JEE Main Previous Year Solved Questions on Atomic Structure

1. If the kinetic energy of an electron is increased four times, the wavelength of the de-Broglie wave associated with it would become

(1) Two times

(2) Half

(3) One fourth

(4) Four times

Solution:

The wavelength λ is inversely proportional to the square root of kinetic energy. So if KE is increased 4 times, the wavelength becomes half.

$\lambda \propto 1/\sqrt{KE}$

Hence option (2) is the answer.

2. Calculate the wavelength (in nanometer) associated with a proton moving at $1.0\times10^{3}ms^{-1}$ (Mass of proton = 1.67×10^{-27}kg and h = 6.63×10^{-34}Js)

(1) 2.5 nm

(2) 14.0 nm

(3) 0.032 nm

(4) 0.40 nm

Solution:

Given $m_p = 1.67\times10^{-27}$kg

$h = 6.63\times10^{-34}$Js

$v = 1.0\times10^{3}ms^{-1}$

We know wavelength λ = h/mv

$\therefore \lambda = 6.63\times10^{-34}/(1.67\times10^{-27} \times 1.0\times10^{3})$

$= 3.97\times10^{-10}$

≈ 0.04nm

Hence option (4) is the answer.

3. The radius of the second Bohr orbit for the hydrogen atom is :

(Planck's constant, h = 6.262×10^{-34}Js: Mass of electron = 9.1091×10^{-31}kg; Charge of electron e = 1.60210×10^{-19}C; permittivity of vacuum $\varepsilon_0 = 8.854185\times10^{-12}kg^{-1}m^{-3}A^{2}$)

(1) 1.65 A

(2) 4.76 A

(3) 0.529 A

(4) 2.12 A

Solution:

Radius of n^{th} Bohr orbit in H atom = $0.53\ n^2/Z$

For hydrogen Z = 1

Radius of 2nd Bohr orbit in H atom = $0.53 \times 2^2/1 = 2.12$

Hence option (4) is the answer.

4. The energy required to break one mole of Cl–Cl bonds in Cl_2 is 242 kJ mol^{-1}. The longest wavelength of light capable of breaking a single Cl–Cl bond is

($C = 3\times10^8$ m/s and $N_A = 6.02\times10^{23}$ mol^{-1})

(1) 494 nm

(2) 594 nm

(3) 640 nm

(4) 700 nm

Solution:

We have B.E = 242KJ/Mol

$E = h_c N_A/\lambda$

$\therefore \lambda = h_c N_A/E$

$= 3\times10^8\times6.626\times10^{-34}\times6.02\times10^{23}/(242\times10^3)$

$= 0.494\times10^{-3}\times10^3$

= 494 nm

Hence option (1) is the answer.

5. Ionisation energy of He^+ is 19.6×10^{-18}J $atom^{-1}$. The energy of the first stationary state (n = 1) of Li^{2+} is

(1)8.82×10^{-17} J $atom^{-1}$

(2) 4.41×10^{-16} J $atom^{-1}$

(3) -4.41×10^{-17} J $atom^{-1}$

(4) -2.2×10^{-15} J $atom^{-1}$

Solution:

Given I.E = 19.6×10^{-18}

I.E $\propto z^2$

(I.E) $Li^{2+}/He^+ = (9/4)\times19.6\times10^{-18}$

$= -4.41\times10^{-17}$

Hence the option (3) is the answer.

6. The frequency of light emitted for the transition n = 4 to n = 2 of He+ is equal to the transition in H atom corresponding to which of the following

(1) n = 3 to n = 1

(2) n = 2 to n = 1

(3) n = 3 to n = 2

(4) n = 4 to n = 3

Solution:

$E = 13.6 \times 4[(1/4)-(1/16)]$

$= 10.2$

$E = hv$

$v = 10.2/h$

$E = 13.6(1)[(1/n_1^2-1/n_2^2)]$

$10.2 = 13.6[(1/n_1^2-1/n_2^2)]$

$102/136 = (n_2^2-n_1^2)/n_1^2n_2^2$

Substitute the given options and find n_1 and n_2

$51/68 = (n_2^2-n_1^2)/n_1^2n_2^2$

$0.75 = (4-1)4 = 3/4 = 0.75$

Hence option (2) is the answer.

7. Based on the equation $\Delta E = -2.0\times10^{-18}$ J $(1/n_2^2 – 1/n_1^2)$ the wavelength of the light that must be absorbed to excite hydrogen electron from level n = 1 to level n= 2 will be (h = 6.625×10^{-34} Js, C = 3×10^8 ms^{-1})

(1) 2.650×10^{-7}m

(2) 1.325×10^{-7}m

(3) 1.325×10^{-10}m

(4) 5.300×10^{-10}m

Solution:

$\Delta E = -2.0\times10^{-18}$ J $(1/n_2^2 – 1/n_1^2)$

$= -2.0\times10^{-18}(1/2^2 – 1/1^2)$

$= -2.0\times10^{-18}(1/4 – 1/1)$

$= -2.0\times10^{-18}(-3/4)$

$= 1.5\times10^{-18}$

Also $\Delta E = hc/\lambda$

So $\lambda = hc/\Delta E$

$= 6.625\times10^{-34} \times 3\times10^8 /1.5\times10^{-18}$

$=13.25\times10^{-8}$

$= 1.325\times10^{-7}$m

Hence option (2) is the answer.

8. The de Broglie wavelength of a car of mass 1000 kg and velocity 36 km/hr is :

(h = 6.63×10^{-34} Js)

(1) 6.626×10^{-31} m

(2) 6.626×10^{-34} m

(3) 6.626×10^{-38} m

(4) 6.626×10^{-30} m

Solution:

Given $h = 6.63\times10^{-34}$ J/s

m = 1000 kg

$v = 36$ km/hr $= 36\times10^3/(60\times60)$ m/s = 10m/s

$\lambda = h/mv$

$= 6.63\times10^{-34} /1000\times10$

$= 6.63\times10^{-38}$ m

Hence option (3) is the answer.

9. If the binding energy of the electron in a hydrogen atom is 13.6 eV, the energy required to remove the electron from the first excited state of Li^{++} is

(1) 13.6 eV (2) 30.6 eV (3) 122.4 eV (4) 3.4 eV

Solution:

$B.E = 13.6\times Z^2/n^2$, Z is the atomic number and n is the orbital quantum number. For Li^{++} , Z = 3 and n = 2 for the first excited state.

$B.E = 13.6\times3^2/2^2$

= 30.6 ev

Hence option (2) is the answer.

10. According to Bohr's theory, the angular momentum of an electron in 5th order orbit is

(1) 25 h/π

(2) 1.0 h/π

(3) 10 h/π

(4) 2.5 h/π

Solution:

n = 5

So angular momentum, = nh/2π

= 5h/2π

= 2.5 h/π

Hence option (4) is the answer.

11. The de Broglie wavelength of a tennis ball of mass 60g moving with a velocity of 10m/s is approximately (Planck's constant, $h = 6.63\times10^{-34}$ Js)

(1) 10^{-31} m

(2) 10^{-16} m

(3) 10^{-25} m

(4) 10^{-33} m

Solution:

Given m = 60 g

v = 10 m/s

λ = h/mv

= $6.6\times10^{-34}/(60\times10^{-3}\times10) = 10^{-33}$ m

Hence option (4) is the answer.

12. In a hydrogen atom, if the energy of an electron in the ground state is 13.6 eV, then that in the 2nd excited state is

(1) 1.51 eV

(2) 3.4 eV

(3) 6.04 eV

(4)13.6 eV

Solution:

The 3^{rd} energy level is the 2^{nd} excited state.

n=3

$E_n = 13.6/n^2 = 13.6/9 = 1.5$ eV

Hence option (1) is the answer.

13. In the Bohr series of lines of hydrogen spectrum, the third line from the red end corresponds to which one of the following inter-orbit jumps of the electron for Bohr orbits in an atom of hydrogen

(1) 5 → 2

(2) 4 → 1

(3) 2→ 5

(4) 3→ 2

Solution:

The lines falling in the visible spectrum include the Balmer series. So the third line would be n_1 = 2 and n_2 = 5. Thus the transition is 5 → 2

Hence option (1) is the answer.

14. Which of the following sets of quantum numbers is correct for an electron present in 4f orbital?

(1) n = 4, l = 3, m = +4, s = +½

(2) n = 3, l = 2, m = -2, s = +½

(3) n = 4, l = 3, m = +1, s = +½

(4) n = 4, l = 4, m = -4, s = -½

Solution:

For 4f orbital, n = 4 and l = 3.

Values of m = -3, -2, -1, 0, +1, +2, +3

Hence option (3) is the answer.

15. The number of d-electrons retained in Fe^{2+} (At.no. of Fe = 26) ion is

(1) 4

(2) 5

(3) 6

(4) 3

Solution:

Configuration of Fe^{2+} = $3d^6$ $4s^0$

Hence option (3) is the answer.

16. Which of the following statements in relation to the hydrogen atom is correct ?

(1)3s orbital is lower in energy than 3p orbital

(2)3p orbital is lower in energy than 3d orbital

(3)3s and 3p orbitals are of lower energy than 3d orbital

(4)3s, 3p and 3d orbitals all have the same energy

Solution:

The Auf-bau principle is not applicable for the Hydrogen atom.

Hence option (4) is the answer.

17. Which of the following sets of quantum numbers represents the highest energy of an atom?

(1)n=3, l =2, m=l, s= +½

(2)n=3, l =2, m=l, s= +½

(3)n=4, l =0, m=0, s= +½

(4)n=3, l =0, m=0, s= +½

Solution:

Maximum value of (n +l) represents the highest energy of the orbital.

Hence option (2) is the answer.

18. The outer electron configuration of Gd (Atomic no. 64) is

(1) $4f^4$ $5d^4$ $6s^2$

(2) $4f^7$ $5d^1$ $6s^2$

(3) $4f^3$ $5d^5$ $6s^2$

(4) $4f^8$ $5d^0$ $6s^2$

Solution:

Gd shows a half-filled f^7 configuration.

Hence option (2) is the answer.