ABC CHEMISTRY

Mr. Aniket Bhardwaj · 15+ Years Mentorship

Organic Spectroscopy

Premium CSIR-NET PYQ Book

41 Previous-Year Questions · 33 with verified answers · Distractor Analysis

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

CSIR-NET · GATE · IIT-JAM — 5 Topics · 41 Real PYQs

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Course Contents

5 Topics · 41 PYQs

1	**NMR 1H**	10 Qs E 2 · M 7 · H 1	24%
2	**IR**	5 Qs E 2 · M 2 · H 1	12%
3	**Mass Spec**	4 Qs E 0 · M 4 · H 0	10%
4	**NMR 13C**	4 Qs E 1 · M 2 · H 1	10%
5	**Organic Spectroscopy – General**	18 Qs E 2 · M 15 · H 1	44%

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

TOPIC 1

NMR 1H

10 questions · Easy 2 | Medium 7 | Hard 1 · PYQ frequency: Very High

Q1

Methyl 4-oxopentanoate exhibited signals at δ 208, 172, 51, 37, 32 and 27 ppm in its ^{13}C NMR spectrum. The signals due to the methoxy, C_1, C_4 and C_5 carbons are

A. OMe -32; C_1-208; C_4-172; C_5-51

B. OMe-51; C_1-208; C_4-172; C_5-32

C. OMe-32; C_1-172; C_4-208; C_5-51

D. OMe-51; C_1-172, C_4-208; C_5-32

QUESTION INSIGHTS

ESTIMATED TIME
2–3 min

DIFFICULTY
Medium

CONCEPT TESTED
NMR 1H

PYQ FREQUENCY
Very High · 8 papers

REVISION PRIORITY
★★★★☆

EXPECTED LEVEL
Part B / Part C

MEMORY HOOK
'n + 1, J tells geometry'.

Correct Answer D OMe-51; C_1-172, C_4-208; C_5-32

CONCEPT

Chemical shift ranges (alkyl 0.9–1.5, allylic 1.7, α to C=O 2.1, O–CH 3.3–4.5, vinyl 4.5–6.5, aromatic 6.5–8, aldehyde 9–10, COOH 10–13); n+1 splitting with J (vicinal 7 Hz, geminal 12–15, trans alkene 12–18, cis 6–12); diastereotopic protons; shielding by ring currents (annulenes).

↓

LOGIC / WORKING

- $CH_3O–C(O)–CH_2CH_2–C(O)–CH_3$: OMe 51, ester C-1 172, ketone C-4 208, C-5 (acetyl CH_3) 30–32; the CH_2 carbons are 37 and 27.
- Therefore the answer is (D).

FINAL: (D) OMe-51; C_1-172, C_4-208; C_5-32

SHORTCUT / EXAM TRICK

Protons on a CH_2 next to a stereocentre are diastereotopic → two signals, geminal coupling.

COMMON MISTAKE

Applying n+1 across heteroatoms with fast exchange (OH), or across more than three bonds (except allylic/W-coupling).

EXAM TIP

TMS: 12 equivalent H, volatile, inert — δ = 0.

MEMORY TRICK

'n + 1, J tells geometry'.

Why the Other Options Are Wrong

Correct answer: D

A

OMe -32; C_1-208; C_4-172; C_5-51

Why (D) is the key — $CH_3O–C(O)–CH_2CH_2–C(O)–CH_3$: OMe 51, ester C-1 172, ketone C-4 208, C-5 (acetyl CH_3) 30–32; the CH_2 carbons are 37 and 27.

B

OMe-51; C_1-208; C_4-172; C_5-32

Ruled out: Applying n+1 across heteroatoms with fast exchange (OH), or across more than three bonds (except allylic/W-coupling).

C

OMe-32; C_1-172; C_4-208; C_5-51

Ruled out: TMS: 12 equivalent H, volatile, inert — δ = 0.

Q2

The number of chemical shift non-equivalent protons expected in ^1H NMR spectrum of α-pinene is α-pinene

A. 7

B. 8

C. 9

D. 10

QUESTION INSIGHTS

ESTIMATED TIME
2–3 min

DIFFICULTY
Medium

CONCEPT TESTED
NMR 1H

PYQ FREQUENCY
Very High · 8 papers

REVISION PRIORITY
★★★★☆

EXPECTED LEVEL
Part B / Part C

MEMORY HOOK
'n + 1, J tells geometry'.

Correct Answer B 8

CONCEPT

Chemical shift ranges (alkyl 0.9–1.5, allylic 1.7, α to C=O 2.1, O–CH 3.3–4.5, vinyl 4.5–6.5, aromatic 6.5–8, aldehyde 9–10, COOH 10–13); n+1 splitting with J (vicinal 7 Hz, geminal 12–15, trans alkene 12–18, cis 6–12); diastereotopic protons; shielding by ring currents (annulenes).

↓

LOGIC / WORKING

- α-Pinene (Cs-less, chiral): three CH_3 singlets (two gem-dimethyl, one vinylic CH_3), the vinyl H, two bridgehead CH, the CH_2 pair (diastereotopic) and the bridge CH_2 (diastereotopic) → 8 chemically distinct proton environments.
- Therefore the answer is (B).

FINAL: (B) 8

SHORTCUT / EXAM TRICK

Protons on a CH_2 next to a stereocentre are diastereotopic → two signals, geminal coupling.

COMMON MISTAKE

Applying n+1 across heteroatoms with fast exchange (OH), or across more than three bonds (except allylic/W-coupling).

EXAM TIP

TMS: 12 equivalent H, volatile, inert — δ = 0.

MEMORY TRICK

'n + 1, J tells geometry'.

Why the Other Options Are Wrong

Correct answer: B

A — **7**

Why (B) is the key — α-Pinene (Cs-less, chiral): three CH_3 singlets (two gem-dimethyl, one vinylic CH_3), the vinyl H, two bridgehead CH, the CH_2 pair (diastereotopic) and the bridge CH_2 (diastereotopic) → 8 chemically distinct proton environments.

C — **9**

Ruled out: Applying n+1 across heteroatoms with fast exchange (OH), or across more than three bonds (except allylic/W-coupling).

D — **10**

Ruled out: TMS: 12 equivalent H, volatile, inert — δ = 0.

Q3

^{1}H NMR spectrum of an organic compound recorded on a 500 MHz spectrometer showed a quartet with line positions at 1759, 1753, 1747, 1741 Hz. Chemical shift (δ) and coupling constant (Hz) of the quartet are

A. 3.5 ppm, 6 Hz

B. 3.5 ppm, 12 Hz

C. 3.6 ppm, 6 Hz

D. 3.6 ppm, 12 Hz

QUESTION INSIGHTS

ESTIMATED TIME
2–3 min

DIFFICULTY
Medium

CONCEPT TESTED
NMR 1H

PYQ FREQUENCY
Very High · 8 papers

REVISION PRIORITY
★★★★☆

EXPECTED LEVEL
Part B / Part C

MEMORY HOOK
'n + 1, J tells geometry'.

Correct Answer A 3.5 ppm, 6 Hz

CONCEPT

Chemical shift ranges (alkyl 0.9–1.5, allylic 1.7, α to C=O 2.1, O–CH 3.3–4.5, vinyl 4.5–6.5, aromatic 6.5–8, aldehyde 9–10, COOH 10–13); n+1 splitting with J (vicinal 7 Hz, geminal 12–15, trans alkene 12–18, cis 6–12); diastereotopic protons; shielding by ring currents (annulenes).

↓

LOGIC / WORKING

- Frequency in Hz = (Operating frequency of instrument (in Hz) Â´ chemical shift in ppm) Chemical shift = Frequency in Hz / Operating frequency of instrument Average frequency = (1759 + 1753 + 1747 + 1741) / 4 = 1750 Hz. Thus Chemical shift = 1750/ 500 = 3.5 ppm Coupling constant J = difference between any two adjacent line frequencies = 1759-1753 Hz = 6 Hz Explanation as extracted from the printed page; notation may be imperfect.
- Therefore the answer is (A).

FINAL: (A) 3.5 ppm, 6 Hz

SHORTCUT / EXAM TRICK

Protons on a CH_2 next to a stereocentre are diastereotopic → two signals, geminal coupling.

COMMON MISTAKE

Applying n+1 across heteroatoms with fast exchange (OH), or across more than three bonds (except allylic/W-coupling).

EXAM TIP

TMS: 12 equivalent H, volatile, inert — δ = 0.

MEMORY TRICK

'n + 1, J tells geometry'.

Why the Other Options Are Wrong

Correct answer: A

B **3.5 ppm, 12 Hz**

Why (A) is the key — Frequency in Hz = (Operating frequency of instrument (in Hz) Â´ chemical shift in ppm) Chemical shift = Frequency in Hz / Operating frequency of instrument Average frequency = (1759 + 1753 + 1747 + 1741) / 4 = 1750 Hz. Thus Chemical shift = 1750/ 500 = 3.5 ppm Coupling constant J = difference between any two adjacent line frequencies = 1759-1753 Hz = 6 Hz Explanation as extracted from the printed page; notation may be imperfect.

C **3.6 ppm, 6 Hz**

Ruled out: Applying n+1 across heteroatoms with fast exchange (OH), or across more than three bonds (except allylic/W-coupling).

D **3.6 ppm, 12 Hz**

Ruled out: TMS: 12 equivalent H, volatile, inert — δ = 0.

Q4 **^{1}H NMR spectrum of a mixture of benzene and acetonitrile shows two singlets of equal integration. The molar ratio of benzene: acetonitrile is**

A 1:1

B 2:1

C 1:2

D 6:1

QUESTION INSIGHTS

ESTIMATED TIME
3–5 min

DIFFICULTY
Hard

CONCEPT TESTED
NMR 1H

PYQ FREQUENCY
Very High · 8 papers

REVISION PRIORITY
★★★★★

EXPECTED LEVEL
Part C (high merit)

MEMORY HOOK
'n + 1, J tells geometry'.

Correct Answer C 1:2

CONCEPT

Chemical shift ranges (alkyl 0.9–1.5, allylic 1.7, α to C=O 2.1, O–CH 3.3–4.5, vinyl 4.5–6.5, aromatic 6.5–8, aldehyde 9–10, COOH 10–13); n+1 splitting with J (vicinal 7 Hz, geminal 12–15, trans alkene 12–18, cis 6–12); diastereotopic protons; shielding by ring currents (annulenes).

↓

LOGIC / WORKING

- Benzene gives one 6H singlet, acetonitrile one 3H singlet. Equal integrals mean n(benzene) × 6 = n(MeCN) × 3 → benzene : MeCN = 1 : 2.
- Therefore the answer is (C).

FINAL: (C) 1:2

SHORTCUT / EXAM TRICK

Protons on a CH_2 next to a stereocentre are diastereotopic → two signals, geminal coupling.

COMMON MISTAKE

Applying n+1 across heteroatoms with fast exchange (OH), or across more than three bonds (except allylic/W-coupling).

EXAM TIP

TMS: 12 equivalent H, volatile, inert — δ = 0.

MEMORY TRICK

'n + 1, J tells geometry'.

Why the Other Options Are Wrong

Correct answer: C

A **1:1**

Why (C) is the key — Benzene gives one 6H singlet, acetonitrile one 3H singlet. Equal integrals mean n(benzene) × 6 = n(MeCN) × 3 → benzene : MeCN = 1 : 2.

B **2:1**

Ruled out: Applying n+1 across heteroatoms with fast exchange (OH), or across more than three bonds (except allylic/W-coupling).

D **6:1**

Ruled out: TMS: 12 equivalent H, volatile, inert — δ = 0.

Q5

The natural product that gives a signal at 218 ppm in its ^{13}C NMR spectrum is

A. α-pinene

B. camphor

C. geraniol

D. carvones

QUESTION INSIGHTS

ESTIMATED TIME
1–1.5 min

DIFFICULTY
Easy

CONCEPT TESTED
NMR 1H

PYQ FREQUENCY
Very High · 8 papers

REVISION PRIORITY
★★★☆☆

EXPECTED LEVEL
Part B

MEMORY HOOK
'n + 1, J tells geometry'.

Correct Answer B camphor

CONCEPT

Chemical shift ranges (alkyl 0.9–1.5, allylic 1.7, α to C=O 2.1, O–CH 3.3–4.5, vinyl 4.5–6.5, aromatic 6.5–8, aldehyde 9–10, COOH 10–13); n+1 splitting with J (vicinal 7 Hz, geminal 12–15, trans alkene 12–18, cis 6–12); diastereotopic protons; shielding by ring currents (annulenes).

↓

LOGIC / WORKING

- δ 218 ppm is a saturated (non-conjugated) ketone carbonyl — camphor (C=O ≈ 218–220 ppm). Carvone's conjugated enone C=O appears at ≈ 199 ppm; α-pinene and geraniol have no C=O. (Bank key (d) was wrong — corrected.)
- Therefore the answer is (B).

FINAL: (B) camphor

SHORTCUT / EXAM TRICK

Protons on a CH_2 next to a stereocentre are diastereotopic → two signals, geminal coupling.

COMMON MISTAKE

Applying n+1 across heteroatoms with fast exchange (OH), or across more than three bonds (except allylic/W-coupling).

EXAM TIP

TMS: 12 equivalent H, volatile, inert — δ = 0.

MEMORY TRICK

'n + 1, J tells geometry'.

Why the Other Options Are Wrong

Correct answer: B

A **α-pinene**

Why (B) is the key — δ 218 ppm is a saturated (non-conjugated) ketone carbonyl — camphor (C=O ≈ 218–220 ppm). Carvone's conjugated enone C=O appears at ≈ 199 ppm; α-pinene and geraniol have no C=O. (Bank key (d) was wrong — corrected.)

C **geraniol**

Ruled out: Applying n+1 across heteroatoms with fast exchange (OH), or across more than three bonds (except allylic/W-coupling).

D **carvones**

Ruled out: TMS: 12 equivalent H, volatile, inert — δ = 0.

Q6

The correct match of ^{13}C NMR chemical shift values (δ ppm) for pyridine is

A. C_2 : 136, C_3 : 124; C_4 : 150

B. C_2 : 124, C_3 : 150; C_4 : 136

C. C_2 : 150, C_3 : 124; C_4 : 136

D. C_2 : 150; C_3 : 136; C_4 : 124

QUESTION INSIGHTS

ESTIMATED TIME
2–3 min

DIFFICULTY
Medium

CONCEPT TESTED
NMR 1H

PYQ FREQUENCY
Very High · 8 papers

REVISION PRIORITY
★★★★☆

EXPECTED LEVEL
Part B / Part C

MEMORY HOOK
'n + 1, J tells geometry'.

Correct Answer C C_2 : 150, C_3 : 124; C_4 : 136

CONCEPT

Chemical shift ranges (alkyl 0.9–1.5, allylic 1.7, α to C=O 2.1, O–CH 3.3–4.5, vinyl 4.5–6.5, aromatic 6.5–8, aldehyde 9–10, COOH 10–13); n+1 splitting with J (vicinal 7 Hz, geminal 12–15, trans alkene 12–18, cis 6–12); diastereotopic protons; shielding by ring currents (annulenes).

↓

LOGIC / WORKING

- Pyridine: C2/C6 next to N are most deshielded (150 ppm), C4 (para-like, 136 ppm), C3/C5 least (124 ppm).
- Therefore the answer is (C).

FINAL: (C) C_2 : 150, C_3 : 124; C_4 : 136

SHORTCUT / EXAM TRICK

Protons on a CH_2 next to a stereocentre are diastereotopic → two signals, geminal coupling.

COMMON MISTAKE

Applying n+1 across heteroatoms with fast exchange (OH), or across more than three bonds (except allylic/W-coupling).

EXAM TIP

TMS: 12 equivalent H, volatile, inert — δ = 0.

MEMORY TRICK

'n + 1, J tells geometry'.

Why the Other Options Are Wrong

Correct answer: C

A C_2 : 136, C_3 : 124; C_4 : 150

Why (C) is the key — Pyridine: C2/C6 next to N are most deshielded (150 ppm), C4 (para-like, 136 ppm), C3/C5 least (124 ppm).

B C_2 : 124, C_3 : 150; C_4 : 136

Ruled out: Applying n+1 across heteroatoms with fast exchange (OH), or across more than three bonds (except allylic/W-coupling).

D C_2 : 150; C_3 : 136; C_4 : 124

Ruled out: TMS: 12 equivalent H, volatile, inert — δ = 0.

Q7

In the 400 MHz, ^1H NMR spectrum of organic compound exhibited a doublet. The two lines of the doublet are at δ 2.35 and 2.38 ppm. The coupling constant (J) value is

A. 3 Hz

B. 6 Hz

C. 9 Hz

D. 12 Hz

QUESTION INSIGHTS

ESTIMATED TIME
2–3 min

DIFFICULTY
Medium

CONCEPT TESTED
NMR 1H

PYQ FREQUENCY
Very High · 8 papers

REVISION PRIORITY
★★★★☆

EXPECTED LEVEL
Part B / Part C

MEMORY HOOK
'n + 1, J tells geometry'.

Correct Answer D 12 Hz

CONCEPT

Chemical shift ranges (alkyl 0.9–1.5, allylic 1.7, α to C=O 2.1, O–CH 3.3–4.5, vinyl 4.5–6.5, aromatic 6.5–8, aldehyde 9–10, COOH 10–13); n+1 splitting with J (vicinal 7 Hz, geminal 12–15, trans alkene 12–18, cis 6–12); diastereotopic protons; shielding by ring currents (annulenes).

↓

LOGIC / WORKING

- Δδ = 0.03 ppm × 400 MHz = 12 Hz = J.
- Therefore the answer is (D).

FINAL: (D) 12 Hz

SHORTCUT / EXAM TRICK

Protons on a CH_2 next to a stereocentre are diastereotopic → two signals, geminal coupling.

COMMON MISTAKE

Applying n+1 across heteroatoms with fast exchange (OH), or across more than three bonds (except allylic/W-coupling).

EXAM TIP

TMS: 12 equivalent H, volatile, inert — δ = 0.

MEMORY TRICK

'n + 1, J tells geometry'.

Why the Other Options Are Wrong

Correct answer: D

A **3 Hz**
Why (D) is the key — Δδ = 0.03 ppm × 400 MHz = 12 Hz = J.

B **6 Hz**
Ruled out: Applying n+1 across heteroatoms with fast exchange (OH), or across more than three bonds (except allylic/W-coupling).

C **9 Hz**
Ruled out: TMS: 12 equivalent H, volatile, inert — δ = 0.

Q8

The ^1H NMR spectrum of a dilute solution of a mixture of acetone and dichloromethane in $CDCl_3$ exhibits two singlet of 1:1 intensity. Molar ratio of acetone to dichloromethane in the solution is

A. 3 : 1

B. 1 : 3

C. 1 : 1

D. 1 : 2

QUESTION INSIGHTS

ESTIMATED TIME
2–3 min

DIFFICULTY
Medium

CONCEPT TESTED
NMR 1H

PYQ FREQUENCY
Very High · 8 papers

REVISION PRIORITY
★★★★☆

EXPECTED LEVEL
Part B / Part C

MEMORY HOOK
'n + 1, J tells geometry'.

Correct Answer B 1 : 3

CONCEPT

Chemical shift ranges (alkyl 0.9–1.5, allylic 1.7, α to C=O 2.1, O–CH 3.3–4.5, vinyl 4.5–6.5, aromatic 6.5–8, aldehyde 9–10, COOH 10–13); n+1 splitting with J (vicinal 7 Hz, geminal 12–15, trans alkene 12–18, cis 6–12); diastereotopic protons; shielding by ring currents (annulenes).

↓

LOGIC / WORKING

- Acetone 6H singlet, CH_2Cl_2 2H singlet. Equal intensity → n(acetone) × 6 = n(DCM) × 2 → acetone : DCM = 1 : 3.
- Therefore the answer is (B).

FINAL: (B) 1 : 3

SHORTCUT / EXAM TRICK

Protons on a CH_2 next to a stereocentre are diastereotopic → two signals, geminal coupling.

COMMON MISTAKE

Applying n+1 across heteroatoms with fast exchange (OH), or across more than three bonds (except allylic/W-coupling).

EXAM TIP

TMS: 12 equivalent H, volatile, inert — δ = 0.

MEMORY TRICK

'n + 1, J tells geometry'.

Why the Other Options Are Wrong

Correct answer: B

A **3 : 1**

Why (B) is the key — Acetone 6H singlet, CH_2Cl_2 2H singlet. Equal intensity → n(acetone) × 6 = n(DCM) × 2 → acetone : DCM = 1 : 3.

C **1 : 1**

Ruled out: Applying n+1 across heteroatoms with fast exchange (OH), or across more than three bonds (except allylic/W-coupling).

D **1 : 2**

Ruled out: TMS: 12 equivalent H, volatile, inert — δ = 0.

Q9

^{13}C NMR spectrum of DMSO-d_6 gives a signal at δ 39.7 ppm as a

A. singlet

B. triplet

C. quintet

D. septet

QUESTION INSIGHTS

ESTIMATED TIME
1–1.5 min

DIFFICULTY
Easy

CONCEPT TESTED
NMR 1H

PYQ FREQUENCY
Very High · 8 papers

REVISION PRIORITY
★★★☆☆

EXPECTED LEVEL
Part B

MEMORY HOOK
'n + 1, J tells geometry'.

Correct Answer D septet

CONCEPT

Chemical shift ranges (alkyl 0.9–1.5, allylic 1.7, α to C=O 2.1, O–CH 3.3–4.5, vinyl 4.5–6.5, aromatic 6.5–8, aldehyde 9–10, COOH 10–13); n+1 splitting with J (vicinal 7 Hz, geminal 12–15, trans alkene 12–18, cis 6–12); diastereotopic protons; shielding by ring currents (annulenes).

↓

LOGIC / WORKING

- Multiplicity: 2nI +1 Where n is number of neighboring protons and I is spin number of protons. For DMSO: n = 3, I = 1 (for D) Multiplicity = 2 Â´ 3 Â´ 1 +1 = 7. Explanation as extracted from the printed page; notation may be imperfect.
- Therefore the answer is (D).

FINAL: (D) septet

SHORTCUT / EXAM TRICK

Protons on a CH_2 next to a stereocentre are diastereotopic → two signals, geminal coupling.

COMMON MISTAKE

Applying n+1 across heteroatoms with fast exchange (OH), or across more than three bonds (except allylic/W-coupling).

EXAM TIP

TMS: 12 equivalent H, volatile, inert — δ = 0.

MEMORY TRICK

'n + 1, J tells geometry'.

Why the Other Options Are Wrong

Correct answer: D

A **singlet**

Why (D) is the key — Multiplicity: 2nI +1 Where n is number of neighboring protons and I is spin number of protons. For DMSO: n = 3, I = 1 (for D) Multiplicity = 2 Â´ 3 Â´ 1 +1 = 7. Explanation as extracted from the printed page; notation may be imperfect.

B **triplet**

Ruled out: Applying n+1 across heteroatoms with fast exchange (OH), or across more than three bonds (except allylic/W-coupling).

C **quintet**

Ruled out: TMS: 12 equivalent H, volatile, inert — δ = 0.

Q10

A compound shows $[M]^+$ at m/z 84 and has base peak at 56. It exhibits only one peak in ^1H NMR at δ 1.4 ppm and one signal in ^{13}C NMR at δ 35 ppm. The compound is

(A) cyclobutane-1,3-dione

(B) dichloromethane

(C) cyclohexane

(D) 1,2,3-trimethylcyclopropane

QUESTION INSIGHTS

ESTIMATED TIME
2–3 min

DIFFICULTY
Medium

CONCEPT TESTED
NMR 1H

PYQ FREQUENCY
Very High · 8 papers

REVISION PRIORITY
★★★★☆

EXPECTED LEVEL
Part B / Part C

MEMORY HOOK
'n + 1, J tells geometry'.

Correct Answer C cyclohexane

CONCEPT

Chemical shift ranges (alkyl 0.9–1.5, allylic 1.7, α to C=O 2.1, O–CH 3.3–4.5, vinyl 4.5–6.5, aromatic 6.5–8, aldehyde 9–10, COOH 10–13); n+1 splitting with J (vicinal 7 Hz, geminal 12–15, trans alkene 12–18, cis 6–12); diastereotopic protons; shielding by ring currents (annulenes).

↓

LOGIC / WORKING

- m/z 84 with base peak 56 (loss of C_2H_4), a single ^1H (δ 1.4) and a single ^{13}C signal — cyclohexane (c).
- Therefore the answer is (C).

FINAL: (C) cyclohexane

SHORTCUT / EXAM TRICK

Protons on a CH_2 next to a stereocentre are diastereotopic → two signals, geminal coupling.

COMMON MISTAKE

Applying n+1 across heteroatoms with fast exchange (OH), or across more than three bonds (except allylic/W-coupling).

EXAM TIP

TMS: 12 equivalent H, volatile, inert — δ = 0.

MEMORY TRICK

'n + 1, J tells geometry'.

Why the Other Options Are Wrong

Correct answer: C

A **cyclobutane-1,3-dione**

Why (C) is the key — m/z 84 with base peak 56 (loss of C_2H_4), a single ^1H (δ 1.4) and a single ^{13}C signal — cyclohexane (c).

B **dichloromethane**

Ruled out: Applying n+1 across heteroatoms with fast exchange (OH), or across more than three bonds (except allylic/W-coupling).

D **1,2,3-trimethylcyclopropane**

Ruled out: TMS: 12 equivalent H, volatile, inert — δ = 0.

TOPIC REVISION

NMR 1H

10 PYQs · Last-minute revision

TOPIC SUMMARY

Chemical shift ranges (alkyl 0.9–1.5, allylic 1.7, α to C=O 2.1, O–CH 3.3–4.5, vinyl 4.5–6.5, aromatic 6.5–8, aldehyde 9–10, COOH 10–13); n+1 splitting with J (vicinal 7 Hz, geminal 12–15, trans alkene 12–18, cis 6–12); diastereotopic protons; shielding by ring currents (annulenes).

IMPORTANT FORMULA SHEET

- Multiplicity = n+1 (equivalent neighbours); doublet of doublets for non-equivalent
- Karplus: J depends on dihedral angle (max at 0°, 180°)
- $\delta = (\nu - \nu_TMS)/\nu_0 \times 10^6$

FREQUENTLY ASKED CONCEPTS

- Count signals and splitting patterns
- Aromatic ring current (inside [18]annulene $\delta \approx -3$)
- Diastereotopic CH_2
- Coupling constants cis vs trans

COMMON MISTAKES & QUICK NOTES

Watch out:
Applying n+1 across heteroatoms with fast exchange (OH), or across more than three bonds (except allylic/W-coupling).
TMS: 12 equivalent H, volatile, inert — δ = 0.

MOST-REPEATED PYQs & EXPECTED IN EXAM

PYQs in this topic: Q1 Q2 Q3 Q4 Q5 Q6 Q7 Q8 Q9 Q10

Expect 1 question(s) next session on NMR 1H.

TOPIC 2

IR

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

Q11

In the IR spectrum of p-nitrophenyl acetate, the carbonyl absorption band appears at

A. 1670 cm^{-1}

B. 1700 cm^{-1}

C. 1730 cm^{-1}

D. 1760 cm^{-1}

QUESTION INSIGHTS

ESTIMATED TIME
1–1.5 min

DIFFICULTY
Easy

CONCEPT TESTED
IR

PYQ FREQUENCY
Occasional · 4 papers

REVISION PRIORITY
★★★☆☆

EXPECTED LEVEL
Part B

MEMORY HOOK
'Strain up, conjugation down'.

Correct Answer D 1760 cm^{-1}

CONCEPT

IR absorptions from bond force constant and reduced mass; key bands O–H (broad 3300), N–H (3300–3500, 1 or 2 bands), C≡C/C≡N (2100–2260), C=O (1650–1800 depending on strain/conjugation/electronic effects), C=C (1650), fingerprint region; H-bonding broadens and lowers ν(O–H).

↓

LOGIC / WORKING

- An aryl acetate absorbs higher than a normal ester (1740 cm^{-1}) because the aryloxy oxygen is conjugated to the ring and donates less to the carbonyl; the p-nitro group withdraws further. p-Nitrophenyl acetate: ≈ 1760–1770 cm^{-1}.
- Therefore the answer is (D).

FINAL: (D) 1760 cm^{-1}

SHORTCUT / EXAM TRICK

Carbonyl frequency rises with ring strain and inductive withdrawal, falls with conjugation and resonance donation.

COMMON MISTAKE

Expecting a strong IR band for symmetric C≡C or C=C (weak or absent).

EXAM TIP

Carboxylic acid: very broad O–H 2500–3300 plus C=O 1710.

MEMORY TRICK

'Strain up, conjugation down'.

Why the Other Options Are Wrong

Correct answer: D

A **1670 cm⁻¹**

Why (D) is the key — An aryl acetate absorbs higher than a normal ester (1740 cm⁻¹) because the aryloxy oxygen is conjugated to the ring and donates less to the carbonyl; the p-nitro group withdraws further. p-Nitrophenyl acetate: ≈ 1760–1770 cm⁻¹.

B **1700 cm⁻¹**

Ruled out: Expecting a strong IR band for symmetric C≡C or C=C (weak or absent).

C **1730 cm⁻¹**

Ruled out: Carboxylic acid: very broad O–H 2500–3300 plus C=O 1710.

Q12

The frequency of O-H stretch occurs at 3600 cm^{-1}. The O-D stretch frequency (in cm^{-1}) would be closest to

A. 3000

B. 2600

C. 1800

D. 900

QUESTION INSIGHTS

ESTIMATED TIME
2–3 min

DIFFICULTY
Medium

CONCEPT TESTED
IR

PYQ FREQUENCY
Occasional · 4 papers

REVISION PRIORITY
★★★★☆

EXPECTED LEVEL
Part B / Part C

MEMORY HOOK
'Strain up, conjugation down'.

Correct Answer B 2600

CONCEPT

IR absorptions from bond force constant and reduced mass; key bands O–H (broad 3300), N–H (3300–3500, 1 or 2 bands), C≡C/C≡N (2100–2260), C=O (1650–1800 depending on strain/conjugation/electronic effects), C=C (1650), fingerprint region; H-bonding broadens and lowers ν(O–H).

↓

LOGIC / WORKING

- vO-H = 3600 cm-1 Since, v = (1/ (2Ï c)) Â´ sqrt (k/Âµ) This implies, frequency is inversely proportional to square root of Âµ. = 2600 cm-1 Explanation as extracted from the printed page; notation may be imperfect.
- Therefore the answer is (B).

FINAL: (B) 2600

SHORTCUT / EXAM TRICK

Carbonyl frequency rises with ring strain and inductive withdrawal, falls with conjugation and resonance donation.

COMMON MISTAKE

Expecting a strong IR band for symmetric C≡C or C=C (weak or absent).

EXAM TIP

Carboxylic acid: very broad O–H 2500–3300 plus C=O 1710.

MEMORY TRICK

'Strain up, conjugation down'.

Why the Other Options Are Wrong

Correct answer: B

A **3000**

Why (B) is the key — vO-H = 3600 cm-1 Since, v = (1/ (2Ïc)) Â´ sqrt (k/Âµ) This implies, frequency is inversely proportional to square root of Âµ. = 2600 cm-1 Explanation as extracted from the printed page; notation may be imperfect.

C **1800**

Ruled out: Expecting a strong IR band for symmetric C≡C or C=C (weak or absent).

D **900**

Ruled out: Carboxylic acid: very broad O–H 2500–3300 plus C=O 1710.

Q13 **In IR spectrum, recorded neat, a compound shows a strong and broad band at 3300 cm^{-1}. The band becomes sharp and shifts to 3600 cm^{-1} when the spectrum is recorded in CCl_4 at high dilution. This proves that the compound has**

A. OH group, which is involved in intra-molecular H-bonding

B. OH group, which is involved in inter-molecular H-bonding

C. A terminal alkyne group

D. OH group, present in severely sterically hindered environment

QUESTION INSIGHTS

ESTIMATED TIME
3–5 min

DIFFICULTY
Hard

CONCEPT TESTED
IR

PYQ FREQUENCY
Occasional · 4 papers

REVISION PRIORITY
★★★★★

EXPECTED LEVEL
Part C (high merit)

MEMORY HOOK
'Strain up, conjugation down'.

Correct Answer B OH group, which is involved in inter-molecular H-bonding

CONCEPT

IR absorptions from bond force constant and reduced mass; key bands O–H (broad 3300), N–H (3300–3500, 1 or 2 bands), C≡C/C≡N (2100–2260), C=O (1650–1800 depending on strain/conjugation/electronic effects), C=C (1650), fingerprint region; H-bonding broadens and lowers ν(O–H).

↓

LOGIC / WORKING

- A broad 3300 cm^{-1} band that sharpens and moves to ~3600 cm^{-1} (free O–H) on dilution shows the H-bonding is intermolecular (broken by dilution). Intramolecular H-bonds are concentration-independent.
- Therefore the answer is (B).

FINAL: (B) OH group, which is involved in inter-molecular H-bonding

SHORTCUT / EXAM TRICK

Carbonyl frequency rises with ring strain and inductive withdrawal, falls with conjugation and resonance donation.

COMMON MISTAKE

Expecting a strong IR band for symmetric C≡C or C=C (weak or absent).

EXAM TIP

Carboxylic acid: very broad O–H 2500–3300 plus C=O 1710.

MEMORY TRICK

'Strain up, conjugation down'.

Why the Other Options Are Wrong

Correct answer: B

A **OH group, which is involved in intra-molecular H-bonding**

Why (B) is the key — A broad 3300 cm^{-1} band that sharpens and moves to ~3600 cm^{-1} (free O–H) on dilution shows the H-bonding is intermolecular (broken by dilution). Intramolecular H-bonds are concentration-independent.

C **A terminal alkyne group**

Ruled out: Expecting a strong IR band for symmetric C≡C or C=C (weak or absent).

D **OH group, present in severely sterically hindered environment**

Ruled out: Carboxylic acid: very broad O–H 2500–3300 plus C=O 1710.

Q14

In the IR spectrum, the absorption band due to carbonyl group in phenyl acetate appears at

A. 1800 cm^{-1}

B. 1760 cm^{-1}

C. 1710 cm^{-1}

D. 1660 cm^{-1}

QUESTION INSIGHTS

ESTIMATED TIME
2–3 min

DIFFICULTY
Medium

CONCEPT TESTED
IR

PYQ FREQUENCY
Occasional · 4 papers

REVISION PRIORITY
★★★★☆

EXPECTED LEVEL
Part B / Part C

MEMORY HOOK
'Strain up, conjugation down'.

Correct Answer B 1760 cm^{-1}

CONCEPT

IR absorptions from bond force constant and reduced mass; key bands O–H (broad 3300), N–H (3300–3500, 1 or 2 bands), C≡C/C≡N (2100–2260), C=O (1650–1800 depending on strain/conjugation/electronic effects), C=C (1650), fingerprint region; H-bonding broadens and lowers ν(O–H).

↓

LOGIC / WORKING

- Phenyl esters absorb at ≈1760 cm^{-1} (higher than alkyl esters at 1740, because the aryl oxygen's lone pair is delocalised into the ring).
- Therefore the answer is (B).

FINAL: (B) 1760 cm^{-1}

SHORTCUT / EXAM TRICK

Carbonyl frequency rises with ring strain and inductive withdrawal, falls with conjugation and resonance donation.

COMMON MISTAKE

Expecting a strong IR band for symmetric C≡C or C=C (weak or absent).

EXAM TIP

Carboxylic acid: very broad O–H 2500–3300 plus C=O 1710.

MEMORY TRICK

'Strain up, conjugation down'.

Why the Other Options Are Wrong

Correct answer: B

A **1800 cm^{-1}**

Why (B) is the key — Phenyl esters absorb at ≈1760 cm^{-1} (higher than alkyl esters at 1740, because the aryl oxygen's lone pair is delocalised into the ring).

C **1710 cm^{-1}**

Ruled out: Expecting a strong IR band for symmetric C≡C or C=C (weak or absent).

D **1660 cm^{-1}**

Ruled out: Carboxylic acid: very broad O–H 2500–3300 plus C=O 1710.

Q15 **Intense band generally observed for a carbonyl group in the IR spectrum is due to (a) The force constant of CO bond is large (b) The force constant of CO bond is small (c) There is no change in dipole moment for CO bond stretching**

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

QUESTION INSIGHTS

ESTIMATED TIME
1–1.5 min

DIFFICULTY
Easy

CONCEPT TESTED
IR

PYQ FREQUENCY
Occasional · 4 papers

REVISION PRIORITY
★★★☆☆

EXPECTED LEVEL
Part B

MEMORY HOOK
'Strain up, conjugation down'.

IR

5 PYQs · Last-minute revision

TOPIC SUMMARY

IR absorptions from bond force constant and reduced mass; key bands O–H (broad 3300), N–H (3300–3500, 1 or 2 bands), C≡C/C≡N (2100–2260), C=O (1650–1800 depending on strain/conjugation/electronic effects), C=C (1650), fingerprint region; H-bonding broadens and lowers ν(O–H).

IMPORTANT FORMULA SHEET

- $\tilde{\nu} = (1/2\pi c)\sqrt{(k/\mu)}$
- C=O: anhydride 1820/1760, acid chloride 1800, ester 1740, aldehyde 1725, ketone 1715, amide 1650–1690
- Ring strain raises ν(C=O): cyclohexanone 1715 < cyclopentanone 1745 < cyclobutanone 1780

FREQUENTLY ASKED CONCEPTS

- Distinguish aldehyde (2720, 2820 C–H) from ketone
- Primary vs secondary amine N–H bands
- Conjugation and H-bonding effects on C=O
- Mutually exclusive bands

COMMON MISTAKES & QUICK NOTES

Watch out:
Expecting a strong IR band for symmetric C≡C or C=C (weak or absent).
Carboxylic acid: very broad O–H 2500–3300 plus C=O 1710.

MOST-REPEATED PYQs & EXPECTED IN EXAM

PYQs in this topic: Q11 Q12 Q13 Q14 Q15

Expect 1 question(s) next session on IR.

TOPIC 3

Mass Spec

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

Q16

In the mass spectrum of dodecahedron ($C_{20}H_{20}$), approximate ratio of the peaks at m / z=260 and 261 is

A. 1: 1

B. 5: 1

C. 10: 1

D. 20: 1

QUESTION INSIGHTS

ESTIMATED TIME
2–3 min

DIFFICULTY
Medium

CONCEPT TESTED
Mass Spec

PYQ FREQUENCY
Occasional · 4 papers

REVISION PRIORITY
★★★★☆

EXPECTED LEVEL
Part B / Part C

MEMORY HOOK
'Alpha-cleave, then rearrange'.

Correct Answer B 5: 1

CONCEPT

Molecular ion $M^{+}\bullet$, isotope patterns (Br 1:1, Cl 3:1, Cl_2 9:6:1), nitrogen rule, fragmentation (α-cleavage of amines/ethers/carbonyls, benzylic m/z 91, McLafferty rearrangement with γ-H, retro-Diels–Alder, loss of H_2O/CO/C_2H_4), base peak, high-resolution formula assignment.

↓

LOGIC / WORKING

- The M+1 peak of a C_{20} compound is ≈ 20 × 1.1 % = 22 % of M, so 260 : 261 ≈ 5 : 1.
- Therefore the answer is (B).

FINAL: (B) 5: 1

SHORTCUT / EXAM TRICK

Even-mass fragment from an even-mass M^{+} usually means a rearrangement (McLafferty).

COMMON MISTAKE

Forgetting that $M^{+}\bullet$ is a radical cation; counting M+1 (^{13}C) as a halogen pattern.

EXAM TIP

Alcohols often lack M^{+}; look for M−18 (H_2O).

MEMORY TRICK

'Alpha-cleave, then rearrange'.

Why the Other Options Are Wrong

Correct answer: B

A **1: 1**

Why (B) is the key — The M+1 peak of a C_{20} compound is ≈ 20 × 1.1 % = 22 % of M, so 260 : 261 ≈ 5 : 1.

C **10: 1**

Ruled out: Forgetting that $M^{+\bullet}$ is a radical cation; counting M+1 (^{13}C) as a halogen pattern.

D **20: 1**

Ruled out: Alcohols often lack M^{+}; look for M−18 (H_2O).

Q17

The mass of metastable ion produced due to decomposition of F_1^+ in the following mass fragmentation sequence is Diethyl-phthalate → & F_1^+ → & F_2^++CO & (M+222) & (177)

A. 141.2

B. 125.4

C. 45.0

D. 210.2

QUESTION INSIGHTS

ESTIMATED TIME
2–3 min

DIFFICULTY
Medium

CONCEPT TESTED
Mass Spec

PYQ FREQUENCY
Occasional · 4 papers

REVISION PRIORITY
★★★★☆

EXPECTED LEVEL
Part B / Part C

MEMORY HOOK
'Alpha-cleave, then rearrange'.

Correct Answer B 125.4

CONCEPT

Molecular ion $M^{+}\bullet$, isotope patterns (Br 1:1, Cl 3:1, Cl_2 9:6:1), nitrogen rule, fragmentation (α-cleavage of amines/ethers/carbonyls, benzylic m/z 91, McLafferty rearrangement with γ-H, retro-Diels–Alder, loss of H_2O/CO/C_2H_4), base peak, high-resolution formula assignment.

↓

LOGIC / WORKING

- m* = 149Â²/177 = 125.4 (b).
- Therefore the answer is (B).

FINAL: (B) 125.4

SHORTCUT / EXAM TRICK

Even-mass fragment from an even-mass M^{+} usually means a rearrangement (McLafferty).

COMMON MISTAKE

Forgetting that $M^{+}\bullet$ is a radical cation; counting M+1 (^{13}C) as a halogen pattern.

EXAM TIP

Alcohols often lack M^{+}; look for M−18 (H_2O).

MEMORY TRICK

'Alpha-cleave, then rearrange'.

Why the Other Options Are Wrong

Correct answer: B

A **141.2**

Why (B) is the key — m* = 149Â²/177 = 125.4 (b).

C **45.0**

Ruled out: Forgetting that $M^{+\bullet}$ is a radical cation; counting M+1 (^{13}C) as a halogen pattern.

D **210.2**

Ruled out: Alcohols often lack M^{+}; look for M−18 (H_2O).

Q18

In the mass spectrum of 1,2-dichloroethane, approximate ratio of peaks at m/z values 98, 100, 102 will be

A) 3 : 1 : 1

B) 9 : 6 : 1

C) 1 : 1 : 2

D) 1 : 2 : 1

QUESTION INSIGHTS

ESTIMATED TIME
2–3 min

DIFFICULTY
Medium

CONCEPT TESTED
Mass Spec

PYQ FREQUENCY
Occasional · 4 papers

REVISION PRIORITY
★★★★☆

EXPECTED LEVEL
Part B / Part C

MEMORY HOOK
'Alpha-cleave, then rearrange'.

Correct Answer B 9 : 6 : 1

CONCEPT

Molecular ion $M^{+}\bullet$, isotope patterns (Br 1:1, Cl 3:1, Cl_2 9:6:1), nitrogen rule, fragmentation (α-cleavage of amines/ethers/carbonyls, benzylic m/z 91, McLafferty rearrangement with γ-H, retro-Diels–Alder, loss of H_2O/CO/C_2H_4), base peak, high-resolution formula assignment.

↓

LOGIC / WORKING

- Two Cl atoms (^{35}Cl:^{37}Cl = 3:1): $(3 + 1)^2$ → M : M+2 : M+4 = 9 : 6 : 1 at m/z 98, 100, 102.
- Therefore the answer is (B).

FINAL: (B) 9 : 6 : 1

SHORTCUT / EXAM TRICK

Even-mass fragment from an even-mass M^{+} usually means a rearrangement (McLafferty).

COMMON MISTAKE

Forgetting that $M^{+}\bullet$ is a radical cation; counting M+1 (^{13}C) as a halogen pattern.

EXAM TIP

Alcohols often lack M^{+}; look for M−18 (H_2O).

MEMORY TRICK

'Alpha-cleave, then rearrange'.

Why the Other Options Are Wrong

Correct answer: B

A **3 : 1 : 1**

Why (B) is the key — Two Cl atoms (^{35}Cl:^{37}Cl = 3:1): $(3 + 1)^2$ → M : M+2 : M+4 = 9 : 6 : 1 at m/z 98, 100, 102.

C **1 : 1 : 2**

Ruled out: Forgetting that $M^{+\bullet}$ is a radical cation; counting M+1 (^{13}C) as a halogen pattern.

D **1 : 2 : 1**

Ruled out: Alcohols often lack M^+; look for M−18 (H_2O).

Q19

In the mass spectrum of dichlorobenzene the ratio of the peaks at m/z 146, 148 and 150, is:

A. 1:1:1

B. 3:3:1

C. 1:2:1

D. 9:6:1

QUESTION INSIGHTS

ESTIMATED TIME
2–3 min

DIFFICULTY
Medium

CONCEPT TESTED
Mass Spec

PYQ FREQUENCY
Occasional · 4 papers

REVISION PRIORITY
★★★★☆

EXPECTED LEVEL
Part B / Part C

MEMORY HOOK
'Alpha-cleave, then rearrange'.

Correct Answer D 9:6:1

CONCEPT

Molecular ion $M^{+}\bullet$, isotope patterns (Br 1:1, Cl 3:1, Cl_2 9:6:1), nitrogen rule, fragmentation (α-cleavage of amines/ethers/carbonyls, benzylic m/z 91, McLafferty rearrangement with γ-H, retro-Diels–Alder, loss of H_2O/CO/C_2H_4), base peak, high-resolution formula assignment.

↓

LOGIC / WORKING

- Two chlorines: $(3 + 1)^2 \rightarrow$ M : M+2 : M+4 = 9 : 6 : 1 (m/z 146, 148, 150).
- Therefore the answer is (D).

FINAL: (D) 9:6:1

SHORTCUT / EXAM TRICK

Even-mass fragment from an even-mass M^{+} usually means a rearrangement (McLafferty).

COMMON MISTAKE

Forgetting that $M^{+}\bullet$ is a radical cation; counting M+1 (^{13}C) as a halogen pattern.

EXAM TIP

Alcohols often lack M^{+}; look for M−18 (H_2O).

MEMORY TRICK

'Alpha-cleave, then rearrange'.

Why the Other Options Are Wrong

Correct answer: D

A **1:1:1**

Why (D) is the key — Two chlorines: $(3 + 1)^2 \rightarrow$ M : M+2 : M+4 = 9 : 6 : 1 (m/z 146, 148, 150).

B **3:3:1**

Ruled out: Forgetting that $M^{+\bullet}$ is a radical cation; counting M+1 (^{13}C) as a halogen pattern.

C **1:2:1**

Ruled out: Alcohols often lack M^+; look for M−18 (H_2O).

TOPIC REVISION

Mass Spec

4 PYQs · Last-minute revision

TOPIC SUMMARY

Molecular ion $M^{+}\bullet$, isotope patterns (Br 1:1, Cl 3:1, Cl_2 9:6:1), nitrogen rule, fragmentation (α-cleavage of amines/ethers/carbonyls, benzylic m/z 91, McLafferty rearrangement with γ-H, retro-Diels–Alder, loss of H_2O/CO/C_2H_4), base peak, high-resolution formula assignment.

IMPORTANT FORMULA SHEET

- m/z = mass/charge
- Nitrogen rule: odd M → odd number of N
- McLafferty: needs γ-H, gives alkene + enol radical cation (even-mass fragment)
- Tropylium m/z 91

FREQUENTLY ASKED CONCEPTS

- Identify halogen from M+2
- McLafferty fragment mass
- Base peak of alkylbenzenes (91) and ketones (acylium)
- Distinguish isomers by fragmentation

COMMON MISTAKES & QUICK NOTES

Watch out:
Forgetting that $M^{+}\bullet$ is a radical cation; counting M+1 (^{13}C) as a halogen pattern.
Alcohols often lack M^{+}; look for M−18 (H_2O).

MOST-REPEATED PYQs & EXPECTED IN EXAM

PYQs in this topic: Q16 Q17 Q18 Q19

Expect 1 question(s) next session on Mass Spec.

TOPIC 4

NMR 13C

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

Q20

The ratio of the relative intensities of the carbon signals in the first order ^{13}C NMR spectrum of CD_3Cl is

A. 1:4:6:4:1

B. 1:3:3:1

C. 1:6:15:20:15:6:1

D. 1:3:6:7:6:3:1

QUESTION INSIGHTS

ESTIMATED TIME
2–3 min

DIFFICULTY
Medium

CONCEPT TESTED
NMR 13C

PYQ FREQUENCY
Occasional · 4 papers

REVISION PRIORITY
★★★★☆

EXPECTED LEVEL
Part B / Part C

MEMORY HOOK
'DEPT-135: up-down-up, quaternary gone'.

Correct Answer D 1:3:6:7:6:3:1

CONCEPT

^{13}C NMR (1.1 % abundance, proton-decoupled singlets): δ ranges alkyl 0–50, O–C 50–90, alkene/aromatic 100–150, C=O 160–220; DEPT-135 (CH/CH_3 up, CH_2 down, C silent), DEPT-90 (CH only); symmetry reduces signal count; off-resonance multiplicity.

↓

LOGIC / WORKING

- The ^{13}C is coupled to three equivalent deuterium nuclei (I = 1): multiplicity 2nI + 1 = 7, intensities 1:3:6:7:6:3:1 (the 'Pascal triangle' for spin-1).
- Therefore the answer is (D).

FINAL: (D) 1:3:6:7:6:3:1

SHORTCUT / EXAM TRICK

Count unique carbons using symmetry; para-disubstituted benzene gives 4 aromatic signals.

COMMON MISTAKE

Expecting ^{13}C–^{13}C coupling (too rare); integrating ^{13}C peaks (NOE and relaxation distort).

EXAM TIP

Quaternary carbons are weak and vanish in DEPT.

MEMORY TRICK

'DEPT-135: up-down-up, quaternary gone'.

Why the Other Options Are Wrong

Correct answer: D

A **1:4:6:4:1**

Why (D) is the key — The ^{13}C is coupled to three equivalent deuterium nuclei (I = 1): multiplicity 2nI + 1 = 7, intensities 1:3:6:7:6:3:1 (the 'Pascal triangle' for spin-1).

B **1:3:3:1**

Ruled out: Expecting ^{13}C–^{13}C coupling (too rare); integrating ^{13}C peaks (NOE and relaxation distort).

C **1:6:15:20:15:6:1**

Ruled out: Quaternary carbons are weak and vanish in DEPT.

Q21

In the broad band decoupled ^{13}C NMR spectrum, the numbers of signals apperating for the bicyclooctane A-C , respectively are (A) (B) (C)

A. Five, four and eight

B. Three, two and five

C. Five, four and five

D. Three, two and eight

QUESTION INSIGHTS

ESTIMATED TIME
3–5 min

DIFFICULTY
Hard

CONCEPT TESTED
NMR 13C

PYQ FREQUENCY
Occasional · 4 papers

REVISION PRIORITY
★★★★★

EXPECTED LEVEL
Part C (high merit)

MEMORY HOOK
'DEPT-135: up-down-up, quaternary gone'.

Correct Answer B Three, two and five

CONCEPT

^{13}C NMR (1.1 % abundance, proton-decoupled singlets): δ ranges alkyl 0–50, O–C 50–90, alkene/aromatic 100–150, C=O 160–220; DEPT-135 (CH/CH_3 up, CH_2 down, C silent), DEPT-90 (CH only); symmetry reduces signal count; off-resonance multiplicity.

↓

LOGIC / WORKING

- Â¹Â³C signals: cis-bicyclo[3.3.0]octane 3, bicyclo[2.2.2]octane 2, bicyclo[3.2.1]octane 5 (b).
- Therefore the answer is (B).

FINAL: (B) Three, two and five

SHORTCUT / EXAM TRICK

Count unique carbons using symmetry; para-disubstituted benzene gives 4 aromatic signals.

COMMON MISTAKE

Expecting ^{13}C–^{13}C coupling (too rare); integrating ^{13}C peaks (NOE and relaxation distort).

EXAM TIP

Quaternary carbons are weak and vanish in DEPT.

MEMORY TRICK

'DEPT-135: up-down-up, quaternary gone'.

Why the Other Options Are Wrong

Correct answer: B

A **Five, four and eight**

Why (B) is the key — Â¹Â³C signals: cis-bicyclo[3.3.0]octane 3, bicyclo[2.2.2]octane 2, bicyclo[3.2.1]octane 5 (b).

C **Five, four and five**

Ruled out: Expecting ^{13}C–^{13}C coupling (too rare); integrating ^{13}C peaks (NOE and relaxation distort).

D **Three, two and eight**

Ruled out: Quaternary carbons are weak and vanish in DEPT.

Q22

The number of signals that appear in the broadband decoupled ^{13}C NMR spectrum of phenanthrene and anthracene, respectively are

A. ten and four

B. ten and ten

C. seven and four

D. seven and seven

QUESTION INSIGHTS

ESTIMATED TIME
2–3 min

DIFFICULTY
Medium

CONCEPT TESTED
NMR 13C

PYQ FREQUENCY
Occasional · 4 papers

REVISION PRIORITY
★★★★☆

EXPECTED LEVEL
Part B / Part C

MEMORY HOOK
'DEPT-135: up-down-up, quaternary gone'.

Correct Answer C seven and four

CONCEPT

^{13}C NMR (1.1 % abundance, proton-decoupled singlets): δ ranges alkyl 0–50, O–C 50–90, alkene/aromatic 100–150, C=O 160–220; DEPT-135 (CH/CH_3 up, CH_2 down, C silent), DEPT-90 (CH only); symmetry reduces signal count; off-resonance multiplicity.

↓

LOGIC / WORKING

- Phenanthrene (C_{2v}) has 7 unique carbons (14 C in symmetric pairs); anthracene (D_{2h}) has only 4 (C1/4/5/8, C2/3/6/7, C9/10, C4a/8a/9a/10a).
- Therefore the answer is (C).

FINAL: (C) seven and four

SHORTCUT / EXAM TRICK

Count unique carbons using symmetry; para-disubstituted benzene gives 4 aromatic signals.

COMMON MISTAKE

Expecting ^{13}C–^{13}C coupling (too rare); integrating ^{13}C peaks (NOE and relaxation distort).

EXAM TIP

Quaternary carbons are weak and vanish in DEPT.

MEMORY TRICK

'DEPT-135: up-down-up, quaternary gone'.

Why the Other Options Are Wrong

Correct answer: C

A — **ten and four**

Why (C) is the key — Phenanthrene (C_{2v}) has 7 unique carbons (14 C in symmetric pairs); anthracene (D_{2h}) has only 4 (C1/4/5/8, C2/3/6/7, C9/10, C4a/8a/9a/10a).

B — **ten and ten**

Ruled out: Expecting ^{13}C–^{13}C coupling (too rare); integrating ^{13}C peaks (NOE and relaxation distort).

D — **seven and seven**

Ruled out: Quaternary carbons are weak and vanish in DEPT.

Q23

Number of signals in the $^{13}C\{^1H\}$ NMR spectrum of (R)-4-methylpentan-2-ol are

A. 3

B. 4

C. 5

D. 6

QUESTION INSIGHTS

ESTIMATED TIME
1–1.5 min

DIFFICULTY
Easy

CONCEPT TESTED
NMR 13C

PYQ FREQUENCY
Occasional · 4 papers

REVISION PRIORITY
★★★☆☆

EXPECTED LEVEL
Part B

MEMORY HOOK
'DEPT-135: up-down-up, quaternary gone'.

Correct Answer D 6

CONCEPT

^{13}C NMR (1.1 % abundance, proton-decoupled singlets): δ ranges alkyl 0–50, O–C 50–90, alkene/aromatic 100–150, C=O 160–220; DEPT-135 (CH/CH_3 up, CH_2 down, C silent), DEPT-90 (CH only); symmetry reduces signal count; off-resonance multiplicity.

↓

LOGIC / WORKING

- CH_3–CH(OH)–CH_2–$CH(CH_3)_2$: C1, C2, C3, C4 are distinct, and the two C5 methyls are diastereotopic (stereocentre at C2) → 6 signals.
- Therefore the answer is (D).

FINAL: (D) 6

SHORTCUT / EXAM TRICK

Count unique carbons using symmetry; para-disubstituted benzene gives 4 aromatic signals.

COMMON MISTAKE

Expecting ^{13}C–^{13}C coupling (too rare); integrating ^{13}C peaks (NOE and relaxation distort).

EXAM TIP

Quaternary carbons are weak and vanish in DEPT.

MEMORY TRICK

'DEPT-135: up-down-up, quaternary gone'.

Why the Other Options Are Wrong

Correct answer: D

A **3**

Why (D) is the key — CH_3–CH(OH)–CH_2–CH(CH_3)$_2$: C1, C2, C3, C4 are distinct, and the two C5 methyls are diastereotopic (stereocentre at C2) → 6 signals.

B **4**

Ruled out: Expecting ^{13}C–^{13}C coupling (too rare); integrating ^{13}C peaks (NOE and relaxation distort).

C **5**

Ruled out: Quaternary carbons are weak and vanish in DEPT.

NMR 13C

TOPIC SUMMARY

^{13}C NMR (1.1 % abundance, proton-decoupled singlets): δ ranges alkyl 0–50, O–C 50–90, alkene/aromatic 100–150, C=O 160–220; DEPT-135 (CH/CH_3 up, CH_2 down, C silent), DEPT-90 (CH only); symmetry reduces signal count; off-resonance multiplicity.

IMPORTANT FORMULA SHEET

- δ: C=O ketone ~205–220, aldehyde ~200, acid/ester ~165–185, aromatic 110–160, alkyne 65–90, CH_3 ~10–30
- DEPT-135: CH, CH_3 positive; CH_2 negative; quaternary absent

FREQUENTLY ASKED CONCEPTS

- Number of ^{13}C signals for symmetric molecules
- DEPT interpretation
- Distinguish ketone from ester carbonyl
- Why ^{13}C spectra are not integrated routinely

COMMON MISTAKES & QUICK NOTES

Watch out:
Expecting ^{13}C–^{13}C coupling (too rare); integrating ^{13}C peaks (NOE and relaxation distort).
Quaternary carbons are weak and vanish in DEPT.

MOST-REPEATED PYQs & EXPECTED IN EXAM

PYQs in this topic: Q20 Q21 Q22 Q23

Expect 1 question(s) next session on NMR 13C.

TOPIC 5

Organic Spectroscopy – General

18 questions · Easy 2 | Medium 15 | Hard 1 · PYQ frequency: High

Q24

An organic compound (MF = $C_8H_{10}O$) exhibited the following ^1H NMR spectral data: δ 2.5 (3H, s), 3.8 (3H, s), 6.8 (2H, d, J = 8 Hz), 7.2 (2H, d, J = 8 Hz) ppm. The compound among the choices, is

A. 4-ethylphenol

B. 2-ethylphenol

C. 4-methylanisole

D. 4-methylbenzyl alcohol

QUESTION INSIGHTS

ESTIMATED TIME
2–3 min

DIFFICULTY
Medium

CONCEPT TESTED
Organic Spectroscopy – General

PYQ FREQUENCY
High · 5 papers

REVISION PRIORITY
★★★★☆

EXPECTED LEVEL
Part B / Part C

MEMORY HOOK
'DBE, IR, NMR, MS — in that order'.

Correct Answer C 4-methylanisole

CONCEPT

UV–Vis (Woodward–Fieser, conjugation), IR (functional groups: C=O 1650–1800, O–H 3200–3600, C≡N 2250), ^{1}H NMR (δ, integration, multiplicity n+1, J), ^{13}C NMR (DEPT), mass spectrometry (M^{+}, M+2 for Cl/Br, McLafferty, α-cleavage, nitrogen rule), degree of unsaturation.

↓

LOGIC / WORKING

- δ 2.3–2.5 (3H, s) = Ar–CH_3; 3.8 (3H, s) = OCH_3; two doublets (2H each, J = 8 Hz) = para-disubstituted benzene (AA′BB′). No CH_2 quartet (rules out ethyl) and no OH → 4-methylanisole.
- Therefore the answer is (C).

FINAL: (C) 4-methylanisole

SHORTCUT / EXAM TRICK

Compute DBE first, then use IR for functional groups, NMR for connectivity.

COMMON MISTAKE

Ignoring exchangeable protons (OH, NH show no coupling and vanish with D_2O).

EXAM TIP

Conjugation lowers ν(C=O) by ~30 cm^{-1} and raises λ_max.

MEMORY TRICK

'DBE, IR, NMR, MS — in that order'.

Why the Other Options Are Wrong

Correct answer: C

A **4-ethylphenol**

Why (C) is the key — δ 2.3–2.5 (3H, s) = Ar–CH_3; 3.8 (3H, s) = OCH_3; two doublets (2H each, J = 8 Hz) = para-disubstituted benzene (AA′BB′). No CH_2 quartet (rules out ethyl) and no OH → 4-methylanisole.

B **2-ethylphenol**

Ruled out: Ignoring exchangeable protons (OH, NH show no coupling and vanish with D_2O).

D **4-methylbenzyl alcohol**

Ruled out: Conjugation lowers ν(C=O) by ~30 cm^{-1} and raises λ_max.

Q25

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

A. Three

B. One

C. Two

D. Six

QUESTION INSIGHTS

ESTIMATED TIME
2–3 min

DIFFICULTY
Medium

CONCEPT TESTED
Organic Spectroscopy – General

PYQ FREQUENCY
High · 5 papers

REVISION PRIORITY
★★★★☆

EXPECTED LEVEL
Part B / Part C

MEMORY HOOK
'DBE, IR, NMR, MS — in that order'.

Correct Answer C Two

CONCEPT

UV–Vis (Woodward–Fieser, conjugation), IR (functional groups: C=O 1650–1800, O–H 3200–3600, C≡N 2250), ^{1}H NMR (δ, integration, multiplicity n+1, J), ^{13}C NMR (DEPT), mass spectrometry (M^{+}, M+2 for Cl/Br, McLafferty, α-cleavage, nitrogen rule), degree of unsaturation.

↓

LOGIC / WORKING

- I = 0 for M thus metal does not couple with phosphorous during NMR spectra. Since there are 2 types of P atoms present in the complex, 2 peaks are seen in 31P NMR spectrum. Explanation as extracted from the printed page; notation may be imperfect.
- Therefore the answer is (C).

FINAL: (C) Two

SHORTCUT / EXAM TRICK

Compute DBE first, then use IR for functional groups, NMR for connectivity.

COMMON MISTAKE

Ignoring exchangeable protons (OH, NH show no coupling and vanish with D_2O).

EXAM TIP

Conjugation lowers ν(C=O) by ~30 cm^{-1} and raises λ_max.

MEMORY TRICK

'DBE, IR, NMR, MS — in that order'.

Why the Other Options Are Wrong

Correct answer: C

A **Three**

Why (C) is the key — I = 0 for M thus metal does not couple with phosphorous during NMR spectra. Since there are 2 types of P atoms present in the complex, 2 peaks are seen in 31P NMR spectrum. Explanation as extracted from the printed page; notation may be imperfect.

B **One**

Ruled out: Ignoring exchangeable protons (OH, NH show no coupling and vanish with D_2O).

D **Six**

Ruled out: Conjugation lowers ν(C=O) by ~30 cm^{-1} and raises λ_max.

Q26

The absorption at λ_max=279 nm (varepsilon=15) in the UV spectrum of acetone is due to

A. π → π^* transition

B. n → π^* transition

C. σ → σ^* transition

D. π → σ^* transition

QUESTION INSIGHTS

ESTIMATED TIME
1–1.5 min

DIFFICULTY
Easy

CONCEPT TESTED
Organic Spectroscopy – General

PYQ FREQUENCY
High · 5 papers

REVISION PRIORITY
★★★☆☆

EXPECTED LEVEL
Part B

MEMORY HOOK
'DBE, IR, NMR, MS — in that order'.

Correct Answer B n → π^* transition

CONCEPT

UV–Vis (Woodward–Fieser, conjugation), IR (functional groups: C=O 1650–1800, O–H 3200–3600, C≡N 2250), ^{1}H NMR (δ, integration, multiplicity n+1, J), ^{13}C NMR (DEPT), mass spectrometry (M^{+}, M+2 for Cl/Br, McLafferty, α-cleavage, nitrogen rule), degree of unsaturation.

↓

LOGIC / WORKING

- A weak band (ε ≈ 15) at ~280 nm for a carbonyl is the symmetry-forbidden n → π* transition; π → π* of acetone is at ~190 nm with ε ~ 10^{3}.
- Therefore the answer is (B).

FINAL: (B) n → π^* transition

SHORTCUT / EXAM TRICK

Compute DBE first, then use IR for functional groups, NMR for connectivity.

COMMON MISTAKE

Ignoring exchangeable protons (OH, NH show no coupling and vanish with D_2O).

EXAM TIP

Conjugation lowers ν(C=O) by ~30 cm^{-1} and raises λ_max.

MEMORY TRICK

'DBE, IR, NMR, MS — in that order'.

Why the Other Options Are Wrong

Correct answer: B

A **π → π^* transition**

Why (B) is the key — A weak band (ε ≈ 15) at ~280 nm for a carbonyl is the symmetry-forbidden n → π* transition; π → π* of acetone is at ~190 nm with ε ~ 10^3.

C **σ → σ^* transition**

Ruled out: Ignoring exchangeable protons (OH, NH show no coupling and vanish with D_2O).

D **π → σ^* transition**

Ruled out: Conjugation lowers ν(C=O) by ~30 cm^{-1} and raises λ_max.

Q27

Using a double beam UV-visible spectrophotometer, Beer's law fails for $K_2Cr_2O_7$ solution when

A. Intensity of light source is changed

B. Detector is not a photomultiplier tube

C. Cuvette of 2cm size is used

D. pH is not kept same in all measurements

QUESTION INSIGHTS

ESTIMATED TIME
2–3 min

DIFFICULTY
Medium

CONCEPT TESTED
Organic Spectroscopy – General

PYQ FREQUENCY
High · 5 papers

REVISION PRIORITY
★★★★☆

EXPECTED LEVEL
Part B / Part C

MEMORY HOOK
'DBE, IR, NMR, MS — in that order'.

Correct Answer D pH is not kept same in all measurements

CONCEPT

UV–Vis (Woodward–Fieser, conjugation), IR (functional groups: C=O 1650–1800, O–H 3200–3600, C≡N 2250), ^{1}H NMR (δ, integration, multiplicity n+1, J), ^{13}C NMR (DEPT), mass spectrometry (M^{+}, M+2 for Cl/Br, McLafferty, α-cleavage, nitrogen rule), degree of unsaturation.

↓

LOGIC / WORKING

- $Cr_2O_7^{2-} \rightleftharpoons 2CrO_4^{2-}$ depends on pH; the two species absorb differently, so unless pH is fixed the absorbing species changes with concentration — a chemical deviation from Beer's law.
- Therefore the answer is (D).

FINAL: (D) pH is not kept same in all measurements

SHORTCUT / EXAM TRICK

Compute DBE first, then use IR for functional groups, NMR for connectivity.

COMMON MISTAKE

Ignoring exchangeable protons (OH, NH show no coupling and vanish with D_2O).

EXAM TIP

Conjugation lowers ν(C=O) by ~30 cm^{-1} and raises λ_max.

MEMORY TRICK

'DBE, IR, NMR, MS — in that order'.

Why the Other Options Are Wrong

Correct answer: D

A **Intensity of light source is changed**

Why (D) is the key — $Cr_2O_7^{2-} \rightleftharpoons 2CrO_4^{2-}$ depends on pH; the two species absorb differently, so unless pH is fixed the absorbing species changes with concentration — a chemical deviation from Beer's law.

B **Detector is not a photomultiplier tube**

Ruled out: Ignoring exchangeable protons (OH, NH show no coupling and vanish with D_2O).

C **Cuvette of 2cm size is used**

Ruled out: Conjugation lowers ν(C=O) by ~30 cm^{-1} and raises λ_max.

Q28

^{1}H NMR spectrum of [18]- annulene shows

A. Only one peak at δ 7.2 (18 H)

B. Only one peak at δ 5.0 (18 H)

C. Two peaks at δ 9.0 (12 H) and δ -3.0 (6 H)

D. Two peaks at δ 9.0 (6 H) and δ -3.0 (12 H)

QUESTION INSIGHTS

ESTIMATED TIME
1–1.5 min

DIFFICULTY
Easy

CONCEPT TESTED
Organic Spectroscopy – General

PYQ FREQUENCY
High · 5 papers

REVISION PRIORITY
★★★☆☆

EXPECTED LEVEL
Part B

MEMORY HOOK
'DBE, IR, NMR, MS — in that order'.

Correct Answer C Two peaks at δ 9.0 (12 H) and δ -3.0 (6 H)

CONCEPT

UV–Vis (Woodward–Fieser, conjugation), IR (functional groups: C=O 1650–1800, O–H 3200–3600, C≡N 2250), ^{1}H NMR (δ, integration, multiplicity n+1, J), ^{13}C NMR (DEPT), mass spectrometry (M^{+}, M+2 for Cl/Br, McLafferty, α-cleavage, nitrogen rule), degree of unsaturation.

↓

LOGIC / WORKING

- [18]Annulene is aromatic (4n+2): the ring current deshields the 12 outer protons (δ ≈ 9.0) and strongly shields the 6 inner protons (δ ≈ −3.0).
- Therefore the answer is (C).

FINAL: (C) Two peaks at δ 9.0 (12 H) and δ -3.0 (6 H)

SHORTCUT / EXAM TRICK

Compute DBE first, then use IR for functional groups, NMR for connectivity.

COMMON MISTAKE

Ignoring exchangeable protons (OH, NH show no coupling and vanish with D_2O).

EXAM TIP

Conjugation lowers ν(C=O) by ~30 cm^{-1} and raises λ_max.

MEMORY TRICK

'DBE, IR, NMR, MS — in that order'.

Why the Other Options Are Wrong

Correct answer: C

A **Only one peak at δ 7.2 (18 H)**

Why (C) is the key — [18]Annulene is aromatic (4n+2): the ring current deshields the 12 outer protons (δ ≈ 9.0) and strongly shields the 6 inner protons (δ ≈ −3.0).

B **Only one peak at δ 5.0 (18 H)**

Ruled out: Ignoring exchangeable protons (OH, NH show no coupling and vanish with D_2O).

D **Two peaks at δ 9.0 (6 H) and δ -3.0 (12 H)**

Ruled out: Conjugation lowers ν(C=O) by ~30 cm^{-1} and raises λ_max.

Q29 **The number of signals that appear in the broad-band decoupled ^{13}C NMR spectrum of ortho-, meta-and para-dichlorobenzenes, respectively, are (c) 4, 4 and 2 (d) 3, 4 and 4**
(Numerical answer type — write the value.)

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

QUESTION INSIGHTS

ESTIMATED TIME
2–3 min

DIFFICULTY
Medium

CONCEPT TESTED
Organic Spectroscopy – General

PYQ FREQUENCY
High · 5 papers

REVISION PRIORITY
★★★★☆

EXPECTED LEVEL
Part B / Part C

MEMORY HOOK
'DBE, IR, NMR, MS — in that order'.

Q30

In the proton decoupled ^{13}C NMR spectrum of 7-norbornanone, the number of signals obtained is

A. 7

B. 3

C. 4

D. 5

QUESTION INSIGHTS

ESTIMATED TIME
2–3 min

DIFFICULTY
Medium

CONCEPT TESTED
Organic Spectroscopy – General

PYQ FREQUENCY
High · 5 papers

REVISION PRIORITY
★★★★☆

EXPECTED LEVEL
Part B / Part C

MEMORY HOOK
'DBE, IR, NMR, MS — in that order'.

Correct Answer B 3

CONCEPT

UV–Vis (Woodward–Fieser, conjugation), IR (functional groups: C=O 1650–1800, O–H 3200–3600, C≡N 2250), ^{1}H NMR (δ, integration, multiplicity n+1, J), ^{13}C NMR (DEPT), mass spectrometry (M^{+}, M+2 for Cl/Br, McLafferty, α-cleavage, nitrogen rule), degree of unsaturation.

↓

LOGIC / WORKING

- 7-Norbornanone (C_{2v}): C7 (C=O), C1 ≡ C4 (bridgeheads), C2 ≡ C3 ≡ C5 ≡ C6 → 3 signals.
- Therefore the answer is (B).

FINAL: (B) 3

SHORTCUT / EXAM TRICK

Compute DBE first, then use IR for functional groups, NMR for connectivity.

COMMON MISTAKE

Ignoring exchangeable protons (OH, NH show no coupling and vanish with D_2O).

EXAM TIP

Conjugation lowers ν(C=O) by ~30 cm^{-1} and raises λ_max.

MEMORY TRICK

'DBE, IR, NMR, MS — in that order'.

Why the Other Options Are Wrong

Correct answer: B

A

7

Why (B) is the key — 7-Norbornanone (C_{2v}): C7 (C=O), C1 ≡ C4 (bridgeheads), C2 ≡ C3 ≡ C5 ≡ C6 → 3 signals.

C

4

Ruled out: Ignoring exchangeable protons (OH, NH show no coupling and vanish with D_2O).

D

5

Ruled out: Conjugation lowers ν(C=O) by ~30 cm^{-1} and raises λ_max.

Q31

The ratio of relative intensities of the two molecular ion peaks of methyl bromide (CH_3Br) in the mass spectrum is:

A. $M^+ : (M+2)^+ = 1:3$

B. $M^+ : (M+2)^+ = 3:1$

C. $M^+ : (M+2)^+ = 1:1$

D. $M^+ : (M+2)^+ = 1:2$

QUESTION INSIGHTS

ESTIMATED TIME
2–3 min

DIFFICULTY
Medium

CONCEPT TESTED
Organic Spectroscopy – General

PYQ FREQUENCY
High · 5 papers

REVISION PRIORITY
★★★★☆

EXPECTED LEVEL
Part B / Part C

MEMORY HOOK
'DBE, IR, NMR, MS — in that order'.

Correct Answer C $M^+ : (M+2)^+ = 1:1$

CONCEPT

UV–Vis (Woodward–Fieser, conjugation), IR (functional groups: C=O 1650–1800, O–H 3200–3600, C≡N 2250), ^{1}H NMR (δ, integration, multiplicity n+1, J), ^{13}C NMR (DEPT), mass spectrometry (M^+, M+2 for Cl/Br, McLafferty, α-cleavage, nitrogen rule), degree of unsaturation.

↓

LOGIC / WORKING

- ^{79}Br : ^{81}Br ≈ 1 : 1, so M^+ (94) and $(M+2)^+$ (96) appear with equal intensity.
- Therefore the answer is (C).

FINAL: (C) $M^+ : (M+2)^+ = 1:1$

SHORTCUT / EXAM TRICK

Compute DBE first, then use IR for functional groups, NMR for connectivity.

COMMON MISTAKE

Ignoring exchangeable protons (OH, NH show no coupling and vanish with D_2O).

EXAM TIP

Conjugation lowers ν(C=O) by ~30 cm^{-1} and raises λ_max.

MEMORY TRICK

'DBE, IR, NMR, MS — in that order'.

Why the Other Options Are Wrong

Correct answer: C

A

$M^+ : (M+2)^+ = 1:3$

Why (C) is the key — $^{79}Br : ^{81}Br \approx 1 : 1$, so M^+ (94) and $(M+2)^+$ (96) appear with equal intensity.

B

$M^+ : (M+2)^+ = 3:1$

Ruled out: Ignoring exchangeable protons (OH, NH show no coupling and vanish with D_2O).

D

$M^+ : (M+2)^+ = 1:2$

Ruled out: Conjugation lowers ν(C=O) by ~30 cm^{-1} and raises λ_max.

Q32 The number of signals that appear in the proton decoupled ^{13}C NMR spectrum of benzonitrile (C_7H_5N) is
(Numerical answer type — write the value.)

ANSWER: 5

QUESTION INSIGHTS

ESTIMATED TIME
2–3 min

DIFFICULTY
Medium

CONCEPT TESTED
Organic Spectroscopy – General

PYQ FREQUENCY
High · 5 papers

REVISION PRIORITY
★★★★☆

EXPECTED LEVEL
Part B / Part C

MEMORY HOOK
Benzonitrile (C_{2v}): C-ipso, C-ortho (2), C-meta (2), C-para and C≡N → 5 signals.

Q33

Among the compound given in the option (a) to (d), the one that exhibits a sharp band at around 3300 cm^{-1} in the IR spectrum is:

(A) 1,2–butadiene

(B) 1,3–butadiene

(C) 1–butyne

(D) 2–butyne

QUESTION INSIGHTS

ESTIMATED TIME
2–3 min

DIFFICULTY
Medium

CONCEPT TESTED
Organic Spectroscopy – General

PYQ FREQUENCY
High · 5 papers

REVISION PRIORITY
★★★★☆

EXPECTED LEVEL
Part B / Part C

MEMORY HOOK
'DBE, IR, NMR, MS — in that order'.

Correct Answer C 1–butyne

CONCEPT

UV–Vis (Woodward–Fieser, conjugation), IR (functional groups: C=O 1650–1800, O–H 3200–3600, C≡N 2250), ^{1}H NMR (δ, integration, multiplicity n+1, J), ^{13}C NMR (DEPT), mass spectrometry (M^{+}, M+2 for Cl/Br, McLafferty, α-cleavage, nitrogen rule), degree of unsaturation.

↓

LOGIC / WORKING

- A sharp, medium band near 3300 cm^{-1} is the ≡C–H stretch of a terminal alkyne (1-butyne; also C≡C at ~2120). 2-Butyne has no ≡C–H; dienes show =C–H above 3000 but weaker, and no 3300 band.
- Therefore the answer is (C).

FINAL: (C) 1–butyne

SHORTCUT / EXAM TRICK

Compute DBE first, then use IR for functional groups, NMR for connectivity.

COMMON MISTAKE

Ignoring exchangeable protons (OH, NH show no coupling and vanish with D_2O).

EXAM TIP

Conjugation lowers ν(C=O) by ~30 cm^{-1} and raises λ_max.

MEMORY TRICK

'DBE, IR, NMR, MS — in that order'.

Why the Other Options Are Wrong

Correct answer: C

A **1,2–butadiene**

Why (C) is the key — A sharp, medium band near 3300 cm^{-1} is the ≡C–H stretch of a terminal alkyne (1-butyne; also C≡C at ~2120). 2-Butyne has no ≡C–H; dienes show =C–H above 3000 but weaker, and no 3300 band.

B **1,3–butadiene**

Ruled out: Ignoring exchangeable protons (OH, NH show no coupling and vanish with D_2O).

D **2–butyne**

Ruled out: Conjugation lowers ν(C=O) by ~30 cm^{-1} and raises λ_max.

Q34

The product of the following reaction gave 6 line ^{13}C NMR spectrum with peaks at δ 175,52,50,46,37,33 ppm. The structure of the product is (a) (b) (c) (d)

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

QUESTION INSIGHTS

ESTIMATED TIME
2–3 min

DIFFICULTY
Medium

CONCEPT TESTED
Organic Spectroscopy – General

PYQ FREQUENCY
High · 5 papers

REVISION PRIORITY
★★★★☆

EXPECTED LEVEL
Part B / Part C

MEMORY HOOK
'DBE, IR, NMR, MS — in that order'.

Q35 **Given the fact that 1, 3-butadiene has a UV absorption of 217nm, the absorption wavelength (in nm) for the conjugated system shown below is ___ (Use these absorption value for auxochromic groups: alkyl: +5; exo-cyclic double bond: +5; every additional conjugated C=C:+30)**
(Numerical answer type — write the value.)

ANSWER: Structure is not reproduced in the question bank — apply Woodward–Fieser

QUESTION INSIGHTS

ESTIMATED TIME
2–3 min

DIFFICULTY
Medium

CONCEPT TESTED
Organic Spectroscopy – General

PYQ FREQUENCY
High · 5 papers

REVISION PRIORITY
★★★★☆

EXPECTED LEVEL
Part B / Part C

MEMORY HOOK
Base value for the diene 217 nm; add +5 per alkyl substituent on the chromophore, +5 per exocyclic C=C, +30 per additional conjugated C=C (+36 for homoannular). λ_max = 217 + Σ increments.

Q36 The m/z value of the detectable fragment formed by McLafferty like rearrangement of the following compound in mass spectrometer is ____
(Numerical answer type — write the value.)

ANSWER: Structure is not reproduced in the question bank — m/z of the enol ion

QUESTION INSIGHTS

ESTIMATED TIME
3–5 min

DIFFICULTY
Hard

CONCEPT TESTED
Organic Spectroscopy – General

PYQ FREQUENCY
High · 5 papers

REVISION PRIORITY
★★★★★

EXPECTED LEVEL
Part C (high merit)

MEMORY HOOK
McLafferty: a γ-H transfers to the carbonyl O through a six-membered TS and the Cβ–Cγ bond cleaves; the detected (charged) fragment is the enol radical-cation, m/z = M − (mass of the expelled alkene).

Q37 The total number of lines expected (due to spin-spin coupling of proton with fluorine and deuterium nuclei) in the ^{1}H NMR spectrum of the following compound is ____ .
(Numerical answer type — write the value.)

ANSWER: Structure is not reproduced in the question bank — use (2nI+1) products

QUESTION INSIGHTS

ESTIMATED TIME
2–3 min

DIFFICULTY
Medium

CONCEPT TESTED
Organic Spectroscopy – General

PYQ FREQUENCY
High · 5 papers

REVISION PRIORITY
★★★★☆

EXPECTED LEVEL
Part B / Part C

MEMORY HOOK
Multiplicity = $\Pi(2nI_i + 1)$: each ^{19}F ($I = ½$) doubles the lines, each ^{2}H ($I = 1$) triples them; e.g. one F and two D → 2 × 5 = 10 lines.

Q38

The ^{13}C NMR spectrum of acetone – d_6 has a signal at 30 ppm as a septet in the intensity ratio

A. 1 : 6 : 15 : 20 : 15 : 6 : 1

B. 1 : 3 : 6 : 7 : 6 : 3 : 1

C. 1 : 2 : 3 : 5 : 3 : 2 : 1

D. 1 : 3 : 7 : 10 : 7 : 3 : 1

QUESTION INSIGHTS

ESTIMATED TIME
2–3 min

DIFFICULTY
Medium

CONCEPT TESTED
Organic Spectroscopy – General

PYQ FREQUENCY
High · 5 papers

REVISION PRIORITY
★★★★☆

EXPECTED LEVEL
Part B / Part C

MEMORY HOOK
'DBE, IR, NMR, MS — in that order'.

Correct Answer B 1 : 3 : 6 : 7 : 6 : 3 : 1

CONCEPT

UV–Vis (Woodward–Fieser, conjugation), IR (functional groups: C=O 1650–1800, O–H 3200–3600, C≡N 2250), ^{1}H NMR (δ, integration, multiplicity n+1, J), ^{13}C NMR (DEPT), mass spectrometry (M^{+}, M+2 for Cl/Br, McLafferty, α-cleavage, nitrogen rule), degree of unsaturation.

↓

LOGIC / WORKING

- Each CD_3 carbon is coupled to three equivalent D (I = 1): 2nI + 1 = 7 lines, intensities 1:3:6:7:6:3:1.
- Therefore the answer is (B).

FINAL: (B) 1 : 3 : 6 : 7 : 6 : 3 : 1

SHORTCUT / EXAM TRICK

Compute DBE first, then use IR for functional groups, NMR for connectivity.

COMMON MISTAKE

Ignoring exchangeable protons (OH, NH show no coupling and vanish with D_2O).

EXAM TIP

Conjugation lowers ν(C=O) by ~30 cm^{-1} and raises λ_max.

MEMORY TRICK

'DBE, IR, NMR, MS — in that order'.

Why the Other Options Are Wrong

Correct answer: B

A **1 : 6 : 15 : 20 : 15 : 6 : 1**

Why (B) is the key — Each CD_3 carbon is coupled to three equivalent D (I = 1): 2nI + 1 = 7 lines, intensities 1:3:6:7:6:3:1.

C **1 : 2 : 3 : 5 : 3 : 2 : 1**

Ruled out: Ignoring exchangeable protons (OH, NH show no coupling and vanish with D_2O).

D **1 : 3 : 7 : 10 : 7 : 3 : 1**

Ruled out: Conjugation lowers ν(C=O) by ~30 cm^{-1} and raises λ_max.

Q39

the elimination product of the following reaction is

A I_2

B CH_3I

C CH_3COI

D I_3^-

QUESTION INSIGHTS

ESTIMATED TIME
2–3 min

DIFFICULTY
Medium

CONCEPT TESTED
Organic Spectroscopy – General

PYQ FREQUENCY
High · 5 papers

REVISION PRIORITY
★★★★☆

EXPECTED LEVEL
Part B / Part C

MEMORY HOOK
'DBE, IR, NMR, MS — in that order'.

Correct Answer C CH_3COI

CONCEPT

UV–Vis (Woodward–Fieser, conjugation), IR (functional groups: C=O 1650–1800, O–H 3200–3600, C≡N 2250), ^1H NMR (δ, integration, multiplicity n+1, J), ^{13}C NMR (DEPT), mass spectrometry (M^+, M+2 for Cl/Br, McLafferty, α-cleavage, nitrogen rule), degree of unsaturation.

↓

LOGIC / WORKING

- In the Monsanto cycle the methyl migrates onto CO (acetyl–Rh(III)); under CO the acetyl and iodide reductively eliminate as acetyl iodide, CH_3COI (c), which is hydrolysed to acetic acid.
- Therefore the answer is (C).

FINAL: (C) CH_3COI

SHORTCUT / EXAM TRICK

Compute DBE first, then use IR for functional groups, NMR for connectivity.

COMMON MISTAKE

Ignoring exchangeable protons (OH, NH show no coupling and vanish with D_2O).

EXAM TIP

Conjugation lowers ν(C=O) by ~30 cm^{-1} and raises λ_max.

MEMORY TRICK

'DBE, IR, NMR, MS — in that order'.

Why the Other Options Are Wrong

Correct answer: C

A I_2

Why (C) is the key — In the Monsanto cycle the methyl migrates onto CO (acetyl–Rh(III)); under CO the acetyl and iodide reductively eliminate as acetyl iodide, CH_3COI (c), which is hydrolysed to acetic acid.

B CH_3I

Ruled out: Ignoring exchangeable protons (OH, NH show no coupling and vanish with D_2O).

D I_3^-

Ruled out: Conjugation lowers ν(C=O) by ~30 cm^{-1} and raises λ_max.

Q40

Major product formed in the following reaction sequence is: (a) (b) (c) (d)

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

QUESTION INSIGHTS

ESTIMATED TIME
2–3 min

DIFFICULTY
Medium

CONCEPT TESTED
Organic Spectroscopy – General

PYQ FREQUENCY
High · 5 papers

REVISION PRIORITY
★★★★☆

EXPECTED LEVEL
Part B / Part C

MEMORY HOOK
'DBE, IR, NMR, MS — in that order'.

Q41 Consider two rectangular sheets, Sheet M and Sheet N of dimensions 6 cm × 4 cm each. Folding operation 1: The sheet is folded into half by joining the short edges of the current shape. Folding operation 2: The sheet is folded into half by joining the long edge of the current shape. Folding operation 1 is carried out on sheet M three times. Folding operation 2 is carried out on sheet N three times. The ratio of perimeters of the final folded shape of sheet N to the final folded shape of sheet M is ___ .

A. 3 : 2

B. 5 : 13

C. 7: 5

D. 13: 7

QUESTION INSIGHTS

ESTIMATED TIME
2–3 min

DIFFICULTY
Medium

CONCEPT TESTED
Organic Spectroscopy – General

PYQ FREQUENCY
High · 5 papers

REVISION PRIORITY
★★★★☆

EXPECTED LEVEL
Part B / Part C

MEMORY HOOK
'DBE, IR, NMR, MS — in that order'.

Correct Answer D 13: 7

CONCEPT

UV–Vis (Woodward–Fieser, conjugation), IR (functional groups: C=O 1650–1800, O–H 3200–3600, C≡N 2250), ^{1}H NMR (δ, integration, multiplicity n+1, J), ^{13}C NMR (DEPT), mass spectrometry (M^{+}, M+2 for Cl/Br, McLafferty, α-cleavage, nitrogen rule), degree of unsaturation.

↓

LOGIC / WORKING

- Sheet M (joining short edges halves the long side each time): 6×4 → 3×4 → 3×2 → 1.5×2, perimeter 7. Sheet N (joining long edges halves the short side): 6×4 → 6×2 → 6×1 → 6×0.5, perimeter 13. N : M = 13 : 7.
- Therefore the answer is (D).

FINAL: (D) 13: 7

SHORTCUT / EXAM TRICK

Compute DBE first, then use IR for functional groups, NMR for connectivity.

COMMON MISTAKE

Ignoring exchangeable protons (OH, NH show no coupling and vanish with D_2O).

EXAM TIP

Conjugation lowers ν(C=O) by ~30 cm^{-1} and raises λ_max.

MEMORY TRICK

'DBE, IR, NMR, MS — in that order'.

Why the Other Options Are Wrong

Correct answer: D

A **3 : 2**

Why (D) is the key — Sheet M (joining short edges halves the long side each time): 6×4 → 3×4 → 3×2 → 1.5×2, perimeter 7. Sheet N (joining long edges halves the short side): 6×4 → 6×2 → 6×1 → 6×0.5, perimeter 13. N : M = 13 : 7.

B **5 : 13**

Ruled out: Ignoring exchangeable protons (OH, NH show no coupling and vanish with D_2O).

C **7: 5**

Ruled out: Conjugation lowers ν(C=O) by ~30 cm^{-1} and raises λ_max.

TOPIC REVISION

Organic Spectroscopy – General

18 PYQs · Last-minute revision

TOPIC SUMMARY

UV–Vis (Woodward–Fieser, conjugation), IR (functional groups: C=O 1650–1800, O–H 3200–3600, C≡N 2250), ^{1}H NMR (δ, integration, multiplicity n+1, J), ^{13}C NMR (DEPT), mass spectrometry (M^{+}, M+2 for Cl/Br, McLafferty, α-cleavage, nitrogen rule), degree of unsaturation.

IMPORTANT FORMULA SHEET

- DBE = (2C + 2 + N − H − X)/2
- Woodward: base 217 (diene) + 5/alkyl + 30/exocyclic… ; enone base 215
- ν(C=O): acid chloride 1800 > ester 1735 > aldehyde 1725 > ketone 1715 > amide 1650
- Nitrogen rule: odd M^{+} → odd N count

FREQUENTLY ASKED CONCEPTS

- Assign structure from combined data
- Count NMR signals/equivalence
- M, M+2 ratios (Cl 3:1, Br 1:1)
- Ring-strain effect on ν(C=O) (cyclobutanone 1780)

COMMON MISTAKES & QUICK NOTES

Watch out:
Ignoring exchangeable protons (OH, NH show no coupling and vanish with D_2O).
Conjugation lowers ν(C=O) by ~30 cm^{-1} and raises λ_max.

MOST-REPEATED PYQs & EXPECTED IN EXAM

PYQs in this topic: Q24 Q25 Q26 Q27 Q28 Q29 Q30 Q31 Q32 Q33 Q34 Q35 Q36 Q37 …

Expect 4 question(s) next session on Organic Spectroscopy – General.

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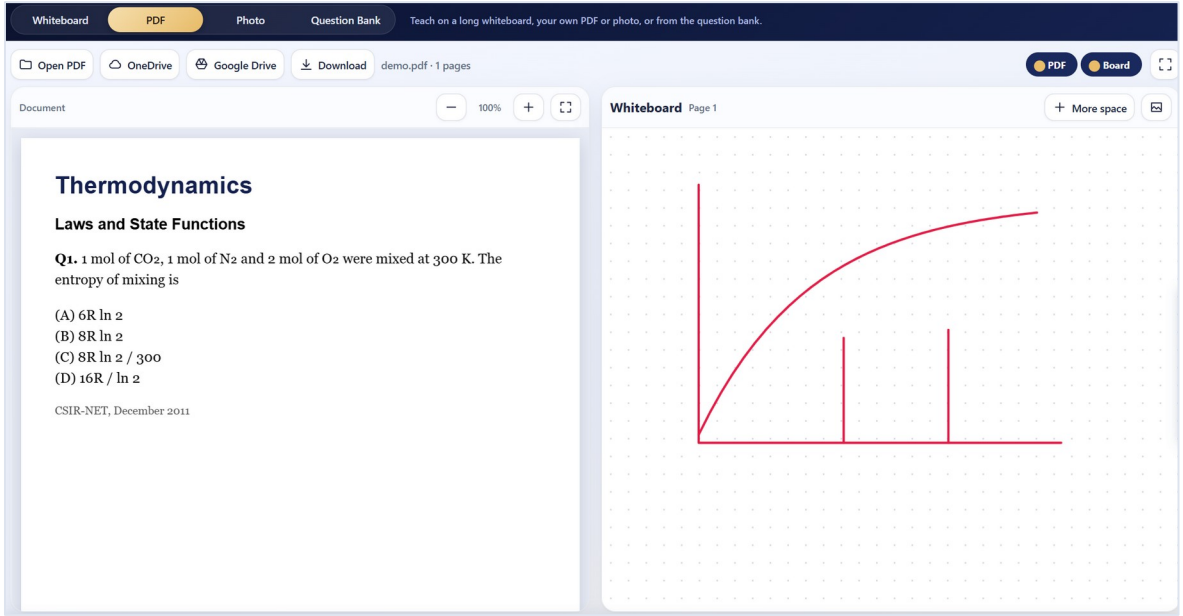
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