Thermodynamics Lesson 2: Quantifying Heat and Changing States

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Outline

Recap: Temperature and Heat Transfer

- Temperature measures average particle KE [N1].
- Heat is energy transferred due to ΔT.
- Mechanisms: Conduction, Convection, Radiation [N4].

Think/Pair/Share: Why does beach sand get much hotter than ocean water under the same sunlight?

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Think/Pair/Share: Why does beach sand get much hotter than ocean water under the same sunlight?

- *Answer Hint:* Different substances require different amounts of energy to change temperature by the same amount.

Heating Up: Specific Heat Capacity

- **Definition:** The amount of heat energy required to raise the temperature of **1 kg** of a substance by **1 K** (or 1 °C).
- Symbol: c
- Units: $\mathrm{J\,kg^{-1}\,K^{-1}}$ or $\mathrm{J\,kg^{-1}\,{}^{\circ}C^{-1}}$
- **High 'c'** (like water: ≈ 4186): Takes a LOT of energy to heat up (and stores a lot).
- **Low 'c'** (like sand/metals: $\approx 800/400$): Heats up quickly with less energy.
- **Formula:** The heat energy (Q) needed for a temperature change (ΔT) depends on mass (m) and specific heat capacity (c):

$$Q = mc\Delta T$$

where $\Delta T = T_{final} - T_{initial}$.

Energy for Phase Changes: Latent Heat

Observation (Heating Curve): When a substance melts or boils, its temperature *remains constant* even though heat is being added. **Why?**

- Energy is used to overcome intermolecular forces (increase potential energy), not increase kinetic energy (temperature).

Definition: Latent heat (L) is the energy absorbed or released per unit mass during a phase change at constant temperature.

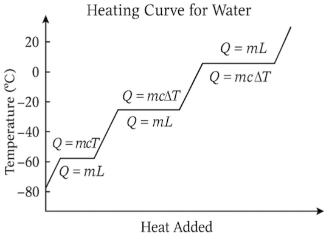
- **Latent Heat of Fusion (L_f):** Energy for solid $\leftrightarrow$ liquid change.
- **Latent Heat of Vaporization (L_v):** Energy for liquid $\leftrightarrow$ gas change. (Typically $L_v > L_f$)

Formula: Heat energy (Q) for phase change of mass (m):

$$Q = mL$$

(Use L_f for melting/freezing, L_v for boiling/condensing)

Putting It Together: The Heating Curve



Temperature vs Energy Added for Water

- **Sloped Sections:** Temperature changes. Energy increases particle KE. Use $Q = mc\Delta T$. (Specific Heat dominates).
- **Flat Sections (Plateaus):** Phase change occurs. Temperature constant. Energy increases particle PE (breaks bonds). Use $Q = mL$. (Latent Heat dominates).

Activity 2 uses PhET simulation to explore this.

Applying the Formulas

Example 1 (Specific Heat): Heat to warm 0.5 kg water from 10°C to 30°C? ($c_w = 4186$)

- $Q = mc\Delta T = (0.5)(4186)(30 - 10) = 41860\,\mathrm{J}$

Example 2 (Latent Heat): Heat to melt 0.1 kg ice at 0°C? ($L_{f,w} = 3.34 \times 10^5$)

- $Q = mL_f = (0.1)(3.34 \times 10^5) = 33400\,\mathrm{J}$

See Worksheet 2 for practice problems.

Lesson 2 Summary

- Specific Heat Capacity (c) relates heat added to temperature change ($Q = mc\Delta T$) [N3].
- Latent Heat (L) relates heat added to phase change ($Q = mL$) [N5].
- Heating curves show temperature changes (slopes) and phase changes (plateaus) [N5 Analyse].
- Energy added during phase change increases potential energy (breaks bonds), not kinetic energy (temperature).

Next Steps:

- Complete Worksheet 2 (Graph analysis, Calculations).
- Complete #MarkSense Quiz 2.
- Preview Lesson 3: Combining concepts in equilibrium problems, Efficiency.

Thank you!

Questions?