Lesson 153: ANSWERS

Table I.

	Ag	Water
Mass	20.0 g	50.0 g
Initial Temperature	200°C	20.0°C
Final Temperature	23.96°C	23.96°C
Change in Temperature	176.04°C	3.96°C
Heat Content	0.235	4.184

Record your observations as you run the experiment.

The metal is added to the water and the lid on the calorimeter closes. The temperature of the water begins to rise. Since the metal is ten times hotter than the water, this makes sense.

Data Analysis and Interpretation

1. Which substance (Ag or water) loses heat when they are combined? Which substance gains heat when they are combined? Which process is endothermic and which is exothermic?

The silver loses heat and the water gains heat. The heat lost by the silver is exothermic. The heat gained by the water is endothermic.

2. Calculate the heat transferred to or from Ag. Use the equation $q = mC_s\Delta t$ (q is heat in Joules, m is mass, C_s is the heat content, and Δt is the change in temperature).

$q = 20.0 \text{ grams} \times 0.235 \frac{J}{g\,^\circ C} \times (23.96^\circ C - 200^\circ C) = -8.27 \times 10^2 \text{ Joules}$

3. Calculate the heat transferred to or from water ($q = mC_s\Delta t$).

$q = 50.0 \text{ grams} \times 4.184 \frac{J}{g\,°C} \times (23.96°C - 20°C) = 8.28 \times 10^2$ Joules

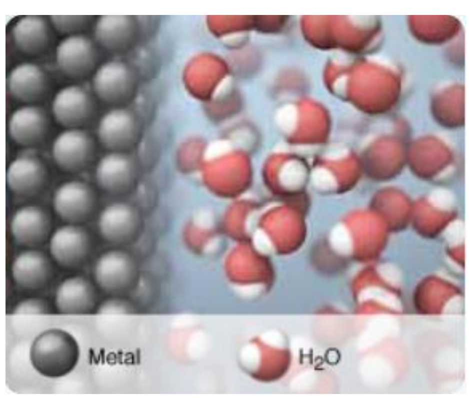
4. Compare the heats associated with the Ag and water. Make a generalization concerning these heats.

The amount of heat lost by the metal and gained by the water is essentially the same value (they differ by 0.01)

5. How would your results have been different if you had used different amounts of Ag and water starting at different temperatures? Try this out by doing new experiments and record your data and conclusions below.

Answers will vary depending on what metals and temperatures are selected.

6. Draw a picture of the microscopic view of a piece of solid silver metal in liquid water.



7. Describe how heat was transferred between the two substances. What did you observe happening during the period just after the silver and water were added to each other? How about when the final temperature was reached? How does this help explain how heat is transferred?

Energy is transferred from the hot metal atoms to the cool water molecules when they collide. Then the water molecule with additional energy collides with another water molecule and transfers energy. This continues to happen as water molecules collide with metal atoms and then with other water molecules. The metal atoms lose energy and the water molecules gain energy until everything is at the same energy.

	Al	Water	Cu	Water	Fe	Water
m	20.0	50.0	20.0	50.0	20.0	50.0
t_i	200°C	20°C	200°C	20°C	200°C	20°C
t_f	34.30°C	34.30°C	26.39°C	26.39°C	27.41°C	27.41°C
Δt	165.70°C	14.30°C	173.61°C	6.39°C	172.59°C	7.41°C
C_s	0.90	4.184	0.385	4.184	0.452	4.184
q	-2.98×10^3	2.99×10^3	-1.34×10^3	1.34×10^3	-1.56×10^3	1.55×10^3
molar heat capacity	24.3		20.0		20.0	

Data Analysis and Interpretation

8. Calculate the heat lost or gained by each metal. Show your work for one of the calculations.

In each system the metal lost heat to the water. Here's the calculation for the Al:

$20.0\text{g} \times 0.90\ \text{J}^{\text{g}-1}\text{°C}^{-1} \times (34.30\text{°C} - 200\text{°C}) = -2.98 \times 10^3$ Joules

9. Compare the results for all four metals. How are they different?

Each metal has a different specific heat. The higher that is, the more hat is transferred to the water and the higher the final temperature.

10. Which metal would make the best cookware? Why?

Aluminum – it underwent the smallest temperature change when heated.

11. Calculate the molar heat capacity for Al, Cu, and Fe in units of $\frac{J}{mol\ {}^{\circ}C}$. Record the value on Table II.

Al: $0.90\ \frac{J}{g\ {}^{\circ}C} \times 26.98\ \frac{g}{mol} = 24.3\ \frac{J}{mol\ {}^{\circ}C}$

Cu: $0.385\ \frac{J}{g\ {}^{\circ}C} \times 63.55\ \frac{g}{mol} = 24.5\ \frac{J}{mol\ {}^{\circ}C}$

Fe: $0.452\ \frac{J}{g\ {}^{\circ}C} \times 55.85\ \frac{g}{mol} = 25.2\ \frac{J}{mol\ {}^{\circ}C}$

	Unknown I	Water	Unknown II	Water
m	20.0	50.0	20.0	50.0
t_i	200°C	20°C	200°C	20°C
t_f	26.44°C	26.44°C	22.18°C	22.18°C
Δt	173.56°C	6.44°C	178.82°C	2.18°C

12. Calculate values for the specific heats for the two unknown metals.

Unknown I

(m x Cs x Δt) -(50 x 4.184 $\frac{J}{g\ ^\circ C}$ x (26.44°C -20.0°C) = -1.35 x 10^3 Joules

$$C_s = \frac{q}{\text{mass}\ \Delta T} = \frac{-1.35 \times 10^3\ \text{Joules}}{20.0 \cdot 173.56\ ^\circ C} = 0.388\ \frac{J}{g\ ^\circ C}$$

Unknown II

(m x Cs x Δt) -(50 x 4.184 $\frac{J}{g\ ^\circ C}$ x (22.18°C -20.0°C) = -4.56 x 10^2 Joules

$$C_s = \frac{q}{\text{mass}\ \Delta T} = \frac{-4.56 \times 10^2\ \text{Joules}}{20.0 \cdot 178.82\ ^\circ C} = 0.128\ \frac{J}{g\ ^\circ C}$$

13. Based on the values in question 11, estimate the molar heat capacity for each unknown metal.

If we average the molar heat capacities of aluminum, copper, and iron, we get

25.0 $\frac{J}{mol\ ^\circ C}$

14. Calculate the molar mass of each unknown metal.

Unknown I: 0.388 $\frac{J}{g\ ^\circ C}$ x MM = 25.0 $\frac{J}{mol\ ^\circ C}$; MM = 64.4 $\frac{g}{mol}$

Unknown II: 0.128 $\frac{J}{g\ ^\circ C}$ x MM = 25.0 $\frac{J}{mol\ ^\circ C}$; MM = 195 $\frac{g}{mol}$

15. Assuming the unknown metals are pure substances, identify them.

Unknown I could be copper or zinc. Unknown II could be platinum or gold.