

Enthalpy and Calorimetry Summative Assessment

Time: 60 min. 8 questions.

Instructions

Answer all eight questions in the space provided or on separate paper. Show all calculations, including formulas, substitutions, and units, for full credit on numeric and short-answer questions. Report molar enthalpy values with the correct sign convention. A periodic table and a calculator are permitted; specific heat capacity of water is $4.19 \text{ J/(g}\cdot^\circ\text{C)}$ unless stated otherwise.

Questions

1. A 50.0 g sample of water absorbs heat, and its temperature rises from 20.0°C to 35.5°C . Using $Q = mc\Delta T$, calculate the heat absorbed by the water. (Outcome)

2. Photosynthesis converts carbon dioxide and water into glucose and oxygen, using energy absorbed from sunlight. This reaction is classified as:

- A) Exothermic, because it releases heat to the surroundings
- B) Endothermic, because it absorbs energy from the surroundings
- C) Exothermic, because chemical bonds are broken
- D) Neither endothermic nor exothermic, because no bonds are formed or broken

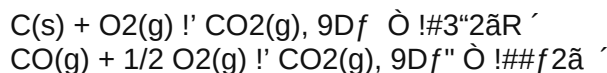
(Outcome)

3. Define enthalpy and molar enthalpy for a chemical reaction. Then determine the molar enthalpy of combustion, in kJ/mol, for octane if the combustion of 4.00 mol of octane releases 1780 kJ of heat. (Outcome)

4. True or false: By convention, a negative value for an exothermic reaction and a positive value for an endothermic reaction. (Outcome)

5. In a coffee-cup calorimeter, 50.0 mL of 1.00 mol/L hydrochloric acid is mixed with 50.0 mL of 1.00 mol/L sodium hydroxide. The temperature of the mixture rises from 21.0°C to 27.8°C . Assume the combined solution has a density of 1.00 g/mL , a specific heat capacity of $4.19 \text{ J/(g}\cdot^\circ\text{C)}$, and that the calorimeter itself absorbs no heat. Calculate the molar enthalpy of neutralization, in kJ/mol. (Outcome)

6. Given the following thermochemical equations:



Use Hess' law to determine ΔH_f° for the reaction $\text{C(s)} + \frac{1}{2} \text{O}_2\text{(g)} \rightarrow \text{CO(g)}$.

- A) -676.5 kJ
- B) -110.5 kJ
- C) 110.5 kJ
- D) -283.0 kJ

(Outcome)

7. Using standard enthalpies of formation, ΔH_f° , $\Delta H_f^\circ(\text{CO}_2\text{(g)}) = -393.5 \text{ kJ/mol}$, $\Delta H_f^\circ(\text{H}_2\text{O(l)}) = -285.8 \text{ kJ/mol}$, $\Delta H_f^\circ(\text{CH}_4\text{(g)}) = -74.6 \text{ kJ/mol}$, and $\Delta H_f^\circ(\text{O}_2\text{(g)}) = 0 \text{ kJ/mol}$, calculate ΔH_r° for the combustion of methane: $\text{CH}_4\text{(g)} + 2\text{O}_2\text{(g)} \rightarrow \text{CO}_2\text{(g)} + 2\text{H}_2\text{O(l)}$

Show your calculation and express your answer in kJ/mol. ([Outcome](#))

8. True or false: A balanced thermochemical equation must specify the physical state of every substance and must include either a ΔH or an energy term, because the enthalpy change of a reaction depends on the physical states of the reactants and products. ([Outcome](#))

Curriculum coverage

Question	Outcome alias
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Answer key

1. $Q = mc\Delta T$. The temperature change is $35.5^\circ\text{C} - 20.0^\circ\text{C} = 15.5^\circ\text{C}$, applied directly in the $Q = mc\Delta T$ formula.

2. B. Photosynthesis requires a continuous input of light energy to proceed, which is the defining feature of an endothermic process.

3. Enthalpy is the heat content of a system at constant pressure, and molar enthalpy is the enthalpy change per mole of a specified substance in a reaction. Molar enthalpy = $1780 \text{ kJ} \div 4.00 \text{ mol} = 445 \text{ kJ/mol}$; since combustion is exothermic, the value is reported as -445 kJ/mol .

4. True. This sign convention reflects that an exothermic reaction loses enthalpy to the surroundings (negative ΔH), while an endothermic reaction gains enthalpy from the surroundings (positive ΔH).

5. $Q = mc\Delta T$. Moles of limiting reagent = $0.0500 \text{ L} \times 1.00 \text{ mol/L} = 0.0500 \text{ mol}$. Molar enthalpy = $-2.85 \text{ kJ} \div 0.0500 \text{ mol} = -57.0 \text{ kJ/mol}$; the value is negative because the temperature rise shows the reaction released heat.

6. B. Subtracting the second equation from the first by Hess' law gives $\Delta H = -285 \text{ kJ}$.

7. $\Delta H = 3 \Delta H_f^\circ(\text{CO}_2) + 2 \Delta H_f^\circ(\text{H}_2\text{O}) - [\Delta H_f^\circ(\text{CH}_4) + 2 \Delta H_f^\circ(\text{O}_2)]$. The products' total formation enthalpy is subtracted from the reactants' according to Hess' law using standard enthalpies of formation.

8. True. Physical state affects the amount of energy absorbed or released, so both state symbols and the ΔH or energy term are required for the equation to communicate the enthalpy change accurately.