ATOMIC STRUCTURE

1. A proton and a Li^{3+} nucleus are accelerated by the same potential. If λ_{Li} and λ_P denote the de Broglie wavelengths of Li^{3+} and proton respectively, then the value of $\frac{\lambda_{Li}}{\lambda_P}$ is $x \times 10^{-1}$. The value of x is ________.

(Rounded off to the nearest integer)

(Mass of Li^{3+} = 8.3 mass of proton)

2. According to Bohr's atomic theory :-

(A) Kinetic energy of electron is $\propto \frac{Z^2}{n^2}$.

(B) The product of velocity (v) of electron and principal quantum number (n), 'vn' $\propto Z^2$.

(C) Frequency of revolution of electron in an orbit is $\propto \frac{Z^3}{n^3}$.

(D) Coulombic force of attraction on the electron is $\propto \frac{Z^3}{n^4}$.

Choose the most appropriate answer from the options given below :

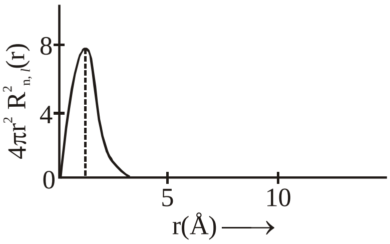
(1) (C) Only

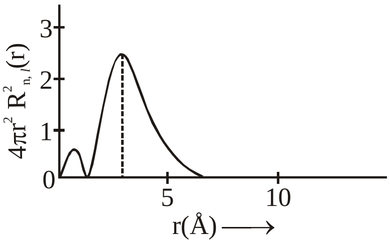
(2) (A) Only

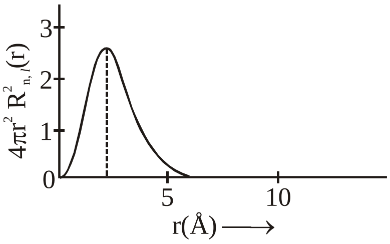
(3) (A), (C) and (D) only

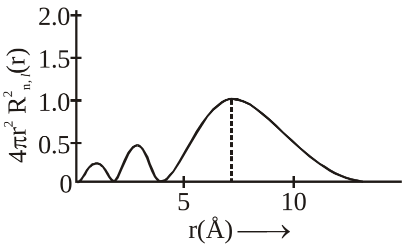
(4) (A) and (D) only

3. The plots of radial distribution functions for various orbitals of hydrogen atom against 'r' are given below:

(A)


(B)


(C)


(D)


The correct plot for 3s orbital is:

(1) (B) (2) (A) (3) (D) (4) (C)

4. Among the following, number of metal/s which can be used as electrodes in the photoelectric cell is _______ (Integer answer)

(A) Li (B) Na (C) Rb (D) Cs

5. The spin only magnetic moment of a divalent ion in aqueous solution (atomic number 29) is _______ BM.

6. Electromagnetic radiation of wavelength 663 nm is just sufficient to ionise the atom of metal A. The ionization energy of metal A in kJ mol^{-1} is _______. (Rounded-off to the nearest integer)

[$h = 6.63 \times 10^{-34}$ Js, $c = 3.00 \times 10^8$ ms^{-1},

$N_A = 6.02 \times 10^{23}$ mol^{-1}]

7. The orbital having two radial as well as two angular nodes is -
(1) 3p (2) 4f (3) 4d (4) 5d

8. A ball weighing 10 g is moving with a velocity of 90 ms^{-1}. If the uncertainty in its velocity is 5%, then the uncertainty in its position is_______$\times 10^{-33}$ m. (Rounded off to the nearest integer)
[Given : $h = 6.63 \times 10^{-34}$ Js]

9. When light of wavelength 248 nm falls on a metal of threshold energy 3.0 eV, the de-Broglie wavelength of emitted electrons is ______ Å. (Round off to the Nearest Integer).
[Use : $\sqrt{3} = 1.73$, $h = 6.63 \times 10^{-34}$ Js
$m_e = 9.1 \times 10^{-31}$ kg ; $c = 3.0 \times 10^{8}$ ms^{-1} ;
$1 eV = 1.6 \times 10^{-19} J$]

10. A certain orbital has n = 4 and $m_L = -3$. The number of radial nodes in this orbital is ________. (Round off to the Nearest Integer).

11. A certain orbital has no angular nodes and two radial nodes. The orbital is :
(1) 2s (2) 3s (3) 3p (4) 2p

12. The oxide that shows magnetic property is :
(1) SiO_2 (2) Mn_3O_4
(3) Na_2O (4) MgO

13. Given below are two statements :
Statement I : Bohr's theory accounts for the stability and line spectrum of Li^+ ion.
Statement II : Bohr's theory was unable to explain the splitting of spectral lines in the presence of a magnetic field.
In the light of the above statements, choose the most appropriate answer from the options given below :
(1) Both statement I and statement II are true.
(2) Statement I is false but statement II is true.
(3) Both statement I and statement II are false.
(4) Statement I is true but statement II is false.

14. For a given chemical reaction $A \rightarrow B$ at 300 K the free energy change is -49.4 kJ mol^{-1} and the enthalpy of reaction is 51.4 kJ mol^{-1}. The entropy change of the reaction is ___ J K^{-1} mol^{-1}.

15. The wavelength of electrons accelerated from rest through a potential difference of 40 kV is $x \times 10^{-12}$ m. The value of x is _____. (Nearest integer)
Given : Mass of electron $= 9.1 \times 10^{-31}$ kg
Charge on an electron $= 1.6 \times 10^{-19}$ C
Planck's constant $= 6.63 \times 10^{-34}$ Js

16. A source of monochromatic radiation of wavelength 400 nm provides 1000 J of energy in 10 seconds. When this radiation falls on the surface of sodium, $x \times 10^{20}$ electrons are ejected per second. Assume that wavelength 400 nm is sufficient for ejection of electron from the surface of sodium metal. The value of x is _______.
(Nearest integer)
($h = 6.626 \times 10^{-34}$ Js)

17. An accelerated electron has a speed of 5×10^{6} ms^{-1} with an uncertainty of 0.02%. The uncertainty in finding its location while in motion is $x \times 10^{-9}$ m. The value of x is _________. (Nearest integer)
[Use mass of electron $= 9.1 \times 10^{-31}$ kg,
$h = 6.63 \times 10^{-34}$ Js, $\pi = 3.14$]

18. Given below are two statements :
Statement I : Rutherford's gold foil experiment cannot explain the line spectrum of hydrogen atom.
Statement II : Bohr's model of hydrogen atom contradicts Heisenberg's uncertainty principle.
In the light of the above statements, choose the **most appropriate** answer from the options given below :
(1) **Statement I** is false but **statement II** is true.
(2) **Statement I** is true but **statement II** is false.
(3) Both **statement I** and **statement II** are false.
(4) Both **statement I** and **statement II** are true.

19. If the Thompson model of the atom was correct, then the result of Rutherford's gold foil experiment would have been :

(1) All of the α-particles pass through the gold foil without decrease in speed.

(2) α-Particles are deflected over a wide range of angles.

(3) All α-particles get bounced back by 180^o

(4) α-Particles pass through the gold foil deflected by small angles and with reduced speed.

20. Given below are two statements.

Statement I: According to Bohr's model of an atom, qualitatively the magnitude of velocity of electron increases with decrease in positive charges on the nucleus as there is no strong hold on the electron by the nucleus.

Statement II: According to Bohr's model of an atom, qualitatively the magnitude of velocity of electron increases with decrease in principal quantum number.

In the light of the above statements, choose the **most appropriate** answer from the options given below:

(1) Both **Statement I** and **Statement II** are false

(2) Both **Statement I** and **Statement II** are true

(3) **Statement I** is false but **Statement II** is true

(4) **Statement I** is true but **Statement II** is false

21. A metal surface is exposed to 500 nm radiation. The threshold frequency of the metal for photoelectric current is 4.3×10^{14} Hz. The velocity of ejected electron is ________ $\times 10^5$ ms^{-1} (Nearest integer)

[Use : $h = 6.63 \times 10^{-34}$Js, $m_e = 9.0 \times 10^{-31}$ kg]

22. The kinetic energy of an electron in the second Bohr orbit of a hydrogen atom is equal to $\frac{h^2}{xma_0^2}$. The value of 10x is _______. (a_0 is radius of Bohr's orbit) (Nearest integer) [Given : $\pi = 3.14$]

23. The number of photons emitted by a monochromatic (single frequency) infrared range finder of power 1 mW and wavelength of 1000 nm, in 0.1 second is $x \times 10^{13}$. The value of x is _____. (Nearest integer)

($h = 6.63 \times 10^{-34}$ Js, $c = 3.00 \times 10^8$ ms^{-1})

24. Ge(Z = 32) in its ground state electronic configuration has x completely filled orbitals with $m_l = 0$. The value of x is _______.

25. The value of magnetic quantum number of the outermost electron of Zn^+ ion is _______.

26. A 50 watt bulb emits monochromatic red light of wavelength of 795 nm. The number of photons emitted per second by the bulb is $x \times 10^{20}$. The value of x is _________.

[Given : $h = 6.63 \times 10^{-34}$ Js and

$c = 3.0 \times 10^8$ ms^{-1}]

SOLUTION

1. Official Ans. by NTA (2)

Sol. $\lambda = \dfrac{h}{\sqrt{2\,mqV}}$

$\dfrac{\lambda_{Li}}{\lambda_p} = \sqrt{\dfrac{m_p(e)V}{m_{Li}(3e)(V)}}$ $\qquad m_{Li} = 8.3\,m_p$

$\dfrac{\lambda_{Li}}{\lambda_p} = \sqrt{\dfrac{1}{8.3\times 3}} = \dfrac{1}{5} = 0.2 = 2\times 10^{-1}$

2. Official Ans. by NTA (4)

Sol. According to Bohr's theory :

(A) $KE = 13.6\dfrac{z^2}{n^2}\dfrac{eV}{atom} \Rightarrow KE \alpha \dfrac{z^2}{n^2}$

(B) speed of e^- $\alpha \dfrac{z}{n}$

$\therefore$ $\boxed{v \times n \alpha z}$

(C) Frequency of revolution of e^- = $\dfrac{v}{2\pi r}$

$\therefore$ $\boxed{\text{frequency}\,\alpha \dfrac{z^2}{n^3}}$

(D) $F = \dfrac{kq_1q_2}{r^2} = \dfrac{kze^2}{r^2}$ $\qquad \left\{ r\,\alpha \dfrac{n^2}{z} \right.$

$\Rightarrow F\alpha \dfrac{z}{\left(\dfrac{n^2}{z}\right)^2}$

$\Rightarrow \boxed{F\alpha \dfrac{z^3}{n^4}}$

3. Official Ans. by NTA (3)

Sol. Number of radial nodes = n – ℓ – 1

= 3 – 0 – 1 = 2

Therefor corresponding graph is (D)

Hence answer is (3)

4. Official Ans. by NTA (1)

Sol. Cs is used as electrodes in the photoelectric cell.

5. Official Ans. by NTA (2)

Sol. Z = 29 (Cu)

Cu^{2+} form $[Cu(H_2O)_4]^{2+}$ complex ion with H_2O.

$[Cu(H_2O)_4]^{2+} \Rightarrow Cu^{2+}$ $[Ar]3d^9$, $H_2O \rightarrow$ WFL

Cu^{2+} | 1⇃ | 1⇃ | 1⇃ | 1⇃ | 1 |
3d

number of unpaired e^- = 1

$\mu = \sqrt{1(1+2)}$ B.M.

$\mu = \sqrt{3} \Rightarrow 1.73$ B.M. $\Rightarrow$ round off ans. $\Rightarrow 2$

6. Official Ans. by NTA (181)

Sol. $E = \dfrac{hc}{\lambda}\times\dfrac{N_A}{1000}$

$= \dfrac{6.63\times 10^{-34}\times 3\times 10^{8}\times 6.02\times 10^{23}}{663\times 10^{-9}\times 1000}$

$= 3 \times 6.02 \times 10$ kJ

= 180.6 kJ

7. Official Ans. by NTA (4)

Sol. $n - l - 1 = 2$

$l = 2$

$n - 2 - 1 = 2$

$n = 5$

8. Official Ans by NTA (1)

Sol. $\Delta v = 90 \times \dfrac{5}{100}$

= 4.5 m/s

$\Delta v.\,\Delta x = \dfrac{h}{4\pi m}$

$\Delta x = \dfrac{h}{4\pi m.\Delta v}$

$= \dfrac{6.63\times 10^{-34}}{4\times 3.14\times 0.01\times 4.5}$

$= 1.17 \times 10^{-33}$

9. Official Ans. by NTA (9)

Sol. Energy incident = $\frac{hc}{\lambda}$

$= \frac{6.63\times10^{-34}\times3.0\times10^{8}}{248\times10^{-9}\times1.6\times10^{-19}}$ eV

$= \frac{6.63\times3\times100}{248\times1.6}$

= 0.05 eV × 100 = 5 eV

Now using

E = ϕ + K.E.

5 = 3 + K.E.

K.E. = 2eV = 3.2×10^{-19} J

for debroglie wavelength $\lambda = \frac{h}{mv}$

$K.E = \frac{1}{2}mv^2$

so $v = \sqrt{\frac{2KE}{m}}$

hence $\lambda = \frac{h}{\sqrt{2KE\times m}}$

$= \frac{6.63\times10^{-34}}{\sqrt{2\times3.2\times10^{-19}\times9.1\times10^{-31}}}$

$= \frac{6.63}{7.6}\times\frac{10^{-34}}{10^{-25}} = \frac{66.3\times10^{-10}m}{7.6}$

= 8.72×10^{-10} m

$\approx 9\times10^{-10}$m

$= 9$Å

10. Official Ans. by NTA (0)

Sol. n = 4 and $m_\ell = -3$

Hence, ℓ value must be 3.

Now, number of radial nodes = $n - \ell - 1$

$= 4 - 3 - 1 = 0$

11. Official Ans. by NTA (2)

Sol. l = 0 ⇒ 's' orbital

$n - l - 1 = 2$

$n - 1 = 2$

n = 3

12. Official Ans. by NTA (2)

Sol. Mn_3O_4 shows magnetic properties.

13. Official Ans. by NTA (2)

Sol. Statement-I is false since Bohr's theory accounts for the stability and spectrum of single electronic species (eg : He^{+}, Li^{2+} etc)

Statement II is true.

14. Official Ans. by NTA (360)

Sol. Given chemical reaction:

$A \xrightarrow[T\ 300K]{} B$ $[\Delta G]_{P,T} = -49.4$ kJ/mol

$\Delta H_{rxn} = 51.4$ kJ/mol

$\Delta S_{rxn} = ?$

⇒ From the relation $[\Delta G]_{P,T} = \Delta H - T\Delta S$

$\Rightarrow \Delta S_{rxn} = \frac{\Delta H_{rxn} - [\Delta G]_{P,T}}{T}$

$= \frac{[51.4-(-49.4)]\times1000}{300}\ \frac{J}{mol\,K}$

$\Rightarrow \Delta S_{rxn} = 336\ \frac{J}{mol\,K}$

15. Official Ans. by NTA (6)

Sol. De-broglie-wave length of electron:

$\lambda_e = \frac{h}{\sqrt{2m(KE)}}$ $\left\{\begin{array}{l}\because e^- \text{ is accelerated} \\ \text{from rest} \\ \Rightarrow KE = q\times V\end{array}\right.$

$\lambda = \frac{h}{\sqrt{2mqv}}$

$= \frac{6.63\times10^{-34}}{\sqrt{2\times1.6\times10^{-19}\times9.1\times10^{-31}\times40\times10^{3}}}$

= 0.614×10^{-11} m

= 6.14×10^{-12} m

Nearest integer = 6

OR

$\lambda = \frac{12.3}{\sqrt{V}}$Å

$= \frac{12.3}{200} = 6.15\times10^{-12}$ m

Ans. is 6

16. Official Ans. by NTA (2)

Sol. Total energy provided by

Source per second = $\frac{1000}{10} = 100J$

Energy required to eject electron $= \frac{hc}{\lambda}$

$= \frac{6.626\times10^{-34}}{400\times10^{-9}}\times3\times10^{8}$

Number of electrons ejected

$= \frac{100}{\frac{6.626\times10^{-34}\times3\times10^{8}}{400\times10^{-9}}}$

$= \frac{400\times10^{-7}\times10^{26}}{6.626\times3}$

$= \frac{40\times10^{-20}}{6.626\times3}$

$= 2.01 \times 10^{20}$

17. Official Ans. by NTA (58)

Sol. $\Delta v = \frac{0.02}{100}\times5\times10^{6} = 10^{3}\ m/s$

$\Delta x . \Delta v = \frac{h}{4\pi m}$

$x \times 10^{-9} \times 10^{3} = \frac{6.63\times10^{-34}}{4\times3.14\times9.1\times10^{-31}}$

$x \times 10^{-9} \times 10^{3} = 0.058 \times 10^{-3}$

$x = \frac{0.058\times10^{-6}}{10^{-9}} = 58$

18. Official Ans. by NTA (4)

Sol. Rutherford's gold foil experiment only proved that electrons are held towards nucleus by electrostatic forces of attraction and move in circular orbits with very high speeds.

Bohr's model gave exact formula for simultaneous calculation of speed & distance of electron from the nucleus, something which was deemed impossible according to Heisenberg.

19. Official Ans. by NTA (4)

Sol. As in Thomson model, protons are diffused (charge is not centred) α- particles deviate by small angles and due to repulsion from protons, their speed decreases.

20. Official Ans. by NTA (3)

Sol. Velocity of electron in Bohr's atom is given by

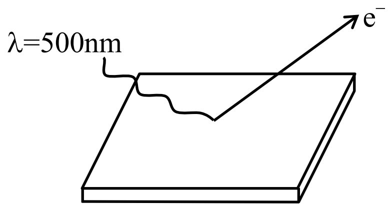
$V \propto \frac{Z}{n}$

Z = atomic number of atom, corresponds to +ve charge so as Z increase velocity increases so statement-I is wrong.

and as 'n' decreases velocity increases so statement-II is correct.

21. Official Ans. by NTA (5)

Sol.



υ : speed of electron having max. K.E.

$\Rightarrow$ from Einstein equation : $E = \phi + K.E._{max}$

$\Rightarrow \frac{hc}{\lambda} = h\upsilon_0 + \frac{1}{2}mv^2$

$\Rightarrow \frac{6.63\times10^{-34}\times3\times10^{8}}{500\times10^{-9}} = 6.63\times10^{-34}\times4.3\times10^{14} + \frac{1}{2}mv^2$

$\Rightarrow \frac{6.63\times30\times10^{-20}}{5} = 6.63\times4.3\times10^{-20} + \frac{1}{2}mv^2$

$\Rightarrow 11.271 \times 10^{-20}\ J = \frac{1}{2} \times 9 \times 10^{-31} \times \upsilon^2$

$\Rightarrow \boxed{\upsilon = 5\times10^{5} m/sec.}$

22. Official Ans. by NTA (3155)

Sol. $mvr = \frac{nh}{2\pi}$

$K.E. = \frac{n^2h^2}{8\pi^2mr^2} = \frac{4h^2}{8\pi^2m(4a_0)^2}$

$= \left(\frac{4}{8\pi^2\times16}\right)\frac{h^2}{ma_0^2}$

$\Rightarrow x = 315.507$

$\Rightarrow 10x = 3155$ (nearest integer)

23. Official Ans. by NTA (50)

Sol. Energy emitted in 0.1 sec.

$$= 0.1\ \text{sec.} \times 10^{-3}\ \frac{J}{s} = 10^{-4}\ J$$

If 'n' photons of λ = 1000 nm are emitted,

then ; $10^{-4} = n \times \frac{hc}{\lambda}$

$$\Rightarrow 10^{-4} = \frac{n \times 6.63 \times 10^{-34} \times 3 \times 10^{8}}{1000 \times 10^{-9}}$$

$\Rightarrow n = 5.02 \times 10^{14} = 50.2 \times 10^{13}$

$\Rightarrow$ 50 (nearest integer)

24. Official Ans. by NTA (7)

Sol.

	$1s^2$	$2s^2$	$2p^6$	$3s$	$3p^6$	$4s^2$	$3d^{10}$	$4p^2$
	⇅	⇅	⇅ ⇅ ⇅	⇅	⇅ ⇅ ⇅	⇅	⇅ ⇅ ⇅ ⇅ ⇅	↑ ↑ _
m =	0	0	–1 0 +1	0	–1 0 +1	0	–2 –1 0 +1 +2	
	(1)	(1)	(1)	(1)	(1	(1)	(1)	

Completely filled orbital with m_ℓ = 0 are

= 1+1+1+1+1+1+1

= 7

So Answer is 7

25. Official Ans. by NTA (0)

Sol. $Zn^+ \rightarrow 1s^2 2s^2 2p^6 3s^2 3p^6 3d^{10} 4s^1$

Outermost electron is in 4s subshell

m = 0

26. Official Ans. by NTA (2)

Sol. Total energy per sec. = 50 J

$$50 = \frac{n \times 6.63 \times 10^{-34} \times 3 \times 10^{8}}{795 \times 10^{-9}}$$

$n = 1998.49 \times 10^{17}$ [n = no. of photons per second]

$= 1.998 \times 10^{20}$

$\simeq 2 \times 10^{20}$

$= x \times 10^{20}$

x = 2