**Virtual Calorimetry Activity - Key**

**Heat Transfer between a Metal and Water**

**Purpose:**

The purpose of this activity is to perform a calorimetry experiment and analyze the transfer of heat from one substance to another. The heat transfer will be quantified using Q = CmT.

**Directions:**

The website with the calorimeter simulation is from Iowa State University. Go to the following website: <http://group.chem.iastate.edu/Greenbowe/sections/projectfolder/flashfiles/thermochem/heat_metal.html> For all calculations, show work and circle your final answers!

**Problem 1**

1. Set the following parameters:
   * Metal = iron
   * Mass = 75 g
   * Temperature = 202 oC
   * Water mass = 50 g
   * Water temp = 25.4 oC
2. Record the specific heat of iron and water from the screen –

**Iron \_\_\_\_0.452 J/gK\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ Water \_\_\_4.18 J/gK\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_**

1. Click the “Start” button. A temperature v. time graph will open and a digital thermometer will display the temperature. What happens to the temperature of the water when the metal is first immersed? What happens to the temperature at the end of the experiment?

**The temperature of the water rises quickly when the metal is first immersed. At the end of the experiment, the temperature levels off.**

1. Record the final temperature of the water.

Final temperature of water **\_\_\_\_\_50.0\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_**

1. What is the final temperature of the iron metal? **\_\_\_\_50.0\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_**
2. Calculate the heat lost by the iron with Q = CmT.

**Q = (0.452 J/gK)(75.00 g)(50.0 – 202.0 oC)** *\*Note the K and oC will not cancel but*

**Q = -5152.8 J** *the T is the same value in both K and oC scales.*

1. Calculate the heat gained by the water with Q = CmT.

**Q = (4.18 J/gK)(50.00 g)(50.0 – 25.40 oC)**

**Q = 5141.4 J**

1. Compare the values you calculated from #5 and #6. Explain how this demonstrates the law of conservation of energy.

**The values are very similar except the metal value is negative and water is positive. Ideally they would be identical. This demonstrates the law of conservation of energy by showing all the heat lost by one object is gained by another object in a closed system.**

1. How long will heat transfer from the hot metal object to the cooler water? (Hint: look at the graph)

**Heat will transfer until the temperature levels off. This happens when the temperature of the two objects is the same. Heat will always flow from a warmer object to a cooler object as long as there is a temperature difference.**

1. Complete the following tables and calculations using the website. Show all work!

**Answers will vary. This key has example calculations. Students may simply put the same value for heat change of metal and heat change of water because of Qlost = Qgained. The differences here are mostly from the final temperature being rounded.**

|  |  |  |
| --- | --- | --- |
|  | **Problem 2** | **Problem 3** |
| Identity of Metal | Gold | Copper |
| Metal Mass (g) | 56.00 | 29.00 |
| Metal Initial Temperature (oC) | 156.0 | 20.00 |
| Water Mass (g) | 85.00 | 155.00 |
| Water Initial Temperature (oC) | 31.80 | 40.00 |
| Water Final Temperature (oC) | 34.2 | 39.6 |
| Metal Final Temperature (oC) | 34.2 | 39.6 |
| Heat change of Metal | *Use Q = CmT*  *873 J* | *Use Q = CmT*  *219 J* |
| Heat change of Water | *Use Q = CmT*  *853 J* | *Use Q = CmT*  *259 J* |

1. Challenge Problem: Metal X has a mass of 58.0 g and an initial temperature of 192.00 oC. The metal is immersed in a calorimeter with 65.00 g of water at 22.60 oC. The specific heat of water is 4.18 J/g oC. Run the simulation to find the final temperature. Calculate 1) the amount of heat gained by the water and 2) the specific heat of the metal. Which metal could this be?

**The simulation will give a final temperature of 39.2 degrees. The hundredths place varies and was dropped.**

1. **Heat gained by water**

**Qgained = CmT**

**Q= (4.18 J/g oC)(65.00g)(39.2 – 22.60 oC)**

**Q = 4510.22 J**

1. **The heat gained by the water equals the heat lost by the metal. Based on this,**

**4510.22 J = -(C)(58.0g)(39.2 – 192.00 oC)**

**C = 0.509 J/g oC**

**The NCDPI chemistry reference tables indicate this metal could be titanium (0.555 J/g oC).**

1. Mastery Problem: *Do not use the simulation for this problem.*

Metal Y has a specific heat of 0.291 J/gK. If a 45.0 g sample of this metal is placed in 105 g of water in a calorimeter. The initial temperature of the metal is 203 oC and the initial temperature of the water is 29.1 oC. What is the final temperature of the system?

**-Qlost = Qgained**

**-(0.291 J/g oC)(45.0g)(x – 203oC) = (4.18 J/g oC)(105g)(x – 29.1 oC)**

**(451.995 J/oC)x = 15430.275 J**

**X = 34.1 oC**

1. Using the data you have collected, describe the direction of heat flow in a closed system.

**Heat flow in a closed system is from the warmer object to the cooler object. Heat flows as long as there is a difference in temperature between two objects.**

1. Analyze the direction of heat flow in the calorimeter using the terms *exothermic* and *endothermic*.

**The warmer object loses heat to its surroundings, which is an exothermic process. The cooler object in the system gains heat from the warmer object, which is an endothermic process. The amount of heat lost by the warmer object is equal to the amount of heat gained by the cooler object in a closed system.**