Energy Diagrams and Calorimetry

Student Worksheet | `g10_u02_w05`

I can: define a system boundary, read an energy diagram, and use temperature-change data to model heat transfer.
Frozen classroom value: $c_{\text{water}} = 4.184\ \text{J g}^{-1}\,°\text{C}^{-1}$. Use $q = mc\Delta T$ with $\Delta T = T_f - T_i$. Each record is a supplied paper/digital data card; default model: water has the stated mass and specific heat, heat exchange with the cup/air is ignored unless the card says otherwise. No heating, mixing, or chemical handling is requested.

1. For a reaction in a cup, name one reasonable system and its surroundings. What quantity crosses the boundary when the water temperature rises?

2. A reaction-system card warms surrounding water from 20.0°C to 24.0°C. Is heat transferred into or out of the reaction system? Assign the sign of q_{water} and q_{rxn}.

3. Explain why a 4.0°C temperature increase alone does not determine heat transferred without also knowing mass and material.

4. An energy diagram card gives reactants at 60 kJ/mol, a peak at 140 kJ/mol, and products at 20 kJ/mol. Calculate ΔH, forward activation energy, and reverse activation energy.

5. Is the modeled process in item 4 exothermic or endothermic? State what an energy diagram can show and one thing it cannot establish about reaction speed.

6. A 50.0 g water card changes from 20.0°C to 25.0°C. Calculate q_{water} in J and kJ.

7. Under the stated no-heat-loss model in item 6, calculate q_{rxn}.

8. A 100.0 g water card changes from 18.0°C to 21.5°C. Calculate q_{water}.

9. Item 8 assigns the temperature change to 0.0500 mol of a reaction as written. Calculate ΔH_{rxn} in kJ/mol and state the sign.

10. A student writes $q = mcT$. Correct the expression and explain why a Celsius temperature can be used for ΔT even though absolute temperature is required in some other chemistry equations.

11. A 75.0 g water record changes from 22.0°C to 27.2°C during a reaction card. Calculate q_{water} and q_{rxn} under the stated model.

12. The record in item 11 corresponds to 0.0250 mol reaction as written. Calculate ΔH_{rxn} in kJ/mol.

13. Compare two water cards: A, 50.0 g warms by 5.00°C; B, 100.0 g warms by 2.50°C. Calculate each q and decide whether they represent equal heat transfer under the same model.

14. Correct this statement: "Bonds store energy, and breaking them releases it." Use the energy language that belongs in a bond-energy calculation.

15. Use supplied mean bond enthalpies (kJ/mol): C–H 413, O=O 498, C=O in CO_2 799, O–H 463. Estimate ΔH for $CH_4 + 2O_2 \rightarrow CO_2 + 2H_2O(g)$ using bonds broken minus bonds formed.

16. Compare the sign from item 15 with its energy-diagram expectation: where should products lie relative to reactants for this model? Why is a bond-energy result an estimate rather than an exact measured enthalpy?

17. A 125.0 g water card changes from 22.0°C to 19.2°C. Calculate q_{water} and q_{rxn} under the model.

18. The item 17 record is assigned to 0.0300 mol reaction. Calculate ΔH_{rxn}. Is the reaction model endothermic or exothermic?

19. Two diagrams have equal $\Delta H = -40$ kJ/mol. Diagram A has $E_a = 30$ kJ/mol; diagram B has $E_a = 90$ kJ/mol. Which has the lower modeled barrier? Why does this comparison not prove a real reaction's rate without more information?

20. A calorimetry card reports a water temperature rise but omits cup heat capacity, heat loss, and whether the reaction went to completion. Write one defensible conclusion and two limitations of the resulting ΔH estimate.