ABC CHEMISTRY

Mr. Aniket Bhardwaj · 15+ Years Mentorship

Nuclear Chemistry

Premium CSIR-NET PYQ Book

26 Previous-Year Questions · 19 with verified answers · Distractor Analysis

3-Slide Solutions | Distractor Analysis | Exam Tricks | Revision Sheets

CSIR-NET · GATE · IIT-JAM — 5 Topics · 26 Real PYQs

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Course Contents

5 Topics · 26 PYQs

1	Nuclear Reactions Q Value	6 Qs E 3 · M 3 · H 0	23%
2	Radioactive Decay Kinetics	6 Qs E 1 · M 5 · H 0	23%
3	Isotope Applications	3 Qs E 1 · M 2 · H 0	12%
4	Fission Fusion	3 Qs E 2 · M 1 · H 0	12%
5	Nuclear Chemistry – General	8 Qs E 5 · M 2 · H 1	31%

Legend: **E** Easy **M** Medium **H** Hard · **%** = exam weightage (share of the chapter)

TOPIC 1

Nuclear Reactions Q Value

6 questions · Easy 3 | Medium 3 | Hard 0 · PYQ frequency: High

Q1

For the nuclear reactions. (A) $_{4}^{8}Be \rightarrow 2\ _{2}^{4}He$ (B) $_{36}^{80}Kr \rightarrow 2\ _{18}^{40}Ar$ (Given masses: ^{8}Be = 8.005300, ^{4}He = 4.002603 and $_{36}^{80}Kr$ = 79.81638, $_{18}^{40}Ar$ = 39.96238) The correct statement is:

A (A) and (B) are both spontaneous fission processes

B (A) is spontaneous fission but (B) is not

C (B) is spontaneous fission but (A) is not

D Both (A) and (B) are not spontaneous fission processes

QUESTION INSIGHTS

ESTIMATED TIME
1–1.5 min

DIFFICULTY
Easy

CONCEPT TESTED
Nuclear Reactions Q Value

PYQ FREQUENCY
High · 5 papers

REVISION PRIORITY
★★★☆☆

EXPECTED LEVEL
Part B

MEMORY HOOK
'Mass lost = energy gained'.

Nuclear Reactions Q Value

Correct Answer D Both (A) and (B) are not spontaneous fission processes

CONCEPT

Q = (Σm_reactants − Σm_products)c²; Q > 0 exoergic; threshold energy for Q < 0 reactions E_th = −Q(1 + m_a/m_A); reaction notation A(a,b)B; cross-section; fission of ^{235}U, fusion D–T; binding energy per nucleon curve.

↓

LOGIC / WORKING

- ^{8}Be (8.005300) is heavier than 2 × ^{4}He (8.005206), so it splits spontaneously; ^{80}Kr (79.81638) is lighter than 2 × ^{40}Ar (79.92476), so that fission is impossible. (A) spontaneous, (B) not.
- Therefore the answer is (D).

FINAL: (D) Both (A) and (B) are not spontaneous fission processes

SHORTCUT / EXAM TRICK

Balance Z and A first; then Q from atomic masses (electron masses cancel if you use atomic masses consistently).

COMMON MISTAKE

Mixing nuclear and atomic masses; forgetting the recoil factor in threshold energy.

EXAM TIP

Fission fragments are neutron-rich → β^- decay chains.

MEMORY TRICK

'Mass lost = energy gained'.

Why the Other Options Are Wrong

Correct answer: D

A **(A) and (B) are both spontaneous fission processes**

Why (D) is the key — ^{8}Be (8.005300) is heavier than 2 × ^{4}He (8.005206), so it splits spontaneously; $^{8}{}^{0}$Kr (79.81638) is lighter than 2 × $^{4}{}^{0}$Ar (79.92476), so that fission is impossible. (A) spontaneous, (B) not.

B **(A) is spontaneous fission but (B) is not**

Ruled out: Mixing nuclear and atomic masses; forgetting the recoil factor in threshold energy.

C **(B) is spontaneous fission but (A) is not**

Ruled out: Fission fragments are neutron-rich → β^- decay chains.

Q2

Identify radioactive capture from the following nuclear reactions:

A. $^{9}Be(\gamma, n)^{8}Be$

B. $^{23}Na(n, \gamma)^{24}Na$

C. $^{63}Cu(p, p\ 3n\ 9\alpha)^{24}Na$

D. $^{107}Ag(n, n)^{107}Ag$

QUESTION INSIGHTS

ESTIMATED TIME
2–3 min

DIFFICULTY
Medium

CONCEPT TESTED
Nuclear Reactions Q Value

PYQ FREQUENCY
High · 5 papers

REVISION PRIORITY
★★★★☆

EXPECTED LEVEL
Part B / Part C

MEMORY HOOK
'Mass lost = energy gained'.

Nuclear Reactions Q Value

Correct Answer B $^{23}Na(n, \gamma)\ ^{24}Na$

CONCEPT

Q = (Σm_reactants − Σm_products)c²; Q > 0 exoergic; threshold energy for Q < 0 reactions E_th = −Q(1 + m_a/m_A); reaction notation A(a,b)B; cross-section; fission of ^{235}U, fusion D–T; binding energy per nucleon curve.

↓

LOGIC / WORKING

- Radiative capture is (n, γ): $^{23}Na(n, \gamma)^{24}Na$ (b).
- Therefore the answer is (B).

FINAL: (B) $^{23}Na(n, \gamma)\ ^{24}Na$

SHORTCUT / EXAM TRICK

Balance Z and A first; then Q from atomic masses (electron masses cancel if you use atomic masses consistently).

COMMON MISTAKE

Mixing nuclear and atomic masses; forgetting the recoil factor in threshold energy.

EXAM TIP

Fission fragments are neutron-rich → β^- decay chains.

MEMORY TRICK

'Mass lost = energy gained'.

Why the Other Options Are Wrong

Correct answer: B

A ^{9} Be(γ, n) ^{8} Be

Why (B) is the key — Radiative capture is (n, γ): ^{23}Na(n, γ)^{24}Na (b).

C ^{63}Cu(p, p 3n 9α) ^{24}Na

Ruled out: Mixing nuclear and atomic masses; forgetting the recoil factor in threshold energy.

D ^{107} Ag(n, n) ^{107} Ag

Ruled out: Fission fragments are neutron-rich → β^- decay chains.

Q3

Consider the nuclear reaction $_{92}X^{234}+\beta+\alpha \rightarrow Y+\gamma+2\ \beta^{+}$ Y is

A $_{92}Y^{238}$

B $_{91}Y^{238}$

C $_{93}Y^{236}$

D $_{94}Y^{238}$

QUESTION INSIGHTS

ESTIMATED TIME
1–1.5 min

DIFFICULTY
Easy

CONCEPT TESTED
Nuclear Reactions Q Value

PYQ FREQUENCY
High · 5 papers

REVISION PRIORITY
★★★☆☆

EXPECTED LEVEL
Part B

MEMORY HOOK
'Mass lost = energy gained'.

Nuclear Reactions Q Value

Correct Answer B $_{91}Y^{238}$

CONCEPT

Q = (Σm_reactants − Σm_products)c²; Q > 0 exoergic; threshold energy for Q < 0 reactions E_th = −Q(1 + m_a/m_A); reaction notation A(a,b)B; cross-section; fission of ^{235}U, fusion D–T; binding energy per nucleon curve.

↓

LOGIC / WORKING

- Mass: 234 + 4 = 238. Charge: 92 − 1 + 2 = Z(Y) + 2, so Z = 91. Y is $^{238}_{91}Y$ (b).
- Therefore the answer is (B).

FINAL: (B) $_{91}Y^{238}$

SHORTCUT / EXAM TRICK

Balance Z and A first; then Q from atomic masses (electron masses cancel if you use atomic masses consistently).

COMMON MISTAKE

Mixing nuclear and atomic masses; forgetting the recoil factor in threshold energy.

EXAM TIP

Fission fragments are neutron-rich → β^- decay chains.

MEMORY TRICK

'Mass lost = energy gained'.

Why the Other Options Are Wrong

Correct answer: B

A

$_{92}Y^{238}$

Why (B) is the key — Mass: 234 + 4 = 238. Charge: 92 − 1 + 2 = Z(Y) + 2, so Z = 91. Y is $^{238}_{91}Y$ (b).

C

$_{93}Y^{236}$

Ruled out: Mixing nuclear and atomic masses; forgetting the recoil factor in threshold energy.

D

$_{94}Y^{238}$

Ruled out: Fission fragments are neutron-rich → β^- decay chains.

Q4

The species ^{19} Ne and ^{14} C emit a positron and β-particle respectively. The resulting species formed are respectively

A. ^{19} Na and ^{14} B

B. ^{19} F and ^{14} N

C. ^{19} Na and ^{14} N

D. ^{19} F and ^{14} B

QUESTION INSIGHTS

ESTIMATED TIME
2–3 min

DIFFICULTY
Medium

CONCEPT TESTED
Nuclear Reactions Q Value

PYQ FREQUENCY
High · 5 papers

REVISION PRIORITY
★★★★☆

EXPECTED LEVEL
Part B / Part C

MEMORY HOOK
'Mass lost = energy gained'.

Nuclear Reactions Q Value

Correct Answer B ^{19}F and ^{14}N

CONCEPT

Q = (Σm_reactants − Σm_products)c²; Q > 0 exoergic; threshold energy for Q < 0 reactions E_th = −Q(1 + m_a/m_A); reaction notation A(a,b)B; cross-section; fission of ^{235}U, fusion D–T; binding energy per nucleon curve.

↓

LOGIC / WORKING

- β^+ emission lowers Z by 1: ^{19}Ne (Z = 10) → ^{19}F. β^- emission raises Z by 1: ^{14}C (Z = 6) → ^{14}N. Mass number unchanged.
- Therefore the answer is (B).

FINAL: (B) ^{19}F and ^{14}N

SHORTCUT / EXAM TRICK

Balance Z and A first; then Q from atomic masses (electron masses cancel if you use atomic masses consistently).

COMMON MISTAKE

Mixing nuclear and atomic masses; forgetting the recoil factor in threshold energy.

EXAM TIP

Fission fragments are neutron-rich → β^- decay chains.

MEMORY TRICK

'Mass lost = energy gained'.

Why the Other Options Are Wrong

Correct answer: B

A — **^{19}Na and ^{14}B**

Why (B) is the key — β^+ emission lowers Z by 1: ^{19}Ne (Z = 10) → ^{19}F. β^- emission raises Z by 1: ^{14}C (Z = 6) → ^{14}N. Mass number unchanged.

C — **^{19}Na and ^{14}N**

Ruled out: Mixing nuclear and atomic masses; forgetting the recoil factor in threshold energy.

D — **^{19}F and ^{14}B**

Ruled out: Fission fragments are neutron-rich → β^- decay chains.

Q5 **Choose the correct statement for magnitude of threshold energy of an endoergic nuclear reaction between stationary nucleus and a moving projectile.**

A. It is greater than |Q| of nuclear reaction

B. It has to be more than kinetic energy of a projectile

C. It is less than |Q| of nuclear reaction

D. It has to be equal to kinetic energy of a projectile

QUESTION INSIGHTS

ESTIMATED TIME
2–3 min

DIFFICULTY
Medium

CONCEPT TESTED
Nuclear Reactions Q Value

PYQ FREQUENCY
High · 5 papers

REVISION PRIORITY
★★★★☆

EXPECTED LEVEL
Part B / Part C

MEMORY HOOK
'Mass lost = energy gained'.

Nuclear Reactions Q Value

Correct Answer A It is greater than |Q| of nuclear reaction

CONCEPT

Q = (Σm_reactants − Σm_products)c²; Q > 0 exoergic; threshold energy for Q < 0 reactions E_th = −Q(1 + m_a/m_A); reaction notation A(a,b)B; cross-section; fission of ^{235}U, fusion D–T; binding energy per nucleon curve.

↓

LOGIC / WORKING

- Momentum conservation makes the threshold energy exceed |Q|: $E_th = |Q|(1 + m_projectile/m_target)$ (a).
- Therefore the answer is (A).

FINAL: (A) It is greater than |Q| of nuclear reaction

SHORTCUT / EXAM TRICK

Balance Z and A first; then Q from atomic masses (electron masses cancel if you use atomic masses consistently).

COMMON MISTAKE

Mixing nuclear and atomic masses; forgetting the recoil factor in threshold energy.

EXAM TIP

Fission fragments are neutron-rich → β^- decay chains.

MEMORY TRICK

'Mass lost = energy gained'.

Why the Other Options Are Wrong

Correct answer: A

B **It has to be more than kinetic energy of a projectile**

Why (A) is the key — Momentum conservation makes the threshold energy exceed |Q|: $E_th = |Q|(1 + m_projectile/m_target)$ (a).

C **It is less than |Q| of nuclear reaction**

Ruled out: Mixing nuclear and atomic masses; forgetting the recoil factor in threshold energy.

D **It has to be equal to kinetic energy of a projectile**

Ruled out: Fission fragments are neutron-rich → β^- decay chains.

Q6 **Which one of the following pairs has two magic numbers for closed nuclear shells? 1. 8, 10 2. 10, 20 3. 50, 82 4. 82, 130 (Numerical answer type — write the value.)**

SELF-PRACTICE answer on record: (C) — options were not printed in the source.

QUESTION INSIGHTS

ESTIMATED TIME
1–1.5 min

DIFFICULTY
Easy

CONCEPT TESTED
Nuclear Reactions Q Value

PYQ FREQUENCY
High · 5 papers

REVISION PRIORITY
★★★☆☆

EXPECTED LEVEL
Part B

MEMORY HOOK
'Mass lost = energy gained'.

TOPIC REVISION

Nuclear Reactions Q Value

6 PYQs · Last-minute revision

TOPIC SUMMARY

Q = (Σm_reactants − Σm_products)c²; Q > 0 exoergic; threshold energy for Q < 0 reactions E_th = −Q(1 + m_a/m_A); reaction notation A(a,b)B; cross-section; fission of ^{235}U, fusion D–T; binding energy per nucleon curve.

IMPORTANT FORMULA SHEET

- Q = Δm × 931.5 MeV (u)
- E_th = −Q (m_a + m_A)/m_A
- BE = [Z m_H + N m_n − M] × 931.5 MeV
- BE/A max ≈ 8.8 MeV at ^{56}Fe/^{62}Ni

FREQUENTLY ASKED CONCEPTS

- Compute Q from masses
- Threshold energy
- Identify the missing particle in a reaction
- Energy released per fission (~200 MeV)

COMMON MISTAKES & QUICK NOTES

Watch out:
Mixing nuclear and atomic masses; forgetting the recoil factor in threshold energy.
Fission fragments are neutron-rich → β^- decay chains.

MOST-REPEATED PYQs & EXPECTED IN EXAM

PYQs in this topic: Q1 Q2 Q3 Q4 Q5 Q6

Expect 1 question(s) next session on Nuclear Reactions Q Value.

TOPIC 2

Radioactive Decay Kinetics

6 questions · Easy 1 | Medium 5 | Hard 0 · PYQ frequency: Rare

Q7

The radioactive isotope used to locate brain tumors is

A. $_{1}^{2}D$

B. $_{7}^{15}N$

C. $_{53}^{131}I$

D. $_{6}^{13}C$

QUESTION INSIGHTS

ESTIMATED TIME
1–1.5 min

DIFFICULTY
Easy

CONCEPT TESTED
Radioactive Decay Kinetics

PYQ FREQUENCY
Rare · 1 paper

REVISION PRIORITY
★★★☆☆

EXPECTED LEVEL
Part B

MEMORY HOOK
'Alpha drops 2 and 4; beta minus adds one proton'.

Correct Answer C $_{53}^{131}\mathrm{I}$

CONCEPT

Radioactive decay is first order: N = N_0e^(−λt), t½ = 0.693/λ; activity A = λN. α, β^-, β^+, EC and γ change Z and A predictably; binding energy per nucleon peaks near Fe-56; radiocarbon and U–Pb dating use the decay law.

↓

LOGIC / WORKING

- ^{131}I (γ/β^- emitter) is the classical radiotracer for thyroid and brain-tumour localisation; D, ^{15}N and ^{13}C are stable isotopes.
- Therefore the answer is (C).

FINAL: (C) $_{53}^{131}\mathrm{I}$

SHORTCUT / EXAM TRICK

Number of half-lives n = $\log_2(N_0/N)$; after n half-lives the fraction left is $1/2^n$.

COMMON MISTAKE

Using $\log_{10}$ with 0.693 (ln 2) — keep ln throughout or use 2.303 with $\log_{10}$.

EXAM TIP

α: Z−2, A−4; β^-: Z+1; β^+/EC: Z−1; γ: no change.

MEMORY TRICK

'Alpha drops 2 and 4; beta minus adds one proton'.

Why the Other Options Are Wrong

Correct answer: C

A $_{1}^{2}$ **D**

Why (C) is the key — ^{131}I (γ/β^- emitter) is the classical radiotracer for thyroid and brain-tumour localisation; D, ^{15}N and ^{13}C are stable isotopes.

B $_{7}^{15}$ **N**

Ruled out: Using $\log_{10}$ with 0.693 (ln 2) — keep ln throughout or use 2.303 with $\log_{10}$.

D $_{6}^{13}$ **C**

Ruled out: α: Z−2, A−4; β^-: Z+1; β^+/EC: Z−1; γ: no change.

Q8

The half-life of a radioactive nuclide is 20 years. If a sample of this nuclide has an activity of 6400 disintegrations per minute (dis/min) today, its activity (dis/min) after 100 years would be

A. 850

B. 1600

C. 200

D. 400

QUESTION INSIGHTS

ESTIMATED TIME
2–3 min

DIFFICULTY
Medium

CONCEPT TESTED
Radioactive Decay Kinetics

PYQ FREQUENCY
Rare · 1 paper

REVISION PRIORITY
★★★★☆

EXPECTED LEVEL
Part B / Part C

MEMORY HOOK
'Alpha drops 2 and 4; beta minus adds one proton'.

Radioactive Decay Kinetics

Correct Answer C 200

CONCEPT

Radioactive decay is first order: $N = N_0 e^{-\lambda t}$, $t_{1/2} = 0.693/\lambda$; activity $A = \lambda N$. α, β^-, β^+, EC and γ change Z and A predictably; binding energy per nucleon peaks near Fe-56; radiocarbon and U–Pb dating use the decay law.

↓

LOGIC / WORKING

- 100 years = 5 half-lives: $6400/2^5 = 200$ dis/min.
- Therefore the answer is (C).

FINAL: (C) 200

SHORTCUT / EXAM TRICK

Number of half-lives $n = \log_2(N_0/N)$; after n half-lives the fraction left is $1/2^n$.

COMMON MISTAKE

Using $\log_{10}$ with 0.693 (ln 2) — keep ln throughout or use 2.303 with $\log_{10}$.

EXAM TIP

α: Z−2, A−4; β^-: Z+1; β^+/EC: Z−1; γ: no change.

MEMORY TRICK

'Alpha drops 2 and 4; beta minus adds one proton'.

Why the Other Options Are Wrong

Correct answer: C

A **850**

Why (C) is the key — 100 years = 5 half-lives: $6400/2^5 = 200$ dis/min.

B **1600**

Ruled out: Using $\log_{10}$ with 0.693 (ln 2) — keep ln throughout or use 2.303 with $\log_{10}$.

D **400**

Ruled out: α: Z−2, A−4; β^-: Z+1; β^+/EC: Z−1; γ: no change.

Q9 The total number of steps involved and number of beta particles emitted in the spontaneous decay of $_{92}^{238}U \rightarrow _{82}^{206}Pb$ respectively, are

A. 8 and 6

B. 14 and 6

C. 6 and 8

D. 14 and 8

QUESTION INSIGHTS

ESTIMATED TIME
2–3 min

DIFFICULTY
Medium

CONCEPT TESTED
Radioactive Decay Kinetics

PYQ FREQUENCY
Rare · 1 paper

REVISION PRIORITY
★★★★☆

EXPECTED LEVEL
Part B / Part C

MEMORY HOOK
'Alpha drops 2 and 4; beta minus adds one proton'.

Correct Answer B 14 and 6

CONCEPT

Radioactive decay is first order: N = N_0e^(−λt), $t_{½}$ = 0.693/λ; activity A = λN. α, β^-, β^+, EC and γ change Z and A predictably; binding energy per nucleon peaks near Fe-56; radiocarbon and U–Pb dating use the decay law.

↓

LOGIC / WORKING

- $^{238}U \rightarrow {}^{206}Pb$: 8 α (A drops 32) and 6 β^- — 14 steps, 6 β particles (b).
- Therefore the answer is (B).

FINAL: (B) 14 and 6

SHORTCUT / EXAM TRICK

Number of half-lives n = $\log_2(N_0/N)$; after n half-lives the fraction left is $1/2^n$.

COMMON MISTAKE

Using $\log_{10}$ with 0.693 (ln 2) — keep ln throughout or use 2.303 with $\log_{10}$.

EXAM TIP

α: Z−2, A−4; β^-: Z+1; β^+/EC: Z−1; γ: no change.

MEMORY TRICK

'Alpha drops 2 and 4; beta minus adds one proton'.

Why the Other Options Are Wrong

Correct answer: B

A — **8 and 6**

Why (B) is the key — $^{238}U \rightarrow {}^{206}Pb$: 8 α (A drops 32) and 6 β^- — 14 steps, 6 β particles (b).

C — **6 and 8**

Ruled out: Using $\log_{10}$ with 0.693 (ln 2) — keep ln throughout or use 2.303 with $\log_{10}$.

D — **14 and 8**

Ruled out: α: Z−2, A−4; β^-: Z+1; β^+/EC: Z−1; γ: no change.

Q10

The number of α and β particle(s), generated in the following radioactive decay process, are:

$_{92}^{238}U \rightarrow {}_{92}^{234}U$

A. one α and two β particle

B. two α and one β particles

C. one α and four β particles

D. no α and four β particles (IIT JAM 2015)

QUESTION INSIGHTS

ESTIMATED TIME
2–3 min

DIFFICULTY
Medium

CONCEPT TESTED
Radioactive Decay Kinetics

PYQ FREQUENCY
Rare · 1 paper

REVISION PRIORITY
★★★★☆

EXPECTED LEVEL
Part B / Part C

MEMORY HOOK
'Alpha drops 2 and 4; beta minus adds one proton'.

Correct Answer A one α and two β particle

CONCEPT

Radioactive decay is first order: $N = N_0 e^{-\lambda t}$, $t_{1/2} = 0.693/\lambda$; activity $A = \lambda N$. α, β^-, β^+, EC and γ change Z and A predictably; binding energy per nucleon peaks near Fe-56; radiocarbon and U–Pb dating use the decay law.

↓

LOGIC / WORKING

- $^{238}U \rightarrow {}^{234}U$: $\Delta A = 4$ → one α (Z 92 → 90), then two β^- bring Z back to 92 ($^{238}U \rightarrow {}^{234}Th \rightarrow {}^{234}Pa \rightarrow {}^{234}U$).
- Therefore the answer is (A).

FINAL: (A) one α and two β particle

SHORTCUT / EXAM TRICK

Number of half-lives $n = \log_2(N_0/N)$; after n half-lives the fraction left is $1/2^n$.

COMMON MISTAKE

Using $\log_{10}$ with 0.693 (ln 2) — keep ln throughout or use 2.303 with $\log_{10}$.

EXAM TIP

α: Z−2, A−4; β^-: Z+1; β^+/EC: Z−1; γ: no change.

MEMORY TRICK

'Alpha drops 2 and 4; beta minus adds one proton'.

Why the Other Options Are Wrong

Correct answer: A

B — **two α and one β particles**

Why (A) is the key — $^{238}U \rightarrow {}^{234}U$: $\Delta A = 4 \rightarrow$ one α (Z 92 → 90), then two β^- bring Z back to 92 ($^{238}U \rightarrow {}^{234}Th \rightarrow {}^{234}Pa \rightarrow {}^{234}U$).

C — **one α and four β particles**

Ruled out: Using $\log_{10}$ with 0.693 (ln 2) — keep ln throughout or use 2.303 with $\log_{10}$.

D — **no α and four β particles (IIT JAM 2015)**

Ruled out: α: Z−2, A−4; β^-: Z+1; β^+/EC: Z−1; γ: no change.

Q11

^{24} Na decays to one-fourth of its initial amount in 29.8 hours. Its decay constant is ____ hour $^{-1}$ (rounded up to four decimal places).
(Numerical answer type — write the value.)

ANSWER: 0.0465 h^{-1}

QUESTION INSIGHTS

ESTIMATED TIME
2–3 min

DIFFICULTY
Medium

CONCEPT TESTED
Radioactive Decay Kinetics

PYQ FREQUENCY
Rare · 1 paper

REVISION PRIORITY
★★★★☆

EXPECTED LEVEL
Part B / Part C

MEMORY HOOK
Decay to ¼ = two half-lives → $t_{1/2}$ = 14.9 h. λ = 0.693/14.9 = 0.0465 h^{-1}.

Q12 A radioactive sample decays to 10 \% of its initial amount in 4600 minutes. The rate constant of this process is ____ hour $^{-1}$ (Round off to two decimal places)
(Numerical answer type — write the value.)

ANSWER: 0.03 h^{-1}

QUESTION INSIGHTS

ESTIMATED TIME
2–3 min

DIFFICULTY
Medium

CONCEPT TESTED
Radioactive Decay Kinetics

PYQ FREQUENCY
Rare · 1 paper

REVISION PRIORITY
★★★★☆

EXPECTED LEVEL
Part B / Part C

MEMORY HOOK
$k = (1/t)\ ln(N_0/N) = ln\ 10/(4600/60\ h) = 2.303/76.67 = 0.030\ h^{-1}$.

TOPIC REVISION

Radioactive Decay Kinetics

6 PYQs · Last-minute revision

TOPIC SUMMARY

Radioactive decay is first order: $N = N_0 e^{-\lambda t}$, $t_{1/2} = 0.693/\lambda$; activity $A = \lambda N$. α, β^-, β^+, EC and γ change Z and A predictably; binding energy per nucleon peaks near Fe-56; radiocarbon and U–Pb dating use the decay law.

IMPORTANT FORMULA SHEET

- $t_{1/2} = 0.693/\lambda$
- $t = (t_{1/2}/0.693)\ \ln(N_0/N)$
- $A = \lambda N$ (Bq, Ci = 3.7×10^{10} Bq)
- $\Delta E = \Delta m\ c^2$ (931.5 MeV per u)

FREQUENTLY ASKED CONCEPTS

- Age from activity ratio
- Decay-chain Z/A bookkeeping
- Binding energy and mass defect
- Secular equilibrium

COMMON MISTAKES & QUICK NOTES

Watch out:
Using $\log_{10}$ with 0.693 (ln 2) — keep ln throughout or use 2.303 with $\log_{10}$.
α: Z−2, A−4; β^-: Z+1; β^+/EC: Z−1; γ: no change.

MOST-REPEATED PYQs & EXPECTED IN EXAM

PYQs in this topic: Q7 Q8 Q9 Q10 Q11 Q12

Expect 6 question(s) next session on Radioactive Decay Kinetics.

TOPIC 3

Isotope Applications

3 questions · Easy 1 | Medium 2 | Hard 0 · PYQ frequency: Rare

Q13

In 'carbon-dating' application of radioisotopes, ^{14}C emits

A. β-particle

B. α-particle

C. γ-radiation

D. Positron

QUESTION INSIGHTS

ESTIMATED TIME
1–1.5 min

DIFFICULTY
Easy

CONCEPT TESTED
Isotope Applications

PYQ FREQUENCY
Rare · 2 papers

REVISION PRIORITY
★★★☆☆

EXPECTED LEVEL
Part B

MEMORY HOOK
'Tracer: same chemistry, different signal'.

Correct Answer A β-particle

CONCEPT

Tracers (^{32}P, ^{14}C, ^{3}H), radiocarbon dating (5730 y), K–Ar and U–Pb geochronology, isotope dilution analysis, neutron activation analysis, medical isotopes (^{99m}Tc, ^{131}I, ^{18}F PET), kinetic isotope effects.

↓

LOGIC / WORKING

- ^{14}C decays by β^- emission to ^{14}N ($t_{1/2}$ 5730 y), the basis of radiocarbon dating.
- Therefore the answer is (A).

FINAL: (A) β-particle

SHORTCUT / EXAM TRICK

^{14}C dating works to ~50 000 years (≈ 9 half-lives).

COMMON MISTAKE

Using the parent's half-life for a daughter-based dating method (K–Ar uses ^{40}K's branching).

EXAM TIP

^{99m}Tc (6 h, 140 keV γ) is generated from ^{99}Mo on an alumina column.

MEMORY TRICK

'Tracer: same chemistry, different signal'.

Why the Other Options Are Wrong

Correct answer: A

B **α-particle**

Why (A) is the key — ^{14}C decays by β^- emission to ^{14}N ($t_{1/2}$ 5730 y), the basis of radiocarbon dating.

C **γ-radiation**

Ruled out: Using the parent's half-life for a daughter-based dating method (K–Ar uses ^{40}K's branching).

D **Positron**

Ruled out: ^{99m}Tc (6 h, 140 keV γ) is generated from ^{99}Mo on an alumina column.

Q14

In boron neutron capture therapy, the initial boron isotope used and the particle generated after neutron capture respectively are:

A. ^{11}B and α particle

B. ^{10}B and α particle

C. ^{11}B and β particle

D. ^{10}B and β particle

QUESTION INSIGHTS

ESTIMATED TIME
2–3 min

DIFFICULTY
Medium

CONCEPT TESTED
Isotope Applications

PYQ FREQUENCY
Rare · 2 papers

REVISION PRIORITY
★★★★☆

EXPECTED LEVEL
Part B / Part C

MEMORY HOOK
'Tracer: same chemistry, different signal'.

Correct Answer B ^{10}B and α particle

CONCEPT

Tracers (^{32}P, ^{14}C, ^{3}H), radiocarbon dating (5730 y), K–Ar and U–Pb geochronology, isotope dilution analysis, neutron activation analysis, medical isotopes (^{99m}Tc, ^{131}I, ^{18}F PET), kinetic isotope effects.

↓

LOGIC / WORKING

- ^{10}B captures a thermal neutron and splits: $^{10}B + n \rightarrow {}^{7}Li + \alpha$; the short-range α particle kills the tumour cell.
- Therefore the answer is (B).

FINAL: (B) ^{10}B and α particle

SHORTCUT / EXAM TRICK

^{14}C dating works to ~50 000 years (≈ 9 half-lives).

COMMON MISTAKE

Using the parent's half-life for a daughter-based dating method (K–Ar uses ^{40}K's branching).

EXAM TIP

^{99m}Tc (6 h, 140 keV γ) is generated from ^{99}Mo on an alumina column.

MEMORY TRICK

'Tracer: same chemistry, different signal'.

Why the Other Options Are Wrong

Correct answer: B

A — **^{11}B and α particle**

Why (B) is the key — ^{10}B captures a thermal neutron and splits: $^{10}B + n \rightarrow {}^{7}Li + \alpha$; the short-range α particle kills the tumour cell.

C — **^{11}B and β particle**

Ruled out: Using the parent's half-life for a daughter-based dating method (K–Ar uses ^{40}K's branching).

D — **^{10}B and β particle**

Ruled out: ^{99m}Tc (6 h, 140 keV γ) is generated from ^{99}Mo on an alumina column.

Q15

The isotope $_{84}Po^{214}$ undergoes one alpha and one beta particle emission sequentially to form an isotope " X ". The number of neutrons in " X " is ____ .
(Numerical answer type — write the value.)

ANSWER: 127

QUESTION INSIGHTS

ESTIMATED TIME
2–3 min

DIFFICULTY
Medium

CONCEPT TESTED
Isotope Applications

PYQ FREQUENCY
Rare · 2 papers

REVISION PRIORITY
★★★★☆

EXPECTED LEVEL
Part B / Part C

MEMORY HOOK
$^{214}Po \rightarrow \alpha \rightarrow {}^{210}Pb\ (Z = 82) \rightarrow \beta^- \rightarrow {}^{210}Bi\ (Z = 83)$.
Neutrons = 210 − 83 = 127.

TOPIC REVISION

Isotope Applications

3 PYQs · Last-minute revision

TOPIC SUMMARY

Tracers (^{32}P, ^{14}C, ^{3}H), radiocarbon dating (5730 y), K–Ar and U–Pb geochronology, isotope dilution analysis, neutron activation analysis, medical isotopes (^{99m}Tc, ^{131}I, ^{18}F PET), kinetic isotope effects.

IMPORTANT FORMULA SHEET

- $t = (t_{½}/0.693)\ \ln(A_0/A)$
- Isotope dilution: $m_x = m_s\ (A_s/A_{mix} - 1)$
- $k_H/k_D \approx 6–8$ for primary KIE at 25 °C

FREQUENTLY ASKED CONCEPTS

- Age from ^{14}C activity
- Which isotope for which organ/imaging
- Neutron activation sensitivity
- Primary vs secondary KIE

COMMON MISTAKES & QUICK NOTES

Watch out:
Using the parent's half-life for a daughter-based dating method (K–Ar uses ^{40}K's branching).
^{99m}Tc (6 h, 140 keV γ) is generated from ^{99}Mo on an alumina column.

MOST-REPEATED PYQs & EXPECTED IN EXAM

PYQs in this topic: Q13 Q14 Q15

Expect 2 question(s) next session on Isotope Applications.

TOPIC 4

Fission Fusion

3 questions · Easy 2 | Medium 1 | Hard 0 · PYQ frequency: Occasional

Q16

The nuclides among the following, capable of undergoing fission by thermal neutrons, are
(A) ^{233}U (B) ^{235}U (C) ^{239}Pu (D) ^{232}Th

(A) A, B and D

(B) A, C and D

(C) B, C and D

(D) A, B and C

QUESTION INSIGHTS

ESTIMATED TIME
1–1.5 min

DIFFICULTY
Easy

CONCEPT TESTED
Fission Fusion

PYQ FREQUENCY
Occasional · 3 papers

REVISION PRIORITY
★★★☆☆

EXPECTED LEVEL
Part B

MEMORY HOOK
'Odd N fissile'.

Correct Answer D A, B and C

CONCEPT

Fission of $^{235}U/^{239}Pu$ by thermal neutrons releases ~200 MeV and 2–3 neutrons (chain reaction, critical mass, moderators, control rods); fusion ($D + T \rightarrow {}^{4}He + n$, 17.6 MeV) needs ~$10^8$ K; breeder reactors convert $^{238}U \rightarrow {}^{239}Pu$.

↓

LOGIC / WORKING

- ^{233}U, ^{235}U and ^{239}Pu are fissile with thermal neutrons; ^{232}Th is fertile (needs neutron capture to ^{233}U) and fissions only with fast neutrons.
- Therefore the answer is (D).

FINAL: (D) A, B and C

SHORTCUT / EXAM TRICK

Odd-N nuclides (^{233}U, ^{235}U, ^{239}Pu) are fissile with slow neutrons; even–even ^{238}U is only fissionable with fast neutrons.

COMMON MISTAKE

Treating fission fragments as symmetric (mass distribution is asymmetric, ~95 and ~140).

EXAM TIP

Cd and B have huge neutron-capture cross-sections → control rods.

MEMORY TRICK

'Odd N fissile'.

Why the Other Options Are Wrong

Correct answer: D

A

A, B and D

Why (D) is the key — ^{233}U, ^{235}U and ^{239}Pu are fissile with thermal neutrons; ^{232}Th is fertile (needs neutron capture to ^{233}U) and fissions only with fast neutrons.

B

A, C and D

Ruled out: Treating fission fragments as symmetric (mass distribution is asymmetric, ~95 and ~140).

C

B, C and D

Ruled out: Cd and B have huge neutron-capture cross-sections → control rods.

Q17 **Consider following statements for fission of U^{235} with thermal neutrons. A. The % of nuclei undergoing unsymmetrical fission is maximum. B. In each fission, one thermal neutron is produced. C. Magnitude of energy released per fission is of the order 200 MeV Correct statement(s) is/are:**

A. A and B

B. B and C

C. A and C

D. C only

QUESTION INSIGHTS

ESTIMATED TIME
1–1.5 min

DIFFICULTY
Easy

CONCEPT TESTED
Fission Fusion

PYQ FREQUENCY
Occasional · 3 papers

REVISION PRIORITY
★★★☆☆

EXPECTED LEVEL
Part B

MEMORY HOOK
'Odd N fissile'.

Correct Answer C A and C

CONCEPT

Fission of $^{235}U/^{239}Pu$ by thermal neutrons releases ~200 MeV and 2–3 neutrons (chain reaction, critical mass, moderators, control rods); fusion ($D + T \rightarrow {}^{4}He + n$, 17.6 MeV) needs ~$10^8$ K; breeder reactors convert $^{238}U \rightarrow {}^{239}Pu$.

↓

LOGIC / WORKING

- Thermal fission of ^{235}U is predominantly asymmetric (mass peaks ~95 and ~140) — A true. About 2.4–2.5 neutrons are released per fission, not one — B false. Energy ≈ 200 MeV per fission — C true. (Bank key (b) was wrong — corrected.)
- Therefore the answer is (C).

FINAL: (C) A and C

SHORTCUT / EXAM TRICK

Odd-N nuclides (^{233}U, ^{235}U, ^{239}Pu) are fissile with slow neutrons; even–even ^{238}U is only fissionable with fast neutrons.

COMMON MISTAKE

Treating fission fragments as symmetric (mass distribution is asymmetric, ~95 and ~140).

EXAM TIP

Cd and B have huge neutron-capture cross-sections → control rods.

MEMORY TRICK

'Odd N fissile'.

Why the Other Options Are Wrong

Correct answer: C

A

A and B

Why (C) is the key — Thermal fission of ^{235}U is predominantly asymmetric (mass peaks ~95 and ~140) — A true. About 2.4–2.5 neutrons are released per fission, not one — B false. Energy ≈ 200 MeV per fission — C true. (Bank key (b) was wrong — corrected.)

B

B and C

Ruled out: Treating fission fragments as symmetric (mass distribution is asymmetric, ~95 and ~140).

D

C only

Ruled out: Cd and B have huge neutron-capture cross-sections → control rods.

Q18

For the following fusion reaction, $4\,{}^{1}H \rightarrow {}^{4}He + 2\,\beta^{+} + 2\,\nu + \gamma$ the Q-value (energy of the reaction) in MeV (rounded off to one decimal place) is ___ . (Given: Mass of ${}^{1}H$ nucleus is 1.007825 u and mass of ${}^{4}He$ nucleus is 4.002604 u)
(Numerical answer type — write the value.)

ANSWER: ≈ 25.7 MeV (26.7 MeV if positron masses are ignored)

QUESTION INSIGHTS

ESTIMATED TIME
2–3 min

DIFFICULTY
Medium

CONCEPT TESTED
Fission Fusion

PYQ FREQUENCY
Occasional · 3 papers

REVISION PRIORITY
★★★★☆

EXPECTED LEVEL
Part B / Part C

MEMORY HOOK
$\Delta m = 4 \times 1.007825 - 4.002604 - 2 \times 0.000549$ (two e^{+} created) = 0.027598 u → $Q = 0.027598 \times 931.5$ = 25.7 MeV. Using atomic masses with no positron correction gives 26.7 MeV.

TOPIC REVISION

Fission Fusion

3 PYQs · Last-minute revision

TOPIC SUMMARY

Fission of $^{235}U/^{239}Pu$ by thermal neutrons releases ~200 MeV and 2–3 neutrons (chain reaction, critical mass, moderators, control rods); fusion ($D + T \rightarrow {}^{4}He + n$, 17.6 MeV) needs ~$10^{8}$ K; breeder reactors convert $^{238}U \rightarrow {}^{239}Pu$.

IMPORTANT FORMULA SHEET

- $^{235}U + n \rightarrow$ fragments + 2–3 n + ~200 MeV
- $D + T \rightarrow {}^{4}He + n + 17.6$ MeV
- k_eff = 1 critical; moderators: D_2O, graphite, H_2O

FREQUENTLY ASKED CONCEPTS

- Why ^{235}U fissions with thermal neutrons but ^{238}U does not (pairing energy)
- Role of moderator and control rods
- Breeder reaction
- Fusion conditions (Lawson criterion)

COMMON MISTAKES & QUICK NOTES

Watch out:
Treating fission fragments as symmetric (mass distribution is asymmetric, ~95 and ~140).
Cd and B have huge neutron-capture cross-sections → control rods.

MOST-REPEATED PYQs & EXPECTED IN EXAM

PYQs in this topic: Q16 Q17 Q18

Expect 1 question(s) next session on Fission Fusion.

TOPIC 5

Nuclear Chemistry – General

8 questions · Easy 5 | Medium 2 | Hard 1 · PYQ frequency: Occasional

Q19

The particles postulated to always accompany the positron emission among are: (A) neutrino, (B) anti-neutrino, (C) electron,

A. A, B and C

B. A and B

C. A and C

D. B and C

QUESTION INSIGHTS

ESTIMATED TIME
1–1.5 min

DIFFICULTY
Easy

CONCEPT TESTED
Nuclear Chemistry – General

PYQ FREQUENCY
Occasional · 4 papers

REVISION PRIORITY
★★★☆☆

EXPECTED LEVEL
Part B

MEMORY HOOK
'Alpha drops 2 and 4; beta minus adds one proton'.

Correct Answer C A and C

CONCEPT

Radioactive decay is first order: $N = N_0 e^{-\lambda t}$, $t_{1/2} = 0.693/\lambda$; activity $A = \lambda N$. α, β^-, β^+, EC and γ change Z and A predictably; binding energy per nucleon peaks near Fe-56; radiocarbon and U–Pb dating use the decay law.

↓

LOGIC / WORKING

- $p \rightarrow n + e^+ + \nu_e$: a neutrino always accompanies positron emission (lepton-number conservation). The emitted positron then annihilates with an electron (two 511 keV γ).
- Therefore the answer is (C).

FINAL: (C) A and C

SHORTCUT / EXAM TRICK

Number of half-lives $n = \log_2(N_0/N)$; after n half-lives the fraction left is $1/2^n$.

COMMON MISTAKE

Using $\log_{10}$ with 0.693 (ln 2) — keep ln throughout or use 2.303 with $\log_{10}$.

EXAM TIP

α: Z−2, A−4; β^-: Z+1; β^+/EC: Z−1; γ: no change.

MEMORY TRICK

'Alpha drops 2 and 4; beta minus adds one proton'.

Why the Other Options Are Wrong

Correct answer: C

A

A, B and C

Why (C) is the key — $p \rightarrow n + e^{+} + \nu_e$: a neutrino always accompanies positron emission (lepton-number conservation). The emitted positron then annihilates with an electron (two 511 keV γ).

B

A and B

Ruled out: Using $\log_{10}$ with 0.693 (ln 2) — keep ln throughout or use 2.303 with $\log_{10}$.

D

B and C

Ruled out: α: Z−2, A−4; β^{-}: Z+1; β^{+}/EC: Z−1; γ: no change.

Q20

In neutron activation analysis the radiation commonly detected is

A. α-rays

B. β-rays

C. γ-rays

D. X-rays

QUESTION INSIGHTS

ESTIMATED TIME
1–1.5 min

DIFFICULTY
Easy

CONCEPT TESTED
Nuclear Chemistry – General

PYQ FREQUENCY
Occasional · 4 papers

REVISION PRIORITY
★★★☆☆

EXPECTED LEVEL
Part B

MEMORY HOOK
'Alpha drops 2 and 4; beta minus adds one proton'.

Correct Answer C γ-rays

CONCEPT

Radioactive decay is first order: N = N_0e^(−λt), t½ = 0.693/λ; activity A = λN. α, β^-, β^+, EC and γ change Z and A predictably; binding energy per nucleon peaks near Fe-56; radiocarbon and U–Pb dating use the decay law.

↓

LOGIC / WORKING

- NAA detects î³-rays (c).
- Therefore the answer is (C).

FINAL: (C) γ-rays

SHORTCUT / EXAM TRICK

Number of half-lives n = $\log_2(N_0/N)$; after n half-lives the fraction left is $1/2^n$.

COMMON MISTAKE

Using $\log_{10}$ with 0.693 (ln 2) — keep ln throughout or use 2.303 with $\log_{10}$.

EXAM TIP

α: Z−2, A−4; β^-: Z+1; β^+/EC: Z−1; γ: no change.

MEMORY TRICK

'Alpha drops 2 and 4; beta minus adds one proton'.

Why the Other Options Are Wrong

Correct answer: C

A **α-rays**

Why (C) is the key — NAA detects Î³-rays (c).

B **β-rays**

Ruled out: Using $\log_{10}$ with 0.693 (ln 2) — keep ln throughout or use 2.303 with $\log_{10}$.

D **X-rays**

Ruled out: α: Z−2, A−4; β^-: Z+1; β^+/EC: Z−1; γ: no change.

Q21

Among the following, the most stable isotope to radioactive decay is

A. $_{82}{}^{20}{}_{6}$ Pb

B. $_{82}{}^{21}{}^{0}$ Pb

C. $_{82}{}^{212}$ Pb

D. $_{82}{}^{214}$ Pb

QUESTION INSIGHTS

ESTIMATED TIME
1–1.5 min

DIFFICULTY
Easy

CONCEPT TESTED
Nuclear Chemistry – General

PYQ FREQUENCY
Occasional · 4 papers

REVISION PRIORITY
★★★☆☆

EXPECTED LEVEL
Part B

MEMORY HOOK
'Alpha drops 2 and 4; beta minus adds one proton'.

Correct Answer A $_{82}{}^{20}{}_{6}$ **Pb**

CONCEPT

Radioactive decay is first order: N = N_0e^(−λt), t½ = 0.693/λ; activity A = λN. α, β^-, β^+, EC and γ change Z and A predictably; binding energy per nucleon peaks near Fe-56; radiocarbon and U–Pb dating use the decay law.

↓

LOGIC / WORKING

- $^{20}{}_{6}$Pb (Z = 82, N = 124) is stable, the end of the U-238 series; ^{210},^{212},^{214}Pb are radioactive (a).
- Therefore the answer is (A).

FINAL: (A) $_{82}{}^{20}{}_{6}$ **Pb**

SHORTCUT / EXAM TRICK

Number of half-lives n = $\log_2(N_0/N)$; after n half-lives the fraction left is $1/2^n$.

COMMON MISTAKE

Using $\log_{10}$ with 0.693 (ln 2) — keep ln throughout or use 2.303 with $\log_{10}$.

EXAM TIP

α: Z−2, A−4; β^-: Z+1; β^+/EC: Z−1; γ: no change.

MEMORY TRICK

'Alpha drops 2 and 4; beta minus adds one proton'.

Why the Other Options Are Wrong

Correct answer: A

B $_{82}^{21^{0}}$ **Pb**

Why (A) is the key — $^{2^{0}6}$Pb (Z = 82, N = 124) is stable, the end of the U-238 series; $^{21^{0}}$,^{212},^{214}Pb are radioactive (a).

C $_{82}^{212}$ **Pb**

Ruled out: Using $\log_{10}$ with 0.693 (ln 2) — keep ln throughout or use 2.303 with $\log_{10}$.

D $_{82}^{214}$ **Pb**

Ruled out: α: Z−2, A−4; β^{-}: Z+1; β^{+}/EC: Z−1; γ: no change.

Q22 The total number of α and β particles emitted in the following radioactive decay is ____ $_{92}^{238}U \rightarrow {}_{82}^{210}Pb$
(Numerical answer type — write the value.)

ANSWER: 11 (7 α + 4 β^-)

QUESTION INSIGHTS

ESTIMATED TIME
2–3 min

DIFFICULTY
Medium

CONCEPT TESTED
Nuclear Chemistry – General

PYQ FREQUENCY
Occasional · 4 papers

REVISION PRIORITY
★★★★☆

EXPECTED LEVEL
Part B / Part C

MEMORY HOOK
ΔA = 238 − 210 = 28 → 7 α. 7 α lower Z by 14 (92 → 78); reaching Z = 82 needs 4 β^-. Total 11 particles.

Q23

The fission reaction of $^{235}_{92}U$ with thermal neutron is represented below. $^{99}_{41}Nb$ and $^{133}_{51}Sb$ are the primary fission fragment pair, which undergo series of radioactive decay to form stable nuclei X_3 and Y_4 (chain enders). The X_3 and Y_4, respectively are:

A $^{99}_{44}Ru$ and $^{133}_{55}Cs$

B $^{96}_{41}Nb$ and $^{13^{0}}_{51}Sb$

C $^{93}_{38}Sr$ and $^{127}_{35}Ag$

D $^{87}_{35}Br$ and $^{124}_{43}Tc$

QUESTION INSIGHTS

ESTIMATED TIME
2–3 min

DIFFICULTY
Medium

CONCEPT TESTED
Nuclear Chemistry – General

PYQ FREQUENCY
Occasional · 4 papers

REVISION PRIORITY
★★★★☆

EXPECTED LEVEL
Part B / Part C

MEMORY HOOK
'Alpha drops 2 and 4; beta minus adds one proton'.

Correct Answer A $^{99}_{44}Ru$ and $^{133}_{55}Cs$

CONCEPT

Radioactive decay is first order: $N = N_0 e^{-\lambda t}$, $t_{1/2} = 0.693/\lambda$; activity $A = \lambda N$. α, β^-, β^+, EC and γ change Z and A predictably; binding energy per nucleon peaks near Fe-56; radiocarbon and U–Pb dating use the decay law.

↓

LOGIC / WORKING

- Neutron-rich fragments β^--decay (A constant, Z rises) until stable: $^{99}Nb \rightarrow {}^{99}Mo \rightarrow {}^{99}Tc \rightarrow {}^{99}Ru$ (stable); $^{133}Sb \rightarrow {}^{133}Te \rightarrow {}^{133}I \rightarrow {}^{133}Xe \rightarrow {}^{133}Cs$ (stable). (Bank key (b) was wrong — corrected.)
- Therefore the answer is (A).

FINAL: (A) $^{99}_{44}Ru$ and $^{133}_{55}Cs$

SHORTCUT / EXAM TRICK

Number of half-lives $n = \log_2(N_0/N)$; after n half-lives the fraction left is $1/2^n$.

COMMON MISTAKE

Using $\log_{10}$ with 0.693 (ln 2) — keep ln throughout or use 2.303 with $\log_{10}$.

EXAM TIP

α: Z−2, A−4; β^-: Z+1; β^+/EC: Z−1; γ: no change.

MEMORY TRICK

'Alpha drops 2 and 4; beta minus adds one proton'.

Why the Other Options Are Wrong

Correct answer: A

B — $^{96}_{41}Nb$ and $^{130}_{51}Sb$

Why (A) is the key — Neutron-rich fragments β^--decay (A constant, Z rises) until stable: $^{99}Nb \rightarrow {}^{99}Mo \rightarrow {}^{99}Tc \rightarrow {}^{99}Ru$ (stable); $^{133}Sb \rightarrow {}^{133}Te \rightarrow {}^{133}I \rightarrow {}^{133}Xe \rightarrow {}^{133}Cs$ (stable). (Bank key (b) was wrong — corrected.)

C — $^{93}_{38}Sr$ and $^{127}_{35}Ag$

Ruled out: Using $\log_{10}$ with 0.693 (ln 2) — keep ln throughout or use 2.303 with $\log_{10}$.

D — $^{87}_{35}Br$ and $^{124}_{43}Tc$

Ruled out: α: Z−2, A−4; β^-: Z+1; β^+/EC: Z−1; γ: no change.

Q24

Given the initial weight of 1 mg of radioactive $_{27}^{60}$Co (half-life =5.27 years), the amount disintegrated in 1 year (rounded off to two decimal places) is ___ mg. (Numerical answer type — write the value.)

ANSWER: 0.12 mg

QUESTION INSIGHTS

ESTIMATED TIME
3–5 min

DIFFICULTY
Hard

CONCEPT TESTED
Nuclear Chemistry – General

PYQ FREQUENCY
Occasional · 4 papers

REVISION PRIORITY
★★★★★

EXPECTED LEVEL
Part C (high merit)

MEMORY HOOK
λ = 0.693/5.27 = 0.1315 y⁻¹. Remaining after 1 y = e^{−0.1315} = 0.877 mg → disintegrated = 1 − 0.877 = 0.12 mg.

Q25

In the process $_{92}^{234}U \longrightarrow _{90}^{230}Th + X$ X is:

A. α particle

B. β-particle

C. β^+-emission

D. γ-emission

QUESTION INSIGHTS

ESTIMATED TIME
1–1.5 min

DIFFICULTY
Easy

CONCEPT TESTED
Nuclear Chemistry – General

PYQ FREQUENCY
Occasional · 4 papers

REVISION PRIORITY
★★★☆☆

EXPECTED LEVEL
Part B

MEMORY HOOK
'Alpha drops 2 and 4; beta minus adds one proton'.

Correct Answer A α particle

CONCEPT

Radioactive decay is first order: N = N_0e^(−λt), t½ = 0.693/λ; activity A = λN. α, β^-, β^+, EC and γ change Z and A predictably; binding energy per nucleon peaks near Fe-56; radiocarbon and U–Pb dating use the decay law.

↓

LOGIC / WORKING

- $^{234}U \rightarrow {}^{23^{o}}Th$ loses 4 mass units and 2 charge units: an α particle.
- Therefore the answer is (A).

FINAL: (A) α particle

SHORTCUT / EXAM TRICK

Number of half-lives n = $\log_2(N_0/N)$; after n half-lives the fraction left is $1/2^n$.

COMMON MISTAKE

Using $\log_{10}$ with 0.693 (ln 2) — keep ln throughout or use 2.303 with $\log_{10}$.

EXAM TIP

α: Z−2, A−4; β^-: Z+1; β^+/EC: Z−1; γ: no change.

MEMORY TRICK

'Alpha drops 2 and 4; beta minus adds one proton'.

Why the Other Options Are Wrong

Correct answer: A

B **β-particle**

Why (A) is the key — $^{234}U \rightarrow {}^{23^{o}}Th$ loses 4 mass units and 2 charge units: an α particle.

C **β^{+}-emission**

Ruled out: Using $\log_{10}$ with 0.693 (ln 2) — keep ln throughout or use 2.303 with $\log_{10}$.

D **γ-emission**

Ruled out: α: Z−2, A−4; β^{-}: Z+1; β^{+}/EC: Z−1; γ: no change.

Q26

In the following equation X is: $_{95}^{241}Am + \alpha \longrightarrow {}_{97}^{243}Bk + X$

A. $2\ {}_{0}^{1}n$

B. ${}_{0}^{1}n$

C. $2\ {}_{1}^{1}n$

D. ${}_{2}^{4}He$

QUESTION INSIGHTS

ESTIMATED TIME
1–1.5 min

DIFFICULTY
Easy

CONCEPT TESTED
Nuclear Chemistry – General

PYQ FREQUENCY
Occasional · 4 papers

REVISION PRIORITY
★★★☆☆

EXPECTED LEVEL
Part B

MEMORY HOOK
'Alpha drops 2 and 4; beta minus adds one proton'.

Correct Answer A $2\ {}_0^1n$

CONCEPT

Radioactive decay is first order: N = N_0e^(−λt), t½ = 0.693/λ; activity A = λN. α, β^-, β^+, EC and γ change Z and A predictably; binding energy per nucleon peaks near Fe-56; radiocarbon and U–Pb dating use the decay law.

↓

LOGIC / WORKING

- $^{241}Am + {}^4He \rightarrow {}^{243}Bk + 2\ {}^1n$: the bombarding α raises Z by 2 and the mass by 4, and two neutrons are released to leave A = 243.
- Therefore the answer is (A).

FINAL: (A) $2\ {}_0^1n$

SHORTCUT / EXAM TRICK

Number of half-lives n = $\log_2(N_0/N)$; after n half-lives the fraction left is $1/2^n$.

COMMON MISTAKE

Using $\log_{10}$ with 0.693 (ln 2) — keep ln throughout or use 2.303 with $\log_{10}$.

EXAM TIP

α: Z−2, A−4; β^-: Z+1; β^+/EC: Z−1; γ: no change.

MEMORY TRICK

'Alpha drops 2 and 4; beta minus adds one proton'.

Why the Other Options Are Wrong

Correct answer: A

B $_{0}^{1}\mathrm{n}$

Why (A) is the key — $^{241}\mathrm{Am} + {}^{4}\mathrm{He} \rightarrow {}^{243}\mathrm{Bk} + 2\,{}^{1}\mathrm{n}$: the bombarding α raises Z by 2 and the mass by 4, and two neutrons are released to leave A = 243.

C $2\,{}_{1}^{1}\mathrm{n}$

Ruled out: Using $\log_{10}$ with 0.693 (ln 2) — keep ln throughout or use 2.303 with $\log_{10}$.

D $_{2}^{4}\mathrm{He}$

Ruled out: α: Z−2, A−4; β^-: Z+1; β^+/EC: Z−1; γ: no change.

TOPIC REVISION

Nuclear Chemistry – General

8 PYQs · Last-minute revision

TOPIC SUMMARY

Radioactive decay is first order: $N = N_0 e^{-\lambda t}$, $t_{1/2} = 0.693/\lambda$; activity $A = \lambda N$. α, β^-, β^+, EC and γ change Z and A predictably; binding energy per nucleon peaks near Fe-56; radiocarbon and U–Pb dating use the decay law.

IMPORTANT FORMULA SHEET

- $t_{1/2} = 0.693/\lambda$
- $t = (t_{1/2}/0.693)\ \ln(N_0/N)$
- $A = \lambda N$ (Bq, Ci = 3.7×10^{10} Bq)
- $\Delta E = \Delta m\ c^2$ (931.5 MeV per u)

FREQUENTLY ASKED CONCEPTS

- Age from activity ratio
- Decay-chain Z/A bookkeeping
- Binding energy and mass defect
- Secular equilibrium

COMMON MISTAKES & QUICK NOTES

Watch out:
Using $\log_{10}$ with 0.693 (ln 2) — keep ln throughout or use 2.303 with $\log_{10}$.
α: Z−2, A−4; β^-: Z+1; β^+/EC: Z−1; γ: no change.

MOST-REPEATED PYQs & EXPECTED IN EXAM

PYQs in this topic: Q19 Q20 Q21 Q22 Q23 Q24 Q25 Q26

Expect 2 question(s) next session on Nuclear Chemistry – General.

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1 Find questions

- Browse
- Question search
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2 Teach one by one

Question Bank

Show each question to students on the board, in your own order.

3 Export

PPTX, DOCX, PNG (zip), HTML, Markdown

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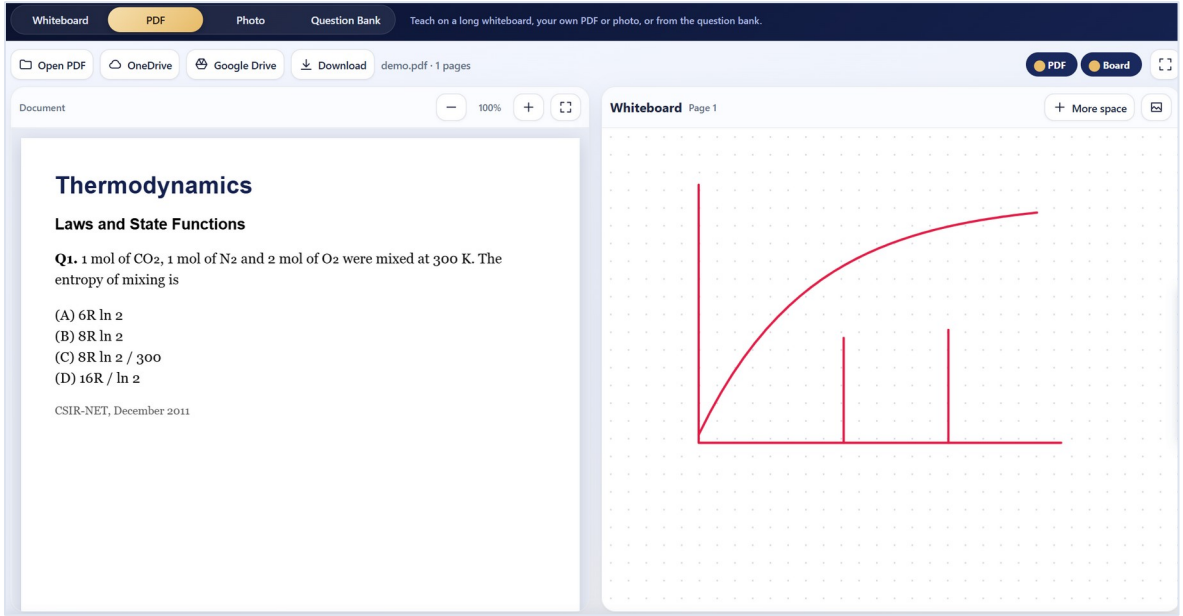
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