PABNA UNIVERSITY OF SCIENCE AND TECHNOLOGY

FACULTY OF ENGINEERING AND TECHNOLOGY

DEPARTMENT OF INFORMATION AND COMMUNICATION ENGINEERING

Assignment
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Question: 5. (a) Give the defects of Rutherford's model of atom. What suggestions were given by Bohr to remove these defects?

Ans:

Defects of Rutherford's Model of Atom:

1. **Unstable Atom:** According to classical physics, electrons moving in circular orbits should radiate energy and spiral into the nucleus, making the atom unstable. But atoms are stable.
2. **No Explanation of Atomic Spectra:** Rutherford's model couldn't explain the line spectra of elements, especially the hydrogen spectrum.

Bohr's Suggestions to Remove These Defects:

1. **Quantized Orbits:** Bohr proposed that electrons revolve in fixed orbits (called energy levels) without radiating energy.
2. **Energy Absorption/Emission:** Electrons emit or absorb energy only when they jump from one orbit to another, explaining the line spectra.

(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.

Ans:

Quantum Number: Quantum numbers are a set of numerical values that describe the unique quantum state of an electron in an atom.

Number of Quantum Numbers: An electron in an orbital is described by **four quantum numbers**.

Significance of Each Quantum Number:

1. **Principal Quantum Number (n):**
    - Indicates the main energy level or shell.
    - Values: 1, 2, 3...
    - Higher *n* means higher energy and distance from the nucleus.

2. **Azimuthal Quantum Number (l):**
    - Indicates the subshell or shape of the orbital.
    - Values: 0 to (n–1)
    - l = 0 (s), 1 (p), 2 (d), 3 (f)
3. **Magnetic Quantum Number (m):**
    - Indicates the orientation of the orbital in space.
    - Values: –l to +l
4. **Spin Quantum Number (s):**
    1. Indicates the spin of the electron.
    2. Values: +½ or –½

Question: 6. (a) Compare the properties of ionic and covalent compounds. Give two examples of each type of compounds.

Ans:

Comparison of Ionic and Covalent Compounds:

Property	**Ionic Compounds**	**Covalent Compounds**
Bond Type	Electrostatic attraction between ions	Sharing of electrons between atoms
Physical State	Mostly solids	Can be solid, liquid, or gas
Melting/Boiling Points	High	Low to moderate
Solubility in Water	Generally soluble	Mostly insoluble or less soluble
Electrical Conductivity	Conducts when molten or in solution	Usually poor conductors

Examples:

- **Ionic Compounds:** Sodium chloride ($NaCl$), Magnesium oxide (MgO)
- **Covalent Compounds:** Water (H_2O), Carbon dioxide (CO_2)

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

Ans:

Co-ordinate Covalent Bond:
A co-ordinate covalent bond (also called a dative bond) is a type of covalent bond in which **both electrons in the shared pair come from the same atom**.

Difference from a Normal Covalent Bond:

Feature	Normal Covalent Bond	Co-ordinate Covalent Bond
Electron Contribution	Each atom contributes one electron	One atom donates both electrons
Representation	Shown by a line (—)	Shown by an arrow (→) from donor to acceptor

Example: In **ammonium ion (NH_4^+)**, the nitrogen atom donates a lone pair to a hydrogen ion (H^+) to form a coordinate bond.

Question: 7. (a) What do you understand by hydrogen bonds? Classify them with examples. Explain why water has abnormally high boiling point.

Ans:

Hydrogen Bond: A **hydrogen bond** is a weak electrostatic attraction between a hydrogen atom (attached to a highly electronegative atom like N, O, or F) and another electronegative atom.

Types of Hydrogen Bonds:

1. **Intermolecular Hydrogen Bond:**
    - Occurs between molecules.

- Example: Between water molecules ($H_2O...H_2O$)

2. **Intramolecular Hydrogen Bond:**
   - Occurs within the same molecule.
   - Example: In o-nitrophenol

Why Water Has an Abnormally High Boiling Point: Water molecules form strong **intermolecular hydrogen bonds**, which require extra energy to break. This raises the boiling point much higher than expected for such a small molecule.

(b) Why bond angles of H2O and NH3 are 104.5° and 107° respectively although central atoms are sp3 hybridized.

Ans:

Reason for Bond Angles in H_2O and NH_3:

Both **H_2O** and **NH_3** have **sp^3 hybridization**, which ideally gives a bond angle of **109.5°**. However, lone pairs repel more strongly than bond pairs, causing distortion.

- **NH_3 (Ammonia):** Has **1 lone pair** and **3 bond pairs**.
  The lone pair repels the bond pairs slightly, reducing the bond angle to **107°**.
- **H_2O (Water):** Has **2 lone pairs** and **2 bond pairs**.
  Greater lone pair repulsion compresses the bond angle further to **104.5°**.

Conclusion:
More lone pairs → more repulsion → smaller bond angle.

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?

Ans:

Ionization Potential:
Ionization potential is the **energy required to remove one mole of electrons from one mole of gaseous atoms** to form positive ions.

Why First < Second Ionization Potential:
The **first ionization potential** involves removing an electron from a neutral atom, which is easier.
The **second ionization potential** is higher because the electron is removed from a **positively charged ion**, where the attraction to the nucleus is stronger.

Variation with Atomic Volume:
As **atomic volume increases**, outer electrons are farther from the nucleus and less tightly held, so **ionization potential decreases**.
Thus, elements with **larger atomic size** have **lower ionization potential**.

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

Ans:

f-block Elements:
f-block elements are the elements in which the **last electron enters the f-orbital**. They include the **lanthanides (atomic numbers 58–71)** and **actinides (atomic numbers 90–103)**, and are placed separately at the bottom of the periodic table.

Why Called Inner Transition Elements:
They are called **inner transition elements** because the **f-orbitals (being inner orbitals)** are filled after the outermost s-orbital. The transition (change in properties) occurs within the **inner electron shells**, unlike the d-block (outer transition) elements.