OBJECTIVE QUESTIONS

1. An electron in an atom jumps in such a way that its kinetic energy changes from x to $x/4$. The change in potential energy will be :

   (a) $+\frac{3}{2}x$ (b) $-\frac{3}{8}x$ (c) $+\frac{3}{4}x$ (d) $-\frac{3}{4}x$

2. The potential energy of an electron in the hydrogen atom is –6.8 eV. Indicate in which excited state, the electron is present?

   (a) First (b) Second (c) Third (d) Fourth

3. What is the potential energy of an electron in N shell of the Be^{3+} ion?

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

4. The kinetic and potential energies (in eV) of electron present in the third Bohr's orbit of hydrogen atom are, respectively:

   (a) –1.51, –3.02 (b) 1.51, –3.02 (c) –3.02, 1.51 (d) 1.51, –1.51

5. The distance between 4th and 3rd Bohr orbits of He^+ is:

(a) 2.645×10^{-10} m (b) 1.322×10^{-10} m

(c) 1.851×10^{-10} m (d) none of these

6. An electron travels with a velocity of x m/s. For a proton to have the same de Broglie wavelength, the velocity will be approximately:

(a) $\frac{1840}{x}$ (b) $\frac{x}{1840}$ (c) $1840x$ (d) $x0$

7. According to Bohr's atomic theory, which of the following is correct?

(a) Potential energy of electron $\propto Z^2/n^2$

(b) The product of velocity of electron and principle quantum number $(n) \propto Z^2$

(c) Frequency of revolution of electron in an orbit $\propto Z^2/n^3$

(d) Coulombic force of attraction on the electron $\propto Z^2/n^2$

8. If an electron is traveling at 200 m/s within 1 m/s uncertainty, what is the theoretical uncertainty in its position in µm (micrometer)?

(a) 14.5 µm (b) 29 µm (c) 58 µm (d) 114 µm

9. For which of the following sets of quantum numbers, an electron will have the highest energy?

	n	l	m	s
(a)	3	2	1	–1/2
(b)	4	3	–1	+1/2
(c)	4	1	–1	+1/2
(d)	5	0	0	–1/2

10. The ratio of $(E_2 - E_1)$ to $(E_4 - E_3)$ for He^+ ion is approximately equal to (where E_n is the energy of nth orbit):

(a) 10 (b) 15 (c) 17 (d) 12

11. If the binding energy of 2nd excited state of a hydrogen-like sample is approximately 24 eV, then the ionization energy of the sample is approximately:

(a) 54.4 eV (b) 24 eV (c) 122.3 eV (d) 216 eV

12. The ionization energy of H atom is 21.79×10^{-19} J. The value of binding energy of the second excited state of Li^{2+} ion:

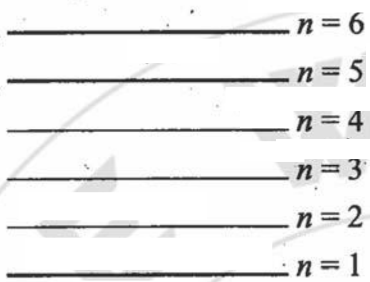
(a) $3^2 \times 21.7 \times 10^{-19}$ J (b) 21.79×10^{-19} J

(c) $\frac{1}{3} \times 21.79 \times 10^{-19}$ J (d) $\frac{1}{3^2} \times 21.79 \times 10^{-19}$ J

13. The wave number of the first line in the Balmer series of hydrogen is 15200 cm^{-1}. What would be the wave number of the first line in the Lyman series of the Be^{3+} ion?

(a) $2.4 \times 10^5\ cm^{-1}$ (b) $24.3 \times 10^5\ cm^{-1}$
(c) $6.08 \times 10^5\ cm^{-1}$ (d) $1.313 \times 10^6\ cm^{-1}$

14. What would be the maximum number of emission lines for atomic hydrogen that you would expect to see with the naked eye if the only electronic energy levels involved are those as shown in the figure?



(a) 4 (b) 6 (c) 5 (d) 15

15. The de Brogile wavelength of an electron moving in a circular orbit is λ. The minimum radius of orbit is:

(a) $\frac{\lambda}{\pi}$ (b) $\frac{\lambda}{2\pi}$ (c) $\frac{\lambda}{4\pi}$ (d) $\frac{\lambda}{3\pi}$

16. An electron, practically at rest, is initially accelerated through a potential difference of 100 V. It then has de Broglie wavelength equal to λ_1 Å. It then gets retarded through 19 V and then has a wavelength λ_2 Å. A further retardation through 32 V changes the wavelength to λ_3. Calculate $(\lambda_3 - \lambda_2)/\lambda_1$.

(a) $\frac{20}{41}$ (b) $\frac{10}{63}$ (c) $\frac{20}{63}$ (d) $\frac{10}{41}$

17. Uncertainty in position of a hypothetical subatomic particle is 1 Å and uncertainty in velocity is $(3.3/4\pi) \times 10^5$ m/s, then the mass of the particle is approximately [$h = 6.6 \times 10^{-34}$ Js]:

(a) 2×10^{-28} kg (b) 2×10^{-27} kg
(c) 2×10^{-29} kg (d) 4×10^{-29} kg

18. What is the total spin value in case of $_{26}Fe^{3+}$ ion?

(a) +1 or –1 (b) +2 or –2 (c) +2.5 or – 2.5 (d) +3 or –3

19. The fraction of volume occupied by the nucleus with respect to the total volume of an atom is:

(a) 10^{-15} (b) 10^{-5} (c) 10^{-30} (d) 10^{-10}

20. Electromagnetic radiations of wavelength 242 nm are just sufficient to ionize sodium atom. Then the ionization energy of sodium in kJ/mol is:

(a) 494.65 (b) 400 (c) 247 (d) 600

21. If a bulb of 40 W is producing a light of wavelength 620 nm with 80% of efficiency, then the number of photons emitted by the bulb in 20 s are (1 eV = 1.6 10^{-19} J, hc = 12400 eV Å):

(a) 2×10^{18} (b) 10^{18} (c) 10^{21} (d) 2×10^{21}

22. What is likely to be principal quantum number for a circular orbit of diameter 20 nm of the hydrogen atom if we assume Bohr orbit to be the same as that represented by the principal quantum number?

(a) 10 (b) 14 (c) 12 (d) 16

23. If velocity of an electron in the first orbit of H atom is V, what will be the velocity of the third orbit of Li^{2+}?

(a) V (b) $V/3$ (c) $3V$ (d) $9V$

24. The species which has its fifth ionization potential equals to 340 eV is:

(a) B^+ (b) C^+ (c) B (d) C

25. The energy of hydrogen atom in its ground state is –13.6 eV. The energy of the level corresponding to $n = 5$ is:

(a) – 0.54 eV (b) – 5.40 eV (c) – 0.85 eV (d) – 2.72 eV

26. In H-atom, if x is the radius of the first Bohr orbit, then de Broglie wavelength of an electron in the third orbit is:

(a) $3\pi x$ (b) $6\pi x$ (c) $\frac{9x}{2}$ (d) $\frac{x}{2}$

27. The uncertainty in the momentum of an electron is 1.0×10^{-5} (kg m)/s. The uncertainty of its position will be ($h = 6.626 \times 10^{-34}$Js):

(a) 1.05×10^{-28} m (b) 1.05×10^{-26} m

(c) 5.27×10^{-30} m (d) 5.25×10^{-28} m

28. Magnetic moment of X^{n+} ($Z = 26$) is $\sqrt{24}$ Bohr magneton. Hence, the number of unpaired electrons and value of n, respectively, are:

(a) 4, 2 (b) 2, 4 (c) 3, 1 (d) 0, 2

29. Consider the ground state of Cr atom ($Z = 24$). The numbers of electrons with the azimuthal quantum numbers $l = 1$ and 2 are, respectively,

(a) 16 and 5 (b) 12 and 5 (c) 16 and 4 (d) 12 and 4

30. Uncertainty in position is twice the uncertainty in momentum. Uncertainty in velocity is:

(a) $\sqrt{\frac{h}{\pi}}$ (b) $\frac{1}{2m}\sqrt{\frac{h}{\pi}}$ (c) $\frac{1}{2m}\sqrt{h}$ (d) $\frac{h}{4\pi}$

31. If wavelength is equal to the distance traveled by the electron in one second, then:

(a) $\lambda = \frac{h}{p}$ (b) $\lambda = \frac{h}{m}$ (c) $\lambda = \sqrt{\frac{h}{p}}$ (d) $\lambda = \sqrt{\frac{h}{m}}$

32. Which describes orbital?

(a) ψ (b) ψ^2 (c) $|\psi^2|$ (d) All

33. Consider an electron in the *n*th orbit of a hydrogen atom in the Bohr model. The circumference of the orbit can be expressed in terms of the de Broglie wavelength λ of the electron as:

(a) $(0.529)n\lambda$ (b) $\sqrt{n}\lambda$
(c) $(13.6)\lambda$ (d) $n\lambda$

34. The wave number of electromagnetic radiation emitted during the transition of electron in-between two levels of Li^{2+} ion whose principal quantum numbers sum is 4 and difference is 2 is:

(a) $3.5R_H$ (b) $4R_H$ (c) $8R_H$ (d) $\frac{8}{9}R_H$

35. The value of the magnetic moment of a particular ion is 2.83 Bohr magneton. The ion is:

(a) Fe^{2+} (b) Ni^{2+} (c) Mn^{2+} (d) Co^{3+}

36. The angular momentum of an electron in a given orbit is *J*. Its kinetic energy will be:

(a) $\frac{1}{2}\frac{J^2}{mr^2}$ (b) $\frac{Jv}{r}$ (c) $\frac{J^2}{2m}$ (d) $\frac{J^2}{2\pi}$

37. For which of the following species, Bohr's theory is not applicable?

(a) Be^{3+} (b) Li^{2+} (c) He^{2+} (d) H

38. For an *f*-orbital, the values of *m* are:

(a) −2, −1, 0, +1, +2 (b) −3, −2, −1, 0, +1, +2, +3
(c) −1, 0, +1 (d) 0, +1, +2, +3

39. The number of unpaired electrons in an atom of atomic number 24 (in ground state) is:

(a) 3 (b) 4 (c) 5 (d) 6

40. In hydrogen spectrum, which of the following lies in the wavelength range 350–700 nm?

(a) Balmer series (b) Lyman series
(c) Brackett series (d) Paschen series

41. The outer electronic configuration of $3s^2\ 3p^5$ is possessed by:

(a) O (b) Cl (c) Br (d) Ar

42. Atomic weight of an element is not necessarily whole number because:

(a) it contains electrons, protons, and neutrons
(b) it contains allotropic forms
(c) atoms are no longer considered indivisible
(d) it contains isotopes

43. The charge on the atom having 17 protons, 18 neutrons, and 18 electrons is:

(a) +1 (b) –1 (c) –2 (d) zero

44. Which of the following electron transition in a hydrogen atom will require the largest amount of energy?

(a) From $n = 1$ to $n = 2$ (b) From $n = 2$ to $n = 3$

(c) From $n = \infty$ to $n = 1$ (d) From $n = 3$ to $n = 5$

45. Which of the following statements is not correct for an electron that has the quantum number $n = 4$ and $m = 2$?

(a) The electron may have the quantum number $s = +1/2$

(b) The electron may have the quantum number $l = 2$

(c) The electron may have the quantum number $m = 2$

(d) The electron may have the quantum number $l = 0, 1, 2$

HINTS AND SOLUTIONS

1. (a) Change in PE $= -\frac{2x}{4} + (2x) \Rightarrow \frac{3}{2}x$

2. (a) $E_n = \frac{1}{2}\text{PE} = -\frac{6.8}{2} = -3.4 \text{ eV}$

$\therefore \quad E_n = \frac{-13.6}{n^2} = -3.4$

$n = 2$ or first excited state

3. (d) Energy of N shell $= \frac{-13.6 \times (4)^2}{(4)^2} = -13.6 \text{ eV}$

$\therefore \quad \text{PE} = 2 \times E = 2 \times -13.6 \text{ eV} = -27.2 \text{ eV}$

4. (b) Total energy of third shell $= \frac{-13.6}{3^2}$

$= -1.51 \text{ eV}$

KE = –Total energy = 1.51 eV

PE $= 2 \times E = -3.02$ eV

5. (c) $r = 0.529 \frac{n^2}{Z}$ Å;

$r_4 - r_3 = 0.539\left(\frac{16}{2} - \frac{9}{2}\right)\text{Å} = 1.851 \times 10^{-10}$ m

6. (b) $\lambda = \frac{h}{m_e x} = \frac{h}{m_p V} = \frac{h}{1840\, m_e V}$ $\quad (\because m_p = 1840\, m_e)$

Hence, $V = \frac{x}{1840}$

7. (c) $v \propto \frac{Z}{n}; r \propto \frac{n^2}{Z}$; frequency of revolution = $\frac{V_n}{2\pi r_n}$;

Coulombic force of attraction = $\frac{Ze^2}{(4\pi\varepsilon_0)r^2}$

8. (c) $\Delta x \approx \frac{h}{4\pi\Delta p} \approx \frac{h}{4\pi \times m\Delta v}$

$$= \frac{6.63 \times 10^{-14}}{4 \times 3.14 \times 9.1 \times 10^{-31} \times 1} \qquad (\because \Delta v = 1 \text{ m/s})$$

$\therefore \quad \Delta x = 58\ \mu\text{m}$

9. (b) $4f$ has the highest energy among $3d$, $4f$, $4p$, $5s$ orbitals.

10. (b) $$\frac{13.6(2)^2\left[\frac{1}{(1)^2} - \frac{1}{(2)^2}\right]}{13.6(2)^2\left[\frac{1}{(3)^2} - \frac{1}{(4)^2}\right]} = 15$$

11. (d) $\frac{13.6(Z)^2}{(3)^2} = 24$

IE = $13.6(Z)^2 = (24 \times 9) = 216$ eV

12. (b) BE = $\frac{21.79 \times 10^{19}(3)^2}{(3)^2} = 21.79 \times 10^{-19}$ J

13. (d) Given $15200 = R(1)^2\left[\frac{1}{(2)^2} - \frac{1}{(3)^2}\right]$ ...(i)

Then $\bar{v} = R(4)^2\left[\frac{1}{(1)^2} - \frac{1}{(2)^2}\right]$ ...(i)

From Eqs. (i) and (ii), we have

$\bar{v} = 1.313 \times 10^6$ cm^{-1}

14. (a) Only four lines are present in visible region, $6 \rightarrow 2$, $5 \rightarrow 2$, $4 \rightarrow 2$, and $3 \rightarrow 2$.

15. (b) We know $2\pi r = n\lambda$

For minimum radius, $n = 1$

$2\pi r_{\text{min}} = \lambda$

$r_{\text{min}} = \frac{\lambda}{2\pi}$

16. (c) $\lambda_1 = \sqrt{\frac{150}{100}}\ \text{Å}$ ...(i)

$$\lambda_2 = \sqrt{\frac{150}{81}}\,\mathring{A} \qquad \ldots(ii)$$

$$\lambda_3 = \sqrt{\frac{150}{49}}\,\mathring{A} \qquad \ldots(iii)$$

From Eqs. (i), (ii), and (iii), we have

$$\frac{\lambda_3 - \lambda_2}{\lambda_1} = \frac{20}{63}$$

17. (c) $\Delta x \times m \times \Delta v \geq \frac{h}{4\pi}$

$$1 \times 10^{-10} \times m \times \frac{3.3}{4\pi} \times 10^5 \geq \frac{6.6 \times 10^{-34}}{4 \times \pi}$$

$m = 2 \times 10^{-29}$ kg

18. (c) Total spin = Number of unpaired $e^- \times \left(\pm\frac{1}{2}\right)$

$$= 5 \times \left(\pm\frac{1}{2}\right) = \pm\frac{5}{2}$$

19. (a) Volume fraction $= \frac{\text{Volume of nucleus}}{\text{Total volume of atom}}$

$$= \frac{(4/3)\pi(10^{-13})^3}{(4/3)\pi(10^{-8})^3} = 10^{-15}$$

20. (a) IE of one sodium atom $= \frac{hC}{\lambda}$

and IE of one mole Na atom $= \frac{hC}{\lambda} N_A$

$$= \frac{6.62 \times 10^{34} \times 3 \times 10^8 \times 6.02 \times 10^{23}}{242 \times 10^{-9}}$$

$$= 494.65 \text{ kJ} \cdot \text{mol}$$

21. (d) Power $= \frac{nhC}{\lambda \times t}$

$$40 \times \frac{80}{100} = \frac{n \times 6.62 \times 10^{34} \times 3 \times 10^8}{620 \times 10^{-9} \times 20}$$

$n = 2 \times 10^{21}$

22. (b) Radius $= 0.529 \frac{n^2}{z} \mathring{A} = 10 \times 10^{-9}$ m

So $n^2 = 189$

or $n \approx 14$

23. (a) $V = 2.188 \times 10^6 \frac{z}{n}$ m/s

Now, $V \propto \frac{z}{n}$

so $\frac{V_{Li^{2+}}}{V_H} = \frac{Z_1/H_1}{Z_2/H_2} = \frac{3/3}{1/1} = 1$

or $V_{Li^{2+}} = V_H$

24. (c) IP = 340 V

so IE = 340 eV = $13.6 \frac{Z^2}{(1)^2}$

so $Z^2 = 25$

so $Z = 5$

25. (a) $E_n = E_1 \frac{Z^2}{n^2}$

$$E_5 = -13.6 \times \frac{(1)^2}{(5)^2} = -0.54 \text{ eV}$$

26. (b) $r_1 = 0.529$ Å

$r_3 = 0.529 \times (3)^2$ Å $= 9x$

so $\lambda = \frac{2\pi r}{n} = \frac{2\pi(9x)}{3} = 6\pi x$

27. (c) $\Delta p \cdot \Delta x = \frac{h}{4\pi}$

$$\Delta x = \frac{6.62 \times 10^{34}}{4 \times 3.14 \times 1 \times 10^{-5}} = 5.27 \times 10^{30} \text{ m}$$

28. (a) Number of unpaired electrons = 4

$X^{n+} = (Z = 26)$

so $N = 2$

29. (b) Cr (Zn = 24)

Electronic configuration: $1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6 4s^1 3d^5$

Number of electron in $l = 1$, i.e., p subshell is 12

Number of electron in $l = 2$, i.e., p subshell is 5

30. (c) $\Delta x = 2\Delta p$

$\Delta x \cdot \Delta p \cdot m = \frac{h}{2} = \frac{h}{4\pi}$

$$2\Delta p \cdot m \cdot \Delta V = \frac{h}{2}$$

$$(\Delta V)^2 = \frac{h}{4m^2} \qquad \text{or} \qquad \Delta V = \frac{\sqrt{h}}{2m}$$

31. (d) $\lambda = v$

Then $\lambda = \frac{h}{mV}$ or $\lambda^2 = \frac{h}{m}$

So $\lambda = \sqrt{\frac{h}{m}}$

32. (b) ψ^2 describes the maximum probability of finding electron, i.e., orbital.

33. (d) $2\pi r = n\lambda =$ circumference

34. (c) $\left.\begin{array}{l} n_1 + n_2 = 4 \\ n_1 - n_2 = 2 \end{array}\right\}$ so $n_1 = 3$ and $n_2 = 1$

$$\bar{v} = R(3)^2 \left\{\frac{1}{(3)^2} - \frac{1}{(1)^2}\right\} = 8R$$

35. (b) Magnetic moment = 2.83

Number of unpaired electrons = 2

Hence Ni^{2+} is the answer.

36. (a) Angular momentum $J = mvr$

$$J^2 = m^2v^2r^2$$

or $\frac{J^2}{2} = \left(\frac{1}{2}mv^2\right)mr^2$

or $KE = \frac{J^2}{2mr^2}$

37. (c) Bohr's theory is applicable only for H and H-like species.

38. (b) Value of $m = -l$, including zero.

39. (d) Electronic configuration of atomic number 24 is

$1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6\ 4s^1\ 3d^5$

40. (a) This is the range of visible region.

41. (b) $3s^2\ 3p^5$ is the configuration of Br.

42. (d) Average atomic mass of Cl is 35.5, due to isotopes

43. (b) Net charge is –1

44. (a) Largest amount of energy is required in $n = \infty$ to $n = 1$.

45. (d) For $m = 2$

$l = 0, 1$ are not possible