Notes: Chapter 4 - Structure of the Atom

● Introduction to the Atom

- **Atom**: The smallest unit of matter consisting of a nucleus (containing protons and neutrons) and electrons moving around the nucleus.
    - **Example**: Atoms of elements like Hydrogen (H) and Oxygen (O) form water (H_2O).

Practice Questions:

1. What is an atom? Describe its main components.
2. Give two examples of how atoms combine to form molecules.
3. How do electrons move within an atom?

Revision Points:

- Atoms consist of a central nucleus with protons and neutrons, and electrons orbit around it.
- Atoms combine to form molecules, the basic units of compounds.

● Discovery of Subatomic Particles

○ Electrons (Discovered by J.J. Thomson)

- **Electrons**: Negatively charged particles that move around the nucleus.
    - **Charge**: -1.
    - **Mass**: Negligible in comparison to protons and neutrons.

○ Protons (Discovered by E. Goldstein)

- **Protons**: Positively charged particles present inside the nucleus.
    - **Charge**: +1.
    - **Mass**: Approximately equal to 1 atomic mass unit (amu).

○ Neutrons (Discovered by James Chadwick)

- **Neutrons**: Neutral particles with no charge found in the nucleus.
    - **Charge**: 0.

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- **Mass**: Similar to that of protons (about 1 amu).

Practice Questions:

1. Who discovered electrons, protons, and neutrons?
2. Compare the mass and charge of protons, neutrons, and electrons.
3. Why are neutrons considered neutral particles?

Revision Points:

- Subatomic particles include electrons (negative), protons (positive), and neutrons (neutral).
- Protons and neutrons are located in the nucleus, while electrons move around it.

● Thomson's Model of the Atom

- **Thomson's Plum Pudding Model**:
  - Describes the atom as a positively charged sphere with negatively charged electrons embedded in it.
  - **Limitations**: Failed to explain the arrangement of electrons and the stability of an atom.

Practice Questions:

1. Explain Thomson's model of the atom.
2. What is the major limitation of Thomson's atomic model?
3. How did Thomson describe the distribution of electrons?

Revision Points:

- Thomson proposed that electrons are scattered within a positively charged sphere.
- His model couldn't explain how the electrons stayed in place or why atoms are stable.

● Rutherford's Nuclear Model of the Atom

- **Rutherford's Gold Foil Experiment**:
  - Alpha particles were directed at a thin gold foil, and most passed through while some were deflected.
- **Conclusions**:
  1. **Nucleus**: Atoms have a small, dense, positively charged center called the nucleus.

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2. **Empty Space**: Most of the atom is empty space.
3. **Electrons**: Electrons revolve around the nucleus in specific orbits.

Practice Questions:

1. Describe Rutherford's gold foil experiment and its observations.
2. What are the key features of Rutherford's atomic model?
3. Why did most alpha particles pass through the gold foil without deflection?

Revision Points:

- The atom consists of a dense nucleus with protons, surrounded by electrons in orbits.
- Most of the atom is empty space, as suggested by Rutherford's experiment.

● Bohr's Model of the Atom

- **Bohr's Atomic Model**:
  - Electrons revolve around the nucleus in **fixed orbits** called energy levels (shells).
  - Each orbit corresponds to a specific energy level.
  - Electrons can jump between energy levels by absorbing or releasing energy.

Practice Questions:

1. Explain Bohr's model of the atom and the concept of energy levels.
2. How do electrons move between different energy levels?
3. What happens when an electron absorbs energy?

Revision Points:

- Bohr's model introduced the concept of quantized energy levels, where electrons orbit the nucleus.
- Electrons move to higher or lower energy levels by absorbing or releasing energy.

● Discovery of Neutrons

- **James Chadwick** discovered the neutron, which explained the missing mass in the atom.
- Neutrons have no charge and are located in the nucleus, contributing to the atomic mass.

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Practice Questions:

1. Who discovered the neutron, and why was it significant?
2. How do neutrons contribute to the mass of an atom?
3. Why are neutrons important for the stability of the nucleus?

Revision Points:

- Neutrons are neutral particles located in the nucleus and add to the atomic mass.
- They were crucial for explaining the stability of the nucleus.

● Atomic Number and Mass Number

○ Atomic Number (Z):

- The number of protons in the nucleus of an atom.
  - **Example**: Hydrogen's atomic number is 1.

○ Mass Number (A):

- The total number of protons and neutrons in the nucleus.
  - **Example**: Carbon has 6 protons and 6 neutrons, so its mass number is 12.

Practice Questions:

1. Define atomic number and mass number. Give examples.
2. How do you calculate the mass number of an atom?
3. Why is the atomic number unique for each element?

Revision Points:

- The atomic number is the number of protons, and the mass number is the sum of protons and neutrons.
- These numbers help identify and distinguish between elements.

● Isotopes and Isobars

○ Isotopes:

- Atoms of the same element with the same atomic number but different mass numbers.
  - **Examples**:

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- Carbon-12 ($_{6}C^{12}$) and Carbon-14 ($_{6}C^{14}$).
- Hydrogen ($_{1}H$), Deuterium ($_{2}H$), Tritium ($_{3}H$).

○ **Isobars:**

- Atoms of different elements with the same mass number but different atomic numbers.
  - **Examples**:
    - Argon ($_{18}Ar^{40}$) and Calcium ($_{20}Ca^{40}$).

Practice Questions:

1. Define isotopes and give two examples.
2. How do isobars differ from isotopes?
3. Why do isotopes of the same element have different mass numbers?

Revision Points:

- Isotopes are variants of the same element with different mass numbers, while isobars are different elements with the same mass number.
- Isotopes have similar chemical properties but differ in physical properties.

● **Distribution of Electrons in Shells**

○ **Electronic Configuration**

- Electrons are arranged in energy levels or shells (K, L, M, N) around the nucleus.
  - **Rules for filling electrons**:
    - The **first shell** (K) can hold up to 2 electrons.
    - The **second shell** (L) can hold up to 8 electrons.
    - The **third shell** (M) can hold up to 18 electrons.

○ **Example of Electronic Configuration:**

- **Sodium (Na)**: Atomic number 11.
  - Configuration: 2 (K), 8 (L), 1 (M).

Practice Questions:

1. Explain the rules for electron distribution in shells.
2. Write the electronic configuration for the following elements:
   - (a) Carbon (Z=6)
   - (b) Oxygen (Z=8)
3. How many electrons can the third shell (M) hold?

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Revision Points:

- Electrons are arranged in energy levels or shells around the nucleus.
- The number of electrons in each shell follows a fixed pattern (2, 8, 18…).

● Valency

○ Definition of Valency:

- **Valency**: The combining capacity of an atom, determined by the number of electrons in the outermost shell.
    - **Example**: The valency of oxygen (O) is 2 because it needs 2 electrons to complete its outer shell.

○ Valency in Different Elements:

- **Hydrogen**: Valency 1.
- **Carbon**: Valency 4.
- **Oxygen**: Valency 2.

Practice Questions:

1. What is valency? Explain how valency is determined.
2. Determine the valency of:
    - (a) Nitrogen (N)
    - (b) Chlorine (Cl)
3. Why is the valency of carbon 4?

Revision Points:

- Valency is the number of electrons an atom needs to gain, lose, or share to attain stability.
- It determines the combining capacity of an atom with other atoms.

● Revision Points Summary

- Atoms consist of protons, neutrons, and electrons.
- Thomson, Rutherford, and Bohr proposed models to explain atomic structure.
- Atomic number and mass number are essential for identifying elements.
- Isotopes have the same atomic number but different mass numbers, while isobars have the same mass number but different atomic numbers.

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- Electron distribution follows the rule of energy levels, and valency indicates an element's combining power.

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