Unit 1 Student Study Guide

Name _____ Date _____

Chemistry, periods 1 & 2 Aversano/Herz

This guide covers the fundamentals of atomic theory, isotopes, and atomic mass calculations. Be sure to review these key concepts and work through the related exercises to strengthen your comprehension. Additionally, it emphasizes electron configurations, how electrons are arranged within atoms, and the progression of atomic models. Make sure to practice determining electron configurations for various elements and revisit the contributions made by different scientists to atomic theory.

1. Atomic Models

Overview:

- Atoms are the fundamental building blocks of matter. Over time, various scientists have contributed to the development of atomic models that explain atomic structure.

Key Atomic Models:

1. Dalton's Model:
   - Atoms are indivisible particles (hard spheres).
   - Atoms of the same element are identical.
   - Atoms combine in simple whole numbers to form compounds.
   - Reactions involve joining, separating, or rearranging atoms.

2. Thomson's Model (Plum Pudding Model):
   - Discovered electrons using a cathode ray tube.
   - Electrons are scattered throughout a positively charged atom.

3. Rutherford's Model:
   - Conducted the Gold Foil Experiment.
   - Determined that most of the atom is empty space.
   - The nucleus is a small, dense, positively charged center.
   - Alpha particles deflected by the nucleus due to its positive charge.

4. Bohr's Model:
   - Electrons orbit the nucleus in specific paths (shells).
   - Each orbit corresponds to a fixed energy level.
   - Electrons move between energy levels by absorbing or releasing energy.

5. Wave-Mechanical (Quantum) Model:
   - Describes electrons as existing in "clouds" or orbitals.
   - Electrons behave both as particles and waves.
   - Orbitals represent the most probable regions where electrons can be found.

Important Concepts:

- Electron Energy Levels:
  - Electrons at higher energy levels have more energy.
  - Movement between energy levels involves quantized energy changes.

- Gold Foil Experiment Conclusion:
  - The atom is mostly empty space with a positively charged nucleus.

Check Your Understanding:

- In what order did these models develop?

- How did Rutherford's experiment challenge Thomson's model?

- What does Bohr's theory explain about electron behavior?

2. Isotopes

Overview:
- Isotopes are atoms of the same element that have different mass numbers due to varying numbers of neutrons.

Key Definitions:

-Atomic Number: Number of protons in an atom (same for all isotopes of an element).
- Mass Number: The total number of protons and neutrons in the nucleus.
- Neutron Number: Found by subtracting the atomic number from the mass number.

Hydrogen Isotopes Example:

- **^{1}H (Protium):** 1 proton, 0 neutrons.
- **^{2}H (Deuterium):** 1 proton, 1 neutron.
- **^{3}H (Tritium):** 1 proton, 2 neutrons.

Carbon Isotopes Example:
- **^{12}C:** 6 protons, 6 neutrons (most abundant, ~98.89%).
- **^{13}C:** 6 protons, 7 neutrons (~1.11%).
- **^{14}C:** Trace amounts (used in radiocarbon dating).

Key Concepts:

- Mass Number vs. Atomic Mass:
  - Mass Number:Total number of protons and neutrons.
  - Atomic Mass: Weighted average of the isotopes' masses based on natural abundance.

Calculating Atomic Mass:

- Use the formula:

$$\text{Atomic Mass} = (\text{Mass of Isotope 1} \times \text{Abundance}) + (\text{Mass of Isotope 2} \times \text{Abundance})$$

Example for Chlorine:

- Cl-35 (75% abundance) and Cl-37 (25% abundance).
- $\text{Atomic Mass} = (35 \times 0.75) + (37 \times 0.25) = 35.5 \, \text{amu}$

Practice Problem:

Calculate the atomic mass of Silicon if Si-28 is 92.23%, Si-29 is 4.67%, and Si-30 is 3.10%.

3. Understanding Isotopic Notations

Notations Example (Hydrogen):

- ^{1}H, ^{2}H, ^{3}H
  - Letter (H):Represents the element (Hydrogen).
  - Top Number (^{1}, ^{2}, ^{3}):Mass number.
  - Bottom Number: Atomic number (1 for Hydrogen).

Key Idea:

- Isotopes differ in neutron number, not proton or electron number.

Practice Problem:
- Determine the mass number of Krypton and calculate the number of neutrons for Am-241.

Summary:

Understanding isotopes involves recognizing how elements can have atoms with varying neutrons while maintaining the same atomic number. The atomic mass of an element reflects the average mass of all its naturally occurring isotopes, weighted by their abundance.

4. Electrons and Atomic Models

1. Development of the Atomic Model

Key Scientist:

- **Bohr's Model:**
  - Electrons revolve around the nucleus in concentric circular orbits, similar to planets around the sun.
  - The position and energy of electrons are determined by their orbits (energy levels).

2. Electron Configurations

Definition:

- Electron configurations are a set of numbers that represent the number of electrons in each principal energy level of an atom. These configurations describe how electrons are distributed in an atom's shells.

Key Concepts:

1. **Electron Distribution:**
    - The number of electrons in an atom equals the atomic number.
    - Electrons fill the lowest energy levels first (closest to the nucleus), following the order of shells.
2. **Electron Capacity by Shell:**
    - 1st shell: Can hold **2** electrons.
    - 2nd shell: Can hold **8** electrons.
    - 3rd shell: Can hold **8** to **18** electrons.
    - 4th shell: Can hold **32** electrons.
3. **Ground State Configuration:**
    - The ground state of an atom is its lowest energy configuration, found in the periodic table.
    - Electrons occupy energy levels sequentially, filling each level before moving to the next.

Example Electron Configurations:

- **Aluminum (Al):** 2-8-3
    - 2 electrons in the 1st shell, 8 in the 2nd, and 3 in the 3rd.
- **Potassium (K):** 2-8-8-1
    - 2 electrons in the 1st shell, 8 in the 2nd, 8 in the 3rd, and 1 in the 4th.
- **Scandium (Sc):** 2-8-9-2
    - 2 electrons in the 1st shell, 8 in the 2nd, 9 in the 3rd, and 2 in the 4th.

3. Important Rules:

1. **Filling Order:**
    - Electrons will not occupy a new energy level until the lower levels are filled.
    - Following this orderly filling sequence ensures electrons are in their most stable configuration (ground state).
2. **Higher Energy Levels:**
    - The further an electron is from the nucleus, the more energy it possesses.

4. Regents Review Questions:

1. **Electron Orbit Theory:**
   Which scientist is responsible for the theory where electrons orbit the nucleus in circular paths like planets around the sun?

2. **Atomic Number Determination:**
   Determine the atomic number of phosphorus-32.

3. **Electron Configuration Practice:**
   What is the electron configuration for potassium and scandium? How do they follow the filling rules?

4. **Energy Levels:**
   Identify the number of electrons that can occupy the 1st, 2nd, 3rd, and 4th shells.