Year 11 Physics - Activity Sheet 3
Thermal Equilibrium Calculations

Thermodynamics

Module 3 - Lesson 3

Aim

To apply the principle of conservation of energy ($Q_{lost} = Q_{gained}$) to solve problems involving thermal equilibrium between substances, incorporating specific heat capacity and potentially latent heat.

Knowledge Nodes Targeted

- N2: Thermal Equilibrium (Applying the concept quantitatively)
- N3: Specific Heat (Used within equilibrium calculations)
- N5: Latent Heat (Used within equilibrium calculations involving phase change)

Activity: Guided and Practice Problem Solving

This activity focuses on applying the concepts learned in Lessons 1 and 2 to quantitative problems. The main tool is the principle of energy conservation in an isolated system.

Core Principle

In an isolated system where hotter and colder substances are mixed, heat energy will transfer from the hotter substance(s) to the colder substance(s) until thermal equilibrium is reached (i.e., they reach the same final temperature, T_f). The total energy lost by the initially hotter substance(s) must equal the total energy gained by the initially colder substance(s).

$$\sum Q_{lost} = \sum Q_{gained}$$

Where Q can be calculated using $Q = mc\Delta T$ for temperature changes and $Q = mL$ for phase changes. Remember:

- For heat loss: $\Delta T = T_{initial,hot} - T_{final}$
- For heat gain: $\Delta T = T_{final} - T_{initial,cold}$
- Phase change energy must be included if a substance melts/freezes or boils/condenses during the process.

Guided Problem (Refer to Worksheet 3 Part 1)

The teacher will guide the class through solving the problem of mixing hot copper with cold water, demonstrating the setup and algebraic solution for the final equilibrium temperature (T_f).

Practice Problems (Refer to Worksheet 3 Part 2)

Students will work individually or in pairs to solve the practice problems provided on the worksheet. These problems may involve:

- Mixing two substances with no phase change (applying $Q = mc\Delta T$ on both sides).
- Mixing substances where one undergoes a phase change (applying $Q = mL$ and $Q = mc\Delta T$ as needed).

Required Data

A data table with specific heat capacities (c) and latent heats (L) for relevant materials (e.g., water, ice, steam, copper, lead, aluminium) is required. (This should be provided with Worksheet 3 or displayed).

Numeracy Focus

- Setting up algebraic equations based on the energy conservation principle.
- Correctly identifying terms for heat loss and heat gain.
- Accurately substituting values (including unit consistency, e.g., mass in kg if 'c' or 'L' are per kg).
- Solving the resulting algebraic equations for the unknown variable (often T_f or an unknown mass).

Literacy Focus

- Clearly justifying the steps taken in the problem-solving process.
- Explaining the meaning of the energy conservation equation in the context of the problem.