*The Nature of Atoms*

**Learning Outcomes**
1. Define the terms electron, proton, and nucleus.
2. Understand the subatomic structure and its role in chemical behavior.
3. Explain the atomic number and its significance.
4. Distinguish between isotones, isotopes, and isobars.

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**Atomic Structure**

- **Nucleus**: Consists of protons (positive) and neutrons (neutral).
- **Protons**: Carry a positive charge (+) and are located in the nucleus.
- **Neutrons**: Carry no charge (0) and are located in the nucleus.
- **Electrons**: Carry a negative charge (−) and are found in energy levels around the nucleus.

**Electrons**

- **Energy Levels**: Electrons are constantly moving in bound orbits called energy levels around the nucleus. These levels are quantized, meaning they can only exist at certain energy levels.
- **Largest Energy Level**: The largest energy level is the K shell, consisting of the nucleus and the first electron shell. It is typically filled with two electrons.

**Isotopes**

- **Isotopes of Carbon**: Carbon-12 has 6 protons and 6 neutrons, while carbon-14 has 6 protons and 8 neutrons.

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**Chemical Behavior**

- **Chemical Reactions**: In chemical reactions, atoms combine or split apart to form different substances. The chemical behavior of an atom is determined by its nucleus (protons and neutrons) and the number of electrons.

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**Electron Configuration**

- **Periodic Table**: The electron configuration of an atom is determined by the number of electron shells it has. Each shell can hold a specific number of electrons, and the electron configuration affects the chemical properties of an atom.

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**Isotopes and Isotopes**

- **Isotopes**: Variations of an element with the same number of protons but different numbers of neutrons. Isotopes have identical chemical properties but can differ in physical properties.

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**Bohr Model**

- **Planetary Model**: The Bohr model represents the atom as a nucleus surrounded by electrons in circular orbits. Each energy level is defined by a specific number of electrons.

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**Quantum Mechanics**

- **Quantum Numbers**: Quantum mechanics describes the behavior of subatomic particles and provides a more accurate model of atomic structure.

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**Conclusion**

- **Atomic Structure**: Understanding atomic structure is crucial for grasping the behavior of elements and their reactions. The three fundamental components of an atom—protons, neutrons, and electrons—determine its chemical behavior.

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**Further Reading**


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**Glossary**

- **Protons**: Particles with a positive electric charge located in the nucleus.
- **Neutrons**: Particles with no electric charge located in the nucleus.
- **Electrons**: Particles with a negative electric charge orbiting the nucleus.
- **Isotopes**: Variations of an element with the same number of protons but different numbers of neutrons.
- **Bohr Model**: A model of the atom that represents electrons in circular orbits around the nucleus.
- **Quantum Mechanics**: A theory that describes the behavior of subatomic particles.

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**Appendix**

- **Periodic Table of Elements**: A table that lists all known elements, arranged by atomic number and atomic mass.
- **Electronic Configuration**: The distribution of electrons in an atom, determined by quantum numbers.

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**References**


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**Assessment**

- **Multiple Choice Questions**: Test your understanding of atomic structure and electron configurations.
- **Essay Questions**: Explain the significance of isotopes in the stability of atoms.

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**Chapter Summary**

- **Key Concepts**: Atomic structure, electron configurations, isotopes, and their chemical behavior.
- **Critical Thinking**: Analyze the implications of quantum mechanics on our understanding of atomic structure.

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**Supplementary Material**

- **Interactive Figures**: Explore electron configurations and atomic structures using interactive diagrams.
- **Video Tutorials**: Watch videos that explain atomic structure and electron configurations in detail.

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**Contact Information**

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So long as the elements can be considered to have the exclusive possession of their individual atoms, their reactions, their physical properties, and the phenomena connected with them, can be explained by regarding them each as a single whole, and the relations which they exhibit are the relations of a single whole to one another. Therefore, the periodic table is a small procedure that has enabled chemists to make the periodic table of elements.
Figure 2.21. The structure of hydrogen bonds: A hydrogen bond forms between molecule A and molecule B. The hydrogen bond is represented as a dashed line. The distance between the atoms involved in the bond is approximately 2.8 Å. In water, hydrogen bonds are strong enough to hold the water molecules together, forming a liquid. If the hydrogen bonds are broken, the water molecules will not remain together, forming a gas.

Water's high specific heat helps maintain temperature

The composition of the water is such that it has a high specific heat, which means that it requires more energy to change its temperature. In other words, it takes more energy to heat water than it does to heat other substances with similar properties. This is because water's high specific heat helps to slow down the temperature changes, making it a good medium for temperature regulation.

W3. The temperature of water is stable when the temperature is above 0°C and below 100°C. When water cools below 0°C, it forms ice, and when it warms above 100°C, it turns into steam. The temperature of water changes very little when heated or cooled, which is why water is often used as a cooling or heating medium in industrial processes.

Learning Outcomes

- Water's ability to absorb and release heat is due to its high specific heat and its ability to form hydrogen bonds.
- The temperature of water is stable when the temperature is above 0°C and below 100°C.
- Water's structure facilitates hydrogen bonding, which allows it to maintain a relatively stable temperature.

Properties of Water

- The high specific heat of water helps to moderate temperature changes.
- Water's ability to form hydrogen bonds helps to keep it from freezing or boiling.
- Water's structure facilitates hydrogen bonding, which allows it to maintain a relatively stable temperature.

Water molecules are cohesive

The cohesive properties of water are due to the strong hydrogen bonds that form between water molecules. These hydrogen bonds form when a hydrogen atom is attached to a highly electronegative atom, such as oxygen or nitrogen. The hydrogen atom is attracted to the highly electronegative atom, which in turn attracts other water molecules to the hydrogen atom. This results in a strong bond between water molecules, which is responsible for the cohesive properties of water.

Water organizes nonpolar molecules

Water molecules are adhesive

The adhesion properties of water are due to the partial electric charges on the water molecules. These charges are opposite in sign to the charges on the surface of the liquid, which results in an attractive force between the water molecules and the surface. This is why water is able to form a film on surfaces, such as amines and other life in lakes to survive the winter.

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Thus, lemon juice is 100 times more acidic than tomato juice, and 1 represents a 10-fold change in the concentration of hydrogen ions.

Basic solutions have pH values above 7. Very strong bases, such as sodium hydroxide (NaOH), have pH values of 12 or more. Many common cleaning substances, such as ammonia, are strong (although dilute) acidic solutions. Despite such variations, a solution neutralizes some of the acid present, and so raises the pH. Thus, buffers help stabilize pH.

Buffers minimize changes in pH. A substance that resists changes in pH is a buffer. Buffers consist of pairs of substances that are related by the following equation:

\[ \text{acid} + \text{base} = \text{salt} + \text{water} \]

The reaction of carbon dioxide and water to form carbonic acid is a crucial one because it permits carbon, essential to life, to enter water from the air. The Earth’s oceans are rich in carbon because of the reaction of carbon dioxide with water.

In a condition called blood acidosis, human blood, which normally has a pH of about 7.4, drops to a pH of about 7.1. This condition is fatal if not treated immediately. The reverse condition, called blood alkalosis, can occur when too much carbonic acid is removed from the blood, typically by respiration.

The molecular basis of life is maintained by a buffer system: blood, HCO₃⁻ / CO₂ / CO₃²⁻. This buffer system resists changes in pH.

Learning Outcome Review 5.6

1. a) A change of 1 pH unit indicates a ten-fold change in hydrogen ion concentration.

b) A change of 0.5 pH units indicates a five-fold change in hydrogen ion concentration.