3. NUCLEAR CHEMISTRY

SYNOPSIS

I. RADIOACTIVITY : ISOTOPES, ISOBARS, KINETICS OF RADIO ACTIVE DECAY, CARBON DATING, NUCLEAR REACTIONS AND APPLICATIONS

Nuclear chemistry is the study of the properties and reactions of atomic nuclei. In nuclear reactions only the nuclides (nuclide : the nucleus of a specific isotope) participate and overall (mass + energy) remains conserved.

Radioactivity

The property of a nucleus emitting radiations like α, β and γ is known as radioactivity and the substance possessing the property is called a radioactive substance. The emission of these particles takes place because of the instability of the nucleus. Radioactivity is a property of nucleus.

Types of Radioactive Decay :

1. α**-decay** causes decrease of atomic number by 2 units and mass number by 4 times, e.g.,

$$^{215}_{84}Po \longrightarrow ^{211}_{82}Pb + ^{4}_{2}He \ ; \ ^{226}_{88}Ra \longrightarrow ^{226}_{86}Rn \longrightarrow ^{226}_{86}Rn + ^{4}_{2}He$$

All nucleides with atomic number greater than 83 are beyond the band of stability and are radioactive.

2. β**-decay** causes increase of atomic number by 1 unit and no change in mass number, e.g.,

$$^{228}_{88}Ra \longrightarrow ^{228}_{89}Ac + ^{0}_{-1}e \ ; \ ^{14}_{6}C \longrightarrow ^{14}_{7}N + ^{0}_{-1}e$$

A neutron is converted to proton in this process $^{1}_{0}n \longrightarrow ^{1}_{1}p + ^{0}_{-1}e$

Such emission occurs for the nuclei lying above the stability belt.

3. γ**-ray** emission ($^{0}_{0}\gamma$) causes no change in atomic number and mass number, since it represents the energy lost, e.g.,

$$^{60}_{28}Ni^{*} \longrightarrow ^{60}_{28}Ni + ^{0}_{0}\gamma$$

4. **Positron Emission :** Causes decrease in the atomic number by 1 unit, e.g.,

$$^{15}_{8}O \longrightarrow ^{15}_{7}N + ^{0}_{+1}e \ ; \ ^{118}_{54}Xe \longrightarrow ^{0}_{+1}e + ^{118}_{53}I$$

A proton is converted to neutron and positron in this process

$$^{1}_{1}p \longrightarrow ^{1}_{0}n + ^{0}_{1}e$$

Such emission occurs for the nuclei lying below the stability belt.

Positron ($^{0}_{+1}e$) is a particle having the same mass as an electron, but positively charged.

5. **Electron-capture :**

Causes decrease in the atomic number by 1 unit, e.g.,

$$^{204}_{84}Po + ^{0}_{-1}e \longrightarrow ^{204}_{83}Bi \ ; \ ^{40}_{19}K + ^{0}_{-1}e \longrightarrow ^{40}_{18}Ar$$

A proton is converted to neutron in this process

$$^{1}_{1}p + ^{0}_{-1}e \longrightarrow ^{1}_{0}n$$

Electron capture occurs with the nuclei lying below the stability belt, in which an electron from the K-shells is captured by the nucleus.

Group Displacement Law (Soddy-Fajans)

In an α-particle emission, the resulting element has a mass number less by four units and atomic number less by two units and so lies two places to the left in the periodic table.

In a β-particle emission the resulting element has the same mass number but has an atomic number greater by one unit and so lies one place to the right in the periodic table.

Neutron/proton ratio and stability zone

For atomic number < 20, most stable nuclei have n:p ratio nearly 1 : 1 (except H & Ar)

For n/p raio > 1.5, nucleus is unstable. Largest stable nucleus is $^{208}_{82}Pb$ for which n/p ratio is 1.53.

For atomic number > 82, there are no stable nuclei

Note : Heaviest stable nuclide is $^{208}_{82}Pb$

$t_{1/2}$ for $^{209}_{83}Bi = 1.9 \times 10^{19}$y, which is α-emitter

Magic numbers and nuclear stability : Nuclei with 2, 8, 20, 28, 50, 82 or 126 protons or neutrons are unusually stable and have a larger number of stable isotopes than neighbouring nuclei in the periodic table. These numbers are called magic numbers. They are supposed to represent completely filled nuclear shells of energy levels.

Nuclei with magic number of protons as well as neutrons have notably high stabilities and are called doubly magic.

[e.g., $^{4}_{2}He$, $^{16}_{8}O$, $^{40}_{20}Ca$ and $^{208}_{82}Pb$]

Even odd theory : Most naturally occuring nuclides have even number of neutrons and even number of protons. 165 such stable nucleides are known. There exist 55 known nucleides with even number of protons and odd number of neutrons, and 50 known stable nucelides with odd number of protons and even number of neutrons. On the other hand the number of known stable nucelides having odd numbers of both neutrons and protons is only 5.

Artificial nuclear reactions :

The first artifical transmutation was carried out by Rutherford in 1919 who bombarded nitrogen gas with alpha particles and obtained hydrogen and oxygen

$$^{14}_{7}N + ^{4}_{2}He \longrightarrow ^{17}_{8}O + ^{1}_{1}H$$

1. **Alpha particle induced or (α,n) type reactions :**

$$^{9}_{4}Be + ^{4}_{2}He \longrightarrow ^{12}_{6}C + ^{1}_{0}n$$

Since α-particles is used and a neutron is produced, the reaction may be termed as (α,n) reaction.

2. **Deuteron-induced or (D, α) type reaction :**

$$^{16}_{8}O + ^{2}_{1}H \longrightarrow ^{14}_{7}N + ^{4}_{2}He$$

3. **Proton-induced or (p, γ) reaction :**

$$^{14}_{7}N + ^{1}_{1}H \longrightarrow ^{15}_{8}O + \gamma$$

4. **Neutron-induced or (n, γ) reaction :**

$$^{31}_{15}P + ^{1}_{0}n \longrightarrow ^{32}_{15}P + \gamma$$

Radioactive decay :

Radioactive decay is a first order process. The rate of nuclear decay is determined from measurements of the activity (A) of a sample

Hence $-\frac{dN}{dt} = \lambda N$ or $N = N_0 e^{-\lambda t}$

where N = number of radioactive nuclei at any time t ; N_0 = number of radioactive nuclei at t = 0; λ = decay constant

S.I.units : The SI unit is becquerel (Bq)

1 disintegration per second (dps) = 1Bq

Other units : 1curie (Ci) = 3.7×10^{10}dps, 1 Rutherford (Rd) = 10^6dps.

Specific activity : Activity per unit mass of radioactive sample (dps/g)

Half life ($t_{1/2}$) : The time taken by half the nuclei (originally present) to decay $t_{1/2} = 0.693/\lambda$

Note : After n half-lives have passed, activity is reduced to $\frac{1}{2^n}$ of its initial value.

Average life (t_{av}) : $t_{av} = 1/\lambda = 1.44\ t_{1/2}$

Radioactive equilibrium : Among the members of a decay chain, the state which prevails when the ratios between the activities of successive members remain constant. (This is not an equilibrium in the strict sense since radioactive decay is an irreversible process).

Secular equilibrium : Radioactive equilibrium where the half life of the intermediate isotope is so long that the change of its activity can be ignored during the period of interest and all activities remain constant.

$$A \xrightarrow{\lambda_A} B \xrightarrow{\lambda_B} C$$

Number of nuclei of B is max. at t_{max} ; $t_{max} = \frac{1}{(\lambda_1 - \lambda_2)} \ln\left(\frac{\lambda_1}{\lambda_2}\right)$; $\frac{dN_B}{dt} = \lambda_A N_A - \lambda_B N_B$

Secular equilibrium occurs when $\frac{dN_B}{dt} = 0$ or $\frac{N_B}{N_A} = \frac{\lambda_A}{\lambda_B}$

Parallel decay $A \xrightarrow{\lambda_1} B$, $A \xrightarrow{\lambda_2} C$ % of B = $\left(\frac{\lambda_1}{\lambda_1 + \lambda_2}\right) \times 100$; % of C = $\left(\frac{\lambda_2}{\lambda_1 + \lambda_2}\right) \times 100$

Applications of Radioactivity :

Uranium dating : Age of the rocks can be determined by using Uranium dating technique.

Carbon Dating : The technique in which radio active carbon is used for estimation of ages of archeological specimen is known as radiocarbon dating.

The radioactive carbon $^{14}_{6}C$ decays by emitting an electron with a half-life period 5600 years.

$^{14}_{6}C \rightarrow ^{14}_{7}N + ^{0}_{-1}e$; $\lambda = \frac{2.303}{t} \log_{10} \frac{N_0}{N_t}$

Radio active isotopes are used in the elucidation of Mechanism of reactions like photo synthesis, ester hydrolysis, polymerisation etc.,

Na^{24} is used to study the disorders in blood circulation.

I^{131} is used to locate the position of Brain tumor.

I^{131} is also used to study the functioning of thyroid gland.

P^{32} is used in the treatment of leukemia.

Co^{50}, Co^{60} are used in the treatment of cancer.

Radio active isotopes are used to estimate the deficiency of minerals in plants and soils.

They are also used in Nuclear Fusion and Nuclear Fusion reactions.

Einstein's mass-energy equation : Energy changes in nuclear reactions can be determined by using Einstein's mass-energy equation $E = mc^2$

Where E is the energy equivalent of mass m and c is the velocity of light

For a change of 1 amu (atomic mass unit), the corresponding energy change,

$E \simeq 931 \times 10^6 eV \simeq 931 MeV$, i.e., a mass of 1 amu is equivalent to 931MeV of energy.

Mass Defect :

It has invariably been found that the actual mass of an isotope of an element is less than the sum of masses of the protons, neutrons and electrons present in it. This difference is called mass defect. The mass defect is nothing, but the loss of mass during the formation of the nucleus of the isotope.

Mass defect in nuclear reaction :

$\Delta m =$ mass of nuclei of reactants – mass of nuclei of products

Energy liberated in nuclear reaction : $\Delta E = \Delta m . c^2$

Mass defect in an isotope formation :

Let m_p, m_n and m_e are the respective masses of proton, neutron and electron. Then, the calculated mass of this isotope.

$M' = Zm_p + Zm_e + (A–Z)m_n = Zm_H + (A–Z)m_n$

$(\because m_p + m_e = \text{Mass of hydrogen atom} = m_H)$

Let M = Actual atomic mass as determined experimentally then, Δm = Mass defect = M' –M.

Binding Energy : Loss of mass during the formation of the nucleus from nucleons is converted into energy. The release of energy imparts stability to the nucleus. The energy released when constituent nucleons combine to form a nucleus, is called binding energy of the nucleus. In other words, energy equal to binding energy will be needed to break up the nucleus into its constituent nucleons. Consequently, the greater the binding energy, the more stable is the nucleus.

Binding Energy and Nuclear Stability :

$$\text{B.E.per nucleon} = \frac{\text{B.E}}{\text{No. of nucleons}}$$

Binding energy per nucleon is a direct indicator of its nuclear stability. Higher the binding energy per nucleon of an isotope, greater is its nuclear stability.

LECTURE SHEET

EXERCISE

(Radioactivity : Isotopes, Isobars, Kinetics of radioactive decay, Carbon dating, Nuclear reaction and applications)

LEVEL-I (MAIN)

Straight Objective Type Questions

1. Which one of the following nuclear reaction is correct :
   1) ${}_6C^{13} + {}_1H^1 \rightarrow {}_7N^{13} + {}_{-1}\beta^0 + \gamma$
   2) ${}_{11}Na^{23} + {}_1H^1 \rightarrow {}_{10}Ne^{20} + {}_2He^4$
   3) ${}_{13}Al^{23} + {}_0n^1 \rightarrow {}_{11}Na^{23} + {}_{-1}e^0$
   4) ${}_{12}Mg^{24} + {}_2He^4 \rightarrow {}_{13}Al^{27} + {}_0n^1$

2. Decrease in atomic no. is observed during :
   1) Alpha emission 2) Electron capture 3) Positron emission 4) all

3. The number of $\alpha-$ and $\beta-$ particles emitted during the transformation of ${}^{232}_{90}Th$ to ${}^{208}_{82}Pb$ is respectively.
   1) 2, 2 2) 4, 2 3) 6, 4 4) 8, 6

4. The number of $\beta-$ particle emitted during the change ${}_aX^c \rightarrow {}_dY^b$ is :
   1) $\frac{a-b}{4}$ 2) $d+\left[\frac{a-b}{2}\right]$ 3) $d-a+\left[\frac{c-b}{2}\right]$ 4) $d+\left[\frac{a-b}{2}\right]-c$

5. The triad of nuclei that represents isotopes is :
   1) ${}_6C^{14}, {}_7N^{14}, {}_9F^{19}$ 2) ${}_6C^{12}, {}_7N^{14}, {}_9F^{19}$ 3) ${}_6C^{14}, {}_6C^{13}, {}_6C^{12}$ 4) ${}_6C^{14}, {}_7N^{14}, {}_9F^{17}$

6. Which of the following nuclei is unstable?
   1) ${}_5B^{10}$ 2) ${}_4Be^{10}$ 3) ${}_7N^{14}$ 4) ${}_8O^{16}$

7. Neutrons are more effective projectiles than protons because they
   1) Are attracted by the nuclei 2) Are not repelled by the nuclei
   3) Travel with high speed 4) None of above

8. The end product of (4n + 2) disintegration series is
   1) ${}_{82}Pb^{204}$ 2) ${}_{82}Pb^{208}$ 3) ${}_{82}Pb^{206}$ 4) ${}_{82}Pb^{209}$

9. The negative value of packing fraction indicates that the isotope is
   1) Unstable 2) Very stable 3) Artificial 4) Stable

10. The number of protons and neutrons for most stable element is
    1) Even-odd 2) Even-even 3) Odd-odd 4) Odd-even

11. If a radioactive element is placed in an evacuated container its rate of disintegration
    1) will be increased 2) will be decreased
    3) will change very slightly 4) will remain unchanged

12. C-14 has a life of 5760 years. 100 mg of sample containing C-14 is reduced to 25 mg in
    1) 11520 years 2) 2880 years 3) 1440 years 4) 17280 years

13. One curie of activity is equivalent to
 1) 3.7×10^{7} disintegrations per second 2) 3.7×10^{10} disintegrations per second
 3) 3.7×10^{4} disintegrations per second 4) None

14. The activity of a radionuclide (X^{100}) is 6.023 curie. If the disintegration constant is 3.7×10^{4} sec^{-1}, the mass of radionuclide is :
 1) 10^{-14}g 2) 10^{-6} g 3) 10^{-15} g 4) 10^{-3} g

15. A radioactive substance has a halflife of 50 days. Fraction of the material left behind after 100day will be :
 1) 50% 2) 75% 3) 12.5% 4) 25%

16. The equipment used to carry out nuclear reaction in a controlled manner is called
 1) Breeder reactor 2) Nuclear reactor 3) Thermonuclear fission 4) Cyclotron

17. Which of the following is not a fissionable material ?
 1) U^{238} 2) U^{234} 3) Pu^{239} 4) U^{235}

18. It two light nuclei are fused together in nuclear reaction, the average energy per necleon
 1) Increases 2) Decreases
 3) Cannot be determined 4) Remains same

19. In nuclear reactors heavy water is used as
 1) Fuel 2) Projectile 3) moderator 4) Arrester

20. The radioisotope used in the treatment of cancer is
 1) C - 12 2) Co-60 3) I^{131} 4) P-31

21. Which of the radioactive isotopes is used for temperature control in blood disease?
 1) $_{15}P^{32}$ 2) H^{3} 3) Rn^{232} 4) I^{131}

Numerical Value Type Questions

22. In the sequence of the following nuclear reaction $^{238}_{98}X \xrightarrow{-\alpha} Y \xrightarrow{-\beta} Z \xrightarrow{-\beta} L \xrightarrow{n\alpha} {}^{218}_{90}M$
 What is the value of n

23. The $^{235}_{92}U$ disintegrates to give 4α and 6β particles. The atomic number of the end product is

24. The binding energy of an element is 64 MeV. If BE/nucleon is 6.4, the number of nucleons are :

25. A radioisotope has half life of 10 years. what percentage of the original amount of it would you expect to remain after 20 years?

26. If 75% quantity of a radioactive isotope disintegrates in 2 hour, its half life would be _____ minute.

LEVEL-II (ADVANCED)

Straight Objective Type Questions

1. Atomic weight of Th is 232 and its atomic number is 90. The number of $\alpha-$ and $\beta-$ particles which will be lost so that an isotope of lead (atomic weight 208 and atomic number 82 is produced is
 a) $4\alpha+6\beta$ b) $6\alpha+4\beta$ c) $8\alpha+2\beta$ c) $10\alpha+2\beta$

2. In which of the following the magic numbers of both protons and neutrons are present
 a) $_{50}Sn^{123}$ b) $_{82}Pb^{208}$ c) $_{82}Pb^{206}$ d) $_{50}Sn^{118}$

3. The halflife of I^{131} is 8 days. Given a sample of I^{131} at t = 0, we can assert that :
   a) No nucleus will decay at t = 4 days
   b) No nucleus will decay before t = 8 days
   c) All nucleus will decay before t = 16 days
   d) A given nucleus may decay at any time after (t = 0)

4. A wooden article and a freshly cut tree show activity 7.6 counts $min^{-1}g^{-1}$ and 15.2 counts $min^{-1}g^{-1}$ of carbon ($t_{1/2}$ = 5760year) respectively. The age of the article is :
   a) 5760 year b) $5760\times\frac{15.2}{7.6}$ year c) $5760\times\frac{7.6}{15.2}$ year d) 5760×(15.2–7.6) year

5. The radioactive decay rate of a radioactive element is found to be 10^3 dps at a certain time. If the half life of element is 1sec, the decay rate after 1 sec, is ____ and after 3 sec, is ___
   a) 500, 125 b) 125, 500 c) 10^3, 10^3 d) 100, 10

6. The counting rate observed from a radioactive source at t = 0 seconds was 1600 counts/sec and at t = 8 sec it was 100 counts/sec. The counting rate observed as count per sec at t = 6 sec will be
   a) 400 b) 300 c) 200 d) 150

7. The number of millimoles of ${}^{14}_{6}C$ equivalent to one millicurie, if $t_{1/2} = 5570$ year and 1 curie = 3.7×10^{10} dps is
   a) 1.56×10^{-2} b) 3.12×10^{-2} c) 4.34×10^{-2} d) 7.80×10^{-2}

8. If N_0 is the initial number of nuclei, number of nuclei ramaining undecayed at the end of nth half life is :
   a) $2^{-n}N_0$ b) 2^nN_0 c) $n^{-2}N_0$ d) n^2N_0

9. The 4n series starts from Th-232 and ends at
   a) Pb-208 b) Bi-209 c) Pb-206 d) Pb-207

10. Living things contain C^{12} and C^{13}, C^{12} is stable and C^{13} decays and declines in proportional quantity. The technique that used this principle for determining the age of fossils skeletons, old trees, and dinosaurs is called
    a) C-12 dating b) Radiocarbon dating c) Carbon age d) Fossil carbon

11. A radioactive substance (parent) decays to it's daughter element, the age of radioactive substance (t) is related to the daughter (d) parent (p) ratio by the equation :
    a) $t=\frac{1}{\lambda}\ln\left(1+\frac{p}{d}\right)$ b) $t=\frac{1}{\lambda}\ln\left(1+\frac{d}{p}\right)$ c) $t=\frac{1}{\lambda}\ln\left(\frac{d}{p}\right)$ d) $t=\frac{1}{\lambda}\ln\left(\frac{p}{d}\right)$

12. The decay of a radioactive element follows first order kinetics. Thus,
    a) Half-life period = a constant/K, where K is decay constant
    b) The rate of decay is independent of temperature
    c) The rate can be altered by changing chemical conditions
    d) The element will be compleely transformed into new element after expiry of two half-life period

13. Slow neutrons can bring about the fission of
    a) ${}_{92}U^{235}$ b) ${}_{82}U^{238}$ c) ${}_{82}Pb^{207}$ d) ${}_{88}U^{226}$

14. Which of the following pairs are isodiapheric pairs ?

a) $_{29}Cu^{65}$ and $_{24}Cr^{55}$ b) $_{29}Cu^{65}$ and $_{24}Cr^{52}$ c) $_{92}U^{235}$ and $_{90}Th^{231}$ d) $_{92}U^{238}$ and $_{90}Th^{231}$

More than One correct answer Type Questions

15. If the densities of nuclei of $_1H^1$ and $_{92}U^{238}$ are X & Y respectively, then incorrect relation is

a) X = Y b) X < Y c) Y = 92X d) Y=238 X

16. Which among these is/are correctly matched ?

a) Positron emission : n/p ratio increase b) K - electron capture : n/p decreases

c) $\beta-$ decay : n/p ratio decreases d) α – decay : n/p ratio increases

17. Which of the following are doubly magic?

a) $^{4}_{2}He$ b) $^{16}_{8}O$ c) $^{208}_{82}Pb$ d) $^{238}_{92}U$

18. Decrease in atomic number is observed during :

a) $\alpha-$ emission b) $\beta-$ emission c) positron emission d) electron capture

19. Which of the following are $\alpha-$ emitters?

a) Po^{213} b) Pb^{215} c) Rn^{222} d) Ra^{226}

20. Which of the following nuclides belong to actinium (U^{235}) series?

a) Pb^{207} b) Po^{215} c) Po^{213} d) $_1H^3$

21. Which among the following nuclides is/are likely to be stable?

a) $_{49}In^{114}$ b) $_{12}Mg^{24}$ c) $_{48}Cd^{114}$ d) $_{15}P^{30}$

22. Which of the following is/are true?

a) The most of radioactive element present in pitchblende is uranium

b) P=32 is use for the treatment of leukaemia

c) CO_2 present in the air contains C-12 only

d) Emission of γ -rays changes the mass number but not atomic number

Linked Comprehension Type Questions

Passage-I :

*The emission of penetraing α,β - particles ($^{4}_{2}$**He and** $^{0}_{-1}$**e respectively**) along with γ -radiation (hv) was noticed from unstable nuclei. All elements having Z > 82 show this phenomenon.The emission was explained in terms of low binding energy (giving $\alpha-$decay), high n/p ratio (neutron decay). γ -emission from a radioactive nuclide is secondary emission.*

23. An element of group III with At. no. 90 and mass number 238 undergoes decay of one α -particle. The newly formed element belongs to :

a) I b) II c) III d) IV

24. The emission of penetrating rays from a radioactive species can be shielded by :

a) Bi blocks b) Pb blocks c) C blocks d) Mg blocks

25. The binding energy of the hydrogen nuclide is :

a) zero b) 13.6 eV c) > 13.6 eV d) < 13.6 eV

Passage-II :

It has been estimated that the total power radiated by the sun is 3.8×10^{26} J per second. The source of energy of stars is a thermonuclear fusion reaction. Energy released in the process of fusion is due to mass defect. $Q = \Delta mc^2$

26. B.E. per nucleon of ${}_1^2H$ and ${}_2^4He$ are 1.1 MeV and 7 MeV respectively. If two deuteron nuclei react to form a single helium nucleus, then the energy released is :

a) 13.9 Mev b) 26.9 Mev c) 23.6 Mev d) 19.2 Mev

27. Mass equivalent to energy 931 Mev is :

a) 6.023×10^{-27} kg b) 1.66×10^{-27} kg

c) 16.66×10^{-27} kg d) 16.02×10^{-27} kg

28. In a nuclear reaction, ${}_1^2H + {}_1^2H \rightarrow {}_2^3He + {}_0^1n$ if the masses of ${}_1^2H$ & ${}_2^3He$ are 2.014741 amu and 3.016977 amu respectively, then the Q-value of the reaction is nearly :

a) 0.00352 Mev b) 3.63 Mev c) 0.82 Mev d) 2.45 Mev

Passage-III :

Unstable nuclei attain stability through disintegration. The nuclear stability is related to neutron proton ratio (n/p). For stable nuclei n/p ratio lies close to unity for elements with low atomic numbers (20 or less) but it is more than 1 for nuclei having higher atomic numbers. Nuclei havign n/p ratio either very high or low undergo nuclear transformation. When n/p ratio is higher than requird for stability, the nuclei have the tendency to emit β-rays. Which when n/p ratio is lower than required for stability, the nuclei either emits α-particles or a positron or capture K-electron.

29. Unstable substance exhibit high radioactivity due to

a) Low p/n ratio b) high p/n ratio c) p/n = 1 d) None

30. β-particle is emitted in radioactivity by

a) Conversion of proton to neutron

b) Conversion of neutrons to proton

c) β- particle is not emitted

d) None

31. Among the following nuclides, the highest tendency to decay by $\beta^{\oplus}$ emission is

a) Cu^{68} b) Cu^{59} c) Cu^{69} d) Cu^{67}

Passage-IV :

In nuclear reactor, moderator is used to slow down the neutrons produced during nuclear fission. Heavy water or graphite moderators slow down the speed of neutrons. The essential characteristics of a moderator are :

i) Its molar mass must be low

ii) It should not absorb neutrons

iii) It should undergo elastic collision with neutrons

32. The moderator in a reactor
   a) Absorbs neutrons
   b) Accelerate neutrons
   c) Slows down neutrons
   d) Absorbs thermal energy produced in the reactors

33. Which of the following is not used as the moderator ?
   a) Heavy water b) Graphite
   c) Beryllium d) Sodium

34. Moderator in the reactor yields
   a) Fast moving neutron b) Thermal neutron
   c) Magnetic neutron d) Electric neutron

Matrix Matching Type Questions

35.

Column-I	Column-II
A) Proton rich nuclides	p) K-electron capture
B) Artificially prepared element	q) Proton emission
C) ${}^{11}_{6}C$	r) Positron emission
D) C - N cycle	s) ${}^{97}_{43}Tc$

36.

Column-I (Particles emitted)	Column-II (Result)
A) One α -particle	p) Isobar
B) One α - and two β - particles	q) Isotope
C) One β - particle	r) Isodiapher
D) γ -radiation	s) Atomic number reduced by two and mass number by four
	t) Nuclear de-excitation

37.

Column-I	Column-II (Characteristic Use)
A) ${}^{32}P$	p) Location of tumour in brain
B) ${}^{24}Na$	q) Location of blood clot and circulatory disorders
C) ${}^{60}Co$	r) Radiotherapy
D) ${}^{131}I$	s) Agriculture research

Integer Type Questions

38. The number of following unstable nucleides emitted β-particle. ${}_{20}Ca^{40}$, ${}_{53}I^{133}$, ${}_{53}I^{121}$, ${}_{90}Th^{232}$, ${}_{6}C^{14}$, ${}_{7}N^{13}$, ${}_{92}U^{235}$

39. The halflife of C-14 is 5600 years. A sample of freshly cut wood from a tree contains 10 mg of C-14. The amount left in the sample after 50000 years is (a – x). The value of (a–x) × 100 is

40. In the following given numbers, how many are the magic numbers ?
   2, 8, 20, 50, 113, 126, 141, 148, 300, 314

KEY SHEET (LECTURE SHEET)

EXERCISE

LEVEL-I

1) 2	2) 4	3) 3	4) 3	5) 3	6) 2	7) 2	8) 3
9) 4	10) 2	11) 4	12) 1	13) 2	14) 3	15) 4	16) 2
17) 1	18) 2	19) 3	20) 2	21) 1	22) 4	23) 90	24) 10
25) 25	26) 60						

LEVEL-II

1) b	2) b	3) d	4) a	5) a	6) c	7) a	8) a
9) a	10) b	11) b	12) a	13) a	14) c	15) bcd	16) acd
17) abc	18) acd	19) ad	20) ab	21) bc	22) bc	23) b	24) b
25) a	26) c	27) b	28) b	29) a	30) b	31) d	32) c
33) b	34) a	35) A-pqr; B-s; C-r; D-r			36) A-rs; B-q; C-p; D-t		
37) A-s; B-q; C-r; D-p			38) 3	39) 2	40) 5		

PRACTICE SHEET

EXERCISE

(Radioactivity : Isotopes, Isobars, Kinetics of radioactive decay, Carbon dating, Nuclear reaction and applications)

LEVEL-I (MAIN)

Straight Objective Type Questions

1. Which of the following isotopes is likely to be most stable?
   1) $^{71}_{30}Zn$ 2) $^{66}_{30}Zn$ 3) $^{64}_{30}Zn$ 4) None of these
2. The radioactive decay produces the species with fastest speed is
   1) α 2) β 3) γ 4) positron
3. A nucleus with an excess of neutrons may decay radioactively with the emission of
   1) a neutron 2) a proton 3) an electron 4) a positron
4. $^{27}_{13}Al$ is a stable isotope. $^{29}_{13}Al$ is expected to disintegrate by
   1) α-emission 2) β-emission 3) positron emission 4) proton emission
5. $^{11}_{6}C$ on decay produces
   1) positron 2) β-particle 3) α-particle 4) none of these
6. In α-decay, n/p ratio
   1) May increase or decrease 2) Remain constant
   3) Decreases 4) Increases

7. In n/p ratio is high, the nucleus tends to stabilize by
   1) The emission of a β-particle 2) Neutron capture
   3) Losing a position 4) Any one of the above

8. In which of the following decays n/p remains constant?
   1) α-emission 2) β-emission 3) γ-emission 4) none

9. A radio active isotope has a half-life of 10 day. If today there are 125g of left, what was its original mass 40 day earlier?
   1) 600 g 2) 1000g 3) 1250g 4) 2000g

10. A sample of rock from moon contains equal number of atoms of uranium and lead ($t_{1/2}$ for $U = 4.5 \times 10^9$ year). The age of the rock would be
    1) 4.5×10^9 year 2) 9×10^9 year 3) 13.5×10^9 year 4) 2.25×10^9 year

11. A radio active substance decays 10% in 5 days. The amount remains after 20 days is [log3 = 0.4711]
    1) 90% 2) 81% 3) 72.9% 4) 65.61%

12. If 50 gms of radio active substance has half life period of 14 hrs. 2 gms of the same substance will have half life of
    1) 56 hrs 2) 3.5 hrs 3) 14 hrs 4) 28 hrs

13. The time of decay for the nuclear reaction is given by $t = 5t_{1/2}$. The relation between average life 'τ' and time of decay (t) is given by
    1) $3\tau \ln 2$ 2) $4\tau \ln 2$ 3) $5\tau \ln 2$ 4) $6\tau \ln 2$

14. A radioactive nuclide is produced at a constant rate of α per second. Its decay constant is λ. If N_0 be the number of nuclei at time t = 0, then what will be the maximum number of possible nuclei ?
    1) $\frac{\alpha}{\lambda}$ 2) $N_0 + \frac{\alpha}{\lambda}$ 3) N_0 4) $\frac{\lambda}{\alpha} + N_0$

15. Calculate the time in which activity of an element reduces to 90% of its original value. The half-life period of the element is 1.4×10^{10} years
    1) $t = 2.13 \times 10^9$ years 2) 1.4×10^9 years 3) 3.21×10^{10} years 4) 1.21×10^9 years

16. Which one of the following nuclear transformation is (n,p) type?
    1) ${}_3Li^7 + {}_1H^1 \longrightarrow {}_4Be^7 + {}_0n^1$ 2) ${}_{33}As^{75} + {}_2He^4 \longrightarrow {}_{35}Br^{78} + {}_0n^1$
    3) ${}_{83}Bi^{209} + {}_1H^2 \longrightarrow {}_{84}Po^{210} + {}_0n^1$ 4) ${}_{21}Sc^{45} + {}_0n^1 \longrightarrow {}_{20}Ca^{45} + {}_0H^1$

17. In a nuclear explosion, the energy is released in the form of
    1) Thermal energy 2) Kinetic energy
    3) Potential energy 4) Electrical energy

18. Insert the missing figure in the following ${}_{25}Mn^{55}(n,\gamma) \longrightarrow$
    1) ${}_{25}Mn^{26}$ 2) ${}_{24}Cr^{56}$ 3) ${}_{24}Mn^{56}$ 4) ${}_{24}Cr^{56}$

19. Which one of the following is an artifical fuel for nuclear reactor?
    1) U^{238} 2) Pu^{238} 3) U^{235} 4) Th^{232}

Numerical Value Type Questions

20. The disintegration constant of radioactive nuclide (X^{100}) is 3.7×10^4 sec^{-1}. If mass of the radioactive nuclide is equal to 2×10^{-15} gm. Then find the radioactivity of the nuclide in curies (Take N_0 = 6.022×10^{23})

21. One mole of A present in a closed vessel undergoes dacay as ${}_{Z}^{m}A \rightarrow {}_{Z-4}^{m-8}B + 2{}_{2}^{4}He$. The volume of He collected at NTP after 20 days is ($t_{1/2}$ = 10 days)

22. The halflife period of a radioactive substance is 10 year. The amount of the substance decayed after 40 years would be ____ %

23. One microgram of phosphorus-32 was injected into a live system for biological studies. The halflife of ${}_{15}P^{32}$ is 14.3 days, calculate the time it will take the radioactivity to fall to 10% of the initial value

24. A radio active isotope having a half-life of 3 days was received after 12 days. It was found that there were 3 gm of the isotope in the container. The initial weight of the isotope when packed was

25. The activity of a sample of radioactive element X^{100} is 6.02 curie. Its decay constant is $3.7\times10^4 s^{-1}$. The inital mass of the sample will be 10^xg, x = ___

26. At radioactive equilibrium, the ratio of two atoms A and B are $3.1 \times 10^9 : 1$. If half life of A is 2×10^{10} years, then what is the half life of B (in years) ?

LEVEL-II (ADVANCED)

Straight Objective Type Questions

1. Calculate the neutron-proton ratio for ${}_6C^{14}$ radioactive nuclide
   a) 1.33 b) 1.58 c) 1.0 d) 1.66

2. Which of the following order is incorrect about α, β and γ
   a) Increasing order of mass $\gamma < \beta < \alpha$
   b) Penetration power $\alpha < \beta < \gamma$
   c) Speed of particles $\alpha < \beta < \gamma$
   d) Ionization capacity $\beta < \gamma < \alpha$

3. Which of the following has magic number of neutrons?
   a) ${}_{13}Al^{27}$ b) ${}_{83}Bi^{209}$ c) ${}_{92}U^{238}$ d) ${}_{26}Fe^{56}$

4. Least branching is found in which of the following radioactive series?
   a) 4n + 2 b) 4n c) 4n + 3 d) 4n + 1

5. The density of nucleus is about ___ times the density of atom
   a) 10^{-14} b) 10^{12} c) 10^{-8} d) 10^{10}

6. The binding energy of an element is 64 MeV. If BE/nucleon is 6.4, then the number of nucleons are
   a) 10 b) 64 c) 16 d) 6

7. In a sample of radioactive material, what fraction of the initial number of active nuclei will remain undisintegrated after half of a half life of the sample ?
   a) $\frac{1}{4}$ b) $\frac{1}{2\sqrt{2}}$ c) $\frac{1}{\sqrt{2}}$ d) $\sqrt{2}-1$

8. 80% of the radioactive nuclei present in a sample is found to remain undecayed after one day. The percentage of undecayed nuclei left after two days will be

a) 64 b) 20 c) 46 d) 80

9. **(A) :** The average life of a radioactive element is infinity.

(R) : As a radioactive element disintegrates, more of it is formed in nature by itself.

a) If both (A) and (R) are correct, and (R) is the correct explanation of (A)

b) If both (A) and (R) are correct, but (R) is not the correct explanation of (A)

c) If (A) is correct, but (R) is incorrect

d) If both (A) and (R) are incorrect

More than One correct answer Type Questions

10. Which of the following not indicated the radius of $_{Z}M^{A}$ nucelus is (outer most configuration $3s^2 3p^1$ and A + Z = 40)

a) 4.2 Fm b) $1.4 \times \sqrt[3]{40}$ Fm

c) $1.4 \times \sqrt[2]{40}$ Fm d) 1.4×40 Fm

11. A radioactive element A decays by the sequence and with half-lives given below:

$$A \xrightarrow[30\,min]{\alpha} B \xrightarrow[2days]{2\beta} C$$

Which of the following statements about this system are correct?

a) The mass number of B is greater than A

b) After two hours, less than 10% of the initial A is left.

c) maximum amount of B present at any time is less than 50% of the initial amount of A.

d) The atomic numbers of A and C are same

12. Which of the following statement is/are correct?

a) The decay constant is independent of external factors like temperature and pressure.

b) Nuclear isomers have same number of protons and neutrons

c) The decay constant is independent of the amount of substance used

d) The value of decay constant generally decreases with rise in temperature.

13. Correct statement is/are

a) when one mole of Radium converted to $Ra_3(PO_4)_2$ activity increases

b) when one mole of Radium converted to $Ra_3(PO_4)_2$ activity decreases

c) when one mole of Radium converted to $Ra_3(PO_4)_2$ activity remains constant

d) among one mole of Radium and one mole $Ra_3(PO_4)_2$ samples, more activity is observed in $Ra_3(PO_4)_2$ sample

14. Which of the following statements are correct?

a) The rest mass of a stable nucleus is lesser than the sum of the rest masses of its separated nucleons

b) The rest mass of a stable nucleus is greater than the sum of the rest masses of its separated nucleons

c) In nuclear fusion, energy is released by fusin two nulei of medium ass (approximately 100 amu)

d) In nuclear fusion, energy is released by fragmentation of a very heavy nucleus

15. It is observed that only 0.39% of the original radioactive sample remains undecayed after eight hours. Hence

a) the half-life of that substance is 1 hour

b) the mean life of the substance is $\frac{1}{\log_e 2}$ hour

c) decay constant of the substance if $(\log_e 2)$ hour^{-1}

d) If the number of radioactive nuclei of this substance at a given instant is 10^8, then the number left after 30 min would be $\sqrt{2}\times10^9$

16. Radon undergoes decay by α -emission $^{288}_{88}Rn \xrightarrow{t_{1/2}=3.8\ decay} {}^{218}_{84}Po + {}^{4}_{2}He$

Which of the following statements will be true for this decay process?

a) If the initial amount of radon was 1mg, the amount of radon left after 11.4 days will be 0.125 mg

b) Activity of radon after 7.6 days will be $N_0 \times (5.3 \times 10^{-7})s^{-1}$ where N_0 is the original number of atoms of the radon

c) The decay constant of radon is $2.1\times10^{-6}s^{-1}$

d) 60% of the radon will decay in 5 days approximately

17. Carbon-14 dating method is not based on the fact that

a) carbon-14 fraction is same in all objects

b) carbon-14 is highly insoluble

c) ratio of carbon-14 and carbon-12 remains constant during disintegration

d) carbon-14 is highly soluble

18. Select the correct statement(s)

a) ^{131}I is used for the treatment of thyroid cancer

b) ^{59}Co cannot be used for treatment of cancer

c) ^{33}P is used for treatment of leukemia

d) Excessive use of radioactive elements cause cancer

Linked Comprehension Type Questions

Passage-I :

Radioactive decay is a statisticle process i,e., we cannot precisely predict the timing of a particular radioactivity of a particular nucleus. The nucleus can disintegrate immediately or it may take infinite time. Simply the probability of the number of nuclei being disintegrated at any instant can be predicted. The rate at which a particular decay process in a radioactive sample is directly proportional to the number of radioactive nuclei present and thus obeys first order kinetics. The factor dN/N expresses the fraction of nuclei decayed in time dt. $t_{1/2}$ is the time in which half of the atoms are decayed and average life is the time for the nucleus to survive before decay.

19. Which of the following relation is correct? ($t_{1/2}$ and $t_{3/4}$ are time requited to complete half and 3/4 decay respectively)

a) $t_{1/2} = 2 \times t_{3/4}$ b) $t_{1/2} = 3 \times t_{3/4}$ c) $t_{3/4} = 2 \times t_{1/2}$ d) $t_{3/4} = 3 \times t_{1/2}$

20. A freshly prepared radioactive source of half period 2 hour emits radiations of intensity which is 64 times of the permissible safe level. The minimum time after which it would be possible to work with this source is :

a) 16 hrs b) 12hrs c) 20hrs d) 24 hrs

21. 75 atoms of a radioactive species are decayed in 2 half lives ($t_{1/2}$ = 1 hr) if 100 atoms are taken initially. Number of atoms decayed if 200 atoms are taken in 2 hr are :

a) 75 b) 150 c) 50 d) 200

Passage-II :

The source of energy of starts is nuclear fusion. Fusion reaction occurs at very high temperature, about 10^7K. Energy released in the process of fusion is due to mass defect. It is also called Q-value. $Q = \Delta mc^2$, Δm = mass defect.

22. The binding energy per nucleon of $_1H^2$ and $_2He^4$ are 1.1MeV and 7MeV respectively. If two deuteron nuclei react to form a single helium nucleus, then the energy released is

a) 13.9 MeV b) 26.9 MeV c) 23.6 MeV d) 19.2 MeV

23. Mass equivalent to the energy 931MeV is

a) 6.02×10^{-27} kg b) 1.662×10^{-27} kg c) 16.666×10^{-27}kg d) 16.02×10^{-27}kg

24. A star has 10^{40} deuterons. It produces energy via the process

$_1H^2 +_1 H^2 \longrightarrow _1H^3 +_1 H^1$; $_1H^2 +_1 H^3 \longrightarrow _2He^4 +_0 n^1$

If the average power radiated by the star is 10^{16}W, then the deuteron supply of the star is exhausted in a time of the order of

a) 10^6s b) 10^8s c) 10^{12}s d) 10^{16}s

Matrix Matching Type Questions

25. **Column-I** | **Column-II**

Column-I	Column-II
A) $_{11}Na^{23}$ + ... $\rightarrow$ $_{11}Na^{24}$ + ...	p) $_0n^1$
B) $2_1H^3 \rightarrow {}_2He^4 + 2$	q) $_1H^1$
C) $_{92}U^{238} \rightarrow {}_{90}Th^{234}$ + ...	r) $_2He^4$
D) $_{29}Cu^{63} \rightarrow {}_{28}Ni^{63}$ + ...	s) $_1e^0$
	t) $_1H^2$

26.

Column-I	Column-II
A) $^{40}_{20}Ca$	p) Unstable, α -emitter
B) $^{133}_{53}I$	q) Unstable, β -emitter
C) $^{121}_{53}I$	r) Unstable, positron emitter
D) $^{232}_{90}Th$	s) Stable

27.

Column-I	Column-II
A) Isotones	p) $_{91}Pa^{234}$ and $_{90}Th^{234}$
B) Isobars	q) $_6C^{12}$ and $_6C^{14}$
C) Isotopes	r) $_{19}K^{39}$ and $_9F^{19}$
D) Isodiaphers	s) $_{18}Ar^{39}$ and $_{19}K^{40}$

Integer Type Questions

28. After 20 min, the amount of certain radioactive substance disintegrate was 15/16th original amount. What is the half-life of the radioactive substance?

29. A, B and C are isodiaphers while C, D and E are isobars. Calculate the difference of protons between A and E_{82}^{206}. $A \rightarrow B \rightarrow C \rightarrow D \rightarrow E$. Given : Isodiaphers and isobars are formed in successive the number of α and β-emitted respectively x and y. Then x + y value is

30. Counter rate meter is used to measure the activity of a radioactive sample. If at certain instant, the count rate was recorded as 475 counter per minute. Five minutes later, the count rate recorded was 270 counts per minute. What is the half life period if the same in minutes?

31. If $t_{3/4}$ and $t_{1/2}$ are time required for completion of 3/4 decay and 1/4 decay, then $t_{3/4} = t_{1/2} \times n$. n is

32. A positron and an electron collide and annihilated to emit two gamma photons of same energy. Calculate the wavelength in pm corresponding to this gamma emission.

KEY SHEET (PRACTICE SHEET)

EXERCISE

LEVEL-I

1) 3 2) 3 3) 3 4) 2 5) 1 6) 4 7) 1 8) 3
9) 4 10) 1 11) 4 12) 3 13) 3 14) 1 15) 1 16) 4
17) 1 18) 1 19) 2 20) 12.04 21) 33.6 22) 93.75
23) 47.52 24) 48 25) –15 26) 6.45

LEVEL-II

1) a 2) d 3) b 4) d 5) b 6) a 7) c 8) a
9) c 10) bcd 11) bd 12) bcd 13) cd 14) ad 15) abcd 16) abc
17) abd 18) ab 19) c 20) b 21) b 22) c 23) b 24) d
25) A-q; B-p; C-r; D-s 26) A-s; B-r; C-q; D-p 27) A-s; B-p; C-q; D-r
28) 5 29) 4 30) 6 31) 2 32) 2

ADDITIONAL PRACTICE EXERCISE

LEVEL-I (MAIN)

Straight Objective Type Questions

1. ^{23}Na is the more stable isotope of Na. Find out the process by which $^{24}_{11}N$ can undergo radioactive decay.
   1) β^- emission 2) α emission 3) β^+ emission 4) K electron capture

2. Two radioactive nucides X and Y have half lives of 30 and 10 minutes respectively. A sample contains the number of nuclides of Y to 4 times that of X. How much time should elapse so that the number of nuclides of X and Y become equal ?
   1) 60 min 2) 30 min 3) 20 min 4) 15 min

3. A radioactive nuclide emits γ-rays due to :
   1) K–electron capture
   2) nuclear transition from highe to lower energy state
   3) presence of greater number of neutrons than protons
   4) presence of greater number of protons than neutrons

4. A certain radioactive material ${}_{Z}^{A}X$ starts emitting α and β particles successively such that the end product is ${}_{Z-3}^{A-8}Y$. The number of α and β particles emitted are
   1) 4 and 3 respectively
   2) 2 and 1 respectively
   3) 3 and 4 respectively
   4) 3 and 8 respectively

LEVEL-II

LECTURE SHEET (ADVANCED)

More than One correct answer Type Questions

1. ${}_{92}^{238}U$ (III B) undergoes following emissions :
   ${}_{92}^{238}U \xrightarrow{-\alpha} A \xrightarrow{-\alpha} B \xrightarrow{-\beta} C$. Which statement(s) is/are incorrect?
   a) A will be of IB group
   b) A will be of IIIB group
   c) B will be of IIA (alkaline earth metal) group
   d) C will be IIIA (boron family) group

2. Target nucleus A is converted to product nucleus B by (p, n) as : A(p, n) B :
   In this case is/are not observed
   a) A and B are isotopes
   b) A and B are isobars
   c) A and B are isotone
   d) B has higheratomic number than that of A

3. Select incorrect statement(s):
   a) ${}^{131}I$ is used for the treatment of thyroid cancer
   b) ${}^{60}Co$ can be used for treatment of cancer
   c) Traces of ${}^{24}Na$ is used to detect the presence of tumors
   d) Radioactivite isotpes used in medicines have very short half lives

4. A radioisotope will not emit
   a) alpha rays and gamma-rays subsequently
   b) gamma rays only
   c) alpha and beta rays simultaneously
   d) beta rays and subsequently gamma rays

5. The mass defect of the nuclear reaction ${}_5B^8 \rightarrow {}_4Be^8 + {}_1e^0$ is Δm, the wrong expression is/are
   a) Δm = atomic mass of $({}_4Be^8 - {}_5B^8)$
   b) Δm = atomic mass of $({}_4Be^8 - {}_5B^8)$ + mass of one electron
   c) Δm = atomic mass of $({}_4Be^8 - {}_5B^8)$ + mass of one positron
   d) Δm = atomic mass of $({}_4Be^8 - {}_5B^8)$ + mass of two electron

PRACTICE SHEET (ADVANCED)

Linked Comprehension Type Questions

Passage-I :

Nuclear binding energy is the energy released during the hypothetical formation of the nucleus by the condensation of individual nucleon. Thus, $\text{Binding energy per nucleons} = \dfrac{\text{Total binding energy}}{\text{Number of nucleons}}$

For example, the mass of hydrogen atom is equal to the sum of the masses of a proton and an electron. For other atoms, the atomic mass is less the sum is the masses of protons, netrons and electrons present. This difference in mass, termed as mass defect is measure of the binding energy of protons and neutrons in the nucleus. The mass-energy relationship postulate d by Einstein is expressed as : $\Delta E = \Delta mc^2$ *where* ΔE *is the energy liberated,* Δm *is the loss of mass, and c is the speed of light.*

1. If M_p amd M_n are masses of proton and neutron respectively. For a nucleus it binding energy is B and it contains Z protons and Neutrons, the correct relation for this nucleus if C is velocity of light is :

   a) $M(N,Z) = NM_n + ZM_p - BC^2$ b) $M(N,Z) = NM_n + ZM_p + BC^2$

   c) $M(N,Z) = NM_N + ZM_p - \dfrac{B}{C^2}$ d) $M(N, Z) = NM_n + ZM_p + \dfrac{B}{C^2}$

2. In the reaction ${}_1^2H + {}_1^3H \rightarrow {}_2^4He + {}_0^1n$, if binding energies of ${}_1^2H$, ${}_1^3H$ and ${}_2^4He$ are respectively a, b and c (in MeV), then the energy released in this reaction is :

   a) a + b + c b) a + b – c c) c –(a + b) d) c + a – b

3. How much heat would be developed per hour from 1 curie of C^{14} source if all the energy of beta decay were imprisoned? Atomic masses of C^{14} and N^{14} are 14.00324 and 14.00307 amu respectively.

   a) 3.36 J b) 3.37 J c) 3.38 J d) 3.39 J

Passage-II :

A radioactive nuclide having n/p > 1.0 undergoes α*–decay,* β*–decay successively. The parent element on* α*-decay looses its atomic no. by two units and mass no. by four units. In* β*–decay the parent gains its atomic no. by one unit whereas mass number remains the same. The* γ*-emission occurs only when daughter element possesses some higher than required for its stability.*

4. An element ${}_{90}^{234}Th$ looses an α - particle. If Th belongs to group III, the daughter element belongs to :

   a) Group I b) Group II c) Group III d) zero group

5. If atomic mass of Th is 232.18 and its atomic no. is 90. If it looses $6-\alpha$ and $4-\beta$ particles, the mass no. of finally stable element is :

   a) 208.18 b) 208 c) 226 d) 212

6. In the nuclear decay of an element (Z = 88, electron = 88, neutron = 145) emitting out ${}_2^4He$ nuclei (an α - particle), the number of proton, electron and neutrons in daughter element is :

   a) 86, 88, 143 b) 86, 86, 143 c) 86, 88, 144 d) 86, 86, 142

7. In the nuclear reaction $\overset{60}{Co} \rightarrow \overset{60}{Co}$, the emission occurs as :

   a) X rays b) γ -rays c) α - particle d) K-electron capture

Matrix Matching Type Questions

8. **Column-I** | **Column-II**

Column-I	Column-II
A) α – emission	p) Mass number changes
B) β – emission	q) Atomic number and mass number are unaffected
C) γ – emission	r) Atomic number decreases
D) β^+ -emission	s) Atomic number increases

9. Column-I includes a few types of nuclear reactions and Column-II lists some of the examples of these reactions. Identify each entry in Column-I with those listed in Column-II.

Column-I	Column-II
A) Particle capture reaction	p) ${}^{3}_{1}H + {}^{3}_{1}H \rightarrow {}^{4}_{2}He + 2{}^{1}_{0}n$
B) Nuclear fission reaction	q) ${}^{63}_{29}Cu + {}^{4}_{2}He \rightarrow {}^{137}_{17}Cl + {}^{16}_{10}n + {}^{14}_{11}H$
C) Nuclear fusion reaction	r) ${}^{238}_{92}U + {}^{1}_{0}n \rightarrow {}^{239}_{92}U + \gamma$
D) Spallation reaction	s) ${}^{235}_{92}U + {}^{1}_{0}n \rightarrow {}^{140}_{56}Ba + {}^{94}_{36}Kr + 2{}^{1}_{0}n$

Integer Type Questions

10. An Atom has atomic mass 232 and atomic number 90. During the course of disintegration, it emits 2β – particles and few α – particles. The resultant atom has atomic mass 212 and atomic number 82. How many α – particles are emitted during this process ?

11. The binding energy of an element is 63 MeV. If B.E./ nucleon is 7, the number of nucleons are

KEY SHEET (ADDITIONAL PRACTICE EXERCISE)

LEVEL-I (MAIN)

1) **1** 2) **2** 3) **2** 4) **2**

LEVEL-II

LECTURE SHEET (ADVANCED)

1) **abd** 2) **acd** 3) **acd** 4) **abd** 5) **abc**

PRACTICE SHEET (ADVANCED)

1) **c** 2) **c** 3) **b** 4) **a** 5) **b** 6) **b** 7) **b**

8) **A-pr; B-s; C-q; D-r** 9) **A-r; B-s; C-p; D-q** 10) **5** 11) **9**