1. Poor Pluto. One day you're the ninth planet. The next day you're the first dwarf planet. To help Pluto with obvious problems of self esteem, we have invented a temperature scale in Pluto's honor. The average temperature on the surface of Pluto is about 34 degrees Kelvin or \(-239^\circ C\) (remember that absolute zero is 0 degrees Kelvin and \(-273^\circ C\)). In the new Pluto temperature scale, zero degrees Kelvin is also zero degrees P, and 34 degrees Kelvin is 1 degree P.
   a. Liquid nitrogen boils at about \(-200^\circ C\). What is that in degrees Pluto? (You may round off to the nearest degree Pluto.)
   b. Dry ice keeps things at a chilly temperature of \(-92^\circ F\). What is that in degrees Pluto? (Round off to the nearest degree P.)
   c. Saturn is always picking on Pluto, pointing out that the atmosphere of Saturn is a balmy 4 degrees Pluto. (This isn't fair since the atmosphere of Saturn is pretty complex, but in places it is a balmy 4 degrees Pluto.) What is that in degrees Celsius? Degrees Fahrenheit?
   d. Water freezes at what temperature Pluto?
   e. Water boils at what temperature Pluto?

2. 20.0 grams of water at a temperature of \(75^\circ C\) are placed in contact with 30.0 grams of water at a temperature of \(25^\circ C\). The system is well insulated so heat cannot escape to the surrounding air, containers, or college students.
   a. When 100 calories have been lost by the hot water...
      i. How much heat is absorbed by the cool water?
      ii. How many calories are lost by each gram of the hot water?
      iii. What is the temperature change of the hot water?
      iv. What is the temperature of the hot water after 100 calories have been transferred?
      v. What is the temperature of the cool water after 100 calories have been transferred?
   b. Okay so let's say a total of 300 calories have been transferred from the \(75^\circ C\) water to the \(25^\circ C\) water.
      i. Now what's the temperature of the warmer water?
      ii. Now what's the temperature of the cooler water?
   c. Not happy yet? Let's say a total of 600 calories have been transferred from the \(75^\circ C\) water to the \(25^\circ C\) water.
      i. Now what's the temperature of the warmer water?
      ii. Now what's the temperature of the cooler water?
   d. If we mix the two samples together, what will be the final temperature?

3. A 100 gram sample of the rock known as basalt is heated to a temperature of \(85^\circ C\) and immersed in 100 grams of water which has a temperature of \(25^\circ C\). The two are swirled together until an equilibrium temperature is reached. Again, he system is well insulated so heat cannot escape to the surrounding air, containers, or college students.
a. Keith predicts that the final temperature of the system will be 55°C since the water has the same mass as the rock and that temperature is exactly halfway between the temperature of the water and the rock. Based on what you have seen in class, do you agree or disagree? What would you predict about the final temperature? Why?
b. Well, Keith wasn't even close. The final temperature turned out to be only 35°C (how was your prediction?). So as the water increased in temperature from 25°C to 35°C, how much heat was absorbed by the water?
c. Your answer to part b actually depends on your knowledge of the specific heat of water. What is the specific heat of water? (Units are important.)
d. As the basalt cooled from 85°C to 35°C, how much heat was released by the basalt? (Think carefully, but you shouldn't have to do any calculating.)
e. How much heat was released by each gram of the basalt?
f. What was the temperature change of the basalt?
g. Based on this experiment, what is the specific heat of basalt?

4. Why is ice cold? Most people would think this is a silly question, but you should know enough about heat and temperature to realize that the answer is actually a little complicated and involved some important principles of thermodynamics. If you take some ice out of the freezer, put it where the temperature is something like 20 degrees Celsius above freezing, the ice stays cold and it makes the air around it cold. Why? What's going on here?

5. The heat of vaporization of water is 540 calories per gram and you should know the specific heat of water by now. Imagine that we take 15.0 grams of liquid water at a temperature of 80°C, put it in a well insulated container, and slowly add 3000 calories of heat.
   a. What happens as the first 300 calories go into the water? What will we have after those 300 calories have been absorbed?
   b. As the next 100 or so calories go into the water, does the temperature continue to rise? Why or why not?
   c. You've established what happens as the first 300 calories are absorbed. What happens as the next 2700 calories are absorbed? What does this heat do to the water?
   d. The heat of vaporization of water is 540 calories per gram. How much liquid water will we have after the last bit of that 2700 calories have been absorbed? (In other words, what will we have after all 3000 calories have been absorbed by the 15 grams of water?)

By the way, all of thermodynamics is also "just a theory." Thermodynamics has been around for about 150 years and at least for objects of the size that we can see, we've never found a problem with it. Still, it is rightfully called the theory of thermodynamics.