ABC CHEMISTRY

Mr. Aniket Bhardwaj · 15+ Years Mentorship

Nuclear, Redox, Phase & Photochemistry

Premium CSIR-NET PYQ Book

21 Previous-Year Questions · 13 with verified answers · Distractor Analysis

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

CSIR-NET · GATE · IIT-JAM — 5 Topics · 21 Real PYQs

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Course Contents

5 Topics · 21 PYQs

1	**Nuclear Chemistry** 6 Qs E 3 · M 3 · H 0	29%	
2	**Redox Reaction** 6 Qs E 5 · M 1 · H 0	29%	
3	**Phase Equilibrium** 4 Qs E 1 · M 3 · H 0	19%	
4	**Photochemistry** 3 Qs E 0 · M 2 · H 1	14%	
5	**Nuclear, Redox, Phase & Photochemistry – General** 2 Qs E 1 · M 1 · H 0	10%	

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

TOPIC 1

Nuclear Chemistry

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

Q1

Saturation factor in neutron activation analysis is (A = induced radioactivity, ψ = neutron flux, σ = effective nuclear cross section, N = no. of target atoms, λ = decay constant)

A. (A)/(ψσ N)

B. (ψσ NA)/(λ)

C. (λ)/(Aψσ N)

D. (ψσ N)/(A)

QUESTION INSIGHTS

ESTIMATED TIME
2–3 min

DIFFICULTY
Medium

CONCEPT TESTED
Nuclear Chemistry

PYQ FREQUENCY
Rare · 2 papers

REVISION PRIORITY
★★★★☆

EXPECTED LEVEL
Part B / Part C

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

Correct Answer A (A)/(ψσ N)

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

- Induced activity $A = \psi\sigma N(1 - e^{-\lambda t})$; the bracket $(1 - e^{-\lambda t})$ is the saturation factor, equal to $A/(\psi\sigma N)$.
- Therefore the answer is (A).

FINAL: (A) (A)/(ψσ N)

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 **(ψσ NA)/(λ)**

Why (A) is the key — Induced activity A = ψσN(1 − e^(−λt)); the bracket (1 − e^(−λt)) is the saturation factor, equal to A/(ψσN).

C **(λ)/(Aψσ N)**

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

D **(ψσ N)/(A)**

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

Q2

The penetrating power (R) and ionizing power (I) of α, β, and γ rays follow the ordering

A. $R_\beta > R_\gamma > R_\alpha$ and $I_\beta > I_\gamma > I_\alpha$

B. $R_\gamma > R_\beta > R_\alpha$ and $I_\beta > I_\gamma > I_\alpha$

C. $R_\beta > R_\alpha > R_\gamma$ and $I_\alpha > I_\beta > I_\gamma$

D. $R_\gamma > R_\beta > R_\alpha$ and $I_\alpha > I_\beta > I_\gamma$

QUESTION INSIGHTS

ESTIMATED TIME
1–1.5 min

DIFFICULTY
Easy

CONCEPT TESTED
Nuclear Chemistry

PYQ FREQUENCY
Rare · 2 papers

REVISION PRIORITY
★★★☆☆

EXPECTED LEVEL
Part B

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

Correct Answer D R_y > R_β > R_α and I_α > I_β > I_y

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

- Penetration: γ > β > α (γ is uncharged, α is heavy and doubly charged); ionising power is the reverse: α > β > γ.
- Therefore the answer is (D).

FINAL: (D) R_y > R_β > R_α and I_α > I_β > I_y

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: D

A **R_β > R_γ > R_α and I_β > I_γ > I_α**

Why (D) is the key — Penetration: γ > β > α (γ is uncharged, α is heavy and doubly charged); ionising power is the reverse: α > β > γ.

B **R_γ > R_β > R_α and I_β > I_γ > I_α**

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

C **R_β > R_α > R_γ and I_α > I_β > I_γ**

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

Q3

The reactive cross section is expected to be the largest for the reaction

A. $Li + Cl_2 \rightarrow LiCl + Cl$

B. $Na + Cl_2$

C. $K + Cl_2$

D. $Rb + Cl_2$

QUESTION INSIGHTS

ESTIMATED TIME
1–1.5 min

DIFFICULTY
Easy

CONCEPT TESTED
Nuclear Chemistry

PYQ FREQUENCY
Rare · 2 papers

REVISION PRIORITY
★★★☆☆

EXPECTED LEVEL
Part B

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

Correct Answer D Rb + Cl_2

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

- Alkali metal + halogen reactions proceed by the harpoon mechanism; the cross-section grows as the ionisation energy of the metal falls (electron jumps at larger distance). Rb has the lowest IE among the options → largest cross-section.
- Therefore the answer is (D).

FINAL: (D) Rb + Cl_2

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: D

A

$Li + Cl_2 \rightarrow LiCl + Cl$

Why (D) is the key — Alkali metal + halogen reactions proceed by the harpoon mechanism; the cross-section grows as the ionisation energy of the metal falls (electron jumps at larger distance). Rb has the lowest IE among the options → largest cross-section.

B

$Na + Cl_2$

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

C

$K + Cl_2$

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

Q4

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
Nuclear Chemistry

PYQ FREQUENCY
Rare · 2 papers

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.

Q5 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
Nuclear Chemistry

PYQ FREQUENCY
Rare · 2 papers

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: $N = N_0 e^{-\lambda t}$, $t_{1/2} = 0.693/\lambda$; 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

- $^{238}U \rightarrow {}^{206}Pb$: mass drops by 32 ⇒ 8 α; charge 92 − 16 = 76 must rise to 82 ⇒ 6 β^-. Total 14 steps, 6 β particles.
- 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 — $^{238}U \rightarrow {}^{206}Pb$: mass drops by 32 ⇒ 8 α; charge 92 − 16 = 76 must rise to 82 ⇒ 6 β^-. Total 14 steps, 6 β particles.

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.

Q6 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: 26.7 MeV

QUESTION INSIGHTS

ESTIMATED TIME
2–3 min

DIFFICULTY
Medium

CONCEPT TESTED
Nuclear Chemistry

PYQ FREQUENCY
Rare · 2 papers

REVISION PRIORITY
★★★★☆

EXPECTED LEVEL
Part B / Part C

MEMORY HOOK
Using the given masses: $\Delta m = 4(1.007825) - 4.002604 = 0.028696$ u → $Q = 0.028696 \times 931.5 = 26.7$ MeV (the positron/annihilation energy is included when atomic masses are used).

TOPIC REVISION

Nuclear Chemistry

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: Q1 Q2 Q3 Q4 Q5 Q6

Expect 3 question(s) next session on Nuclear Chemistry.

TOPIC 2

Redox Reaction

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

Q7

The number of P = O bonds present in the tetrabasic acid $H_4P_2O_7$ is:

A. Three

B. Two

C. One

D. None

QUESTION INSIGHTS

ESTIMATED TIME
1–1.5 min

DIFFICULTY
Easy

CONCEPT TESTED
Redox Reaction

PYQ FREQUENCY
Rare · 1 paper

REVISION PRIORITY
★★★☆☆

EXPECTED LEVEL
Part B

MEMORY HOOK
'OIL RIG: Oxidation Is Loss, Reduction Is Gain'.

Correct Answer B Two

CONCEPT

Oxidation state bookkeeping; balancing by half-reactions in acid/base; cell potential $E°_{cell} = E°_{cathode} - E°_{anode}$; Nernst equation; $\Delta G° = -nFE°$; K from E°.

↓

LOGIC / WORKING

- Pyrophosphoric acid $H_4P_2O_7$ has two tetrahedral P atoms bridged by one O, each carrying one P=O and two P–OH: two P=O bonds, four acidic OH (tetrabasic).
- Therefore the answer is (B).

FINAL: (B) Two

SHORTCUT / EXAM TRICK

A species disproportionates when E°(right) > E°(left) in its Latimer diagram.

COMMON MISTAKE

Reversing the sign of E° when reversing a half-reaction and also multiplying it by n.

EXAM TIP

E° is intensive — never multiply it by stoichiometric coefficients; ΔG° is extensive.

MEMORY TRICK

'OIL RIG: Oxidation Is Loss, Reduction Is Gain'.

Why the Other Options Are Wrong

Correct answer: B

A **Three**

Why (B) is the key — Pyrophosphoric acid $H_4P_2O_7$ has two tetrahedral P atoms bridged by one O, each carrying one P=O and two P–OH: two P=O bonds, four acidic OH (tetrabasic).

C **One**

Ruled out: Reversing the sign of E° when reversing a half-reaction and also multiplying it by n.

D **None**

Ruled out: E° is intensive — never multiply it by stoichiometric coefficients; ΔG° is extensive.

Q8

Indicator used in redox titration is

(A) Eriochrome black T

(B) Methyl orange

(C) Phenolphthalein

(D) Methylene blue

QUESTION INSIGHTS

ESTIMATED TIME
1–1.5 min

DIFFICULTY
Easy

CONCEPT TESTED
Redox Reaction

PYQ FREQUENCY
Rare · 1 paper

REVISION PRIORITY
★★★☆☆

EXPECTED LEVEL
Part B

MEMORY HOOK
'OIL RIG: Oxidation Is Loss, Reduction Is Gain'.

Correct Answer D Methylene blue

CONCEPT

Oxidation state bookkeeping; balancing by half-reactions in acid/base; cell potential $E°_{cell} = E°_{cathode} - E°_{anode}$; Nernst equation; $\Delta G° = -nFE°$; K from E°.

↓

LOGIC / WORKING

- Methylene blue is a redox indicator (blue ⇌ colourless leuco form). Eriochrome black T is a metal-ion indicator; methyl orange and phenolphthalein are acid–base indicators.
- Therefore the answer is (D).

FINAL: (D) Methylene blue

SHORTCUT / EXAM TRICK

A species disproportionates when E°(right) > E°(left) in its Latimer diagram.

COMMON MISTAKE

Reversing the sign of E° when reversing a half-reaction and also multiplying it by n.

EXAM TIP

E° is intensive — never multiply it by stoichiometric coefficients; ΔG° is extensive.

MEMORY TRICK

'OIL RIG: Oxidation Is Loss, Reduction Is Gain'.

Why the Other Options Are Wrong

Correct answer: D

A **Eriochrome black T**

Why (D) is the key — Methylene blue is a redox indicator (blue ⇌ colourless leuco form). Eriochrome black T is a metal-ion indicator; methyl orange and phenolphthalein are acid–base indicators.

B **Methyl orange**

Ruled out: Reversing the sign of E° when reversing a half-reaction and also multiplying it by n.

C **Phenolphthalein**

Ruled out: E° is intensive — never multiply it by stoichiometric coefficients; ΔG° is extensive.

Q9

The number of S-S bond(s) in tetrathionate ion is ____.
(Numerical answer type — write the value.)

ANSWER: 3

QUESTION INSIGHTS

ESTIMATED TIME
1–1.5 min

DIFFICULTY
Easy

CONCEPT TESTED
Redox Reaction

PYQ FREQUENCY
Rare · 1 paper

REVISION PRIORITY
★★★☆☆

EXPECTED LEVEL
Part B

MEMORY HOOK
Tetrathionate $S_4O_6^{2-}$ is $^-O_3S–S–S–SO_3^-$: a chain of four S atoms with three S–S bonds.

Q10

The volume of 0.3 M ferrous ammonium sulphate solution required for the completion of redox titration with 20 mL of 0.1 M potassium dichromate solution is _____ mL. 10. The number of lone pairs present in phosphonic acid (phosphorus acid) is _____

(Numerical answer type — write the value.)

ANSWER: 40 mL

QUESTION INSIGHTS

ESTIMATED TIME
2–3 min

DIFFICULTY
Medium

CONCEPT TESTED
Redox Reaction

PYQ FREQUENCY
Rare · 1 paper

REVISION PRIORITY
★★★★☆

EXPECTED LEVEL
Part B / Part C

MEMORY HOOK
$Cr_2O_7^{2-}$ takes 6 e^-: 20 mL × 0.1 M = 2 mmol dichromate = 12 mmol electrons = 12 mmol Fe^{2+}. V = 12/0.3 = 40 mL.

Q11

The number of lone pairs present in phosphonic acid (phosphorus acid) is ___ (Numerical answer type — write the value.)

ANSWER: 6

QUESTION INSIGHTS

ESTIMATED TIME
1–1.5 min

DIFFICULTY
Easy

CONCEPT TESTED
Redox Reaction

PYQ FREQUENCY
Rare · 1 paper

REVISION PRIORITY
★★★☆☆

EXPECTED LEVEL
Part B

MEMORY HOOK
Phosphonic acid $HP(=O)(OH)_2$: the P=O oxygen has 2 lone pairs and each OH oxygen 2 → 6 lone pairs (P has none; it is four-coordinate).

Q12

The value of 'n' in $[P_nO_{18}]^{6-}$ is ___
(Numerical answer type — write the value.)

ANSWER: 6

QUESTION INSIGHTS

ESTIMATED TIME
1–1.5 min

DIFFICULTY
Easy

CONCEPT TESTED
Redox Reaction

PYQ FREQUENCY
Rare · 1 paper

REVISION PRIORITY
★★★☆☆

EXPECTED LEVEL
Part B

MEMORY HOOK
Cyclic metaphosphates are $(PO_3^-)_n$: $[P_nO_{3n}]^{n-}$. O_{18} → $n = 6$ → $P_6O_{18}^{6-}$ (hexametaphosphate).

TOPIC REVISION

Redox Reaction

6 PYQs · Last-minute revision

TOPIC SUMMARY

Oxidation state bookkeeping; balancing by half-reactions in acid/base; cell potential E°cell = E°cathode − E°anode; Nernst equation; ΔG° = −nFE°; K from E°.

IMPORTANT FORMULA SHEET

- $E = E^\circ - (0.0592/n) \log Q$ (25 °C)
- $\Delta G^\circ = -nFE^\circ$
- $\log K = nE^\circ/0.0592$
- $E^\circ(MnO_4^-/Mn^{2+}) = 1.51$ V

FREQUENTLY ASKED CONCEPTS

- Balancing in basic medium
- Disproportionation prediction
- Latimer/Frost diagrams
- Equivalent weight of oxidants

COMMON MISTAKES & QUICK NOTES

Watch out:
Reversing the sign of E° when reversing a half-reaction and also multiplying it by n.
E° is intensive — never multiply it by stoichiometric coefficients; ΔG° is extensive.

MOST-REPEATED PYQs & EXPECTED IN EXAM

PYQs in this topic: Q7 Q8 Q9 Q10 Q11 Q12

Expect 6 question(s) next session on Redox Reaction.

TOPIC 3

Phase Equilibrium

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

Q13

For the following system in equilibrium, $CaCO_3(s) \rightleftharpoons CaO(s) + CO_2(g)$ the number of components, (C), phases (P) and degrees of freedom (F), respectively, are

A. 2, 2, 2

B. 1, 3, 0

C. 3, 3, 2

D. 2, 3, 1

QUESTION INSIGHTS

ESTIMATED TIME
2–3 min

DIFFICULTY
Medium

CONCEPT TESTED
Phase Equilibrium

PYQ FREQUENCY
Rare · 1 paper

REVISION PRIORITY
★★★★☆

EXPECTED LEVEL
Part B / Part C

MEMORY HOOK
'F = C − P + 2: Freedom = Components − Phases + 2'.

Correct Answer D 2, 3, 1

CONCEPT

Gibbs phase rule F = C − P + 2; Clapeyron and Clausius–Clapeyron equations describe phase boundaries; Raoult's law and colligative properties; eutectic and azeotrope behaviour in binary diagrams.

↓

LOGIC / WORKING

- Three phases (two solids + gas), two components (CaO and CO_2 suffice to make $CaCO_3$): F = 2 − 3 + 2 = 1.
- Therefore the answer is (D).

FINAL: (D) 2, 3, 1

SHORTCUT / EXAM TRICK

At a triple point of a pure substance F = 0; along a two-phase line F = 1.

COMMON MISTAKE

Counting components as the number of species instead of independent constituents.

EXAM TIP

Water's melting line slopes left (ΔV < 0): pressure lowers the melting point.

MEMORY TRICK

'F = C − P + 2: Freedom = Components − Phases + 2'.

Why the Other Options Are Wrong

Correct answer: D

A **2, 2, 2**

Why (D) is the key — Three phases (two solids + gas), two components (CaO and CO_2 suffice to make $CaCO_3$): F = 2 − 3 + 2 = 1.

B **1, 3, 0**

Ruled out: Counting components as the number of species instead of independent constituents.

C **3, 3, 2**

Ruled out: Water's melting line slopes left ($\Delta V < 0$): pressure lowers the melting point.

Q14

The vapour pressures of solid and liquid chlorine are given by $\log_e P^{\wedge}solid = 24 - (3900)/(T)$ and $\log_e P^{\wedge}liq = 18 - (2600)/(T)$ where P_{solid} and P_{liq} are the vapour pressures (in Torr) of solid and liquid chlorine near the triple point, respectively and T is the absolute temperature. The ratio of the slope of the solid-gas curve to the slope of the liquid gas curve at the triple point in the P-T diagram is ___ IIT JAM 2014 (Numerical answer type — write the value.)

ANSWER: 1.5

QUESTION INSIGHTS

ESTIMATED TIME
2–3 min

DIFFICULTY
Medium

CONCEPT TESTED
Phase Equilibrium

PYQ FREQUENCY
Rare · 1 paper

REVISION PRIORITY
★★★★☆

EXPECTED LEVEL
Part B / Part C

MEMORY HOOK
$dP/dT = P \times d(\ln P)/dT = P \times (3900/T^2)$ for the solid and $P \times (2600/T^2)$ for the liquid. At the triple point P and T are common, so the slope ratio is 3900/2600 = 1.5 (sublimation line is steeper, $\Delta H_{sub} > \Delta H_{vap}$).

Q15 **The number of degrees of freedom in the homogeneous liquid region of a two component system with a eutectic point, at one atmosphere pressure, is:**

A 0

B 1

C 2

D 3

QUESTION INSIGHTS

ESTIMATED TIME
2–3 min

DIFFICULTY
Medium

CONCEPT TESTED
Phase Equilibrium

PYQ FREQUENCY
Rare · 1 paper

REVISION PRIORITY
★★★★☆

EXPECTED LEVEL
Part B / Part C

MEMORY HOOK
'F = C − P + 2: Freedom = Components − Phases + 2'.

Correct Answer C 2

CONCEPT

Gibbs phase rule F = C − P + 2; Clapeyron and Clausius–Clapeyron equations describe phase boundaries; Raoult's law and colligative properties; eutectic and azeotrope behaviour in binary diagrams.

↓

LOGIC / WORKING

- Condensed-phase rule at fixed pressure: F = C − P + 1 = 2 − 1 + 1 = 2 (temperature and composition can both vary in the single liquid phase).
- Therefore the answer is (C).

FINAL: (C) 2

SHORTCUT / EXAM TRICK

At a triple point of a pure substance F = 0; along a two-phase line F = 1.

COMMON MISTAKE

Counting components as the number of species instead of independent constituents.

EXAM TIP

Water's melting line slopes left (ΔV < 0): pressure lowers the melting point.

MEMORY TRICK

'F = C − P + 2: Freedom = Components − Phases + 2'.

Why the Other Options Are Wrong

Correct answer: C

A **0**

Why (C) is the key — Condensed-phase rule at fixed pressure: F = C − P + 1 = 2 − 1 + 1 = 2 (temperature and composition can both vary in the single liquid phase).

B **1**

Ruled out: Counting components as the number of species instead of independent constituents.

D **3**

Ruled out: Water's melting line slopes left (ΔV < 0): pressure lowers the melting point.

Q16

The number of degrees of freedom of liquid water in equilibrium with ice is

A. 0

B. 1

C. 2

D. 3

QUESTION INSIGHTS

ESTIMATED TIME
1–1.5 min

DIFFICULTY
Easy

CONCEPT TESTED
Phase Equilibrium

PYQ FREQUENCY
Rare · 1 paper

REVISION PRIORITY
★★★☆☆

EXPECTED LEVEL
Part B

MEMORY HOOK
'F = C − P + 2: Freedom = Components − Phases + 2'.

Correct Answer B 1

CONCEPT

Gibbs phase rule F = C − P + 2; Clapeyron and Clausius–Clapeyron equations describe phase boundaries; Raoult's law and colligative properties; eutectic and azeotrope behaviour in binary diagrams.

↓

LOGIC / WORKING

- One component, two phases: F = 1 − 2 + 2 = 1 (choose T, and p is fixed on the melting line).
- Therefore the answer is (B).

FINAL: (B) 1

SHORTCUT / EXAM TRICK

At a triple point of a pure substance F = 0; along a two-phase line F = 1.

COMMON MISTAKE

Counting components as the number of species instead of independent constituents.

EXAM TIP

Water's melting line slopes left (ΔV < 0): pressure lowers the melting point.

MEMORY TRICK

'F = C − P + 2: Freedom = Components − Phases + 2'.

Why the Other Options Are Wrong

Correct answer: B

A **0**

Why (B) is the key — One component, two phases: F = 1 − 2 + 2 = 1 (choose T, and p is fixed on the melting line).

C **2**

Ruled out: Counting components as the number of species instead of independent constituents.

D **3**

Ruled out: Water's melting line slopes left (ΔV < 0): pressure lowers the melting point.

TOPIC REVISION

Phase Equilibrium

4 PYQs · Last-minute revision

TOPIC SUMMARY

Gibbs phase rule F = C − P + 2; Clapeyron and Clausius–Clapeyron equations describe phase boundaries; Raoult's law and colligative properties; eutectic and azeotrope behaviour in binary diagrams.

IMPORTANT FORMULA SHEET

- $F = C - P + 2$
- $dp/dT = \Delta H/(T\Delta V)$
- $\ln(p_2/p_1) = -(\Delta H_{vap}/R)(1/T_2 - 1/T_1)$
- $\Delta T_f = K_f m$; $\pi = cRT$

FREQUENTLY ASKED CONCEPTS

- Degrees of freedom at triple/eutectic points
- Slope of solid–liquid line for water
- Lever rule
- Azeotropes

COMMON MISTAKES & QUICK NOTES

Watch out:
Counting components as the number of species instead of independent constituents.
Water's melting line slopes left (ΔV < 0): pressure lowers the melting point.

MOST-REPEATED PYQs & EXPECTED IN EXAM

PYQs in this topic: Q13 Q14 Q15 Q16

Expect 4 question(s) next session on Phase Equilibrium.

TOPIC 4

Photochemistry

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

Q17

A solution containing a metal complex absorbs at 480 nm with molar extinction coefficient of 15,000 L mol⁻¹ cm⁻¹. If the path length of the cell is 1.0 cm and transmittance is 20.5%, the concentration (in mol L⁻¹) of the metal complex is:

A 2.29×10^{-5}

B 8.75×10^{-5}

C 4.59×10^{-5}

D 1.37×10^{-5}

QUESTION INSIGHTS

ESTIMATED TIME
2–3 min

DIFFICULTY
Medium

CONCEPT TESTED
Photochemistry

PYQ FREQUENCY
Rare · 1 paper

REVISION PRIORITY
★★★★☆

EXPECTED LEVEL
Part B / Part C

MEMORY HOOK
'Fluoresce Fast (singlet), Phosphoresce Prolonged (triplet)'.

Correct Answer C 4.59 × 10⁻⁵

CONCEPT

Grotthuss–Draper and Stark–Einstein laws; quantum yield Φ = molecules reacted / photons absorbed; Jablonski diagram (fluorescence from S_1, phosphorescence from T_1); Stern–Volmer quenching.

↓

LOGIC / WORKING

- $A = -\log T = -\log 0.205 = 0.688$; $c = A/(\varepsilon l) = 0.688/(15\,000 \times 1) = 4.59\times10^{-5}$ mol L^{-1}.
- Therefore the answer is (C).

FINAL: (C) 4.59 × 10⁻⁵

SHORTCUT / EXAM TRICK

Energy per mole of photons ≈ 119 600/λ(nm) kJ mol^{-1}.

COMMON MISTAKE

Confusing quantum yield of the primary step (≤ 1) with the overall yield (can be ≫ 1).

EXAM TIP

Phosphorescence is slow because $T_1 \rightarrow S_0$ is spin-forbidden.

MEMORY TRICK

'Fluoresce Fast (singlet), Phosphoresce Prolonged (triplet)'.

Why the Other Options Are Wrong

Correct answer: C

A **2.29×10^{-5}**

Why (C) is the key — $A = -\log T = -\log 0.205 = 0.688$; $c = A/(\varepsilon l) = 0.688/(15\,000 \times 1) = 4.59 \times 10^{-5}$ mol L^{-1}.

B **8.75×10^{-5}**

Ruled out: Confusing quantum yield of the primary step (≤ 1) with the overall yield (can be $\gg 1$).

D **1.37×10^{-5}**

Ruled out: Phosphorescence is slow because $T_1 \rightarrow S_0$ is spin-forbidden.

Q18

Fluorescence quantum yield and fluorescence lifetime of a molecule are 0.4 and 5 × 10^{-9} s, respectively. If the fluorescence decay rate constant is Y × 10^{7} s^{-1}, the value of Y (rounded off to nearest integer) is _____ 6. The number of photons emitted per nanosecond by a deuterium lamp (400 nm) having a power of 1 microwatt (rounded off to the nearest integer) is _____. [h = 6.626 × 10^{-34} kg m^2 s^{-1}; c = 3.0 × 10^{8} m s^{-1}]
(Numerical answer type — write the value.)

ANSWER: Y = 8; ≈ 2012 photons ns^{-1}

QUESTION INSIGHTS

ESTIMATED TIME
2–3 min

DIFFICULTY
Medium

CONCEPT TESTED
Photochemistry

PYQ FREQUENCY
Rare · 1 paper

REVISION PRIORITY
★★★★☆

EXPECTED LEVEL
Part B / Part C

MEMORY HOOK
$k_f = \Phi_f/\tau = 0.4/(5\times10^{-9}) = 8\times10^{7}\ s^{-1} \rightarrow Y = 8$. Photon energy at 400 nm = $hc/\lambda = 4.97\times10^{-19}$ J; 1 μW delivers 10^{-15} J per ns → $10^{-15}/4.97\times10^{-19} \approx 2012$ photons per ns.

Q19 The molar absorption coefficient of a substance dissolved in cyclohexane is 1710 L mol^{-1} cm^{-1} at 500 nm. The reduction in intensity of light of the same wavelength that passes through a cell of 1 mm path length containing a 2 mmol L^{-1} solution (rounded off to one decimal place) is ___%.
(Numerical answer type — write the value.)

ANSWER: 54.5 %

QUESTION INSIGHTS

ESTIMATED TIME
3–5 min

DIFFICULTY
Hard

CONCEPT TESTED
Photochemistry

PYQ FREQUENCY
Rare · 1 paper

REVISION PRIORITY
★★★★★

EXPECTED LEVEL
Part C (high merit)

MEMORY HOOK
$A = \varepsilon c l = 1710 \times 2\times10^{-3} \times 0.1 = 0.342$; $T = 10^{(-0.342)} = 0.455$, so the intensity is reduced by $100 - 45.5 = 54.5$ %.

TOPIC REVISION

Photochemistry

3 PYQs · Last-minute revision

TOPIC SUMMARY

Grotthuss–Draper and Stark–Einstein laws; quantum yield Φ = molecules reacted / photons absorbed; Jablonski diagram (fluorescence from S_1, phosphorescence from T_1); Stern–Volmer quenching.

IMPORTANT FORMULA SHEET

- $E = h\nu = hc/\lambda$; 1 einstein = N_A photons
- Φ = rate/I_{abs}
- Stern–Volmer: $\Phi_0/\Phi = 1 + k_q \tau_0[Q]$
- $\tau = 1/(k_f + k_{ic} + k_{isc})$

FREQUENTLY ASKED CONCEPTS

- Quantum yield > 1 (chain reactions)
- Fluorescence vs phosphorescence
- Stern–Volmer plot slope
- Energy of a photon in kJ mol^{-1}

COMMON MISTAKES & QUICK NOTES

Watch out:
Confusing quantum yield of the primary step (≤ 1) with the overall yield (can be ≫ 1).
Phosphorescence is slow because $T_1 \rightarrow S_0$ is spin-forbidden.

MOST-REPEATED PYQs & EXPECTED IN EXAM

PYQs in this topic: Q17 Q18 Q19

Expect 3 question(s) next session on Photochemistry.

TOPIC 5

Nuclear, Redox, Phase & Photochemistry – General

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

Q20

The chemical potential of a component, μ_i, in a given mixture is:

A $((\partial G)/(\partial n_i))_{T,V,n_j}$

B $((\partial G)/(\partial n_i))_{T,P,n_j}$

C $((\partial G)/(\partial n_i))_{T,P,n_i}$

D $((\partial G)/(n_i))$

QUESTION INSIGHTS

ESTIMATED TIME
1–1.5 min

DIFFICULTY
Easy

CONCEPT TESTED
Nuclear, Redox, Phase & Photochemistry – General

PYQ FREQUENCY
Rare · 1 paper

REVISION PRIORITY
★★★☆☆

EXPECTED LEVEL
Part B

MEMORY HOOK
'μ equal across phases ⇒ equilibrium'.

Correct Answer B $((\partial G)/(\partial n_i))_{T,P,n_j}$

CONCEPT

$\mu_i = (\partial G/\partial n_i)_{T,p,n_j}$; for an ideal gas $\mu = \mu^\circ + RT \ln(p/p^\circ)$; equal μ across phases at equilibrium; Gibbs–Duhem $\Sigma n_i d\mu_i = 0$.

↓

LOGIC / WORKING

- Chemical potential is the partial molar Gibbs energy: $\mu_i = (\partial G/\partial n_i)$ at constant T, p and all other n_j.
- Therefore the answer is (B).

FINAL: (B) $((\partial G)/(\partial n_i))_{T,P,n_j}$

SHORTCUT / EXAM TRICK

Matter flows from high μ to low μ — μ is the 'escaping tendency'.

COMMON MISTAKE

Treating μ as extensive; it is a partial molar (intensive) quantity.

EXAM TIP

For a pure substance $\mu = G_m$.

MEMORY TRICK

'μ equal across phases ⇒ equilibrium'.

Why the Other Options Are Wrong

Correct answer: B

A $((\partial G)/(\partial n_i))_{T,V,n_j}$

Why (B) is the key — Chemical potential is the partial molar Gibbs energy: $\mu_i = (\partial G/\partial n_i)$ at constant T, p and all other n_j.

C $((\partial G)/(\partial n_i))_{T,P,n_i}$

Ruled out: Treating μ as extensive; it is a partial molar (intensive) quantity.

D $((\partial G)/(n_i))$

Ruled out: For a pure substance μ = G_m.

Q21

Which molecule has zero bond order ?

A H_2^+

B H_2

C HeH

D He_2

QUESTION INSIGHTS

ESTIMATED TIME
2–3 min

DIFFICULTY
Medium

CONCEPT TESTED
Nuclear, Redox, Phase & Photochemistry – General

PYQ FREQUENCY
Rare · 1 paper

REVISION PRIORITY
★★★★☆

EXPECTED LEVEL
Part B / Part C

MEMORY HOOK
'μ equal across phases ⇒ equilibrium'.

Correct Answer D He_2

CONCEPT

$\mu_i = (\partial G/\partial n_i)_{T,p,n_j}$; for an ideal gas $\mu = \mu^\circ + RT \ln(p/p^\circ)$; equal μ across phases at equilibrium; Gibbs–Duhem $\Sigma n_i d\mu_i = 0$.

↓

LOGIC / WORKING

- He_2 $(\sigma 1s)^2(\sigma^* 1s)^2$: bond order $(2 - 2)/2 = 0$ — no stable molecule. H_2^+ ½, H_2 1, HeH ½.
- Therefore the answer is (D).

FINAL: (D) He_2

SHORTCUT / EXAM TRICK

Matter flows from high μ to low μ — μ is the 'escaping tendency'.

COMMON MISTAKE

Treating μ as extensive; it is a partial molar (intensive) quantity.

EXAM TIP

For a pure substance $\mu = G_m$.

MEMORY TRICK

'μ equal across phases ⇒ equilibrium'.

Why the Other Options Are Wrong

Correct answer: D

A H_2^+

Why (D) is the key — He_2 $(\sigma 1s)^2(\sigma^* 1s)^2$: bond order $(2-2)/2 = 0$ — no stable molecule. H_2^+ ½, H_2 1, HeH ½.

B H_2

Ruled out: Treating μ as extensive; it is a partial molar (intensive) quantity.

C HeH

Ruled out: For a pure substance μ = G_m.

Nuclear, Redox, Phase & Photochemistry – General

TOPIC SUMMARY

$\mu_i = (\partial G/\partial n_i)_{T,p,n_j}$; for an ideal gas $\mu = \mu^\circ + RT \ln(p/p^\circ)$; equal μ across phases at equilibrium; Gibbs–Duhem $\Sigma n_i d\mu_i = 0$.

IMPORTANT FORMULA SHEET

- $\mu = \mu^\circ + RT \ln a$
- $\Delta G_{mix} = nRT \Sigma x_i \ln x_i$
- $\Sigma\, n_i\, d\mu_i = 0$ (T, p const)

FREQUENTLY ASKED CONCEPTS

- μ of components in ideal solution
- Phase equilibrium condition
- Activity and activity coefficient

COMMON MISTAKES & QUICK NOTES

Watch out:
Treating μ as extensive; it is a partial molar (intensive) quantity.
For a pure substance $\mu = G_m$.

MOST-REPEATED PYQs & EXPECTED IN EXAM

PYQs in this topic: Q20 Q21

Expect 2 question(s) next session on Nuclear, Redox, Phase & Photochemistry – General.

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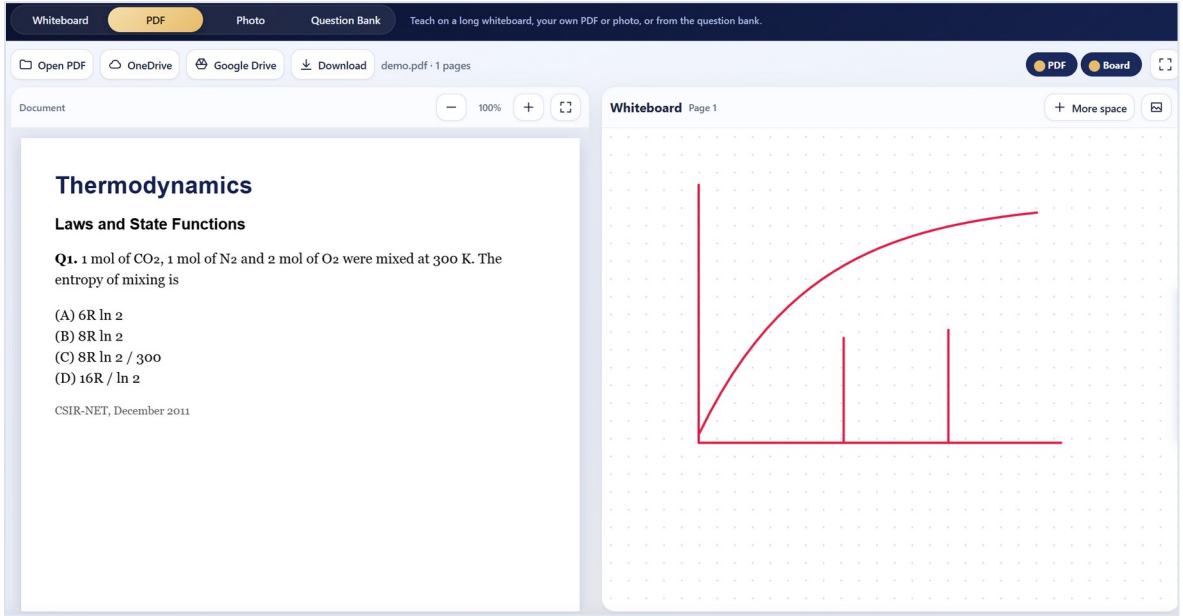
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