Alcohol Phenol Ether

Physical Properties of Alcohols

1. **Boiling Points**
   - Alcohols have higher boiling points compared to hydrocarbons, ethers, and haloalkanes of similar molecular masses due to the presence of intermolecular hydrogen bonding.
   - The boiling points increase with the number of carbon atoms (van der Waals forces increase) and decrease with branching (decrease in surface area and van der Waals forces).
2. **Solubility**
   - Alcohols are soluble in water due to their ability to form hydrogen bonds with water molecules.
   - Solubility decreases with the increase in size of the alkyl group (hydrophobic effect). Lower molecular mass alcohols are miscible with water in all proportions.
3. **Density and Viscosity**
   - Alcohols are generally less dense than water.
   - The viscosity of alcohols increases with the increase in molecular weight and the number of hydroxyl groups.

Chemical Properties of Alcohols

1. **Acidity of Alcohols**
   - Alcohols are weakly acidic and can donate a proton (Brönsted acids). The acidic character decreases with the increase in alkyl chain length.
   - Alcohols react with active metals like sodium, potassium, and aluminum to form alkoxides and hydrogen gas.

$$2\text{R-OH} + 2\text{Na} \rightarrow 2\text{R-ONa} + \text{H}_2$$

2. **Reaction with Hydrogen Halides**
   - Alcohols react with hydrogen halides (HX) to form alkyl halides. This reaction is commonly used to distinguish between primary, secondary, and tertiary alcohols (Lucas test).

$$\text{R-OH} + \text{HX} \rightarrow \text{R-X} + \text{H}_2\text{O}$$

3. **Dehydration**
   - Alcohols undergo dehydration to form alkenes when heated with concentrated sulfuric acid or phosphoric acid.

$$\text{CH}_3\text{CH}_2\text{OH} \xrightarrow[443\ \text{K}]{\text{H}_2\text{SO}_4} \text{CH}_2 = \text{CH}_2 + \text{H}_2\text{O}$$

4. **Oxidation**
   - Primary alcohols are oxidized to aldehydes and further to carboxylic acids.
   - Secondary alcohols are oxidized to ketones.
   - Tertiary alcohols are resistant to oxidation but can be oxidized under strong conditions to form carboxylic acids.

$$\text{R-CH}_2\text{OH} \xrightarrow{[O]} \text{R-CHO} \xrightarrow{[O]} \text{R-COOH}$$

5. **Esterification**
    - Alcohols react with carboxylic acids in the presence of an acid catalyst to form esters.

$$\text{R-OH} + \text{R'-COOH} \xrightarrow{H^+} \text{R-COOR'} + \text{H}_2\text{O}$$

6. **Reaction with Sodium**
    - Alcohols react with sodium to form alkoxides and hydrogen gas, demonstrating their weakly acidic nature.

$$2\text{R-OH} + 2\text{Na} \rightarrow 2\text{R-ONa} + \text{H}_2$$

Summary of Reactions Involving Cleavage of Bonds

- **O–H Bond Cleavage**: Reactivity as acids, forming alkoxides.
- **C–O Bond Cleavage**: Conversion to alkyl halides, dehydration to alkenes.

These points cover the essential physical and chemical properties of alcohols, emphasizing their behavior in various reactions and interactions.