucleus as a function of time is given by $N_y(t) = \{N_0 \lambda_x / (\lambda_x - \lambda_y)\} [\exp(-\lambda_y t) - \exp(-\lambda_x t)]$. Find the time at which N_Y is maximum and determine the populations X and Z at the instant. **[IIT-JEE 2001]**

6. A nucleus at rest undergoes a decay emitting an α–particle of de–Broglie wavelength, $\lambda = 5.76 \quad 10^{-15}$ m. If the mass of the daughter nucleus is 223.610 amu and that of the α–particle 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)

[IIT-JEE 2001]

7. In a nuclear reactor ^{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 yr, find the total mass of uranium required. **[IIT-JEE 2001]**

8. 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). (i) Find the atomic number of the atom. (ii) Calculate the smallest wavelength emitted in these transitions. (Take hc = 1240 eV–nm, ground state energy of hydrogen atom = –13.6 eV) **[IIT-JEE 2002]**

9. Two metallic plates A and B each of area $5 \quad 10^{-4}$ m^2, are placed parallel to each other at separation of 1 cm. Plate B carries a positive charge of $33.7 \quad 10^{-12}$ C. A monochromatic beam of light, with photons of energy 5 eV each, starts falling on place A at t = 0 so that 10^{16} photons fall on it per square meter per second. Assume that the photoelectron is emitted for every 10^{16} 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 2 eV. (Take $\varepsilon_0 = 8.85 \quad 10^{-12}$C^2 / N – m^2) **[IIT-JEE 2002]**

Determine :

(i) The number of photoelectrons emitted up to t = 10 s,

(ii) The magnitude of the electric field between the plates A and B at t = 10 s and

(iii) The kinetic energy of the most energetic photoelectrons emitted at t = 10s when it reaches plate B.

Neglect the time taken by the photoelectron to reach plate B.

10. Characteristic X–ray of frequency $4.2 \quad 10^{18}$ Hz are produced when transitions from L–shell to K–shell take place in a certain target material. Use Mosley's law to determine the atomic number of the target material. Given Rydberg constant $R = 1.1 \quad 10^7$ m^{-1}. **[IIT-JEE 2003]**

11. In a photoelectric experiment set–up, photons of energy 5 eV falls on the cathode having work function 3 eV. (i) If the saturation current is i_A = 4 μA for intensity 10^{-5} W/m^2, then plot a graph between anode potential and current. (ii) Also draw a graph for intensity of incident radiation 2 10^{-5} W/m^2. **[IIT-JEE 2003]**

12. A radioactive element decays by β–emission. A detector records n beta particles in 2 s and in next 2 s it records 0.75 n beta particles. Find mean life correct to nearest whole number. Given $\ell n|2| = 0.6931$, $\ell n|3| = 1.0986$. **[IIT-JEE 2003]**

13. Wavelengths belonging to Balmer series lying in the range of 450 nm to 750 nm were used to eject photoelectrons from a metal surface whose work function is 2.0 eV. Find (in eV) the maximum kinetic energy of the emitted photoelectrons.(Take $\frac{hc}{e}$ = 1242 eV nm) **[IIT-JEE 2004]**

14. A rock is 1.5 10^9 yr old. The rock contains ^{238}U which disintegrates to form ^{206}Pb. Assume that there was no ^{206}Pb in the rock initially and it is the only stable product formed by the decay. Calculate the ratio of number of nuclei of ^{238}U to that of ^{206}Pb in the rock. Half–life of ^{238}U is 4.5 10^9 yr. ($2^{1/3}$ = 1.259) **[IIT-JEE 2004]**

15. X–rays are incident on a target metal atom having 30 neutrons. The ratio of atomic radius of the target atom and ${}^4_2$He is $(14)^{1/3}$. **[IIT-JEE 2005]**

(i) Find the atomic number of target atom.

(ii) Find the frequency of K_α line emitted by this metal. R = 1.1 10^7 m^{-1}, c = 3 10^8 m/s

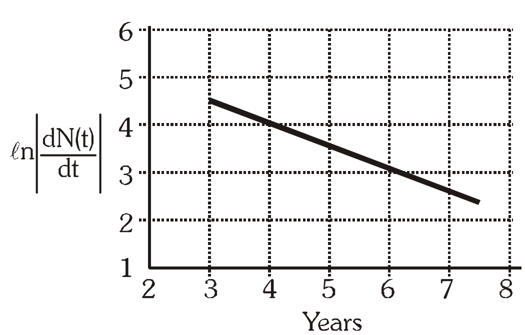
16. The potential energy of a particle varies as $U(x) = E_0$ for $0 \le x \le 1$ and $U(x) = 0$ for $x > 1$

For $0 \le x \le 1$. de–Broglie wavelengths is λ_1 and for x > 1 the de–Broglie wavelength is λ_2.

Total energy of the particle is $2E_0$. Find $\frac{\lambda_1}{\lambda_2}$. **[IIT-JEE 2005]**

17. An α–particle and a proton are accelerated from rest by a potential difference of 100 V. After this, their de Broglie wavelengths are λ_α and λ_p respectively. The ratio $\frac{\lambda_p}{\lambda_\alpha}$, to the nearest integer, is **[IIT-JEE 2010]**

18. To determine the half life of a radioactive element, a student plots a graph of $\ell n\left|\frac{dN(t)}{dt}\right|$ versus t. Here $\frac{dN(t)}{dt}$ 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 **[IIT-JEE 2010]**



19. The work functions of Silver and sodium are 4.6 and 2.3 eV, repetitively. The ratio of the slope of the stopping potential versus frequency plot for Silver to that of Sodium is. **[JEE Advanced 2013]**

20. A freshly prepared sample of a radioisotope of half-life 1386 s has activity 10^3 distintegrations per second. Given that $\ell n\ 2 = 0.693$, 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 Advanced 2013]**

PREVIOUS YEARS QUESTIONS **ANSWER KEY** EXERCISE –5(B)

- <u>MCQ's (Single)</u>

1.	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
B	C	D	B	B	C	A	C	B	C	C	A	D	D	D	A	C	D	B	A
21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40
A	C	A	D	A	B	A	B	D	C	A	C	B	B	A	A	B	A	A	B

- <u>MCQ's (Multiple)</u> **1.** C,D **2.** A,D **3.** A,C **4.** B,D **5.** AC

- <u>Match the column</u> **1.** (A) p,r (B) p,q,s (C) p (D) q **2.** (A) p,q,t (B) q (C) s (D) s
- Matching List Type **1.** C

- <u>Comprehension Based Questions</u>

Comprehension#1	1. C	2. C	3. A
Comprehension#2	1. D	2. A	3. B,C,D
Comprehension#3	1. A	2. B	3. D
Comprehension#4	1. D	2. B	3. C
Comprehension#5	1. A	2. C	

- <u>Assertion–Reason</u> **1.** B
- <u>Subjective Questions</u>

1. (i) $\frac{1}{\lambda}[\alpha - (\alpha - \lambda N_0)e^{-\lambda t}]$ (ii) (A) $\frac{3}{2}N_0$ (B) $2N_0$ **2.** During combination 3.4 eV. After combination 3.84 eV, 2.64 eV

3. n = 2, Z = 4, –217.6 eV, 10.58 eV **4.** 6.25 10^{11}, zero, 5.0 eV

5. (i) $\frac{dN_X}{dt} = -\lambda_X N_X$, $\frac{dN_Y}{dt} = \lambda_X N_X - \lambda_Y N_Y$, $\frac{dN_Z}{dt} = \lambda_Y N_Y$ (ii) 16.48 s (iii) $N_X = 1.92\ \ 10^{19}$, $N_Z = 2.32\ \ 10^{19}$

6. 6.25 MeV, 227.62 amu **7.** 3.847 10^4 kg

8. (i) Z = 3 (ii) 4052.3 nm **9.** (i) 5 10^7 (ii) 2 10^3 N/C (iii) 23 eV

10. Z = 42 **12.** 6.947 s

13. 0.55 eV **14.** 3.861

15. (i) 26 (ii) 1.55 10^{18} Hz **16.** $\sqrt{2}$

17. 3 **18.** 8

19. 1 **20.** 4