Atomic Structure

Question1

The work function of Cu is 7.68×10^{-19} J. If photons of wavelength 221 nm are made to strike the surface of the metal, the kinetic energy (in J) of the ejected electrons will be ($h = 6.63 \times 10^{-34}$Js)

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Options:

A.

2.64×10^{-18}

B.

1.32×10^{-19}

C.

2.64×10^{-19}

D.

6.60×10^{-19}

Answer: B

Solution:

$$\lambda = 221 \text{ nm} = 221 \times 10^{-9} \text{ m}$$

$$\text{Using } E = \frac{hc}{\lambda} = \frac{6.63 \times 10^{-34} \times 3 \times 10^{8}}{221 \times 10^{-9}}$$

$$E = 9 \times 10^{-19} \text{ J}$$

$$\text{KE}_{\text{max}} = E - \phi$$

$$\Rightarrow \text{KE}_{\text{max}} = \left(9.0 \times 10^{-19} - 7.68 \times 10^{-19}\right)$$

$$\text{KE}_{\text{max}} = 1.32 \times 10^{-19} \text{ J}$$

Question2

In an element with atomic number $(Z)25$, the number of electrons with $(n + l)$ value equal to 3 and 4 are x and y respectively. The value of $(x + y)$ is

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Options:

A.

21

B.

12

C.

14

D.

16

Answer: D

Solution:

$Z = 25 = 1s^2 2s^2 2p^6 3s^2 3p^6 3d^5 4s^2$

For $2p^6 : n = 2, l = 1$, so $(n + l) = 3$

It contains 6 electrons

For $3s^2 : n = 3, l = 0, (n + l) = 3 + 0 = 3$

If contains 2 electrons

$x = 6 + 2 = 8$

For $3p^6 : n = 3, l = 1, (n + l) = 4$

It contains 6 electrons

For $4s^2, n = 4, l = 0, (n + l) = 4$

It contains 2 electrons

$Y = 2 + 6 = 8$
$x + y = 8 + 8 = 16$

Question3

a, b, c, d are electromagnetic radiations. Frequencies of a, b are 3×10^{15} Hz, 2×10^{14} Hz, respectively, whereas wavelength of c, d are 400 nm, 750 nm, respectively. The increasing order of their energies is

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Options:

A.

b, d, c, a

B.

a, d, c, b

C.

a, b, c, d

D.

b, c, d, a

Answer: A

Solution:

First of all calculate the frequency of c and d

$$\begin{aligned} v_c &= \frac{c}{\lambda_c} = \frac{3 \times 10^8}{400 \times 10^{-9}} \\ &= 7.5 \times 10^{14} \text{ Hz} \\ v_d &= \frac{c}{\lambda_d} = \frac{3 \times 10^8}{750 \times 10^{-8}} \\ &= 4 \times 10^{14} \text{ Hz} \end{aligned}$$

Now we know

$E = hv$ or $E \propto v$

So, higher the frequency, greater will be the energy thus, E is in order

$$\begin{aligned} 3 \times 10^{15} \text{ Hz} > 7.5 \times 10^{14} \text{ Hz} > 4 \times 10^{14} \text{ Hz} \\ > 2 \times 10^{14} \text{ Hz} \end{aligned}$$

or the correct increasing order is $b

Question4

The number of electrons with magnetic quantum number, $m_l = 0$ in the elements with atomic numbers $Z = 24$ and $Z = 29$ are respectively.

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Options:

A.

12,13

B.

12,12

C.

13,12

D.

14,15

Answer: A

Solution:

$\mathrm{Cr}(24) = [\mathrm{Ar}]3d^5 4s^1$

For $1s^2, 2s^2, 3s^2, 4s^1$ each s-orbital has $m_l = 0$

contibuting 2 electron (except $4s^1$)

For $2p^6, 3p^6$: each p shell has one orbital $m_l = 0$

Contributing 2 electrons each

For $3d^5$: d subshell has one orbital with $m_l = 0$

Contributing 1 electron.

Total $2 + 2 + 2 + 1 + 2 + 2 + 1 = 12$

$\mathrm{Cu} = [\mathrm{Ar}]3d^{10} 4s^1$

$1s^2 2s^2 3s^2 4s^1$ = each will contribute 2 electrons

$2p^6, 3p^6$: each will contribute 2 electrons

$3d^{10}$: contribute 2 electron

$2 + 2 + 2 + 1 + 2 + 2 + 2 = 13$

Question5

Which of the following represents the wavelength of spectral line of Balmer series of He^+ ion?

$(R =$ Rydberg constant, $n > 2)$

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Options:

A.

$\frac{n^2}{R(n-2)(n+2)}$

B.

$\frac{R(n-2)(n+2)}{n^2}$

C.

$\frac{n^2}{4R(n-2)(n+2)}$

D.

$\frac{4R(n-2)(n+2)}{n^2}$

Answer: A

Solution:

Using Rydberg formula

$\frac{1}{\lambda} = Rz^2 \left[\frac{1}{n_f^2} - \frac{1}{n_i^2}\right]$

for He^+, $z = 2$, for Balmer series, $n_f = 2$

The initial energy level, $n_i = n$ where $n > 2$

$$\frac{1}{\lambda} = R(2)^2 \left[\frac{1}{2^2} - \frac{1}{n^2}\right]$$
$$\Rightarrow \quad \frac{1}{\lambda} = 4R\left(\frac{1}{4} - \frac{1}{n^2}\right)$$

On simplifying above equation

$$\lambda = \frac{n^2}{R(n^2 - 4)}$$
$$\Rightarrow \quad \lambda = \frac{n^2}{R(n-2)(n+2)}$$

Question6

The work functions (in eV) of Mg, Cu, Ag, Na respectively are 3.7, 4.8, 4.3, 2.3. From how many metals, the electrons will be ejected if their surfaces are irradiated with an electromagnetic radiation of wavelength 300 nm ?

$\left(h = 6.6 \times 10^{-34} \text{Js}, 1\text{eV} = 1.6 \times 10^{-19} \text{ J}\right)$

Options:

A.

1

B.

4

C.

2

D.

3

Answer: C

Solution:

Using the formula, $E = \frac{hc}{\lambda}$

The approx value of $hc = 120\text{eV. nm}$

$E = \frac{1240\text{eV}\cdot\text{ nm}}{300\text{ nm}} = 4.13\text{eV}$

For Mg : $4.13\text{eV} > 3.7\text{ev}$, so electron will be ejected

For Cu : $4.13\text{eV} < 4.8\text{eV}$, no electron ejected

For Ag : $4.13 < 4.3\text{eV}$, no electron ejected

For Na : $4.13 > 2.3\text{eV}$, so electron will be ejected

Thus, 2 metals will eject electron.

Question7

The uncertainty in the velocities of two particles A and B are 0.03 and 0.01 ms^{-1} respectively. The mass of B is four times to the mass of A. The ratio of uncertainties in their positions is

Options:

A.

$\frac{4}{3}$

B.

$\frac{3}{4}$

C.

$\frac{16}{9}$

D.

$\frac{9}{16}$

Answer: A

Solution:

Uncertainty principle for particle A;

$\Delta x_A\left(m_A \cdot \Delta v_A\right)=\frac{h}{4 \pi} \qquad \ldots(i)$

For particle B,

$\Delta x_B\left(m_B \cdot \Delta v_B\right)=\frac{h}{4 \pi} \qquad \ldots(ii)$

Divide Eq. (i) by Eq. (ii)

$\frac{\Delta x_A}{\Delta x_B}=\frac{m_B \cdot \Delta v_B}{m_A \cdot \Delta v_A}$

Now substitute the given value

$$\begin{aligned} m_B & =4 m_A, \Delta v_A=0.03 \\ \Delta v_B & =0.01 \\ \frac{\Delta x_A}{\Delta x_B} & =\frac{0.04}{0.03}=\frac{4}{3} \end{aligned}$$

Question8

The total maximum number of electrons possible in $3d$. $6d$, $5s$ and $4f$ orbitals with m_l (magnetic quantum number) value -2 is

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Options:

A.

6

B.

8

C.

10

D.

12

Answer: A

Solution:

For s-orbital, $l = 0$

For d-orbital, $l = 2$

For f-orbital, $l = 3$

For, f-orbital m_1 values can be $-3, -2, -1, 0 + 1, +2, +3$

So, $4f$ can have $m_l = -2$

Each orbital with $m_l = -2$ can hold 2 electrons.

Orbitals that can have $m_l = -2$ are $3d, 4f$ and $6d$

Total electron $= 2 + 2 + 2 = 6$

Question9

The radius of fourth orbit in He^{+}ion is ' R_1'pm and radius of third orbit in Li^{2+} ion is ' R_2'pm. The value of ($R_1 - R_2$) in pm is

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Options:

A.

132.25

B.

529.00

C.

264.50

D.

793.50

Answer: C

Solution:

Using the formula for nth orbit of Bohr's orbit,

$r_n = \frac{a_0 n^2}{Z}$

For R_1 of He^{+},

Given, $n = 4, Z = 2$

$$R_1 = \frac{a_0 n^2}{Z}$$

$$\Rightarrow \quad R_1 = 52.9 \times \frac{16}{2} = 423.2 \mathrm{pm}$$

For R_2 $\left(\mathrm{Li}^{2+}\right)$

$$n = 3, z = 3$$

$$R_2 = 52.9 \times \frac{3^2}{3} = 158.7 \mathrm{pm}$$

$R_1 - R_2 = 423.2 - 158.7 = 264.50 \mathrm{pm}$

Question10

The de-Broglie wavelengths of two fast moving particles X, Y are $1 \text{ nm}, 3 \text{ nm}$ respectively. Mass of X is nine times the mass of Y. The ratio of kinetic energies of X, Y is

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Options:

A.

$1:3$

B.

$1:1$

C.

$9:1$

D.

$1:9$

Answer: B

Solution:

de-Broglie wavelength is, $\lambda = \frac{h}{p}$

$$\Rightarrow \quad \lambda = \frac{h}{\sqrt{2mKE}} \text{ or } \quad \text{KE} = \frac{h^2}{2m\lambda^2}$$

$$\frac{(\text{KE})_X}{(\text{KE})_Y} = \frac{\frac{h^2}{2m\lambda_x^2}}{\frac{h^2}{2m\lambda_Y^2}} = \frac{9}{9} = 1:1$$

Question11

The difference between the radii of 3rd and 2nd orbit of H -atom is $x$pm. The difference between the radii of 4th and 3rd orbit of Li^{2+}

ion is y pm. $y : x$ is equal to

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Options:

A.

$15 : 7$

B.

$7 : 15$

C.

$3 : 1$

D.

$1 : 3$

Answer: B

Solution:

The radii of nth orbit of hydrogen atom,

$r_n = \frac{a_0 n^2}{z}$

For hydrogen atom the radii of 3 rd and 2nd obit respectively can be calculated as

$$r_3 = \frac{a_0 3^2}{1} = 9a_0 \quad (z = 1)$$
$$r_2 = \frac{a_0 2^2}{1} = 4a_0$$
$$x = r_3 - r_2 = 9a_0 - 4a_0 = 5a_0$$

For Li^{2+} ion, the radii of 3rd and 4th orbit respectively can be calculated as

$$r_4 = a_0 \frac{4^2}{3} = \frac{16a_0}{3} \quad (z = 3)$$
$$r_3 = a_0 \frac{3^2}{3} = 3a_0$$
$$y = r_4 - r_3 = \frac{7a_0}{3}$$
$$y : x = \frac{7a_0}{3} \times \frac{1}{5a_0} = 7 : 15$$

Question12

The de-Broglie wavelength of an electron in the third Bohr orbit of H -atom is

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Options:

A.

$3\pi \times 5.29\text{pm}$

B.

$4\pi \times 52.9\text{pm}$

C.

$6\pi \times 52.9\text{pm}$

D.

$2\pi \times 5.29\text{pm}$

Answer: C

Solution:

Radius of nth orbit of H -atom.

$$r_n = r_0 \times n^2$$
$$r_3 = 3^2 \times 52.9\text{pm}$$

Using Bohr's postulate of angular momentum

$mvr = \frac{nh}{2\pi} \Rightarrow mv = \frac{3h}{2\pi r}$

According to de-Broglie

$$\lambda = \frac{h}{mv} = \frac{h}{3h/2\pi r} = \frac{2\pi r}{3}$$
$$\Rightarrow \lambda = \frac{2\pi \times 3^2 \times 52.9}{3}$$
$$\Rightarrow \lambda = 6\pi \times 52.9\text{pm}$$

Question13

The wavenumber of the first line $(n_2 = 3)$ in the Balmer series of hydrogen is overline $\bar{v}_1$ cm^{-1}. What is the wavenumber (in cm^{-1}) of the second line ($n_2 = 4$) in the Balmer series of He^{+}?

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Options:

A.

$\frac{5\bar{V}_1}{27}$

B.

$\frac{27\bar{V}_1}{5}$

C.

$\frac{27\bar{v}_1}{20}$

D.

$\frac{20\bar{v}_1}{27}$

Answer: B

Solution:

Using the Rydberg formula for wavenumber

$\bar{v} = Rz^2\left[\frac{1}{n_1^2} - \frac{1}{n_2^2}\right]$

for wavenumber of 1st line of H atom

$n_1 = 2, n_2 = 3, z = 1$

$$\bar{v}_{\mathrm{H}} = R\left[\frac{1}{4} - \frac{1}{9}\right]$$

$$\bar{v}_{\mathrm{H}} = R\left[\frac{5}{36}\right] \qquad \ldots(i)$$

The wavenumber of 2 nd line of He^{+}

$n_1 = 2, n_2 = 4, z = 2$

$$\bar{v}^{+}_{\mathrm{He}} = 4R\left[\frac{1}{4} - \frac{1}{16}\right] = R\left(\frac{3}{4}\right) \qquad \ldots(ii)$$

Divide Eq. (ii) by Eq. (i)

$\bar{v}\mathrm{He}^{+} = \frac{27}{5}\bar{v}_{\mathrm{H}}$ or $\frac{27}{5}\bar{v}_1$

Question14

Which of the following sets of quantum numbers is not possible for the electron?

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Options:

A.

$n = 3, I = 1, m = 0, s = +\frac{1}{2}$

B.

$n = 4, I = 0, m = 0, s = -\frac{1}{2}$

C.

$n = 3, I = 3, m = -3, s = +\frac{1}{2}$

D.

$n = 1, l = 0, m = 0, s = -\frac{1}{2}$

Answer: C

Solution:

For set $n = 3, l = 3, m - 3, s = +\frac{1}{2}$ is not possible.

The value of l varies from 0 to $(n - 1)$

So, $n = 3, l$ can have value $0, 1, 2$ only

Question15

The uncertainty in the position of electron (Δx) is approximately 100 pm . The uncertainty in momentum (in kgms^{-1}) of an electron $\left[h=6.626\times10^{-34}\mathrm{Js}\right]$

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Options:

A.

1.104×10^{-22}

B.

0.527×10^{-27}

C.

0.527×10^{-24}

D.

1.055×10^{-24}

Answer: C

Solution:

Heisenberg's uncertainty principle,

$\Delta x\cdot\Delta p\geq\frac{h}{4\pi}$

Substituting the values

$$\Delta p\geq\frac{6.626\times10^{-34}\mathrm{Js}}{4\times3.14\times100\times10^{-12}\ \mathrm{m}}$$
$$\Delta p=0.527\times10^{-24}\ \mathrm{kg\ m/s}$$

Question16

Which of the following statements are correct?

I. The energy of hydrogen atom in its ground state is -13.6 eV .

II. On the basis of Bohr's model, the radius of the 3rd orbit of hydrogen atom is 158.7 pm .

III. The order of radius of the first orbit of $\mathrm{H}, \mathrm{He}^{+}, \mathrm{Li}^{2+}$ and Be^{3+} is $\mathrm{H}>\mathrm{He}^{+}>\mathrm{Li}^{2+}>\mathrm{Be}^{3+}$.

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Options:

A.

II and III only

B.

I and III only

C.

I and II only

D.

I, II and III

Answer: B

Solution:

Among the given options, statement given in I and III are correct, while II is incorrect. The correct form of II is, 3rd orbit radius

$$r_n=n^2 \times r_1$$
$$r_3=9 \times 52.9=476.1 \mathrm{pm}$$

Question17

When a metal surface is irradiated with light of frequency x Hz, the kinetic energy of emitted photoelectrons is z J. When the same metal is irradiated with light of frequency y Hz, the kinetic energy of emitted electrons is $z/3$ J. What is threshold frequency (in Hz) of metal?

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Options:

A.

$\frac{3}{2}(y-x)$

B.

$\left(\frac{3y-x}{2}\right)$

C.

$\left(\frac{2y-x}{3}\right)$

D.

$\frac{2}{3}(y-x)$

Answer: B

Solution:

Kinetic energy, when x frequency light is irradiated

$z=h\left(x-f_0\right) \qquad \ldots(i)$

Kinetic energy, when y frequency light is irradiated

$\frac{z}{3}=h\left[y-f_0\right] \qquad \ldots(ii)$

divide Eq. (i) and (ii)

$\frac{z}{\frac{z}{3}}=\frac{h(x-f_0)}{h(y-f_0)} \Rightarrow 3=\frac{x-f_0}{y-f_0}$

On solving for f_0

$f_0=\frac{3y-x}{2}$

Question18

Identify the correct statements from the following

I. Isotopes of an element show different chemical behaviour.

II. Lyman series of lines of hydrogen spectrum appear in UV region.

III. The oscillating electric and magnetic field components of electromagnetic radiation are perpendicular to each other and both are perpendicular to the direction of propagation of radiation.

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Options:

A.

II and III only

B.

I and II only

C.

I and III only

D.

I. II, III

Answer: A

Solution:

Among the given statements, statements given is II and III are correct. While statement I is incorrect. The correct form of statement I is Isotopes of an element shows same chemical behaviour.

Question19

The sum of number of angular nodes and radial nodes for $4d$-orbital is

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Options:

A. 2

B. 3

C. 4

D. 5

Answer: B

Solution:

To find the sum of angular and radial nodes for a $4d$ orbital, follow these steps:

Radial Nodes Calculation:

The formula for determining the number of radial nodes is $n - l - 1$.

For a $4d$ orbital, the principal quantum number $n = 4$ and the azimuthal quantum number $l = 2$.

Therefore, the number of radial nodes is:

$4 - 2 - 1 = 1$

Angular Nodes Calculation:

The number of angular nodes is simply given by the azimuthal quantum number l.

Hence, for the $4d$ orbital:

$l = 2$

Sum of Angular and Radial Nodes:

Adding the two types of nodes gives:

$2 + 1 = 3$

So, the sum of angular and radial nodes for a $4d$ orbital is 3.

Question20

If the position of the electron was measured with an accuracy of +0.002 nm . The uncertainty in the momentum of it would be (in kgms^{-1} **)**

$\left(h=6.626\times 10^{-34}\mathrm{Js}\right)$

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Options:

A. 2.637×10^{-23}

B. 2.637×10^{-24}

C. 8.283×10^{-23}

D. 8.283×10^{-24}

Answer: A

Solution:

Given:

Position uncertainty: $\Delta x=0.002\,\mathrm{nm}=0.002\times 10^{-9}\,\mathrm{m}$

Planck's constant: $h=6.626\times 10^{-34}\,\mathrm{Js}$

According to the Heisenberg uncertainty principle:

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

Solving for the uncertainty in momentum (Δp):

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

Substitute the given values into the equation:

$\Delta p=\frac{6.626\times 10^{-34}}{4\times 3.14\times 0.002\times 10^{-9}}$

Calculating the above expression results in:

$\Delta p=2.637\times 10^{-23}\,\mathrm{kg\ m/s}$

This is the uncertainty in the momentum of the electron.

Question21

The de-Broglie wavelength of an electron with kinetic energy of 2.5 eV is (in m) $\left(1 \mathrm{eV}=1.6 \times 10^{-19}\right.$ J, $m_e=9 \times 10^{-31}$ kg)

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Options:

A. $\frac{h \times 10^{-25}}{\sqrt{72}}$

B. $\frac{h \times 10^{25}}{\sqrt{72}}$

C. $\frac{\sqrt{72}}{h \times 10^{-25}}$

D. $\frac{\sqrt{72}}{h \times 10^{25}}$

Answer: B

Solution:

To determine the de Broglie wavelength of an electron with a kinetic energy of 2.5 eV, we use the following information:

Kinetic Energy (KE) = 2.5 eV

Mass of electron (M_e) = 9×10^{-31} kg

Conversion factor: $1 \mathrm{eV}=1.6 \times 10^{-19}$ J

The de Broglie wavelength (λ) is given by:

$$\lambda=\frac{h}{p}=\frac{h}{\sqrt{2 M_e \times \mathrm{KE}}}$$

where:

$$p=\sqrt{2 M_e \times \mathrm{KE}}$$

Therefore, substituting the given values, we find:

$$\lambda=\frac{h}{\sqrt{2 \times 9 \times 10^{-31} \times 2.5 \times 1.6 \times 10^{-19}}}$$

Simplifying the expression inside the square root:

$$\lambda=\frac{h}{\sqrt{72} \times 10^{-25}}=\frac{h \times 10^{25}}{\sqrt{72}} \mathrm{~m}$$

Question22

The ratio of ground state energy of Li^{2+}, He^{+}, H is

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Options:

A. 3 : 2 : 1

B. 1 : 2 : 3

C. 9 : 4 : 1

D. 1 : 4 : 9

Answer: C

Solution:

The energy of the nth orbit for an atom with atomic number Z is given by:

$$E_n = -R_{\mathrm{H}}\left(\frac{Z^2}{n^2}\right)$$

Here, R_{H} is the Rydberg constant.

For the ground state of different ions and atoms, where $n = 1$:

Lithium ion (Li^{2+}):

$Z = 3, n = 1$

$E_{\mathrm{Li}^{2+}} = -R_{\mathrm{H}}\left(\frac{9}{1}\right)$

$= -9R_{\mathrm{H}}$

Helium ion (He^{+}):

$Z = 2, n = 1$

$E_{\mathrm{He}^{+}} = -R_{\mathrm{H}}\left(\frac{4}{1}\right)$

$= -4R_{\mathrm{H}}$

Hydrogen atom (H):

$Z = 1, n = 1$

$E_{\mathrm{H}} = -R_{\mathrm{H}}$

The ratio of the ground state energies for Li^{2+}, He^{+}, and H:

$E_{Li^{2+}} : E_{He^{+}} : E_H = 9 : 4 : 1$

Question23

If the longest wavelength of spectral line of Paschen series of Li^{2+} ion spectrum is $x\overset{o}{A}$. Then the longest wavelength (in $\overset{o}{A}$) of Lyman series of hydrogen spectrum is

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Options:

A. $\frac{12}{7x}$

B. $\frac{7x}{12}$

C. $\frac{20x}{27}$

D. $\frac{27x}{20}$

Answer: B

Solution:

Given that the longest wavelength of the Paschen series for the Li^{2+} ion is x Å, we use the formula for the wavelength of spectral lines:

$\frac{1}{\lambda} = R\left[\frac{1}{n_1^2} - \frac{1}{n_2^2}\right]Z^2$

Paschen Series for Li^{2+}:

For the longest wavelength in the Paschen series, the transitions are from $n_2 = 4$ to $n_1 = 3$.

The atomic number Z for lithium is 3.

The formula becomes:

$\frac{1}{x} = R\left[\frac{1}{3^2} - \frac{1}{4^2}\right] \times 3^2$

Calculating the values:

$\frac{1}{x} = R\left[\frac{1}{9} - \frac{1}{16}\right] \times 9$

$\frac{1}{x} = R\left[\frac{7}{144}\right] \times 9$

Solving for R:

$R = \frac{16}{7x}$ (\AA^{-1})

Lyman Series for Hydrogen:

For the longest wavelength in the Lyman series, the transition is from $n_2 = 2$ to $n_1 = 1$.

The atomic number Z for hydrogen is 1.

Using the value derived for R:

$\frac{1}{\lambda} = \frac{16}{7x}\left[\frac{1}{1} - \frac{1}{4}\right]$

Further simplification:

$\frac{1}{\lambda} = \frac{16}{7x} \times \frac{3}{4}$

Therefore, the longest wavelength λ for the Lyman series in hydrogen is:

$\lambda = \frac{7x}{12}$ \AA

This guides students in calculating the Lyman series' longest wavelength based on known parameters from the Paschen series for the Li^{2+} ion.

Question24

If v_0 is the threshold frequency of a metal X, the correct relation between de-Broglie wavelength (λ) associated with photoelectron and frequency (v) of the incident radiation is

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Options:

A. $\lambda \propto \frac{1}{\sqrt{v-v_0}}$

B. $\lambda \propto \frac{1}{(v-v_0)^{1/4}}$

C. $\lambda \propto \frac{1}{(v-v_0)^{3/4}}$

D. $\lambda \propto \sqrt{v - v_0}$

Answer: A

Solution:

The de Broglie wavelength for an electron is given by the formula:

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

where E is the kinetic energy of the electron.

According to the photoelectric effect, the kinetic energy E of the photoelectron can be found by subtracting the work function of the metal from the energy of the incident photon:

$E = hv - hv_0$

This implies:

$E \propto (v - v_0)$

Thus, we have:

$\lambda \propto \frac{1}{\sqrt{E}} \Rightarrow \lambda \propto \frac{1}{\sqrt{v - v_0}}$

Question25

The difference in radii between fourth and third Bohr orbit of He^{+}(in m) is

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Options:

A. 2.64×10^{-10}

B. 1.85×10^{-12}

C. 1.85×10^{-10}

D. 1.85×10^{-9}

Answer: C

Solution:

According to Bohr's postulate, the radius is given by $r = 0.529 \frac{n^2}{Z} \stackrel{\circ}{A}$ (where, Z is atomic number and $n =$ orbit)

For 4th orbit of He^{+} ion

$r_4 = 0.529 \left[\frac{16}{2}\right] \stackrel{\circ}{A} \qquad \ldots (i)$

For 3rd orbit of He^{+} ion

$r_3 = 0.529\left[\frac{9}{2}\right]\overset{\circ}{A}$ $\quad \ldots(ii)$

Eqs. (i) - (ii)

$$r_4 - r_3 = \frac{0.529}{2}[16 - 9] \times 10^{-10}\text{ m}$$
$$\Delta r = 1.85 \times 10^{-10}\text{ m}$$

Question26

If λ_0 and λ are respectively the threshold wavelength and wavelength of incident light the velocity of photo electrons ejected from the metal surface is

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Options:

A. $\sqrt{\frac{2h}{m}(\lambda_0 - \lambda)}$

B. $\sqrt{\frac{2hc}{m}\left(\frac{\lambda_0-\lambda}{\lambda\lambda_0}\right)}$

C. $\sqrt{\frac{2hc}{m}(\lambda_0 - \lambda)}$

D. $\sqrt{\frac{2h}{m}\left(\frac{1}{\lambda_0} - \frac{1}{\lambda}\right)}$

Answer: B

Solution:

In the context of the photoelectric effect, the energy of an incident photon is used to overcome the work function of the metal and to provide kinetic energy (KE) to the ejected photoelectrons. This relationship is described by Einstein's photoelectric equation:

$h\nu = h\nu_0 + \text{KE}$

Here, ν is the frequency of the incident light, ν_0 is the threshold frequency, and h is Planck's constant.

The kinetic energy (KE) of the ejected photoelectrons can be expressed as:

$\text{KE} = \frac{1}{2}mv^2 = h\nu - h\nu_0$

Since frequency ν can be related to wavelength λ by the equation $\nu = \frac{c}{\lambda}$, where c is the speed of light, the equation becomes:

$$\frac{1}{2}mv^2 = hc\left(\frac{1}{\lambda} - \frac{1}{\lambda_0}\right)$$

Solving for v, the velocity of the ejected photoelectrons, we have:

$$v = \sqrt{\frac{2hc}{m}\left(\frac{\lambda_0-\lambda}{\lambda\lambda_0}\right)}$$

Thus, the velocity of the ejected photoelectrons is derived from this equation, showing the relationship between the incident light wavelength, the threshold wavelength, and the resulting kinetic energy imparted to the electrons.

Question27

The energy of third orbit of Li^{2+} ion (in J) is

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Options:

A. -2.18×10^{-18}

B. -6.54×10^{-18}

C. -7.3×10^{-19}

D. $+2.18 \times 10^{-18}$

Answer: A

Solution:

The energy of the nth orbital of an atom, as described by Bohr's postulate, is given by the following formula:

$$E_n = -\frac{2.18\times10^{-18}\times Z^2}{n^2}\ \mathrm{J}$$

In this equation:

Z is the atomic number, which for lithium (Li) is 3.

n is the principal quantum number, and for the third orbit, $n = 3$.

Substituting these values into the formula:

$$E_n = \frac{-2.18\times10^{-18}\times3^2}{3^2}\ \mathrm{J}$$

$E_n = \frac{-2.18 \times 10^{-18} \times 9}{9}$ J

$E_n = -2.18 \times 10^{-18}$ J

Thus, the energy of the third orbit of the Li^{2+} ion is -2.18×10^{-18} J.

Question28

The number of d electrons in Fe is equal to which of the following?

(i) Total number of ' s ' electrons of Mg .

(ii) Total number of ' p ' electrons of Cl .

(iii) Total number of ' p ' electrons of Ne .

The correct option is

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Options:

A. (i), (ii) only

B. (ii), (iii) only

C. (i), (iii) only

D. (i), (ii), (iii)

Answer: C

Solution:

Element	Atomic number	Electronic configuration
Fe	26	$1s^2 2s^2 2p^6 3s^2 3p^6 4s^2 3d^6$
Cl	17	$1s^2 2s^2 2p^6 3s^2 3p^5$
Mg	12	$1s^2 2s^2 2p^6 3s^2$
Ne	10	$1s^2 2s^2 2p^6$

Total number of d electrons in Fe $= 6$

Total number of s electrons in Mg $= 6$

Total number of p electrons in Cl $= 11$

Total number of p electrons in Ne $= 6$

Question29

If uncertainty in position and momentum of an electron are equal, then uncertainty in its velocity is

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Options:

A. $\frac{1}{2m}\sqrt{\frac{h}{\pi}}$

B. $\frac{1}{m}\sqrt{\frac{h}{\pi}}$

C. $\sqrt{\frac{h}{\pi}}$

D. $m\sqrt{\frac{h}{\pi}}$

Answer: A

Solution:

According to the Heisenberg Uncertainty Principle, the product of the uncertainties in position (Δx) and momentum (Δp) of a particle is given by:

$\Delta x \cdot \Delta p = \frac{h}{4\pi} \quad \ldots \text{(i)}$

In this scenario, it is stated that the uncertainty in the position (Δx) is equal to the uncertainty in momentum (Δp). Therefore, we can express this as:

$\Delta x = \Delta p \quad \text{or} \quad \Delta x = m\Delta v \quad \ldots \text{(ii)}$

where m is the mass of the electron and Δv is the uncertainty in velocity. Substituting this relationship into Eq. (i), we have:

$(m\Delta v)(m\Delta v) = \frac{h}{4\pi}$

Simplifying this equation, we find:

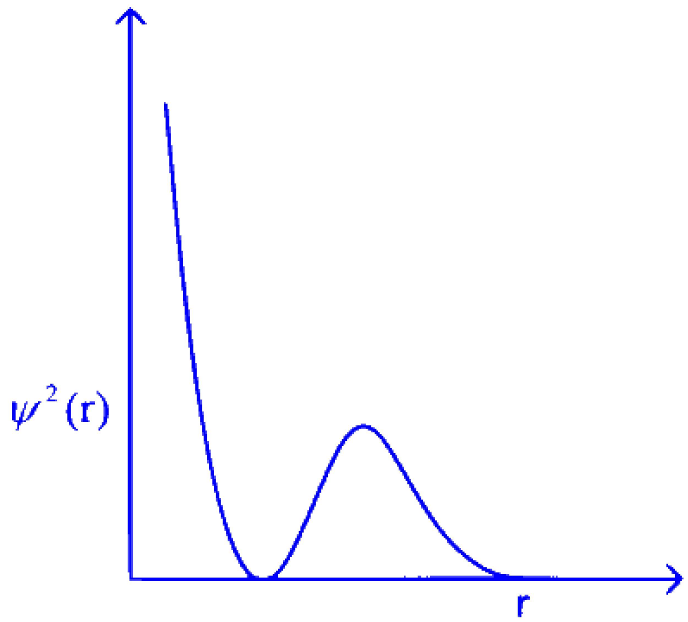
$(\Delta v)^2 = \frac{h}{4\pi m^2}$

Taking the square root of both sides, the uncertainty in velocity (Δv) is calculated as:

$\Delta v = \frac{1}{2m}\sqrt{\frac{h}{\pi}}$

Question30

The graph between variation of probability density. $\psi^2(r)$ and distance of the electron from the nucleus, r is shown below. This represents



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Options:

A. 1s-orbital

B. $2s$-orbital

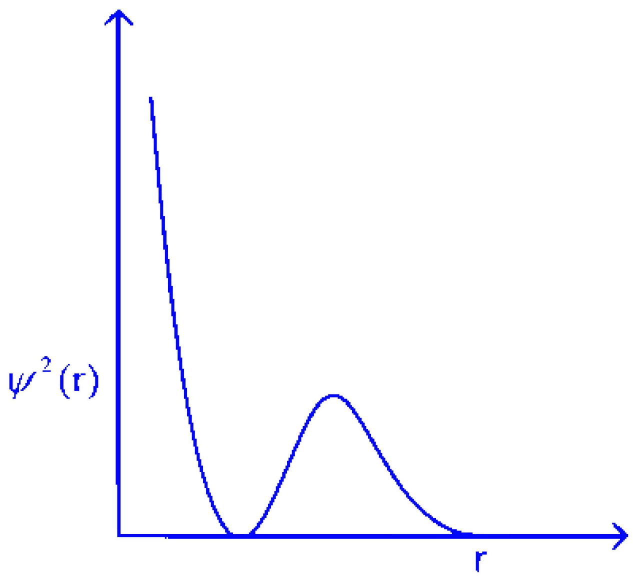
C. 3 s-orbital

D. $4s$-orbital

Answer: B

Solution:

From the graph, $\left[\psi^2(r) \text{ vs } r\right]$



It touches r axis at one point, which , means it has only one radical node and at $r=0$ it has some value which shows that it should be for ' s ' orbital.

$\therefore n-l-1=1$ (where, $l=0$)

$n-1=1$
$n=2$

Hence, $2s$-orbital.

Question31

The angular momentum of an electron in a stationary state of $\mathrm{Li}^{2+}(Z=3)$ is $3h/\pi$. The radius and energy of that stationary state are respectively

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Options:

A.

$3.174 \overset{\circ}{A}, -5.45 \times 10^{-19}$ J

B.

$6.348 \overset{\circ}{A}, -5.45 \times 10^{-19}$ J

C.

$6.348 \overset{\circ}{A}, +5.45 \times 10^{-18}$ J

D.

$2.116 \overset{\circ}{A}, -5.45 \times 10^{-19}$ J

Answer: B

Solution:

For an electron in a stationary state of $\mathrm{Li}^{2+}(Z=3)$, we are given that the angular momentum is $\frac{3h}{\pi}$.

Determining n:

Using Bohr's postulate for angular momentum:

$L = \frac{nh}{2\pi}$

Set this equal to the given angular momentum:

$\frac{3h}{\pi} = \frac{nh}{2\pi}$

Solving for n:

$3 \times 2 = n \quad \Rightarrow \quad n = 6$

Calculating the Radius:

The formula for the radius in Bohr's model is:

$r = r_0 \frac{n^2}{Z}$

where $r_0 = 0.529$ Å. Substituting the known values:

$r = 0.529 \times \frac{36}{3} = 6.348$ Å

Calculating the Energy:

The energy of the electron is given by:

$E = -13.6 \text{ eV} \times \frac{Z^2}{n^2}$

Converting to joules:

$E = -13.6 \times 1.6 \times 10^{-19} \times \frac{9}{36}$

$E = -5.45 \times 10^{-19} \text{ J}$

Thus, the radius is 6.348 Å and the energy is -5.45×10^{-19} J.

Question32

Identify the pair of elements in which number of electrons in ($n-1$) shell is same

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Options:

A. Fe, Mn

B. Zn, Fe

C. K, Sc

D. Mn, Cr

Answer: D

Solution:

Let's analyze the electron configurations of the given elements, focusing on the electrons in the (n – 1) shell. For transition elements in period 4, the outermost electrons are in the 4s orbital (n = 4), and the immediately inner electrons in the 3d orbitals belong to the (n – 1) = 3 shell.

For transition metals, we interpret "(n – 1) shell" as referring to the electrons in the 3d orbital (since n = 4 for period 4 elements).

Look at the electron configurations:

Mn (atomic no. 25): $[Ar]\, 3d^5\, 4s^2$

Cr (atomic no. 24): $[Ar]\, 3d^5\, 4s^1$

Even though Cr shows an exception (its 4s electron count is 1 instead of 2 due to extra stability of a half-filled 3d subshell), what matters here is the number of electrons in the 3d orbital.

Both Mn and Cr have:

3d electrons: $3d^5$

Checking the other options:

Fe: $[Ar]\, 3d^6\, 4s^2$ and **Mn:** $[Ar]\, 3d^5\, 4s^2$ have different numbers of 3d electrons (6 vs. 5).

Zn: $[Ar]\, 3d^{10}\, 4s^2$ and **Fe:** $[Ar]\, 3d^6\, 4s^2$ (10 vs. 6 in 3d).

K (atomic no. 19): $[Ar]\, 4s^1$ has no 3d electrons, while **Sc (atomic no. 21):** $[Ar]\, 3d^1\, 4s^2$ has one.

Thus, the only pair with the same number of electrons in the (n – 1) (i.e., the 3d) shell is Mn and Cr.

Therefore, the answer is:

Option D (Mn, Cr).

Question33

In the ground state of hydrogen atom, electron absorbs 1.5 times energy than the minimum energy $\left(2.18 \times 10^{-18}\ \mathrm{J}\right)$ to escape from the atom. The wavelength of the emitted electron (in m) is ($m_e = 9 \times 10^{-31}$ kg)

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Options:

A. $\frac{h \times 10^{24}}{\sqrt{1.962}}$

B. $\frac{h}{\sqrt{1.962}} \times 10^{23}$

C. $\frac{h}{\sqrt{1.962}} \times 10^{25}$

D. $\frac{h}{\sqrt{1.962}} \times 10^{22}$

Answer: A

Solution:

To determine the wavelength of the emitted electron, we can use the following process:

First, calculate the energy absorbed by the electron:

$J = 1.5 \times 2.18 \times 10^{-18}\,\mathrm{J} = 3.27 \times 10^{-18}\,\mathrm{J}\,(\mathrm{i})$

Using Einstein's photoelectric equation, we find the excess energy, which is the energy used by the emitted electron:

$$\begin{aligned} E &= \text{Total energy absorbed} - \text{Threshold energy} \\ &= 3.27 \times 10^{-18}\,\mathrm{J} - 2.18 \times 10^{-18}\,\mathrm{J} \\ &= 1.09 \times 10^{-18}\,\mathrm{J}\,(\mathrm{ii}) \end{aligned}$$

The wavelength λ of the emitted electron is given by:

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

Substituting the given values into this equation:

$\lambda = \frac{h}{\sqrt{2 \times 9 \times 10^{-31} \times 1.09 \times 10^{-18}}} = \frac{h \times 10^{24}}{\sqrt{1.962}}\,\mathrm{m}$

Question34

A golf ball of mass m g has a speed of $50\ \mathrm{ms}^{-1}$. If the speed can be measured within accuracy of 2% the uncertainty in the position is (in m)

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Options:

A. $\frac{h}{4\pi m}$

B. $\frac{h}{16\pi m}$

C. $\frac{h}{4\pi m} \times 10^3$

D. $\frac{h}{16\pi m} \times 10^3$

Answer: C

Solution:

Let's refine the explanation for clarity and professionalism:

The problem involves calculating the uncertainty in the position of a golf ball using the Heisenberg uncertainty principle. We are given:

The mass of the ball: m grams, which converts to $m = 1 \times 10^{-3}$ kilograms.

The speed (velocity) of the ball: $v = 50\,\mathrm{ms}^{-1}$.

The speed measurement has an uncertainty of 2%. Therefore, the uncertainty in speed, Δv, is calculated as follows:

$\Delta v = 2\%\text{ of }50\,\mathrm{ms}^{-1} = \frac{2\times 50}{100} = 1\,\mathrm{ms}^{-1}$

According to the Heisenberg uncertainty principle:

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

where Δx is the uncertainty in position and Δp is the uncertainty in momentum. Since momentum p is mass times velocity ($p = m \times v$), we can write:

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

Solving for Δx, we get:

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

Substituting the known values, we find:

$\Delta x = \frac{h}{4\pi\times 1\times 10^{-3}\times 1} = \frac{h}{4\pi m} \times 10^3\,\mathrm{m}$

This result shows the uncertainty in the position is $\frac{h}{4\pi m} \times 10^3$ meters.

Question35

The de-Broglie wavelength of a particle of mass 1 mg moving with a velocity of $10\ \mathrm{ms}^{-1}$ is $\left(\mathrm{h} = 6.63 \times 10^{-34}\mathrm{Js}\ \right)$

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Options:

A. 6.63×10^{-20} m

B. 663×10^{-31} m

C. 663×10^{-34} m

D. 663×10^{-22} m

Answer: A

Solution:

To calculate the de-Broglie wavelength of a particle, we use the formula:

$\lambda = \frac{h}{mv}$

where λ is the wavelength, h is Planck's constant, m is the mass of the particle, and v is the velocity of the particle.

Given:

Mass $m = 1\,\text{mg} = 1 \times 10^{-3}\,\text{g} = 1 \times 10^{-6}\,\text{kg}$

Velocity $v = 10\,\text{m/s}$

Planck's constant $h = 6.63 \times 10^{-34}\,\text{Js}$

Substitute these values into the formula:

$\lambda = \frac{6.63 \times 10^{-34}}{1 \times 10^{-6} \times 10} = \frac{6.63 \times 10^{-34}}{10^{-5}} = 6.63 \times 10^{-29}\,\text{m}$

Therefore, the de-Broglie wavelength of the particle is 6.63×10^{-29} m.

Question36

Correct set of four quantum numbers for the valence electron of strontium $(z = 38)$ is

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Options:

A. $5.0.0 + \frac{1}{2}$

B. $51, a + \frac{1}{2}$

C. $5.11 + \frac{1}{2}$

D. $6, aa + \frac{1}{2}$

Answer: A

Solution:

The correct set of four quantum numbers for the valence electron of strontium $(Z = 38)$ is derived from its electronic configuration.

Electronic Configuration of Strontium $(Z = 38)$:

$1s^2\,2s^2\,2p^6\,3s^2\,3p^6\,4s^2\,3d^{10}\,4p^6\,5s^2$

For the Valence Shell Electron $(5s^2)$**:**

Principal Quantum Number (n)**:** 5

Azimuthal Quantum Number (l)**:** 0 (since it is an s-orbital)

Magnetic Quantum Number (m)**:** 0 (since m ranges from $-l$ to $+l$, and for $l = 0$, $m = 0$)

Spin Quantum Number: $\frac{1}{2}$

Thus, the correct set of quantum numbers for the valence electron is $(5, 0, 0, \frac{1}{2})$.

Question37

The wavelength associated with the electron moving in the first orbit of hydrogen atom with velocity $2.2 \times 10^6 \text{ ms}^{-1}$ (in nm) is

$$\left(m_e = 9.0 \times 10^{-31} \text{ kg}, h = 6.6 \times 10^{-34} \text{Js}\right)$$

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Options:

A. 0.66

B. 0.33

C. 0.22

D. 0.44

Answer: B

Solution:

The wavelength associated with an electron moving in the first orbit of a hydrogen atom with a velocity of $2.2 \times 10^6 \text{ ms}^{-1}$ (in nm) can be determined as follows:

Given values:

$m_e = 9.0 \times 10^{-31} \text{ kg}, \ h = 6.626 \times 10^{-34} \text{ Js}$

According to de Broglie's equation:

$\lambda = \frac{h}{mv}$

Where:

λ is the wavelength,

h is Planck's constant (6.626×10^{-34} Js),

m is the mass of the electron (9.0×10^{-31} kg),

and v is the velocity of the electron (2.2×10^{6} m/s).

Substituting the given values:

$$\lambda = \frac{6.626 \times 10^{-34}}{9.0 \times 10^{-31} \times 2.2 \times 10^{6}}$$
$$= 0.33 \times 10^{-9}\ \mathrm{m}$$

This simplifies to 0.33 nm (since $1\ \mathrm{nm} = 10^{-9}\ \mathrm{m}$).

Question38

The energy required (in eV) to excite an electron of H -atom from the ground state to the third state is

AP EAPCET 2022 - 5th July Morning Shift

Options:

A. +0.85

B. -3.4

C. 12.1

D. -12.1

Answer: C

Solution:

The energy required (in eV) to excite an electron in a hydrogen atom from the ground state to the third state is calculated as follows:

First, we use the formula for the energy of an electron in a specific state:

$$E = \frac{-13.6 Z^2}{n^2}$$

For the ground state (n = 1) of a hydrogen atom (Z = 1):

$E_1 = \frac{-13.6\times1^2}{1^2} = -13.6 \text{ eV}$

For the third state (n = 3) of a hydrogen atom (Z = 1):

$E_3 = \frac{-13.6\times1^2}{3^2} = -1.511 \text{ eV}$

The energy required to excite the electron from the ground state to the third state is given by:

$\Delta E = E_3 - E_1 = -1.511 - (-13.6) = 12.089 \text{ eV} \approx 12.1 \text{ eV}$

Question39

The maximum number of electrons present in an orbital with $n = 4, l = 3$ is

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Options:

A. 6

B. 14

C. 10

D. 2

Answer: D

Solution:

An orbital can have maximum two electrons. Hence, an orbital with $n = 4$ and $l = 3$ can have maximum two electrons.

Question40

Which quantum number provides information about the shape of an orbital?

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Options:

A. Spin quantum number

B. Azimuthal quantum number

C. Magnetic quantum number

D. Principal quantum number

Answer: B

Solution:

Azimuthal or angular quantum number (l) describes about the shape of the orbitals. Orbital having $l = 0$ have spherical shape$l = 1$, Dumbell$l = 2$, Double dumbell

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Question41

If Δx is the uncertainty in position and Δv is the uncertainty in velocity of a particle are equal, the correct expression for uncertainty in momentum for the same particle is

AP EAPCET 2022 - 4th July Morning Shift

Options:

A. $\frac{1}{4}\sqrt{\frac{mh}{\pi}}$

B. $\frac{1}{3}\sqrt{\frac{mh}{2\pi}}$

C. $\frac{1}{2}\sqrt{\frac{mh}{\pi}}$

D. $\frac{1}{2}\sqrt{\frac{h}{m\pi}}$

Answer: C

Solution:

Given, $\Delta x =$ uncertainty in position

$\Delta v =$ uncertainty in velocity we know, $\Delta p = m\Delta v$, where Δp is the uncertainty in momentum and m is the mass of particle. Using Heisenberg's uncertainty principle,

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

As $\quad \Delta x = \Delta v$

So, $\Delta v \cdot m\Delta v = \frac{h}{4\pi}$

On multiplying both sides with m, we get

$m\Delta v \cdot m\Delta v = \frac{mh}{4\pi}$

Thus, $\Delta p^2 = \frac{mh}{4\pi} \Rightarrow \Delta p = \sqrt{\frac{mh}{4\pi}}$

Hence, $\Delta p = \frac{1}{2}\sqrt{\frac{mh}{\pi}}$

Question42

The number of radial nodes and angular nodes of a $4f$-orbital are respectively

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Options:

A. 0, 3

B. 1, 2

C. 2, 1

D. 2, 0

Answer: A

Solution:

Number of radial nodes, $R_n = n - l - 1$

Number of angular nodes, $A_n = l$

For $4f$-orbital,

Principal quantum number, $n = 4$

Azimuthal quantum number, $l = 3$

Thus,

$$R_n = 4 - 3 - 1 = 0$$
$$A_n = 3$$

Hence, radial nodes and angular nodes for $4f$-orbital are 0 and 3 respectively.

Question43

A subshell $n = 3, l = 2$ can accommodate maximum of

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Options:

A. 10 electrons

B. 6 electrons

C. 18 electrons

D. 16 electrons

Answer: A

Solution:

$n = 3$, means 3rd shell

Azimuthal quantum number, $l = n - 1$

$\Rightarrow \quad l = 0, 1, 2$

(0 means s subshell, 1 means p subshell and 2 means d subshell)

So, $\quad l = 2$ means d subshell

$\therefore$ $3d$ subshell can accommodate maximum $2(2l + 1)$ 10 electrons.

Question44

If the work function for the photoelectronemission of a metal is 3.75 eV, then thethreshold wavelength of the radiation neededfor the ejection of the electron isapproximately

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Options:

A. 315 nm

B. 280 nm

C. 330 nm

D. 290 nm

Answer: C

Solution:

$$\psi(\text{ work function }) = \frac{hc}{\lambda_0}$$
$$\lambda_0 = \text{ threshold wavelength}$$
$$3.75 \times 1.6 \times 10^{-19} = \frac{6.62 \times 10^{-34} \times 3 \times 10^8}{\lambda_0}$$
$$\lambda_0 = \frac{6.62 \times 3 \times 10^{-34} \times 10^8}{3.75 \times 1.6 \times 10^{-19}}$$
$$= 3.30 \times 10^{-7} = 330 \times 10^{-9}$$
$$= 330 \text{ nm.}$$

Question45

With increasing principal quantum number, the energy difference between adjacent energy levels in H-atom ....

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Options:

A. decreases

B. increases

C. remain constant

D. decreases at low level of n and increases for higher value of n

Answer: A

Solution:

Difference in energy is given as

$$\Delta E = \frac{-Z^2 R}{n^2}$$

$$\Delta E \propto \frac{1}{n^2}$$

Therefore, as principal quantum number (n) increases, the energy of transition decreases (Negative sign indicates the spin of electron).

Question46

The number of protons, neutrons and electrons in ${}^{13}_{6}C$ respectively are

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Options:

A. 6, 7, 6

B. 13, 6, 6

C. 6, 7, 13

D. 6, 6, 13

Answer: A

Solution:

Number of protons, neutrons and electrons in ${}^{13}_{6}C$ are

Atomic number = 6

Atomic number = number of protons = number of electrons = 6

$\therefore$ Protons (p) = 6

Electrons (e) = 6

Atomic mass = number of protons + number of neutrons

$13 = 6 + x \Rightarrow x = 7$ (Atomic mass = 13)

Question47

The masses of an electron, a proton and a neutron respectively will be n the ratio

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Options:

A. 1 : 1836.15 : 1838.68

B. 1 : 1856.15 : 1858.68

C. 1 : 1834.15 : 1836.68

D. 1 : 1846.15 : 1848.68

Answer: A

Solution:

Mass of proton $(p) = 1.6726 \times 10^{-27}$ kg

Mass of neutron $(n) = 1.6749 \times 10^{-27}$ kg

Mass of electron $(e) = 9.1 \times 10^{-31}$ kg

Mass of proton is 1836.16 times heavier than electron.

Mass of neutron is 1838.68 times heavier than electron.

Ratio of mass of electron, proton and neutron will be

Mass of e : Mass of p : Mass of n

1 : 1836.16 : 1838.68

Question48

Match the following species with the correct number of electrons present in them.

	Species		Number of electrons
A.	Be^{2+}	(i)	0
B.	H^{+}	(ii)	10
C.	Na^{+}	(iii)	2
D.	Mg^{+}	(iv)	11
		(v)	4

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Options:

A. A - (iv), B - (iii), C - (ii), D - (i)

B. A - (i), B - (ii), C - (iii), D - (iv)

C. A - (v), B - (iv), C - (i), D - (iii)

D. A - (iii), B - (i), C - (ii), D - (iv)

Answer: D

Solution:

Number of electrons present in the following species

Atomic number = number of electrons in neutral species.

(i) $Be^{2+} \Rightarrow$ Atomic number $= 4$

It donate 2 electrons and acquire +2 charge.

$\therefore$ Number of electrons $= 2$

(ii) $H^{+} \Rightarrow$ Atomic number $= 1$

It donate 1 electron and acquire +1 charge.

Number of electrons $= 0$

(iii) $Na^{+} \Rightarrow$ Atomic number $= 11$

+1 charge represent donation of 1 electron.

Number of electrons $= 10$

(iv) $Mg^{+} \Rightarrow$ Atomic number $= 12$

Mg^{+} represent donation of 1 electron.

Number of electrons $= 11$

$$\therefore \quad Be^{2+} = 2, H^{+} = 0$$
$$Na^{+} = 10, Mg^{+} = 11$$

Question49

Assuming that the incident radiation iscapable of ejecting photoelectrons from allthe given metals, the lowest kinetic energy ofthe ejected photoelectron is observed withwhich of the given metals?

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Options:

A. Na

B. Li

C. Ag

D. Cu

Answer: D

Solution:

Metals emit electrons when light shines upon them. The phenomenon is called as photoelectric effect and the electrons emitted in such manner are called photoelectrons.

Relation between kinetic energy and frequency is kinetic energy $= \phi - h\mathrm{v}$

Here $\phi =$ metal work function

Kinetic energy of photoelectrons depends on frequency of incident light and metal work function. Cu has maximum metal work function's value.

Hence, Cu have minimum kinetic energy of ejected photoelectrons than alkali metals.

Question50

If the energies of two light radiations E_1 and E_2 are $25 \mathrm{~eV}$ and $100 \mathrm{~eV}$ respectively, then their respective wavelengths λ_1 and λ_2 would be in the ratio $\lambda_1 : \lambda_2$

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Options:

A. 2 : 1

B. 4 : 1

C. 1 : 4

D. 1 : 2

Answer: B

Solution:

We know that, energy $= hc/\lambda$

Here, $h =$ Planck's constant (Js)

$c =$ speed of light (m/s)

$\lambda =$ wavelength (m)

Now for energy $E_1 = 25\text{eV}$

$E_1 = hc/\lambda_1 \Rightarrow 25 = hc/\lambda_1$ ..... (i)

Similarly for energy,

$E_2 = hc/\lambda_2$

$100 = hc/\lambda_2$ ..... (ii)

By divide E_1 and E_2, we get

$25/100 = \lambda_2/\lambda_1 \Rightarrow 1/4 = \lambda_2/\lambda_1$
$\lambda_1 : \lambda_2 = 4 : 1$ or $\lambda_1 = 4\lambda_2$

Question51

If two particles A and B are moving with thesame velocity, but wavelength of A is foundto be double than that of B. Which of thefollowing statement is correct?

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Options:

A. Both A and B have same mass.

B. Mass of A is half that of B.

C. Mass of B is half that of A.

D. Mass of B is one-fourth that of A.

Answer: B

Solution:

Let us consider, particle A having velocity $= v_A$ and particle B having velocity $= v_B$

According to de-Broglie wavelength, $\lambda = \frac{h}{mv}$

here, $h =$ Planck constant

$m =$ mass of electron

$v =$ velocity of particle

Now, $\lambda_A = \frac{h}{m_A v_A}$ and $\lambda_B = \frac{h}{m_B v_B}$

Wavelength of A is found to be double than of B.

i.e. $\lambda_A = 2 \times \lambda_B$ ..... (i)

Put value of λ_A and λ_B in Eq. (i)

$$2 \times \frac{h}{m_B v_B} = \frac{h}{m_A v_A} \quad (\text{ For } v_A = v_B)$$
$$\frac{2}{m_B} = \frac{1}{m_A} \quad \left[m_A = \frac{m_B}{2}\right]$$

Here, mass of A is half that of B.

Question52

The spectrum of helium is expected to be similar to that of

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Options:

A. Li^+

B. H

C. Na

D. He^+

Answer: A

Solution:

Number of electrons in lithium ion (Li^+) is 2.

Number of electrons in helium is 2.

The spectrum of an atom depend on the numberof electrons present in it.

Li^+ (Z = 3)

He (Z = 2)

(Both have same electrons = 2)

Question53

On the basis of Bohr's model, the radius ofthe 3rd orbit is

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Options:

A. equal to the radius of 1st orbit

B. 3 times the radius of 1st orbit

C. 5 times the radius of 1st orbit

D. 9 times the radius of 1st orbit

Answer: D

Solution:

Bohr radius of hydrogen atom is first orbit in H-atom.

Bohr radius $(r_n) = \left(\frac{n^2}{Z}\right)\left(\frac{n^2}{4\pi^2 me^2}\right)$

$r_n = \frac{n^2}{Z} \times 0.529 \overset{o}{A}$

For first orbit $(n = 1), r_1 = \left(\frac{1}{Z}\right) \times 0.529 \overset{o}{A}$ ..... (i)

For second orbit $(n = 2), r_2 = \left(\frac{4}{Z}\right) \times 0.529 \overset{o}{A}$ ..... (ii)

For third orbit $(n = 3), r_3 = \left(\frac{9}{Z}\right) \times 0.529 \overset{o}{A}$ .... (iii)

Now divided (iii) by (i), we get

$r_3 = 9r_1$

The radius of 3rd orbit is 9 times the radius of 1st orbit.
