# PhysicsByAaryan

CSIR NET . GATE . JEST . BARC - Physics

# Molecular physics - CSIR NET Physics PYQs

Atomic and Molecular Physics . All PYQs (2015-2025) with answer key

**13 questions . Answer key included**

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**Q1. [Dec 2015] . 5.0 marks**

Atomic and Molecular Physics > Molecular physics

| CSIR NET | 2015 Dec | 5 M |
|---|---|---|

The first ionization potential of $K$ is 4.34 eV , the electron affinity of $CI$ is 3.82 eV and the equilibrium separation of $KCI$ is $0.3nm$. The required to dissociate

a $KCI$ molecule into a $K$ and a $CI$ atom is

1. 8.62 eV
2. 8.16 eV
3. 4.28 eV
4. 4.14 eV

**Q2. [June 2015] . 5.0 marks**

Atomic and Molecular Physics > Molecular physics

| CSIR NET | 2015 June | 5 M |
|---|---|---|

A diatomic molecule has vibrational states with energies $E_v = \hbar\omega\left(v + \frac{1}{2}\right)$ and rotational states with energies $E_j = Bj(j+1)$, where $v$ and $j$ are non-negative integers. Consider the transitions in which both the initial and final states are restricted to $v \leq 1$ and $j \leq 2$ and subject to the selection rules $\Delta v = \pm 1$ and $\Delta j = \pm 1$. Then the largest allowed energy of transition is

1. $\hbar\omega - 3B$
2. $\hbar\omega - B$
3. $\hbar\omega + 4B$
4. $2\hbar\omega + B$

**Q3. [Dec 2018] . 5.0 marks**

Atomic and Molecular Physics > Molecular physics

| CSIR NET | 2018 Dec | 5M |
|---|---|---|

The diatomic molecule HF has an absorption line in the rotational band at $40\ \text{cm}^{-1}$ for the isotope $^{18}F$. The corresponding line for the isotope $^{19}F$ will be shifted by approximately

1. $0.05\ \text{cm}^{-1}$
2. $0.11\ \text{cm}^{-1}$
3. $0.33\ \text{cm}^{-1}$
4. $0.01\ \text{cm}^{-1}$

**Q4. [Dec 2019] . 5.0 marks**

Atomic and Molecular Physics > Molecular physics

| CSIR NET | 2019 Dec | 5M |
|---|---|---|

In a spectrum resulting from Raman scattering, let $I_R$ denote the intensity of Rayleigh scattering and $I_S$ and $I_{AS}$ denote the most intense Stokes line and the most intense anti Stokes line, respectively. The correct order of these intensities is

1. $I_S > I_R > I_{AS}$
2. $I_R > I_S > I_{AS}$
3. $I_{AS} > I_R > I_S$
4. $I_R > I_{AS} > I_S$

**Q5. [June 2019] . 5.0 marks**

Atomic and Molecular Physics > Molecular physics

| CSIR NET | 2019 June | 5M |
|---|---|---|

The energy levels corresponding to the rotational motion of a molecule are $E_J = BJ(J+1)cm^{-1}$ where $J = 0,1,2,\ldots$, and $B$ is a constant. Pure rotational Raman transitions follow the selection rule $\Delta J = 0, \pm 2$. When the molecule is irradiated, the separation between the closest Stokes and anti-Stokes lines (in $\mathrm{cm}^{-1}$) is

1. $6B$
2. $12B$
3. $4B$
4. $8B$

**Q6. [June 2020] . 5.0 marks**

Atomic and Molecular Physics > Molecular physics

| CSIR NET | 2020 June | 5M |
|---|---|---|

The absorption lines arising from pure rotational effects of HCl are observed at $83.03\ \text{cm}^{-1}$, $103.73\ \text{cm}^{-1}$, $124.30\ \text{cm}^{-1}$, $145.03\ \text{cm}^{-1}$ and $165.51\ \text{cm}^{-1}$. The moment of inertia of the HCl molecule is (take $\frac{\hbar}{2\pi c} = 5.6 \times 10^{-44}\ \text{kg} - \text{m}$ )

1. $1.1 \times 10^{-48}\ \text{kg} - \text{m}^2$
2. $2.8 \times 10^{-47}\ \text{kg} - \text{m}^2$
3. $2.8 \times 10^{-48}\ \text{kg} - \text{m}^2$
4. $1.1 \times 10^{-42}\ \text{kg} - \text{m}^2$

**Q7. [June 2022] . 5.0 marks**

Atomic and Molecular Physics > Molecular physics

| CSIR NET | 2022 June | 5M |
|---|---|---|

The Raman rotational-vibrational spectrum of nitrogen molecules is observed using an incident radiation of wavenumber $12500\,\mathrm{cm}^{-1}$. In the first shift band, the wavenumbers of the observed lines (in $\mathrm{cm}^{-1}$ ) are 10150, 10158, 10170, 10182 and 10190. The values of vibrational frequency and rotational constant (in $\mathrm{cm}^{-1}$ ), respectively, are

1. 2330 and 2
2. 2350 and 2
3. 2350 and 3
4. 2330 and 3

**Q8. [Dec 2023] . 5.0 marks**

Atomic and Molecular Physics > Molecular physics

| CSIR NET | 2023 Dec | 5 M |
|---|---|---|

In the rotational-vibrational spectrum of an idealized carbon monoxide (CO) molecule, ignoring rotational-vibrational coupling, two transitions between adjacent vibrational levels with wavelength $\lambda_1$ and $\lambda_2$, correspond to the rotational transition from $J' = 0$ to $J'' = 1$ and $J' = 1$ to $J'' = 0$, respectively. Given that the reduced mass of CO is $1.2 \times^{-26}$ kg, equilibrium bond length of CO is 0.12 nm and vibrational frequency is $5 \times 10^{13}$ Hz, the ratio of $\frac{\lambda_1}{\lambda_2}$ is closest to

1. 0.9963
2. 0.0963
3. 1.002
4. 1.203

**Q9. [June 2023] . 5.0 marks**

Atomic and Molecular Physics > Molecular physics

| CSIR NET | 2023 June | 5M |
|---|---|---|

Let the separation of the frequencies of the first Stokes and the first anti-Stokes lines in the pure rotational Raman Spectrum of the $H_2$ molecule be $\Delta v(H_2)$, while the corresponding quantity for $D_2$ is $\Delta v(D_2)$. The ratio $\Delta v(H_2)/\Delta v(D_2)$ is

1. 0.6
2. 1.2
3. 1
4. 2

**Q10. [June 2024] . 5.0 marks**

Atomic and Molecular Physics > Molecular physics

| CSIR NET | 2024 June | 5M |
|---|---|---|

Rotational energy of a molecule in the angular momentum state $j$ is given by $E_j = \frac{\hbar^2}{2I} j(j+1)$, where $I$ is the moment of inertia of the molecule. The probability that the molecule will be in its ground state at temperature $T$ (such that $k_B T \gg \frac{\hbar^2}{2I}$), is

1. $\frac{3}{2}\frac{\hbar^2}{Ik_BT}$
2. $\frac{2}{3}\frac{\hbar^2}{Ik_BT}$
3. $\frac{1}{2}\frac{\hbar^2}{Ik_BT}$
4. $\frac{\hbar^2}{Ik_BT}$

**Q11. [June 2024] . 5.0 marks**

Atomic and Molecular Physics > Molecular physics

| CSIR NET | 2024 June | 5M |
|---|---|---|

The bond dissociation energy of a molecule is defined as the energy required to dissociate it. For $H_2$ and $H_2^+$ molecules, the bond dissociation energies are 4.478 eV and 2.651 eV respectively. If the equilibrium bond lengths of both $H_2$ and $H_2^+$ are identical, the value of the ionization potential of hydrogen molecule will be closest to

1. 15.427 eV
2. 11.773 eV
3. 20.729 eV
4. 6.471 eV

**Q12. [Dec 2025] . 5.0 marks**

Atomic and Molecular Physics > Molecular physics

| CSIR NET | 2025 Dec | 5M | AMP |
|---|---|---|---|

The bond dissociation energy of OH molecule is 4.18 eV with rotational constant $18.8\ \mathrm{cm}^{-1}$. For rotational induced dissociation, the minimum value of rotational quantum number is closest to

1. 114
2. 454
3. 45
4. 90

**Q13. [June 2025] . 5.0 marks**

Atomic and Molecular Physics > Molecular physics

| CSIR NET | 2025 June | 5M | AMP |
|---|---|---|---|

In a rotational-vibrational spectrum of $\mathrm{HCl}\left(\mathrm{H}^{35}\mathrm{Cl}\right)$, the first $R$-branch line and the first $P$-branch line are observed at $\lambda^{-1} = 2906\ \mathrm{cm}^{-1}$ and $\lambda^{-1} = 2865\ \mathrm{cm}^{-1}$, respectively. The equilibrium bond length of this molecule would be closest to

1. $0.2\text{Å}$
2. $1.3\text{Å}$
3. $13\text{Å}$
4. $2.1\text{Å}$

# Answer Key

13 questions . Subject and topic for quick revision

| Q. No | Subject | Topic | Answer |
|---|---|---|---|
| Q1 | Atomic and Molecular Physics | Molecular physics | **3** |
| Q2 | Atomic and Molecular Physics | Molecular physics | **3** |
| Q3 | Atomic and Molecular Physics | Molecular physics | **2** |
| Q4 | Atomic and Molecular Physics | Molecular physics | **2** |
| Q5 | Atomic and Molecular Physics | Molecular physics | **2** |
| Q6 | Atomic and Molecular Physics | Molecular physics | **2** |
| Q7 | Atomic and Molecular Physics | Molecular physics | **1** |
| Q8 | Atomic and Molecular Physics | Molecular physics | **Drop** |
| Q9 | Atomic and Molecular Physics | Molecular physics | **4** |
| Q10 | Atomic and Molecular Physics | Molecular physics | **3** |
| Q11 | Atomic and Molecular Physics | Molecular physics | **1** |
| Q12 | Atomic and Molecular Physics | Molecular physics | **3** |
| Q13 | Atomic and Molecular Physics | Molecular physics | **2** |

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