Objective Problems (Level 2)

1. A ray of light of wavelength 5030 Å is incident on a totally reflecting surface. The momentum delivered by the ray is equal to
   (a) 6.63×10^{-27} kg-m/s
   (b) 2.63×10^{-27} kg-m/s
   (c) 1.25×10^{-24} kg-m/s
   (d) None of the above

2. What is the binding eneergy per nucleon of ${}_6C^{12}$ nucleus?
   Given : Mass of C^{12} $(m_c) = 12.000$ u
   Mass of proton $(m_p) = 1.0078$ u
   Mass of neutron $(m_n) = 1.0087$ u
   and $1 \text{ amu} = 931.4 \dfrac{\text{MeV}}{c^2}$
   (a) 5.26 MeV (b) 6.2 MeV
   (c) 4.65 MeV (d) 7.68 MeV

3. Energy of 24.6 eV is required to remove one of the electrons from a neutral helium atom. The energy (in eV) required to remove both the electrons from a neutral helium atom is
   (a) 38.2 (b) 49.2
   (c) 51.8 (d) 79.0

4. If the radius of first Bohr's orbit is x, then de-Broglie wavelength of electron in 3rd orbit is nearly
   (a) $2\pi x$ (b) $6\pi x$
   (c) $9x$ (d) $\dfrac{x}{3}$

5. A star initially has 10^{40} deuterons. It produces energy *via* the processes ${}_1^2H + {}_1^2H \rightarrow {}_1^3H + p$ and ${}_1^2H + {}_1^3H \rightarrow {}_2^4He + n$
   Where the masses of the nuclei are
   $m({}^2H) = 2.014$ amu, $m(p) = 1.007$ amu, $m(n) = 1.008$ amu and $m({}^4He) = 4.001$ amu, if the average power radiated by the star is 10^{16} W. The deuteron supply of the star is exhausted in a time of the order of
   (a) 10^{18} s (b) 10^{28} s
   (c) 10^{12} s (d) 10^{16} s

6. Assuming that about 200 MeV energy is released per fission of ${}_{92}U^{235}$ nuclei. What would be the mass of U^{235} consumed per day in the fission of reactor of power 1 MW approximately?
   (a) 10 kg (b) 1 kg
   (c) 1 g (d) 10 g

7. The ratio between acceleration of the electron in singly ionized helium atom and doubly ionized lithium atom (both in ground state) is
(a) $\frac{4}{9}$ (b) $\frac{27}{8}$
(c) $\frac{8}{27}$ (d) $\frac{9}{4}$

8. A H-atom moving with speed v makes a head on collision with a H-atom at rest. Both atoms are in ground state. The minimum value of velocity v for which one of the atom may excite is
(a) 6.25×10^4 m/s (b) 8×10^4 m/s
(c) 7.25×10^4 m/s (d) 13.6×10^4 m/s
Note : $m_H = 1.67 \times 10^{-27}$ kg

9. In the reaction ${}_1^2H + {}_2^3H \rightarrow {}_2^4He + {}_0^1n$, if the binding energies per nucleon of ${}_1^2H$, ${}_1^3H$ and ${}_2^4He$, are x, y and z respectively. Then energy released in the process is
(a) $2x + 3y - 4z$ (b) $4z - 2x - 3y$
(c) $2x + 3y - 5z$ (d) None of these

10. In Moseley's equation, $\sqrt{v} = a(Z - b)$, for X-rays
(a) a is independent but b depends on target material
(b) both a and b are independent of the target material
(c) both a and b depend on the target material
(d) b is independent but a depends on the target material

11. The activity of a sample of radioactive material is A_1 at time t_1 and A_2 at time $t_2 (t_2 > t_1)$. Its mean life is T. Then
(a) $A_1 t_1 = A_2 t_2$ (b) $\frac{A_1 - A_2}{t_2 - t_1} =$ constant
(c) $A_2 = A_1 e^{(t_1 - t_2)/T}$ (d) $A_2 = A_1 e^{(t_1/t_2)/T}$

12. A particular nucleus in a large population of identical radioactive nuclei did survive 5 half lifes of that isotope. Then the probability that this surviving nucleus will survive the next half-life is
(a) $\frac{1}{32}$ (b) $\frac{1}{5}$ (c) $\frac{1}{2}$ (d) $\frac{1}{10}$

13. 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 some time if the de-Broglie wavelengths of the two are λ_1 and λ_1 then
(a) $\lambda_1 = \lambda_2$ (b) $\lambda_1 > \lambda_1$
(c) $\lambda_1 < \lambda_2$ (d) $\lambda_1 > \lambda_2$ or $\lambda_1 < \lambda_2$

14. A stationary radioactive nucleus of mass 210 units disintegrates into an alpha particle of mass 4 units and residual nucleus of mass 206 units. If the kinetic energy of the alpha particle is E, the kinetic energy of the residual nucleus is
(a) $\left(\frac{2}{105}\right)E$ (b) $\left(\frac{2}{103}\right)E$
(c) $\left(\frac{103}{2}\right)E$ (d) $\left(\frac{105}{2}\right)E$

15. The magnetic field at the centre of a hydrogen atom due to the motion of the electron in the first Bohr orbit is B. The magnetic field at the centre due to the motion of the electron in the second Bohr orbit will be
(a) $\frac{B}{4}$ (b) $\frac{B}{8}$
(c) $\frac{B}{32}$ (d) $\frac{B}{64}$

16. An excited hydrogen atom emits a photon of wavelength λ in returning to the ground state. The quantum number n of the excited state is given by (R = Rydberg constant)
(a) $\sqrt{\lambda R(\lambda R - 1)}$ (b) $\sqrt{\frac{\lambda R}{(\lambda R - 1)}}$
(c) $\sqrt{\frac{(\lambda R - 1)}{\lambda R}}$ (d) $\sqrt{\frac{1}{\lambda R(\lambda R - 1)}}$

17. Magnetic moment of an electron in nth orbit of hydrogen atom is
(a) $\frac{neh}{\pi m}$ (b) $\frac{neh}{4\pi m}$
(c) $\frac{meh}{2\pi n}$ (d) $\frac{meh}{4\pi n}$
[m = mass of electron, h = Planck's constant]

18. The probability of survival of a radioactive nucleus for one mean life is
(a) $\frac{1}{e}$ (b) $1 - \frac{1}{e}$
(c) $\frac{\ln 2}{e}$ (d) $1 - \frac{\ln 2}{e}$

19. When the voltage applied to an X-ray tube is increased from $V_1 = 10$ kV to $V_2 = 20$ kV, the wavelength difference between the K_α line and the short wavelength limit of the continuous X-ray spectrum increases by a factor 3. The atomic number of the element of which the tube anticathode is made will be
(a) 62 (b) 56
(c) 45 (d) 29

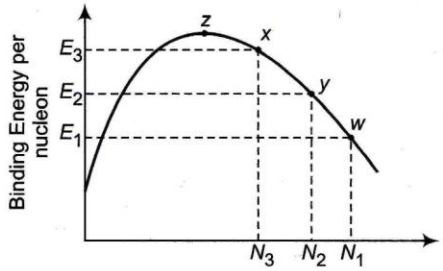
20. Light of wavelength 330 nm falling on a piece of metal ejects electrons with sufficient energy with requires voltage V_0 to prevent them from reaching a collector. In the same setup, light of wavelength 220 nm, ejects electrons which require twice the voltage V_0 to stop them in reaching a collector. The numerical value of voltage V_0 is
(a) $\frac{16}{15}$ V (b) $\frac{15}{16}$ V
(c) $\frac{15}{8}$ V (d) $\frac{8}{15}$ V

21. Maximum KE of a photoelectron is E when the wavelength of incident light is λ. If energy becomes four times when wavelength is reduced to one-third, then work function of the metal is
(a) $\frac{3hc}{\lambda}$ (b) $\frac{hc}{3\lambda}$
(c) $\frac{hc}{\lambda}$ (d) $\frac{hc}{2\lambda}$

22. If the frequency of K_α X-ray emitted from the element with atomic number 31 is f, then the frequency of K_α X-ray emitted from the element with atomic number 51 would be
(a) $\frac{5f}{3}$ (b) $\frac{51f}{31}$
(c) $\frac{9f}{25}$ (d) $\frac{25f}{9}$

23. According to Moseley's law the ratio of the slope of graph between $\sqrt{f}$ and Z for K_β and K_α is
(a) $\sqrt{\frac{32}{27}}$ (b) $\sqrt{\frac{27}{32}}$
(c) $\sqrt{\frac{5}{36}}$ (d) $\sqrt{\frac{36}{5}}$

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



(a) $E_1N_1 - (E_2N_2 + E_3N_3)$
(b) $(E_2N_2 + E_3N_3 - E_1N_1)$
(c) $E_2N_2 + E_1N_1 - E_3N_3$
(d) $E_1N_1 + E_3N_3 - E_2N_2$

25. Two radioactive nuclei A and B have disintegration constants λ_A and λ_B and initially N_A and N_B number of nuclei of them are taken, then the time after which their undisintegrated nuclei are same is

(a) $\frac{\lambda_A\lambda_B}{(\lambda_A - \lambda_B)} \ln\left(\frac{N_B}{N_A}\right)$ (b) $\frac{1}{(\lambda_A + \lambda_B)} \ln\left(\frac{N_B}{N_A}\right)$
(c) $\frac{1}{(\lambda_B - \lambda_A)} \ln\left(\frac{N_B}{N_A}\right)$ (d) $\frac{1}{(\lambda_A - \lambda_B)} \ln\left(\frac{N_B}{N_A}\right)$

26. Light of wavelength 0.6 μm from a sodium lamp falls on a photocell and causes the emission of photoelectrons for which the stopping potential is 0.5 V. With light of wavelength 0.4 μm from a sodium lamp, stopping potential is 1.5 V. With this data, the value of h/e is

(a) 4×10^{-19} Vs (b) 0.25×10^{15} Vs
(c) 4×10^{-15} Vs (d) 4×10^{-8} Vs

27. In a hypothetical Bohr hydrogen, the mass of the electron is doubled. The energy E_0 and radius r_0 of the first orbit will be (a_0 is the Bohr's first orbit radius of hydrogen)

(a) $E_0 = -27.2$ eV, $r_0 = \frac{a_0}{2}$ (b) $E_0 = -27.2$ eV, $r_0 = a_0$
(c) $E_0 = -13.6$ eV, $r_0 = \frac{a_0}{2}$ (d) $E_0 = -13.6$ eV, $r_0 = a_0$

28. Imagine an atom made up of a proton and a hypothetical particle of double the mass of the electron but having the same charge as the electron. Apply the Bohr atomic model and consider all possible transitions of this hypothetical particle to the first excited level. The longest wavelength of photon in the Balmer series has wavelength λ (given in terms of the Rydberg constant R for hydrogen atom) equal to

(a) $\frac{9}{(5R)}$ (b) $\frac{36}{(5R)}$
(c) $\frac{18}{(5R)}$ (d) $\frac{4}{(5R)}$

29. A photon has the same wavelength as the de-Broglie wavelength of electron. Given that c = speed of light and v = speed of electron. Which of the following relation is correct? [Here E_e = Kinetic energy of electron, E_{ph} = energy of photon, p_e = momentum of electron and p_{ph} = momentum of photon]

(a) $\frac{E_e}{E_{ph}} = \frac{2c}{v}$ (b) $\frac{E_e}{E_{ph}} = \frac{v}{2c}$
(c) $\frac{p_e}{p_{ph}} = \frac{2c}{v}$ (d) $\frac{p_e}{p_{ph}} = \frac{c}{2v}$

30. The ratio of speed of the electron in the first Bohr orbit of hydrogen and the speed of light is equal to (where e, h and c have their usual meanings)

(a) $\frac{2\pi hc}{e^2}$ (b) $\frac{e^2c}{2\pi h}$
(c) $\frac{e^2h}{2\pi c}$ (d) $\frac{e^2}{2\varepsilon_0 hc}$

31. In a hydrogen atom, the binding energy of the electron in the ground state is E_1. Then the frequency of revolution of the electron in the nth orbit is

(a) $\frac{2E_1}{n^3h}$ (b) $\frac{2E_1n^3}{h}$
(c) $\sqrt{\frac{2mE_1}{n^3h}}$ (d) $\frac{E_1n^2}{h}$

32. de-Broglie wavelength of an electron in the nth Bohr orbit of hydrogen atom 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

33. When photons of energy 4.25 eV strike the surface of a metal A, the ejected photoelectron have maximum kinetic energy T_A expressed in eV and de-Broglie wavelength λ_A. The maximum kinetic energy of photoelectron liberated from another metal B by photons of energy 4.70 eV is $T_B = (T_A - 1.50)$ eV. If the de-Broglie wavelength of these photoelectron is $\lambda_B = 2\lambda_A$, then choose the wrong option

(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

34. 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 two states. Assume the Bohr model to be valid. The time period of the electron in the initial state is eight times in the final state. The possible values of n_1 and n_2 are

(a) $n_1 = 4$, $n_2 = 2$
(b) $n_1 = 8$, $n_2 = 2$
(c) $n_1 = 8$, $n_2 = 1$
(d) $n_1 = 6$, $n_2 = 2$

35. A photon of energy E ejects a photoelectron from a metal surface whose work function is W_0. If electron having maximum kinetic energy enters into a uniform magnetic field of induction B in a direction perpendicular to the field and describes a circular path of radius r, then the radius r is given by, (in the usual notation)

(a) $\frac{\sqrt{2m(E - W_0)}}{eB}$ (b) $\sqrt{2m(E - W_0)\, eB}$
(c) $\frac{\sqrt{2m(E - W_0)}}{mB}$ (d) None of these

36. Two radioactive materials X_1 and X_2 have decay constants 10λ 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) $\left(\frac{1}{10\lambda}\right)$ (b) $\frac{1}{(11\lambda)}$
(c) $\frac{11}{(10\lambda)}$ (d) $\frac{1}{(9\lambda)}$

37. A plane EM wave of frequency 30 MHz travels in free space along the x-direction. The electric field component of the wave at a particular point of space and time is $E = 6$ V/m along y-direction. Its magnetic field component B at this point would be

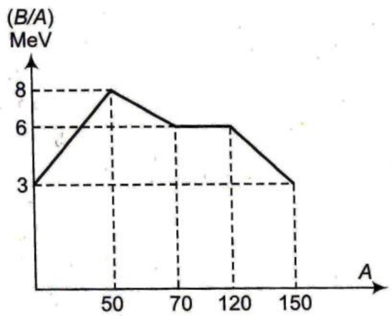
(a) 2×10^{8}T along z-direction

(b) 6×10^{8}T along x-direction

(c) 2×10^{-8}T along negative x-direction

(d) 2×10^{-8}T along z-direction

38. Assume that the nuclear binding energy per nucleons (B/A) *versus* mass number (A) is as shown in the figure. Consider a nucleus of $A = 110$. Fission of this nucleus results into 2 fragments.



Which of the following could possibly be the mass number of the resulting nuclei to release energy in fission?

(a) 55 and 55 (b) 70 and 40

(c) 100 and 10 (d) 90 and 20

39. A radioactive material decays by simultaneous emission of two particles with respective half-lives 1620 yr and 810 yr. The time, after which one-fourth of the material remains undecayed, is

(a) 3860 yr (b) 4240 yr (c) 2380 yr (d) 1080 yr

40. The recoil momentum of H-atom due to the transition of an electron from $n = 4$ state to $n = 1$ state is

(a) 13.6×10^{-19} kg-m/s (b) 6.8×10^{-27} kg-m/s

(c) 12.75×10^{-24} kg-m/s (d) None of these

41. The half-life of radium is 1620 yr and its atomic weight is 226 kg/K-mol. The number of atoms that will decay from its 1 g sample per second will be (Avogadro's number $N = 6.023 \times 10^{23}$ atom/mol)

(a) 3.61×10^{10} (b) 3.6×10^{12}

(c) 3.11×10^{15} (d) 31.1×10^{15}

42. A radioactive element A of decay constant λ_A decays into another radioactive element B of decay constant λ_B. Initially the number of active nuclei of A was N_0 and B was absent in the sample. The maximum number of active nuclei of B is found at $t = 2\frac{\ln 2}{\lambda_A}$. The maximum number of active nuclei of B is

(a) $\frac{N_0}{4}$ (b) $\frac{\lambda_A}{\lambda_B} N_0 e^{-\lambda_B t}$

(c) $\frac{\lambda_A}{\lambda_B}\frac{N_0}{4}$ (d) None of these

43. A bone containing 200 g carbon-14 has a β-decay rate of 375 decay / min. Calcualte the time that has elapsed since the death of the living one. Given the rate of decay for the living organism = 15 deca per min per gram of carbon and half-life of Carbon-14 = 5730 year

(a) 22920 year (b) 11460 year

(c) 17190 year (d) None of these

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

(a) $-\frac{G^2M^2m^2}{h^2}$ (b) $-\frac{2\pi^2G^2M^2m^2}{h^2}$

(c) $-\frac{2\pi^2GM^2m^3}{h^2}$ (d) None of these

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

(a) $T\ln\left(\frac{A_P}{A_Q}\right)$ (b) $T\ln\left(\frac{A_Q}{A_P}\right)$ (c) $T\left(\frac{A_P}{A_Q}\right)$ (d) $T\left(\frac{A_P}{A_Q}\right)$

46. The acceleration of electron in the first orbit of hydrogen atom is

(a) $\frac{4\pi^2 m}{h^3}$ (b) $\frac{h^2}{4\pi^2 mr}$ (c) $\frac{h^2}{4\pi^2 m^2 r^3}$ (d) $\frac{m^2h^2}{4\pi^2 r^3}$

47. n alpha particles per second are emitted from N atoms of a radioactive element. Half-life of the radioactive element is

(a) $\frac{n}{N}$ sec (b) $\frac{N}{n}$ sec

(c) $\frac{0.693\,N}{n}$ sec (d) $\frac{0.693\,n}{N}$ sec

48. An α-particle accelerated through V volt is fired towards a nucleus. Its distance of closest approach is r. If a proton accelerated through the same potential is fired towards the same nucleus, the distance of closest approach of proton will be

(a) r (b) $2r$ (c) $\frac{r}{2}$ (d) $\frac{r}{4}$