

Introduction to Heat Energy

Introduction to Heat Energy – Study Notes

1. What Is Heat Energy?

- **Definition:** Heat (thermal energy) is the form of energy that flows between objects or systems due to a temperature difference.
- **Key Idea:** It is energy in transit; when it stops flowing, it becomes internal energy of the material.

2. Fundamental Concepts

Concept	Explanation	Typical Symbol
Temperature	Measure of the average kinetic energy of particles in a substance.	(T)
Internal Energy (U)	Total microscopic kinetic + potential energy of all particles in a system.	(U)
Heat (Q)	Energy transferred because of a temperature gradient.	(Q)
Work (W)	Energy transferred by forces acting through a distance (e.g., compression, expansion).	(W)
First Law of Thermodynamics	Energy cannot be created or destroyed; ($\Delta U = Q - W$).	—

3. Modes of Heat Transfer

Mode	Mechanism	Typical Examples
Conduction	Direct molecular collisions transfer kinetic energy through a material.	Metal rod heated at one end.
Convection	Bulk movement of fluid (liquid or gas) carries heat.	Boiling water, atmospheric circulation.
Radiation	Emission of electromagnetic waves (infrared) from a body's surface.	Sunlight, heat from a fireplace.

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4. Quantifying Heat

1. Specific Heat Capacity (c)

- Amount of heat required to raise the temperature of 1 kg of a substance by 1 K (or 1 °C).
- Formula: $Q = m c \Delta T$

2. Latent Heat

- Heat needed for a phase change at constant temperature.
- Fusion (melting):** $Q = m L_f$
- Vaporization (boiling):** $Q = m L_v$

3. Heat Flow Rate

- Fourier's Law (conduction):** $\dot{Q} = -k A \frac{dT}{dx}$
- Newton's Law of Cooling (convection):** $\dot{Q} = h A (T_{\text{surface}} - T_{\infty})$
- Stefan-Boltzmann Law (radiation):** $\dot{Q} = \epsilon \sigma A (T_{\text{surface}}^4 - T_{\text{surroundings}}^4)$

5. Energy Units

Quantity	SI Unit	Common Non-SI Units
Energy / Heat	Joule (J)	calorie (cal), British Thermal Unit (BTU)
Power (heat rate)	Watt (W = J/s)	kilowatt (kW), horsepower (hp)
Specific Heat	J/kg·K	cal/g·°C
Latent Heat	J/kg	cal/g

Conversion: 1 cal = 4.184 J; 1 BTU = 1055 J.

6. Practical Applications

Field	Application	Heat/Energy Principle
**Domestic heating		