Secondary School Physics Notes

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Detailed Notes

Chapter 8. Heat Energy: Temperature and its Measurements

8.1 Heat and Temperature

- **Heat:** A form of energy transfer due to a temperature difference. It flows from a hotter body to a colder body. Unit: Joule (J).
- **Temperature:** A measure of the average kinetic energy of the particles within a substance. It indicates the degree of hotness or coldness of an object. Unit: Celsius (°C), Fahrenheit (°F), Kelvin (K).
- **Distinction:** Heat is energy in transit; temperature is a measure of the average internal energy.

8.2 Methods of Measuring Temperature

- **Thermometers:** Devices used to measure temperature. They rely on properties of materials that change predictably with temperature (e.g., expansion of liquids, resistance of metals).
- **Thermometric Property:** The physical property of a substance that changes uniformly with temperature.

8.3 Good Temperature and Temperature Scales of Thermometers

- **Good Thermometric Property:** Must change linearly and significantly with temperature, be easily measurable, and be sensitive.
- **Temperature Scales:**
    - **Celsius Scale (°C):** Water freezes at 0°C and boils at 100°C (at standard atmospheric pressure).
    - **Fahrenheit Scale (°F):** Water freezes at 32°F and boils at 212°F.
    - **Kelvin Scale (K):** The absolute temperature scale. 0 K (absolute zero) is the lowest possible temperature.
        - **Conversion:** K = °C + 273.15

8.4 Types of Thermometers

- **Liquid-in-glass Thermometers:** Most common (e.g., mercury or alcohol thermometers). Rely on thermal expansion of the liquid.

- **Bimetallic Strip Thermometers:** Two different metals with different expansion rates bonded together. Used in thermostats.
- **Resistance Thermometers:** Measure temperature by the change in electrical resistance of a material (e.g., platinum resistance thermometer, thermistors).
- **Thermocouple Thermometers:** Measure temperature based on the voltage produced at the junction of two different metals. Good for very high or very low temperatures.
- **Pyrometers:** Measure very high temperatures by detecting thermal radiation (non-contact).

8.5 Molecular Explanation of Temperature

- Temperature is directly related to the average kinetic energy of the atoms or molecules within a substance.
- Higher temperature means faster average molecular motion.
- Absolute zero (0 K) is the theoretical temperature at which all molecular motion ceases.

8.6 Summary

- Heat is energy transfer, temperature is average kinetic energy.
- Thermometers use thermometric properties to measure temperature.
- Celsius, Fahrenheit, and Kelvin are common temperature scales.
- Temperature is a manifestation of molecular motion.

Chapter 9. Measurement of Heat Energy

9.1 Specific Heat Capacity

- **Definition:** The amount of heat energy required to raise the temperature of 1 kg of a substance by 1 Kelvin (or 1°C).
- **Symbol:** c
- **Formula:** $Q = \Delta T$, where Q is heat energy, m is mass, c is specific heat capacity, ΔT is change in temperature.
- **Unit:** Joules per kilogram per Kelvin ($J\ kg^{-1}\ K^{-1}$).
- Water has a high specific heat capacity (4200 $J\ kg^{-1}\ K^{-1}$), meaning it takes a lot of energy to heat it up.

9.2 Change of State; Latent Heat

- **Change of State (Phase Change):** The transition of a substance from one physical state to another (e.g., solid to liquid, liquid to gas). This occurs at constant temperature.
- **Latent Heat:** The hidden heat energy absorbed or released during a phase change without a change in temperature.
    - **Latent Heat of Fusion (L_f):** Heat required to change 1 kg of a substance from solid to liquid at its melting point. (Q = mLf)
    - **Latent Heat of Vaporization (Lv):** Heat required to change 1 kg of a substance from liquid to gas at its boiling point. (Q = mLv)
- **Unit:** Joules per kilogram ($J\ kg^{-1}$).

9.3 Evaporation

- **Definition:** The process by which liquid changes into gas at a temperature below its boiling point.
- **Mechanism:** Energetic molecules near the surface escape from the liquid.
- **Cooling Effect:** Evaporation causes cooling because the more energetic molecules leave, reducing the average kinetic energy (and thus temperature) of the remaining liquid.
- **Factors Affecting Evaporation:** Temperature, surface area, humidity, air movement.

9.4 Boiling

- **Definition:** The process by which a liquid changes into gas rapidly at a specific temperature (boiling point) throughout the entire liquid, forming bubbles of vapor.
- **Boiling Point:** The temperature at which the vapor pressure of the liquid equals the external atmospheric pressure.
- Boiling is a specific form of vaporization that occurs at a fixed temperature for a given pressure.

9.5 Summary

- Specific heat capacity relates heat energy to temperature change.
- Latent heat is absorbed/released during phase changes at constant temperature.
- Evaporation is surface vaporization, causing cooling.
- Boiling is bulk vaporization at a specific boiling point.