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IIT-JAM BIOTECHNOLOGY

ATOMIC STRUCTURE

PART A: IIT-JAM PREVIOUS YEARS QUESTION

1. If the ionization energy of H is 13.59 eV, then the ionization energy of He^+ will be **[JAM 2005]**

   (a) 13.59 eV (b) 27.18 eV (c) $(13.59)^2$ eV (d) 54.36 eV

2. The average distance of an electron from the nucleus in the ground state of hydrogen atom (in units of Bohr radius a_0) is **[JAM 2005]**

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

3. The ionization energy of a hydrogen atom is 13.6 eV. The first excitation potential of the hydrogen atom is **[JAM 2006]**

   (a) higher than 13.6 eV (b) lower than 13.6 eV

   (c) same (d) twice the ionization energy

4. The set of quantum numbers, $n = 2, l = 2, m = 0$ **[JAM 2007]**

   (a) is forbidden

   (b) describes an electron in a 2*d* orbital

   (c) describes an electron in a 2*p* orbital

   (d) describes one of the five orbitals of similar type

5. A hydrogen atom in the 3rd excited state can have **[JAM 2007]**

   (a) 3 Lyman, 2 Balmer and 1 Paschen transitions

   (b) 2 Balmer and 1 Paschen transitions

   (c) 2 Lyman and 1 Paschen transitions

   (d) 2 Lyman, 3 Balmer and 1 Paschen transitions

6. The ionization energy for a hydrogen atom in its first excited state ($n = 2$) is **[JAM 2008]**

   (a) 13.6 eV (b) 3.4 eV (c) –3.4 eV (d) –13.6 eV

7. de-Broglie wavelengths of two electrons which start from rest and accelerated by potentials V and 4V are λ_1 and λ_2 respectively. The ratio $\lambda_1 : \lambda_2$ is **[JAM 2008]**

   (a) 1 : 2 (b) 1 : 4 (c) 2 : 1 (d) 4 : 1

8. The difference in the number of nodes for the quantum numbers $n = 4$ and $n = 1$, for a 1 – D box is

   (a) 1 (b) 2 (c) 3 (d) 4 **[JAM 2011]**

9. The series that corresponds to transition from higher levels to $n = 4$ in the hydrogen spectrum is **[JAM 2012]**

   (a) Paschen (b) Balmer (c) Pfund (d) Brackett

10. The radius of first "Bohr's stationary orbit" for hydrogen atom is 0.53Å. The radius of the second orbit is **[JAM 2013]**

    (a) 1.06Å (b) 1.59Å (c) 2.12Å (d) 4.24Å

11. Calculate the wavelength of the alpha particle, if its mass = 6.6×10^{-27} kg and velocity = 2×10^{7} m/s. Assume Planck's constant $h = 6.6 \times 10^{-34}$ Js. **[JAM 2013]**

(a) 5.0×10^{-12} m (b) 5.0×10^{-13} m (c) 5.0×10^{-14} m (d) 5.0×10^{-15} m

12. Calculate the wavelength of the alpha particle, if its mass = 6.6×10^{-27} kg and velocity = 2×10^{7} m/s. Assume Planck's constant $h = 6.6 \times 10^{-34}$ Js. **[JAM 2013]**

(a) 5.0×10^{-12} m (b) 5.0×10^{-13} m (c) 5.0×10^{-14} m (d) 5.0×10^{-15} m

13. If an atomic orbital has 2 radial nodes and 1 angular node, it is a **[JAM 2014]**

(a) 2*p* orbital (b) 3*d* orbital (c) 3*p* orbital (d) 4*p* orbital

14. The postulates of Bohr's theory of the atom are **[JAM 2014]**

(I) Electrons move in stable circular orbits around the nucleus

(II) Electrons may absorb light of specific energy and be excited to higher energy states

(III) Angular momentum of electrons in stable orbits is quantized

(IV) Angular momentum of electrons in stable orbits is uncertain

(a) I, II, III and IV (b) I and II (c) I, II and III (d) I, II and IV

15. The speed of an electron (v), in the lowest energy orbit in the Bohr model of the Hydrogen atom divided by the speed of light in vacuum (c), is given by (where m is the mass of the electron, M is the mass of proton, ε_0 is the permittivity of free space, a_0 is the Bohr radius) **[JAM 2015]**

(a) $\frac{v}{c} = \frac{1}{4\pi\varepsilon_0}\frac{e^2}{\hbar c}$ (b) $\frac{v}{c} = \frac{e^4}{32\pi^2\varepsilon_0^2\hbar^2c^2}$ (c) $\frac{v}{c} = \frac{m}{M}$ (d) $\frac{v}{c} = \frac{\hbar}{mca_0}$

16. An alpha particle and a proton have the same de Broglie wavelength. Which of the following is also the same for the two particles if they are moving at non-relativistic speeds? **[JAM 2016]**

(a) Frequency (b) Kinetic energy (c) Momentum (d) Speed

17. Two sources P and Q produce electromagnetic waves with wavelength λ and 2λ, respectively. Source P ejects a photon with a maximum kinetic energy of 4.0 eV from a metal with work function 2.0 eV. The maximum kinetic energy (eV) of a photon ejected by source Q from the same metal is _____ **[JAM 2017]**

18. An X-ray tube operates at 30kV. If one electron converts 10% of its energy into a photon at first collision, then the wavelength of the photon (correct to two decimal places) is _____Å.
[$h = 4.14 \times 10^{-15}$ eVs^{-1}, $c = 3 \times 10^{3}$ ms^{-1} and $e = 1.6 \times 10^{-19}$C] **[JAM 2017]**

19. The orbital angular momentum of hydrogen atom in the ground state is _____.

(a) 0 (b) $\frac{h}{2\pi}$ (c) $\frac{h}{2}$ (d) h **[JAM 2019]**

20. The vibrational frequency (expressed in wavenumber) of $^{1}H^{35}Cl$ is 2990.6 cm^{-1}. Assuming that the force constant is same in both the cases, vibrational frequency (in cm^{-1}) of $^{2}D^{35}Cl$ is _____ **[JAM 2020]**

21. Energy of the electron in hydrogen atom in its ground state is 13.6 eV. The energy required (in eV) to move the electron from its ground state to the first excited state, rounded off to TWO decimal places, is ____ **[JAM 2020]**

22. The de Broglie wavelength of a proton moving at a speed of 1.0 m/s is _____Å.
[Planck's constant = 6.626×10^{-34} m^2 kg/s; $m_p = 1.67 \times 10^{-27}$ kg] **[JAM 2021]**

23. The potential difference to accelerate an electron was quadrupled. By what factor does the *de Broglie* wavelength of the electron beam change_____ **[JAM 2022]**

PART B: JNU PREVIOUS YEARS QUESTION

1. The quantum numbers n, l, m_1 and m_s for the two electrons of the helium atom in its ground state are

(a) $1, 0, 0, \frac{1}{2}$ (b) $1, 0, 0, -\frac{1}{2}$ (c) $1, 0, 0, \pm\frac{1}{2}$ (d) $1, 1, 0, \pm\frac{1}{2}$ **[JNU-2003]**

for both the electrons.

2. The amount of energy required to remove an electron from $n = 2$ state of the hydrogen atom is
(a) 27·2 eV (b) 13·6 eV (c) 6·8 eV (d) 3·4 eV **[JNU-2003]**

3. The work function of a substance is 4·0 eV. The longest wavelength of light that can cause photoelectron emission from the substance is approximately **[JNU-2003]**
(a) 540 nm (b) 400 nm (c) 310 nm (d) 220 nm

4. Which of the following has the smallest de Broglie wavelength? **[JNU-2004]**
(a) Electron (b) Proton
(c) A molecule of methane (d) A molecule of carbon dioxide

5. The work function of a photoelectric material is 3.3 eV; the threshold frequency will be equal to
(a) 8×10^{4} Hz (b) 8×10^{56} Hz (c) 8×10^{10} Hz (d) 8×10^{14} Hz **[JNU-2005]**

6. The ionization energy for a hydrogen atom is 13.6 eV. The energy of the third lowest electronic level in doubly ionized lithium is **[JNU-2006]**
(a) –13.6 eV (b) –30.60 eV (c) –54.4 eV (d) –122.40 eV

7. Four quantum numbers n, l, m_l, m_s of four energy states of *p*-subshell of *M*-shell are as follows. Which one is wrong combination? **[JNU-2006]**

(a) 3 1 1 1/2
3 1 0 1/2
3 1 1 1/2
3 1 0 –1/2

(b) 3 1 1 1/2
3 1 –1 –1/2
3 1 0 1/2
3 1 0 –1/2

(c) 3 1 0 1/2
3 1 1 1/2
3 1 –1 1/2
3 1 –1 –1/2

(d) 3 1 1 1/2
3 1 –1 1/2
3 1 0 1/2
3 1 1 –1/2

8. Which of the following sets of quantum numbers is an impossible combination? **[JNU-2007]**
(a) *n*- 3, *l*- 2, *m*- –2, *s*- +1/2 (b) *n*- 4, *l*- 0, *m*- 0, *s*- +1/2
(c) *n*- 3, *l*- 2, *m*- –3, *s*- +1/2 (d) *n*- 5, *l*- 3, *m*- 0, *s*- –1/2

9. A neutral atom has two electrons in $n = 1$, eight electrons in $n = 2$ and six electrons in $n = 3$ level. The number of *d* electrons present in the atom is **[JNU-2007]**
(a) six (b) four (c) one (d) zero

10. Balmer series arises in the hydrogen spectrum due to electron transitions in the atom from
(a) $n = 3, 4, 5, 6, 7$ to $n = 2$ (b) $n = 2, 3, 4, 5, 6, 7$ to $n = 1$ **[JNU-2007]**
(c) $n = 4, 5, 6, 7$ to $n = 3$ (d) $n = 5, 6, 7, 8$ to $n = 4$

11. The normal Zeeman splitting of the cadmium red line of 6438 Å when the atoms are placed in a magnetic field of 0.009 tesla is **[JNU-2007]**
(a) 1.74×10^{-3} Å (b) 2.43×10^{-3} Å (c) 4.62×10^{-4} Å (d) 2.59×10^{-2} Å

12. Which of the following metals exhibits photoelectric effect readily? **[JNU-2008]**
(a) Cs (b) Na (c) Li (d) Mg

13. Sodium and copper have work function 2.3 eV and 4.5 eV respectively. Then the ratio of the threshold wavelength is nearest to **[JNU-2008]**
(a) 1 : 1 (b) 2 : 1 (c) 4 : 1 (d) 1 : 4

14. Which of the following has largest de-Broglie wavelength provided all have equal velocity?
(a) O_2 (b) NH_3 (c) SO_2 (d) N_2 **[JNU-2008]**

15. If the second Bohr's radius of hydrogen atom is $4\,a_0$, then the radius of the fifth Bohr's orbit in hydrogen atom is **[JNU-2009]**
(a) $5\,a_0$ (b) $10\,a_0$ (c) $20\,a_0$ (d) $25\,a_0$

16. If the kinetic energy of a free electron doubles, its de Broglie wavelength changes by the factor
(a) 2 (b) 1/2 (c) $\sqrt{2}$ (d) $1/\sqrt{2}$ **[JNU-2009]**

17. A moving electron has energy 728 eV. Its velocity is **[JNU-2009]**
(a) 728 m/sec (b) 1.6×10^{10} m/sec (c) 1.6×10^{7} m/sec (d) None of these

18. According to Schrodinger, a particle is equivalent to **[JNU-2009]**
(a) wave packet (b) single wave (c) light wave (d) It is not a wave

19. Region of near IR is **[JNU-2009]**
(a) 0.8 to 2.5μ (b) 2.5 to 15μ (c) 15 to 200μ (d) None of these

20. The size of nucleus of an atom is of the order of (in cm) **[JNU-2009]**
(a) 10^{-8} (b) 10^{-13} (c) 10^{-4} (d) 10^{-6}

21. The maximum number of electron in 5*f* sublevel is **[JNU-2009]**
(a) 14 (b) 18 (c) 32 (d) 36

22. The spectrum resulting from blackbody radiation is **[JNU-2010]**
(a) line spectrum (b) continuous spectrum
(c) band spectrum (d) line as well as band spectrum

23. Splitting of spectral lines in an electric field is known as **[JNU-2010]**
(a) Zeeman effect (b) Compton effect (c) Stark effect (d) Bohr effect

24. The order of radius of the nucleus of an atom is **[JNU-2011]**
(a) 10^{-10} m (b) 10^{-12} m (c) 10^{-15} m (d) 10^{-17} m

25. For the explanation of the atomic structure, Bohr used **[JNU-2011]**
(a) quantization of linear momentum (b) quantization of angular momentum
(c) quantization of frequency (d) quantization of energy

26. Normal Zeeman effect is due to **[JNU-2011]**
(a) strong electric field (b) strong magnetic field
(c) weak electric field (d) weak magnetic field

27. In the Bohr model of the atom, if the radius of electrons's orbit in the ground state is a_0, the radius of the orbit of the n = 3 level is **[JNU-2012]**
(a) $2a_0$ (b) $3a_0$ (c) $4a_0$ (d) $9a_0$

28. The de Broglie wavelength of a particle of mass m and velocity v is **[JNU-2012]**
(a) h/mv (b) hmv (c) mh/v (d) m/hv

29. The presence of three unpaired electrons in 2p orbital of nitrogen follows **[JNU-2012]**
(a) Heisenberg uncertainty principle (b) Aufbau principle
(c) Hund rule (d) Pauli exclusion principle

30. de Broglie wavelength of an electron moving with a velocity of 5.3×10^{6} m/s (mass of electron $= 9.1\times10^{-31}$ kg and Planck's constant $= 6.6\times10^{-34}$ J s) is **[JNU-2013]**
(a) 0.0137 Å (b) 0.137 Å (c) 1.37 Å (d) 13.7 Å

31. Calculate the energy in kcal per mole associated with a radiation of a wavelength 300 nm $\left(h = 1.58\times10^{-37}\text{ kcal-s}, c = 3.0\times10^{8}\text{ m s}^{-1}\right)$. **[JNU-2014]**
(a) 90.49 (b) 94.09 (c) 99.04 (d) 109.49

32. The magnetic quantum number is related to **[JNU-2014]**
(a) size (b) shape (c) orientation (d) spin

33. When yellow light is incident on a surface, no electrons are emitted while green light can emit. If blue light is incident on the surface, then **[JNU-2014]**
(a) no electrons are emitted
(b) electrons of the same energy as when green light was incident are emitted
(c) electrons of higher energy are emitted
(d) electrons of lower energy are emitted

34. The ionization enthalpy of hydrogen atom is 1.312×10^{6} J mol^{-1}. The energy required to excite the electron in the atom from n = 1 to n = 2 is **[JNU-2014]**
(a) 8.51×10^{5} J mol^{-1} (b) 6.56×10^{5} J mol^{-1} (c) 7.56×10^{5} J mol^{-1} (d) 9.84×10^{5} J mol^{-1}

35. For photoelectric effect to occur, the incident light should **[JNU-2015]**
(a) have high intensity (b) have minimum threshold frequency
(c) satisfy both (a) and (b) (d) fall on the object for longer time

36. The light of wavelength 5000 Å falls on a sensitive plate of work function 1.9 eV. The kinetic energy of emitted photoelectrons is given by **[JNU-2015]**
(a) 0.938×10^{-16} J (b) 0.938×10^{-19} J (c) 0.938×10^{-22} J (d) 2.002×10^{-16} J

37. The valence electron of $^{63}_{29}$Cu lies in the **[JNU-2016]**
(a) K shell (b) M shell (c) N shell (d) L shell

38. Suppose that in hydrogen atom the electron is in the $n = 2$ state. The minimum energy (in eV) required to produce a H^+ ion will be **[JNU-2016]**

(a) 27.2 (b) 13.6 (c) 6.8 (d) 3.4

39. Number of *f* orbitals are **[JNU-2016]**

(a) 5 (b) 3 (c) 7 (d) 14

40. The relation between energy (E) and wavelength (λ) is **[JNU-2016]**

(a) $E = hc/\lambda$ (b) $E = h/\lambda$ (c) $E = hc\lambda$ (d) $E = hc/\lambda^2$

Answer Key

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1. (d)	**2. (c)**	**3. (b)**	**4. (a)**	**5. (a)**	**6. (b)**	**7. (c)**
8. (c)	**9. (d)**	**10. (c)**	**11. (d)**	**12. (d)**	**13. (d)**	**14. (c)**
15. (d)	**16. (c)**	**17. (1ev)**	**18. (4.14 Å)**	**19. (a,b)**	**20. (2143.80)**	
21. (10.20)	**22. (3967.66)**	**23. (0.5)**				

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1. (c)	**2. (d)**	**3. (c)**	**4. (d)**	**5. (d)**	**6. (a)**	**7. (a)**
8. (c)	**9. (d)**	**10. (a)**	**11. (a)**	**12. (a)**	**13. (b)**	**14. (b)**
15. (d)	**16. (d)**	**17. (c)**	**18. (a)**	**19. (a)**	**20. (b)**	**21. (a)**
22. (b)	**23. (c)**	**24. (c)**	**25. (b)**	**26. (d)**	**27. (d)**	**28. (a)**
29. (c)	**30. (c)**	**31. (b)**	**32. (c)**	**33. (c)**	**34. (d)**	**35. (b)**
36. (b)	**37.(c)**	**38. (d)**	**39.(c)**	**40. (a)**		