PhysicsByAaryan

CSIR NET . GATE . JEST . BARC - Physics

CSIR NET Physics - Atomic and Molecular Physics

All PYQs (2015-2025) with answer key

63 questions . Answer key included

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Q1. [Dec 2015] . 5.0 marks

Atomic and Molecular Physics > "LS, JJ and other interactions"

CSIR NET	2015 Dec	5 M

The LS configurations of the ground state of $^{12}\mathrm{Mg}$, $^{13}\mathrm{Al}$, $^{17}\mathrm{Cl}$ and $^{18}\mathrm{Ar}$ are, respectively,

1. $^3S_1$, $^2P_{1/2}$, $^2P_{1/2}$ and $^1S_0$
2. $^3S_1$, $^2P_{3/2}$, $^2P_{3/2}$ and $^3S_1$
3. $^1S_0$, $^2P_{1/2}$, $^2P_{3/2}$ and $^1S_0$
4. $^1S_0$, $^2P_{3/2}$, $^2P_{1/2}$ and $^3S_1$

Q2. [Dec 2015] . 5.0 marks

Atomic and Molecular Physics > Lasers

CSIR NET	2015 Dec	5 M

For a two level system, the population of atoms in the upper and lower levels are 3×10^{18} and , respectively. If the coefficient of stimulated emission is $3.0 \times 10^5\ \mathrm{m}^3/W - s^3$ and the energy density is $9.0\ \mathrm{J}/m^3 - Hz$, the rate of stimulated emission will be

1. $6.3 \times 10^{16}\ \mathrm{s}^{-1}$
2. $4.1 \times 10^{16}\ \mathrm{s}^{-1}$
3. $2.7 \times 10^{16}\ \mathrm{s}^{-1}$
4. $1.8 \times 10^{16}\ \mathrm{s}^{-1}$

Q3. [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

Q4. [June 2015] . 3.5 marks

Atomic and Molecular Physics > Lasers

CSIR NET	2015 June	3.5 M

In a two-state system, the transition rate of a particle from state 1 to state 2 is t_{12}, and the transition rate from state 2 to state 1 is t_{21}. In the steady state, the probability of finding the particle in state 1 is

1. $\frac{t_{21}}{t_{12}+t_{21}}$
2. $\frac{t_{12}}{t_{12}+t_{21}}$
3. $\frac{t_{12}t_{21}}{t_{12}+t_{21}}$
4. $\frac{t_{12}-t_{21}}{t_{12}+t_{21}}$

Q5. [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. $2\hbar\omega + B$

Q6. [June 2015] . 5.0 marks

Atomic and Molecular Physics > "LS, JJ and other interactions"

CSIR NET	2015 June	5 M

Of the following term symbols of the np^2 atomic configurations, $^1S_0$, $^3P_0$, $^3P_1$, $^3P_2$ and $^1D_2$, which is the ground state?

1. $^3P_0$
2. $^1S_0$
3. $^3P_2$
4. $^3P_1$

Q7. [June 2015] . 5.0 marks

Atomic and Molecular Physics > Lasers

CSIR NET	2015 June	5 M

A $He - Ne$ laser operates by using two energy levels of Ne separated by 2.26 eV . Under steady state conditions of optical pumping, the equivalent temperature of the system at which the ratio of the number of atoms in the upper state to that in the lower state will be $1/20$, is approximately (the Boltzmann constant $k_B = 8.6 \times 10^{-5}\text{eV/K}$)

1. 10^{10} K
2. 10^{8} K
3. 10^{6} K
4. 10^{4} K

Q8. [Dec 2016] . 5.0 marks

Atomic and Molecular Physics > "LS, JJ and other interactions"

CSIR NET	2016 Dec	5M

In the $L-S$ coupling scheme, the terms arising from two non-equivalent p-electrons are

1. $^3\mathrm{S}, {}^1\mathrm{P}, {}^3\mathrm{P}, {}^1\mathrm{D}, {}^3\mathrm{D}$
2. $^1S, {}^3S, {}^1P, {}^1D$
3. $^1S, {}^3S, {}^3P, {}^3D$
4. $^1S, {}^3S, {}^1P, {}^3P, {}^1D, {}^3D$

Q9. [Dec 2016] . 5.0 marks

Atomic and Molecular Physics > "LS, JJ and other interactions"

CSIR NET	2016 Dec	5M

The total spin of a hydrogen atom is due to the contribution of the spins of the electron and the proton. In the high temperature limit, the ratio of the number of atoms in the spin-1 state to the number in the spin-0 state is

1. 2
2. 3
3. $1/2$
4. $1/3$

Q10. [Dec 2016] . 5.0 marks

Atomic and Molecular Physics > Lasers

CSIR NET	2016 Dec	5M

A two level system in a thermal (black body) environment can decay from the excited state by both spontaneous and thermally stimulated emission. At room temperature (300 K), the frequency below which thermal emission dominates over spontaneous emission is nearest to

1. 10^{13} Hz

2. 10^{8} Hz

3. 10^{5} Hz

4. 10^{11} Hz

Q11. [June 2016] . 5.0 marks

Atomic and Molecular Physics > "LS, JJ and other interactions"

CSIR NET	2016 June	5M

The ground state electronic configuration of $^{22}\mathrm{Ti}$ is $[\mathrm{Ar}]3d^2 4s^2$. Which state, in the standard spectroscopic notations, is not possible in this configuration?

1. $^1F_3$
2. $^1S_0$
3. $^1D_2$
4. $^3P_0$

Q12. [June 2016] . 5.0 marks

Atomic and Molecular Physics > Zeeman effect

CSIR NET	2016 June	5M

In a normal Zeeman effect experiment using a magnetic field of strength 0.3 T , the splitting between the components of a 660 nm spectral line is

1. 12 pm
2. 10 pm
3. 3.8 pm
4. 6 pm

Q13. [June 2016] . 5.0 marks

Atomic and Molecular Physics > Lasers

CSIR NET	2016 June	5M

The separation between the energy levels of a two-level atom is 2 eV . Suppose that 4×10^{20} atoms are in the ground state and 7×10^{20} atoms are pumped into the excited state just before lasing starts. How much energy will be released in a single laser pulse?

1. 24.6 J
2. 22.4 J
3. 98 J
4. 48 J

Q14. [Dec 2017] . 3.5 marks

Atomic and Molecular Physics > Lasers

CSIR NET	2017 Dec	3.5M

Consider a system of identical atoms in equilibrium with blackbody radiation in a cavity at temperature T. The equilibrium probabilities for each atom being in the ground state $|0\rangle$ and an excited state $|1\rangle$ are P_0 and P_1 respectively. Let n be the average number of photons in a mode in the cavity that causes transition between the two states. Let $W_{0\to1}$ and $W_{1\to0}$ denote, respectively, the squares of the matrix elements corresponding to the atomic transitions $|0\rangle \to |1\rangle$ and $|1\rangle \to |0\rangle$. Which of the following equations hold in equilibrium?

1. $P_0 n W_{0\to1} = P_1 W_{1\to0}$
2. $P_0 n W_{0\to1} = P_1 n W_{1\to0}$
3. $P_0 n W_{0\to1} = P_1 W_{1\to0} - P_1 n W_{1\to0}$
4. $P_0 n W_{0\to1} = P_1 W_{1\to0} + P_1 n W_{1\to0}$

Q15. [Dec 2017] . 5.0 marks

Atomic and Molecular Physics > Zeeman effect

CSIR NET	2017 Dec	5M

The Zeeman shift of the energy of a state with quantum numbers L, S, J and m_J is

$$H_z = \frac{m_J \mu_B B}{J(J+1)} \left(\langle \vec{L}.\vec{J} \rangle + g_s \langle \vec{S}.\vec{J} \rangle \right)$$

Where B is the applied magnetic field, g_s is the g-factor for the spin and $\frac{\mu_B}{h} = 1.4\text{MHz} - G^{-1}$, where h is the Planck constant. The approximate frequency shift of the $S = 0, L = 1$ and $m_J = 1$ state, at a magnetic field of $1G$, is

1. 10 MHz
2. 1.4 MHz
3. 5 MHz
4. 2.8 MHz

Q16. [Dec 2017] . 5.0 marks

Atomic and Molecular Physics > "LS, JJ and other interactions"

CSIR NET	2017 Dec	5M

The separations between the adjacent levels of a normal multiplet are found to be $22\,\mathrm{cm}^{-1}$ and $33\,\mathrm{cm}^{-1}$. Assume that the multiplet is described well by the $L-S$ coupling scheme and the Lande's interval rule, namely $E(J)-E(J-1)=AJ$, where A is a constant. The term notaions for this multiplet is

1. $^3P_{0,1,2}$
2. $^3F_{2,3,4}$
3. $^3G_{3,4,5}$
4. $^3D_{1,2,3}$

Q17. [Dec 2017] . 5.0 marks

Atomic and Molecular Physics > "LS, JJ and other interactions"

CSIR NET	2017 Dec	5M

If the fine structure splitting between the $2\,^2P_{3/2}$ and $2\,^2P_{3/2}$ levels in the hydrogen atom is $0.4\,\mathrm{cm}^{-1}$, the corresponding splitting in Li^{2+} will approximately be

1. $1.2\,\mathrm{cm}^{-1}$
2. $10.8\,\mathrm{cm}^{-1}$
3. $32.4\,\mathrm{cm}^{-1}$
4. $36.8\,\mathrm{cm}^{-1}$

Q18. [June 2017] . 5.0 marks

Atomic and Molecular Physics > Zeeman effect

CSIR NET	2017 June	5M

An atomic spectral line is observed to split into nine components due to Zeeman shift. If the upper state of the atom is $^3D_2$ then the lower state will be

1. $^3F_2$
2. $^3F_1$
3. $^3P_1$
4. $^3P_2$

Q19. [June 2017] . 5.0 marks

Atomic and Molecular Physics > Lasers

CSIR NET	2017 June	5M

If the coefficient of stimulated emission for a particular transition is $2.1 \times 10^{19}\ \mathrm{m^3\ W^{-1}\ s^{-3}}$ and the emitted photon is at wavelength $3000\ \text{Å}$, then the lifetime of the excited state is approximately

1. $20\ ns$
2. $40\ ns$
3. 80 ns
4. 100 ns

Q20. [June 2017] . 5.0 marks

Atomic and Molecular Physics > Xray and alkali spectra

CSIR NET	2017 June	5M

If the binding energies of the electron in the K and L shells of silver atom are 25.4 keV and 3.34 keV , respectively, then the kinetic energy of the Auger electron will be approximately

1. 22 keV
2. 9.3 keV
3. 10.5 keV
4. 18.7 keV

Q21. [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 $40\ \mathrm{cm}^{-1}$ for the isotope ^{18}F. The corresponding line for the isotope ^{19}F will be shifted by approximately

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

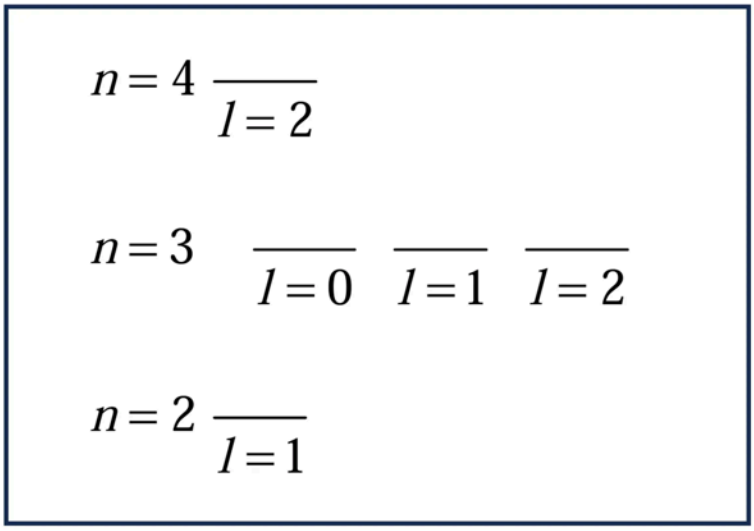
Q22. [Dec 2018] . 5.0 marks

Atomic and Molecular Physics > Bohar Model and h-atom model

CSIR NET	2018 Dec	5M

The excited state ($n = 4, l = 2$) of an election in an atom may decay to one or more of the lower energy levels shown in the diagram below. Of the total emitted light, a fraction $\frac{1}{4}$ comes from the decay to the state ($n = 2, l = 1$). Based on selection rules, the fractional intensity of the emission line due to the decay to the state ($n = 3, l = 1$)

1. $\frac{3}{4}$
2. $\frac{1}{2}$
3. $\frac{1}{4}$
4. 0



Q23. [Dec 2018] . 5.0 marks

Atomic and Molecular Physics > Lasers

CSIR NET	2018 Dec	5M

The volume of an optical cavity is $1\,\mathrm{cm}^3$. The number of modes it can support within a bandwidth of 0.1 nm , centered at $\lambda = 500\,\mathrm{nm}$, is of the order of

1. 10^3
2. 10^5
3. 10^{10}
4. 10^7

Q24. [June 2018] . 5.0 marks

Atomic and Molecular Physics > Xray and alkali spectra

CSIR NET	2018 June	5M

A photon of energy 115.62 keV ionizes a K-shell electron of a Be atom. One L-shell electron jumps to the K-shell to fill this vacancy and emits a photon of energy 109.2 keV in the process. If the ionization potential for the L-shell is 6.4 keV , the kinetic energy of the ionized electron is

1. 6.42 keV
2. 12.82 keV
3. 20 eV
4. 32 eV

Q25. [June 2018] . 5.0 marks

Atomic and Molecular Physics > Angular momentum in Atomic Physics

CSIR NET	2018 June	5M

The value of the Lande g - factor for a fine-structure level defined by the quantum number $L = 1, J = 2$ and $S = 1$, is

1. $\frac{11}{6}$
2. $\frac{4}{3}$
3. $\frac{8}{3}$
4. $\frac{3}{2}$

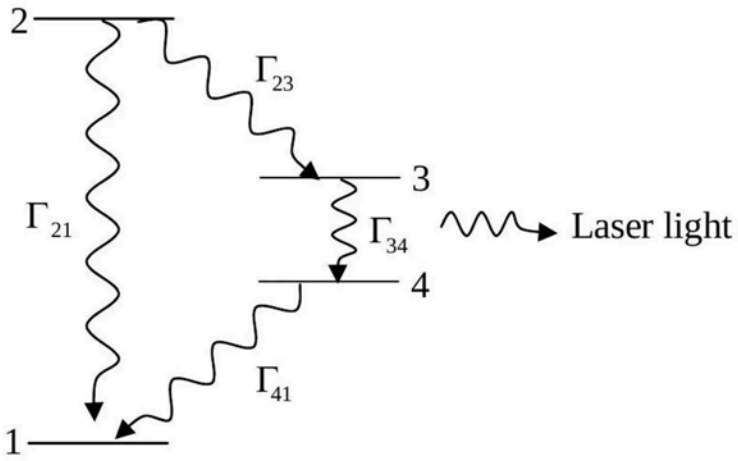
Q26. [June 2018] . 5.0 marks

Atomic and Molecular Physics > Lasers

CSIR NET	2018 June	5M

The electronic energy level diagram of a molecule is shown in the following figure, Let Γ_{ij} denote the decay rate for a transition from the level i to j. The molecules are optically pumped from level 1 to 2 . For the transition from level 3 to level 4 to be a lasing transition, the decay rates have to satisfy

1. $\Gamma_{21} > \Gamma_{23} > \Gamma_{41} > \Gamma_{34}$
2. $\Gamma_{21} > \Gamma_{41} > \Gamma_{23} > \Gamma_{34}$
3. $\Gamma_{41} > \Gamma_{23} > \Gamma_{21} > \Gamma_{34}$
4. $\Gamma_{41} > \Gamma_{21} > \Gamma_{34} > \Gamma_{23}$



Q27. [Dec 2019] . 5.0 marks

Atomic and Molecular Physics > "LS, JJ and other interactions"

CSIR NET	2019 Dec	5M

The outermost shell of an atom of an element is $3d^3$. The spectral symbol for the ground state is

1. ${}^4F_{3/2}$
2. ${}^4F_{9/2}$
3. ${}^4D_{7/2}$
4. ${}^4D_{1/2}$

Q28. [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. $I_R > I_{AS} > I_S$

Q29. [Dec 2019] . 5.0 marks

Atomic and Molecular Physics > Bohar Model and h-atom model

CSIR NET	2019 Dec	5M

A negative muon, which has a mass nearly 200 times that of an electron, replaces an electron in a Li atom. The lowest ionization energy for the muonic Li atom is approximately

1. the same as that of He
2. the same as that of normal Li
3. 200 times larger than that of normal Li
4. the same as that of normal Be

Q30. [Dec 2019] . 5.0 marks

Atomic and Molecular Physics > Doppler broadening

CSIR NET	2019 Dec	5M

The mean kinetic energy per atom in a sodium vapour lamp is 0.33 eV . Given that the mass of sodium is approximately $22.5 \times 10^9 \text{eV}$, the ratio of the Doppler width of an optical line to its central frequency is

1. 7×10^{-7}
2. 6×10^{-6}
3. 5×10^{-5}
4. 4×10^{-4}

Q31. [June 2019] . 5.0 marks

Atomic and Molecular Physics > Angular momentum in Atomic Physics

CSIR NET	2019 June	5M

A doubly charged ion in the angular momentum state $(J = 2, J_3 = 1)$ meets a gas of polarized electrons $\left(S_3 = \frac{1}{2}\right)$ and gets neutralized. If the orbital angular momentum transferred in the process is zero, the probability that the neutral atom is in the $(J = 2, J_3 = 2)$ state is

1. $\frac{2}{5}$
2. $\frac{2}{3}$
3. $\frac{1}{5}$
4. $\frac{1}{3}$

Q32. [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 $J = 0,1,2,$ ..., 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 cm^{-1}) is

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

Q33. [June 2019] . 5.0 marks

Atomic and Molecular Physics > Lasers

CSIR NET	2019 June	5M

The cavity of a He-Ne laser emitting at 632.8 nm , consists of two mirrors separated by a distance of 35 cm . If the oscillations in the laser cavity occur at frequencies within the gain bandwidth of 1.3 GHz , the number of longitudinal modes allowed in the cavity is

1. 1
2. 2
3. 3
4. 4

Q34. [June 2020] . 3.5 marks

Atomic and Molecular Physics > Bohar Model and h-atom model

CSIR NET	2020 June	3.5M

The wavelength of the first Balmer line of hydrogen is $656\ \text{nm}$. The wavelength of the corresponding line for a hydrogenic atom with $Z = 6$ and nuclear mass of $19.92 \times 10^{-27}\ \text{kg}$ is

1. 18.2 nm
2. 109.3 nm
3. 143.5 nm
4. 393.6 nm

Q35. [June 2020] . 5.0 marks

Atomic and Molecular Physics > Angular momentum in Atomic Physics

CSIR NET	2020 June	5M

If we take the nuclear spin I into account, the total angular momentum is $\vec{\mathrm{F}} = \vec{\mathrm{L}} + \vec{\mathrm{S}} + \vec{\mathrm{I}}$, where $\vec{\mathrm{L}}$ and $\vec{\mathrm{S}}$ are the orbital and spin angular momenta of the electron. The Hamiltonian of the hydrogen atom is corrected by the additional interaction $\lambda\vec{\mathrm{I}} \cdot (\vec{\mathrm{L}} + \vec{\mathrm{S}})$, where $\lambda > 0$ is a constant. The total angular momentum quantum number F of the p - orbital state with the lowest energy is

1. 0
2. 1
3. 1/2
4. 3/2

Q36. [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. $1.1 \times 10^{-42}\ \text{kg} - \text{m}^2$

Q37. [June 2020] . 5.0 marks

Atomic and Molecular Physics > Lasers

CSIR NET	2020 June	5M

The energies of the 3 lowest states of an atom are $E_0 = -14\,eV, E_1 = -9\,eV$ and $E_2 = -7\,eV$. The Einstein coefficients are $A_{10} = 3 \times 10^8\,s^{-1}$, $A_{20} = 1.2 \times 10^8\,s^{-1}$ and $A_{21} = 8 \times 10^7 s^{-1}$. If a large number of atoms are in the energy level E_2, the mean radiative lifetime of this excited state is

1. $8.3 \times 10^{-9}\,s$
2. $1 \times 10^{-8}\,s$
3. $0.5 \times 10^{-8}\,s$
4. $1.2 \times 10^{-8}\,s$

Q38. [June 2021] . 5.0 marks

Atomic and Molecular Physics > Bohar Model and h-atom model

CSIR NET	2021 June	5M

The $|3,0,0\rangle$ state in the standard notation $|n,l,m\rangle$ of the H-atom in the non-relativistic theory decays to the state $|1,0,0\rangle$ via two dipole transition. The transition route and the corresponding probability are

1. $|3,0,0\rangle \rightarrow |2,1,-1\rangle \rightarrow |1,0,0\rangle$ and 1/4
2. $|3,0,0\rangle \rightarrow |2,1,1\rangle \rightarrow |1,0,0\rangle$ and 1/4
3. $|3,0,0\rangle \rightarrow |2,1,0\rangle \rightarrow |1,0,0\rangle$ and $1/3$
4. $|3,0,0\rangle \rightarrow |2,1,0\rangle \rightarrow |1,0,0\rangle$ and $2/3$

Q39. [June 2021] . 5.0 marks

Atomic and Molecular Physics > Doppler broadening

CSIR NET	2021 June	5M

Diffuse hydrogen gas within a galaxy may be assumed to follow a Maxwell distribution at temperature $10^6\,\mathrm{K}$, while the temperature appropriate for the H gas in the inter-galactic space, following the same distribution, may be taken to be $10^4\,\mathrm{K}$. The ratio of thermal broadening $\Delta\nu_{\mathrm{G}}/\Delta\nu_{\mathrm{IG}}$ of the Lyman- α line from the H-atoms within the galaxy to that from the intergalactic space is closest to

1. 100
2. 1/100
3. 10
4. 1/10

Q40. [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 cm^{-1}) are 10150, 10158, 10170, 10182 and 10190. The values of vibrational frequency and rotational constant (in cm^{-1}), respectively, are

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

Q41. [June 2022] . 5.0 marks

Atomic and Molecular Physics > "LS, JJ and other interactions"

CSIR NET	2022 June	5M

The electronic configuration of ^{12}C is $1s^2 2s^2 2p^2$. Including LS coupling, the correct ordering of its energies is

1. $E(^3P_2) < E(^3P_1) < E(^3P_0) < E(^1D_2)$
2. $E(^3P_0) < E(^3P_1) < E(^3P_2) < E(^1D_2)$
3. $E(^1D_2) < E(^3P_2) < E(^3P_1) < E(^3P_0)$
4. $E(^3P_1) < E(^3P_0) < E(^3P_2) < E(^1D_2)$

Q42. [June 2022] . 5.0 marks

Atomic and Molecular Physics > Bohar Model and h-atom model

CSIR NET	2022 June	5M

In the absorption spectrum of H-atom, the frequency of transition from the ground state to the first excited state is v_H. The corresponding frequency for a bound state of a positively charged muon (μ^+) and an electron is v_μ. Using $m_\mu = 10^{-28}$ kg, $m_e = 10^{-30}$ kg and $m_p \gg m_e, m_\mu$, the value of $(v_\mu - v_H)/v_H$ is

1. 0.001
2. -0.001
3. -0.01
4. 0.01

Q43. [Dec 2023] . 5.0 marks

Atomic and Molecular Physics > Bohar Model and h-atom model

CSIR NET	2023 Dec	5 M

The ionization potential of hydrogen atom is 13.6 eV and λ_H and λ_D denote longest wavelengths in Balmer spectrum of hydrogen and deuterium atoms, respectively. Ignoring the fine and hyperfine structures, the percentage difference $y = \frac{\lambda_H - \lambda_D}{\lambda_H} \times 100$, is closest to

1. 1.0003%
2. -0.03%
3. 0.03%
4. -1.0003%

Q44. [Dec 2023] . 5.0 marks

Atomic and Molecular Physics > Zeeman effect

CSIR NET	2023 Dec	5 M

A solar probe mission detects a fractional wavelength shift $(\Delta\lambda/\lambda)$ of the spectral line $\lambda = 630\ \text{nm}$ within a sunspot to be of the order of 10^{-5}. Assuming this shift is caused by the normal Zeeman effect (i.e., neglecting other physical effects), the estimated magnetic field (in tesla) within the observed sunspot is closest to

1. 3×10^{-5}
2. 300
3. 0.3
4. 3×10^{5}

Q45. [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 λ_1 and λ_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 5×10^{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

Q46. [June 2023] . 5.0 marks

Atomic and Molecular Physics > Bohar Model and h-atom model

CSIR NET	2023 June	5M

The electron cloud (of the outermost electrons) of an ensemble of atoms of atomic number Z is described by a continuous charge density $\rho(r)$ that adjusts itself so that the electrons at the Fermi level have zero energy. If $V(r)$ is the local electrostatic potential, then $\rho(r)$ is

1. $\frac{e}{3\pi^2\hbar^3}[2m_e eV(\mathbf{r})]^{3/2}$
2. $\frac{Ze}{3\pi^2\hbar^3}[2m_e eV(\mathbf{r})]^{3/2}$
3. $\frac{e}{3\pi^2\hbar^3}[Zm_e eV(\mathbf{r})]^{3/2}$
4. $\frac{e}{3\pi^2\hbar^3}[m_e eV(\mathbf{r})]^{3/2}$

Q47. [June 2023] . 5.0 marks

Atomic and Molecular Physics > Zeeman effect

CSIR NET	2023 June	5M

The red line of wavelength 644 nm in the emission spectrum of Cd corresponds to a transition from the $^1D_2$ level to the $^1P_1$ level. In the presence of a weak magnetic field, this spectral line will split into (ignore hyperfine structure)

1. 9 lines
2. 6 lines
3. 3 lines
4. 2 lines

Q48. [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

Q49. [Dec 2024] . 5.0 marks

Atomic and Molecular Physics > "LS, JJ and other interactions"

CSIR NET	2024 Dec	5M

The hyperfine splitting of the ground state of the hydrogen atom is given as

$$\Delta E \propto \frac{g_p g_e}{m_p m_e a^3}$$

where g_p and g_e are the nuclear and electron Landê g factors respectively, and a is the orbital radius of the ground state. It is given that g (proton) $= 5.59$. In Hydrogen, transition between these split levels corresponds to radiation of wavelength 21 cm .

If the proton is replaced by a positron, the corresponding wavelength would be

1. 2.6 mm
2. 3.2 mm
3. 3.2 cm
4. 2.6 cm

Q50. [Dec 2024] . 5.0 marks

Atomic and Molecular Physics > Bohar Model and h-atom model

CSIR NET	2024 Dec	5M

A hydrogen atom, excited to electronic configuration $3S_{1/2}$ (nL_j notation), relaxes to the ground state via electric dipole transitions. Considering only fine structure and ignoring hyperfine structure, the maximum number of emitted spectral lines is

1. 3
2. 6
3. 1
4. 4

Q51. [Dec 2024] . 5.0 marks

Atomic and Molecular Physics > "LS, JJ and other interactions"

CSIR NET	2024 Dec	5M

Consider the Bromine ion Br^{+}in its ground state. The atomic number of Br is 35. The fine structure term symbol $\left({}^{2S+1}L_J\right)$ under the LS coupling scheme for the lowest energy state of this ion would be

1. ${}^3P_2$
2. ${}^3P_0$
3. ${}^1D_2$
4. ${}^4S_{3/2}$

Q52. [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. $\frac{\hbar^2}{Ik_BT}$

Q53. [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

Q54. [June 2024] . 5.0 marks

Atomic and Molecular Physics > Xray and alkali spectra

CSIR NET	2024 June	5M

Helium atom is excited to a state with the configuration $(2s2p)$ with an energy 58.3 eV . After some time, this atom spontaneously ejects a single electron. The value of the orbital angular momentum quantum number (l) of the ejected electron in the final state of the system is (*Ionization potential of* $He(1s)^2$ *is 24.6 eV*)

1. 1
2. 0
3. 2
4. 3

Q55. [June 2024] . 5.0 marks

Atomic and Molecular Physics > Bohar Model and h-atom model

CSIR NET	2024 June	5M

An atom of mass m, initially at rest, resonantly absorbs a photon. It makes a transition from the ground state to an excited state and also gets a momentum kick. If the difference between the energies of the ground state and the excited state is $\hbar\Delta$, the angular frequency of the absorbed photon is closest to

1. $\Delta\left(1+\frac{3}{2}\frac{\hbar\Delta}{2mc^2}\right)$
2. $\Delta\left(1+\frac{1}{2}\frac{\hbar\Delta}{mc^2}\right)$
3. $\Delta\left(1+\frac{\hbar\Delta}{mc^2}\right)$
4. $\Delta\left(1+2\frac{\hbar\Delta}{mc^2}\right)$

Q56. [Dec 2025] . 5.0 marks

Atomic and Molecular Physics > Lasers

CSIR NET	2025 Dec	5M	AMP

An optical cavity of a laser, formed by two plane mirrors, is filled up with an active medium. The medium emits radiation at wavelengths 450 nm , 600 nm , and 750 nm . If the medium is continuously pumped, at which cavity length among the following, will all three wavelengths be amplified?

1. 750μ m
2. 1500μ m
3. 600μ m
4. 450μ m

Q57. [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 $18.8\ \text{cm}^{-1}$. For rotational induced dissociation, the minimum value of rotational quantum number is closest to

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

Q58. [Dec 2025] . 5.0 marks

Atomic and Molecular Physics > Doppler broadening

CSIR NET	2025 Dec	5M	AMP

Consider an emission line of wave length $\lambda = 550$ nm of Argon ($A = 40, Z = 18$) at a temperature 400 K . The full Doppler width of the emission line will be closest to

1. 10^{-2} nm

2. 10^{-1} nm

3. 10^{-3} nm

4. 10^{-5} nm

Q59. [Dec 2025] . 5.0 marks

Atomic and Molecular Physics > Zeeman effect

CSIR NET	2025 Dec	5M	AMP

A hydrogen atom is in a weak external magnetic field $\vec{B}$. Consider an electron of this atom with $\left(l = 1, s = \frac{1}{2}\right)$ and total $j = \frac{3}{2}$. There are multiple energy levels for this electron due to the magnetic field. The energy spacing between any two adjacent levels (in units of $\mu_B B$) is

1. $\frac{1}{2}$
2. $\frac{1}{3}$
3. $\frac{3}{4}$
4. $\frac{4}{3}$

Q60. [June 2025] . 5.0 marks

Atomic and Molecular Physics > Lasers

CSIR NET	2025 June	5M	AMP

A highly collimated laser beam with a diameter of 1 cm and wavelength 500 nm is directed from the earth's surface towards the moon ($\sim 384{,}000$ km away from the earth). Assuming ideal diffraction limited propagation in vacuum, which of the following best estimates the diameter of the beam upon returning to the earth after reflection from an ideal reflector installed on the moon.

1. 200 m
2. 20 m
3. 20 km
4. 200 km

Q61. [June 2025] . 5.0 marks

Atomic and Molecular Physics > Lasers

CSIR NET	2025 June	5M	AMP

Consider a laser cooling experiment where atoms are slowed down by an inelastic process of absorption and subsequent emission of photons. If light of wavelength 776.5 nm is used to slow down potassium atoms (mass number 39) with initial speed $130\ \mathrm{ms}^{-1}$, the number of such absorption and emission cycles needed to bring the atoms to rest is closest to

1. 10^3

2. 10^2

3. 10^5

4. 10^4

Q62. [June 2025] . 5.0 marks

Atomic and Molecular Physics > Zeeman effect

CSIR NET	2025 June	5M	AMP

An atom is subjected to a weak magnetic field $B = 0.1T$. A spectral line of wavelength 184.9 nm corresponding to a $J = 1$ to $J = 0$ transition splits into three components. The highest and the lowest components are separated by 3.2×10^{-4} nm. The magnetic moment of the atom in $J = 1$ state (in units of Bohr magneton) is

1. 2.82
2. 0.71
3. 1.41
4. 4.23

Q63. [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. 0.2Å
2. 1.3Å
3. 13Å
4. 2.1Å

Answer Key

63 questions . Subject and topic for quick revision

Q. No	Subject	Topic	Answer
Q1	Atomic and Molecular Physics	"LS, JJ and other interactions"	**3**
Q2	Atomic and Molecular Physics	Lasers	**3**
Q3	Atomic and Molecular Physics	Molecular physics	**3**
Q4	Atomic and Molecular Physics	Lasers	**1**
Q5	Atomic and Molecular Physics	Molecular physics	**3**
Q6	Atomic and Molecular Physics	"LS, JJ and other interactions"	**1**
Q7	Atomic and Molecular Physics	Lasers	**4**
Q8	Atomic and Molecular Physics	"LS, JJ and other interactions"	**4**
Q9	Atomic and Molecular Physics	"LS, JJ and other interactions"	**2**
Q10	Atomic and Molecular Physics	Lasers	**1**
Q11	Atomic and Molecular Physics	"LS, JJ and other interactions"	**1**
Q12	Atomic and Molecular Physics	Zeeman effect	**4**
Q13	Atomic and Molecular Physics	Lasers	**4**
Q14	Atomic and Molecular Physics	Lasers	**4**
Q15	Atomic and Molecular Physics	Zeeman effect	**2**
Q16	Atomic and Molecular Physics	"LS, JJ and other interactions"	**4**
Q17	Atomic and Molecular Physics	"LS, JJ and other interactions"	**3**
Q18	Atomic and Molecular Physics	Zeeman effect	**3**
Q19	Atomic and Molecular Physics	Lasers	**3**
Q20	Atomic and Molecular Physics	Xray and alkali spectra	**4**
Q21	Atomic and Molecular Physics	Molecular physics	**2**
Q22	Atomic and Molecular Physics	Bohar Model and h-atom model	**1**
Q23	Atomic and Molecular Physics	Lasers	**3**
Q24	Atomic and Molecular Physics	Xray and alkali spectra	**3**
Q25	Atomic and Molecular Physics	Angular momentum in Atomic Physics	**4**
Q26	Atomic and Molecular Physics	Lasers	**None**
Q27	Atomic and Molecular Physics	"LS, JJ and other interactions"	**1**
Q28	Atomic and Molecular Physics	Molecular physics	**2**
Q29	Atomic and Molecular Physics	Bohar Model and h-atom model	**1**
Q30	Atomic and Molecular Physics	Doppler broadening	**2**
Q31	Atomic and Molecular Physics	Angular momentum in Atomic Physics	**4**
Q32	Atomic and Molecular Physics	Molecular physics	**2**
Q33	Atomic and Molecular Physics	Lasers	**3**
Q34	Atomic and Molecular Physics	Bohar Model and h-atom model	**1**
Q35	Atomic and Molecular Physics	Angular momentum in Atomic Physics	**2**
Q36	Atomic and Molecular Physics	Molecular physics	**2**
Q37	Atomic and Molecular Physics	Lasers	**3**
Q38	Atomic and Molecular Physics	Bohar Model and h-atom model	**3**
Q39	Atomic and Molecular Physics	Doppler broadening	**3**
Q40	Atomic and Molecular Physics	Molecular physics	**1**

Answer Key (cont.)

Q. No	Subject	Topic	Answer
Q41	Atomic and Molecular Physics	"LS, JJ and other interactions"	**2**
Q42	Atomic and Molecular Physics	Bohar Model and h-atom model	**3**
Q43	Atomic and Molecular Physics	Bohar Model and h-atom model	**3**
Q44	Atomic and Molecular Physics	Zeeman effect	**3**
Q45	Atomic and Molecular Physics	Molecular physics	**Drop**
Q46	Atomic and Molecular Physics	Bohar Model and h-atom model	**1**
Q47	Atomic and Molecular Physics	Zeeman effect	**3**
Q48	Atomic and Molecular Physics	Molecular physics	**4**
Q49	Atomic and Molecular Physics	"LS, JJ and other interactions"	**1**
Q50	Atomic and Molecular Physics	Bohar Model and h-atom model	**4**
Q51	Atomic and Molecular Physics	"LS, JJ and other interactions"	**1**
Q52	Atomic and Molecular Physics	Molecular physics	**3**
Q53	Atomic and Molecular Physics	Molecular physics	**1**
Q54	Atomic and Molecular Physics	Xray and alkali spectra	**1**
Q55	Atomic and Molecular Physics	Bohar Model and h-atom model	**2**
Q56	Atomic and Molecular Physics	Lasers	**4**
Q57	Atomic and Molecular Physics	Molecular physics	**3**
Q58	Atomic and Molecular Physics	Doppler broadening	**3**
Q59	Atomic and Molecular Physics	Zeeman effect	**4**
Q60	Atomic and Molecular Physics	Lasers	**3**
Q61	Atomic and Molecular Physics	Lasers	**4**
Q62	Atomic and Molecular Physics	Zeeman effect	**3**
Q63	Atomic and Molecular Physics	Molecular physics	**2**

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