[SINGLE CORRECT CHOICE TYPE]

Q.1 If for material having, atomic number Z_1 and Z_2 correspond to K_α line having frequencies equal to v_1 and v_2 respectively. Then for any material having atomic number Z_3 will correspond to frequency

(A) $\left[\left(\frac{\sqrt{v_2}-\sqrt{v_1}}{Z_2-Z_1}\right)(Z_3-Z_1)+\sqrt{v_1}\right]^2$ (B) $\left(\frac{\sqrt{v_2}-\sqrt{v_1}}{Z_2-Z_1}\right)(Z_3-Z_1)+\sqrt{v_1}$

(C) $\left(\frac{v_2-v_1}{\sqrt{Z_2}-\sqrt{Z_1}}\right)\left(\sqrt{Z_3}-\sqrt{Z_1}\right)+v_2$ (D) $\left[\left(\frac{v_2-v_1}{Z_2-Z_1}\right)(Z_3-Z_1)+v_2\right]^2$

Q.2 Binding energy of A = X MeV, B = Y MeV, C=Z MeV [X > Y > Z], A person in a lab tries to break each nucleus into its constituents with the help of energy S MeV [y < S < x], then which of the following nuclei may break?

(A) B and C (B) C and A (C) A and B (D) only C

Q.3 A photon of wavelength λ_1 strikes a He^+ ion in its first excited state and is capable of exciting it to higher state. Photon is completely absorbed. As a result, He^+ ion emit radiation of wavelength λ_2. Ratio of $\lambda_{1(max)}/\lambda_{2(max)}$ is

(A) 1 : 1 (B) 32 : 5 (C) 4 : 3 (D) none of these.

Q.4 A radioactive material decays by simultaneous emission of three particles with respective half lives t_1, t_2, t_3 minutes. The time in minutes after which $\frac{1}{3}$ rd of material remains undecayed is

(A) $\frac{t_1t_2t_3\log_e 3}{(\log_e 2)(t_1t_2+t_2t_3+t_1t_3)}$ (B) $\frac{t_1t_2t_3\log_e 3}{(\log_e 2)(t_1+t_2+t_3)}$

(C) $\frac{t_1t_2t_3\log_e 2}{(\log_e 3)(t_1+t_2+t_3)}$ (C) $\frac{t_1t_2t_3\log_e 2}{(\log_e 3)(t_1t_2+t_1t_3+t_2t_3)}$

Q.5 He^+ atom returns from its 4^{th} excited state to its 3^{rd} excited state and from 3^{rd} excited state to first exicited state. The emitted radiations fall on a metallic plate of work function 5.0 eV. The maximum possible kinetic energy with which photoelectron emitted is

(A) 5.2 eV (B) 2.64 eV

(C) 2.56 eV (D) photoelectron not emitted

Q.6 An electron of mass m_e and charge -e (e > 0) moves in a closed orbit in a uniform magnetic field, B acting perpendicular to the plane of the orbit. If Bohr's quantization rule for angular momentum were to be applied to this system, the minimum magnetic flux passing through the orbit equals

(A) zero (B) $\frac{h}{2e}$ (C) $\frac{h}{e}$ (D) none of the above

Q.7 For two hydrogen like atoms each with their electron in 3rd excited state first atom emits a radiation in the range of ultra violet region for transition of electron directly to ground state. There is another radiation from second atom. Second radiation must not fall in range of

(A) Infra red (B) γ-ray (C) ultra violet (D) visible light

[MULTIPLE CORRECT CHOICE TYPE]

Q.8 In the α-decay of a U-238 nucleus the energy released in the decay is Q. The U-238 nucleus was initially stationary. Which of the following is (are) true?

(A) Ratio of K.E. of α-particle and Thorium nucleus is 117 : 2

(B) Ratio of K.E. of Thorium nucleus and α-particle and 1 : 234

(C) Momentum of α-particle is $(234Qm_{\alpha}/119]^{1/2}$

(D) Recoil velocity of Thorium nucleus is $(234Q/119 \times 117m_{Th}]^{1/2}$

Q.9 An X-ray tube is operating at 50 kV and 20 mA. The target material of the tube has mass of 1 kg and specific heat 495 J kg^{-1} $°C^{-1}$. One precent of applied electric power is converted into X-rays and the remaining energy goes into heating the target. Then

(A) a suitable target material must have high melting temperature

(B) a suitable target material must have low thermal conductivity

(C) the average rate of rise of temperature of the target would be 2°C/sec

(D) the minimum wavelength of X-rays emitted is about 0.25×10^{-10} m

Q.10 Which of the following are not dependent on the intensity of the incident radiation in a photoelectric experiment?

(A) Amount of photoelectric current

(B) Stopping potential to reduce the photoelectric current to zero

(C) Work function of the surface

(D) Maximum kinetic energy of photoelectrons

Q.11 A hydrogen like gas atoms absorb radiations of wavelength λ_0 and consequently emit radiations of 6 difference wavelengths of which, three wavelengths are shorter than λ_0. Choose the correct alternative(s).

(A) The final excited state of the atoms is n = 3

(B) The final excited state of the atoms is n = 4

(C) The initial state of the atoms is n = 2

(D) The initial state of the atoms is n = 3

[PARAGRAPH TYPE]

Paragraph for question nos. 12 to 14

Consider the reaction

$$_1^2H + _1^2H \longrightarrow _1^3H + _1^1H$$

The Q value is 4.0 MeV, and so this nuclear reaction liberates about 1 MeV per nucleon, roughly the same as the fission reaction. This reaction can be performed in the laboratory, by accelerating a beam of deuterons on to a deuterium target. In order to observe the reaction, we must get the incident and target deuterons closed enough that the nuclear force can produce the reaction ; that is, we must overcome the mutual Coulomb repulsion of the two particles. We can estimate this Coulomb repulsion by calculating the electrostatic repulsion of two deuterons when they are just touching. The radius of a deuteron is about 1.5 fm, and the electrostatic potential energy of the two charges separated by about 3 fm is about 0.5 MeV.

We can produce such a beam of deuterons in many of the accelerators available in nuclear physics laboratories. The beam currents of such accelerators are typically of the order of microamperes. If every particle in the beam produced a reaction (hardly a reasonable assumption!), the total power produced would be 4W. An output of 4W (assuming we could extract every bit of the energy liberated in the reaction, which appears as the kinetic energies of the products ^1H and ^3H) hardly makes this device a useful power source!.

Q.12 According to the passage, the fusion reaction initiated by accelerators in laboratories is not useful source of energy because
(A) Q value per reaction is very low. (B) The energy losses are high.
(C) Radioactive daughter nuclei are produced. (D) The power output is low.

Q.13 For initiating the reaction, the energy of incident deuterons should be of the order of
(A) 0.5 MeV (B) 1.0 MeV (C) 4.0 MeV (D) 4.5 MeV

Q.14 Given : mass of hydrogen atom = 1.0078 amu, mass of Deuterium atom = 2.0141 amu and 1 amu = 931.5 MeV/c^2. What is the mass of tritium atom?
(A) 3.0161 amu (B) 3.0204 amu (C) 3.0247 amu (D) 3.0118 amu

[SUBJECTIVE TYPE - FILL IN THE BLANKS]

Q.15 A ^{7}Li target is bombarded with a proton beam current of 10^{-4} A for 1 hour to produce ^{7}Be of activity 1.8×10^8 disintegrations per second. Assuming that one ^{7}Be radioactive nucleus is produced by bombarding 1000 protons. The half life of ^{7}Be is __________ days.

Q.16 A nucleus decay into two daughter nuclei which have their velocity ratio equal to 2:1. The ratio of their nuclear size (radius) is __________.

Q.17 The probability of a radioactive atom to survive 5 times of half life is __________.

Q.18 A nucleus at rest undergoes a decay emitting an α particle of de-Broglie wavelength $\lambda = 5.76 \times 10^{-15}$ m. The mass of the daughter nucleus is 223.610 a.m.u. and that of the α particle is 4.002 a.m.u. The total kinetic energy in the final state is __________ MeV. And the mass of the parent nucleus is ________a.m.u.

Q.19 The kinetic energy of neutron in a neutron beam is 0.0327 eV. If half life of neutron is 700 sec, find the fraction of neutrons decaying before traveling a distance 10 m is ___________.

Q.20 A X-rays tube with a copper target is found to be emitting lines other than those due to copper. The k_α line of copper is known to have a wavelength 1.5405 Å and the other two k_α lines observed have wavelengths 0.7092 Å and 1.6578Å. Metal target have _________ & _________impurities (name of element).

ANSWER KEY

Q.1	A	Q.2	A	Q.3	A	Q.4	A	Q.5	A	Q.6	B	Q.7	B
Q.8	AC	Q.9	ACD	Q.10	BCD	Q.11	BC	Q.12	D	Q.13	B	Q.14	A
Q.15	100.26 days			Q.16	$1:2^{1/3}$	Q.17	$[(2)^{-5}]$	Q.18	227.61883amu				
Q.19	4×10^{-6}			Q.20	Z = 42, 28								

HINTS AND SOLUTIONS

Q.1 A

Sol. If $\sqrt{V}$ for k_α lines are platted against atomic number it will be straight line

$$\sqrt{V}-\sqrt{V_1}=\left(\frac{\sqrt{v_2}-\sqrt{v_1}}{Z_2-Z_1}\right)(Z-Z_1)$$

$$\text{or, }\left[\left(\frac{\sqrt{v_2}-\sqrt{v_1}}{Z_2-Z_1}\right)(Z_3-Z_1)+\sqrt{v_1}\right]^2$$

Q.2 A

Q.3 A

Sol. $\lambda_{1(max)}=\frac{hc}{\Delta E_{2\to 3}}$

$$\lambda_{2(max)}=\frac{hc}{\Delta E_{3\to 2}}$$

$$\lambda_{1(max)}/\lambda_{2(max)}=\frac{hc}{hc}\times\frac{\Delta E_{3\to 2}}{\Delta E_{2\to 3}}=1$$

Q.8 AC

Sol. $\frac{P^2}{2m_\alpha}+\frac{P^2}{2m_{th}}=Q \quad \Rightarrow P=\left(\frac{2m_\alpha m_{th}Q}{m_\alpha+m_{th}}\right)^{1/2}$ and $\frac{K.E_\alpha}{K.E_{th}}=\frac{m_{th}}{m_\alpha}=\frac{234}{4}$

Q.10 BCD

Sol.$_{VJ}$ Intensity increases no. of photon coming on plates therefore it wouldn't change stopping potential work function maximum K.E.

Q.13 B

Sol. $\frac{1}{2}\mu v_r^2 \geq \Delta E$

$$\frac{1}{2}\frac{m}{2}(v-0)^2 \geq 0.5$$

$$\therefore \frac{1}{2}mv^2 \geq 1\text{ MeV}$$

Q.14 A

Sol. $Q=(m_T+m_H-2m_D)C^2$

$4=(m_T+1.0078-2\times 2.0141)\times 931.5$

$4.294\times 10^{-3}=m_T+1.0078-4.0282$

$4.0282-1.0078-0.0043=m_T=3.0161$ amu

Q.15 Ans: 100.26 days.

Q.16 Ans. $(1:2^{1/3})$

Sol. $R\ \alpha\ A^{1/3}$

Where R radius of nuclei.

Q.17 Ans. $[(2)^{-5}]$

Sol. $\frac{N}{N_0} = \left(\frac{1}{2}\right)^{t/T} = \left(\frac{1}{2}\right)^{5T/T} = 2^{-5}$

Q.18 Ans. 227.61883amu

Sol. $(m_P - m_\alpha - m_D) \times 931.47 = (K_\alpha + K_D)$ in MeV ...(i)

$P_\alpha = h/\lambda_\alpha = 1.15 \times 10^{-19}$ kg-m/s

Since initial linear momentum of the system is zero, $P_\alpha = P_D$

$\therefore K_\alpha = P^2{}_\alpha/(2m_\alpha) = 1 \times 10^{-12}$ J ; $K_D = P^2{}_D/(2m_D) = 1.78 \times 10^{-14}$ J.

$\therefore$ Total KE $= K_\alpha + K_D = 1.0178 \times 10^{-12}$ J $= 6.36$ MeV.

Putting it in equation (1)

$m_P = m_\alpha + m_D + \{(K_\alpha + K_D)$ in MeV$\}/931.47 = 227.61883$amu.

(Taking 1 amu $= 1.66 \times 10^{-27}$ kg)

Q.19 Ans. 4×10^{-6}

Sol. Velocity of neutrons $= \sqrt{\frac{2eV}{m_n}} = \sqrt{\frac{2 \times 1.6 \times 10^{-19} \times 0.0327}{1.67 \times 10^{-27}}}$

$= \sqrt{6.29 \times 10^6}$ m/s $= 2.5 \times 10^3$ m/s

Time taken by neutron to cover the distance 10 m

$t = \frac{10}{2.5 \times 10^3} = 4 \times 10^{-3}$ seconds $<< T_{1/2}$

$\lambda = \frac{0.693}{700} = 9.9 \times 10^{-4}$ /sec

Fraction decayed $= 1 - e^{-\lambda t} \approx \lambda t = 4 \times 10^{-6}$

Q.20 Ans. Z = 42, 28

Sol. According to Moseley's equation for k_α radiation ;

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

$\frac{\lambda_1}{\lambda} = \frac{(z-1)^2}{(z_1-1)^2} = \frac{0.7092}{1.5405}$

z = 29 for cu, hence $z_1 - 1 = 28\sqrt{\frac{1.5405}{0.7092}} = 41$

or $z_1 = 42$

$\therefore$ Impurity is molybdenum

similarly; $\frac{\lambda_2}{\lambda_1} = \frac{(z-1)^2}{(z_2-1)^2} = \frac{1.6578}{1.5405}$

or $z_2 - 1 = 28\sqrt{\frac{1.5405}{1.6578}} = 27$

$z_2 = 28$

It is atomic number of Nickel.

Hence the other impurity is Nickel.