ABC CHEMISTRY

Mr. Aniket Bhardwaj · 15+ Years Mentorship

Inorganic Spectroscopy

Premium CSIR-NET PYQ Book

36 Previous-Year Questions · 34 with verified answers · Distractor Analysis

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

CSIR-NET · GATE · IIT-JAM — 3 Topics · 36 Real PYQs

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Course Contents

3 Topics · 36 PYQs

1 **Mossbauer**
4 Qs E 1 · M 3 · H 0 — 11%

2 **Electronic Spectra Tanabe Sugano**
3 Qs E 0 · M 2 · H 1 — 8%

3 **Inorganic Spectroscopy – General**
29 Qs E 9 · M 20 · H 0 — 81%

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

TOPIC 1

Mossbauer

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

Q1

Consider the following statements for $[FeO_4]^{2-}$ (A) It is stable in the pH range 0-14 (B) It is stable in strongly basic medium only (C) It is a very strong oxidizing agent (D) The isomer shift in its Mossbauer spectrum is more negative compared to that of $FeCl_3$. The correct statements are

A. A, C and D

B. B, C and D

C. B and C

D. C and D

QUESTION INSIGHTS

ESTIMATED TIME
1–1.5 min

DIFFICULTY
Easy

CONCEPT TESTED
Mossbauer

PYQ FREQUENCY
Occasional · 4 papers

REVISION PRIORITY
★★★☆☆

EXPECTED LEVEL
Part B

MEMORY HOOK
'δ says oxidation, ΔE_Q says symmetry'.

Correct Answer B B, C and D

CONCEPT

^{57}Fe Mössbauer: isomer shift δ reflects s-electron density (oxidation/spin state), quadrupole splitting ΔE_Q reflects electric-field-gradient asymmetry, magnetic hyperfine gives six lines; also ^{119}Sn, ^{197}Au, ^{129}I.

↓

LOGIC / WORKING

- Ferrate(VI) is stable only in strongly basic solution and is a very strong oxidant. Its higher s-electron density gives a more negative isomer shift than Fe(III) in $FeCl_3$. B, C and D (b).
- Therefore the answer is (B).

FINAL: (B) B, C and D

SHORTCUT / EXAM TRICK

High δ and large ΔE_Q → high-spin Fe(II); low δ, small ΔE_Q → high-spin Fe(III).

COMMON MISTAKE

Linking δ to ligand field strength only — it tracks 4s density via 3d shielding.

EXAM TIP

Mixed-valence Fe_3O_4 above the Verwey transition shows one averaged Fe signal for the octahedral sites.

MEMORY TRICK

'δ says oxidation, ΔE_Q says symmetry'.

Why the Other Options Are Wrong

Correct answer: B

A

A, C and D

Why (B) is the key — Ferrate(VI) is stable only in strongly basic solution and is a very strong oxidant. Its higher s-electron density gives a more negative isomer shift than Fe(III) in $FeCl_3$. B, C and D (b).

C

B and C

Ruled out: Linking δ to ligand field strength only — it tracks 4s density via 3d shielding.

D

C and D

Ruled out: Mixed-valence Fe_3O_4 above the Verwey transition shows one averaged Fe signal for the octahedral sites.

Q2

In Mossbauer spectrum of a sample containing iron recorded in the presence of a static magnetic field, the number of possible allowed transition(s) is

A. Two

B. Four

C. Six

D. Eight

QUESTION INSIGHTS

ESTIMATED TIME
2–3 min

DIFFICULTY
Medium

CONCEPT TESTED
Mossbauer

PYQ FREQUENCY
Occasional · 4 papers

REVISION PRIORITY
★★★★☆

EXPECTED LEVEL
Part B / Part C

MEMORY HOOK
'δ says oxidation, ΔE_Q says symmetry'.

Correct Answer C Six

CONCEPT

^{57}Fe Mössbauer: isomer shift δ reflects s-electron density (oxidation/spin state), quadrupole splitting ΔE_Q reflects electric-field-gradient asymmetry, magnetic hyperfine gives six lines; also ^{119}Sn, ^{197}Au, ^{129}I.

↓

LOGIC / WORKING

- Magnetic field lifts the degeneracy: I = 3/2 excited state → 4 sublevels, I = 1/2 ground state → 2. With ΔmI = 0, ±1 (M1 transition) six lines appear — the classic sextet of α-Fe.
- Therefore the answer is (C).

FINAL: (C) Six

SHORTCUT / EXAM TRICK

High δ and large ΔE_Q → high-spin Fe(II); low δ, small ΔE_Q → high-spin Fe(III).

COMMON MISTAKE

Linking δ to ligand field strength only — it tracks 4s density via 3d shielding.

EXAM TIP

Mixed-valence Fe_3O_4 above the Verwey transition shows one averaged Fe signal for the octahedral sites.

MEMORY TRICK

'δ says oxidation, ΔE_Q says symmetry'.

Why the Other Options Are Wrong

Correct answer: C

A **Two**

Why (C) is the key — Magnetic field lifts the degeneracy: I = 3/2 excited state → 4 sublevels, I = 1/2 ground state → 2. With ΔmI = 0, ±1 (M1 transition) six lines appear — the classic sextet of α-Fe.

B **Four**

Ruled out: Linking δ to ligand field strength only — it tracks 4s density via 3d shielding.

D **Eight**

Ruled out: Mixed-valence Fe_3O_4 above the Verwey transition shows one averaged Fe signal for the octahedral sites.

Q3 The reduced form of a metal ion M in a complex is NMR active. On oxidation, the complex gives an EPR signal with g_parallel=2.2 and g_perp=2.0. Mossbauer spectroscopy cannot characteristic the metal complex. The M is

A Zn

B Sn

C Cu

D Fe

QUESTION INSIGHTS

ESTIMATED TIME
2–3 min

DIFFICULTY
Medium

CONCEPT TESTED
Mossbauer

PYQ FREQUENCY
Occasional · 4 papers

REVISION PRIORITY
★★★★☆

EXPECTED LEVEL
Part B / Part C

MEMORY HOOK
'δ says oxidation, ΔE_Q says symmetry'.

Correct Answer C Cu

CONCEPT

^{57}Fe Mössbauer: isomer shift δ reflects s-electron density (oxidation/spin state), quadrupole splitting ΔE_Q reflects electric-field-gradient asymmetry, magnetic hyperfine gives six lines; also ^{119}Sn, ^{197}Au, ^{129}I.

↓

LOGIC / WORKING

- Cu(I) is d^{10} (diamagnetic, $^{63/65}$Cu NMR-active); Cu(II) is d^9 with an axial EPR spectrum ($g_\parallel > g_\perp > 2$); copper has no Mössbauer isotope.
- Therefore the answer is (C).

FINAL: (C) Cu

SHORTCUT / EXAM TRICK

High δ and large ΔE_Q → high-spin Fe(II); low δ, small ΔE_Q → high-spin Fe(III).

COMMON MISTAKE

Linking δ to ligand field strength only — it tracks 4s density via 3d shielding.

EXAM TIP

Mixed-valence Fe_3O_4 above the Verwey transition shows one averaged Fe signal for the octahedral sites.

MEMORY TRICK

'δ says oxidation, ΔE_Q says symmetry'.

Why the Other Options Are Wrong

Correct answer: C

A **Zn**

Why (C) is the key — Cu(I) is d^{10} (diamagnetic, ^{63}/^{65}Cu NMR-active); Cu(II) is d^{9} with an axial EPR spectrum ($g_{\parallel} > g_{\perp} > 2$); copper has no Mössbauer isotope.

B **Sn**

Ruled out: Linking δ to ligand field strength only — it tracks 4s density via 3d shielding.

D **Fe**

Ruled out: Mixed-valence Fe_3O_4 above the Verwey transition shows one averaged Fe signal for the octahedral sites.

Q4

To record Mossbauer spectrum of Fe containing samples, a source 'X' is used. X after a nuclear transformation (Y), gives γ-radiation used in Mössbauer spectroscopy. (a) ^{57}Fe, β-emission (c) ^{57}Co, electron capture (b) ^{57}Co, β-emission (d) ^{57}Fe, electron capture

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

QUESTION INSIGHTS

ESTIMATED TIME
2–3 min

DIFFICULTY
Medium

CONCEPT TESTED
Mossbauer

PYQ FREQUENCY
Occasional · 4 papers

REVISION PRIORITY
★★★★☆

EXPECTED LEVEL
Part B / Part C

MEMORY HOOK
'δ says oxidation, ΔE_Q says symmetry'.

TOPIC REVISION

Mossbauer

4 PYQs · Last-minute revision

TOPIC SUMMARY

^{57}Fe Mössbauer: isomer shift δ reflects s-electron density (oxidation/spin state), quadrupole splitting ΔE_Q reflects electric-field-gradient asymmetry, magnetic hyperfine gives six lines; also ^{119}Sn, ^{197}Au, ^{129}I.

IMPORTANT FORMULA SHEET

- δ(Fe^{2+} HS) ≈ 1.0–1.4 mm/s; Fe^{3+} HS ≈ 0.3–0.5; Fe^{2+} LS ≈ 0–0.2
- ΔE_Q large for HS Fe^{2+} (asymmetric d^6), small for HS Fe^{3+} (d^5 symmetric)
- Magnetic sextet: ΔE ∝ B_hf

FREQUENTLY ASKED CONCEPTS

- Distinguish Fe^{2+}/Fe^{3+} and HS/LS
- Why ferrocene shows a large ΔE_Q
- Prussian blue: two Fe sites
- Six-line pattern origin

COMMON MISTAKES & QUICK NOTES

Watch out:
Linking δ to ligand field strength only — it tracks 4s density via 3d shielding.
Mixed-valence Fe_3O_4 above the Verwey transition shows one averaged Fe signal for the octahedral sites.

MOST-REPEATED PYQs & EXPECTED IN EXAM

PYQs in this topic: Q1 Q2 Q3 Q4

Expect 1 question(s) next session on Mossbauer.

TOPIC 2

Electronic Spectra Tanabe Sugano

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

Q5

The expected number of ^{19}F NMR spectral lines, including satellites, for $[XeF_5]^-$ is [Abundance of ^{129}Xe (I = 1/2) = 26\%]

A. two

B. twenty one

C. three

D. one

QUESTION INSIGHTS

ESTIMATED TIME
2–3 min

DIFFICULTY
Medium

CONCEPT TESTED
Electronic Spectra Tanabe Sugano

PYQ FREQUENCY
Occasional · 3 papers

REVISION PRIORITY
★★★★☆

EXPECTED LEVEL
Part B / Part C

MEMORY HOOK
'Three bands for d^3 and d^8'.

Correct Answer C three

CONCEPT

Tanabe–Sugano diagrams plot E/B vs Δ_o/B for each d^n; the ground term and spin-allowed transitions give the number of bands; d^3 (Cr^{3+}) and d^8 (Ni^{2+}) show three bands; ratios of band energies give Δ_o/B, then Δ_o and B (nephelauxetic ratio β = B_complex/B_free).

↓

LOGIC / WORKING

- rx;xH [XeF5]- = = 7 = sp3d3 hybridzation ; Shape = Pentagonal Planar as 74% Xe are NMR inactive hence a singlet of five fluorine and due to 26% nuclei a doublet of satellite. Hence, total number of signal is 3. Explanation as extracted from the printed page; notation may be imperfect.
- Therefore the answer is (C).

FINAL: (C) three

SHORTCUT / EXAM TRICK

$d^2 \leftrightarrow d^8$ and $d^3 \leftrightarrow d^7$ diagrams are related by the hole formalism; d^5 HS has no spin-allowed transition.

COMMON MISTAKE

Reading Δ_o directly from a band for d^2 or d^7 (only d^1, d^3, d^8, d^9 give Δ_o from ν_1).

EXAM TIP

Nephelauxetic series (β decreasing): $F^- > H_2O > NH_3 > en > Cl^- > Br^- > I^-$.

MEMORY TRICK

'Three bands for d^3 and d^8'.

Why the Other Options Are Wrong

Correct answer: C

A — **two**

Why (C) is the key — rx;xH [XeF5]- = = 7 = sp3d3 hybridzation ; Shape = Pentagonal Planar as 74% Xe are NMR inactive hence a singlet of five fluorine and due to 26% nuclei a doublet of satellite. Hence, total number of signal is 3. Explanation as extracted from the printed page; notation may be imperfect.

B — **twenty one**

Ruled out: Reading Δ_o directly from a band for d^2 or d^7 (only d^1, d^3, d^8, d^9 give Δ_o from ν_1).

D — **one**

Ruled out: Nephelauxetic series (β decreasing): $F^- > H_2O > NH_3 > en > Cl^- > Br^- > I^-$.

Q6

The correct order of the isomeric shift in Mössbauer spectra (^{57}Fe source) of iron compounds is

A. Fe(II) > Fe(III) > Fe(IV)

B. Fe(III) > Fe(II) > Fe(IV)

C. Fe(IV) > Fe(III) Fe(II)

D. Fe(IV) > Fe(II) > Fe(III)

QUESTION INSIGHTS

ESTIMATED TIME
3–5 min

DIFFICULTY
Hard

CONCEPT TESTED
Electronic Spectra Tanabe Sugano

PYQ FREQUENCY
Occasional · 3 papers

REVISION PRIORITY
★★★★★

EXPECTED LEVEL
Part C (high merit)

MEMORY HOOK
'Three bands for d^3 and d^8'.

Correct Answer A Fe(II) > Fe(III) > Fe(IV)

CONCEPT

Tanabe–Sugano diagrams plot E/B vs Δ_o/B for each d^n; the ground term and spin-allowed transitions give the number of bands; d^3 (Cr^{3+}) and d^8 (Ni^{2+}) show three bands; ratios of band energies give Δ_o/B, then Δ_o and B (nephelauxetic ratio β = B_complex/B_free).

↓

LOGIC / WORKING

- Isomer shift decreases with s-electron density at the nucleus; higher oxidation state removes d electrons, lowers d-shielding and raises s-density. For ^{57}Fe (ΔR/R < 0) δ: Fe(II) > Fe(III) > Fe(IV).
- Therefore the answer is (A).

FINAL: (A) Fe(II) > Fe(III) > Fe(IV)

SHORTCUT / EXAM TRICK

$d^2 \leftrightarrow d^8$ and $d^3 \leftrightarrow d^7$ diagrams are related by the hole formalism; d^5 HS has no spin-allowed transition.

COMMON MISTAKE

Reading Δ_o directly from a band for d^2 or d^7 (only d^1, d^3, d^8, d^9 give Δ_o from ν_1).

EXAM TIP

Nephelauxetic series (β decreasing): $F^- > H_2O > NH_3 > en > Cl^- > Br^- > I^-$.

MEMORY TRICK

'Three bands for d^3 and d^8'.

Why the Other Options Are Wrong

Correct answer: A

B **Fe(III) > Fe(II) > Fe(IV)**

Why (A) is the key — Isomer shift decreases with s-electron density at the nucleus; higher oxidation state removes d electrons, lowers d-shielding and raises s-density. For ^{57}Fe ($\Delta R/R < 0$) δ: Fe(II) > Fe(III) > Fe(IV).

C **Fe(IV) > Fe(III) Fe(II)**

Ruled out: Reading Δ_o directly from a band for d^2 or d^7 (only d^1, d^3, d^8, d^9 give Δ_o from ν_1).

D **Fe(IV) > Fe(II) > Fe(III)**

Ruled out: Nephelauxetic series (β decreasing): $F^- > H_2O > NH_3 > en > Cl^- > Br^- > I^-$.

Q7

The numbers of lines shown by the BH_3 part of the molecule $Ph_3P.^{11}BH_3$ in the ^1H and ^{11}B NMR spectra are, respectively [I(^{11}B)=3 / 2 ; I(^{31}P)=1 / 2]

A. 8 and 8

B. 4 and 8

C. 3 and 6

D. 6 and 3

QUESTION INSIGHTS

ESTIMATED TIME
2–3 min

DIFFICULTY
Medium

CONCEPT TESTED
Electronic Spectra Tanabe Sugano

PYQ FREQUENCY
Occasional · 3 papers

REVISION PRIORITY
★★★★☆

EXPECTED LEVEL
Part B / Part C

MEMORY HOOK
'Three bands for d^3 and d^8'.

Correct Answer A 8 and 8

CONCEPT

Tanabe–Sugano diagrams plot E/B vs Δ_o/B for each d^n; the ground term and spin-allowed transitions give the number of bands; d^3 (Cr^{3+}) and d^8 (Ni^{2+}) show three bands; ratios of band energies give Δ_o/B, then Δ_o and B (nephelauxetic ratio β = B_complex/B_free).

↓

LOGIC / WORKING

- BH_3 protons: coupled to ^{11}B (I = 3/2, 4 lines) and ^{31}P (2) → 8 lines; ^{11}B: coupled to 3 H (4 lines) and ^{31}P (2) → 8 lines.
- Therefore the answer is (A).

FINAL: (A) 8 and 8

SHORTCUT / EXAM TRICK

$d^2 \leftrightarrow d^8$ and $d^3 \leftrightarrow d^7$ diagrams are related by the hole formalism; d^5 HS has no spin-allowed transition.

COMMON MISTAKE

Reading Δ_o directly from a band for d^2 or d^7 (only d^1, d^3, d^8, d^9 give Δ_o from ν_1).

EXAM TIP

Nephelauxetic series (β decreasing): $F^- > H_2O > NH_3 > en > Cl^- > Br^- > I^-$.

MEMORY TRICK

'Three bands for d^3 and d^8'.

Why the Other Options Are Wrong

Correct answer: A

B **4 and 8**

Why (A) is the key — BH_3 protons: coupled to ^{11}B (I = 3/2, 4 lines) and ^{31}P (2) → 8 lines; ^{11}B: coupled to 3 H (4 lines) and ^{31}P (2) → 8 lines.

C **3 and 6**

Ruled out: Reading Δ_o directly from a band for d^2 or d^7 (only d^1, d^3, d^8, d^9 give Δ_o from ν_1).

D **6 and 3**

Ruled out: Nephelauxetic series (β decreasing): $F^- > H_2O > NH_3 > en > Cl^- > Br^- > I^-$.

TOPIC REVISION

Electronic Spectra Tanabe Sugano

3 PYQs · Last-minute revision

TOPIC SUMMARY

Tanabe–Sugano diagrams plot E/B vs Δ_o/B for each d^n; the ground term and spin-allowed transitions give the number of bands; d^3 (Cr^{3+}) and d^8 (Ni^{2+}) show three bands; ratios of band energies give Δ_o/B, then Δ_o and B (nephelauxetic ratio β = B_complex/B_free).

IMPORTANT FORMULA SHEET

- d^3/d^8 octahedral: $\nu_1 = \Delta_o$ ($^4A_2g \rightarrow {}^4T_2g$)
- d^1, d^9: single band = Δ_o
- $\beta = B/B_0 < 1$ (covalency)
- High-spin/low-spin crossover near $\Delta_o/B \approx 20$ (d^6)

FREQUENTLY ASKED CONCEPTS

- Number of spin-allowed bands for each d^n
- Ground terms (d^3 ^4A_2g, d^8 ^3A_2g, d^5 ^6A_1g)
- Using ν_2/ν_1 to get Δ_o/B
- Why $[Mn(H_2O)_6]^{2+}$ has many weak bands

COMMON MISTAKES & QUICK NOTES

Watch out:
Reading Δ_o directly from a band for d^2 or d^7 (only d^1, d^3, d^8, d^9 give Δ_o from ν_1).
Nephelauxetic series (β decreasing): $F^- > H_2O > NH_3 > en > Cl^- > Br^- > I^-$.

MOST-REPEATED PYQs & EXPECTED IN EXAM

PYQs in this topic: Q5 Q6 Q7

Expect 1 question(s) next session on Electronic Spectra Tanabe Sugano.

TOPIC 3

Inorganic Spectroscopy – General

29 questions · Easy 9 | Medium 20 | Hard 0 · PYQ frequency: Very High

Q8

In the ^{19}F NMR spectrum of PF_5, the number of signals and multiplicity, at room temperature are

A. One, singlet

B. One, doublet

C. Two, doublet

D. Two, singlet

QUESTION INSIGHTS

ESTIMATED TIME
2–3 min

DIFFICULTY
Medium

CONCEPT TESTED
Inorganic Spectroscopy – General

PYQ FREQUENCY
Very High · 11 paper

REVISION PRIORITY
★★★★☆

EXPECTED LEVEL
Part B / Part C

MEMORY HOOK
'Weak = d–d, strong = CT'.

Correct Answer B One, doublet

CONCEPT

Electronic spectra of transition-metal complexes (d–d: Laporte/spin rules, Tanabe–Sugano diagrams, Racah B, nephelauxetic effect, Jahn–Teller), charge-transfer bands (MnO_4^-, CrO_4^{2-}), IR of CO/NO/N_2 ligands (back-bonding lowers ν), Mössbauer (isomer shift, quadrupole splitting), EPR (g, hyperfine), magnetism (μ, Curie–Weiss), NMR of inorganic nuclei (^{19}F, ^{31}P, ^{11}B, ^{195}Pt).

LOGIC / WORKING

- PF undergoes fast Berry pseudorotation at room temperature, so all five F are equivalent: one signal, split into a doublet by P.
- Therefore the answer is (B).

FINAL: (B) One, doublet

SHORTCUT / EXAM TRICK

More electron-rich metal → more back-bonding → lower ν(CO): $[V(CO)_6]^-$ < $Cr(CO)_6$ < $[Mn(CO)_6]^+$.

COMMON MISTAKE

Assigning intense colours to d–d transitions (they are weak; intense = charge transfer).

EXAM TIP

Number of ν(CO) IR bands reveals geometry: cis-$M(CO)_2L_4$ 2 bands, trans 1 band.

MEMORY TRICK

'Weak = d–d, strong = CT'.

Why the Other Options Are Wrong

Correct answer: B

A — **One, singlet**

Why (B) is the key — PF undergoes fast Berry pseudorotation at room temperature, so all five F are equivalent: one signal, split into a doublet by P.

C — **Two, doublet**

Ruled out: Assigning intense colours to d–d transitions (they are weak; intense = charge transfer).

D — **Two, singlet**

Ruled out: Number of ν(CO) IR bands reveals geometry: cis-$M(CO)_2L_4$ 2 bands, trans 1 band.

Q9

Find out the number of lines in the ^{31}P NMR signal for diagram

A. 3

B. 6

C. 18

D. 90

QUESTION INSIGHTS

ESTIMATED TIME
2–3 min

DIFFICULTY
Medium

CONCEPT TESTED
Inorganic Spectroscopy – General

PYQ FREQUENCY
Very High · 11 paper

REVISION PRIORITY
★★★★☆

EXPECTED LEVEL
Part B / Part C

MEMORY HOOK
'Weak = d–d, strong = CT'.

Correct Answer D 90

CONCEPT

Electronic spectra of transition-metal complexes (d–d: Laporte/spin rules, Tanabe–Sugano diagrams, Racah B, nephelauxetic effect, Jahn–Teller), charge-transfer bands (MnO_4^-, CrO_4^{2-}), IR of CO/NO/N_2 ligands (back-bonding lowers ν), Mössbauer (isomer shift, quadrupole splitting), EPR (g, hyperfine), magnetism (μ, Curie–Weiss), NMR of inorganic nuclei (^{19}F, ^{31}P, ^{11}B, ^{195}Pt).

LOGIC / WORKING

- ^{31}P couples to the P–H (doublet), two ^{19}F (triplet), two ^{15}N (I = ½, triplet) and four N–H protons (quintet): 2 × 3 × 3 × 5 = 90 lines (d).
- Therefore the answer is (D).

FINAL: (D) 90

SHORTCUT / EXAM TRICK

More electron-rich metal → more back-bonding → lower ν(CO): $[V(CO)_6]^-$ < $Cr(CO)_6$ < $[Mn(CO)_6]^+$.

COMMON MISTAKE

Assigning intense colours to d–d transitions (they are weak; intense = charge transfer).

EXAM TIP

Number of ν(CO) IR bands reveals geometry: cis-$M(CO)_2L_4$ 2 bands, trans 1 band.

MEMORY TRICK

'Weak = d–d, strong = CT'.

Why the Other Options Are Wrong

Correct answer: D

A **3**

Why (D) is the key — ^{31}P couples to the P–H (doublet), two ^{19}F (triplet), two ^{15}N (I = ½, triplet) and four N–H protons (quintet): 2 × 3 × 3 × 5 = 90 lines (d).

B **6**

Ruled out: Assigning intense colours to d–d transitions (they are weak; intense = charge transfer).

C **18**

Ruled out: Number of ν(CO) IR bands reveals geometry: cis-$M(CO)_2L_4$ 2 bands, trans 1 band.

Q10

The number of lines exhibited by a high resolution EPR spectrum of the species, $[Cu(\text{ ethylenediamine })_2]^{2+}$ is [Nuclear spin (I) of Cu=3 / 2 and that of N=1]

A. 12

B. 15

C. 20

D. 36

QUESTION INSIGHTS

ESTIMATED TIME
2–3 min

DIFFICULTY
Medium

CONCEPT TESTED
Inorganic Spectroscopy – General

PYQ FREQUENCY
Very High · 11 paper

REVISION PRIORITY
★★★★☆

EXPECTED LEVEL
Part B / Part C

MEMORY HOOK
'Weak = d–d, strong = CT'.

Correct Answer D 36

CONCEPT

Electronic spectra of transition-metal complexes (d–d: Laporte/spin rules, Tanabe–Sugano diagrams, Racah B, nephelauxetic effect, Jahn–Teller), charge-transfer bands (MnO_4^-, CrO_4^{2-}), IR of CO/NO/N_2 ligands (back-bonding lowers ν), Mössbauer (isomer shift, quadrupole splitting), EPR (g, hyperfine), magnetism (μ, Curie–Weiss), NMR of inorganic nuclei (^{19}F, ^{31}P, ^{11}B, ^{195}Pt).

LOGIC / WORKING

- Cu (I = 3/2) gives 4 lines; four equivalent N (I = 1) split each into 2Â·4Â·1 + 1 = 9: 36 lines.
- Therefore the answer is (D).

FINAL: (D) 36

SHORTCUT / EXAM TRICK

More electron-rich metal → more back-bonding → lower ν(CO): $[V(CO)_6]^-$ < $Cr(CO)_6$ < $[Mn(CO)_6]^+$.

COMMON MISTAKE

Assigning intense colours to d–d transitions (they are weak; intense = charge transfer).

EXAM TIP

Number of ν(CO) IR bands reveals geometry: cis-$M(CO)_2L_4$ 2 bands, trans 1 band.

MEMORY TRICK

'Weak = d–d, strong = CT'.

Why the Other Options Are Wrong

Correct answer: D

A **12**

Why (D) is the key — Cu (I = 3/2) gives 4 lines; four equivalent N (I = 1) split each into 2Â·4Â·1 + 1 = 9: 36 lines.

B **15**

Ruled out: Assigning intense colours to d–d transitions (they are weak; intense = charge transfer).

C **20**

Ruled out: Number of ν(CO) IR bands reveals geometry: cis-$M(CO)_2L_4$ 2 bands, trans 1 band.

Q11

The number of lines in EPR spectrum of CD_3 (I_D=1) is

A) 3

B) 5

C) 7

D) 9

QUESTION INSIGHTS

ESTIMATED TIME
1–1.5 min

DIFFICULTY
Easy

CONCEPT TESTED
Inorganic Spectroscopy – General

PYQ FREQUENCY
Very High · 11 paper

REVISION PRIORITY
★★★☆☆

EXPECTED LEVEL
Part B

MEMORY HOOK
'Weak = d–d, strong = CT'.

Correct Answer C 7

CONCEPT

Electronic spectra of transition-metal complexes (d–d: Laporte/spin rules, Tanabe–Sugano diagrams, Racah B, nephelauxetic effect, Jahn–Teller), charge-transfer bands (MnO_4^-, CrO_4^{2-}), IR of CO/NO/N_2 ligands (back-bonding lowers ν), Mössbauer (isomer shift, quadrupole splitting), EPR (g, hyperfine), magnetism (μ, Curie–Weiss), NMR of inorganic nuclei (^{19}F, ^{31}P, ^{11}B, ^{195}Pt).

LOGIC / WORKING

- CD_3: 2nI + 1 = 7 lines (c).
- Therefore the answer is (C).

FINAL: (C) 7

SHORTCUT / EXAM TRICK

More electron-rich metal → more back-bonding → lower ν(CO): $[V(CO)_6]^-$ < $Cr(CO)_6$ < $[Mn(CO)_6]^+$.

COMMON MISTAKE

Assigning intense colours to d–d transitions (they are weak; intense = charge transfer).

EXAM TIP

Number of ν(CO) IR bands reveals geometry: cis-$M(CO)_2L_4$ 2 bands, trans 1 band.

MEMORY TRICK

'Weak = d–d, strong = CT'.

Why the Other Options Are Wrong

Correct answer: C

A **3**

Why (C) is the key — CD_3: 2nI + 1 = 7 lines (c).

B **5**

Ruled out: Assigning intense colours to d–d transitions (they are weak; intense = charge transfer).

D **9**

Ruled out: Number of ν(CO) IR bands reveals geometry: cis-$M(CO)_2L_4$ 2 bands, trans 1 band.

Q12

In the EPR spectrum of tetragonal Cu(II) complex, when g_parallel > g_perp > g_e, the unpaired electron resides in the orbital.

A. d_{xy}

B. $d_{x^2-y^2}$

C. d_{z^2}

D. d_{xz}

QUESTION INSIGHTS

ESTIMATED TIME
2–3 min

DIFFICULTY
Medium

CONCEPT TESTED
Inorganic Spectroscopy – General

PYQ FREQUENCY
Very High · 11 paper

REVISION PRIORITY
★★★★☆

EXPECTED LEVEL
Part B / Part C

MEMORY HOOK
'Weak = d–d, strong = CT'.

Correct Answer B $d_{x^2-y^2}$

CONCEPT

Electronic spectra of transition-metal complexes (d–d: Laporte/spin rules, Tanabe–Sugano diagrams, Racah B, nephelauxetic effect, Jahn–Teller), charge-transfer bands (MnO_4^-, CrO_4^{2-}), IR of CO/NO/N_2 ligands (back-bonding lowers ν), Mössbauer (isomer shift, quadrupole splitting), EPR (g, hyperfine), magnetism (μ, Curie–Weiss), NMR of inorganic nuclei (^{19}F, ^{31}P, ^{11}B, ^{195}Pt).

LOGIC / WORKING

- Gives the evidence that Cu on is present in tetragonally distorted octahedral field, the unpaired electron resides in the orbital d x2-y2 Explanation as extracted from the printed page; notation may be imperfect.
- Therefore the answer is (B).

FINAL: (B) $d_{x^2-y^2}$

SHORTCUT / EXAM TRICK

More electron-rich metal → more back-bonding → lower ν(CO): $[V(CO)_6]^-$ < $Cr(CO)_6$ < $[Mn(CO)_6]^+$.

COMMON MISTAKE

Assigning intense colours to d–d transitions (they are weak; intense = charge transfer).

EXAM TIP

Number of ν(CO) IR bands reveals geometry: cis-$M(CO)_2L_4$ 2 bands, trans 1 band.

MEMORY TRICK

'Weak = d–d, strong = CT'.

Why the Other Options Are Wrong

Correct answer: B

A d_{xy}

Why (B) is the key — Gives the evidence that Cu on is present in tetragonally distorted octahedral field, the unpaired electron resides in the orbital d x2-y2 Explanation as extracted from the printed page; notation may be imperfect.

C d_{z^2}

Ruled out: Assigning intense colours to d–d transitions (they are weak; intense = charge transfer).

D d_{xz}

Ruled out: Number of ν(CO) IR bands reveals geometry: cis-$M(CO)_2L_4$ 2 bands, trans 1 band.

Q13

The low temperature (-98^circC) ^{19}F NMR spectrum of SF_4, shows doublet of triplets with the point group symmetry.

A. C_{3v}

B. C_{4v}

C. T_d

D. C_{2v}

QUESTION INSIGHTS

ESTIMATED TIME
2–3 min

DIFFICULTY
Medium

CONCEPT TESTED
Inorganic Spectroscopy – General

PYQ FREQUENCY
Very High · 11 paper

REVISION PRIORITY
★★★★☆

EXPECTED LEVEL
Part B / Part C

MEMORY HOOK
'Weak = d–d, strong = CT'.

Correct Answer D C_{2v}

CONCEPT

Electronic spectra of transition-metal complexes (d–d: Laporte/spin rules, Tanabe–Sugano diagrams, Racah B, nephelauxetic effect, Jahn–Teller), charge-transfer bands (MnO_4^-, CrO_4^{2-}), IR of CO/NO/N_2 ligands (back-bonding lowers ν), Mössbauer (isomer shift, quadrupole splitting), EPR (g, hyperfine), magnetism (μ, Curie–Weiss), NMR of inorganic nuclei (^{19}F, ^{31}P, ^{11}B, ^{195}Pt).

LOGIC / WORKING

- At −98 °C SF_4 is a frozen see-saw (C_2v): two axial and two equatorial F, each pair a triplet — the observed pair of triplets.
- Therefore the answer is (D).

FINAL: (D) C_{2v}

SHORTCUT / EXAM TRICK

More electron-rich metal → more back-bonding → lower ν(CO): $[V(CO)_6]^-$ < $Cr(CO)_6$ < $[Mn(CO)_6]^+$.

COMMON MISTAKE

Assigning intense colours to d–d transitions (they are weak; intense = charge transfer).

EXAM TIP

Number of ν(CO) IR bands reveals geometry: cis-$M(CO)_2L_4$ 2 bands, trans 1 band.

MEMORY TRICK

'Weak = d–d, strong = CT'.

Why the Other Options Are Wrong

Correct answer: D

A C_{3v}

Why (D) is the key — At −98 °C SF_4 is a frozen see-saw (C_2v): two axial and two equatorial F, each pair a triplet — the observed pair of triplets.

B C_{4v}

Ruled out: Assigning intense colours to d–d transitions (they are weak; intense = charge transfer).

C T_d

Ruled out: Number of ν(CO) IR bands reveals geometry: cis-$M(CO)_2L_4$ 2 bands, trans 1 band.

Q14

The total numbers of fine and hyperfine EPR lines expected for octahedral high-spin Mn(II) complexes are respectively (I=5 / 2 for Mn)

A. 3 and 30

B. 5 and 33

C. 5 and 30

D. 4 and 24

QUESTION INSIGHTS

ESTIMATED TIME
2–3 min

DIFFICULTY
Medium

CONCEPT TESTED
Inorganic Spectroscopy – General

PYQ FREQUENCY
Very High · 11 paper

REVISION PRIORITY
★★★★☆

EXPECTED LEVEL
Part B / Part C

MEMORY HOOK
'Weak = d–d, strong = CT'.

Correct Answer C 5 and 30

CONCEPT

Electronic spectra of transition-metal complexes (d–d: Laporte/spin rules, Tanabe–Sugano diagrams, Racah B, nephelauxetic effect, Jahn–Teller), charge-transfer bands (MnO_4^-, CrO_4^{2-}), IR of CO/NO/N_2 ligands (back-bonding lowers ν), Mössbauer (isomer shift, quadrupole splitting), EPR (g, hyperfine), magnetism (μ, Curie–Weiss), NMR of inorganic nuclei (^{19}F, ^{31}P, ^{11}B, ^{195}Pt).

LOGIC / WORKING

- S = 5/2 gives 2S = 5 fine-structure transitions; each is split by ^{55}Mn (I = 5/2) into 2I + 1 = 6 hyperfine lines: 30 in all.
- Therefore the answer is (C).

FINAL: (C) 5 and 30

SHORTCUT / EXAM TRICK

More electron-rich metal → more back-bonding → lower ν(CO): $[V(CO)_6]^-$ < $Cr(CO)_6$ < $[Mn(CO)_6]^+$.

COMMON MISTAKE

Assigning intense colours to d–d transitions (they are weak; intense = charge transfer).

EXAM TIP

Number of ν(CO) IR bands reveals geometry: cis-$M(CO)_2L_4$ 2 bands, trans 1 band.

MEMORY TRICK

'Weak = d–d, strong = CT'.

Why the Other Options Are Wrong

Correct answer: C

A **3 and 30**

Why (C) is the key — S = 5/2 gives 2S = 5 fine-structure transitions; each is split by ^{55}Mn (I = 5/2) into 2I + 1 = 6 hyperfine lines: 30 in all.

B **5 and 33**

Ruled out: Assigning intense colours to d–d transitions (they are weak; intense = charge transfer).

D **4 and 24**

Ruled out: Number of ν(CO) IR bands reveals geometry: cis-$M(CO)_2L_4$ 2 bands, trans 1 band.

Q15

For a tetragonally distorted Cr(III) complex, zero-field splitting results in the following number of Kramers doublets:

A. 1

B. 2

C. 3

D. 4

QUESTION INSIGHTS

ESTIMATED TIME
2–3 min

DIFFICULTY
Medium

CONCEPT TESTED
Inorganic Spectroscopy – General

PYQ FREQUENCY
Very High · 11 paper

REVISION PRIORITY
★★★★☆

EXPECTED LEVEL
Part B / Part C

MEMORY HOOK
'Weak = d–d, strong = CT'.

Correct Answer B 2

CONCEPT

Electronic spectra of transition-metal complexes (d–d: Laporte/spin rules, Tanabe–Sugano diagrams, Racah B, nephelauxetic effect, Jahn–Teller), charge-transfer bands (MnO_4^-, CrO_4^{2-}), IR of CO/NO/N_2 ligands (back-bonding lowers ν), Mössbauer (isomer shift, quadrupole splitting), EPR (g, hyperfine), magnetism (μ, Curie–Weiss), NMR of inorganic nuclei (^{19}F, ^{31}P, ^{11}B, ^{195}Pt).

LOGIC / WORKING

- S = 3/2 splits under zero-field splitting into two Kramers doublets, m_s = Â±1/2 and Â±3/2.
- Therefore the answer is (B).

FINAL: (B) 2

SHORTCUT / EXAM TRICK

More electron-rich metal → more back-bonding → lower ν(CO): $[V(CO)_6]^-$ < $Cr(CO)_6$ < $[Mn(CO)_6]^+$.

COMMON MISTAKE

Assigning intense colours to d–d transitions (they are weak; intense = charge transfer).

EXAM TIP

Number of ν(CO) IR bands reveals geometry: cis-$M(CO)_2L_4$ 2 bands, trans 1 band.

MEMORY TRICK

'Weak = d–d, strong = CT'.

Why the Other Options Are Wrong

Correct answer: B

A **1**

Why (B) is the key — S = 3/2 splits under zero-field splitting into two Kramers doublets, m_s = Â±1/2 and Â±3/2.

C **3**

Ruled out: Assigning intense colours to d–d transitions (they are weak; intense = charge transfer).

D **4**

Ruled out: Number of ν(CO) IR bands reveals geometry: cis-$M(CO)_2L_4$ 2 bands, trans 1 band.

Q16

In Mössbauer experiment, a source emitting at 14.4 KeV(3.48×10^{18} Hz) had to be moved towards absorber at 2.2 mms^{-1} for resonance. The shift in the frequency between the source and the absorber is

A. 15.0 MHz

B. 20.0 MHz

C. 25.5 MHz

D. 30.0 MHz

QUESTION INSIGHTS

ESTIMATED TIME
2–3 min

DIFFICULTY
Medium

CONCEPT TESTED
Inorganic Spectroscopy – General

PYQ FREQUENCY
Very High · 11 paper

REVISION PRIORITY
★★★★☆

EXPECTED LEVEL
Part B / Part C

MEMORY HOOK
'Weak = d–d, strong = CT'.

Correct Answer C 25.5 MHz

CONCEPT

Electronic spectra of transition-metal complexes (d–d: Laporte/spin rules, Tanabe–Sugano diagrams, Racah B, nephelauxetic effect, Jahn–Teller), charge-transfer bands (MnO_4^-, CrO_4^{2-}), IR of CO/NO/N_2 ligands (back-bonding lowers ν), Mössbauer (isomer shift, quadrupole splitting), EPR (g, hyperfine), magnetism (μ, Curie–Weiss), NMR of inorganic nuclei (^{19}F, ^{31}P, ^{11}B, ^{195}Pt).

LOGIC / WORKING

- $\Delta\nu = \nu\, v/c = 3.48\times10^{18} \times 2.2\times10^{-3}/3\times10^{8} = 2.55\times10^{7}$ Hz = 25.5 MHz.
- Therefore the answer is (C).

FINAL: (C) 25.5 MHz

SHORTCUT / EXAM TRICK

More electron-rich metal → more back-bonding → lower ν(CO): $[V(CO)_6]^-$ < $Cr(CO)_6$ < $[Mn(CO)_6]^+$.

COMMON MISTAKE

Assigning intense colours to d–d transitions (they are weak; intense = charge transfer).

EXAM TIP

Number of ν(CO) IR bands reveals geometry: cis-$M(CO)_2L_4$ 2 bands, trans 1 band.

MEMORY TRICK

'Weak = d–d, strong = CT'.

Why the Other Options Are Wrong

Correct answer: C

A **15.0 MHz**

Why (C) is the key — $\Delta\nu = \nu\, v/c = 3.48\times10^{18} \times 2.2\times10^{-3}/3\times10^{8} = 2.55\times10^{7}$ Hz = 25.5 MHz.

B **20.0 MHz**

Ruled out: Assigning intense colours to d–d transitions (they are weak; intense = charge transfer).

D **30.0 MHz**

Ruled out: Number of ν(CO) IR bands reveals geometry: cis-$M(CO)_2L_4$ 2 bands, trans 1 band.

Q17

The ^{19}F NMR spectrum of ClF_3 shows

A. doublet and triplet for a T-shaped structure

B. singlet for a trigonal planar structure

C. singlet for a trigonal pyramidal structure

D. doublet and singlet for a T-shaped structure

QUESTION INSIGHTS

ESTIMATED TIME
1–1.5 min

DIFFICULTY
Easy

CONCEPT TESTED
Inorganic Spectroscopy – General

PYQ FREQUENCY
Very High · 11 paper

REVISION PRIORITY
★★★☆☆

EXPECTED LEVEL
Part B

MEMORY HOOK
'Weak = d–d, strong = CT'.

Correct Answer A doublet and triplet for a T-shaped structure

CONCEPT

Electronic spectra of transition-metal complexes (d–d: Laporte/spin rules, Tanabe–Sugano diagrams, Racah B, nephelauxetic effect, Jahn–Teller), charge-transfer bands (MnO_4^-, CrO_4^{2-}), IR of CO/NO/N_2 ligands (back-bonding lowers ν), Mössbauer (isomer shift, quadrupole splitting), EPR (g, hyperfine), magnetism (μ, Curie–Weiss), NMR of inorganic nuclei (^{19}F, ^{31}P, ^{11}B, ^{195}Pt).

LOGIC / WORKING

- T-shaped ClF_3 has two equivalent axial F (doublet) and one equatorial F (triplet).
- Therefore the answer is (A).

FINAL: (A) doublet and triplet for a T-shaped structure

SHORTCUT / EXAM TRICK

More electron-rich metal → more back-bonding → lower ν(CO): $[V(CO)_6]^-$ < $Cr(CO)_6$ < $[Mn(CO)_6]^+$.

COMMON MISTAKE

Assigning intense colours to d–d transitions (they are weak; intense = charge transfer).

EXAM TIP

Number of ν(CO) IR bands reveals geometry: cis-$M(CO)_2L_4$ 2 bands, trans 1 band.

MEMORY TRICK

'Weak = d–d, strong = CT'.

Why the Other Options Are Wrong

Correct answer: A

B **singlet for a trigonal planar structure**

Why (A) is the key — T-shaped ClF_3 has two equivalent axial F (doublet) and one equatorial F (triplet).

C **singlet for a trigonal pyramidal structure**

Ruled out: Assigning intense colours to d–d transitions (they are weak; intense = charge transfer).

D **doublet and singlet for a T-shaped structure**

Ruled out: Number of ν(CO) IR bands reveals geometry: cis-$M(CO)_2L_4$ 2 bands, trans 1 band.

Q18

The number of lines in the ESR spectrum of CD_3 is (the spin of D is 1)

A. 1

B. 3

C. 4

D. 7

QUESTION INSIGHTS

ESTIMATED TIME
1–1.5 min

DIFFICULTY
Easy

CONCEPT TESTED
Inorganic Spectroscopy – General

PYQ FREQUENCY
Very High · 11 paper

REVISION PRIORITY
★★★☆☆

EXPECTED LEVEL
Part B

MEMORY HOOK
'Weak = d–d, strong = CT'.

Correct Answer D 7

CONCEPT

Electronic spectra of transition-metal complexes (d–d: Laporte/spin rules, Tanabe–Sugano diagrams, Racah B, nephelauxetic effect, Jahn–Teller), charge-transfer bands (MnO_4^-, CrO_4^{2-}), IR of CO/NO/N_2 ligands (back-bonding lowers ν), Mössbauer (isomer shift, quadrupole splitting), EPR (g, hyperfine), magnetism (μ, Curie–Weiss), NMR of inorganic nuclei (^{19}F, ^{31}P, ^{11}B, ^{195}Pt).

LOGIC / WORKING

- Three equivalent deuterons (I = 1): 2nI + 1 = 2 × 3 × 1 + 1 = 7 lines.
- Therefore the answer is (D).

FINAL: (D) 7

SHORTCUT / EXAM TRICK

More electron-rich metal → more back-bonding → lower ν(CO): $[V(CO)_6]^-$ < $Cr(CO)_6$ < $[Mn(CO)_6]^+$.

COMMON MISTAKE

Assigning intense colours to d–d transitions (they are weak; intense = charge transfer).

EXAM TIP

Number of ν(CO) IR bands reveals geometry: cis-$M(CO)_2L_4$ 2 bands, trans 1 band.

MEMORY TRICK

'Weak = d–d, strong = CT'.

Why the Other Options Are Wrong

Correct answer: D

A **1**

Why (D) is the key — Three equivalent deuterons (I = 1): 2nI + 1 = 2 × 3 × 1 + 1 = 7 lines.

B **3**

Ruled out: Assigning intense colours to d–d transitions (they are weak; intense = charge transfer).

C **4**

Ruled out: Number of ν(CO) IR bands reveals geometry: cis-$M(CO)_2L_4$ 2 bands, trans 1 band.

Q19

EPR spectrum of a free radical containing nuclei with nonzero nuclear spin is obtained if the following selection rules are observed-

A. $\Delta m_s=0, \Delta m_I=0$

B. $\Delta m_s= \pm 1, \Delta m_I=0$

C. $\Delta m_s= \pm 1, \Delta m_I= \pm 1$

D. $\Delta m_s=0, \Delta m_I= \pm 1$

QUESTION INSIGHTS

ESTIMATED TIME
2–3 min

DIFFICULTY
Medium

CONCEPT TESTED
Inorganic Spectroscopy – General

PYQ FREQUENCY
Very High · 11 paper

REVISION PRIORITY
★★★★☆

EXPECTED LEVEL
Part B / Part C

MEMORY HOOK
'Weak = d–d, strong = CT'.

Correct Answer B Δ m_s= ± 1, Δ m_l=0

CONCEPT

Electronic spectra of transition-metal complexes (d–d: Laporte/spin rules, Tanabe–Sugano diagrams, Racah B, nephelauxetic effect, Jahn–Teller), charge-transfer bands (MnO_4^-, CrO_4^{2-}), IR of CO/NO/N_2 ligands (back-bonding lowers ν), Mössbauer (isomer shift, quadrupole splitting), EPR (g, hyperfine), magnetism (μ, Curie–Weiss), NMR of inorganic nuclei (^{19}F, ^{31}P, ^{11}B, ^{195}Pt).

LOGIC / WORKING

- EPR transitions flip the electron spin only: Î m$_s$ = Â±1 with Î m_I = 0.
- Therefore the answer is (B).

FINAL: (B) Δ m_s= ± 1, Δ m_l=0

SHORTCUT / EXAM TRICK

More electron-rich metal → more back-bonding → lower ν(CO): $[V(CO)_6]^-$ < $Cr(CO)_6$ < $[Mn(CO)_6]^+$.

COMMON MISTAKE

Assigning intense colours to d–d transitions (they are weak; intense = charge transfer).

EXAM TIP

Number of ν(CO) IR bands reveals geometry: cis-$M(CO)_2L_4$ 2 bands, trans 1 band.

MEMORY TRICK

'Weak = d–d, strong = CT'.

Why the Other Options Are Wrong

Correct answer: B

A **Δ m_s=0, Δ m_I=0**

Why (B) is the key — EPR transitions flip the electron spin only: Î□m$_s$ = Â±1 with Î□m_I = 0.

C **Δ m_s= ± 1, Δ m_I= ± 1**

Ruled out: Assigning intense colours to d–d transitions (they are weak; intense = charge transfer).

D **Δ m_s=0, Δ m_I= ± 1**

Ruled out: Number of ν(CO) IR bands reveals geometry: cis-$M(CO)_2L_4$ 2 bands, trans 1 band.

Q20

The ^{119}Sn NMR chemical shift (approximately in ppm) corresponding to $(\eta^5\text{-Cp})_2Sn$ (relative to Me_4Sn) is

A. -4

B. +137

C. +346

D. -2200

QUESTION INSIGHTS

ESTIMATED TIME
2–3 min

DIFFICULTY
Medium

CONCEPT TESTED
Inorganic Spectroscopy – General

PYQ FREQUENCY
Very High · 11 paper

REVISION PRIORITY
★★★★☆

EXPECTED LEVEL
Part B / Part C

MEMORY HOOK
'Weak = d–d, strong = CT'.

Correct Answer D -2200

CONCEPT

Electronic spectra of transition-metal complexes (d–d: Laporte/spin rules, Tanabe–Sugano diagrams, Racah B, nephelauxetic effect, Jahn–Teller), charge-transfer bands (MnO_4^-, CrO_4^{2-}), IR of CO/NO/N_2 ligands (back-bonding lowers ν), Mössbauer (isomer shift, quadrupole splitting), EPR (g, hyperfine), magnetism (μ, Curie–Weiss), NMR of inorganic nuclei (^{19}F, ^{31}P, ^{11}B, ^{195}Pt).

LOGIC / WORKING

- Stannocene (Sn(II), bent sandwich) is strongly shielded: δ(^{119}Sn) ≈ −2200 ppm vs Me_4Sn, far outside the Sn(IV) range (±~500 ppm).
- Therefore the answer is (D).

FINAL: (D) -2200

SHORTCUT / EXAM TRICK

More electron-rich metal → more back-bonding → lower ν(CO): $[V(CO)_6]^-$ < $Cr(CO)_6$ < $[Mn(CO)_6]^+$.

COMMON MISTAKE

Assigning intense colours to d–d transitions (they are weak; intense = charge transfer).

EXAM TIP

Number of ν(CO) IR bands reveals geometry: cis-$M(CO)_2L_4$ 2 bands, trans 1 band.

MEMORY TRICK

'Weak = d–d, strong = CT'.

Why the Other Options Are Wrong

Correct answer: D

A **-4**

Why (D) is the key — Stannocene (Sn(II), bent sandwich) is strongly shielded: δ(^{119}Sn) ≈ −2200 ppm vs Me_4Sn, far outside the Sn(IV) range (±~500 ppm).

B **+137**

Ruled out: Assigning intense colours to d–d transitions (they are weak; intense = charge transfer).

C **+346**

Ruled out: Number of ν(CO) IR bands reveals geometry: cis-$M(CO)_2L_4$ 2 bands, trans 1 band.

Q21

Mössbauer spectrum of a metal complex gives information about

A. oxidation state and spin state of metal

B. types of ligands coordinated to metal

C. nuclear spin state of metal

D. geometry of metal

QUESTION INSIGHTS

ESTIMATED TIME
1–1.5 min

DIFFICULTY
Easy

CONCEPT TESTED
Inorganic Spectroscopy – General

PYQ FREQUENCY
Very High · 11 paper

REVISION PRIORITY
★★★☆☆

EXPECTED LEVEL
Part B

MEMORY HOOK
'Weak = d–d, strong = CT'.

Correct Answer A oxidation state and spin state of metal

CONCEPT

Electronic spectra of transition-metal complexes (d–d: Laporte/spin rules, Tanabe–Sugano diagrams, Racah B, nephelauxetic effect, Jahn–Teller), charge-transfer bands (MnO_4^-, CrO_4^{2-}), IR of CO/NO/N_2 ligands (back-bonding lowers ν), Mössbauer (isomer shift, quadrupole splitting), EPR (g, hyperfine), magnetism (μ, Curie–Weiss), NMR of inorganic nuclei (^{19}F, ^{31}P, ^{11}B, ^{195}Pt).

LOGIC / WORKING

- Mössbauer isomer shift and quadrupole splitting reflect the oxidation state and spin state (and coordination environment) of iron; the nuclear spin is a fixed property of the isotope, not information obtained. (Bank key (c) was wrong — corrected.)
- Therefore the answer is (A).

FINAL: (A) oxidation state and spin state of metal

SHORTCUT / EXAM TRICK

More electron-rich metal → more back-bonding → lower ν(CO): $[V(CO)_6]^-$ < $Cr(CO)_6$ < $[Mn(CO)_6]^+$.

COMMON MISTAKE

Assigning intense colours to d–d transitions (they are weak; intense = charge transfer).

EXAM TIP

Number of ν(CO) IR bands reveals geometry: cis-$M(CO)_2L_4$ 2 bands, trans 1 band.

MEMORY TRICK

'Weak = d–d, strong = CT'.

Why the Other Options Are Wrong

Correct answer: A

B **types of ligands coordinated to metal**

Why (A) is the key — Mössbauer isomer shift and quadrupole splitting reflect the oxidation state and spin state (and coordination environment) of iron; the nuclear spin is a fixed property of the isotope, not information obtained. (Bank key (c) was wrong — corrected.)

C **nuclear spin state of metal**

Ruled out: Assigning intense colours to d–d transitions (they are weak; intense = charge transfer).

D **geometry of metal**

Ruled out: Number of ν(CO) IR bands reveals geometry: cis-$M(CO)_2L_4$ 2 bands, trans 1 band.

Q22

Identify correct statements for the EPR spectrum of $VO(acac)_2$ [with one pyramidal geometry at vanadium] at 77 K [$I(^{51}V)=7/2$] (A) It has two g values & (B) It has one g value (C) It has 8 lines only & (D) It has two patterns of 8 lines each. Correct statements are --

(A) A and D

(B) A and C

(C) B and C

(D) B and D

QUESTION INSIGHTS

ESTIMATED TIME
2–3 min

DIFFICULTY
Medium

CONCEPT TESTED
Inorganic Spectroscopy – General

PYQ FREQUENCY
Very High · 11 paper

REVISION PRIORITY
★★★★☆

EXPECTED LEVEL
Part B / Part C

MEMORY HOOK
'Weak = d–d, strong = CT'.

Correct Answer A A and D

CONCEPT

Electronic spectra of transition-metal complexes (d–d: Laporte/spin rules, Tanabe–Sugano diagrams, Racah B, nephelauxetic effect, Jahn–Teller), charge-transfer bands (MnO_4^-, CrO_4^{2-}), IR of CO/NO/N_2 ligands (back-bonding lowers ν), Mössbauer (isomer shift, quadrupole splitting), EPR (g, hyperfine), magnetism (μ, Curie–Weiss), NMR of inorganic nuclei (^{19}F, ^{31}P, ^{11}B, ^{195}Pt).

LOGIC / WORKING

- Frozen $VO(acac)_2$ is axial: two g values (A) and two sets of eight ^{51}V hyperfine lines (D) — A and D (a).
- Therefore the answer is (A).

FINAL: (A) A and D

SHORTCUT / EXAM TRICK

More electron-rich metal → more back-bonding → lower ν(CO): $[V(CO)_6]^-$ < $Cr(CO)_6$ < $[Mn(CO)_6]^+$.

COMMON MISTAKE

Assigning intense colours to d–d transitions (they are weak; intense = charge transfer).

EXAM TIP

Number of ν(CO) IR bands reveals geometry: cis-$M(CO)_2L_4$ 2 bands, trans 1 band.

MEMORY TRICK

'Weak = d–d, strong = CT'.

Why the Other Options Are Wrong

Correct answer: A

B **A and C**

Why (A) is the key — Frozen $VO(acac)_2$ is axial: two g values (A) and two sets of eight ^{51}V hyperfine lines (D) — A and D (a).

C **B and C**

Ruled out: Assigning intense colours to d–d transitions (they are weak; intense = charge transfer).

D **B and D**

Ruled out: Number of ν(CO) IR bands reveals geometry: cis-$M(CO)_2L_4$ 2 bands, trans 1 band.

Q23

Identify correct statements for the EPR spectrum of $VO(acac)_2$ [with square pyramidal geometry at vanadium] at 77K [I(^{51}V) = 7/2] (A) It has two g values (C) It has one g value (B) It has 8 lines only (D) It has two patterns of 8 lines each. Correct statements are - (a) A and D (c) B and C (b) A and C (d) B and D

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

QUESTION INSIGHTS

ESTIMATED TIME
2–3 min

DIFFICULTY
Medium

CONCEPT TESTED
Inorganic Spectroscopy – General

PYQ FREQUENCY
Very High · 11 paper

REVISION PRIORITY
★★★★☆

EXPECTED LEVEL
Part B / Part C

MEMORY HOOK
'Weak = d–d, strong = CT'.

Q24

Mössbauer spectrum of complex $[Fe(1,10\text{-phenanthroline})_2(NCS)_2]$ shows two lines at 300 K, four lines at 186 K, and again two lines at 77 K. This can be attributed to A. change in the coordination mode of NCS B. change in the spin-state of iron C. cis-trans isomerisation D. change in metal-ligand bond distances The correct statements are

A. A and B

B. B and C

C. A and C

D. B and D

QUESTION INSIGHTS

ESTIMATED TIME
2–3 min

DIFFICULTY
Medium

CONCEPT TESTED
Inorganic Spectroscopy – General

PYQ FREQUENCY
Very High · 11 paper

REVISION PRIORITY
★★★★☆

EXPECTED LEVEL
Part B / Part C

MEMORY HOOK
'Weak = d–d, strong = CT'.

Correct Answer D B and D

CONCEPT

Electronic spectra of transition-metal complexes (d–d: Laporte/spin rules, Tanabe–Sugano diagrams, Racah B, nephelauxetic effect, Jahn–Teller), charge-transfer bands (MnO_4^-, CrO_4^{2-}), IR of CO/NO/N_2 ligands (back-bonding lowers ν), Mössbauer (isomer shift, quadrupole splitting), EPR (g, hyperfine), magnetism (μ, Curie–Weiss), NMR of inorganic nuclei (^{19}F, ^{31}P, ^{11}B, ^{195}Pt).

LOGIC / WORKING

- $[Fe(phen)_2(NCS)_2]$ is the classic spin-crossover complex: high-spin Fe(II) doublet at 300 K, both spin states (two doublets = four lines) near $T_{½} \approx 176$ K, low-spin doublet at 77 K. HS→LS shortens the Fe–N bonds by ~0.2 Å. So B and D. (Bank key (a) — corrected; NCS coordination mode does not change.)
- Therefore the answer is (D).

FINAL: (D) B and D

SHORTCUT / EXAM TRICK

More electron-rich metal → more back-bonding → lower ν(CO): $[V(CO)_6]^-$ < $Cr(CO)_6$ < $[Mn(CO)_6]^+$.

COMMON MISTAKE

Assigning intense colours to d–d transitions (they are weak; intense = charge transfer).

EXAM TIP

Number of ν(CO) IR bands reveals geometry: cis-$M(CO)_2L_4$ 2 bands, trans 1 band.

MEMORY TRICK

'Weak = d–d, strong = CT'.

Why the Other Options Are Wrong

Correct answer: D

A

A and B

Why (D) is the key — $[Fe(phen)_2(NCS)_2]$ is the classic spin-crossover complex: high-spin Fe(II) doublet at 300 K, both spin states (two doublets = four lines) near $T_{½} \approx 176$ K, low-spin doublet at 77 K. HS → LS shortens the Fe–N bonds by ~0.2 Å. So B and D. (Bank key (a) — corrected; NCS coordination mode does not change.)

B

B and C

Ruled out: Assigning intense colours to d–d transitions (they are weak; intense = charge transfer).

C

A and C

Ruled out: Number of ν(CO) IR bands reveals geometry: cis-$M(CO)_2L_4$ 2 bands, trans 1 band.

Q25

$(R_3Ge)_2$ on photolysis gives a radical which shows ESR spectrum. The ESR signals carrying the signature of ^{73}Ge (I=9/2) are in terms of

A. Nine lines

B. Ten lines

C. Two lines

D. One line

QUESTION INSIGHTS

ESTIMATED TIME
2–3 min

DIFFICULTY
Medium

CONCEPT TESTED
Inorganic Spectroscopy – General

PYQ FREQUENCY
Very High · 11 paper

REVISION PRIORITY
★★★★☆

EXPECTED LEVEL
Part B / Part C

MEMORY HOOK
'Weak = d–d, strong = CT'.

Correct Answer B Ten lines

CONCEPT

Electronic spectra of transition-metal complexes (d–d: Laporte/spin rules, Tanabe–Sugano diagrams, Racah B, nephelauxetic effect, Jahn–Teller), charge-transfer bands (MnO_4^-, CrO_4^{2-}), IR of CO/NO/N_2 ligands (back-bonding lowers ν), Mössbauer (isomer shift, quadrupole splitting), EPR (g, hyperfine), magnetism (μ, Curie–Weiss), NMR of inorganic nuclei (^{19}F, ^{31}P, ^{11}B, ^{195}Pt).

LOGIC / WORKING

- Coupling to ^{73}Ge (I = 9/2) gives 2I + 1 = 10 lines.
- Therefore the answer is (B).

FINAL: (B) Ten lines

SHORTCUT / EXAM TRICK

More electron-rich metal → more back-bonding → lower ν(CO): $[V(CO)_6]^-$ < $Cr(CO)_6$ < $[Mn(CO)_6]^+$.

COMMON MISTAKE

Assigning intense colours to d–d transitions (they are weak; intense = charge transfer).

EXAM TIP

Number of ν(CO) IR bands reveals geometry: cis-$M(CO)_2L_4$ 2 bands, trans 1 band.

MEMORY TRICK

'Weak = d–d, strong = CT'.

Why the Other Options Are Wrong

Correct answer: B

A **Nine lines**

Why (B) is the key — Coupling to ^{73}Ge (I = 9/2) gives 2I + 1 = 10 lines.

C **Two lines**

Ruled out: Assigning intense colours to d–d transitions (they are weak; intense = charge transfer).

D **One line**

Ruled out: Number of ν(CO) IR bands reveals geometry: cis-$M(CO)_2L_4$ 2 bands, trans 1 band.

Q26

The $^{31}P(^{1}H)$ NMR spectrum of 2,2,6,6-$N_4P_4Cl_4(NMe_2)_4$ is expected to show

A. two triplets

B. two doublets

C. one doublet and one triplet

D. one quartet and one doublet

QUESTION INSIGHTS

ESTIMATED TIME
1–1.5 min

DIFFICULTY
Easy

CONCEPT TESTED
Inorganic Spectroscopy – General

PYQ FREQUENCY
Very High · 11 paper

REVISION PRIORITY
★★★☆☆

EXPECTED LEVEL
Part B

MEMORY HOOK
'Weak = d–d, strong = CT'.

Correct Answer A two triplets

CONCEPT

Electronic spectra of transition-metal complexes (d–d: Laporte/spin rules, Tanabe–Sugano diagrams, Racah B, nephelauxetic effect, Jahn–Teller), charge-transfer bands (MnO_4^-, CrO_4^{2-}), IR of CO/NO/N_2 ligands (back-bonding lowers ν), Mössbauer (isomer shift, quadrupole splitting), EPR (g, hyperfine), magnetism (μ, Curie–Weiss), NMR of inorganic nuclei (^{19}F, ^{31}P, ^{11}B, ^{195}Pt).

LOGIC / WORKING

- 2,2,6,6-substitution gives two PCl_2 and two $P(NMe_2)_2$ phosphorus atoms alternating around the ring; each P couples to two equivalent neighbours of the other kind, so each type appears as a triplet: two triplets.
- Therefore the answer is (A).

FINAL: (A) two triplets

SHORTCUT / EXAM TRICK

More electron-rich metal → more back-bonding → lower ν(CO): $[V(CO)_6]^-$ < $Cr(CO)_6$ < $[Mn(CO)_6]^+$.

COMMON MISTAKE

Assigning intense colours to d–d transitions (they are weak; intense = charge transfer).

EXAM TIP

Number of ν(CO) IR bands reveals geometry: cis-$M(CO)_2L_4$ 2 bands, trans 1 band.

MEMORY TRICK

'Weak = d–d, strong = CT'.

Why the Other Options Are Wrong

Correct answer: A

B **two doublets**

Why (A) is the key — 2,2,6,6-substitution gives two PCl_2 and two $P(NMe_2)_2$ phosphorus atoms alternating around the ring; each P couples to two equivalent neighbours of the other kind, so each type appears as a triplet: two triplets.

C **one doublet and one triplet**

Ruled out: Assigning intense colours to d–d transitions (they are weak; intense = charge transfer).

D **one quartet and one doublet**

Ruled out: Number of ν(CO) IR bands reveals geometry: cis-$M(CO)_2L_4$ 2 bands, trans 1 band.

Q27

In the $^{31}P\{^{1}H\}$ NMR spectrum of a diamagnetic complex mer-$[M(PR_3)_3Cl_3]$ (M = transition metal, I = 0) expected number of resonance(s) is

A. Three

B. One

C. Two

D. Six

QUESTION INSIGHTS

ESTIMATED TIME
2–3 min

DIFFICULTY
Medium

CONCEPT TESTED
Inorganic Spectroscopy – General

PYQ FREQUENCY
Very High · 11 paper

REVISION PRIORITY
★★★★☆

EXPECTED LEVEL
Part B / Part C

MEMORY HOOK
'Weak = d–d, strong = CT'.

Correct Answer C Two

CONCEPT

Electronic spectra of transition-metal complexes (d–d: Laporte/spin rules, Tanabe–Sugano diagrams, Racah B, nephelauxetic effect, Jahn–Teller), charge-transfer bands (MnO_4^-, CrO_4^{2-}), IR of CO/NO/N_2 ligands (back-bonding lowers ν), Mössbauer (isomer shift, quadrupole splitting), EPR (g, hyperfine), magnetism (μ, Curie–Weiss), NMR of inorganic nuclei (^{19}F, ^{31}P, ^{11}B, ^{195}Pt).

LOGIC / WORKING

- mer-[M(PR3)3Cl3] Explanation as extracted from the printed page; notation may be imperfect.
- Therefore the answer is (C).

FINAL: (C) Two

SHORTCUT / EXAM TRICK

More electron-rich metal → more back-bonding → lower ν(CO): $[V(CO)_6]^-$ < $Cr(CO)_6$ < $[Mn(CO)_6]^+$.

COMMON MISTAKE

Assigning intense colours to d–d transitions (they are weak; intense = charge transfer).

EXAM TIP

Number of ν(CO) IR bands reveals geometry: cis-$M(CO)_2L_4$ 2 bands, trans 1 band.

MEMORY TRICK

'Weak = d–d, strong = CT'.

Why the Other Options Are Wrong

Correct answer: C

A **Three**

Why (C) is the key — mer-[M(PR3)3Cl3] Explanation as extracted from the printed page; notation may be imperfect.

B **One**

Ruled out: Assigning intense colours to d–d transitions (they are weak; intense = charge transfer).

D **Six**

Ruled out: Number of ν(CO) IR bands reveals geometry: cis-$M(CO)_2L_4$ 2 bands, trans 1 band.

Q28

A radical contains ^{14}N(I=1) with hyperfine constant 1.61 mT and two equivalent protons (I=1 / 2) with hyperfine constant 0.35 mT . The ESR spectrum will exhibit.

A. 3 lines

B. 6 lines

C. 7 lines

D. 9 lines

QUESTION INSIGHTS

ESTIMATED TIME
2–3 min

DIFFICULTY
Medium

CONCEPT TESTED
Inorganic Spectroscopy – General

PYQ FREQUENCY
Very High · 11 paper

REVISION PRIORITY
★★★★☆

EXPECTED LEVEL
Part B / Part C

MEMORY HOOK
'Weak = d–d, strong = CT'.

Correct Answer D 9 lines

CONCEPT

Electronic spectra of transition-metal complexes (d–d: Laporte/spin rules, Tanabe–Sugano diagrams, Racah B, nephelauxetic effect, Jahn–Teller), charge-transfer bands (MnO_4^-, CrO_4^{2-}), IR of CO/NO/N_2 ligands (back-bonding lowers ν), Mössbauer (isomer shift, quadrupole splitting), EPR (g, hyperfine), magnetism (μ, Curie–Weiss), NMR of inorganic nuclei (^{19}F, ^{31}P, ^{11}B, ^{195}Pt).

LOGIC / WORKING

- One ^{14}N (I = 1) gives 3 lines, each split into 3 by two equivalent protons: 3 × 3 = 9 (d).
- Therefore the answer is (D).

FINAL: (D) 9 lines

SHORTCUT / EXAM TRICK

More electron-rich metal → more back-bonding → lower ν(CO): $[V(CO)_6]^-$ < $Cr(CO)_6$ < $[Mn(CO)_6]^+$.

COMMON MISTAKE

Assigning intense colours to d–d transitions (they are weak; intense = charge transfer).

EXAM TIP

Number of ν(CO) IR bands reveals geometry: cis-$M(CO)_2L_4$ 2 bands, trans 1 band.

MEMORY TRICK

'Weak = d–d, strong = CT'.

Why the Other Options Are Wrong

Correct answer: D

A **3 lines**

Why (D) is the key — One ^{14}N (I = 1) gives 3 lines, each split into 3 by two equivalent protons: 3 × 3 = 9 (d).

B **6 lines**

Ruled out: Assigning intense colours to d–d transitions (they are weak; intense = charge transfer).

C **7 lines**

Ruled out: Number of ν(CO) IR bands reveals geometry: cis-$M(CO)_2L_4$ 2 bands, trans 1 band.

Q29

In the proton decoupled ^{13}C and ^{31}P NMR spectra of $(CH_3)_3P=O$, the number of lines observed, respectively, are

A. two and one

B. one and two

C. three and one

D. two and two

QUESTION INSIGHTS

ESTIMATED TIME
2–3 min

DIFFICULTY
Medium

CONCEPT TESTED
Inorganic Spectroscopy – General

PYQ FREQUENCY
Very High · 11 paper

REVISION PRIORITY
★★★★☆

EXPECTED LEVEL
Part B / Part C

MEMORY HOOK
'Weak = d–d, strong = CT'.

Correct Answer A two and one

CONCEPT

Electronic spectra of transition-metal complexes (d–d: Laporte/spin rules, Tanabe–Sugano diagrams, Racah B, nephelauxetic effect, Jahn–Teller), charge-transfer bands (MnO_4^-, CrO_4^{2-}), IR of CO/NO/N_2 ligands (back-bonding lowers ν), Mössbauer (isomer shift, quadrupole splitting), EPR (g, hyperfine), magnetism (μ, Curie–Weiss), NMR of inorganic nuclei (^{19}F, ^{31}P, ^{11}B, ^{195}Pt).

LOGIC / WORKING

- $(CH_3)_3P{=}O$: the three methyl carbons are equivalent, and $^{13}C^1H$ shows them as a doublet ($^1J_{PC}$) — two lines; $^{31}P^1H$ is a single line.
- Therefore the answer is (A).

FINAL: (A) two and one

SHORTCUT / EXAM TRICK

More electron-rich metal → more back-bonding → lower ν(CO): $[V(CO)_6]^-$ < $Cr(CO)_6$ < $[Mn(CO)_6]^+$.

COMMON MISTAKE

Assigning intense colours to d–d transitions (they are weak; intense = charge transfer).

EXAM TIP

Number of ν(CO) IR bands reveals geometry: cis-$M(CO)_2L_4$ 2 bands, trans 1 band.

MEMORY TRICK

'Weak = d–d, strong = CT'.

Why the Other Options Are Wrong

Correct answer: A

B — **one and two**

Why (A) is the key — $(CH_3)_3P{=}O$: the three methyl carbons are equivalent, and $^{13}C^{1}H$ shows them as a doublet ($^{1}J_{PC}$) — two lines; $^{31}P^{1}H$ is a single line.

C — **three and one**

Ruled out: Assigning intense colours to d–d transitions (they are weak; intense = charge transfer).

D — **two and two**

Ruled out: Number of ν(CO) IR bands reveals geometry: cis-$M(CO)_2L_4$ 2 bands, trans 1 band.

Q30

If ClF_3 were to be stereochemically rigid, its ^{19}F NMR spectrum (I for ^{19}F=(1)/(2)) would be (assume that Cl is not NMR active)

A. a doublet and a triplet

B. a singlet

C. a doublet and a singlet

D. two singlets

QUESTION INSIGHTS

ESTIMATED TIME
1–1.5 min

DIFFICULTY
Easy

CONCEPT TESTED
Inorganic Spectroscopy – General

PYQ FREQUENCY
Very High · 11 paper

REVISION PRIORITY
★★★☆☆

EXPECTED LEVEL
Part B

MEMORY HOOK
'Weak = d–d, strong = CT'.

Correct Answer A a doublet and a triplet

CONCEPT

Electronic spectra of transition-metal complexes (d–d: Laporte/spin rules, Tanabe–Sugano diagrams, Racah B, nephelauxetic effect, Jahn–Teller), charge-transfer bands (MnO_4^-, CrO_4^{2-}), IR of CO/NO/N_2 ligands (back-bonding lowers ν), Mössbauer (isomer shift, quadrupole splitting), EPR (g, hyperfine), magnetism (μ, Curie–Weiss), NMR of inorganic nuclei (^{19}F, ^{31}P, ^{11}B, ^{195}Pt).

LOGIC / WORKING

- Rigid T-shaped ClF_3: two equivalent axial F (doublet, coupled to the equatorial F) and one equatorial F (triplet, coupled to the two axial F).
- Therefore the answer is (A).

FINAL: (A) a doublet and a triplet

SHORTCUT / EXAM TRICK

More electron-rich metal → more back-bonding → lower ν(CO): $[V(CO)_6]^-$ < $Cr(CO)_6$ < $[Mn(CO)_6]^+$.

COMMON MISTAKE

Assigning intense colours to d–d transitions (they are weak; intense = charge transfer).

EXAM TIP

Number of ν(CO) IR bands reveals geometry: cis-$M(CO)_2L_4$ 2 bands, trans 1 band.

MEMORY TRICK

'Weak = d–d, strong = CT'.

Why the Other Options Are Wrong

Correct answer: A

B **a singlet**

Why (A) is the key — Rigid T-shaped ClF_3: two equivalent axial F (doublet, coupled to the equatorial F) and one equatorial F (triplet, coupled to the two axial F).

C **a doublet and a singlet**

Ruled out: Assigning intense colours to d–d transitions (they are weak; intense = charge transfer).

D **two singlets**

Ruled out: Number of ν(CO) IR bands reveals geometry: cis-$M(CO)_2L_4$ 2 bands, trans 1 band.

Q31

Upon heating, compound X is converted to Y, which has the same molecular formula as that of X. The ^1H NMR spectrum of Y shows two doublets centered at 3.0 ppm (separation of two lines 20 Hz) and 4.0 ppm (separation of two 15 Hz) respectively. Compound Y is:

A. $(CH_3O)_2P(O)(OH)$

B. $(CH_3O)_3P(O)$

C. $(CH_3O)_2(CH_3)P(O)$

D. $(CH_3O)_2(CH_3)P(OH)$

QUESTION INSIGHTS

ESTIMATED TIME
2–3 min

DIFFICULTY
Medium

CONCEPT TESTED
Inorganic Spectroscopy – General

PYQ FREQUENCY
Very High · 11 paper

REVISION PRIORITY
★★★★☆

EXPECTED LEVEL
Part B / Part C

MEMORY HOOK
'Weak = d–d, strong = CT'.

Correct Answer C $(CH_3O)_2(CH_3)P(O)$

CONCEPT

Electronic spectra of transition-metal complexes (d–d: Laporte/spin rules, Tanabe–Sugano diagrams, Racah B, nephelauxetic effect, Jahn–Teller), charge-transfer bands (MnO_4^-, CrO_4^{2-}), IR of CO/NO/N_2 ligands (back-bonding lowers ν), Mössbauer (isomer shift, quadrupole splitting), EPR (g, hyperfine), magnetism (μ, Curie–Weiss), NMR of inorganic nuclei (^{19}F, ^{31}P, ^{11}B, ^{195}Pt).

LOGIC / WORKING

- X = $(CH_3O)_3P$ (trimethyl phosphite) rearranges on heating (Michaelis–Arbuzov) to Y = $(CH_3O)_2P(O)CH_3$, same formula $C_3H_9O_3P$. Two doublets: P–CH_3 ($^2J_{PH}$ ≈ 15–20 Hz) and P–OCH_3 ($^3J_{PH}$ ≈ 11–15 Hz); $(CH_3O)_3P(O)$ would give a single doublet. (Bank key (b) — verify.)
- Therefore the answer is (C).

FINAL: (C) $(CH_3O)_2(CH_3)P(O)$

SHORTCUT / EXAM TRICK

More electron-rich metal → more back-bonding → lower ν(CO): $[V(CO)_6]^-$ < $Cr(CO)_6$ < $[Mn(CO)_6]^+$.

COMMON MISTAKE

Assigning intense colours to d–d transitions (they are weak; intense = charge transfer).

EXAM TIP

Number of ν(CO) IR bands reveals geometry: cis-$M(CO)_2L_4$ 2 bands, trans 1 band.

MEMORY TRICK

'Weak = d–d, strong = CT'.

Why the Other Options Are Wrong

Correct answer: C

A **$(CH_3O)_2P(O)(OH)$**

Why (C) is the key — X = $(CH_3O)_3P$ (trimethyl phosphite) rearranges on heating (Michaelis–Arbuzov) to Y = $(CH_3O)_2P(O)CH_3$, same formula $C_3H_9O_3P$. Two doublets: P–CH_3 ($^2J_{PH}$ ≈ 15–20 Hz) and P–OCH_3 ($^3J_{PH}$ ≈ 11–15 Hz); $(CH_3O)_3P(O)$ would give a single doublet. (Bank key (b) — verify.)

B **$(CH_3O)_3P(O)$**

Ruled out: Assigning intense colours to d–d transitions (they are weak; intense = charge transfer).

D **$(CH_3O)_2(CH_3)P(OH)$**

Ruled out: Number of ν(CO) IR bands reveals geometry: cis-$M(CO)_2L_4$ 2 bands, trans 1 band.

Q32

The ^{31}P NMR spectrum of P_4S_3 consists of

A. a singlet

B. a doublet and a triplet

C. a doublet and a quartet

D. two doublets

QUESTION INSIGHTS

ESTIMATED TIME
1–1.5 min

DIFFICULTY
Easy

CONCEPT TESTED
Inorganic Spectroscopy – General

PYQ FREQUENCY
Very High · 11 paper

REVISION PRIORITY
★★★☆☆

EXPECTED LEVEL
Part B

MEMORY HOOK
'Weak = d–d, strong = CT'.

Correct Answer C a doublet and a quartet

CONCEPT

Electronic spectra of transition-metal complexes (d–d: Laporte/spin rules, Tanabe–Sugano diagrams, Racah B, nephelauxetic effect, Jahn–Teller), charge-transfer bands (MnO_4^-, CrO_4^{2-}), IR of CO/NO/N_2 ligands (back-bonding lowers ν), Mössbauer (isomer shift, quadrupole splitting), EPR (g, hyperfine), magnetism (μ, Curie–Weiss), NMR of inorganic nuclei (^{19}F, ^{31}P, ^{11}B, ^{195}Pt).

LOGIC / WORKING

- P_4S_3: one apical P bonded to three S; three equivalent basal P in a P_3 ring. Apical P couples to 3 P → quartet; basal P couple to 1 apical P → doublet (intensity 1:3).
- Therefore the answer is (C).

FINAL: (C) a doublet and a quartet

SHORTCUT / EXAM TRICK

More electron-rich metal → more back-bonding → lower ν(CO): $[V(CO)_6]^-$ < $Cr(CO)_6$ < $[Mn(CO)_6]^+$.

COMMON MISTAKE

Assigning intense colours to d–d transitions (they are weak; intense = charge transfer).

EXAM TIP

Number of ν(CO) IR bands reveals geometry: cis-$M(CO)_2L_4$ 2 bands, trans 1 band.

MEMORY TRICK

'Weak = d–d, strong = CT'.

Why the Other Options Are Wrong

Correct answer: C

A **a singlet**

Why (C) is the key — P_4S_3: one apical P bonded to three S; three equivalent basal P in a P_3 ring. Apical P couples to 3 P → quartet; basal P couple to 1 apical P → doublet (intensity 1:3).

B **a doublet and a triplet**

Ruled out: Assigning intense colours to d–d transitions (they are weak; intense = charge transfer).

D **two doublets**

Ruled out: Number of ν(CO) IR bands reveals geometry: cis-$M(CO)_2L_4$ 2 bands, trans 1 band.

Q33

The ^{1}H NMR spectrum of HD consists of a

A. singlet

B. 1:1 doublet

C. 1:1:1 triplet

D. 1:2:1 triplet

QUESTION INSIGHTS

ESTIMATED TIME
1–1.5 min

DIFFICULTY
Easy

CONCEPT TESTED
Inorganic Spectroscopy – General

PYQ FREQUENCY
Very High · 11 paper

REVISION PRIORITY
★★★☆☆

EXPECTED LEVEL
Part B

MEMORY HOOK
'Weak = d–d, strong = CT'.

Correct Answer C 1:1:1 triplet

CONCEPT

Electronic spectra of transition-metal complexes (d–d: Laporte/spin rules, Tanabe–Sugano diagrams, Racah B, nephelauxetic effect, Jahn–Teller), charge-transfer bands (MnO_4^-, CrO_4^{2-}), IR of CO/NO/N_2 ligands (back-bonding lowers ν), Mössbauer (isomer shift, quadrupole splitting), EPR (g, hyperfine), magnetism (μ, Curie–Weiss), NMR of inorganic nuclei (^{19}F, ^{31}P, ^{11}B, ^{195}Pt).

LOGIC / WORKING

- The proton couples to one D (I = 1): 2I + 1 = 3 equally intense lines (c).
- Therefore the answer is (C).

FINAL: (C) 1:1:1 triplet

SHORTCUT / EXAM TRICK

More electron-rich metal → more back-bonding → lower ν(CO): $[V(CO)_6]^-$ < $Cr(CO)_6$ < $[Mn(CO)_6]^+$.

COMMON MISTAKE

Assigning intense colours to d–d transitions (they are weak; intense = charge transfer).

EXAM TIP

Number of ν(CO) IR bands reveals geometry: cis-$M(CO)_2L_4$ 2 bands, trans 1 band.

MEMORY TRICK

'Weak = d–d, strong = CT'.

Why the Other Options Are Wrong

Correct answer: C

A **singlet**

Why (C) is the key — The proton couples to one D (I = 1): 2I + 1 = 3 equally intense lines (c).

B **1:1 doublet**

Ruled out: Assigning intense colours to d–d transitions (they are weak; intense = charge transfer).

D **1:2:1 triplet**

Ruled out: Number of ν(CO) IR bands reveals geometry: cis-$M(CO)_2L_4$ 2 bands, trans 1 band.

Q34

The value of 'g' and the number of signals observed for the references standard, diphenylpicry lhydrazyl (DPPH), in the solid stae ESR spectrum are, respectively

A. 2.0036 and 1

B. 2.0036 and 3

C. 2.2461 and 1

D. 2.2416 and 3

QUESTION INSIGHTS

ESTIMATED TIME
2–3 min

DIFFICULTY
Medium

CONCEPT TESTED
Inorganic Spectroscopy – General

PYQ FREQUENCY
Very High · 11 paper

REVISION PRIORITY
★★★★☆

EXPECTED LEVEL
Part B / Part C

MEMORY HOOK
'Weak = d–d, strong = CT'.

Correct Answer A 2.0036 and 1

CONCEPT

Electronic spectra of transition-metal complexes (d–d: Laporte/spin rules, Tanabe–Sugano diagrams, Racah B, nephelauxetic effect, Jahn–Teller), charge-transfer bands (MnO_4^-, CrO_4^{2-}), IR of CO/NO/N_2 ligands (back-bonding lowers ν), Mössbauer (isomer shift, quadrupole splitting), EPR (g, hyperfine), magnetism (μ, Curie–Weiss), NMR of inorganic nuclei (^{19}F, ^{31}P, ^{11}B, ^{195}Pt).

LOGIC / WORKING

- DPPH is the g-value standard: g = 2.0036, and in the solid state the hyperfine structure is exchange-narrowed to a single line.
- Therefore the answer is (A).

FINAL: (A) 2.0036 and 1

SHORTCUT / EXAM TRICK

More electron-rich metal → more back-bonding → lower ν(CO): $[V(CO)_6]^-$ < $Cr(CO)_6$ < $[Mn(CO)_6]^+$.

COMMON MISTAKE

Assigning intense colours to d–d transitions (they are weak; intense = charge transfer).

EXAM TIP

Number of ν(CO) IR bands reveals geometry: cis-$M(CO)_2L_4$ 2 bands, trans 1 band.

MEMORY TRICK

'Weak = d–d, strong = CT'.

Why the Other Options Are Wrong

Correct answer: A

B **2.0036 and 3**

Why (A) is the key — DPPH is the g-value standard: g = 2.0036, and in the solid state the hyperfine structure is exchange-narrowed to a single line.

C **2.2461 and 1**

Ruled out: Assigning intense colours to d–d transitions (they are weak; intense = charge transfer).

D **2.2416 and 3**

Ruled out: Number of ν(CO) IR bands reveals geometry: cis-$M(CO)_2L_4$ 2 bands, trans 1 band.

Q35

The ^{19} F NMR spectrum of ClF_3 when measured at -60^° C will be observed as a

A. singlet

B. doublet

C. doublet and triplet

D. doublet of doublet and a doublet of triplet

QUESTION INSIGHTS

ESTIMATED TIME
1–1.5 min

DIFFICULTY
Easy

CONCEPT TESTED
Inorganic Spectroscopy – General

PYQ FREQUENCY
Very High · 11 paper

REVISION PRIORITY
★★★☆☆

EXPECTED LEVEL
Part B

MEMORY HOOK
'Weak = d–d, strong = CT'.

Correct Answer C doublet and triplet

CONCEPT

Electronic spectra of transition-metal complexes (d–d: Laporte/spin rules, Tanabe–Sugano diagrams, Racah B, nephelauxetic effect, Jahn–Teller), charge-transfer bands (MnO_4^-, CrO_4^{2-}), IR of CO/NO/N_2 ligands (back-bonding lowers ν), Mössbauer (isomer shift, quadrupole splitting), EPR (g, hyperfine), magnetism (μ, Curie–Weiss), NMR of inorganic nuclei (^{19}F, ^{31}P, ^{11}B, ^{195}Pt).

LOGIC / WORKING

- At −60 °C exchange is frozen: the two equivalent axial F couple to the equatorial F (a doublet, 2F) and the equatorial F couples to the two axial F (a triplet, 1F).
- Therefore the answer is (C).

FINAL: (C) doublet and triplet

SHORTCUT / EXAM TRICK

More electron-rich metal → more back-bonding → lower ν(CO): $[V(CO)_6]^-$ < $Cr(CO)_6$ < $[Mn(CO)_6]^+$.

COMMON MISTAKE

Assigning intense colours to d–d transitions (they are weak; intense = charge transfer).

EXAM TIP

Number of ν(CO) IR bands reveals geometry: cis-$M(CO)_2L_4$ 2 bands, trans 1 band.

MEMORY TRICK

'Weak = d–d, strong = CT'.

Why the Other Options Are Wrong

Correct answer: C

A **singlet**

Why (C) is the key — At −60 °C exchange is frozen: the two equivalent axial F couple to the equatorial F (a doublet, 2F) and the equatorial F couples to the two axial F (a triplet, 1F).

B **doublet**

Ruled out: Assigning intense colours to d–d transitions (they are weak; intense = charge transfer).

D **doublet of doublet and a doublet of triplet**

Ruled out: Number of ν(CO) IR bands reveals geometry: cis-$M(CO)_2L_4$ 2 bands, trans 1 band.

Q36

In the EPR spectrum of a methyl radical, the number of the lines and their relative intensities, respectively, are

A. 1 and 1

B. 3 and 1: 2: 1

C. 4 and 1: 2: 2: 1

D. 4 and 1 : 3 : 3 : 1

QUESTION INSIGHTS

ESTIMATED TIME
2–3 min

DIFFICULTY
Medium

CONCEPT TESTED
Inorganic Spectroscopy – General

PYQ FREQUENCY
Very High · 11 paper

REVISION PRIORITY
★★★★☆

EXPECTED LEVEL
Part B / Part C

MEMORY HOOK
'Weak = d–d, strong = CT'.

Correct Answer D 4 and 1 : 3 : 3 : 1

CONCEPT

Electronic spectra of transition-metal complexes (d–d: Laporte/spin rules, Tanabe–Sugano diagrams, Racah B, nephelauxetic effect, Jahn–Teller), charge-transfer bands (MnO_4^-, CrO_4^{2-}), IR of CO/NO/N_2 ligands (back-bonding lowers ν), Mössbauer (isomer shift, quadrupole splitting), EPR (g, hyperfine), magnetism (μ, Curie–Weiss), NMR of inorganic nuclei (^{19}F, ^{31}P, ^{11}B, ^{195}Pt).

LOGIC / WORKING

- Three equivalent protons: n + 1 = 4 lines, 1 : 3 : 3 : 1 (d).
- Therefore the answer is (D).

FINAL: (D) 4 and 1 : 3 : 3 : 1

SHORTCUT / EXAM TRICK

More electron-rich metal → more back-bonding → lower ν(CO): $[V(CO)_6]^-$ < $Cr(CO)_6$ < $[Mn(CO)_6]^+$.

COMMON MISTAKE

Assigning intense colours to d–d transitions (they are weak; intense = charge transfer).

EXAM TIP

Number of ν(CO) IR bands reveals geometry: cis-$M(CO)_2L_4$ 2 bands, trans 1 band.

MEMORY TRICK

'Weak = d–d, strong = CT'.

Why the Other Options Are Wrong

Correct answer: D

A **1 and 1**

Why (D) is the key — Three equivalent protons: n + 1 = 4 lines, 1 : 3 : 3 : 1 (d).

B **3 and 1: 2: 1**

Ruled out: Assigning intense colours to d–d transitions (they are weak; intense = charge transfer).

C **4 and 1: 2: 2: 1**

Ruled out: Number of ν(CO) IR bands reveals geometry: cis-$M(CO)_2L_4$ 2 bands, trans 1 band.

TOPIC REVISION

Inorganic Spectroscopy – General

29 PYQs · Last-minute revision

TOPIC SUMMARY

Electronic spectra of transition-metal complexes (d–d: Laporte/spin rules, Tanabe–Sugano diagrams, Racah B, nephelauxetic effect, Jahn–Teller), charge-transfer bands (MnO_4^-, CrO_4^{2-}), IR of CO/NO/N_2 ligands (back-bonding lowers ν), Mössbauer (isomer shift, quadrupole splitting), EPR (g, hyperfine), magnetism (μ, Curie–Weiss), NMR of inorganic nuclei (^{19}F, ^{31}P, ^{11}B, ^{195}Pt).

IMPORTANT FORMULA SHEET

- $\mu_{so} = \sqrt{n(n+2)}\ \mu_B$
- Δ_o from ν_1 (d^1, d^9: $\Delta_o = \nu_1$); B from Tanabe–Sugano
- ε: spin-forbidden < 1, Laporte-forbidden 1–100, Td 100–1000, CT > 1000
- ν(CO): free 2143, terminal 2100–1850, bridging 1850–1700 cm^{-1}

FREQUENTLY ASKED CONCEPTS

- Number of d–d bands for d^3/d^8 (3) and d^2/d^7
- Why Mn^{2+} is pale and MnO_4^- intense
- ν(CO) order with ligand donor strength
- Mössbauer of Fe(II)/Fe(III) HS/LS
- EPR of Cu(II) (4 lines, I = 3/2)

COMMON MISTAKES & QUICK NOTES

Watch out:
Assigning intense colours to d–d transitions (they are weak; intense = charge transfer).
Number of ν(CO) IR bands reveals geometry: cis-$M(CO)_2L_4$ 2 bands, trans 1 band.

MOST-REPEATED PYQs & EXPECTED IN EXAM

PYQs in this topic: Q8 Q9 Q10 Q11 Q12 Q13 Q14 Q15 Q16 Q17 Q18 Q19 Q20 Q21 …

Expect 3 question(s) next session on Inorganic Spectroscopy – General.

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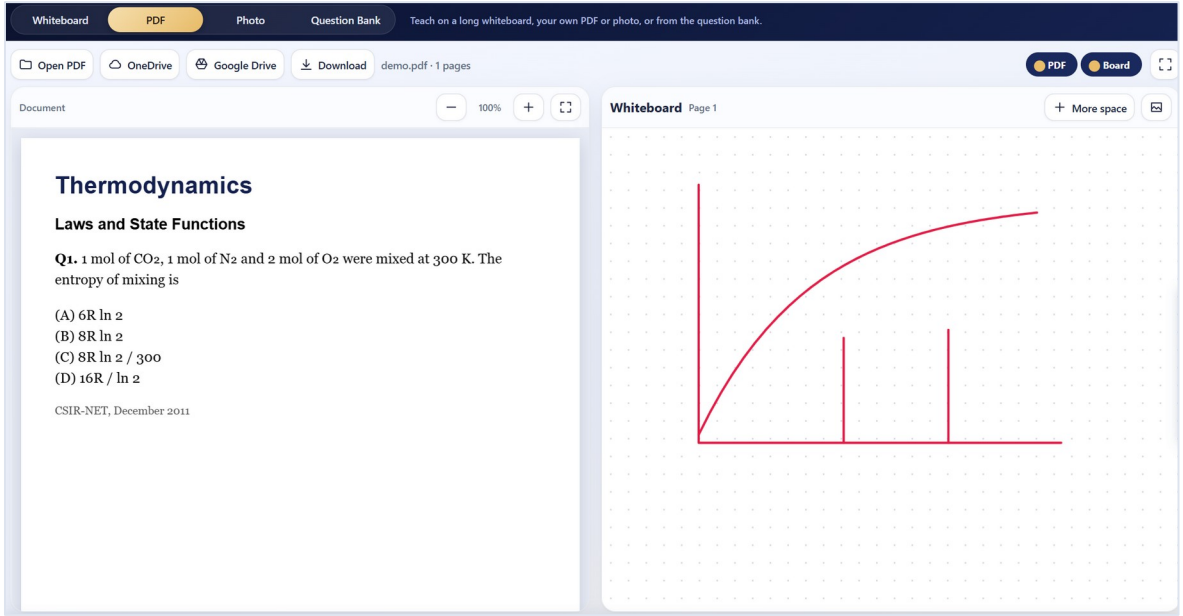
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