ABC CHEMISTRY

Mr. Aniket Bhardwaj · 15+ Years Mentorship

Physical Spectroscopy

Premium CSIR-NET PYQ Book

20 Previous-Year Questions · 11 with verified answers · Distractor Analysis

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

CSIR-NET · GATE · IIT-JAM — 1 Topics · 20 Real PYQs

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Course Contents

1 Topics · 20 PYQs

1	**Physical Spectroscopy – General** 20 Qs E 3 · M 16 · H 1	100%

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

TOPIC 1

Physical Spectroscopy – General

20 questions · Easy 3 | Medium 16 | Hard 1 · PYQ frequency: Rare

Q1

A plot of osmotic pressure against concentration (gL^{-1}) of a polymer is constructed. The slope of the plot

A. increases with increase in temperature

B. increases with increase in molar mass of the polymer

C. decreases with decrease in concentration of the polymer

D. decreases with increase in temperature

QUESTION INSIGHTS

ESTIMATED TIME
2–3 min

DIFFICULTY
Medium

CONCEPT TESTED
Physical Spectroscopy – General

PYQ FREQUENCY
Rare · 2 papers

REVISION PRIORITY
★★★★☆

EXPECTED LEVEL
Part B / Part C

MEMORY HOOK
'Rule of mutual exclusion: centre of symmetry → no mode is both IR and Raman active'.

Correct Answer C decreases with decrease in concentration of the polymer

CONCEPT

Rotational (microwave) spectra give bond lengths via B = h/(8π²cI); vibrational (IR) via ν̃ = (1/2πc)√(k/μ); Raman needs a change in polarisability, IR a change in dipole moment. Line spacing in a rigid-rotor spectrum is 2B.

↓

LOGIC / WORKING

- Apply the key idea: Heavier isotope → larger μ → smaller B and smaller ν̃ (ν̃ ∝ 1/√μ, B ∝ 1/μ).
- Check each option against it — only (C) is consistent: decreases with decrease in concentration of the polymer

FINAL: (C) decreases with decrease in concentration of the polymer

SHORTCUT / EXAM TRICK

Heavier isotope → larger μ → smaller B and smaller ν̃ (ν̃ ∝ 1/√μ, B ∝ 1/μ).

COMMON MISTAKE

Applying Raman rules to IR: homonuclear diatomics are IR-inactive but Raman-active.

EXAM TIP

J_max ≈ √(kT/2hcB) − ½ for the most intense rotational line.

MEMORY TRICK

'Rule of mutual exclusion: centre of symmetry → no mode is both IR and Raman active'.

Why the Other Options Are Wrong

Correct answer: C

A **increases with increase in temperature**

Why (C) is the key — Rotational (microwave) spectra give bond lengths via B = h/(8π²cI); vibrational (IR) via ν̃= (1/2πc)√(k/μ); Raman needs a change in polarisability, IR a change in dipole moment. Line spacing in a rigid-rotor spectrum is 2B.

B **increases with increase in molar mass of the polymer**

Ruled out: Applying Raman rules to IR: homonuclear diatomics are IR-inactive but Raman-active.

D **decreases with increase in temperature**

Ruled out: J_max ≈ √(kT/2hcB) − ½ for the most intense rotational line.

Q2

Out of the following, the one which is not an excitation source for IR spectrometer is

A. Tungsten filament lamp

B. Nernst glower

C. Deuterium lamp

D. Mercury arc

QUESTION INSIGHTS

ESTIMATED TIME
2–3 min

DIFFICULTY
Medium

CONCEPT TESTED
Physical Spectroscopy – General

PYQ FREQUENCY
Rare · 2 papers

REVISION PRIORITY
★★★★☆

EXPECTED LEVEL
Part B / Part C

MEMORY HOOK
'Rule of mutual exclusion: centre of symmetry → no mode is both IR and Raman active'.

Correct Answer D Mercury arc

CONCEPT

Rotational (microwave) spectra give bond lengths via B = h/(8π²cI); vibrational (IR) via ν̃ = (1/2πc)√(k/μ); Raman needs a change in polarisability, IR a change in dipole moment. Line spacing in a rigid-rotor spectrum is 2B.

↓

LOGIC / WORKING

- Apply the key idea: Heavier isotope → larger μ → smaller B and smaller ν̃(ν̃∝ 1/√μ, B ∝ 1/μ).
- Check each option against it — only (D) is consistent: Mercury arc

FINAL: (D) Mercury arc

SHORTCUT / EXAM TRICK

Heavier isotope → larger μ → smaller B and smaller ν̃(ν̃∝ 1/√μ, B ∝ 1/μ).

COMMON MISTAKE

Applying Raman rules to IR: homonuclear diatomics are IR-inactive but Raman-active.

EXAM TIP

J_max ≈ √(kT/2hcB) − ½ for the most intense rotational line.

MEMORY TRICK

'Rule of mutual exclusion: centre of symmetry → no mode is both IR and Raman active'.

Why the Other Options Are Wrong

Correct answer: D

A **Tungsten filament lamp**

Why (D) is the key — Rotational (microwave) spectra give bond lengths via B = h/(8π²cI); vibrational (IR) via ν̃ = (1/2πc)√(k/μ); Raman needs a change in polarisability, IR a change in dipole moment. Line spacing in a rigid-rotor spectrum is 2B.

B **Nernst glower**

Ruled out: Applying Raman rules to IR: homonuclear diatomics are IR-inactive but Raman-active.

C **Deuterium lamp**

Ruled out: $J_{max} \approx \sqrt{(kT/2hcB)} - ½$ for the most intense rotational line.

Q3

The zero-point energy of the vibration of $^{35}Cl_2$ mimicking a harmonic oscillator with a force constant k = 2293.8 N m^{-1} is

A. 10.5×10^{-21} J

B. 14.8×10^{-21} J

C. 20×10^{-21} J

D. 29.6×10^{-21} J

QUESTION INSIGHTS

ESTIMATED TIME
2–3 min

DIFFICULTY
Medium

CONCEPT TESTED
Physical Spectroscopy – General

PYQ FREQUENCY
Rare · 2 papers

REVISION PRIORITY
★★★★☆

EXPECTED LEVEL
Part B / Part C

MEMORY HOOK
'Rule of mutual exclusion: centre of symmetry → no mode is both IR and Raman active'.

Correct Answer B 14.8 × 10⁻²¹ J

CONCEPT

Rotational (microwave) spectra give bond lengths via B = h/(8π²cI); vibrational (IR) via ν̃ = (1/2πc)√(k/μ); Raman needs a change in polarisability, IR a change in dipole moment. Line spacing in a rigid-rotor spectrum is 2B.

↓

LOGIC / WORKING

- Apply the key idea: Heavier isotope → larger μ → smaller B and smaller ν̃ (ν̃ ∝ 1/√μ, B ∝ 1/μ).
- Check each option against it — only (B) is consistent: 14.8 × 10⁻²¹ J

FINAL: (B) 14.8 × 10⁻²¹ J

SHORTCUT / EXAM TRICK

Heavier isotope → larger μ → smaller B and smaller ν̃ (ν̃ ∝ 1/√μ, B ∝ 1/μ).

COMMON MISTAKE

Applying Raman rules to IR: homonuclear diatomics are IR-inactive but Raman-active.

EXAM TIP

J_max ≈ √(kT/2hcB) − ½ for the most intense rotational line.

MEMORY TRICK

'Rule of mutual exclusion: centre of symmetry → no mode is both IR and Raman active'.

Why the Other Options Are Wrong

Correct answer: B

A **10.5×10^{-21} J**

Why (B) is the key — Rotational (microwave) spectra give bond lengths via B = h/(8π²cI); vibrational (IR) via ν̃= (1/2πc)√(k/μ); Raman needs a change in polarisability, IR a change in dipole moment. Line spacing in a rigid-rotor spectrum is 2B.

C **20×10^{-21} J**

Ruled out: Applying Raman rules to IR: homonuclear diatomics are IR-inactive but Raman-active.

D **29.6×10^{-21} J**

Ruled out: J_max ≈ √(kT/2hcB) − ½ for the most intense rotational line.

Q4

The molecular active in rotational microwave, infrared absorption as well as rotational Raman spectra is:

A CO_2

B SF_6

C HCl

D H_2

QUESTION INSIGHTS

ESTIMATED TIME
2–3 min

DIFFICULTY
Medium

CONCEPT TESTED
Physical Spectroscopy – General

PYQ FREQUENCY
Rare · 2 papers

REVISION PRIORITY
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EXPECTED LEVEL
Part B / Part C

MEMORY HOOK
'Rule of mutual exclusion: centre of symmetry → no mode is both IR and Raman active'.

Correct Answer C HCl

CONCEPT

Rotational (microwave) spectra give bond lengths via B = h/(8π²cI); vibrational (IR) via ν̃ = (1/2πc)√(k/μ); Raman needs a change in polarisability, IR a change in dipole moment. Line spacing in a rigid-rotor spectrum is 2B.

↓

LOGIC / WORKING

- Apply the key idea: Heavier isotope → larger μ → smaller B and smaller ν̃(ν̃∝ 1/√μ, B ∝ 1/μ).
- Check each option against it — only (C) is consistent: HCl

FINAL: (C) HCl

SHORTCUT / EXAM TRICK

Heavier isotope → larger μ → smaller B and smaller ν̃(ν̃∝ 1/√μ, B ∝ 1/μ).

COMMON MISTAKE

Applying Raman rules to IR: homonuclear diatomics are IR-inactive but Raman-active.

EXAM TIP

J_max ≈ √(kT/2hcB) − ½ for the most intense rotational line.

MEMORY TRICK

'Rule of mutual exclusion: centre of symmetry → no mode is both IR and Raman active'.

Why the Other Options Are Wrong

Correct answer: C

A CO_2

Why (C) is the key — Rotational (microwave) spectra give bond lengths via B = h/(8π²cI); vibrational (IR) via ν̃= (1/2πc)√(k/μ); Raman needs a change in polarisability, IR a change in dipole moment. Line spacing in a rigid-rotor spectrum is 2B.

B SF_6

Ruled out: Applying Raman rules to IR: homonuclear diatomics are IR-inactive but Raman-active.

D H_2

Ruled out: J_max ≈ √(kT/2hcB) − ½ for the most intense rotational line.

Q5

The anharmonicity constant (cm^{-1}) of the diatomic molecule is:

A. 0.018

B. 0.012

C. 0.006

D. 0.003

QUESTION INSIGHTS

ESTIMATED TIME
2–3 min

DIFFICULTY
Medium

CONCEPT TESTED
Physical Spectroscopy – General

PYQ FREQUENCY
Rare · 2 papers

REVISION PRIORITY
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EXPECTED LEVEL
Part B / Part C

MEMORY HOOK
'Rule of mutual exclusion: centre of symmetry → no mode is both IR and Raman active'.

Correct Answer C 0.006

CONCEPT

Rotational (microwave) spectra give bond lengths via B = h/(8π²cI); vibrational (IR) via ν̃ = (1/2πc)√(k/μ); Raman needs a change in polarisability, IR a change in dipole moment. Line spacing in a rigid-rotor spectrum is 2B.

↓

LOGIC / WORKING

- Apply the key idea: Heavier isotope → larger μ → smaller B and smaller ν̃(ν̃∝ 1/√μ, B ∝ 1/μ).
- Check each option against it — only (C) is consistent: 0.006

FINAL: (C) 0.006

SHORTCUT / EXAM TRICK

Heavier isotope → larger μ → smaller B and smaller ν̃(ν̃∝ 1/√μ, B ∝ 1/μ).

COMMON MISTAKE

Applying Raman rules to IR: homonuclear diatomics are IR-inactive but Raman-active.

EXAM TIP

J_max ≈ √(kT/2hcB) − ½ for the most intense rotational line.

MEMORY TRICK

'Rule of mutual exclusion: centre of symmetry → no mode is both IR and Raman active'.

Why the Other Options Are Wrong

Correct answer: C

A **0.018**

Why (C) is the key — Rotational (microwave) spectra give bond lengths via B = h/(8π²cI); vibrational (IR) via ν̃= (1/2πc)√(k/μ); Raman needs a change in polarisability, IR a change in dipole moment. Line spacing in a rigid-rotor spectrum is 2B.

B **0.012**

Ruled out: Applying Raman rules to IR: homonuclear diatomics are IR-inactive but Raman-active.

D **0.003**

Ruled out: J_max ≈ √(kT/2hcB) − ½ for the most intense rotational line.

Q6

The rotational Raman spectrum of $^{19}F_2$ shows a series of Stokes lines at 19230.769 cm^{-1}, 19227.238 cm^{-1} and 19223.707 cm^{-1}. The rotational constant for $^{19}F_2$ in GHz is:

A. 26.484

B. 52.968

C. 105.936

D. 3.531

SELF-PRACTICE official answer key not printed in the source — attempt this, then verify.

QUESTION INSIGHTS

ESTIMATED TIME
2–3 min

DIFFICULTY
Medium

CONCEPT TESTED
Physical Spectroscopy – General

PYQ FREQUENCY
Rare · 2 papers

REVISION PRIORITY
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EXPECTED LEVEL
Part B / Part C

MEMORY HOOK
'Rule of mutual exclusion: centre of symmetry → no mode is both IR and Raman active'.

Q7

The most populated rotational state for HCl (B = 8.5 cm^{-1}) at 300 K is:

A. 2

B. 3

C. 5

D. 7

QUESTION INSIGHTS

ESTIMATED TIME
1–1.5 min

DIFFICULTY
Easy

CONCEPT TESTED
Physical Spectroscopy – General

PYQ FREQUENCY
Rare · 2 papers

REVISION PRIORITY
★★★☆☆

EXPECTED LEVEL
Part B

MEMORY HOOK
'Rule of mutual exclusion: centre of symmetry → no mode is both IR and Raman active'.

Correct Answer B 3

CONCEPT

Rotational (microwave) spectra give bond lengths via B = h/(8π²cI); vibrational (IR) via ν̃ = (1/2πc)√(k/μ); Raman needs a change in polarisability, IR a change in dipole moment. Line spacing in a rigid-rotor spectrum is 2B.

↓

LOGIC / WORKING

- Apply the key idea: Heavier isotope → larger μ → smaller B and smaller ν̃(ν̃∝ 1/√μ, B ∝ 1/μ).
- Check each option against it — only (B) is consistent: 3

FINAL: (B) 3

SHORTCUT / EXAM TRICK

Heavier isotope → larger μ → smaller B and smaller ν̃(ν̃∝ 1/√μ, B ∝ 1/μ).

COMMON MISTAKE

Applying Raman rules to IR: homonuclear diatomics are IR-inactive but Raman-active.

EXAM TIP

J_max ≈ √(kT/2hcB) − ½ for the most intense rotational line.

MEMORY TRICK

'Rule of mutual exclusion: centre of symmetry → no mode is both IR and Raman active'.

Why the Other Options Are Wrong

Correct answer: B

A **2**

Why (B) is the key — Rotational (microwave) spectra give bond lengths via B = h/(8π²cI); vibrational (IR) via ν̃= (1/2πc)√(k/μ); Raman needs a change in polarisability, IR a change in dipole moment. Line spacing in a rigid-rotor spectrum is 2B.

C **5**

Ruled out: Applying Raman rules to IR: homonuclear diatomics are IR-inactive but Raman-active.

D **7**

Ruled out: J_max ≈ √(kT/2hcB) − ½ for the most intense rotational line.

Q8

The ratio of life times of two states that gives rise to line widths of 1.0 cm^{-1} and 0.2 cm^{-1} respectively is:

A. 1 : 2

B. 1 : 5

C. 2 : 1

D. 5 : 1

QUESTION INSIGHTS

ESTIMATED TIME
2–3 min

DIFFICULTY
Medium

CONCEPT TESTED
Physical Spectroscopy – General

PYQ FREQUENCY
Rare · 2 papers

REVISION PRIORITY
★★★★☆

EXPECTED LEVEL
Part B / Part C

MEMORY HOOK
'Rule of mutual exclusion: centre of symmetry → no mode is both IR and Raman active'.

Correct Answer B 1 : 5

CONCEPT

Rotational (microwave) spectra give bond lengths via B = h/(8π²cI); vibrational (IR) via ν̃ = (1/2πc)√(k/μ); Raman needs a change in polarisability, IR a change in dipole moment. Line spacing in a rigid-rotor spectrum is 2B.

↓

LOGIC / WORKING

- Apply the key idea: Heavier isotope → larger μ → smaller B and smaller ν̃(ν̃∝ 1/√μ, B ∝ 1/μ).
- Check each option against it — only (B) is consistent: 1 : 5

FINAL: (B) 1 : 5

SHORTCUT / EXAM TRICK

Heavier isotope → larger μ → smaller B and smaller ν̃(ν̃∝ 1/√μ, B ∝ 1/μ).

COMMON MISTAKE

Applying Raman rules to IR: homonuclear diatomics are IR-inactive but Raman-active.

EXAM TIP

J_max ≈ √(kT/2hcB) − ½ for the most intense rotational line.

MEMORY TRICK

'Rule of mutual exclusion: centre of symmetry → no mode is both IR and Raman active'.

Why the Other Options Are Wrong

Correct answer: B

A **1 : 2**

Why (B) is the key — Rotational (microwave) spectra give bond lengths via B = h/(8π²cI); vibrational (IR) via ν̃= (1/2πc)√(k/μ); Raman needs a change in polarisability, IR a change in dipole moment. Line spacing in a rigid-rotor spectrum is 2B.

C **2 : 1**

Ruled out: Applying Raman rules to IR: homonuclear diatomics are IR-inactive but Raman-active.

D **5 : 1**

Ruled out: J_max ≈ √(kT/2hcB) − ½ for the most intense rotational line.

Q9

The region of electromagnetic spectrum employed in the electron spin resonance (ESR) spectroscopy is:

A. radiowave

B. microwave

C. infrared

D. visible

QUESTION INSIGHTS

ESTIMATED TIME
2–3 min

DIFFICULTY
Medium

CONCEPT TESTED
Physical Spectroscopy – General

PYQ FREQUENCY
Rare · 2 papers

REVISION PRIORITY
★★★★☆

EXPECTED LEVEL
Part B / Part C

MEMORY HOOK
'Rule of mutual exclusion: centre of symmetry → no mode is both IR and Raman active'.

Correct Answer B microwave

CONCEPT

Rotational (microwave) spectra give bond lengths via B = h/(8π²cI); vibrational (IR) via ν̃ = (1/2πc)√(k/μ); Raman needs a change in polarisability, IR a change in dipole moment. Line spacing in a rigid-rotor spectrum is 2B.

↓

LOGIC / WORKING

- Apply the key idea: Heavier isotope → larger μ → smaller B and smaller ν̃(ν̃∝ 1/√μ, B ∝ 1/μ).
- Check each option against it — only (B) is consistent: microwave

FINAL: (B) microwave

SHORTCUT / EXAM TRICK

Heavier isotope → larger μ → smaller B and smaller ν̃(ν̃∝ 1/√μ, B ∝ 1/μ).

COMMON MISTAKE

Applying Raman rules to IR: homonuclear diatomics are IR-inactive but Raman-active.

EXAM TIP

J_max ≈ √(kT/2hcB) − ½ for the most intense rotational line.

MEMORY TRICK

'Rule of mutual exclusion: centre of symmetry → no mode is both IR and Raman active'.

Why the Other Options Are Wrong

Correct answer: B

A **radiowave**

Why (B) is the key — Rotational (microwave) spectra give bond lengths via B = h/(8π²cI); vibrational (IR) via ν̃= (1/2πc)√(k/μ); Raman needs a change in polarisability, IR a change in dipole moment. Line spacing in a rigid-rotor spectrum is 2B.

C **infrared**

Ruled out: Applying Raman rules to IR: homonuclear diatomics are IR-inactive but Raman-active.

D **visible**

Ruled out: J_max ≈ √(kT/2hcB) − ½ for the most intense rotational line.

Q10

The frequency of radiation (in cm^{-1} units) required to rotationally excite the molecule from J = 0 to J = 1 state is

A. 1.4

B. 2.8

C. 3.2

D. 3.6

QUESTION INSIGHTS

ESTIMATED TIME
2–3 min

DIFFICULTY
Medium

CONCEPT TESTED
Physical Spectroscopy – General

PYQ FREQUENCY
Rare · 2 papers

REVISION PRIORITY
★★★★☆

EXPECTED LEVEL
Part B / Part C

MEMORY HOOK
'Rule of mutual exclusion: centre of symmetry → no mode is both IR and Raman active'.

Correct Answer B 2.8

CONCEPT

Rotational (microwave) spectra give bond lengths via B = h/(8π²cI); vibrational (IR) via ν̃= (1/2πc)√(k/μ); Raman needs a change in polarisability, IR a change in dipole moment. Line spacing in a rigid-rotor spectrum is 2B.

↓

LOGIC / WORKING

- Apply the key idea: Heavier isotope → larger μ → smaller B and smaller ν̃(ν̃∝ 1/√μ, B ∝ 1/μ).
- Check each option against it — only (B) is consistent: 2.8

FINAL: (B) 2.8

SHORTCUT / EXAM TRICK

Heavier isotope → larger μ → smaller B and smaller ν̃(ν̃∝ 1/√μ, B ∝ 1/μ).

COMMON MISTAKE

Applying Raman rules to IR: homonuclear diatomics are IR-inactive but Raman-active.

EXAM TIP

J_max ≈ √(kT/2hcB) − ½ for the most intense rotational line.

MEMORY TRICK

'Rule of mutual exclusion: centre of symmetry → no mode is both IR and Raman active'.

Why the Other Options Are Wrong

Correct answer: B

A **1.4**

Why (B) is the key — Rotational (microwave) spectra give bond lengths via B = h/(8π²cI); vibrational (IR) via ν̃= (1/2πc)√(k/μ); Raman needs a change in polarisability, IR a change in dipole moment. Line spacing in a rigid-rotor spectrum is 2B.

C **3.2**

Ruled out: Applying Raman rules to IR: homonuclear diatomics are IR-inactive but Raman-active.

D **3.6**

Ruled out: J_max ≈ √(kT/2hcB) − ½ for the most intense rotational line.

Q11

The bond that gives the most intense band in the infrared spectrum for its stretching vibrations is

A. C – H

B. N – H

C. O – H

D. S – H

SELF-PRACTICE official answer key not printed in the source — attempt this, then verify.

QUESTION INSIGHTS

ESTIMATED TIME
2–3 min

DIFFICULTY
Medium

CONCEPT TESTED
Physical Spectroscopy – General

PYQ FREQUENCY
Rare · 2 papers

REVISION PRIORITY
★★★★☆

EXPECTED LEVEL
Part B / Part C

MEMORY HOOK
'Rule of mutual exclusion: centre of symmetry → no mode is both IR and Raman active'.

Q12

The number of IR active vibrational normal modes of CO_2 is ___
(Numerical answer type — write the value.)

SELF-PRACTICE official answer key not printed in the source — attempt this, then verify.

QUESTION INSIGHTS

ESTIMATED TIME
1–1.5 min

DIFFICULTY
Easy

CONCEPT TESTED
Physical Spectroscopy – General

PYQ FREQUENCY
Rare · 2 papers

REVISION PRIORITY
★★★☆☆

EXPECTED LEVEL
Part B

MEMORY HOOK
'Rule of mutual exclusion: centre of symmetry → no mode is both IR and Raman active'.

Q13

For a diatomic vibrating rotor, in vibrational level v = 3 and rotational level J, the sum of the rotational and vibrational energies is 11493.6 cm^{-1}. Its equilibrium oscillation frequency is 2998.3 cm^{-1}, anharmonicity constant is 0.0124 and rotational constant under rigid rotor approximation is 9.716 cm^{-1}. The value of J is ___. (Up to nearest integer)
(Numerical answer type — write the value.)

SELF-PRACTICE official answer key not printed in the source — attempt this, then verify.

QUESTION INSIGHTS

ESTIMATED TIME
2–3 min

DIFFICULTY
Medium

CONCEPT TESTED
Physical Spectroscopy – General

PYQ FREQUENCY
Rare · 2 papers

REVISION PRIORITY
★★★★☆

EXPECTED LEVEL
Part B / Part C

MEMORY HOOK
'Rule of mutual exclusion: centre of symmetry → no mode is both IR and Raman active'.

Q14

The frequency (in cm^{-1}, rounded off to two decimal places) for pure rotational line in the spectrum of NO molecule due to change in the quantum number from J = 1 to J = 2 is ___
(Given: Moment of inertia of NO = 1.6427×10^{-46} kg m^2; h = 6.626×10^{-34} J s; c = 3×10^8 m/s)
(Numerical answer type — write the value.)

SELF-PRACTICE official answer key not printed in the source — attempt this, then verify.

QUESTION INSIGHTS

ESTIMATED TIME
2–3 min

DIFFICULTY
Medium

CONCEPT TESTED
Physical Spectroscopy – General

PYQ FREQUENCY
Rare · 2 papers

REVISION PRIORITY
★★★★☆

EXPECTED LEVEL
Part B / Part C

MEMORY HOOK
'Rule of mutual exclusion: centre of symmetry → no mode is both IR and Raman active'.

Q15

Assuming no interaction between vibrational and rotational energy levels in HF, the frequency (in cm^{-1}, rounded off to the nearest integer) of the R branch line originating from J = 4 in its IR spectrum is _____ (Given: Rotational constant for HF = 19.35 cm^{-1}; ν_0 = 4138.52 cm^{-1})
(Numerical answer type — write the value.)

SELF-PRACTICE official answer key not printed in the source — attempt this, then verify.

QUESTION INSIGHTS

ESTIMATED TIME
2–3 min

DIFFICULTY
Medium

CONCEPT TESTED
Physical Spectroscopy – General

PYQ FREQUENCY
Rare · 2 papers

REVISION PRIORITY
★★★★☆

EXPECTED LEVEL
Part B / Part C

MEMORY HOOK
'Rule of mutual exclusion: centre of symmetry → no mode is both IR and Raman active'.

Q16 **The carbon-oxygen bond in an organic compound absorbs electromagnetic radiation of frequency 6×10^{13} Hz. This frequency corresponds to the region:**

A. Infrared

B. Microwave

C. Ultraviolet

D. Visible

QUESTION INSIGHTS

ESTIMATED TIME
2–3 min

DIFFICULTY
Medium

CONCEPT TESTED
Physical Spectroscopy – General

PYQ FREQUENCY
Rare · 2 papers

REVISION PRIORITY
★★★★☆

EXPECTED LEVEL
Part B / Part C

MEMORY HOOK
'Rule of mutual exclusion: centre of symmetry → no mode is both IR and Raman active'.

Correct Answer A Infrared

CONCEPT

Rotational (microwave) spectra give bond lengths via B = h/(8π²cI); vibrational (IR) via ν̃ = (1/2πc)√(k/μ); Raman needs a change in polarisability, IR a change in dipole moment. Line spacing in a rigid-rotor spectrum is 2B.

↓

LOGIC / WORKING

- Apply the key idea: Heavier isotope → larger μ → smaller B and smaller ν̃(ν̃∝ 1/√μ, B ∝ 1/μ).
- Check each option against it — only (A) is consistent: Infrared

FINAL: (A) Infrared

SHORTCUT / EXAM TRICK

Heavier isotope → larger μ → smaller B and smaller ν̃(ν̃∝ 1/√μ, B ∝ 1/μ).

COMMON MISTAKE

Applying Raman rules to IR: homonuclear diatomics are IR-inactive but Raman-active.

EXAM TIP

J_max ≈ √(kT/2hcB) − ½ for the most intense rotational line.

MEMORY TRICK

'Rule of mutual exclusion: centre of symmetry → no mode is both IR and Raman active'.

Why the Other Options Are Wrong

Correct answer: A

B **Microwave**

Why (A) is the key — Rotational (microwave) spectra give bond lengths via B = h/(8π²cI); vibrational (IR) via ν̃= (1/2πc)√(k/μ); Raman needs a change in polarisability, IR a change in dipole moment. Line spacing in a rigid-rotor spectrum is 2B.

C **Ultraviolet**

Ruled out: Applying Raman rules to IR: homonuclear diatomics are IR-inactive but Raman-active.

D **Visible**

Ruled out: J_max ≈ √(kT/2hcB) − ½ for the most intense rotational line.

Q17

The correct order of the fundamental vibrational frequencies of the following diatomic molecules is

A $^{1}H^{35}Cl > {}^{1}H^{37}Cl > {}^{2}D^{35}Cl$

B $^{2}D^{35}Cl > {}^{1}H^{37}Cl > {}^{1}H^{35}Cl$

C $^{1}H^{37}Cl > {}^{1}H^{35}Cl > {}^{2}D^{35}Cl$

D $^{1}H^{37}Cl > {}^{2}D^{35}Cl > {}^{1}H^{35}Cl$

QUESTION INSIGHTS

ESTIMATED TIME
3–5 min

DIFFICULTY
Hard

CONCEPT TESTED
Physical Spectroscopy – General

PYQ FREQUENCY
Rare · 2 papers

REVISION PRIORITY
★★★★★

EXPECTED LEVEL
Part C (high merit)

MEMORY HOOK
'Rule of mutual exclusion: centre of symmetry → no mode is both IR and Raman active'.

Correct Answer A $^{1}H^{35}Cl > {}^{1}H^{37}Cl > {}^{2}D^{35}Cl$

CONCEPT

Rotational (microwave) spectra give bond lengths via B = h/(8π²cI); vibrational (IR) via ν̃ = (1/2πc)√(k/μ); Raman needs a change in polarisability, IR a change in dipole moment. Line spacing in a rigid-rotor spectrum is 2B.

↓

LOGIC / WORKING

- Apply the key idea: Heavier isotope → larger μ → smaller B and smaller ν̃ (ν̃ ∝ 1/√μ, B ∝ 1/μ).
- Check each option against it — only (A) is consistent: $^{1}H^{35}Cl > {}^{1}H^{37}Cl > {}^{2}D^{35}Cl$

FINAL: (A) $^{1}H^{35}Cl > {}^{1}H^{37}Cl > {}^{2}D^{35}Cl$

SHORTCUT / EXAM TRICK

Heavier isotope → larger μ → smaller B and smaller ν̃ (ν̃ ∝ 1/√μ, B ∝ 1/μ).

COMMON MISTAKE

Applying Raman rules to IR: homonuclear diatomics are IR-inactive but Raman-active.

EXAM TIP

J_max ≈ √(kT/2hcB) − ½ for the most intense rotational line.

MEMORY TRICK

'Rule of mutual exclusion: centre of symmetry → no mode is both IR and Raman active'.

Why the Other Options Are Wrong

Correct answer: A

B $^{2}D^{35}Cl > {}^{1}H^{37}Cl > {}^{1}H^{35}Cl$

Why (A) is the key — Rotational (microwave) spectra give bond lengths via B = h/(8π²cI); vibrational (IR) via $\tilde{\nu} = (1/2\pi c)\sqrt{(k/\mu)}$; Raman needs a change in polarisability, IR a change in dipole moment. Line spacing in a rigid-rotor spectrum is 2B.

C $^{1}H^{37}Cl > {}^{1}H^{35}Cl > {}^{2}D^{35}Cl$

Ruled out: Applying Raman rules to IR: homonuclear diatomics are IR-inactive but Raman-active.

D $^{1}H^{37}Cl > {}^{2}D^{35}Cl > {}^{1}H^{35}Cl$

Ruled out: $J_{max} \approx \sqrt{(kT/2hcB)} - ½$ for the most intense rotational line.

Q18

For H_2 molecule, the fundamental vibrational frequency (ν_e) in wavenumbers can be taken as 4400 cm^{-1}. The zero-point energy of the molecule is ___ kJ mol^{-1} (rounded up to two decimal places). [h = 6.6 × 10^{-34} J s, c = 3 × 10^8 m s^{-1}, N_A = 6 × 10^{23} mol^{-1}]
(Numerical answer type — write the value.)

SELF-PRACTICE official answer key not printed in the source — attempt this, then verify.

QUESTION INSIGHTS

ESTIMATED TIME
2–3 min

DIFFICULTY
Medium

CONCEPT TESTED
Physical Spectroscopy – General

PYQ FREQUENCY
Rare · 2 papers

REVISION PRIORITY
★★★★☆

EXPECTED LEVEL
Part B / Part C

MEMORY HOOK
'Rule of mutual exclusion: centre of symmetry → no mode is both IR and Raman active'.

Q19

Among the following, microwave active molecule(s) is/are

A. trans-dichloroethene

B. 1,2-dinitrobenzene

C. 3-methylphenol

D. para-aminophenol

SELF-PRACTICE official answer key not printed in the source — attempt this, then verify.

QUESTION INSIGHTS

ESTIMATED TIME
1–1.5 min

DIFFICULTY
Easy

CONCEPT TESTED
Physical Spectroscopy – General

PYQ FREQUENCY
Rare · 2 papers

REVISION PRIORITY
★★★☆☆

EXPECTED LEVEL
Part B

MEMORY HOOK
'Rule of mutual exclusion: centre of symmetry → no mode is both IR and Raman active'.

Q20

The forces constant for $H^{35}Cl$ and $D^{35}Cl$ are the same and both can be considered as harmonic oscillators. $H^{35}Cl$ has a fundamental vibrational transition at 2886 cm^{-1}. The ratio of the zero-point energy of $H^{35}Cl$ to that of $D^{35}Cl$ is (d) 1.946 (a) 0.515 (b) 0.717 (c) 1.395
(Numerical answer type — write the value.)

SELF-PRACTICE official answer key not printed in the source — attempt this, then verify.

QUESTION INSIGHTS

ESTIMATED TIME
2–3 min

DIFFICULTY
Medium

CONCEPT TESTED
Physical Spectroscopy – General

PYQ FREQUENCY
Rare · 2 papers

REVISION PRIORITY
★★★★☆

EXPECTED LEVEL
Part B / Part C

MEMORY HOOK
'Rule of mutual exclusion: centre of symmetry → no mode is both IR and Raman active'.

TOPIC REVISION

Physical Spectroscopy – General

20 PYQs · Last-minute revision

TOPIC SUMMARY

Rotational (microwave) spectra give bond lengths via B = h/(8π²cI); vibrational (IR) via ν̃= (1/2πc)√(k/μ); Raman needs a change in polarisability, IR a change in dipole moment. Line spacing in a rigid-rotor spectrum is 2B.

IMPORTANT FORMULA SHEET

- $E_J = BJ(J+1)$; $\Delta E = 2B(J+1)$
- $B = h/(8\pi^2cI)$, $I = \mu r^2$
- $\tilde{\nu} = (1/2\pi c)\sqrt{(k/\mu)}$
- $\Delta E(vib) = \hbar\omega(1 - 2x_e(v+1))$

FREQUENTLY ASKED CONCEPTS

- Selection rules (IR, Raman, rotational)
- Isotope effect on B and ν̃
- Most populated J level
- Degrees of freedom 3N−6 / 3N−5

COMMON MISTAKES & QUICK NOTES

Watch out:
Applying Raman rules to IR: homonuclear diatomics are IR-inactive but Raman-active.
$J_{max} \approx \sqrt{(kT/2hcB)} - ½$ for the most intense rotational line.

MOST-REPEATED PYQs & EXPECTED IN EXAM

PYQs in this topic: Q1 Q2 Q3 Q4 Q5 Q6 Q7 Q8 Q9 Q10 Q11 Q12 Q13 Q14 …

Expect 10 question(s) next session on Physical Spectroscopy – General.

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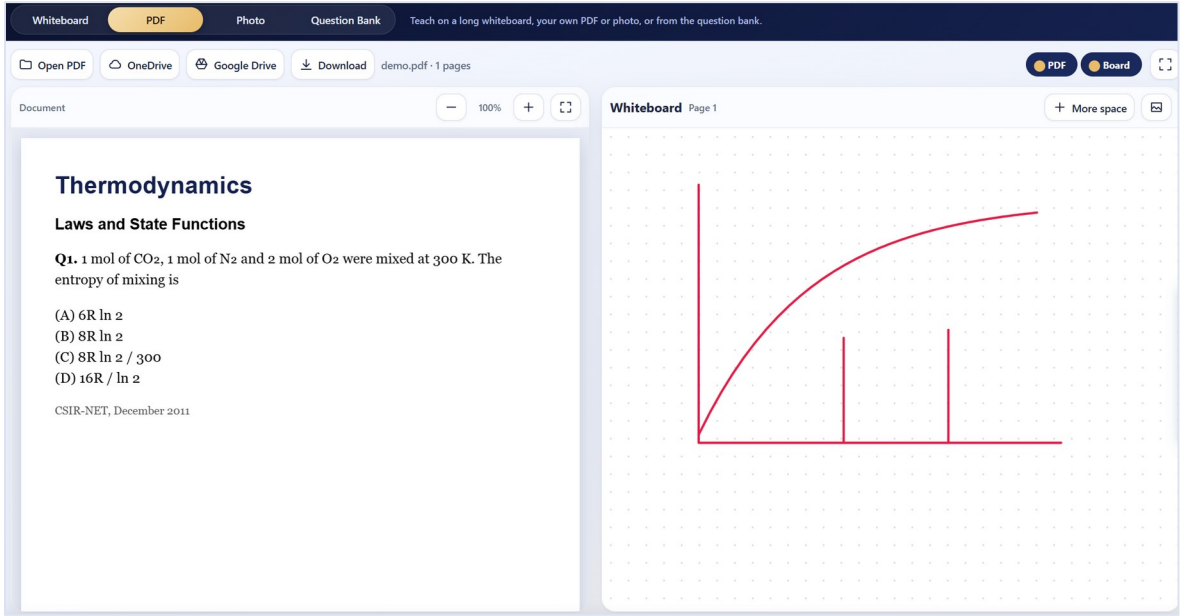
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