Atomic Structure

NET/JRF Previous Years' Question

Q1. The term symbol of molecule with electronic configuration **[NET JUNE 2011]**

$1\sigma_g^{\ 2}\ 1\sigma_u^{\ 2}\ 2\sigma_g^{\ 2}\ 2\sigma_u^{\ 2}\ 1\pi_u^{\ 1}\ 1\pi_u^{\ 1}$ Is:

(a) ${}^1\Sigma_g^+$ (b) ${}^3\Sigma_g^-$ (c) ${}^i\Sigma_g^-$ (d) ${}^3\Sigma_g^+$

Q2. The possible J values for ${}^3D$ term symbol are **[NET JUNE 2011]**

(a) 2 (b) 3 (c) 4 (d) 5

Q3. The term symbol for the ground state of nitrogen atoms is **[NET DEC. 2011]**

(a) ${}^3P_0$ (b) ${}^4P_{3/2}$ (c) ${}^1P_1$ (d) ${}^4S_{3/2}$

Q4. Observe the following electronic transition of a diatomic molecule. **[NET DEC. 2011]**

(a) ${}^1\Sigma_g^+ \rightarrow {}^3\Sigma_g^+$ (b) ${}^1\Sigma_u^+ \rightarrow {}^1\Sigma_g^+$ (c) ${}^1\Delta_u \rightarrow {}^1\Sigma_g^+$ (d) ${}^1\Pi_g \rightarrow {}^1\Sigma_u^+$

The allowed transitions are

(a) A and C only (b) B and D

(c) A , B and C only (d) A , C and D only

Q5. Which of the following is true for the radial part of the hydrogen atom wavefunctions $R_{n\ell}(r)$ (n principle quantum number) and the nodes associated with them? **[NET Dec. 2011]**

(a) The radial part of only S function is non-zero at the origin and has $n-1$ nodes.

(b) The radial part of S function is zero at the origin and have n number of nodes.

(c) All radial function have values of zero at the origin and have $n-1$ nodes.

(d) The radial parts of all S function are zero at the origin and have no nodes.

Q6. For hydrogen-like atom with a nuclear charge Z, the energy of orbital with principal quantum number 'n'' follows the relation. **[NET JUNE 2012]**

(a) $E_n \propto n^2Z^2$ (b) $E_n \propto -\frac{Z^2}{n}$ (c) $E_n \propto -\frac{Z}{n}$ (d) $E_n \propto -\frac{Z^2}{n^2}$

Q7. The set of allowed electronic transitions among the following is **[NET JUNE 2012]**

(A) ${}^4\Sigma \rightarrow {}^2\Pi$ (B) ${}^3\Sigma \rightarrow {}^3\Pi$ (C) ${}^1\Delta \rightarrow {}^1\Delta$ (D) ${}^2\Pi \rightarrow {}^2\Pi$ (E) ${}^3\Sigma \rightarrow {}^3\Delta$

(a) A, B, E (b) A, C, E (c) B, C, D (d) C, D, E

Q8. For an odd nucleon in 'g' nuclear orbital and parallel to I, spin and parity are **[NET DEC. 2012]**

(a) $9/2$ And $(+)$ (b) $7/2$ and $(+)$ (c) $9/2$ and $(-)$ (d) $7/2$ and $(-)$

Q9. The electric dipole allowed transition in a d^2 atomic system is **[NET DEC. 2012]**

(a) ${}^3F \to {}^1D$ (b) ${}^3F \to {}^1P$ (c) ${}^3F \to {}^3D$ (d) ${}^3F \to {}^3P$

Q10. In a many-electron atom, the total orbital angular momentum L and spin S are good quantum numbers instead of the individual orbital l_1, l_2 and spin s_1, s_2 angular momenta in the presence of

(a) Inter-electron repulsion (b) spin-orbit interaction **[NET DEC. 2012]**

(c) Hyperfine coupling (d) external magnetic fields

Q11. What is the atomic terms symbol for helium atom wit electronic configuration $1s^2$? **[NET JUNE 2013]**

(a) ${}^2S_{1/2}$ (b) ${}^1P_0$ (c) ${}^1S_0$ (d) ${}^1S_1$

Q12. The ground state term symbol for Nb (atomic number 41) is ${}^6D$. The electronic configuration corresponding to this term symbol is **[NET JUNE 2013]**

(a) $Kr\ 4d^3 5s^2$ (b) $Kr\ 4d^4 5s^1$ (c) $Kr\ 4d^5 5s^0$ (d) $Kr\ 4d^3 5s^{-1} 5p^1$

Q13. If a homonuclear diatomic molecule is oriented along the Z-axis, the molecular orbital formed by linear combination of p , orbitals of the two atoms is **[NET DEC. 2013]**

(a) σ (b) σ^* (c) π (d) δ

Q14. For an electronic configuration of two non-equivalent π electronic $\left[\pi^1, \pi^1\right]$, which of the following terms is not possible? **[NET DEC. 2013]**

(a) ${}^1\Sigma$ (b) ${}^3\Sigma$ (c) ${}^3\Delta$ (d) ${}^3\Phi$

Q15. The ground state forms of Sm^{3+} and Eu^{3+} respectively, are **[NET DEC. 2013]**

(a) ${}^7F_0$ And ${}^6H_{5/2}$ (b) ${}^6H_{5/2}$ and ${}^7F_0$ (c) ${}^2F_{5/2}$ and ${}^5I_4$ (d) ${}^7F_6$ and ${}^2F_{7/2}$

Q16. The term symbol that is NOT allowed for the np^2 configuration is **[NET JUNE 2014]**

(a) ${}^1D$ (b) ${}^3P$ (c) ${}^1S$ (d) ${}^3D$

Q17. If the ionization energy of H atoms is x, the ionization energy of Li^{2+}, is **[NET JUNE 2014]**

(a) $2x$ (b) $3x$ (c) $9x$ (d) $27x$

Q18. The S and L values for ${}^{15}N$ atom respectively, are **[NET DEC. 2014]**

(a) $\frac{1}{2}$ And 1 (b) $\frac{1}{2}$ and 0 (c) 1 and 0 (d) $\frac{3}{2}$ and 0

Q19. If $D_0(A)$ and $I\ A$ refer respectively to the dissociation energy and ionization potential of A (where A is either H, H_2 or H_2^+ species), the correct relation among the following is **[NET DEC. 2014]**

(a) $D_0\ H_2 = D_0\ H_2^{+} + I\ H - I\ H_2$ (b) $D_0\ H_2 = D_0\ H_2^{+} - I\ H + I\ H_2$

(c) $D_0\ H_2^{+} = D_0\ H_2 + I\ H + I\ H_2$ (d) $D_0\ H_2^{+} = D_0\ H_2 - I\ H - I\ H_2$

Q20. The configuration $Ne\ 2p^1 3p^1$ has a ^3D term. Its levels are **[NET DEC. 2014]**

(a) $^3D_{3/2}, {}^3D_{1/2}$ (b) $^3D_{5/2}, {}^3D_{3/2}, {}^3D_{1/2}$

(c) $^3D_3, {}^3D_2, {}^3D_1$ (d) $^3D_3, {}^3D_2, {}^3D_1, {}^3D_0$

Q21. The geometric cross-section (in barn) of nucleus $A = 125, r_0 = 1,4 \times 10^{-15}$ m approximately is **[NET DEC. 2014]**

(a) 1.05 (b) 1.54 (c) 2.05 (d) 2.54

Q22. Wavelength $(\lambda \text{ in nm})$ of the Lyman series for a one-electron is in the range $24 \le \lambda \le 30$. The ionization energy of the ion will be closest to $\left(1\int = \frac{10^{19}}{1.6} eV\right)$ **[NET DEC. 2014]**

(a) $32eV$ (b) $42eV$ (c) $52eV$ (d) $62eV$

Q23. The electric-dipole allowed transition among the following is **[NET June 2015]**

(a) $^3S \rightarrow {}^3D$ (b) $^3S \rightarrow {}^3P$ (c) $^3S \rightarrow {}^1D$ (d) $^3S \rightarrow {}^1F$

Q24. The lowest energy-state of an atom with electronic configuration $ns^1 np^1$ has the term symbol

(a) $^3P_1$ (b) $^1P_1$ (c) $^3P_2$ (d) $^3P_0$

Q25. The geometric cross section of ^{125}Sn (in barn) in nearly **[NET JUNE 2015]**

(a) 1.33 (b) 1.53 (c) 1.73 (d) 1.93

Q26. The term symbol for the first excited state of Be with the electronic configuration $1s^2 2s^1 3s^1$ is

(a) $^3S_1$ (b) $^3S_0$ (c) $^1S_0$ (d) $^2S_{1/2}$ **[NET JUNE 2015]**

Q27. The symmetry-allowed atomic transition among the following is **[NET DEC. 2015]**

(a) $^3F \rightarrow {}^1D$ (b) $^3F \rightarrow {}^3D$ (c) $^3F \rightarrow {}^1P$ (d) $^3F \rightarrow {}^3P$

Q28. Possible term symbol(s) of the excited states of Na atom with the electronic configuration $\left[1s^2 2s^2 2p^6 3p^1\right]$ is/are **[NET DEC. 2015]**

(a) $^2S_{1/2}$ (b) $^2P_{3/2}$ and $^2P_{1/2}$ (c) $^1S_0$ and $^1P_1$ (d) $^3P_0$ and $^3P_1$

Q29. The ionization energy of hydrogen atom in its ground states is approximately $13.6eV$. The potential energy of He^+, in its ground state is approximately **[NET JUNE 2016]**

(a) -54.4eV (b) -27.2eV (c) -13.6eV (d) -108.8eV

Q30. The first excited state of hydrogen molecule is **[NET JUNE 2016]**

(a) ${}^1\Sigma_g^+$ (b) ${}^1\Sigma_u^-$ (c) ${}^3\Sigma_g^-$ (d) ${}^3\Sigma_u^+$

Q31. The lowest energy term for the d^6 configuration is **[NET June 2016]**

(a) ${}^2\text{D}$ (b) ${}^5\text{D}$ (c) ${}^1\text{P}$ (d) ${}^1\text{D}$

Q32. A constant of motion of hydrogen atom in the presence of spin-orbit coupling is **[NET Dec. 2016]**

(a) ℓ (b) S (c) $\ell + \text{s}$ (d) $\ell - \text{s}$

Q33. The highest molecular orbitals for an excited electronic configuration of the oxygen molecule are $\left[1\pi_g\right]^1 3\sigma_u{}^1$. A possible molecular term symbol for oxygen with this electronic configuration is **[NET Dec. 2016]**

(a) ${}^1\pi$ (b) ${}^3\sum$ (c) ${}^1\Delta$ (d) ${}^1\sum$

Q34. The transition that belongs to the Lyman series in the hydrogen-atom spectrum is **[NET Dec. 2016]**

(a) $1\text{s} \leftarrow 4\text{s}$ (b) $1\text{s} \leftarrow 4\text{p}$ (c) $2\text{s} \leftarrow 4\text{s}$ (d) $2\text{s} \leftarrow 4\text{p}$

Q35. For the electronic configuration $1\text{s}^2 2\text{s}^2 2\text{p}^4$, two of the possible term symbols are ${}^1\text{S}$ and ${}^3\text{P}$. The remaining term is **[NET June 2017]**

(a) ${}^1\text{D}$ (b) ${}^1\text{F}$ (c) ${}^3\text{D}$ (d) ${}^3\text{F}$

Q36. The total degeneracy of the ground term of CO^{II} (high spin) in octahedral geometry is **[NET June 2018]**

(a) 18 (b) 12 (c) 28 (d) 9

Q37. The term symbol for the ground state of B_2 is **[NET June 2018]**

(a) ${}^1\Sigma_g^+$ (b) ${}^1\Sigma_g^-$ (c) ${}^3\Sigma_g^-$ (d) ${}^3\Sigma_g^+$

Q38. The lowest energy state of a $1s^1 2s^1$ electronic configuration, according to Hund's rule is

(a) ${}^3\text{S}_0$ (b) ${}^1\text{S}_0$ (c) ${}^3\text{S}_1$ (d) ${}^1\text{S}_1$ **[NET June 2018]**

Q39. The allowed electronic transition in fluorine molecule is

(a) $\Sigma_g^+ \to \Sigma_g^+$ (b) $\Sigma_g^+ \to \Sigma_g^-$ (c) $\Sigma_g^+ \to \Pi_u$ (d) $\Sigma_g^+ \to \Delta_u$

Q40. The spectrum of sodium atom has a closely separated doublet at 16956.2 and 16973.4 cm $^{-1}$. The higher energy transition is due to **[NET Dec. 2018]**

(a) ${}^2\text{P}_{3/2} \to {}^2\text{S}_{1/2}$ (b) ${}^2\text{P}_{1/2} \to {}^2\text{S}_{1/2}$ (c) ${}^2\text{P}_{3/2} \to {}^2\text{P}_{1/2}$ (d) ${}^2\text{S}_{1/2} \to {}^2\text{P}_{3/2}$

Answer Key

1. (b)	2. (b)	3. (d)	4. (b)	5. (a)	6. (d)	7. (c)
8. (a)	9. (c)	10. (a)	11. (c)	12. (b)	13. (c)	14. (d)
15. (b)	16. (d)	17. (c)	18. (d)	19. (b)	20. (c)	21. (b)
22. (c)	23. (b)	24. (d)	25. (b)	26. (a)	27. (b)	28. (b)
29. (d)	30. (d)	31. (b)	32. (c)	33. (a)	34. (b)	35. (a)
36. (c)	37. (c)	39. (c)	40.(a)			

GATE Previous Years' Question

Q1. $^{3}P_{3/2}$ Is the ground state of **[GATE 2000]**

(a) H (b) Li (c) B (d) F

Q2. The ground state of aluminium atoms is **[GATE 2002]**

(a) $^{2}P_{1/2}$ (b) $^{2}P_{3/2}$ (c) $^{4}D_{5/2}$ (d) $^{4}S_{3/2}$

Q3. The ground state term symbol for p^3 and d^3 electronic configuration respectively, are

[GATE 2002]

(a) ^{4}S and ^{4}F (b) ^{4}D and ^{4}F (c) ^{1}D and ^{4}F (d) ^{4}S and ^{2}G

Q4. The ground state term of V^{3+} ion is **[GATE 2007]**

(a) ^{3}F (b) ^{2}F (c) ^{3}P (d) ^{2}D

Q5. For a homonuclear diatomic molecule, the bonding molecular orbital is **[GATE 2007]**

(a) σ_u Of lowest energy (b) σ_u of second lowest energy

(c) π_g Of lowest energy (d) π_u of lowest energy

Q6. If Δy and ΔP_y are the uncertainties in the y-coordinate and the y component of the momentum of a Particle respectively, then, according to uncertainty principle $\Delta y \, \Delta P_y$ is

$\left(\hbar = \dfrac{h}{2\pi} \text{ and h is Planck's constant}\right)$ **[GATE 2012]**

(a) $\geq \hbar$ (b) $> \hbar/2$ (c) $> \hbar$ (d) $\geq \hbar/2$

Q7. Choose the allowed transition **[GATE 2012]**

(a) $^{1}\Sigma_{g}^{+} \rightarrow ^{3}\Sigma_{u}^{+}$ (b) $^{1}\Sigma_{g}^{+} \rightarrow ^{3}\Sigma_{u}^{-}$ (c) $^{1}\Sigma_{g}^{+} \rightarrow ^{1}\Sigma_{u}^{+}$ (d) $^{1}\Sigma_{g}^{+} \rightarrow ^{1}\Sigma_{u}^{-}$

Q8. Let ϕ_x^C and ϕ_z^C denote the wavefunctions of the $2p_x$ and $2p_z$ orbitals of carbon, respectively, and ϕ_x^0 and ϕ_z^0 represent the wavefunction of the $2p_x$ and $2p_z$ orbitals of oxygen, respectively. If C_1 and C_2 are constants used in linear combination and the CO molecule is oriented along the z axis than, according to molecular orbital theory, the $\pi-$bonding molecular orbital has a wavefunction given by **[GATE 2012]**

(a) $C_1\phi_z^C + C_2\phi_x^0$ (b) $C_1\phi_z^C + C_2\phi_z^0$ (c) $C_1\phi_x^C + C_2\phi_z^0$ (d) $C_1\phi_x^C + C_2\phi_x^0$

Q9. The value of the magnetic quantum number of a p_x orbitals **[GATE 2014]**

(a) -1 (b) 0 (c) $+1$ (d) undefined

Answer Key

1. (d) 2. (d) 3. (a) 4. (a) 5. (d) 6. (d) 7. (c)

8. (d) 9. (d)

TIFR Previous Years' Question

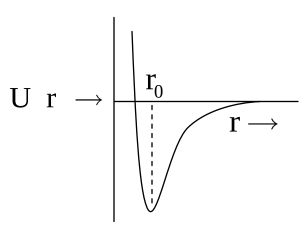
Q1. What terms can arise from the configuration $2p^1 3p^1$? **[TIFR 2013]**

(a) $^3D, ^1D, ^3P, ^1P, ^3S, ^1S$ (b) $^3D, ^3P, ^3S$

(c) $^1D, ^1P, ^1S$ (d) $^1D, ^3P, ^3S$

Q2. The potential energy of a diatomic molecule, as a function of the internclear separation r, is approximated as $U(r) = \frac{A}{r^a} - \frac{B}{r^b}$ **[TIFR 2014]**

Where A and B are positive constants and $a > b$

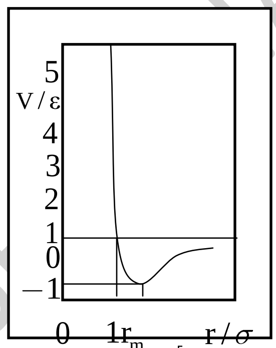


As shown in the above figure, r_0 is the equilibrium bond length, what is the energy necessary to break the bond from its equilibrium position?

(a) $\frac{A}{r_0^a} - \frac{B}{r_0^b}$ (b) $\frac{B}{r_0^b} - \frac{C}{r_0^a}$ (c) $\frac{A}{r_0^a}\left(\frac{a}{b} - 1\right)$ (d) both (b) and (c)

Q3. The short-ranged intermolecular interactions are often described by the Lennard-Jones potential $V(r) = 4\varepsilon\left[(\sigma/r)^{12} - (\sigma/r)^{6}\right]$, which gives the internal energy of interaction between two molecules as a function of intermolecular separation. Here is the depth of the potential well, σ is the finite distance at which the potential reaches its minimum. At r_m, the potential function has the value - ε. **[TIFR 2019]**

If you would like to express the same potential energy function in terms of r_m and ε, the function should be



(a) $V(r) = \varepsilon\left[(r_m/r)^{12} - 2(r_m/r)^{6}\right]$ (b) $V(r) = \varepsilon\left[(r_m/r)^{12}\right]$

(c) $V(r) = 4\varepsilon\left[(r_m/r)^{12} - (r_m/r)^{6}\right]$ (d) $V(r) = \varepsilon\left[2(r_m/r)^{12} - (r_m/r)^{6}\right]$

Answer Key

1. (a) 2. (d) 3. (*)

Other Examinations Previous Years' Question

Q1. A $3p$ atomic orbital has

(a) One radial node and one angular node (b) two angular nodes

(c) One angular node (d) one radial node.

Q2. The ground term symbol of the metal ion present in hemoglobin is

(a) ${}^1S_0$ (b) ${}^5D_4$ (c) ${}^5D_{3/2}$ (d) ${}^5D_0$

Q3. The energies of the $1s$ orbital in H, He^{+} and Li^{2+} are in the ratio,

(a) $H : He^{+} : Li^{2+} = 1:1:1$ (b) $H : He^{+} : Li^{2+} = 1:2:3$
(c) $H : He^{+} : Li^{2+} = 1:4:9$ (d) $H : He^{+} : Li^{2+} = 1:1/4:1/9$

Q4. The number of radial nodes in the $4s$ orbital of the $H-$atom in a finite distance from the nucleus is:

(a) 6 (b) 4 (c) 2 (d) 3

Q5. The possible J values for ^{3}D terms symbol are

(a) 2 (b) 3 (c) 4 (d) 5

Q6. The number of nodes that π^{*} orbital in $CH_2 = CH_2$ is

(a) 1 (b) 2 (c) 3 (d) 0

Q7. The effective nuclear charge Z^{*} for the $1s$ electron of $_{8}O$ according Slater's rules is nearly.

(a) 4.55 (b) 3.45 (c) 7.65 (d) 5.45

Q8. For a one-electron atom with nuclear charge Z, the speed v_n of the electron in some n-th stationary orbit satisfies

(a) $v_n \propto Z$ (b) $v_n \propto Z^{2}$ (c) $v_n \propto Z^{-1}$ (d) $v_n \propto Z^{-2}$

Q9. If the ionization energy of hydrogen atom is $13.6 eV$, the expected third ionization energy of the lithium atom is:

(a) $13.6 \times 3 eV$ (b) $13.6 \times 2 eV$ (c) $13.6 \times 6 eV$ (d) $13.6 \times 9 eV$

Q10. The orbital angular momentum (in units of $h/2\pi$ where h is the Planck's constant) of an electron in the $3d$ orbital is

(a) 2 (b) 3 (c) $2^{1/2}$ (d) $6^{1/2}$

Q11. A $1s$ orbital refers to

(a) A circular track in an atom in which an electron travels.

(b) A one electron wave function

(c) An observable property of the system.

(d) A Hermitian operator.

Q12. As per the uncertainty principle, $\Delta x . \Delta p_y$ =

(a) h (b) $h/2\pi$ (c) λ (d) zero

Q13. The ionisation potential of hydrogen atom is $13.6 eV$. The first ionisation potential of a sodium atoms. Assuming that the energy of its outer electron can represented by a $H-$atom like model with an effective nuclear charge of 1.84, is

(a) $46.0 eV$ (b) $11.5 eV$ (c) $5.1 eV$ (d) $2.9 eV$

Q14. The lowest energy state of the $1s^2\ 2s^1\ 3s^1$ configuration of Be is

(a) $^1S_0$ (d) $^1D_2$ (c) $^3S_1$ (d) $^3P_1$

Q15. The atomic term symbol for the helium atom in its ground state is

(a) $^3S_1$ (d) $^3P_2$ (c) $^3S_0$ (d) $^1S_0$

Q16. The energy of a 355nm photon can be converted to the wave number equal to

(a) $21171 cm^{-1}$ (b) $21269 cm^{-1}$ (c) $21160 cm^{-1}$ (d) $28169 cm^{-1}$

Q17. When a hydrogen atoms is placed in an electric field along the $y-$ axis, the orbital that mixes most with the ground state 1s orbital is

(a) 2s (b) $2p_x$ (c) $2p_y$ (d) $2p_x$

Q18. The term symbol that is NOT allowed for the np^2 configuration is

(a) ^1D (b) ^3P (c) ^1S (d) ^3D

Q19. The term symbol for the ground state of nitrogen atoms is

(a) $^3P_0$ (b) $^4P_{3/2}$ (c) $^1P_1$ (d) $^4S_{3/2}$

Q20. The orbital with two radial and two angular nodes is?

(a) 3p (b) 5d (c) 5f (d) 8d

Q21. Which of the following molecular orbitals has two nodal planes?

(a) $\sigma_{2s\ g}$ (b) $\pi_{2p_x\ u}$ (c) $\pi_{2p_x\ g}$ (d) $\sigma_{2p_x\ g}$

Q22. In the presence of external magnetic field the transitions $^3D_1 \longrightarrow {}^3P_1$ splits into

(a) 3 (b) 5 (c) 7 (d) 9

Answer Key

1. (a)	2. (b)	3. (c)	4. (d)	5. (b)	6. (b)	7. (c)
8. (a)	9. (d)	10. (d)	11. (b)	12. (d)	13. (a)	14. (c)
15. (d)	16. (d)	17. (c)	18. (a)	19. (d)	20. (b)	21. (c)
22. (d)						