Chapter-9

1. Thermal Energy, Heat, and Temperature

- **Thermal Energy:** Total internal energy of all particles in a substance due to their motion.
- **Heat:** Energy transferred from a hotter object to a cooler one.
- **Temperature:** A measure of the degree of hotness or coldness of an object.

Difference between Heat and Temperature

Heat	Temperature
Energy in transit	Degree of hotness
Depends on mass and material	Independent of mass
SI unit: Joule (J)	SI unit: Kelvin (K)
Measured with calorimeter	Measured with thermometer

2. Effect of Heat on Volume (Thermal Expansion)

When heat is supplied, substances expand.

Expansion by State:

- **Solids:** Expand slightly
- **Liquids:** Expand more than solids
- **Gases:** Expand the most

Examples:

- Railway tracks bend in summer
- Electric wires sag when hot
- Bottles bulge when heated

3. Anomalous Expansion of Water

- Water **contracts** from 100°C to 4°C
- **Expands** below 4°C until it freezes
- This is **anomalous** (unusual) behavior

Implications:

- Ice floats on water
- Aquatic life survives in frozen lakes
- Surface freezes first; bottom remains liquid

Applications:

- Cooling systems
- Lake ecosystems
- Climate regulation

4. Specific Heat Capacity

Definition:
Heat required to raise the temperature of 1 kg of a substance by 1°C

Heat Energy Formula

$Q = mc\Delta T$

Where:

- **Q** = Heat energy (Joules)
- **m** = Mass (kg)
- **c** = Specific heat capacity (J/kg°C)
- **ΔT** = Temperature change (°C)

Water:

- High specific heat = 4200 J/kg°C

Uses:

- Car radiators
- Hot water bottles
- Climate moderation (coastal areas)

5. Factors Affecting Heat Absorption

- **Color:** Dark surfaces absorb more
- **Surface area:** Larger = more heat gain
- **Material:** Different capacities
- **Mass:** More mass = more heat needed
- **Specific heat:** Substances vary

6. Heat Equation & Sample Numerical

Heat Energy Formula

$Q = mc\Delta T$

Where:

- **Q** = Heat energy (Joules)
- **m** = Mass (kg)
- **c** = Specific heat capacity (J/kg°C)
- **ΔT** = Temperature change (°C)

Example:

Find the heat needed to raise 2 kg of water from 20°C to 60°C.

$Q = 2 \times 4200 \times (60 - 20) = 336{,}000$ J

Answer: 336,000 Joules

7. Calorimetry and Its Principle

- **Calorimetry:** The science of measuring heat changes
- **Principle:**

Heat Exchange Principle

Heat lost by hot object = Heat gained by cold object

$m_1c_1(T_1 - T_f) = m_2c_2(T_f - T_2)$

Where:

- **m_1, m_2** = Mass of hot and cold objects
- **c_1, c_2** = Specific heat capacities
- **T_1** = Initial temperature of hot object
- **T_2** = Initial temperature of cold object
- **T_f** = Final equilibrium temperature

🔢 Worked Example: Heat Exchange

Problem: A 1 kg copper block at 100°C is placed in 2 kg of water at 30°C.

Given:

- Mass of copper = 1 kg
- Initial temperature of copper = 100°C
- Specific heat of copper = 390 J/kg°C
- Mass of water = 2 kg
- Initial temperature of water = 30°C
- Specific heat of water = 4200 J/kg°C

Equation:

```
(1)(390)(100 − T) = (2)(4200)(T − 30)
```

Step 1: Expand both sides

```
390(100 − T) = 39000 − 390T
8400(T − 30) = 8400T − 252000
```

Step 2: Set both sides equal

```
39000 − 390T = 8400T − 252000
```

Step 3: Solve for T

```
Bring variables to one side:
39000 + 252000 = 8400T + 390T
291000 = 8790T

T = 291000 ÷ 8790 ≈ 33.1°C
```

☑ **Final Answer: T ≈ 33.1°C**

8. Types of Thermometers

Type	Principle	Uses
Liquid Thermometer	Thermal expansion of mercury/alcohol	Household use
Digital Thermometer	Electronic sensors	Accurate and safe
Radiation Thermometer	Infrared detection	Remote sensing, industry

9. Calibration of Thermometer

- **Lower Fixed Point:** 0°C (melting point of ice)
- **Upper Fixed Point:** 100°C (boiling point of water)
- **Divided into 100 parts** = Celsius scale

Interesting Facts

- Boiling water stays at 100°C at sea level
- Black surfaces heat up faster than white ones
- Water's high specific heat stabilizes Earth's climate
- Anomalous expansion of water helps fish survive in frozen lakes

Quick Revision Summary

- **Heat** flows from **hot** to **cold**
- $Q = mc\Delta T$
- Heat causes **expansion**
- Water has **high specific heat**
- **Calorimetry**: heat lost = heat gained
- Thermometers: types and uses
- Anomalous water behavior supports life

Common Mistakes to Avoid

- Mixing **heat** and **temperature**
- Forgetting to **convert grams to kg**
- Wrong application of **heat formula**
- Assuming **all materials** expand equally
- Confusing **thermal energy** with temperature