



Practice Set-1

- a.** $\frac{1}{2}\lambda_1\lambda_2N_0t^2$ **b.** $\frac{\lambda_1\lambda_2}{2(\lambda_1+\lambda_2)}N_0t$
c. $(\lambda_1+\lambda_2)^2N_0t^2$ **d.** $(\lambda_1+\lambda_2)N_0t$

$$1\text{amu} \approx 938\text{MeV})$$

[NET/JRF (DEC-2016)]

- a. 32.2MeV b. 3MeV c. 19.3MeV d. 931.5MeV

Solution:

From conservation of energy

$$E_{\alpha} + m_{\alpha}c^2 = m_{1H^3}c^2 + m_{1H^1}c^2$$

$$\text{or } E_{\alpha} = [m_{1H^3} + m_{1H^1} - m_{\alpha}] \times 938\text{MeV} = 19.5\text{MeV}$$

So the correct answer is **Option (c)**

3. If in a spontaneous α -decay of ${}_{92}^{232}\text{U}$ at rest, the total energy released in the reaction is Q , then the energy carried by the α -particle is

[NET/JRF (JUNE-2017)]

- a. $57Q/58$ b. $Q/57$ c. $Q/58$ d. $23Q/58$

Solution:Energy carried by the α - particle is

$$KE_{\alpha} = \left(\frac{A-4}{A} \right) Q = \frac{228}{232} Q = \frac{57}{58} Q$$

So the correct answer is **Option (a)**

4. The reaction ${}^{63}\text{Cu}_{29} + p \rightarrow {}^{63}\text{Zn}_{30} + n$ is followed by a prompt β -decay of zinc ${}^{63}\text{Zn}_{30} \rightarrow {}^{63}\text{Cu}_{29} + e^+ + \nu_e$. If the maximum energy of the positron is 2.4MeV, the Q value of the original reaction in MeV is nearest to [Take the masses of electron, proton and neutron to be $0.5\text{MeV}/c^2$, $938\text{MeV}/c^2$ and $939.5\text{MeV}/c^2$, respectively.]

[NET/JRF (JUNE-2018)]

- a. -4.4 b. -2.4 c. -4.8 d. -3.4

Solution:

$$\text{For } {}^{63}\text{Zn}_{30} \rightarrow {}^{63}\text{Cu}_{29} + e^+ + \nu_e$$

$$Q_1 = (Zn - 30e) - [Cu - 29e + e] = Zn - Cu - 2e = 2.4\text{MeV}$$

$$\text{For } {}^{63}\text{Cu}_{29} + p \rightarrow {}^{63}\text{Zn}_{30} + n$$

$$Q_0 = [(Cu - 29e) + p] - [(Zn - 30e) + n]$$

$$= Cu - Zn + e + p - n = (-Q_1 - 2e) + e + p - n = -Q_1[e - p + n]$$

$$= -2.4 - (0.5 - 938 + 939.5) = -4.4\text{MeV}$$

So the correct answer is **Option (a)**

5. A nucleus decays by the emission of a gamma ray from an excited state of spin parity 2^+ to the ground state with spin-parity 0^+ what is the type of the corresponding radiation?

[NET/JRF (DEC-2018)]

- a. Magnetic dipole b. Electric quadrupole
c. Electric dipole d. Magnetic quadrupole

Solution:

$$I_i = 2, \quad I_+ = 0$$

$\Rightarrow L = 2$ and parity change

\therefore The transition is of electric quadrupole (E_2) nature.

So the correct answer is **Option (b)**

6. The ground state of $^{207}_{12}\text{Pb}$ nucleus has spin-parity $J^P = \frac{1}{2}^-$, while the first excited state has $J^P = \frac{5}{2}^-$. The electromagnetic radiation emitted when the nucleus makes a transition from the first excited state to ground state are

[NET/JRF (JUNE-2012)]

a. E2 and E3

b. M2 or E3

c. E2 or M3

d. M2 or M3

Solution:

No parity change; $\Delta J = 2, 3$

For E_l type, $\Delta\pi = (-1)^l$, (for no parity change $l = 2$)

For M_l type, $\Delta\pi = (-1)^{l+1}$, (for no parity change $l = 3$)

$\Delta J = 2$, No parity change $\rightarrow E2$; $\Delta J = 3$, No parity change $\rightarrow M3$

So the correct answer is **Option (c)**

Answer key

Q.No.	Answer	Q.No.	Answer
1	a	2	c
3	a	4	a
5	b	6	c
7		8	
9		10	
11		12	
13		14	
15			

Practice Set-2

1. A radioactive element X has a half-life of 30 hours. It decays via alpha, beta and gamma emissions with the branching ratio for beta decay being 0.75. The partial half-life for beta decay in unit of hours is——

[GATE-2019]

Solution: Branching ratio is the fraction of particles (here β) which decays by an individual decay mode with respect to the total number of particles which decays

$$BR = \frac{\left(\frac{dN}{dt}\right)_\beta}{\left(\frac{dN}{dt}\right)_\alpha + \left(\frac{dN}{dt}\right)_\beta + \left(\frac{dN}{dt}\right)_\gamma} = \frac{(T_{1/2})_\alpha}{(T_{1/2})_\beta} \Rightarrow (T_{1/2})_\beta = \frac{(T_{1/2})_\alpha}{BR} = \frac{30}{0.75} = 40 \text{ hours}$$

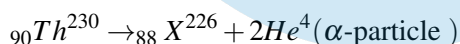
So the correct answer is **40**

2. An α particle is emitted by a ${}^{230}_{90}\text{Th}$ nucleus. Assuming the potential to be purely Coulombic beyond the point of separation, the height of the Coulomb barrier is MeV (up to two decimal places).
 $\left(\frac{e^2}{4\pi\epsilon_0} = 1.44\text{MeV} \cdot \text{fm}, r_0 = 1.30\text{fm}\right)$

[GATE-2018]

Solution:

The height of coulomb barrier for α particle from



$$V_C = \frac{1}{4\pi\epsilon_0} \left(\frac{2ze^2}{R} \right)$$

Here, $R_0 = 1.3\text{fm}$, $\frac{e^2}{4\pi\epsilon_0} = 1.44\text{MeVfm}$

And $R = R_0 A^{1/3}$

Here, we consider pure Coulombic interaction

$$A_{Th}^{1/3} = A_X^{1/3} + A_\alpha^{1/3} = (226)^{1/3} + (4)^{1/3} = (6.09 + 1.58) = 7.67, \quad R = R_0 A_{Th}^{1/3} = 1.3(7.67)$$

Hence, $V_C = \left(\frac{e^2}{4\pi\epsilon_0} \right) \frac{2 \times 90}{1.3(7.67)} = \frac{180 \times 1.44 \text{ MeV}}{1.3 \times 7.67 \text{ fm}}$

$$V_C = 25.995\text{MeV}$$

So the correct answer is **25.995**

3. Consider the reaction ${}^{54}_{25}\text{Mn} + e^- \rightarrow {}^{54}_{24}\text{Cr} + X$. The particle X is

[GATE-2016]

- a. γ b. ν_e c. n d. π^0

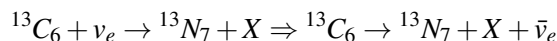
Solution: So the correct answer is **Option (b)**

4. In the nuclear reaction ${}^{13}\text{C}_6 + \nu_e \rightarrow {}^{13}\text{N}_7 + X$, the particle X is

[GATE-2017]

- a. An electron b. An anti-electron
 c. A muon d. A pion

Solution:



$$L_e = 0 \quad 0 + 1 - 1$$

To conserve the Lepton number L_e , X should be e^-

So the correct answer is **Option (a)**

5. In the β -decay of neutron $n \rightarrow p + e - \bar{\nu}_e$, the anti-neutrino $\bar{\nu}_e$, escapes detection. Its existence is inferred from the measurement of

[GATE-2011]

- Energy distribution of electrons
- Angular distribution of electrons
- Helicity distribution of electrons
- Forward-backward asymmetry of electrons

Solution: So the correct answer is **Option (a)**

6. In the β decay process, the transition $2^+ \rightarrow 3^+$, is

[GATE-2013]

- Allowed both by Fermi and Gamow-Teller selection rule
- Allowed by Fermi and but not by Gamow-Teller selection rule
- Not allowed by Fermi but allowed by Gamow-Teller selection rule
- Not allowed both by Fermi and Gamow-Teller selection rule

Solution:

According to Fermi Selection Rule:

$$\Delta I = 0, \quad \text{Parity} = \text{No Change}$$

According to Gamow-Teller Selection Rule: $\Delta I = 0, \pm 1, \quad \text{Parity} = \text{No Change}$

In the β decay process, the transition $2^+ \rightarrow 3^+$, $\Delta I = \pm 1, \quad \text{Parity} = \text{No Change}$.

So the correct answer is **Option (c)**

7. A nucleus X undergoes a first forbidden β -decay to nucleus Y . If the angular momentum (I) and parity (P), denoted by I^P as $\frac{7}{2}^-$ for X , which of the following is a possible I^P value for Y ?

[GATE-2014]

- $\frac{1}{2}^+$
- $\frac{1}{2}^-$
- $\frac{3}{2}^+$
- $\frac{3}{2}^-$

Solution:

For first forbidden β -decay; $\Delta I = 0, 1$ or 2 and Parity does change.

So the correct answer is **Option (c)**

8. A beam of X - ray of intensity I_0 is incident normally on a metal sheet of thickness 2 mm. The intensity of the transmitted beam is $0.025I_0$. The linear absorption coefficient of the metal sheet (in m^{-1}) is—— (upto one decimal place)

[GATE-2015]

Solution:

$$I = I_0 e^{-\mu x} \Rightarrow \mu = \frac{1}{x} \ln \left(\frac{I_0}{I} \right) = \frac{1}{2 \times 10^{-3}} \ln \left(\frac{I_0}{0.025 I_0} \right) = \frac{1}{2 \times 10^{-3}} \ln(40)$$

$$\Rightarrow \mu = \frac{2.303}{2 \times 10^{-3}} [\log_{10} 40] = 1.151 \times 10^3 [2 \times 0.3010 + 1] = 1844.4 \text{ m}^{-1}$$

So the correct answer is **1844.4**

9. The atomic masses of $^{152}_{63}\text{Eu}$, $^{152}_{62}\text{Sm}$, ^1_1H and neutron are 151.921749, 151.919756, 1.007825 and 1.008665 in atomic mass units (amu), respectively. Using the above information, the Q -value of the reaction $^{152}_{63}\text{Eu} + n \rightarrow ^{152}_{62}\text{Sm} + p$ is $\text{---} \times 10^{-3}$ amu (upto three decimal places)

[GATE-2015]

Solution:

$$Q = 152.930414 - (152.927581) = 2.833 \times 10^{-3} \text{ a.m.u.}$$

So the correct answer is **2.833**

10. The atomic masses of $^{152}_{63}\text{Eu}$, $^{152}_{62}\text{Sm}$, ^1_1H and neutron are 151.921749, 151.919756, 1.007825 and 1.008665 in atomic mass units (amu), respectively. Using the above information, the Q -value of the reaction $^{152}_{63}\text{Eu} + n \rightarrow ^{152}_{62}\text{Sm} + p$ is $\text{---} \times 10^{-3}$ amu (upto three decimal places)

[GATE-2015]

Solution:

$$Q = 152.930414 - (152.927581) = 2.833 \times 10^{-3} \text{ a.m.u.}$$

So the correct answer is **2.833****Answer key**

Q.No.	Answer	Q.No.	Answer
1	40	2	25.995
3	b	4	a
5	a	6	c
7	c	8	1844.4
9	2.833	10	2.833
11		12	
13		14	
15			