MODERN PHYSICS

1. At a given instant, say t = 0, two radioactive substances A and B have equal activities. The ratio $\frac{R_B}{R_A}$ of their activities after time t itself decays with time t as e^{-3t}. If the half-life of A is $\ell n2$, the half-life of B is :

(1) $\frac{ln2}{2}$ (2) $2ln2$ (3) $\frac{ln2}{4}$ (4) $4ln2$

2. The magnetic field associated with a light wave is given, at the origin, by

$B = B_0 [\sin(3.14 \times 10^7)ct + \sin(6.28 \times 10^7)ct]$.

If this light falls on a silver plate having a work function of 4.7 eV, what will be the maximum kinetic energy of the photo electrons ?

($c = 3 \times 10^8 ms^{-1}$, $h = 6.6 \times 10^{-34}$ J-s)

(1) 7.72 eV (2) 8.52 eV

(3) 12.5 eV (4) 6.82 eV

3. A sample of radioactive material A, that has an activity of 10 mCi(1 Ci = 3.7×10^{10} decays/s), has twice the number of nuclei as another sample of a different radioactive maternal B which has an activity of 20 mCi. The correct choices for hall-lives of A and B would then be respectively :

(1) 20 days and 5 days

(2) 20 days and 10 days

(3) 5 days and 10 days

(4) 10 days and 40 days

4. Surface of certain metal is first illuminated with light of wavelength λ_1 =350 nm and then, by light of wavelength λ_2=540 nm. It is found that the maximum speed of the photo electrons in the two cases differ by a factor of 2. The work function of the metal (in eV) is close to:

(Energjr of photon = $\frac{1240}{\lambda(\text{in nm})}$eV)

(1) 1.8 (2) 1.4 (3) 2.5 (4) 5.6

5. Condiser the nuclear fission

$Ne^{20} \rightarrow 2He^4 + C^{12}$

Given that the binding energy/nucleon of Ne^{20}, He^4 and C^{12} are, respectively, 8.03 MeV, 7.07 MeV and 7.86 MeV, identify the correct statement :

(1) 8.3 MeV energy will be released

(2) energy of 12.4 MeV will be supplied

(3) energy of 11.9 MeV has to be supplied

(4) energy of 3.6 MeV will be released

6. A metal plate of area 1×10^{-4} m^2 is illuminated by a radiation of intensity 16 mW/m^2.The work function of the metal is 5eV. The energy of the incident photons is 10 eV and only 10% of it produces photo electrons. The number of emitted photo electrons per second and their maximum energy, respectively, will be : [1 eV = 1.6×10^{-19}J]

(1) 10^{10} and 5 eV (2) 10^{14} and 10 eV

(3) 10^{12} and 5 eV (4) 10^{11} and 5 eV

7. Using a nuclear counter the count rate of emitted particles from a radioactive source is measured. At t = 0 it was 1600 counts per second and t = 8 seconds it was 100 counts per second. The count rate observed, as counts per second, at t = 6 seconds is close to :

(1) 150 (2) 360 (3) 200 (4) 400

8. In an electron microscope, the resolution that can be achieved is of the order of the wavelength of electrons used. To resolve a width of 7.5×10^{-12}m, the minimum electron energy required is close to :

(1) 100 keV (2) 500 keV

(3) 25 keV (4) 1 keV

9. In a hydrogen like atom, when an electron jumps from the M - shell to the L - shell, the wavelength of emitted radiation is λ. If an electron jumps from N-shell to the L-shell, the wavelength of emitted radiation will be :-

(1) $\frac{27}{20}\lambda$ (2) $\frac{16}{25}\lambda$ (3) $\frac{20}{27}\lambda$ (4) $\frac{25}{16}\lambda$

10. In a photoelectric experiment, the wavelength of the light incident on a metal is changed from 300 nm to 400 nm. The decrease in the stopping potential is close to :

$\left(\frac{hc}{e} = 1240\,\text{nm} - \text{V}\right)$

(1) 0.5 V (2) 1.0 V

(3) 2.0 V (4) 1.5 V

11. A hydrogen atom, initially in the ground state is excited by absorbing a photon of wavelength 980Å. The radius of the atom in the excited state, it terms of Bohr radius a_0, will be :

(h_c = 12500 eV – Å)

(1) $9a_0$ (2) $25a_0$

(3) $4a_0$ (4) $16a_0$

12. If the deBronglie wavelenght of an electron is equal to 10^{-3} times the wavelength of a photon of frequency 6×10^{14} Hz, then the speed of electron is equal to :

(Speed of light = 3×10^8 m/s

Planck's constant = 6.63×10^{-34} J.s

Mass of electron = 9.1×10^{-31} kg)

(1) 1.45×10^6 m/s (2) 1.7×10^6 m/s

(3) 1.8×10^6 m/s (4) 1.1×10^6 m/s

13. When a certain photosensistive surface is illuminated with monochromatic light of frequency ν, the stopping potential for the photo current is $-V_0/2$. When the surface is illuminated by monochromatic light of frequency ν/2, the stopping potential is $-V_0$. The threshold frequency for photoelectric emission is:

(1) $\frac{3\nu}{2}$ (2) 2ν (3) $\frac{4}{3}\nu$ (4) $\frac{5\nu}{3}$

14. In a radioactive decay chain, the initial nucleus is ${}^{232}_{90}\text{Th}$. At the end there are 6 α-particles and 4 β-particles which are emitted. If the end nucleus, If ${}^{A}_{Z}X$, A and Z are given by :

(1) A = 208; Z = 80 (2) A = 202; Z = 80

(3) A = 200; Z = 81 (4) A = 208; Z = 82

15. An alpha-particle of mass m suffers 1-dimensional elastic coolision with a nucleus at rest of unknown mass. It is scattered directly backwards losing, 64% of its initial kinetic energy. The mass of the nucleus is :-

(1) 4 m (2) 3.5 m (3) 2 m (4) 1.5 m

16. In a Frank-Hertz experiment, an electron of energy 5.6 eV passes through mercury vapour and emerges with an energy 0.7 eV. The minimum wavelength of photons emitted by mercury atoms is close to :-

(1) 2020 nm (2) 220 nm

(3) 250 nm (4) 1700 nm

17. A particle of mass m moves in a circular orbit in a central potential field $U(r) = \frac{1}{2}kr^2$. If Bohr's quantization conditions are applied, radii of possible orbitals and energy levels vary with quantum number n as:

(1) $r_n \propto n^2$, $E_n \propto \frac{1}{n^2}$ (2) $r_n \propto \sqrt{n}, E_n \propto \frac{1}{n}$

(3) $r_n \propto n$, $E_n \propto n$ (4) $r_n \propto \sqrt{n}$, $E_n \propto n$

18. A particle A of mass 'm' and charge 'q' is accelerated by a potential difference of 50 V. Another particle B of mass '4 m' and charge 'q' is accelerated by a potential difference of 2500 V. The ratio of de-Broglie wavelengths $\frac{\lambda_A}{\lambda_B}$ is close to :

(1) 10.00 (2) 14.14

(3) 4.47 (4) 0.07

19. The ratio of mass densities of nuclei of ^{40}Ca and ^{16}O is close to :-

(1) 1 (2) 2

(3) 0.1 (4) 5

20. A damped harmonic oscillator has a frequency of 5 oscillations per second. The amplitude drops to half its value for every 10 oscillations. The time it will take to drop to $\frac{1}{1000}$ of the original amplitude is close to :-

(1) 100 s (2) 20 s (3) 10 s (4) 50 s

21. A nucleus A, with a finite de-broglie wavelength λ_A, undergoes spontaneous fission into two nuclei B and C of equal mass. B flies in the same direction as that of A, while C flies in the opposite direction with a velocity equal to half of that of B. The de-Broglie wavelengths λ_B and λ_C of B and C are respectively :-

(1) $2\lambda_A, \lambda_A$ (2) $\lambda_A, 2\lambda_A$

(3) $\lambda_A, \frac{\lambda_A}{2}$ (4) $\frac{\lambda_A}{2}, \lambda_A$

22. Radiation coming from transitions n = 2 to n = 1 of hydrogen atoms fall on He$^+$ ions in n = 1 and n = 2 states. The possible transition of helium ions as they absorb energy from the radiation is :

(1) $n = 1 \rightarrow n = 4$

(2) $n = 2 \rightarrow n = 4$

(3) $n = 2 \rightarrow n = 5$

(4) $n = 2 \rightarrow n = 3$

23. Two particles move at right angle to each other. Their de-Broglie wavelengths are λ_1 and λ_2 respectively. The particles suffer perfectly inelastic collision. The de-Broglie wavelength λ, of the final particle, is given by :

(1) $\lambda = \frac{\lambda_1 + \lambda_2}{2}$ (2) $\frac{2}{\lambda} = \frac{1}{\lambda_1} + \frac{1}{\lambda_2}$

(3) $\lambda = \sqrt{\lambda_1 \lambda_2}$ (4) $\frac{1}{\lambda^2} = \frac{1}{\lambda_1^2} + \frac{1}{\lambda_2^2}$

24. A particle 'P' is formed due to a completely inelastic collision of particles 'x' and 'y' having de-Broglie wavelengths 'λ_x' and 'λ_y' respectively. If x and y were moving in opposite directions, then the de-Broglie wavelength of 'P' is :-

(1) $\lambda_x + \lambda_y$ (2) $\frac{\lambda_x \lambda_y}{\lambda_x + \lambda_y}$

(3) $\frac{\lambda_x \lambda_y}{|\lambda_x - \lambda_y|}$ (4) $\lambda_x - \lambda_y$

25. 50 W/m^2 energy density of sunlight is normally incident on the surface of a solar panel. Some part of incident energy (25%) is reflected from the surface and the rest is absorbed. The force exerted on 1m^2 surface area will be close to ($c = 3 \times 10^8$ m/s) :-

(1) 15×10^{-8} N (2) 35×10^{-8} N

(3) 10×10^{-8} N (4) 20×10^{-8} N

26. A He$^+$ ion is in its first excited state. Its ionization energy is :-

(1) 6.04 eV (2) 13.60 eV

(3) 54.40 eV (4) 48.36 eV

27. The electric field of light wave is given as $\vec{E} = 10^{-3} \cos\left(\frac{2\pi x}{5 \times 10^{-7}} - 2\pi \times 6 \times 10^{14} t\right) \hat{x} \frac{N}{C}$. This light falls on a metal plate of work function 2eV. The stopping potential of the photo-electrons is :

Given, E (in eV) = $\frac{12375}{\lambda(\text{in Å})}$

(1) 0.48 V (2) 2.0 V

(3) 2.48 V (4) 0.72 V

28. Taking the wavelength of first Balmer line in hydrogen spectrum (n = 3 to n = 2) as 660 nm, the wavelength of the 2nd Balmer line (n = 4 to n = 2) will be :

(1) 889.2 nm (2) 642.7 nm

(3) 488.9 nm (4) 388.9 nm

29. Light is incident normally on a completely absorbing surface with an energy flux of 25 Wcm^{-2}. if the surface has an area of 25 cm^{-2}, the momentum transferred to the surface in 40 min time duration will be :

(1) 5.0×10^{-3} Ns (2) 3.5×10^{-6} Ns

(3) 1.4×10^{-6} Ns (4) 6.3×10^{-4} Ns

30. A 2 mW laser operates at a wavelength of 500 nm. The number of photons that will be emitted per second is :

[Given Planck's constant $h = 6.6 \times 10^{-34}$ Js, speed of light $c = 3.0 \times 10^{8}$ m/s]

(1) 2×10^{16} (2) 1.5×10^{16}

(3) 5×10^{15} (4) 1×10^{16}

31. In Li^{++}, electron in first Bohr orbit is excited to a level by a radiation of wavelength λ. when the ion gets deexcited to the ground state in all possible ways (including intermediate emissions), a total of six spectral lines are observed. What is the value of λ ?

(Given : $h = 6.63 \times 10^{-34}$ Js; $c = 3 \times 10^{8}$ ms^{-1})

(1) 9.4 nm (2) 12.3 nm

(3) 10.8 nm (4) 11.4 nm

32. Two radioactive substances A and B have decay constants 5λ and λ respectively. At t = 0, a sample has the same number of the two nuclei. The time taken for the ratio of the number of nuclei to become $\left(\frac{1}{e}\right)^2$ will be :

(1) 1 / 4λ (2) 1 / λ

(3) 1 / 2λ (4) 2 / λ

33. A proton, an electron, and a Helium nucleus, have the same energy. They are in circular orbits in a plane due to magnetic field perpendicualr to the plane. Let r_p, r_e and r_{He} be their respective radii, then,

(1) $r_e > r_p > r_{He}$ (2) $r_e < r_p < r_{He}$

(3) $r_e < r_p = r_{He}$ (4) $r_e > r_p = r_{He}$

34. In a photoelectric effect experiment the threshold wavelength of the light is 380 nm. If the wavelentgh of incident light is 260 nm, the maximum kinetic energy of emitted electrons will be: Given E (in eV) = $\frac{1237}{\lambda(\text{in nm})}$

(1) 1.5 eV (2) 4.5 eV

(3) 15.1 eV (4) 3.0 eV

35. Two radioactive materials A and B have decay constants 10λ and λ, respectively. It initially they have the same number of nuclei, then the ratio of the number of nuclei of A to that of B will be 1/e after a time :

(1) $\frac{11}{10\lambda}$ (2) $\frac{1}{9\lambda}$ (3) $\frac{1}{10\lambda}$ (4) $\frac{1}{11\lambda}$

36. The electron in a hydrogen atom first jumps from the third excited state to the second excited state and subsequently to the first excited state. The ratio of the respective wavelengths, λ_1/λ_2, of the photons emitted in this process is :

(1) 9/7 (2) 7/5

(3) 27/5 (4) 20/7

37. Consider an electron in a hydrogen atom, revolving in its second excited state (having radius 4.65Å). The de-Broglie wavelength of this electron is :

(1) 12.9 Å (2) 3.5 Å

(3) 9.7 Å (4) 6.6 Å

38. Half lives of two radioactive nuclei A and B are 10 minutes and 20 minutes, respectively. If, initially a sample has equal number of nuclei, then after 60 minutes, the ratio of decayed numbers of nuclei A and B will be :

(1) 9 : 8 (2) 1 : 8

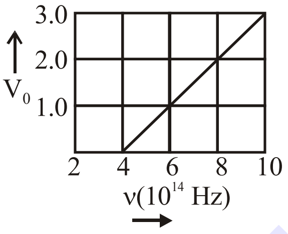
(3) 8 : 1 (4) 3 : 8

39. The stopping potential V_0 (in volt) as a function of frequency (ν) for a sodium emitter, is shown in the figure. The work function of sodium, from the data plotted in the figure, will be :

(Given : Planck's constant

(h) = 6.63×10^{-34} Js, electron

charge e = 1.6×10^{-19} C)



(1) 1.95 eV (2) 1.82 eV

(3) 1.66 eV (4) 2.12 eV

40. An excited He^+ ion emits two photons in succession, with wavelengths 108.5 nm and 30.4 nm, in making a transition to ground state. The quantum number n, corresponding to its initial excited state is (for photon of wavelength λ, energy $E = \frac{1240 eV}{\lambda(\text{in nm})}$) :

(1) n = 5 (2) n = 4

(3) n = 6 (4) n = 7

SOLUTION

1. Ans. (3)

Half life of A = $\ell n2$

$t_{1/2} = \frac{\ell n2}{\lambda}$

$\lambda_A = 1$

at t = 0 $R_A = R_B$

$N_A e^{-\lambda AT} = N_B e^{-\lambda BT}$

$N_A = N_B$ at t = 0

at t = t $\frac{R_B}{R_A} = \frac{N_0 e^{-\lambda_B t}}{N_0 e^{-\lambda_A t}}$

$e^{-(\lambda_B - \lambda_A)t} = e^{-t}$

$\lambda_B - \lambda_A = 3$

$\lambda_B = 3 + \lambda_A = 4$

$t_{1/2} = \frac{\ell n2}{\lambda_B} = \frac{\ell n2}{4}$

2. Ans. (1)

$B = B_0 \sin(\pi \times 10^7 C)t + B_0 \sin(2\pi \times 10^7 C)t$

since there are two EM waves with different frequency, to get maximum kinetic energy we take the photon with higher frequency

$B_1 = B_0 \sin(\pi \times 10^7 C)t$ $\nu_1 = \frac{10^7}{2} \times C$

$B_2 = B_0 \sin(2\pi \times 10^7 C)t$

$\nu_2 = 10^7 C$

where C is speed of light $C = 3 \times 10^8$ m/s

$\nu_2 > \nu_1$

so KE of photoelectron will be maximum for photon of higher energy.

$\nu_2 = 10^7 C$ Hz

$h\nu = \phi + KE_{max}$

energy of photon

$E_{ph} = h\nu = 6.6 \times 10^{-34} \times 10^7 \times 3 \times 10^9$

$E_{ph} = 6.6 \times 3 \times 10^{-19}$J

$= \frac{6.6 \times 3 \times 10^{-19}}{1.6 \times 10^{-19}} eV = 12.375 eV$

$KE_{max} = E_{ph} - \phi$

$= 12.375 - 4.7 = 7.675$ eV ≈ 7.7 eV

3. Ans. (1)

Activity A = λN

For A $10 = (2N_0)\lambda_A$

For B $20 = N_0 \lambda_B$

$\therefore \lambda_B = 4\lambda_A \Rightarrow (T_{1/2})_A = 4(T_{1/2})_B$

4. Ans. (1)

$\frac{hc}{\lambda_1} = \phi + \frac{1}{2}m(2v)^2$

$\frac{hc}{\lambda_2} = \phi + \frac{1}{2}mv^2$

$\Rightarrow \frac{\frac{hc}{\lambda_1} - \phi}{\frac{hc}{\lambda_2} - \phi} = 4 \Rightarrow \frac{hc}{\lambda_1} - \phi = \frac{4hc}{\lambda_2} - 4\phi$

$\Rightarrow \frac{4hc}{\lambda_2} - \frac{hc}{\lambda_1} = 3\phi$

$\Rightarrow \phi = \frac{1}{3}hc\left(\frac{4}{\lambda_2} - \frac{1}{\lambda_1}\right)$

$= \frac{1}{3} \times 1240\left(\frac{4 \times 350 - 540}{350 \times 540}\right)$

= 1.8 eV

5. Ans. (3)

$Ne^{20} \rightarrow 2He^4 + C^{12}$

8.03×20 $2 \times 7.07 \times 4 + 7.86 \times 12$

$\because$ value = $(BE)_{product} - (BE)_{react} = -9.72$ MeV

So 9.72 MeV will have to be supplied.

No answer matching but closest answer is option (3).

6. Ans. (4)

$I = \frac{nE}{At}$

$16 \times 10^{-3} = \left(\frac{n}{t}\right)_{Photon} \frac{10 \times 1.6 \times 10^{-19}}{10^{-4}} = 10^{12}$

7. Ans. (3)

at t = 0, $A_0 = \frac{dN}{dt} = 1600 C/s$

at t = 8s, A = 100 C/s

$\frac{A}{A_0} = \frac{1}{16}$ in 8 sec

Therefor half life is $t_{1/2} = 2$ sec

$\therefore$ Activity at t = 6 will be $1600\left(\frac{1}{2}\right)^3$

= 200 C/s

$\therefore$ correct answer is (3)

8. Ans. (3)

$\lambda = \frac{h}{p}$ $\{\lambda = 7.5 \times 10^{-12}\}$

$P = \frac{h}{\lambda}$

$$KE = \frac{P^2}{2m} = \frac{(h/\lambda)^2}{2m} = \frac{\left\{\frac{6.6\times10^{-34}}{7.5\times10^{-12}}\right\}}{2\times9.1\times10^{-31}} J$$

KE = 25 Kev

9. Ans. (3)

For M → L steel

$$\frac{1}{\lambda} = K\left(\frac{1}{2^2} - \frac{1}{3^2}\right) = \frac{K\times5}{36}$$

for N → L

$$\frac{1}{\lambda'} = K\left(\frac{1}{2^2} - \frac{1}{4^2}\right) = \frac{K\times3}{16}$$

$$\lambda' = \frac{20}{27}\lambda$$

10. Ans. (2)

$\frac{hc}{\lambda_1} = \phi + eV_1$ .... (i)

$\frac{hc}{\lambda_2} = \phi + eV_2$ .... (ii)

(i) – (ii)

$$hc\left(\frac{1}{\lambda_1} - \frac{1}{\lambda_2}\right) = e(V_1 - V_2)$$

$$\Rightarrow V_1 - V_2 = \frac{hc}{e}\left(\frac{\lambda_2 - \lambda_1}{\lambda_1 - \lambda_2}\right)$$

$$= (1240nm - V)\frac{100nm}{300nm \times 400nm}$$

= 1V

11. Ans. (4)

Energy of photon = $\frac{12500}{980} = 12.75eV$

∴ Electron will excite to n= 4

Since 'R' ∝ n^2

∴ Radius of atom will be $16a_0$

12. Ans. (1)

$$\frac{h}{mv} = 10^{-3}\left(\frac{3\times10^8}{6\times10^{14}}\right)$$

$$v = \frac{6.63\times10^{-34}\times6\times10^{14}}{9.1\times10^{-31}\times3\times10^5}$$

$v = 1.45 \times 10^6$ m/s

13. Ans. (Bonus)

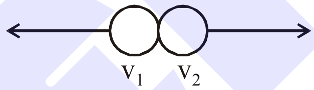
According to JEE-Mains Ans. key (1)

14. Ans. (4)

$${}^{232}_{90}Th \longrightarrow {}^{208}_{78}Y + {}^{4}_{2}He$$

$${}^{208}_{78}Y \longrightarrow {}^{208}_{82}X + 4\beta \text{ praticle}$$

15. Ans. (1)



$mv_0 = mv_2 - mv_1$

$\frac{1}{2}mV_1^2 = 0.36\times\frac{1}{2}mV_0^2$

$v_1 = 0.6v_0$

$\frac{1}{2}MV_2^2 = 0.64\times\frac{1}{2}mV_0^2$

$V_2 = \sqrt{\frac{m}{M}}\times0.8V_0$

$mV_0 = \sqrt{mM}\times0.8V_0 - m\times0.6V_0$

$\Rightarrow 1.6m = 0.8\sqrt{mM}$

$4m^2 = mM$

16. Ans. (3)

$$\lambda = \frac{1240}{5.6-0.7} nm$$

17. Ans. (4)

$$F = \frac{dV}{dr} = kr = \frac{mv^2}{r}$$

$$mvr = \frac{nh}{2\pi}$$

$r^2 \propto n$

$r^2 \propto \sqrt{n}$

$$E = \frac{1}{2}kr^2 + \frac{1}{2}mv^2 \propto r^2$$

$\propto n$

18. Ans. (2)

K.E. acquired by charge = K = qV

$$\lambda = \frac{h}{p} = \frac{h}{\sqrt{2mK}} = \frac{h}{\sqrt{2mqV}}$$

$$\therefore \frac{\lambda_A}{\lambda_B} = \frac{\sqrt{2m_Bq_BV_B}}{\sqrt{2m_Aq_AV_A}} = \sqrt{\frac{4m.q.2500}{m.q.50}} = 2\sqrt{50}$$

= 2 × 7.07 = 14.14

19. Ans. (1)

Sol. mass densities of all nuclei are same so their ratio is 1.

20. Ans. (2)

Sol. $A = A_0e^{-\gamma t}$

$A = \frac{A_0}{2}$ after 10 oscillations

$\because$ After 2 seconds

$$\frac{A_0}{2} = A_0e^{-\gamma(2)}$$

$2 = e^{2\gamma}$

$\ell n2 = 2\gamma$

$$\gamma = \frac{\ell n2}{2}$$

$\because A = A_0e^{-\gamma t}$

$$\ell n\frac{A_0}{A} = \gamma t$$

$$\ell n1000 = \frac{\ell n2}{2}t$$

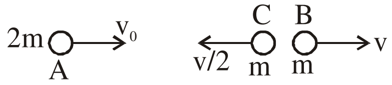
$$2\left(\frac{3\ell n10}{\ell n2}\right) = t$$

$$\frac{6\ell n10}{\ell n2} = t$$

t = 19.931 sec

t ≈ 20 sec

21. Ans. (4)

Sol. 

let mass of B and C is m each.

By momentum conservation

$$2mv_0 = mv - \frac{mv}{2}$$

$v = 4v_0$

$p_A = 2mv_0$ $p_B = 4mv_0$ $p_c = 2mv_0$

De-Broglie wavelength $\lambda = \frac{h}{p}$

$$\lambda_A = \frac{h}{2mv_0} ; \lambda_B = \frac{h}{4mv_0} ; \lambda_C = \frac{h}{2mv_0}$$

22. Ans. (2)

Sol. Energy released for transition n = 2 to n = 1 of hydrogen atom

$$E = 13.6Z^2\left(\frac{1}{n_1^2} - \frac{1}{n_2^2}\right)$$

$Z = 1, n_1 = 1, n_2 = 2$

$$E = 13.6 \times 1 \times \left(\frac{1}{1^2} - \frac{1}{2^2}\right)$$

$$E = 13.6 \times \frac{3}{4}eV$$

For He^+ ion z = 2

(1) n = 1 to n = 4

$$E = 13.6 \times 2^2 \times \left(\frac{1}{1^2} - \frac{1}{4^2}\right) = 13.6 \times \frac{15}{4}eV$$

(2) n = 2 to n = 4

$$E = 13.6 \times 2^2 \times \left(\frac{1}{2^2} - \frac{1}{4^2}\right) = 13.6 \times \frac{3}{4}eV$$

(3) n = 2 to n = 5

$$E = 13.6 \times 2^2 \times \left(\frac{1}{2^2} - \frac{1}{5^2}\right) = 13.6 \times \frac{21}{25}eV$$

(4) n = 2 to n = 3

$$E = 13.6 \times 2^2 \times \left(\frac{1}{2^2} - \frac{1}{3^2}\right) = 13.6 \times \frac{5}{9}eV$$

Energy required for transition of He^+ for n = 2 to n = 4 matches exactly with energy released in transition of H for n = 2 to n = 1.

23. **Ans. (4)**

Sol.  $\frac{h}{\lambda_1} = P_1$  $P_2 = \frac{h}{\lambda_2}$

$$\vec{P}_1 = \frac{h}{\lambda_1}\hat{i}$$

$$\& \ \vec{P}_2 = \frac{h}{\lambda_2}\hat{j}$$

Using momentum conservation

$$\vec{P} = \vec{P}_1 + \vec{P}_2$$

$$= \frac{h}{\lambda_1}\hat{i} + \frac{h}{\lambda_2}\hat{j}$$

$$|\vec{P}| = \sqrt{\left(\frac{h}{\lambda_1}\right)^2 + \left(\frac{h}{\lambda_2}\right)^2}$$

$$\frac{h}{\lambda} = \sqrt{\left(\frac{h}{\lambda_1}\right)^2 + \left(\frac{h}{\lambda_2}\right)^2}$$

$$\frac{1}{\lambda^2} = \frac{1}{\lambda_1^2} + \frac{1}{\lambda_2^2}$$

24. **Ans. (3)**

Sol. ⓧ⟶ ⟵ⓨ = Ⓟ⟶

By momentum conservation

$P_x - P_y = P_P$

$$\frac{h}{\lambda_x} - \frac{h}{\lambda_y} = \frac{h}{\lambda_p}$$

$$\lambda_p = \frac{\lambda_x \lambda_y}{|\lambda_y - \lambda_x|}.$$

25. **Ans. (4)**

Sol. Force on the surface (25% reflecting and rest absorbing)

$$F = \frac{25}{100}\left(\frac{2I}{C}\right) + \frac{75}{100}\left(\frac{I}{C}\right) = \frac{125}{100}\left(\frac{I}{C}\right)$$

$$= \frac{125}{100} \times \left(\frac{50}{3\times10^8}\right) = 20.83 \times 10^{-8}\ \text{N}.$$

26. **Ans. (2)**

Sol. Energy levels in Hydrogen like atom is given by

$$E = -13.6\ \frac{z^2}{n^2}\ \text{eV}$$

As He$^+$ is 1st excited state

$\therefore\ z = 2,\ n = 2$

$E = -13.6$ eV

As total energy of He$^+$ in 1st excited state is -13.6 eV, ionisation energy should be $+13.6$eV.

27. **Ans. (1)**

Sol. $\omega = 6 \times 10^{14} \times 2\pi$

$f = 6 \times 10^{14}$

$C = f\lambda$

$$\lambda = \frac{C}{f} = \frac{3\times10^8}{6\times10^{14}} = 5000\text{Å}$$

energy of photon $\Rightarrow \frac{12375}{5000}$

$= 2.475$ eV

from Einstein's equation

$KE_{max} = E - \phi$

$eV_s = E - \phi$

$eV_s = 2.475 - 2$

$eV_s = 0.475 - 2$

$eV_s = 0.475$ eV

$V_s = 0.475$ V $= 0.48$ volt

Option (1)

28. **Ans. (3)**

Sol. $\frac{1}{660} = R\left(\frac{1}{2^2} - \frac{1}{3^2}\right) = \frac{5R}{36}$ ....(1)

$\frac{1}{\lambda} = R\left(\frac{1}{2^2} - \frac{1}{4^2}\right) = \frac{3R}{16}$ ....(2)

divide equation (1) with (2)

$$\frac{\lambda}{660} = \frac{5\times16}{36\times3}$$

$$\lambda = \frac{4400}{9} = 488.88 = 488.9\ \text{nm}$$

Option (3)

29. Ans. (1)

Sol. Pressure = $\frac{I}{C}$

Force = Pressure × Area = $\frac{I}{C}$. Area

Momentum transferred = Force . Δt

$$= \frac{I}{C}\text{. Area .}\Delta t$$

$$= \frac{25\times10^{4}}{3\times10^{8}}\times25\times10^{-4}\times40\times60$$

$$= 5\times10^{-3}\text{ N-s}$$

30. Ans. (3)

Sol. $P = \frac{n.\,hc}{\lambda}$

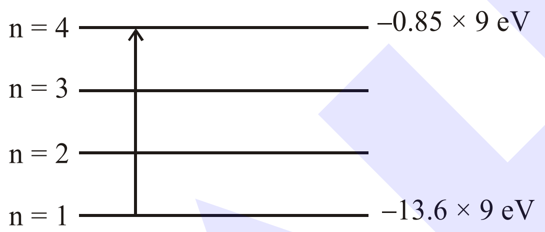
$$n = \frac{P\lambda}{h.c}$$

$$= \frac{2\times10^{-3}\times500\times10^{-9}}{6.6\times10^{-34}\times3\times10^{8}}$$

$$= 1.5\times10^{16}$$

31. Ans. (3)

Sol.



$$\Delta E = \frac{hc}{\lambda}$$

$$13.6\times9-0.85\times9 = \frac{hc}{\lambda}$$

$$\lambda = \frac{hc}{9\times(13.6-0.85)\text{eV}}$$

$$= \frac{1240\text{eV.nm}}{9\times12.75\text{eV}}$$

$$\lambda = 10.8\text{ nm}$$

32. Ans. (3)

Sol. $N_A = N_0\,e^{-5\lambda t}$

$N_B = N_0\,e^{-\lambda t}$

$$\frac{N_A}{N_B} = \frac{e^{-5\lambda t}}{e^{-\lambda t}} = \frac{1}{e^{2}}$$

$$\Rightarrow e^{-4\lambda t} = e^{-2}$$

$$\Rightarrow 4\lambda t = 2$$

$$\Rightarrow t = \frac{1}{2\lambda}$$

33. Ans. (3)

Sol. $r = \frac{mv}{qB} = \frac{\sqrt{2mK}}{qB}$

$r_{He} = r_p > r_e$

34. Ans. (1)

Sol. $K_{max} = \frac{hc}{\lambda}-\frac{hc}{\lambda_0}$

$$\Rightarrow K_{max} = hc\left(\frac{\lambda_0-\lambda}{\lambda\lambda_0}\right)$$

$$\Rightarrow K_{max} = (1237)\left(\frac{380-260}{380\times260}\right)$$

$$= 1.5\text{ eV}$$

35. Ans. (2)

Sol. $N_1 = N_0 e^{-10\lambda t}$

$N_2 = N_0 e^{-\lambda t}$

$$\frac{1}{e} = \frac{N_1}{N_2} = e^{-9\lambda t}$$

$$\Rightarrow 9\lambda t = 1$$

$$t = \frac{1}{9\lambda}$$

36. Ans. (4)

Sol. $\frac{1}{\lambda}=R\left(\frac{1}{n_f^2}-\frac{1}{n_i^2}\right)$

$\frac{1}{\lambda_1}=R\left(\frac{1}{3^2}-\frac{1}{4^2}\right)$

$\frac{1}{\lambda_1}=R\left(\frac{7}{9\times16}\right)$

$\frac{1}{\lambda_2}=R\left(\frac{1}{2^2}-\frac{1}{3^2}\right)$

$=R\left(\frac{5}{4\times9}\right)$

$\frac{\lambda_1}{\lambda_2}=\frac{\frac{5}{36}}{\frac{7}{9\times16}}$

$=\frac{20}{7}$

37. Ans. (3)

Sol. $2\pi r_n = n\lambda_n$

$\lambda_3=\frac{2\pi(4.65\times10^{-10})}{3}$

$\lambda_3 = 9.7$ Å

38. Ans. (1)

Sol. $N_A=N_{OA}e^{-\lambda t}=\frac{N_{OA}}{2^{t/t_{1/2}}}=\frac{N_{OA}}{2^6}$

$\therefore$ Number of nuclei decayed

$=N_{OA}-\frac{N_{OA}}{2^6}=\frac{63N_{OA}}{64}$

$N_B=N_{OB}e^{-\lambda t}=\frac{N_{OB}}{2^{t/t_{1/2}}}=\frac{N_{OB}}{2^3}$

$\therefore$ Number of nuclei decayed

$=N_{OB}-\frac{N_{OB}}{2^3}=\frac{7N_{OB}}{8}$

Since $N_{OA}=N_{OB}$

$\therefore$ Ratio of decayed numbers of nuclei

A & B $=\frac{63N_{OA}\times8}{64\times7N_{OB}}=\frac{9}{8}$

39. Ans. (3)

Sol. $h\nu=\phi+ev_0$

$v_0=\frac{h\nu}{e}-\frac{\phi}{e}$

v_0 is zero for $\nu = 4\times10^{14}$ Hz

$0=\frac{h\nu}{e}-\frac{\phi}{e}\Rightarrow\phi=h\nu$

$=\frac{6.63\times10^{-34}\times4\times10^{14}}{1.6\times10^{-19}}$ = 1.66 ev.

40. Ans. (1)

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

$\frac{1}{1085}=R\left(\frac{1}{m^2}-\frac{1}{n^2}\right)2^2$

$\frac{1}{304}=R\left(\frac{1}{1^2}-\frac{1}{m^2}\right)2^2$

$\therefore$ m = 2

$\therefore$ n = 5