Atomic Structure

Question1

Calculate the frequency in Hz of orange colour light having wavelength 600 nm .

$$\left[\mathrm{C}=3\times10^{8}\ \mathrm{ms}^{-1}\right]$$

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Options:

A.

5.4×10^{14} Hz

B.

5.0×10^{14} Hz

C.

5.8×10^{14} Hz

D.

6.2×10^{14} Hz

Answer: B

Solution:

We use the relation:

$\nu=\frac{c}{\lambda}$

where

- $c = 3 \times 10^8$ m/s,
- $\lambda = 600\,\text{nm} = 600 \times 10^{-9}\,\text{m} = 6.0 \times 10^{-7}\,\text{m}$.

Step 1: Substitute values

$\nu = \frac{3.0 \times 10^8}{6.0 \times 10^{-7}}$

Step 2: Simplify

$\nu = \frac{3.0}{6.0} \times 10^{8+7}$

$\nu = 0.5 \times 10^{15}$

$\nu = 5.0 \times 10^{14}\,\text{Hz}$

✅ **Final Answer:**

The frequency is

Option B: $5.0 \times 10^{14}\,\text{Hz}$

Question2

"Pairing of electrons in the orbitals belonging to the same subshell does not occur unless each orbital belonging to that subshell has got one electron each." This statement is known as

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Options:

A.

Pauli's exclusion principle

B.

Hund's rule

C.

Aufbau rule

D.

Heisenberg uncertainty principle

Answer: B

Solution:

The statement:

"Pairing of electrons in the orbitals belonging to the same subshell does not occur unless each orbital belonging to that subshell has got one electron each."

This is the **Hund's Rule of Maximum Multiplicity**, which states that electrons occupy orbitals of the same subshell singly with parallel spins as far as possible before pairing.

✅ **Correct Answer: Option B — Hund's rule**

Question3

"It is impossible to determine simultaneously the exact position and exact momentum of an electron." This statement is called

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Options:

A. Pauli's exclusion principle

B. Hund's rule

C. Aufbau rule

D. Heisenberg uncertainty principle

Answer: D

Solution:

The correct answer is:

Option D: Heisenberg uncertainty principle ✅

This principle states that it is fundamentally impossible to determine simultaneously the exact position and exact momentum of a particle, such as an electron.

Question4

Which of the following elements contains maximum number of unpaired electrons?

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Options:

A. Fluorine

B. Sodium

C. Nitrogen

D. Oxygen

Answer: C

Solution:

Fluorine $\left(F^9\right)$: $1s^2 2s^2 2p^5$

Sodium $\left(\mathrm{Na}^{11}\right)$: $1\mathrm{~s}^2 2\mathrm{~s}^2 2\mathrm{p}^6 3\mathrm{~s}^1$

Nitrogen $\left(N^7\right)$: $1s^2 2s^2 2p^3$

Oxygen $\left(\mathrm{O}^8\right)$: $1\mathrm{~s}^2 2\mathrm{~s}^2 2\mathrm{p}^4$

Nitrogen has 3 unpaired electrons which is maximum among the given options.

Question5

Which from following d-orbitals has different shape as compared with others?

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Options:

A. d_{xy}

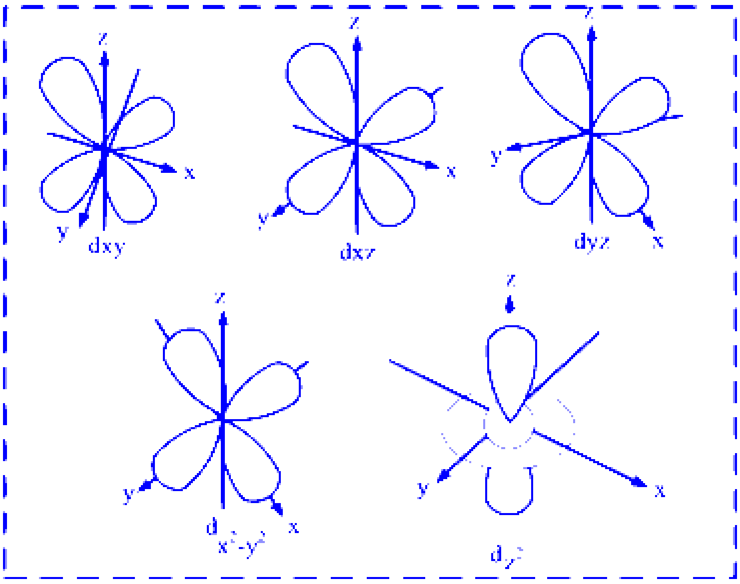
B. d_{yz}

C. d_{xz}

D. d_{z^2}

Answer: D

Solution:



Question6

What is the number of node in 2 s orbital?

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Options:

A. 0

B. 1

C. 2

D. 3

Answer: B

Solution:

The electron cloud of 2 s orbital shows one radial node, which is a region with nearly zero probability density.

Total nodes $= n-1=2-1=1$

Question7

What is the numerical value of angular momentum for an electron in first orbit of hydrogen atom? ($\mathrm{h}=6.626 \times 10^{-34} \mathrm{Js}$)

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Options:

A. 1.05×10^{-34}.

B. 2.10×10^{-34}

C. 3.16×10^{-34}

D. 4.22×10^{-34}

Answer: A

Solution:

The angular momentum of an electron in a given stationary orbit of hydrogen atom

$= m\mathrm{vr} = \frac{\mathrm{nh}}{2\pi}$ (where $n = 1, 2, 3, \ldots$)

Angular momentum of an electron in first orbit

$$\text{of hydrogen atom } = \frac{1 \times \mathrm{h}}{2\pi} = \frac{1 \times 6.626 \times 10^{-34}}{2 \times 3.14} = 1.05 \times 10^{-34}$$

Question8

Which from following is NOT hydrogen like species?

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Options:

A. Li^{+2}

B. Be^{+3}

C. Li^{+}

D. He^{+}

Answer: C

Solution:

Step 1: Recall definition

A *hydrogen-like species* has **only one electron** (just as hydrogen itself).

That means the species should be either H itself or any ion/atom with only one electron remaining, e.g., He^{+}, Li^{2+}, Be^{3+}, etc.

Step 2: Check each option

- **Option A: Li^{2+}**

  Neutral Li has atomic number 3 → 3 electrons. Li^{2+} means $3 - 2 = 1$ electron left. ✓ Hydrogen-like.

- **Option B: Be^{3+}**

  Be atomic number 4 → 4 electrons. Be^{3+} has 1 electron left. ✓ Hydrogen-like.

- **Option C: Li^{+}**

  Li has $Z = 3$. Li^{+} means $3 - 1 = 2$ electrons. ❌ Not hydrogen-like, because more than 1 electron.

- **Option D: He^{+}**

  He has $Z = 2$. He^{+} means $2 - 1 = 1$ electron. ✓ Hydrogen-like.

✅ Final Answer:

The NOT hydrogen-like species is:

Option C: Li^+

Question9

Which from following statements is NOT true about isotopes?

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Options:

A. These are the atoms of same elements.

B. They have same chemical properties.

C. They occupy same position in the modern periodic table.

D. They have equal number of neutrons.

Answer: D

Solution:

We are asked: "**Which of the following statements is NOT true about isotopes?**"

Recall:

- Isotopes are atoms of the same element (same number of protons, different number of neutrons).
- They have the same chemical properties because they have the same electron configuration.
- In the modern periodic table, they occupy the same position (since arrangement is based on atomic number, not mass number).
- They **do not** necessarily have an equal number of neutrons (that's what makes them isotopes).

✅ So the statement which is NOT true:

Option D: They have equal number of neutrons.

Question10

Calculate the energy per mole of photon of electromagnetic radiation having wavelength

$700 \text{ nm} \left[\text{h} = 6.626 \times 10^{-34} \text{Js}, \text{c} = 3 \times 10^{8} \text{ m/s} \right]$

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Options:

A. 1.71×10^{5} J

B. 1.02×10^{5} J

C. 1.84×10^{5} J

D. 1.55×10^{5} J

Answer: A

Solution:

Given data:

- Wavelength, $\lambda = 700 \text{ nm} = 700 \times 10^{-9}$ m
- Planck's constant, $h = 6.626 \times 10^{-34}$ Js
- Speed of light, $c = 3 \times 10^{8}$ m/s
- Avogadro's number, $N_A = 6.022 \times 10^{23} \text{ mol}^{-1}$

Step 1: Energy of one photon

The energy of one photon is given by:

$E = \frac{hc}{\lambda}$

Substitute the values:

$E = \frac{6.626 \times 10^{-34} \times 3 \times 10^{8}}{700 \times 10^{-9}}$

Calculate numerator and denominator separately:

- Numerator: $6.626 \times 10^{-34} \times 3 \times 10^{8} = 1.9878 \times 10^{-25}$
- Denominator: $700 \times 10^{-9} = 7 \times 10^{2} \times 10^{-9} = 7 \times 10^{-7}$

So,

$E = \frac{1.9878 \times 10^{-25}}{7 \times 10^{-7}}$

$E = \frac{1.9878}{7} \times 10^{-25+7}$

$E \approx 0.284 \times 10^{-18}$

$E = 2.84 \times 10^{-19}$ J

Step 2: Energy per mole of photon

Multiply by Avogadro's number to get energy per mole:

Energy per mole $= E \times N_A$

$= 2.84 \times 10^{-19} \times 6.022 \times 10^{23}$

Calculate:

$2.84 \times 6.022 = 17.106$

$10^{-19} \times 10^{23} = 10^4$

Energy per mole $= 17.106 \times 10^4$ J

$= 1.71 \times 10^5$ J

Final answer:

$\boxed{1.71 \times 10^5 \text{ J}}$

Correct option: Option A

Question11

"No two electrons in an atom can have the identical set of four quantum numbers." The statement is known as

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Options:

A. Pauli's exclusion principle.

B. Hund's rule.

C. Aufbau rule.

D. Heisenberg uncertainty principle.

Answer: A

Solution:

The correct answer is:

Option A: Pauli's exclusion principle.

Explanation:

- The four quantum numbers are: principal quantum number (n), azimuthal quantum number (l), magnetic quantum number (m), and spin quantum number (s).
- According to **Pauli's Exclusion Principle**, *no two electrons in the same atom can have an identical set of all four quantum numbers*.
- This principle explains why an orbital can hold **a maximum of two electrons**, and they must have **opposite spins**.

Other rules in comparison:

- **Hund's rule**: Electrons occupy degenerate orbitals singly before pairing.
- **Aufbau rule**: Electrons fill orbitals in order of increasing energy.
- **Heisenberg uncertainty principle**: It is impossible to know both position and momentum of an electron simultaneously with certainty.

So, the statement given in the question directly refers to **Pauli's Exclusion Principle**. ✅

Question12

Calculate the energy associated with third orbit of He^+.

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Options:

A. -4.8×10^{-19} J

B. -1.45×10^{-19} J

C. -19.36×10^{-19} J

D. -9.69×10^{-19} J

Answer: D

Solution:

Energy of an electron in the nth orbit of a hydrogen-like atom (like He^+) is given by:

$$E_n = -\frac{Z^2 R_H}{n^2}$$

where

Z = atomic number

R_H = Rydberg constant $= 2.18 \times 10^{-18}$ J

n = orbit number

For He^+:

$Z = 2$

$n = 3$

Substitute the values:

$$E_3 = -\frac{(2)^2 \times 2.18 \times 10^{-18}}{(3)^2}$$

Calculate stepwise:

1. $(2)^2 = 4$
2. $(3)^2 = 9$
3. $4 \times 2.18 \times 10^{-18} = 8.72 \times 10^{-18}$

So,

$$E_3 = -\frac{8.72 \times 10^{-18}}{9}$$

Now divide:

$E_3 = -0.968 \times 10^{-18}$

To write this in standard form:

$E_3 = -9.68 \times 10^{-19}$ J

Correct answer:

Option D: -9.69×10^{-19} J

(Note: The negligible difference is due to rounding of Rydberg constant in options.)

Question13

What is the wavenumber of the photon emitted during transition from the orbit $n = 5$ to that of $n = 2$ in hydrogen atom? $\left[R_H = 109677 \text{ cm}^{-1}\right]$

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Options:

A. 23032 cm^{-1}

B. 46064 cm^{-1}

C. 69096 cm^{-1}

D. 92128 cm^{-1}

Answer: A

Solution:

$$\begin{aligned}\overline{\mathrm{v}} &= 109677\left[\frac{1}{\mathrm{n}_{\mathrm{f}}^2}-\frac{1}{\mathrm{n}_{\mathrm{i}}^2}\right] \mathrm{cm}^{-1} \\ &= 109677\left[\frac{1}{2^2}-\frac{1}{5^2}\right] \mathrm{cm}^{-1} \\ &= 109677\left[\frac{1}{4}-\frac{1}{25}\right] \mathrm{cm}^{-1}\end{aligned}$$

$$\begin{aligned}&= 109677\left[\frac{25-4}{25 \times 4}\right] \mathrm{cm}^{-1} \\ &= 109677\left[\frac{21}{100}\right] \mathrm{cm}^{-1} \\ &= 23032 \mathrm{~cm}^{-1}\end{aligned}$$

Question14

Calculate the longest wavelength in hydrogen emission spectrum of Lyman series. $\left(\mathrm{R}_{\mathrm{H}}=109677 \mathrm{~cm}^{-1}\right)$

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Options:

A. 1.331×10^{-5} cm

B. 1.216×10^{-5} cm

C. 1.445×10^{-5} cm

D. 1.556×10^{-5} cm

Answer: B

Solution:

For the Lyman series, the transitions are to $n_1 = 1$ from higher energy levels $n_2 = 2, 3, 4, \ldots$.

The **longest wavelength** will correspond to the **smallest energy difference**, i.e., when $n_2 = 2$ (from $n = 2$ to $n = 1$; this is the first line of the Lyman series).

The wavelength of emitted light in the hydrogen spectrum is given by the **Rydberg formula**:

$$\tilde{\nu} = \frac{1}{\lambda} = R_H \left(\frac{1}{n_1^2} - \frac{1}{n_2^2} \right)$$

For Lyman series ($n_1 = 1, n_2 = 2$):

$$\frac{1}{\lambda} = R_H \left(1 - \frac{1}{4} \right) = R_H \left(\frac{3}{4} \right)$$

Insert $R_H = 109677 \text{ cm}^{-1}$:

$$\frac{1}{\lambda} = 109677 \times \frac{3}{4} = 82257.75 \text{ cm}^{-1}$$

Therefore,

$$\lambda = \frac{1}{82257.75}$$

Calculate:

$$\lambda = 1.21568 \times 10^{-5} \text{ cm}$$

Rounded to three significant digits:

$$\boxed{1.216 \times 10^{-5} \text{ cm}}$$

Correct Option: B

Question15

What is de Broglie's wavelength for a particle having mass 6.64×10^{-27} kg moving with velocity of $3 \times 10^3 \text{ ms}^{-1}$? $\left[\text{h} = 6.63 \times 10^{-34} \text{Js} \right]$

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Options:

A. 0.111 nm

B. 0.0333 nm

C. 1.22 nm

D. 2.42 nm

Answer: B

Solution:

$$\lambda = \frac{\mathrm{h}}{\mathrm{mv}} = \frac{6.63 \times 10^{-34}\ \mathrm{J.s}}{6.64 \times 10^{-27}\ \mathrm{kg} \times 3 \times 10^{3}\ \mathrm{ms}^{-1}}$$
$$= 0.0333 \times 10^{-9}\ \mathrm{m}$$
$$= 0.033\ \mathrm{nm}$$

Question16

Which of the following series of emission spectral lines for hydrogen observed in visible region?

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Options:

A. Paschen

B. Lyman

C. Pfund

D. Balmer

Answer: D

Solution:

The series of emission spectral lines for hydrogen that are observed in the visible region is the **Balmer series**.

Explanation

The hydrogen atom's electron transitions between different energy levels produce emission spectra. These transitions are categorized into different series named after their discoverers:

Lyman Series: Transitions from higher energy levels to $n = 1$. This series lies in the ultraviolet region.

Balmer Series: Transitions from higher energy levels to $n = 2$. This series includes wavelengths that fall within the visible spectrum.

Paschen Series: Transitions from higher energy levels to $n = 3$. This series is in the infrared region.

Pfund Series: Transitions from higher energy levels to $n = 5$. This series is also in the infrared region.

Thus, the Balmer series is the only one with spectral lines in the visible region of the electromagnetic spectrum.

Question17

What is wavenumber of a radiation having wavelength 0.25μ m ?

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Options:

A. $2.5 \times 10^6 \mathrm{~m}^{-1}$

B. $4.0 \times 10^6 \mathrm{~m}^{-1}$

C. $6.5 \times 10^6 \mathrm{~m}^{-1}$

D. $8.0 \times 10^6 \mathrm{~m}^{-1}$

Answer: B

Solution:

The wavenumber of a radiation is defined as the reciprocal of its wavelength. The formula for calculating the wavenumber ($\tilde{\nu}$) is given by:

$\tilde{\nu} = \frac{1}{\lambda}$

where λ is the wavelength of the radiation.

Given that the wavelength $\lambda = 0.25\,\mu\text{m}$, we first need to convert this wavelength into meters:

$1\,\mu\text{m} = 1 \times 10^{-6}\,\text{m}$

Thus,

$\lambda = 0.25 \times 10^{-6}\,\text{m}$

Now, compute the wavenumber:

$\tilde{\nu} = \frac{1}{0.25\times10^{-6}\,\text{m}} = \frac{1}{0.25} \times 10^{6} = 4.0 \times 10^{6}\,\text{m}^{-1}$

Therefore, the wavenumber of the given radiation is:

Option B: $4.0 \times 10^{6}\ \text{m}^{-1}$

Question18

Which of the following species contain 20 electrons?

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Options:

A. K^{+}

B. Ca

C. Mg

D. Cl

Answer: B

Solution:

Species	No. of electrons
K^{+}	$19 - 1 = 18$
Cl	17
Ca	20

Species	No. of electrons
Mg	12

Question19

Calculate the radius of first orbit of He^{+}.

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Options:

A. 24.45 pm

B. 13.23 pm

C. 48.62 pm

D. 39.46 pm

Answer: A

Solution:

$r_n = \frac{52.9(n)^2}{Z} pm$

He^{+} is a hydrogen-like species having $Z = 2$.

Radius of the first orbit of He^{+}

$= r_1 = \frac{52.9 \times (1)^2}{2} pm = 26.45 pm$

Question20

What is the designation of an orbital with quantum numbers $n = 4$ and $l = 3$?

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Options:

A. 4s

B. 4p

C. 4d

D. 4f

Answer: D

Solution:

The principal quantum number $n = 4$ indicates the energy level of the electron in the orbital. The azimuthal (or angular momentum) quantum number l determines the subshell or type of orbital within that energy level. The values of l are associated with specific types of orbitals, as follows:

$l = 0$ corresponds to an **s** orbital

$l = 1$ corresponds to a **p** orbital

$l = 2$ corresponds to a **d** orbital

$l = 3$ corresponds to an **f** orbital

Given the quantum number $l = 3$, the orbital type is an **f** orbital. Therefore, when $n = 4$ and $l = 3$, the designation of the orbital is **4f**.

The correct option is **D**: 4f.

Question21

Find the number of electrons that generate 1 coulomb charge?

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Options:

A. 6.24×10^{18}

B. 1.25×10^{18}

C. 6.22×10^{23}

D. 3.12×10^{18}

Answer: A

Solution:

The charge of a single electron is approximately 1.602×10^{-19} coulombs. To find the number of electrons that generate a total charge of 1 coulomb, use the formula:

$n = \frac{\text{total charge}}{\text{charge per electron}}$

Substituting the values:

$n = \frac{1 \text{ coulomb}}{1.602 \times 10^{-19} \text{ coulombs/electron}}$

This simplifies to:

$n \approx 6.24 \times 10^{18}$ electrons

Therefore, the number of electrons that generate 1 coulomb of charge is approximately 6.24×10^{18}, which corresponds to Option A.

Question22

Calculate the radius of first orbit of Li^{++}.

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Options:

A. 70.53 pm

B. 158.7 pm

C. 17.63 pm

D. 282.13 pm

Answer: C

Solution:

The radius of the first orbit of a hydrogen-like atom can be calculated using the formula:

$r_n = \frac{n^2 \cdot h^2}{4\pi^2 \cdot m_e \cdot e^2 \cdot Z}$

Simplifying further using the Bohr radius (a_0), which is the radius of the first orbit of hydrogen ($n = 1, Z = 1$):

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

where:

n is the principal quantum number (for the first orbit, $n = 1$),

Z is the atomic number of the element,

$a_0 = 0.529\,\text{Å} = 52.9\,\text{pm}$ (Bohr radius).

For Li^{++}, the atomic number $Z = 3$, and we are looking at the first orbit ($n = 1$). Substituting these into the formula gives:

$r_1 = \frac{1^2 \cdot 52.9\text{ pm}}{3} = \frac{52.9\text{ pm}}{3} = 17.63\,\text{pm}$

Thus, the radius of the first orbit of Li^{++} is **17.63 pm**, which corresponds to Option C.

Question23

What is the total number of orbitals present in N shell?

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Options:

A. 1

B. 4

C. 9

D. 16

Answer: D

Solution:

Symbol of Shell	Value of Principal quantum number (n)	Value of Azimuthal Quantum number (l)	Symbol of shbshell	Total Number of orbitals in the subshell $= 2l+1$
N	n = 4	$l=0$	4s	$2\times0+1=1$
		$l=1$	4p	$2\times1+1=3$
		$l=2$	4d	$2\times2+1=5$
		$l=3$	4f	$2\times3+1=7$

Hence, the total number of orbitals

$= 1+3+5+7 = 16.$

Question24

Which from following statements is NOT correct regarding Bohr model?

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Options:

A. It failed to account for finer details of hydrogen spectrum.

B. It is unable to explain atomic spectrum other than hydrogen.

C. It explains Zeeman effect.

D. It failed to explain ability of atoms to form molecules by chemical bonds.

Answer: C

Solution:

Option C

The Bohr model is not capable of explaining the Zeeman effect, which is the splitting of spectral lines in the presence of a magnetic field. The Bohr model primarily provides an explanation for the hydrogen atom's spectral lines but lacks the complexity needed to account for phenomena like the Zeeman effect or other complex atomic behaviors.

Question25

Identify the orbital having highest energy from following:

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Options:

A. 2p

B. 3s

C. 3d

D. 4p

Answer: D

Solution:

Higher the sum of $(\mathrm{n}+l)$ value of an orbital, the higher is its energy. If two orbitals have same value of $(\mathrm{n}+l)$, then the orbital with higher value of n will have more energy.

Orbital Energy	Principal quantum number (n)	Anzimuthal quantum number (l)	(n+l
2p	$\mathrm{n}=2$	$l=1$	$2+1=3$
3s	$\mathrm{n}=3$	$l=0$	$3+0=3, \mathrm{n}=3$
3d	$\mathrm{n}=3$	$l=2$	$3+2=5, \mathrm{n}=3$
4p	$\mathrm{n}=4$	$l=1$	$4+1=5, \mathrm{n}=4$ (higher)

Question26

Which of the following equations gives angular momentum of an electron in a stationary orbit?

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Options:

A. $\mathrm{mvr} = \frac{2\pi}{\mathrm{h}} \times \mathrm{n}$

B. $\mathrm{mvr} = \mathrm{n} \times \frac{\mathrm{h}}{2\pi}$

C. $\mathrm{mvh} = \mathrm{n} \times \frac{\mathrm{r}}{2\pi}$

D. $\mathrm{mv} = \left(\frac{\mathrm{h} \times \mathrm{r}}{2\pi}\right)\mathrm{n}$

Answer: B

Solution:

The angular momentum of an electron in a stationary orbit is quantized and given by Bohr's model of the atom. According to Bohr's postulate, the angular momentum (L) is an integral multiple of $\frac{h}{2\pi}$, where h is Planck's constant and n is the principal quantum number (an integer).

Therefore, the correct equation that represents the angular momentum of an electron in a stationary orbit is:

$mvr = n \times \frac{h}{2\pi}$

This matches Option B. Here, m is the mass of the electron, v is its velocity, and r is the radius of the orbit. The quantization condition suggests that the allowed orbits are those where the angular momentum is $(n\hbar)$, with $\hbar$ being the reduced Planck's constant ($\hbar = \frac{h}{2\pi}$).

In summary, Bohr's model states that the electron can only occupy orbits for which its angular momentum is quantized according to:

$L = n\hbar = n \times \frac{h}{2\pi}$

This leads to specific, discrete energy levels and orbits, a fundamental aspect of the quantum theory of atoms.

Question27

What is the wave number of lowest transition associated with Lyman series?

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Options:

A. $\bar{v} = \mathrm{R_H}\left(\frac{3}{4}\right)$

B. $\bar{v} = \mathrm{R_H}\left(\frac{5}{36}\right)$

C. $\bar{v} = \mathrm{R_H}\left(\frac{4}{3}\right)$

D. $\bar{v} = \mathrm{R_H}\left(\frac{36}{5}\right)$

Answer: A

Solution:

The Lyman series involves electronic transitions from higher energy levels to the lowest energy level ($n = 1$) in a hydrogen atom. The wave number ($\bar{v}$) for any transition in the hydrogen atom can be expressed using the Rydberg formula:

$$\bar{v} = \mathrm{R_H}\left(\frac{1}{n_1^2} - \frac{1}{n_2^2}\right)$$

For the Lyman series, $n_1 = 1$. The lowest transition corresponds to $n_2 = 2$, which is the smallest possible transition into $n_1 = 1$. Thus, substituting these values into the formula:

$$\bar{v} = \mathrm{R_H}\left(\frac{1}{1^2} - \frac{1}{2^2}\right) = \mathrm{R_H}\left(1 - \frac{1}{4}\right) = \mathrm{R_H}\left(\frac{3}{4}\right)$$

Therefore, the correct option for the wave number of the lowest transition in the Lyman series is:

Option A

$$\bar{v} = \mathrm{R_H}\left(\frac{3}{4}\right)$$

Question28

Which of the following orbitals is represented by $\mathrm{n} = 3$ and $l = 2$?

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Options:

A. 3s

B. 3p

C. 3d

D. 3f

Answer: C

Solution:

n	1	2	3	4
	K	L	M	N

l	0	1	2	3
	s	p	d	f

$\therefore$ 3 d orbital is represented by $\mathrm{n}=3$ and $l=2$.

Question29

What is the frequency of violet light having wavelength 400 nm ?

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Options:

A. 3.0×10^{14} Hz

B. 4.0×10^{14} Hz

C. 7.5×10^{14} Hz

D. 9.0×10^{14} Hz

Answer: C

Solution:

The frequency of light is given by the formula:

$f=\frac{c}{\lambda}$

where

f is the frequency,

c is the speed of light (3.0×10^{8} m/s),

λ is the wavelength.

For violet light with a wavelength of 400 nm:

First, convert the wavelength from nanometers to meters:

$400 \text{ nm} = 400 \times 10^{-9} \text{ m}$

Now, substitute the values into the frequency formula:

$f = \frac{3.0 \times 10^8 \text{ m/s}}{400 \times 10^{-9} \text{ m}} = \frac{3.0 \times 10^8}{4.0 \times 10^{-7}}$

Calculating this gives:

$f = 7.5 \times 10^{14} \text{ Hz}$

Therefore, the frequency of violet light with a wavelength of 400 nm is 7.5×10^{14} Hz. Thus, the correct option is **Option C**.

Question30

Which of the following is radius of first orbit of He^+ ?

MHT CET 2024 10th May Morning Shift

Options:

A. 52.90 pm

B. 78.90 pm

C. 26.45 pm

D. 13.35 pm

Answer: C

Solution:

Radius of n^{th} orbit $= r_n = \frac{52.9 \times (n)^2}{Z}$ pm

He^+ is a hydrogen-like species having $Z = 2$.

Radius of the first orbit of He^+
$= r_1$
$= \frac{52.9 \times (1)^2}{2} pm$
$= 26.45 pm$

Question31

Which parameter is indicated by the number of waves passing through a given point in one second?

MHT CET 2024 9th May Evening Shift

Options:

A. Wavelength

B. Frequency

C. Wave number

D. Amplitude

Answer: B

Solution:

The parameter indicated by the number of waves passing through a given point in one second is **Frequency**.

Frequency is defined as the number of complete cycles of a periodic wave passing through a given point per unit time. It is denoted by the symbol f and is measured in hertz (Hz), where one hertz is equivalent to one cycle per second. The relationship between frequency and other wave properties can be described by the formula:

$f = \frac{v}{\lambda}$

where:

f is the frequency,

v is the wave velocity or speed, and

λ is the wavelength, which is the distance between consecutive points of the same phase in a wave, such as the distance between crests.

In contrast:

Wavelength is the distance between successive identical points of a wave (Option A).

Wave number is the spatial frequency of a wave, given as the number of wavelengths per unit distance, typically measured in reciprocal meters (Option C).

Amplitude is the maximum displacement of points on a wave from the rest position, effectively the height of the wave peaks (Option D).

Therefore, option B is the correct choice, and it is essential in characterizing wave behavior in various fields such as physics, acoustics, and electromagnetism.

Question32

Which of the following rules states that it is impossible to determine simultaneously the exact position and exact momentum of an electron?

MHT CET 2024 9th May Morning Shift

Options:

A. Aufbau's principle

B. de Broglie's hypothesis

C. Heisenberg uncertainty principle

D. Pauli's exclusion principle

Answer: C

Solution:

Option C: Heisenberg uncertainty principle

The Heisenberg uncertainty principle is a fundamental concept in quantum mechanics. It states that it is impossible to simultaneously know both the exact position (x) and the exact momentum (p) of a particle, such as an electron, with absolute precision. Mathematically, this is expressed as:

$\Delta x \cdot \Delta p \geq \frac{\hbar}{2}$

where:

Δx is the uncertainty in position,

Δp is the uncertainty in momentum,

$\hbar$ is the reduced Planck's constant, equal to $\frac{h}{2\pi}$ with h being Planck's constant.

This inequality shows that as you attempt to measure one of these properties more precisely, the other becomes more uncertain. This principle highlights the intrinsic limitations of measuring quantum systems and is a fundamental characteristic of the behavior of particles at the quantum level. It reflects the wave-particle duality of matter and underpins numerous phenomena in quantum mechanics.

Question33

Which from following pairs is an example of isotones?

MHT CET 2024 9th May Morning Shift

Options:

A. ${}_{6}^{12}\mathrm{C}; {}_{6}^{14}\mathrm{C}$

B. ${}_{6}^{12}\mathrm{C}; {}_{5}^{11}\mathrm{B}$

C. ${}_{6}^{14}\mathrm{C}; {}_{7}^{14}\mathrm{N}$

D. ${}_{6}^{13}\mathrm{C}; {}_{5}^{11}\mathrm{B}$

Answer: B

Solution:

Isotones are nuclei that have the same number of neutrons but different numbers of protons. To find the number of neutrons in a nucleus, subtract the atomic number (the number of protons) from the mass number (the sum of protons and neutrons).

Let's analyze each option:

Option A: ${}_{6}^{12}\mathrm{C}$ and ${}_{6}^{14}\mathrm{C}$

Number of neutrons in ${}_{6}^{12}\mathrm{C}$: $12-6=6$

Number of neutrons in ${}_{6}^{14}\mathrm{C}$: $14-6=8$

Not isotones (neutron numbers are different).

Option B: ${}_{6}^{12}\mathrm{C}$ and ${}_{5}^{11}\mathrm{B}$

Number of neutrons in ${}_{6}^{12}\mathrm{C}$: $12-6=6$

Number of neutrons in ${}_{5}^{11}\mathrm{B}$: $11-5=6$

Isotones (neutron numbers are the same).

Option C: ${}_{6}^{14}\mathrm{C}$ and ${}_{7}^{14}\mathrm{N}$

Number of neutrons in ${}_{6}^{14}\mathrm{C}$: $14 - 6 = 8$

Number of neutrons in ${}_{7}^{14}\mathrm{N}$: $14 - 7 = 7$

Not isotones (neutron numbers are different).

Option D: ${}_{6}^{13}\mathrm{C}$ and ${}_{5}^{11}\mathrm{B}$

Number of neutrons in ${}_{6}^{13}\mathrm{C}$: $13 - 6 = 7$

Number of neutrons in ${}_{5}^{11}\mathrm{B}$: $11 - 5 = 6$

Not isotones (neutron numbers are different).

Thus, the correct answer is **Option B**: ${}_{6}^{12}\mathrm{C}$ and ${}_{5}^{11}\mathrm{B}$ are isotones.

Question34

Identify the orbital having lowest energy from following.

MHT CET 2024 4th May Evening Shift

Options:

A. 2p

B. 3s

C. 3d

D. 4p

Answer: A

Solution:

The energy of an orbital in an atom depends on both the principal quantum number (n) and the azimuthal quantum number (l). According to the general trend, for orbitals with different principal quantum numbers, the one with the lower n typically has lower energy. For orbitals with the same n, the one with the lower l value will have lower energy.

To identify the orbital with the lowest energy from the given options, consider:

The principal quantum number (n):

2p: $n=2$

3s: $n=3$

3d: $n=3$

4p: $n=4$

The azimuthal quantum number (l) values for the different orbitals are:

2p: $l=1$

3s: $l=0$

3d: $l=2$

4p: $l=1$

The energy order for orbitals generally increases with increasing values of $(n+l)$, and for orbitals with the same $(n+l)$ value, the one with the smaller n has the lower energy.

Calculating $(n+l)$:

2p: $2+1=3$

3s: $3+0=3$

3d: $3+2=5$

4p: $4+1=5$

Among the options with the same $(n+l)$ value (2p and 3s), 2p has the lower principal quantum number ($n=2$ vs. $n=3$). Thus, the orbital with the lowest energy is:

Option A: 2p

Question35

Calculate radius of fourth orbit of B^{4+} ion.

MHT CET 2024 4th May Evening Shift

Options:

A. 169.3 pm

B. 211.6 pm

C. 380.8 pm

D. 413.2 pm

Answer: A

Solution:

$r_n = \frac{52.9(n)^2}{Z} pm$

B^{4+} is a hydrogen-like species having $Z = 5$.

Radius of the fourth orbit of B^{4+}

$$= r_4 = \frac{52.9 \times (4)^2}{5} pm$$
$$= 169.3pm$$

Question36

Calculate wave length for emission of a photon having wave number 11516 cm^{-1}.

MHT CET 2024 4th May Morning Shift

Options:

A. 216 nm

B. 434 nm

C. 868 nm

D. 642 nm

Answer: C

Solution:

The wavelength of a photon is inversely related to the wave number. The relationship between the wave number ($\tilde{\nu}$) and the wavelength (λ) is given by the formula:

$\lambda = \frac{1}{\tilde{\nu}}$

Given the wave number $\tilde{\nu} = 11516\,\text{cm}^{-1}$, first convert the wave number to meters:

The wave number in units of meters is $11516\,\text{m}^{-1}$.

To find the wavelength in meters:

$\lambda = \frac{1}{11516\,\text{m}^{-1}} = 8.684 \times 10^{-5}\,\text{m}$

To convert meters to nanometers (since $1\,\text{m} = 10^9\,\text{nm}$):

$\lambda = 8.684 \times 10^{-5}\,\text{m} \times 10^9\,\text{nm/m} = 868.4\,\text{nm}$

Therefore, the wavelength for the emission of a photon with a wave number of $11516\,\text{cm}^{-1}$ is approximately 868 nm.

The correct answer is **Option C**: 868 nm.

Question37

Which of the following statements is correct regarding isobars?

MHT CET 2024 4th May Morning Shift

Options:

A. These have same number of neutrons.

B. These are the atoms of different elements.

C. These have same atomic number.

D. These have different mass number.

Answer: B

Solution:

Isobars are the atoms of different elements having the same mass number but different atomic number. For example, ${}_{6}^{14}\text{C}$ and ${}_{7}^{14}\text{N}$.

Question38

What is the energy associated with first orbit of He^+?

MHT CET 2024 3rd May Evening Shift

Options:

A. -2.18×10^{-18} J

B. -4.36×10^{-18} J

C. -6.54×10^{-18} J

D. -8.72×10^{-18} J

Answer: D

Solution:

To find the energy associated with the first orbit of He^+, we can use the formula for the energy levels of hydrogen-like ions:

$$E_n = -\frac{Z^2 \times R_H}{n^2}$$

where:

E_n is the energy of the n-th orbit,

Z is the atomic number of the ion,

R_H is the Rydberg constant for hydrogen (2.18×10^{-18} J),

n is the principal quantum number.

For He^+, the atomic number $Z = 2$ and we are looking at the first orbit, so $n = 1$.

Plugging in these values:

$$E_1 = -\frac{2^2 \times 2.18 \times 10^{-18} \text{ J}}{1^2}$$

$$E_1 = -\frac{4 \times 2.18 \times 10^{-18} \text{ J}}{1}$$

$$E_1 = -8.72 \times 10^{-18} \text{ J}$$

Thus, the energy associated with the first orbit of He^+ is -8.72×10^{-18} J. Therefore, the correct option is:

Option D -8.72×10^{-18} J.

Question39

What is the wave number of lowest transition in Balmer series?

MHT CET 2024 3rd May Evening Shift

Options:

A. $\mathrm{R_H}\left(\frac{36}{5}\right)$

B. $\mathrm{R_H}\left(\frac{5}{36}\right)$

C. $\mathrm{R_H}\left(\frac{21}{100}\right)$

D. $\mathrm{R_H}\left(\frac{100}{21}\right)$

Answer: B

Solution:

The Balmer series corresponds to electron transitions where the final level is $n_f = 2$, and the initial level n_i is any level from $n = 3$ onwards. The wave number ($\bar{\nu}$), which is the reciprocal of the wavelength, can be calculated using the Rydberg formula:

$$\bar{\nu} = \mathrm{R_H}\left(\frac{1}{n_f^2} - \frac{1}{n_i^2}\right)$$

For the lowest transition in the Balmer series, where $n_f = 2$ and $n_i = 3$, the wave number is calculated as:

$$\bar{\nu} = \mathrm{R_H}\left(\frac{1}{2^2} - \frac{1}{3^2}\right)$$

Calculating this gives:

$$\bar{\nu} = \mathrm{R_H}\left(\frac{1}{4} - \frac{1}{9}\right)$$

Simplifying inside the parentheses:

$$\bar{\nu} = \mathrm{R_H}\left(\frac{9}{36} - \frac{4}{36}\right) = \mathrm{R_H}\left(\frac{5}{36}\right)$$

Thus, the wave number of the lowest transition in the Balmer series is given by option B:

$$\mathrm{R_H}\left(\frac{5}{36}\right)$$

Question40

What is the amount of energy associated with first orbit of monopositive helium ion? $\left[R_H = 2.18 \times 10^{-18}\ J\right]$

MHT CET 2024 3rd May Morning Shift

Options:

A. -1.9×10^{-18} J

B. -4.36×10^{-18} J

C. -6.54×10^{-18} J

D. -8.72×10^{-18} J

Answer: D

Solution:

The energy of an electron in the n-th orbit of a hydrogen-like atom (or ion) is given by the formula:

$E_n = -\frac{Z^2 \cdot R_H}{n^2}$

where:

E_n is the energy of the electron in the n-th orbit,

Z is the atomic number of the ion,

R_H is the Rydberg constant for hydrogen, 2.18×10^{-18} J,

n is the principal quantum number.

For a monopositive helium ion (He^+), the atomic number Z is 2. We need to calculate the energy for the first orbit ($n = 1$):

Substitute the values into the formula:

$E_1 = -\frac{2^2 \cdot 2.18 \times 10^{-18}\ J}{1^2}$

Calculating further:

$E_1 = -\frac{4 \cdot 2.18 \times 10^{-18}\ J}{1}$

$E_1 = -8.72 \times 10^{-18}$ J

Therefore, the amount of energy associated with the first orbit of a monopositive helium ion is:

Option D: -8.72×10^{-18} J

Question41

What is the representation of an element having mass number of 40 and 21 neutrons in it?

MHT CET 2024 3rd May Morning Shift

Options:

A. ${}^{40}_{18}\mathrm{X}$

B. ${}^{40}_{19}\mathrm{X}$

C. ${}^{40}_{12}\mathrm{X}$

D. ${}^{40}_{20}\mathrm{X}$

Answer: B

Solution:

The mass number of an element, denoted by the superscript, is the sum of the protons (atomic number) and the neutrons in the nucleus. Given a mass number of 40 and 21 neutrons, the number of protons can be calculated as follows:

$\text{Number of protons} = \text{Mass number} - \text{Number of neutrons} = 40 - 21 = 19$

Thus, the atomic number (number of protons) is 19, which corresponds to the element Potassium (K). The correct representation of this element is:

Option B:

${}^{40}_{19}\mathrm{K}$

Question42

Which of the following orbitals have same value of $(\mathrm{n}+l)$ as that of 3 d orbital?

MHT CET 2024 2nd May Evening Shift

Options:

A. 4s

B. 3s

C. 4p

D. 2p

Answer: C

Solution:

Orbital	Value of Principal quantum number (n)	Value of Azimuthal quantum number (l)	$(n+l)$
3d	$n=3$	$l=2$	5
4s	$n=4$	$l=0$	4
3s	$n=3$	$l=0$	3
4p	$n=4$	$l=1$	5
2p	$n=2$	$l=1$	3

Thus, 3d and 4p orbitals have the same values of $(n+l)$.

Question43

What is momentum of a microscopic particle having de Broglie's wavelength 6.0 A?

$$\left(\mathrm{h}=6.63\times10^{-34}\mathrm{Js}\right)$$

MHT CET 2024 2nd May Evening Shift

Options:

A. 4.6×10^{-24} kg ms^{-1}

B. 1.1×10^{-24} kg ms^{-1}

C. 3.18×10^{-24} kg ms^{-1}

D. 6.36×10^{-24} kg ms^{-1}

Answer: B

Solution:

The momentum of a microscopic particle can be determined using de Broglie's hypothesis, which relates the momentum of a particle to its wavelength. The de Broglie wavelength formula is:

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

Where:

λ is the de Broglie wavelength of the particle.

h is Planck's constant (6.63×10^{-34} Js).

p is the momentum of the particle.

Rearranging the formula to solve for the momentum p, we have:

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

Given:

$\lambda = 6.0\,\text{Å} = 6.0 \times 10^{-10}\,\text{m}$

$h = 6.63 \times 10^{-34}\,\text{Js}$

Plugging these values into the formula, we find:

$p = \frac{6.63 \times 10^{-34}\ \text{Js}}{6.0 \times 10^{-10}\ \text{m}}$

Calculating the above expression gives:

$p = 1.105 \times 10^{-24}$ kg ms^{-1}

Therefore, the momentum of the particle is closest to option B:

Option B: 1.1×10^{-24} kg ms^{-1}

Question44

What is energy associated with fourth orbit of hydrogen atom?

$\left(\mathrm{R_H} = 2.18 \times 10^{-18} \mathrm{~J}\right)$

MHT CET 2024 2nd May Morning Shift

Options:

A. $-0.436 \times 10^{-18} \mathrm{~J}$

B. $-0.545 \times 10^{-18} \mathrm{~J}$

C. $-0.242 \times 10^{-18} \mathrm{~J}$

D. $-0.136 \times 10^{-18} \mathrm{~J}$

Answer: D

Solution:

The energy associated with the fourth orbit (n = 4) of a hydrogen atom can be determined using the formula for the energy of an electron in the nth orbit of a hydrogen atom:

$E_n = -\frac{\mathrm{R_H}}{n^2}$

where

E_n is the energy of the electron in joules,

$\mathrm{R_H}$ is the Rydberg constant for hydrogen (2.18×10^{-18} J),

n is the principal quantum number of the orbit.

Substituting $n = 4$ into the formula:

$E_4 = -\frac{2.18 \times 10^{-18} \mathrm{~J}}{4^2}$

Calculating the above expression:

$E_4 = -\frac{2.18 \times 10^{-18} \mathrm{~J}}{16} = -0.13625 \times 10^{-18} \mathrm{~J}$

Rounding off to three significant figures gives:

$E_4 \approx -0.136 \times 10^{-18} \mathrm{~J}$

Therefore, the energy associated with the fourth orbit of a hydrogen atom is approximately -0.136×10^{-18} J, which corresponds to Option D.

Question45

Which from following species does not have number of electrons similar to other three species?

MHT CET 2024 2nd May Morning Shift

Options:

A. Ne

B. O^{--}

C. Na

D. Na^{+}

Answer: C

Solution:

To determine which species does not have the same number of electrons as the other three, we'll calculate the number of electrons in each species.

Option A: Ne (Neon atom)

Atomic Number of Neon (Ne): 10

Number of Electrons: Since Ne is a neutral atom, it has the same number of electrons as protons.

Electrons in $\mathrm{Ne} = 10$

Option B: O^{--} (Oxygen ion with a 2- charge)

Atomic Number of Oxygen (O): 8

Number of Electrons in Neutral Oxygen Atom: 8

Charge: $2-$ means it has gained **2 extra electrons**.

Electrons in $O^{2-} = 8 + 2 = 10$

Option C: Na (Sodium atom)

Atomic Number of Sodium (Na): 11

Number of Electrons: Since Na is a neutral atom, it has the same number of electrons as protons.

Electrons in Na $= 11$

Option D: Na^+ (Sodium ion with a +1 charge)

Atomic Number of Sodium (Na): 11

Number of Electrons in Neutral Sodium Atom: 11

Charge: $+$ means it has **lost 1 electron**.

Electrons in $Na^+ = 11 - 1 = 10$

Summary:

Ne (Option A): 10 electrons

O^{2-} **(Option B):** 10 electrons

Na (Option C): 11 electrons

Na^+ **(Option D):** 10 electrons

Conclusion:

Option C (Na) has **11 electrons**, which is different from the other species that each have **10 electrons**.

Therefore, **Option C does not have the same number of electrons as the other three species**.

Answer: Option C

Question46

Calculate the frequency if wavelength is 750 nm.

MHT CET 2023 14th May Evening Shift

Options:

A. 2×10^{14} Hz

B. 4×10^{14} Hz

C. 6×10^{15} Hz

D. 8×10^{15} Hz

Answer: B

Solution:

To calculate the frequency of light when the wavelength is given, we can use the relationship between speed, frequency, and wavelength. This relationship is given by the equation:

$c = \lambda \cdot \nu$

where:

- c is the speed of light in a vacuum ($c \approx 3 \times 10^8$ m/s),
- λ is the wavelength in meters,
- ν (nu) is the frequency in hertz (Hz).

To find the frequency, we can rearrange the equation to solve for ν:

$\nu = \frac{c}{\lambda}$

Given that the wavelength is 750 nm (nanometers), we have to convert the wavelength into meters for our calculations because the speed of light is in meters per second. There are 1×10^9 nanometers in one meter, so:

$750 \text{ nm} = 750 \times 10^{-9} \text{ m}$

Now, let's insert the values for c and λ into our equation:

$\nu = \frac{3 \times 10^8 \text{ m/s}}{750 \times 10^{-9} \text{ m}}$

Calculating the frequency ν:

$\nu = \frac{3 \times 10^8}{750 \times 10^{-9}} = \frac{3 \times 10^8}{0.75 \times 10^{-6}} = \frac{3}{0.75} \times 10^{8+6}$

$\nu = 4 \times 10^{14}$ Hz

Therefore, the frequency of light with a wavelength of 750 nm is 4×10^{14} Hz, which corresponds to Option B.

Question47

Find the number of orbitals and maximum electrons respectively present in M-shell?

MHT CET 2023 14th May Morning Shift

Options:

A. $4, 8$

B. $9, 18$

C. $16, 32$

D. $1, 2$

Answer: B

Solution:

Symbol of Shell	Value of Principal quantum number (n)	Value of Azimuthal Quantum number (l)	Symbol of subshell	Total Number of orbitals in the subshell $= 2l + 1$
M	$n = 3$	$l = 0$	3s	$2 \times 0 + 1 = 1$
		$l = 1$	3p	$2 \times 1 + 1 = 3$
		$l = 2$	3d	$2 \times 2 + 1 = 5$

Hence, the total number of orbitals $= 1 + 3 + 5 = 9$. Each orbital accommodates 2 electrons. Therefore, total number of electrons in M-Shell is 18.

Question48

Calculate radius of third orbit of He^+.

MHT CET 2023 14th May Morning Shift

Options:

A. 52.9 pm

B. 105.8 pm

C. 238.1 pm

D. 423.2 pm

Answer: C

Solution:

$r_n = \frac{52.9(n)^2}{Z} pm$

He^+ is a hydrogen-like species having $Z = 2$.

Radius of the third orbit of He^+

$= r_3 = \frac{52.9 \times (3)^2}{2} pm = 238.1$ pm

Question49

Which of the following electromagnetic radiations possesses lowest energy?

MHT CET 2023 13th May Evening Shift

Options:

A. Radio waves

B. Microwaves

C. Infrared

D. Ultraviolet

Answer: A

Solution:

In electromagnetic radiations, radio waves have longest wavelength and least frequency. So by $E = hv$ equation, the radiation with least frequency i.e. radio waves will have lowest energy.

Question50

Calculate the wave number of photon emitted during transition from the orbit of $n = 3$ to $n = 2$ in hydrogen atom $\left(R_H = 109677 \text{ cm}^{-1}\right)$.

MHT CET 2023 13th May Evening Shift

Options:

A. 15354.8 cm^{-1}

B. 82257.8 cm^{-1}

C. 30515.4 cm^{-1}

D. 41128.5 cm^{-1}

Answer: A

Solution:

Given,

$$\begin{aligned} n_2 &= 3 \\ n_1 &= 2 \\ R_{\mathrm{H}} &= 109677 \text{ cm}^{-1} \\ \bar{v} \text{ (wave number) } &= ? \end{aligned}$$

Using formula,

$$\bar{v} = 109677\left[\frac{1}{n_1^2} - \frac{1}{n_2^2}\right] \text{cm}^{-1}$$

$$\bar{v} = 109677\left[\frac{1}{(2)^2} - \frac{1}{(3)^2}\right] \text{cm}^{-1}$$

$$\bar{v} = 109677\left[\frac{9-4}{36}\right] \text{cm}^{-1}$$

$$\bar{v} = 109677 \times \frac{5}{36} \text{ cm}^{-1}$$

$$\bar{v} = 15232.9 \text{ cm}^{-1}$$

Question51

Find the radius of fourth orbit of hydrogen atom if its radius of first orbit is R pm.

MHT CET 2023 13th May Morning Shift

Options:

A. R pm

B. 4 R pm

C. 9 R pm

D. 16 R pm

Answer: D

Solution:

Radius of nth orbit of H-atom, $r_n = n^2 a_0$ where a_0 = radius of the first orbit Radius of the fourth orbit of H-atom $= r_4 = (4)^2$ R pm = 16 R pm

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Question52

Which from following coloured light has the highest energy?

MHT CET 2023 12th May Evening Shift

Options:

A. Red

B. Blue

C. Yellow

D. Violet

Answer: D

Solution:

Shorter the wavelength, larger is the frequency, and higher is the energy. Violet light has the shortest wavelength (400 nm).

Question53

What is the radius of the fourth orbit of hydrogen atom?

MHT CET 2023 12th May Evening Shift

Options:

A. 846.4 pm

B. 211.6 pm

C. 476.1 pm

D. 1322.5 pm

Answer: A

Solution:

$r_n = \frac{52.9(n)^2}{Z}$ pm

For hydrogen, $Z = 1$

$r_n = \frac{52.9 \times 4^2}{1} = 846.4$ pm

Question54

Calculate the frequency of blue light having wavelength 440 nm.

MHT CET 2023 12th May Morning Shift

Options:

A. 6.82×10^{14} Hz

B. 7.5×10^{14} Hz

C. 4.0×10^{14} Hz

D. 5.26×10^{14} Hz

Answer: A

Solution:

$\nu = \frac{c}{\lambda} = \frac{3.0 \times 10^8 \text{ m s}^{-1}}{440 \times 10^{-9} \text{ m}} = 6.82 \times 10^{14}$ Hz

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Question55

Which of following pairs is an example of isoelectronic species?

MHT CET 2023 12th May Morning Shift

Options:

A. $O^{--}; Na^{+}$

B. $O^{--}; F$

C. $K; Ca^{++}$

D. $Ar; Al^{+3}$

Answer: A

Solution:

Atoms and ions having the same number of electrons are isoelectronic species. O^{--} and Na^{+} containing 10 electrons each are isoelectronic species.

Question56

Which of the following statements is NOT true about Bohr atomic model?

MHT CET 2023 11th May Evening Shift

Options:

A. An electron in hydrogen atom can move around the nucleus in one of the many possible orbits of fixed radius and energy.

B. The energy of an electron in the orbit does not change with time.

C. An electron can move only in those orbits for which angular momentum is integral multiple of $\frac{h}{2\pi}$.

D. This model can explain the ability of atoms to form molecules by chemical bonds.

Answer: D

Solution:

Bohr atomic model could not explain the ability of atoms to form molecules by chemical bonds.

Question57

Which from following elements is isoelectronic with Na^{+}?

MHT CET 2023 11th May Evening Shift

Options:

A. F

B. O

C. Mg

D. Ne

Answer: D

Solution:

Atoms and ions having the same number of electrons are isoelectronic.

Species	No. of electrons
Na^+	$11 - 1 = 10$
F	9
O	8
Mg	12
Ne	10

Question58

Which from following equations is used to express the angular momentum of an electron in a stationary state?

MHT CET 2023 11th May Morning Shift

Options:

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

B. $\mathrm{mvr} = \frac{2\pi}{\mathrm{nh}}$

C. $r = \frac{mvh}{n2\pi}$

D. $\mathrm{mv} = \frac{2\pi\mathrm{r}}{\mathrm{nh}}$

Answer: A

Solution:

The angular momentum of an electron in a stationary state (according to **Bohr's quantization condition**) is given by:

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

where

- m = mass of electron
- v = velocity
- r = radius of orbit
- $n = 1, 2, 3, \ldots$
- h = Planck's constant

✅ **Correct answer: A** — $mvr = \frac{nh}{2\pi}$

Question59

Which emission transition series is obtained when electron jumps from $n_2 = \infty$ to $n_1 = 1$?

MHT CET 2023 11th May Morning Shift

Options:

A. Balmer

B. Lyman

C. Paschen

D. Bracket

Answer: B

Solution:

When electron jumps from higher energy level to $n = 1$, the emission line corresponds to Lyman series.

Question60

What is the radius of fourth orbit of Be^{+++} ?

MHT CET 2023 10th May Evening Shift

Options:

A. 211.6 pm

B. 158.7 pm

C. 52.9 pm

D. 13.2 pm

Answer: A

Solution:

Be^{+++} is a hydrogen-like species having $\mathrm{Z}=4$. Radius of the fourth orbit of Be^{+++}

$=\mathrm{r}_4=\frac{52.9\times(4)^2}{4}\mathrm{pm}=211.6\ \mathrm{pm}$

Question61

What is angular momentum of an electron in fourth orbit of hydrogen atom?

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Options:

A. $\frac{\mathrm{h}}{2\pi}$

B. $\frac{\mathrm{h}}{\pi}$

C. $\frac{2\ \mathrm{h}}{\pi}$

D. $\frac{3h}{\pi}$

Answer: C

Solution:

The angular momentum of an electron in a given stationary orbit of hydrogen atom

$= mvr = \frac{nh}{2\pi}$ (where n = 1, 2, 3)

Angular momentum of an electron in fourth orbit of hydrogen atom $= \frac{4h}{2\pi} = \frac{2h}{\pi}$

Question62

Which of the following species is NOT isoelectronic with neon?

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Options:

A. O^{2-}

B. Na

C. Mg^{2+}

D. Al^{3+}

Answer: B

Solution:

Atoms and ions having the same number of electrons and isoelectronic.

Species	No. of electrons
Neon	10
O^{2-}	$8 + 2 = 10$
Na	11
Mg^{2+}	$12 - 2 = 10$

Species	No. of electrons
Al^{3+}	$13-3=10$

Question63

Identify the physical quantity that is measured in Candela.

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Options:

A. Energy

B. Work

C. Force

D. Luminous intensity

Answer: D

Solution:

The answer is Option D : Luminous intensity.

Luminous intensity is a measure of the wavelength-weighted power emitted by a light source in a particular direction per unit solid angle, based on the luminosity function, a standardized model of the sensitivity of the human eye. The SI unit of luminous intensity is the candela (cd). It is one of the seven base units in the International System of Units (SI).

Energy, work, and force are different physical quantities that are not measured in candela :

- **Energy** is the capacity to do work and is measured in joules (J) in the SI system.
- **Work** is the energy transferred to an object via the application of force along a displacement, also measured in joules.
- **Force** is an interaction that, when unopposed, will change the motion of an object. It is measured in newtons (N) in the SI system.

Therefore, the correct answer is D, as candela specifically relates to the measurement of luminous intensity, not to energy, work, or force.

Question64

Identify degenerate orbitals from following for hydrogen atom.

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Options:

A. 1s and 2s

B. 1s and 2p

C. 2s and 2p

D. 3s and 2p

Answer: C

Solution:

An increasing order of energies of orbitals in the hydrogen atom is given by:

$1 \mathrm{~s} < 2 \mathrm{~s} = 2 \mathrm{p} < 3 \mathrm{~s} = 3 \mathrm{p} = 3 \mathrm{~d} < \ldots$

Thus, in hydrogen atom $2s$ and $2p$ are degenerate orbitals.

Question65

Which of the following statements is NOT true about Rutherford atomic model?

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Options:

A. Each atom consists of massive, +vely charged centre.

B. The electrons are revolving continuously around the nucleus.

C. This model does not describe the distribution of electrons around the nucleus.

D. This model describes the energies of electrons.

Answer: D

Solution:

Bohr's atomic model describes the energies of electrons.

Question66

What is the wave number of photon emitted during transition from orbit, n $= 4$ to n $= 2$ in hydrogen atom $\left[R_H = 109677 \text{ cm}^{-1}\right]$

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Options:

A. 20564.44 cm^{-1}

B. 23032.17 cm^{-1}

C. 15354.78 cm^{-1}

D. 25225.7 cm^{-1}

Answer: A

Solution:

$$\begin{aligned}\bar{v} &= 109677\left[\frac{1}{2^2} - \frac{1}{4^2}\right]\text{cm}^{-1}\\ &= 109677\left[\frac{1}{4} - \frac{1}{16}\right]\text{cm}^{-1}\\ &= 109677\left[\frac{12}{64}\right]\text{cm}^{-1}\\ &= 20564.44 \text{ cm}^{-1}\end{aligned}$$

Question67

Which from following rule / principle states that "No two electrons in an atom can have the same set of four quantum numbers"?

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Options:

A. Pauli's exclusion principle

B. Hund's rule

C. Aufbau rule

D. Heisenberg uncertainty principle

Answer: A

Solution:

The statement **“No two electrons in an atom can have the same set of four quantum numbers”** is given by **Pauli’s Exclusion Principle** .

✅ **Correct answer: A — Pauli’s exclusion principle**

Question68

Calculate the wavenumber of the photon emitted during transition from the orbit of $n=2$ to $n=1$ in hydrogen atom. $\left[R_H=109677 \mathrm{~cm}^{-1}\right]$

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Options:

A. $27419.3 \mathrm{~cm}^{-}$

B. 109677.0 cm^{-1}

C. 12064.5 cm^{-1}

D. 82257.8 cm^{-1}

Answer: D

Solution:

For hydrogen atom,

$\bar{v} = 109677 \left[\frac{1}{{n_f}^2} - \frac{1}{{n_i}^2}\right] \text{cm}^{-1}$

Here, $\mathrm{n_i} = 2, \mathrm{n_f} = 1$

$$\begin{aligned} \therefore \quad \bar{v} &= 109677 \left[\frac{1}{1^2} - \frac{1}{2^2}\right] \text{cm}^{-1} \\ &= 109677 \left[\frac{1}{1} - \frac{1}{4}\right] \text{cm}^{-1} \\ &= 109677 \left[\frac{3}{4}\right] \text{cm}^{-1} \\ &= 82257.8 \text{ cm}^{-1} \end{aligned}$$

Question69

What is maximum number of electrons accommodated in a subshell having azimuthal quantum number, $\ell = 2$?

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Options:

A. 10

B. 12

C. 14

D. 18

Answer: A

Solution:

To determine the maximum number of electrons accommodated in a subshell with an azimuthal quantum number (ℓ) of 2, we first need to understand the relationship between quantum numbers and electron capacity.

The azimuthal quantum number (ℓ) defines the subshell. The value of ℓ ranges from 0 to n-1, where n is the principal quantum number. For $\ell = 2$, we are dealing with the d-subshell.

The formula for the maximum number of electrons that can be accommodated in a subshell is given by:

$$\text{Maximum number of electrons} \quad = 2(2\ell + 1)$$

Substituting $\ell = 2$ into the formula, we get:

$$\text{Maximum number of electrons} \quad = 2(2 \times 2 + 1)$$

$$\text{Maximum number of electrons} \quad = 2(4 + 1) = 2 \times 5 = 10$$

Therefore, the maximum number of electrons in a d-subshell (where $\ell = 2$) is 10.

Option A is correct: 10

Question70

How many values of magnetic quantum number are possible for each value of azimuthal quantum number?

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Options:

A. $n\ell$

B. $2\ell + 1$

C. $n - \ell$

D. 2ℓ

Answer: B

Solution:

In quantum mechanics, the azimuthal quantum number, symbolized as ℓ, determines the shape of an electron's orbital. For each value of ℓ, the magnetic quantum number, symbolized as m_ℓ, determines the orientation of that orbital in space. The magnetic quantum number can take on integer values ranging from $-\ell$ to $+\ell$, including zero.

Therefore, for a given ℓ value, the possible values of m_ℓ are:

$$m_\ell = -\ell, -(\ell - 1), \ldots, 0, \ldots, (\ell - 1), \ell$$

This results in a total of:

$$2\ell + 1$$

values. Thus, the correct answer is:

Option B

$2\ell + 1$

Question71

What is the frequency of yellow light having wavelength $580 \mathrm{~nm}$?

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Options:

A. $193 \times 10^{-9} \mathrm{~Hz}$

B. $517 \times 10^{-14} \mathrm{~Hz}$

C. $5.17 \times 10^{14} \mathrm{~Hz}$

D. $580 \times 10^{-9} \mathrm{~Hz}$

Answer: C

Solution:

To determine the frequency of yellow light, we use the relationship between the speed of light, wavelength, and frequency given by the formula:

$$c = \lambda \nu$$

Where:

c is the speed of light in a vacuum ($3 \times 10^8 \mathrm{~m/s}$)

λ is the wavelength ($580 \mathrm{~nm}$ or $580 \times 10^{-9} \mathrm{~m}$)

ν is the frequency we need to find.

Rearranging the formula to solve for frequency, we get:

$\nu = \frac{c}{\lambda}$

Substitute the given values:

$\nu = \frac{3 \times 10^8 \mathrm{~m/s}}{580 \times 10^{-9} \mathrm{~m}}$

Now, calculate the frequency:

$\nu = \frac{3 \times 10^8}{580 \times 10^{-9}}$

$\nu = \frac{3 \times 10^8}{580 \times 10^{-9}} = 5.17 \times 10^{14} \mathrm{~Hz}$

Therefore, the correct answer is:

Option C

$5.17 \times 10^{14} \mathrm{~Hz}$

Question72

Two electrons occupying the same orbital are distinguished by

MHT CET 2021 23th September Morning Shift

Options:

A. Principal quantum number

B. Azimuthal quantum number

C. Magnetic quantum number

D. Spin quantum number

Answer: D

Solution:

Electrons in an atom are described by a set of four quantum numbers: principal quantum number (n), azimuthal quantum number (l), magnetic quantum number (m), and spin quantum number (s). The Pauli exclusion principle states that no two electrons in the same atom can have identical sets of all four quantum numbers. Thus, two electrons occupying the same orbital must differ by at least one of these quantum numbers.

Since the principal quantum number (n), azimuthal quantum number (l), and magnetic quantum number (m) are determined by the specific orbital, these three quantum numbers will be the same for both electrons in the same orbital.

The spin quantum number (s) distinguishes the two electrons in the same orbital. The spin quantum number can take on one of two possible values: +1/2 or -1/2. These values correspond to the two possible spin orientations of the electron, often referred to as "spin up" and "spin down."

Therefore, the correct answer is:

Option D: Spin quantum number

Question73

What is the energy of an electron in stationary state corresponding to $\mathrm{n}=2$?

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Options:

A. $-1.45 \times 10^{-18} \mathrm{~J}$

B. $-0.545 \times 10^{-18} \mathrm{~J}$

C. $-3.45 \times 10^{-18} \mathrm{~J}$

D. $-2.5 \times 10^{-18} \mathrm{~J}$

Answer: B

Solution:

Energy of the stationary state corresponding to $\mathrm{n}=2$ is

$E_2=-2.18 \times 10^{-18}\left(1 /(2)^2\right)=-0.545 \times 10^{-18} \mathrm{~J}$

Question74

The wavelength of blue light is $480 \mathrm{~nm}$. What is frequency of this light?

MHT CET 2021 22th September Morning Shift

Options:

A. $4.8 \times 10^9 \mathrm{~Hz}$

B. $2.25 \times 10^{14} \mathrm{~Hz}$

C. $6.25 \times 10^{14} \mathrm{~Hz}$

D. $5.25 \times 10^9 \mathrm{~Hz}$

Answer: C

Solution:

To find the frequency of light, we use the relationship between the speed of light (c), wavelength (λ), and frequency (ν). This relationship is given by the equation:

$c=\lambda \nu$

Where:

- c is the speed of light, which is approximately $3 \times 10^8 \mathrm{~m} / \mathrm{s}$.
- λ is the wavelength, which is given as 480 nm.
- ν is the frequency, which we need to find.

First, we need to convert the wavelength from nanometers to meters:

$480 \mathrm{~nm}=480 \times 10^{-9} \mathrm{~m}$

Now we can rearrange the equation to solve for the frequency ν:

$\nu=\frac{c}{\lambda}$

Substitute the values into the equation:

$\nu=\frac{3 \times 10^8 \mathrm{~m} / \mathrm{s}}{480 \times 10^{-9} \mathrm{~m}}$

Calculate the frequency:

$\nu=\frac{3 \times 10^8}{480 \times 10^{-9}}$

$\nu=\frac{3 \times 10^8}{4.8 \times 10^{-7}}$

$\nu=6.25 \times 10^{14} \mathrm{~Hz}$

Therefore, the frequency of blue light with a wavelength of 480 nm is 6.25×10^{14} Hz. The correct answer is:

Option C
6.25×10^{14} Hz

Question75

What is the wavelength for a wave having frequency 50 Hz?

MHT CET 2021 21th September Evening Shift

Options:

A. 1.6×10^6 m

B. 6×10^{-2} m

C. 6×10^6 m

D. 15×10^2 m

Answer: C

Solution:

$v = 50 \text{ Hz} = 50 \text{ s}^{-1}, c = 3 \times 10^8 \text{ m s}^{-1}$

$$\lambda = \frac{c}{v} = \frac{3 \times 10^8 \text{ m s}^{-1}}{50 \text{ s}^{-1}} = 6 \times 10^6 \text{ m}$$

Question76

The wavelength of a spectral line of caesium is 460 nm. What is the frequency of spectral line?

MHT CET 2021 21th September Morning Shift

Options:

A. 4.5×10^8 Hz

B. 6.5×10^{14} Hz

C. 3×10^9 Hz

D. 5.6×10^{14} Hz

Answer: B

Solution:

$\lambda = 460 \text{ nm} = 460 \times 10^{-9} \text{ m}, \quad v = ?$

$v = \frac{c}{\lambda} = \frac{3 \times 10^8 \text{ m s}^{-1}}{460 \times 10^{-9} \text{ m}} = 6.5 \times 10^{14} \text{ Hz}$

Question77

What is the value of frequency of radiation when transition occurs between two stationary states that differ in energy by ΔE ?

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Options:

A. $v = \frac{2\pi}{h}$

B. $v = \frac{h}{\Delta E}$

C. $v = \frac{\Delta E}{h}$

D. $v = \frac{h}{2\pi}$

Answer: C

Solution:

Bohr's frequency rule,

$v = \frac{\Delta E}{h} = \frac{E_2 - E_1}{h}$

Question78

Identify an orbital with the quantum numbers n = 4, l = 3, m = 0.

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Options:

A. 4f

B. 4p

C. 4s

D. 4d

Answer: A

Solution:

For f-orbital $\Rightarrow l = 3$

When, $n = 4, l = 3, m = 0$

$\Rightarrow$ The orbital is 4f.

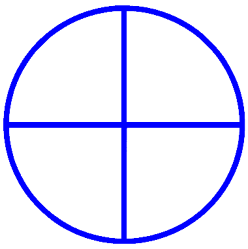
Question79

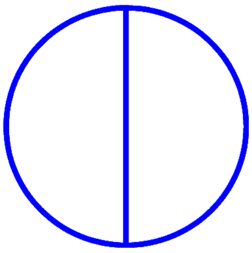
Identify the symbol used for water according to Dalton's atomic theory?

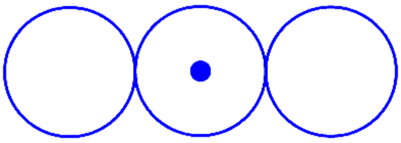
MHT CET 2020 16th October Morning Shift

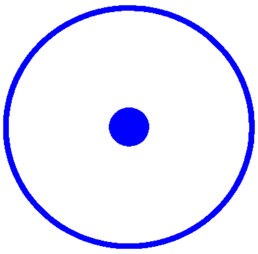
Options:

A.



B. 

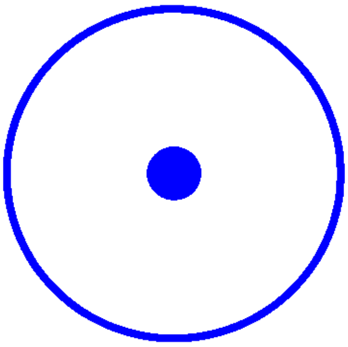
C. 

D. 

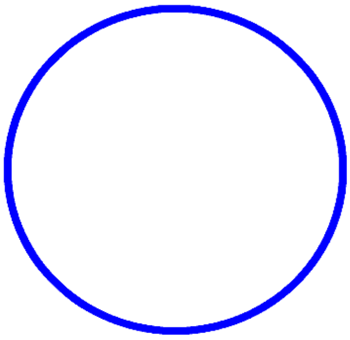
Answer: D

Solution:

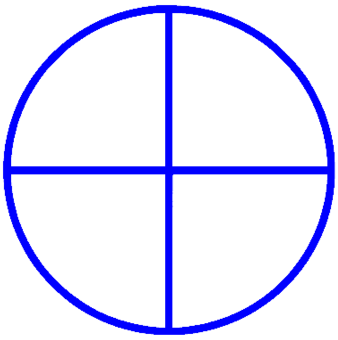
According to Dalton's atomic theory, symbol of hydrogen is



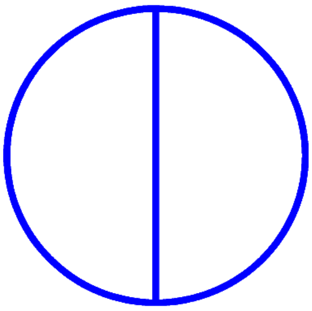
and for oxygen



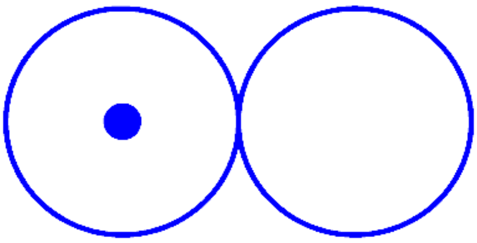
and for sulphur



and for nitrogen



. In the given option



this symbol represent the water molecule.
