Heat Lab Worksheet

Thermochemistry: heat, enthalpy, and calorimetry · Logical Home Schooling

Name: _____ **Date:** _____ **Period:** _____

In this lab you will use Heat Lab to classify processes as exothermic or endothermic, connect ΔH to bond energies, compare specific heats, use a calorimeter to identify a metal and measure a heat of reaction, and calculate ΔH with Hess's Law and enthalpies of formation.

Link: www.logicalhomeschooling.com/heat-lab.html

Objectives

By the end of this lab you will be able to:

- Classify processes as exothermic or endothermic and give the sign of ΔH.
- Explain ΔH in terms of energy absorbed breaking bonds and released forming bonds.
- Use q = mcΔT with specific heat and calorimetry data.
- Calculate ΔH using Hess's Law and standard enthalpies of formation.

Materials: a computer or tablet with Heat Lab open, a calculator, a pencil, this worksheet. Time: about 60 minutes.

Key equations. $q = m \cdot c \cdot \Delta T$ · $\Delta T = T_{final} - T_{initial}$ · $q_{lost} = -q_{gained}$ · ΔH = (bonds broken) – (bonds formed) · $\Delta H°rxn = \Sigma \Delta H°f(\text{products}) - \Sigma \Delta H°f(\text{reactants})$. **Exothermic:** $\Delta H < 0$. **Endothermic:** $\Delta H > 0$. c(water) = 4.18 J/g·°C.

Part 1: Pre-lab

1. Define *system* and *surroundings* in your own words.

2. When you hold an ice cube, your hand feels cold. Which way is heat flowing?

Part 2: Stage 1, Exothermic or endothermic

Process	Surroundings: T start → T end	Heat in or out of system?	Exo or endo?	Sign of ΔH
Hand warmer				
Cold pack				
Gas stove (methane burning)				
Ice melting in your hand				
Baking soda + vinegar				

Bonds and ΔH: $CH_4 + 2\ O_2 \rightarrow CO_2 + 2\ H_2O$

Step	Bonds	Energy (kJ)	Absorbed or released?
Break reactant bonds	4 C–H, 2 O=O		
Form product bonds	2 C=O, 4 O–H		
ΔH (show work)			

3. Use your answer to explain why burning methane releases energy.

Part 3: Stage 2, Specific heat

Each sample: 100 g, starting at 20.0 °C, receives 4000 J.

Sample	Specific heat (J/g·°C)	Final temperature (°C)	ΔT (°C)
Water			
Sand			
Aluminum			
Iron			

1. What is the relationship between specific heat and temperature change, for the same heat and mass?

2. Show the calculation of ΔT for iron using $\Delta T = q \div (m \cdot c)$.

3. How much heat warms 250 g of water from 20 °C to 80 °C? Show your work.

4. Explain why the sand on a beach gets much hotter than the ocean during the day.

Part 4: Stage 3, Calorimetry

Identify a metal. 50.0 g of metal at 100.0 °C is dropped into 100.0 g of water at 20.0 °C.

Quantity	Value and work
Final temperature	
q gained by the water (J)	
ΔT of the metal (°C)	
Specific heat of the metal (J/g·°C)	
Identity of the metal	

Heat of neutralization. 50.0 mL of 1.00 M HCl + 50.0 mL of 1.00 M NaOH, both at 21.0 °C. Mass of solution = 100.0 g.

Quantity	Value and work
Highest temperature	
q absorbed by the solution (J)	
Moles of water formed	
ΔH per mole of water (kJ/mol, with sign)	

Sketch the temperature vs. time graph for the neutralization.

1. Why is the ΔH negative even though the solution's temperature went up?

2. Why are foam cups used instead of a metal can? How would heat loss affect your ΔH value?

Part 5: Stage 4, Hess's Law (challenge)

Target: $C(s) + 2\ H_2(g) \rightarrow CH_4(g)$

Known reaction	ΔH (kJ)	Flip? Multiply?	Adjusted ΔH
1. $C(s) + O_2(g) \rightarrow CO_2(g)$	–393.5		
2. $H_2(g) + ½\ O_2(g) \rightarrow H_2O(l)$	–285.8		
3. $CH_4(g) + 2\ O_2(g) \rightarrow CO_2(g) + 2\ H_2O(l)$	–890.3		
Target ΔH			

Enthalpies of formation: $CH_4(g) + 2\ O_2(g) \rightarrow CO_2(g) + 2\ H_2O(l)$

ΔH°f of $O_2(g)$	ΣΔH°f products	ΣΔH°f reactants	ΔH°rxn

1. Why does flipping a reaction change the sign of its ΔH?

Part 6: Practice problems

Answer these **without** Heat Lab. Show your work and units.

1. How much heat is needed to raise 500 g of water from 15 °C to 100 °C? Give the answer in kJ.

2. A 25.0 g piece of aluminum absorbs 450 J. By how much does its temperature rise? ($c = 0.897$ J/g·°C)

3. 2.00 g of a snack is burned under 200.0 g of water, which warms from 22.0 °C to 47.5 °C. How many joules per gram did the snack release?

4. Given $2\ H_2(g) + O_2(g) \rightarrow 2\ H_2O(l)$, ΔH = –571.6 kJ, find ΔH for $2\ H_2O(l) \rightarrow 2\ H_2(g) + O_2(g)$, and for $H_2(g) + ½\ O_2(g) \rightarrow H_2O(l)$.

5. Use ΔH°f values (CO_2 –393.5, $H_2O(l)$ –285.8, $C_2H_5OH(l)$ –277.7 kJ/mol) to find ΔH for $C_2H_5OH(l) + 3\ O_2(g) \rightarrow 2\ CO_2(g) + 3\ H_2O(l)$.

Conclusion

Write 3 to 5 sentences explaining how chemists measure and calculate the heat of a reaction. Use the words **exothermic**, **endothermic**, **specific heat**, **calorimeter**, and **Hess's Law**.