Chapter 7: *Density and Temperature*

7.1 Introduction to Density

Density is defined as the mass of an object per unit volume. It is a physical property that helps us understand the "compactness" of a substance.

$$\rho = \frac{m}{V}$$

where:

- ρ is the density (in kg/m^3 or g/cm^3),
- m is the mass (in kg or g),
- V is the volume (in m^3 or cm^3).

7.2 Measuring Densities of Different Substances

- **Density of Liquids**: To measure the density of liquids, use a graduated measuring cylinder and a balance.
    a. Measure the mass of the empty cylinder.
    b. Add the liquid and measure its volume.
    c. Subtract the mass of the empty cylinder from the mass of the cylinder with the liquid.
    d. Calculate the density by dividing the mass by the volume.

  Example: If a liquid has a mass of 60 g and volume of 60 mL, the density would be:

  Density $= \frac{60}{60} = 1$ g/mL

7.3 Density of Regularly Shaped Solids

To find the density of regularly shaped solids:

1. Measure the mass of the solid using a balance.
2. Calculate the volume using the shape's formula (e.g., for a cube, $V = \text{side}^3$).

3. Calculate the density using the formula:

$$\rho = \frac{\text{mass}}{\text{volume}}$$

7.4 ***Density of Irregular Shaped Solids (Displacement Method)***

For irregular solids:

1. Measure the mass of the object.
2. Immerse the object in a graduated cylinder with water.
3. Measure the initial and final water volumes.
4. The difference in volume gives the volume of the object.
5. Calculate the density:

$$\text{Density} = \frac{\text{mass}}{\text{volume}}$$

7.5 ***States of Matter***

Matter exists in three main states:

1. **Solids**: Particles are closely packed with strong attractive forces, allowing only vibration.
2. **Liquids**: Particles are loosely packed and can flow.
3. **Gases**: Particles are far apart and move freely.

The density is highest in solids and lowest in gases.

7.6 ***Plasma as the Fourth State of Matter***

Plasma consists of ions and free electrons and exists at very high temperatures or pressures, like in the sun, neon lights, or lightning.

7.7 ***Relationship Between the Motion of Particles and Temperature***

As temperature increases, the kinetic energy of particles increases. This results in faster particle motion, which leads to expansion in solids, liquids, and gases.

7.8 ***Internal Energy and Temperature of a Substance***

Internal energy is the total energy (kinetic + potential) of the particles in a substance. As temperature increases, the internal energy increases, particularly the kinetic energy of particles.

7.9 ***Variation in Physical Properties as a Tool for Measuring Temperature***

- **Expansion of Liquids**: Used in liquid-in-glass thermometers.
- **Variation of Volume and Pressure**: Used in gas thermometers.
- **Variation in Colour**: Used in liquid crystal thermometers.

7.10 ***Fixed Points in Calibration of Thermometers***

Fixed points are standard reference points to calibrate thermometers. Commonly used fixed points:

- **Lower reference point**: Freezing point of water (0°C, 273 K).
- **Upper reference point**: Boiling point of water (100°C, 373 K).

7.11 ***Sensitivity, Range, and Linearity of Thermometers***

- **Sensitivity**: Ability of a thermometer to detect small changes in temperature.
- **Range**: The temperature range a thermometer can measure.
- **Linearity**: How evenly a thermometer measures temperature changes across its range.

7.12 ***Structure of Liquid-in-Glass and Thermocouple Thermometers***

- **Liquid-in-glass thermometers**: Liquid (like mercury or alcohol) expands and contracts with temperature changes.
- **Thermocouple thermometers**: Measure temperature based on voltage differences between two different metals.

All Formulae (Collected at End)

1. **Density**:

   $\rho = \frac{m}{V}$

2. **Volume of a Cube**:

   $V = \text{side}^3$

3. **Density of Irregular Shaped Solid (Displacement Method)**:

   $\text{Density} = \frac{\text{Mass}}{\text{Volume from Displacement}}$

4. **Thermal Expansion**:

   $\Delta L = \alpha L_0 \Delta T$

   where:

   - ΔL is the change in length,
   - α is the coefficient of linear expansion,
   - L_0 is the original length,
   - ΔT is the change in temperature.

5. **Pressure-Volume Relationship (Boyle's Law)**:

   $P_1 V_1 = P_2 V_2$

6. **Volume-Temperature Relationship (Charles's Law)**:

   $\frac{V_1}{T_1} = \frac{V_2}{T_2}$

7. **Centripetal Force**:

   $F_c = \frac{mv^2}{r}$

8. **Orbital Speed**:

   $v = \frac{2\pi r}{T}$

9. **Terminal Velocity**:

   $\text{Weight} = \text{Drag force}$

