South Pasadena • AP Chemistry
Name_____________________________
Period __ Date __/__/__

6 • Energy and Chemical Reactions

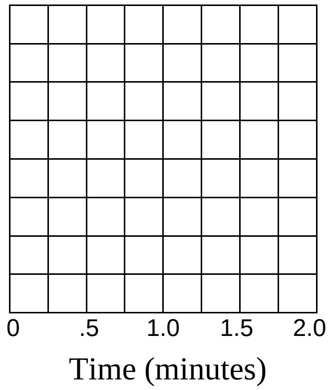
UNITS AND CALORIMETRY

If we mix hot and cold water, it is not surprising that the mixture will have a medium temperature. We can explain this temperature in terms of heat gained and heat lost. Measuring this heat (formerly measured in calories) is called **calorimetry**. The equation we use is $q = m \cdot C \cdot \Delta T$.

1. One tricky part of actually making these measurements is the fact that you cannot accurately measure the temperature of a mixture at the **instant** of mixing. We utilize a **graphical technique**. A 35.0-mL sample of water at 95.0°C and mixed with 150. mL of water at 15.0°C in an insulated cup and the temperature is recorded after 30 seconds and every 30 seconds as shown. Plot the data, use a ruler to draw a straight line that best fits the data, and determine the theoretical temperature of liquids when they were mixed (time = 0.00 minutes). Use this temperature for the "final temperature" as you calculate ΔT in questions 2(a) and 2(b) below. (Label the vertical axis as 26 – 30 °C… two lines per degree.)

DATA:

Time (minutes)	**Temperature (°C)**
0.00	
0.50	28.3
1.0	27.6
1.5	26.8
2.0	26.0



2. a. Calculate the energy gained (Δq) by the cold water ($\Delta q_{cold} = m_{cold} C \Delta T_{cold}$) [$C = 4.184\ J \cdot g^{-1} \cdot {}^\circ C^{-1}$]

   b. Calculate the energy lost (Δq) by the hot water ($\Delta q_{hot} = m_{hot} C \Delta T_{hot}$)

3. Another feature of actual heat measurements is that the heat gained by the cold water does not exactly match the heat lost by the hot water. Calculate the absolute difference between the energy lost by the hot water (Δq_{hot}) and the energy gained by the cold water (Δq_{cold}). _______________

4. Where did this energy go?

5. We can use our data to calculate the **calorimeter constant** in $J \cdot {}^\circ C^{-1}$ by dividing the absolute difference in energy by the temperature change (ΔT_{hot}) of the hot water. This would be a **correction factor** in lab.

$$\text{calorimeter constant} = \frac{|\Delta q_{hot} - \Delta q_{cold}|}{\Delta T_{hot}} =$$

6. Let's try a standard **calorimetry** problem.
A pot of water (2.5 Liters of water) initially at 25.0°C is heated to boiling. How much energy (in kJ) is needed to heat the water?

7. We don't always have to use water. Let's measure the **specific heat capacity** of **aluminum shot**.

"shot" are these little pellets.

DATA:

mass of dry insulated cup: _______________

mass of cup with cold water: _______________

initial temperature of water: _______________

initial temperature of Al shot: _______________

mass of cup + hot Al shot: _______________

final temperature reached: _______________

Calculate the heat gained by the cold water, q_{water}. (show work):

Assume that all of the heat lost by the Al went into the cold water to warm it up (i,e,, $q_{water} = -q_{Al}$).
Calculate the specific heat capacity of the Al, C_{Al}. Remember: $q_{Al} = m_{Al} \cdot C_{Al} \cdot \Delta T_{Al}$ (show work)
The accepted value is 0.900 $J \cdot g^{-1} \cdot {}^\circ C^{-1}$ Note: this also reported as $J \cdot g^{-1} \cdot K^{-1}$… ΔT in °C or K is the same.

8. **Somewhat Confusing Definitions:**
There are several terms used in this chapter that sound very similar. Use the data provided to calculate each of them to clarify the differences. I've added some "Notes" that I hope will help.
74.8 J of heat is required to raise the temperature of 18.69 g of silver from 10.0°C to 27.0°C.

a. What is the **heat capacity** of the silver sample? (J/°C)
Note: This is a useful value only for this specific sample of silver. This is the number you would measure in a lab for a calorimeter as we did in question 5. The calorimeter constant would be the heat capacity of the calorimeter.

b. What is the **specific heat capacity** of silver? (J/g·°C)
Note: This is a useful value for any sample of silver that is changing temperature. This is equivalent to the 4.184 $J \cdot g^{-1} \cdot {}^\circ C^{-1}$ that we use for water. This value is also called the **specific heat**.

c. What is the **molar heat capacity** of silver? (J/mol·°C)
Note: This value is closely related to specific heat capacity. ***We never see this one again.*** It is important only to make the point that many metals have **different** specific heat capacities, but they have similar **molar** heat capacities… this is the Law of Dulong and Petit… (not part of the AP curriculum).