Physics 123 section 2 CID ___________

Homework 4

Score ________ / 30

1. (4 pts) Your water heater is broken, so you plan to heat your bath water by hoisting buckets of water up really high, and then tipping the buckets so that the water falls down into the bathtub, converting the water's potential energy into heat. If you want to increase the temperature of the water by 15 °C, how high will you have to lift the buckets?

2. (5 pts) Imagine an ideal aluminum calorimeter with a mass of 150 g (i.e. an aluminum cup with a mass of 150 g which is thermally isolated from the rest of the world). The calorimeter contains 200 g of water in thermal equilibrium with the calorimeter at a temperature of 25 °C. I then heat an 80 g piece of an unknown metal to a temperature of 100 °C and then drop it into the calorimeter. The system comes into thermal equilibrium at a temperature of 27.32 °C. (a) What is the specific heat of the metal? (b) From the table in your book, determine what the metal is.

3. (5 pts) An aluminum calorimeter with a mass of 125 g contains 200 g of water at 25 °C. I then drop in a 150 g cube of ice at -12 °C. (a) How much ice will be left when the system reaches thermal equilibrium, and (b) what will the temperature of the system when it reaches equilibrium.

4. (5 pts) An aluminum calorimeter with a mass of 125 g contains 200 g of water at 25 °C. I then drop in a 150 g cube of ice at -72 °C. (a) How much ice will be left when the system reaches thermal equilibrium, and (b) what will the temperature of the system when it reaches equilibrium.

5. (4 pts) A 20 kg iron shell from a tank goes off course and lands in a frozen lake. If the shell is moving at 400 m/s and is at a temperature of 35 °C when it hits the 0 °C ice, how much ice will melt?

6. (7 pts) The following may or may not work out well, depending on your microwave, etc. If it does work, you will get a wonderful feeling of awe for the power of physics. If it doesn't, its still a good exercise and it will help you understand the frustrations of an experimental physicist. As long as you do the calculations correctly, the grader will be sympathetic if your experimental results aren't so good.

Get a microwave, a watch, a pencil, a microwave safe container, a measuring cup, water, and several pieces of ice. If you don't have a measuring cup, use the conversion factors on the next page and use a drinking cup as a measuring cup. Note that if you don't have a microwave there are microwaves in the Wilkinson center and on the overlook above the Pendulum Court in the ESC. If you don't have ice, you could probably get some from the drink machines in the Wilkinson center.

Put some ice into the microwave safe container and the measuring cup, and then fill them with water. Stir the water with the pencil for several minutes until the water and ice are in equilibrium (if all of the ice melts, add more). Since ice melts at 0 degrees Celsius, and water freezes at 0 degrees Celsius, we know that water and ice in equilibrium will be at zero degrees. Now remove the ice from the measuring cup, and pour water from the microwave safe container into the measuring cup until you reach the desired volume of water (you choose the volume, but I would suggest something near 1 cup). Pour out the remainder of the water in the microwave safe container. You now have a known volume of water at a temperature of about 0 degrees Celsius. Quickly pour this water in the microwave safe container and put it into the microwave on high. With your watch measure the time it takes for the water to boil (when the water starts to boil, it is at 100 degrees Celsius).

(a) Derive a symbolic expression for the heating power of the microwave, P, in terms of the volume V and density ρ of water, the temperature change ΔT, the time to make this temperature change t, and the specific heat of water c.

(b) Plug in the numbers and determine the heating power of your microwave (in Watts).

(c) Derive a symbolic expression for the time required to melt a piece of ice with volume V, density ρ, and latent heat L in a microwave with heating power P.

(d) Measure as best as you can the volume of an ice cube, then put it into the container. Now nuke it in the microwave on high and measure how long it takes to melt the ice cube.

(e) Given the measured volume of your ice cube and the measured heating power, what time does the expression you derived in part (c) predict.

The density of water is $1000\,\mathrm{kg/m^3}$. The density of ice is $971\,\mathrm{kg/m^3}$. The specific heat of water is $4186\,\mathrm{J/kg{\cdot}^\circ C}$. The latent heat of fusion for water is $3.33\times10^5\,\mathrm{J/kg}$.

Conversion Factors 1 liter $= 10^{-3}\,\mathrm{m}^3$, 1 cup $=$ .240 liter, 1 fluid oz $=$ 0.0296 liters, 1 pint $=$ 16 fluid oz, 1 quart $=$ 32 fluid oz

Extra problems I recommend you work (not to be turned in)

- Most electrical outlets in newer homes can deliver a maximum power of about 1800 Watts. Using this much power, how long would it take to heat up a bathtub containing $0.4\,\mathrm{m}^3$ of water from $25\,^\circ\mathrm{C}$ to $35\,^\circ\mathrm{C}$?
- If I have an insulated container of negligible mass which contains 200 g of water at $25\,^\circ\mathrm{C}$, how much ice at a temperature of $-10\,^\circ\mathrm{C}$ would I have to add such that when the system reached thermal equilibrium I would actually end up with more ice in the cup than the amount that I added?