PUST

ASSINGMENT

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Assignment

Question 5

(a) Give the defects of Rutherford's model of atom. What suggestions were given by Bohr to remove these defects?

Answer:
Defects of Rutherford's Model:

1. **Electron Spiral Collapse:** According to classical physics, electrons in circular orbits should emit radiation, lose energy, and collapse into the nucleus, making the atom unstable.
2. **No Explanation for Atomic Spectra:** The model failed to explain why atoms emit discrete line spectra (e.g., hydrogen spectrum).

Bohr's Modifications:

1. **Stationary Orbits:** Electrons revolve in specific, stable orbits (quantized) without radiating energy.
2. **Energy Quantization:** Electrons absorb/emit energy only when jumping between orbits. The energy difference corresponds to specific spectral lines.

(b) What do you understand by the term "Quantum number"? How many quantum numbers has an electron in an orbital? Explain the significance of each quantum number.

Answer:
A quantum number describes the unique properties of an electron's orbital and its state in an atom. There are four quantum numbers:

1. **Principal Quantum Number (n):** Determines the energy level and size of the orbital (e.g., n = 1, 2, 3...).
2. **Azimuthal Quantum Number (l):** Defines the orbital's shape (s, p, d, f) and ranges from 0 to (n−1).
3. **Magnetic Quantum Number (m):** Specifies the orientation of the orbital in space (values from −l to +l).
4. **Spin Quantum Number (s):** Indicates the electron's intrinsic spin (+½ or −½).

Question 6

(a) Compare the properties of ionic and covalent compounds. Give two examples of each type of compounds.

Answer:

(a) Comparison between Ionic and Covalent Compounds:

Property	Ionic Compounds	Covalent Compounds
Formation	Formed by transfer of electrons from one atom to another.	Formed by sharing of electrons between atoms.
Type of elements	Usually between metals and non-metals.	Usually between non-metals.
Physical state	Generally solid at room temperature.	Can be solid, liquid, or gas.
Melting and boiling points	High melting and boiling points.	Low to moderate melting and boiling points.
Electrical conductivity	Conducts electricity when dissolved in water or molten.	Generally poor conductors (except in some cases).
Solubility	Soluble in water but insoluble in organic solvents.	Soluble in organic solvents but less soluble in water.

(b) What is a co-ordinate covalent bond? How does it differ from a normal covalent bond?

Answer:
Coordinate Covalent Bond: A bond where both shared electrons are contributed by a single atom. Example: Formation of NH_4^+ (Ammonium ion), where NH_3 donates a lone pair to H^+.

- Difference: In normal covalent bonds, each atom contributes one electron to the bond.

Question 7

(a) What do you understand by hydrogen bonds? Classify them with examples. Explain why water has abnormally high boiling point.

Answer:

Hydrogen Bond:

- A strong dipole-dipole attraction between a hydrogen atom (covalently bonded to N, O, or F) and another electronegative atom (N, O, or F).

- Strength: Weaker than covalent bonds but stronger than van der Waals forces (e.g., H-bond energy: 5–30 kJ/mol).

Classification:

Intermolecular H-Bonding: Occurs between molecules.

Examples:

- Water H2O): Each molecule forms H-bonds with four others.
- Hydrogen fluoride (HF): Chains of H-bonded molecules.
- Intramolecular H-Bonding: Occurs within a single molecule.
- Example: Ortho-nitrophenol, where H-bonding between –OH and $–NO_2$ groups reduces solubility in water.

Water's High Boiling Point:

- Water's extensive intermolecular H-bonding requires significant energy to break, raising its boiling point to 100°C. Comparatively, H2S(no H-bonding) boils at −60°C.

(b) Why bond angles of H2O and NH3 are 104.5° and 107° respectively although central atoms are *sp*3 hybridized.

Answer:

Both H2O (water) and (ammonia) have *sp*3-hybridized central atoms, leading to a tetrahedral geometry (ideal bond angle: 109.5°). However, lone pair repulsion distorts the angles:

Water (H2O):

- Oxygen has two lone pairs. Lone pairs occupy more space than bonding pairs, exerting stronger repulsion.
- This reduces the bond angle to 104.5°(less than tetrahedral).

Ammonia (NH3):

- Nitrogen has one lone pair. The repulsion is less severe, resulting in a bond angle of 107°.
- Comparison:

Methane (CH4) has no lone pairs and a perfect tetrahedral angle (109.5°).

Question 8

(a) What do you mean by the 'ionization potential' of an element? Why the first ionization potential of an element is less than the second ionization potential? How does the ionization potential of an element vary with atomic volume?

Answer :

Ionization Potential (IP):

The minimum energy required to remove the outermost electron from a gaseous atom in its ground state.
Example: First ionization potential of sodium (Na) is 496 kJ/mol.

$IP_1 < IP_2$:

After losing one electron, the atom becomes a cation (Na^+).
The remaining electrons experience stronger nuclear attraction due to reduced electron shielding and increased effective nuclear charge.
Thus, removing a second electron (e.g., $Na^+ \rightarrow Na^{2+}$) requires more energy (IP_2 = 4562 kJ/mol).

Relation to Atomic Volume:

Larger atomic volume→ Electrons are farther from the nucleus →Weaker nuclear attraction→Lower ionization potential.
Example: Alkali metals (e.g., K, Na) have large atomic sizes and low IP.
Trend in Periodic Table:

Ipincreases across a period (left to right) due to decreasing atomic size.
IP decreases down a group due to increasing atomic size.

(b) What do you mean by f-block elements? Why f-block elements are called inner transition elements?

Answer:

f-Block Elements:

- Elements where electrons fill the 4f (lanthanides) or 5f (actinides) orbitals.
- Examples:
- Lanthanides: Cerium (Ce), Europium (Eu).
- Actinides: Uranium (U), Plutonium (Pu).

Inner Transition Elements:

The term "inner" refers to the filling of inner $(n-2)f$ orbitals (e.g., 4f orbitals are inner to the 5s, 5p orbitals).
These elements are placed below the main periodic table to maintain its compact structure.

Properties:

- High melting points.
- Paramagnetic (due to unpaired f-electrons).