Year 11 Physics - Worksheet 3
Thermodynamics: Equilibrium Efficiency

Student Name: _____ ID: _____

Module 3

Part 1: Equilibrium Problem Solving (Knowledge Nodes N2 Apply, N3 Apply)

1. State the principle of energy conservation applied when calculating the final temperature of a mixture in an isolated system. [N2 Concept]

2. **Guided Problem:** Calculate the final equilibrium temperature (T_f) when 50g (0.05kg) of copper ($c_{Cu} = 385\,\mathrm{J\,kg^{-1}\,K^{-1}}$) initially at 90°C is placed into 100g (0.1kg) of water ($c_{water} = 4186\,\mathrm{J\,kg^{-1}\,K^{-1}}$) initially at 15°C. Assume no heat loss to the surroundings.

Step 1: Identify the hotter object (loses heat) and colder object (gains heat). Hotter: Copper (Cu) at $T_{i,Cu} = 90°\mathrm{C}$ Colder: Water (w) at $T_{i,w} = 15°\mathrm{C}$

Step 2: Write the energy conservation equation: $Q_{lost,Cu} = Q_{gained,w}$

Step 3: Substitute the formula $Q = mc\Delta T$ for each side. Remember ΔT is always positive change, so for the losing side, $\Delta T = T_{initial} - T_{final}$, and for the gaining side, $\Delta T = T_{final} - T_{initial}$. $(mc\Delta T)_{Cu} = (mc\Delta T)_w$ $(m_{Cu})(c_{Cu})(T_{i,Cu} - T_f) = (m_w)(c_w)(T_f - T_{i,w})$

Step 4: Substitute known values. $(0.05)(385)(90 - T_f) = (0.1)(4186)(T_f - 15)$

Step 5: Solve algebraically for T_f. Show your working below. [Numeracy N2, N3] Final Temperature

$T_f =$ _____ °C

Part 2: Practice Problems Concepts (N2, N3, N5, Inquiry Q3)

(Use the provided data table for c and L values)

1. Calculate the final equilibrium temperature if 200g (0.2kg) of lead ($c_{Pb} = 128\,\mathrm{J\,kg^{-1}\,K^{-1}}$) at 100°C is mixed with 100g (0.1kg) of water ($c_w = 4186\,\mathrm{J\,kg^{-1}\,K^{-1}}$) at 25°C. Assume no heat loss. [N2 Apply, N3 Apply]

2. **Challenge Problem:** How much ice at 0°C must be added to 400g (0.4kg) of water at 60°C to lower the final mixture temperature to exactly 10°C? ($L_{f,water} = 3.34 \times 10^5\,\mathrm{J\,kg^{-1}}$, $c_{water} = 4186\,\mathrm{J\,kg^{-1}\,K^{-1}}$) [N2 Apply, N3 Apply, N5 Apply] (Hint: The ice melts first, then the resulting water warms up. The original water cools down. $Q_{lost} = Q_{gained,melting} + Q_{gained,warming\_melted\_ice}$)

3. Define Thermal Efficiency qualitatively (in terms of energy input and useful energy output). Give ONE reason why waste heat is always produced in practical energy conversions (e.g., in a car engine). [Literacy Inquiry Q3]

#MarkSense Quiz 3

Instructions: Choose the best answer for multiple choice questions. Show working for calculations.

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1. Thermal equilibrium between two objects in contact is reached when: [N2]

A. Their masses are equal.

B. Their total thermal energies are equal.

C. There is no net flow of heat between them.

D. One object has lost all its heat.

Answer: _____

2. If a highly efficient machine converts 100J of input energy into 40J of useful work, how much energy was wasted, likely as heat? [Inquiry Q3 Concept]

A. 40 J

B. 60 J

C. 100 J

D. 140 J

Answer: _____

3. 50g of Metal X ($c = 500\,\text{J}\,\text{kg}^{-1}\,\text{K}^{-1}$) at 100°C is dropped into 100g of Water ($c = 4186\,\text{J}\,\text{kg}^{-1}\,\text{K}^{-1}$) at 20°C. Set up the equation $Q_{lost} = Q_{gained}$ that you would use to find the final temperature (T_f). Do NOT solve it. (2 marks) [N2 Apply, N3 Apply]