A-Level Notes for Pearson Edexcel

Michael Tang

Compile Date: December 30, 2024

Contents

Chapter 1

Math

Chapter 2

Biology

2.1 Molecules, Transport and Health

2.1.1 Chemistry for Biologists

Chemistry of Life

Ionic Bonding (离子键)

- **Definition:** Atoms transfer electrons to achieve a stable electron configuration, resulting in positively charged cations and negatively charged anions.
- **Key Properties:**
  - High melting and boiling points.
  - Solubility in polar solvents like water.
- **Example:** Sodium (Na 钠) and chlorine (Cl 氯) form sodium chloride ($NaCl$ 氯). Sodium donates an electron to chlorine, forming a strong ionic bond.

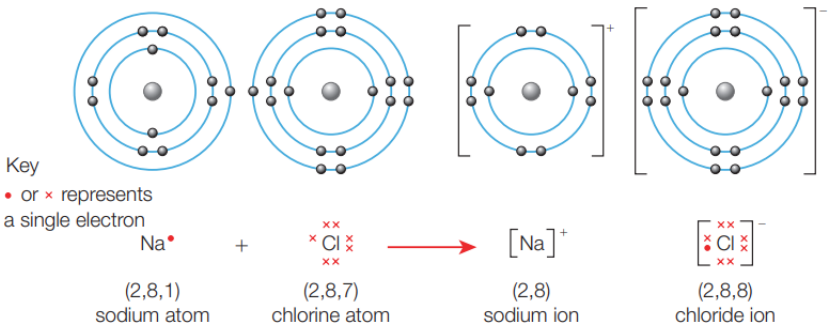

Figure 2.1: The formation of sodium chloride.

Covalent Bonding (共价键)

- **Definition:** Atoms shere electrons to achieve stability.
- **Polarity** (极性)**:** Unequal sharing of electrons leads to polar molecules (极性分子 e.g., water).
- **Dipoles** (偶极子)**:** Partial charges within the molecule, represented as δ^+ (positive) and δ^- (negative).

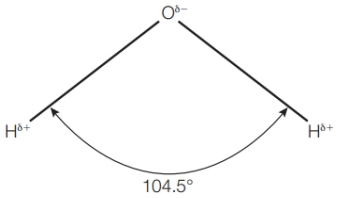

Figure 2.2: A model of a water molecule showing dipoles.

- **Examples:** Formation of hydrogen (H_2 氢气) molecules and the formation of water (H_2O 水).

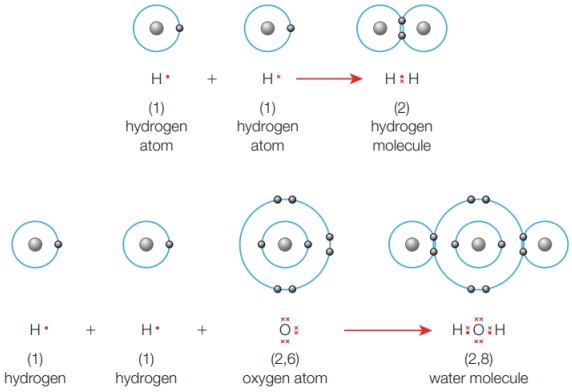

Figure 2.3: The formation of hydrogen molecules and water molecules are examples of covalent bonding.

Chemistry of Water

- **Molecular Structure**
  - **Polar Molecule:** Water (H_2O) has a bent structure with a partial charges (see figure 2.2) - oxygen is δ^-, and hydrogen is δ^+.
  - **Hydrogen Bonding (氢键):** Weak attractions between water molecules, providing cohesion (凝聚力) and a relatively high boiling point.

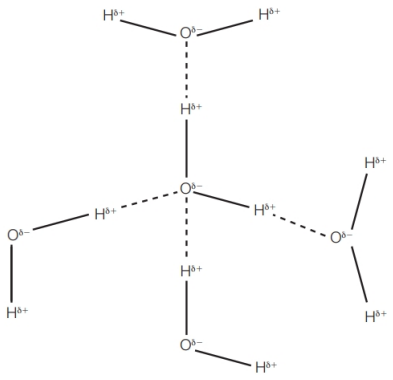

Figure 2.4: Hydrogen bonding in water molecules, based on attraction between positive and negative dipoles.

- **Unique Properties**

- **Solvent (溶剂) Properties**
  - Excellent solvent for ionic and polar substances (物质).

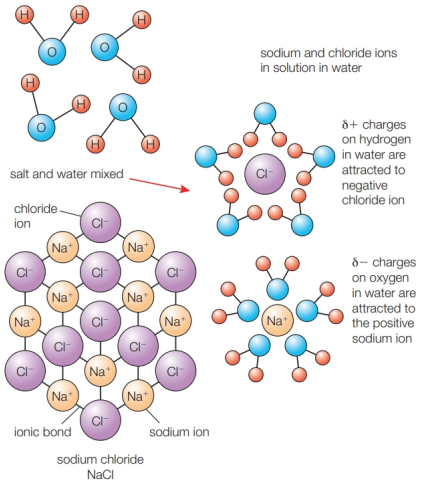

Figure 2.5: A model of sodium chloride dissolving in water as a result of the interactions between the charges on sodium and chloride ions and the dipoles of the water molecules.

  - Facilitates (促进) biochemical (生化) reactions in aqueous solutions (水溶液).
- **Thermal (热) Stability**
  - High specific heat capacity [1] (比热容) moderates temperature changes.
  - Ice floats due to lower density (密度) compared to liquid water, insulating (隔热) the aquatic (水生) life.
- **Cohesion (凝聚力) and Adhesion (粘附力)**
  - Enables water transport in plants.
  - High surface tension due to hydrogen bonding.

Importance of Water

- **Biological Reactions:** All cellular reactions occur in an aqueous environment.
- **Transport Medium:** Dissolves and carries nutrients (营养物质), gases, and waste products (废物).
- **Habitat:** Provides a stable environment for diverse (多样的) life forms.
- **Temperature Regulation:**
  - Evaporation (蒸发) cools organisms.
  - High specific heat stability ecosystems.
- **Structural Support:** Turgor pressure [2] (胀压) in plants depends on water.

[1] **Heat capacity:** Heat capacity refers to the amount of heat energy required to raise the temperature of a substance by one degree Celsius. It reflects the substance's ability to store thermal energy (热能). c is the symbol of heat capacity. The general formula of heat capacity is $c = \frac{Q}{m(t-t_0)} = \frac{Q}{m\Delta t}$. $\mathrm{J\,kg^{-1}\,K^{-1}}$ is the SI unit of heat capacity and $\frac{J}{(kg\cdot^\circ C)}$ is the common unit.

[2] **Turgor pressure:** Turgor pressure is the pressure exerted by the water-filled vacuole (液泡)

Importance of Inorganic (无机) Ions

- **Nitrate Ions (NO_3^- 硝酸根离子):** Vital for DNA [3] and protein synthesis (蛋白质合成) in plants. (see sections 1A.5, 2B.3, and chapter 5A).
- **Phosphate Ions (PO_4^{3-} 磷酸根离子):** Essential for ATP [4], DNA [3], and RNA [5] (see section 2B.3 and chapter 5A).
- **Chloride Ions (Cl^- 氯离子):** Needed in all living organisms to make AT and ADP as well as DNA and RNA (see chapters 7C and 8A).

---

against the cell wall in plant cells. It results from water entering the cell by osmosis (渗透) and helps maintain the cell's rigidity (刚性), supporting the plant's structure and preventing wilting (枯萎).

[3] **DNA (Deoxyribonucleic Acid 脱氧核糖核酸):** DNA is a molecule that carries the genetic instructions (遗传信息) used in the growth, development, functioning, and reproduction of all living organisms. It consists of two strands forming a double helix (螺旋), with each strand (股) made up of nucleotide bases (核苷酸碱基) (adenine 腺嘌呤, thymine 胸腺嘧啶, cytosine 胞嘧啶, and guanine 鸟嘌呤). These bases pair (碱基对) specifically (A-T, C-G) and encode the instructions for synthesizing (合成) proteins, which determine an organism's traits (特征).

[4] **ATP (Adenosine Triphosphate 腺嘌呤核苷三磷酸):** ATP is a molecule that acts as the primary energy carrier in cells. It consists of an adenosine molecule (腺苷分子) bonded to three phosphate (磷酸盐) groups. When ATP is broken down into ADP (adenosine diphosphate 二磷酸腺苷/核苷酸) and a phosphate group, energy is released to fuel cellular processes such as muscle contraction, active transport, and chemical synthesis.

[5] **RNA (Ribonucleic Acid 核糖核酸):** RNA is a single-stranded nucleic acid (单链核酸) that plays a crucial role in protein synthesis and gene expression. It is composed of ribose sugar (核糖/单糖), phosphate groups, and four nitrogenous bases (含氮碱基): adenine (A 腺嘌呤), uracil (U 尿嘧啶), cytosine (C 胞嘧啶), and guanine (G 鸟嘌呤). Unlike DNA, RNA contains uracil instead of thymine. Types of RNA include: mRNA [6] (messager RNA 信使核糖核酸), tRNA [7] (transfer RNA 转运核糖核酸), and rRNA [8] (ribosomal RNA 核糖体).

[6] **mRNA:** mRNA is a type of RNA that carries the genetic information from DNA in the cell nucleus to the ribosome (核糖体), where it is used as a template for protein synthesis. It is transcribed from DNA and contains codons [9] (密码子) that specify the amino acids (氨基酸) to be incorporated into the protein.

[7] **tRNA:** tRNA is a type of RNA that helps decode the genetic instructions in mRNA during protein synthesis. It carries specific amino acids to the ribosome, where it pairs its anticodon [10] (反密码子) with the complementary codon on the mRNA sequence. This ensures that amino acids are added in the correct sequence to form a protein.

[8] **rRNA:** rRNA is a type of RNA that is a key structural and functional component of ribosomes, the molecular machines [11] (分子机器) that synthesize proteins. rRNA helps align mRNA and tRNA during protein synthesis and catalyzes the formation of peptide bonds (肽键) between amino acids, facilitating the assembly of proteins.

[9] **Codon:** A codon is a sequence of three nucleotide bases in mRNA that corresponds to a specific amino acid or a stop signal during protein synthesis. For example, the codon AUG [12] (起始密码子) codes for the amino acid methionine (蛋氨酸) and also serves as the start signal for translation.

[10] **Anticodon:** An anticodon is a sequence of three nucleotide bases on a tRNA molecule that is complementary to a codon on the mRNA strand. During protein synthesis, the anticodon pairs with its corresponding codon, ensuring that the correct amino acid is added to the growing polypeptide chain.

[11] **Molecular machines:** Molecular machines are complex biomolecules or assemblies of molecules that perform specific tasks within a cell, often converting energy into mechanical work. Examples include ribosomes for protein synthesis, ATP synthase for energy production, and motor proteins [13] (马达蛋白) like kinesin (驱动蛋白) for intracellular transport (细胞内运输).

[12] **Codon AUG:** The codon AUG serves two critical roles in protein synthesis: start codon, it signals the beginning of translation, indicating where the ribosome should start assembling the protein; and amino acid, AUG codes for the amino acid methionine (Met), which is often the first amino acid in newly synthesized proteins. This dual function makes AUG essential in the initiation of protein synthesis.

[13] **Motor proteins:** Motor proteins are specialized molecular machines that convert chemical energy from ATP into mechanical work to perform cellular movements. They play key roles in intracellular transport, cell division, and structural support. Examples include: kinesin (驱动蛋白), dynein (动力蛋白), and myosin (肌球蛋白).

- **Hydrogencarbonate Ions (HCO_3^- 碳酸氢根离子):** Needed in nerve impulses, sweating, and many secretory systems (分泌系统) in animals (see section 1B.2).
- **Sodium Ions (Na^+ 钠离子):** Critical in nerve impulses and secretory functions (see chapter 8A).
- **Magnesium Ions (Mg^{2+} 镁离子):** Needed for production of chorophyll (叶绿素) in plants (see chapter 5A).
- **Hydrogen Ions (H^+ 氢离子):** Needed in cellular respiration (呼吸) and photosynthesis (光合作用), and in numerous pumps and systems as well as pH balance (see section 2A.4 and chapters 5A and 7A).
- **Calcium Ions (Ca^{2+} 钙离子):** Needed for the formation of calcium pectate (果胶酸钙) for middle lamella (中膜) between two cell walls in plants, and for bone formation and muscle contraction in animals (see section 4A.1 and chapters 7B and 7C).

2.2 Carbohydrates: Mono- and Disaccharides

Chapter 3

Chemistry

Chapter 4

Physics