Heating Unit Project: Starting Points and Foundation Concepts

Quantity	Symbol	Unit	Meaning
heat	*Q*	joule (J)	Energy transfer that produces or results from a difference in temperature
temperature	*T*	ºC or K	Measure of the kinetic energy of molecular motion
temperature change	Δ*T*	ºC or K	Difference between the final and initial temperatures for a process
heat capacity	*C*	J $^{o}C^{-1}$ or J K^{-1}	Heat required to change the temperature of a substance one degree

heat flux   q   W (J/sec)   Rate of heat transfer (Q/time)

Thermal Conductivity

Thermal conductivity, k, is the property of a material that indicates its ability to conduct heat. Thermal conductivity is measured in watts per kelvin per meter ($W \cdot K^{-1} \cdot m^{-1}$). Multiplied by a temperature difference (in kelvins, K) and an area (in square meters, m^2), and divided by a thickness (in meters, m) the thermal conductivity predicts the heat that can be transferred (in watts, W) through a piece of material.

Heat Transfer Sign Conventions:

Exothermic: -   (heat leaving system)

Endothermic: + (heat entering system)

Types of Heat Transfer

Conduction is the transfer of heat between substances that are in direct contact with each other. The better the conductor, the more rapidly heat will be transferred. Conduction occurs when a substance is heated, particles will gain more energy, and vibrate more. These molecules then bump into nearby particles and transfer some of their energy to them. This then continues and passes the energy from the hot end down to the colder end of the substance. The heat transferred depends upon the thermal conductivity (C_p) and the temperature difference.

$$q = Q/t = C_p \Delta T$$

Convection is the way heat is transferred from one area to another when there is a "bulk movement of matter." It is the movement of of material, taking the heat from one area and placing it in another. The heat transfer coefficient,) depends on the particular situation. The units are $W/(m^2 \bullet K)$. The heat transferred depends upon the heat transfer coefficient, the area of contact and the temperature difference

$$q = Q/t = h\, A\, \Delta T$$

1. Make a drawing of your understanding of the project and compare with the one below:

How is this problem the same? How is my problem different?

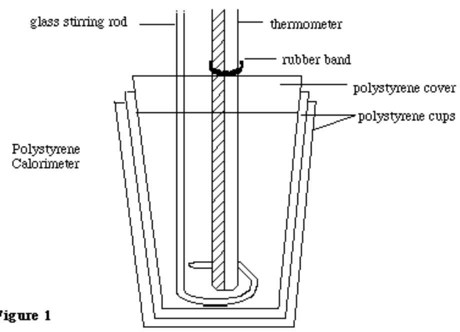
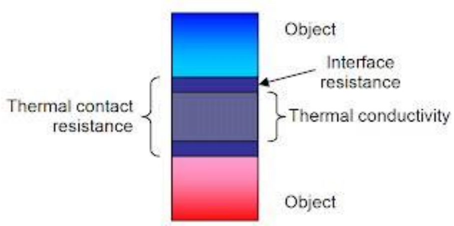
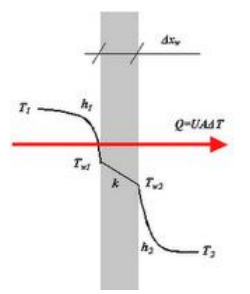


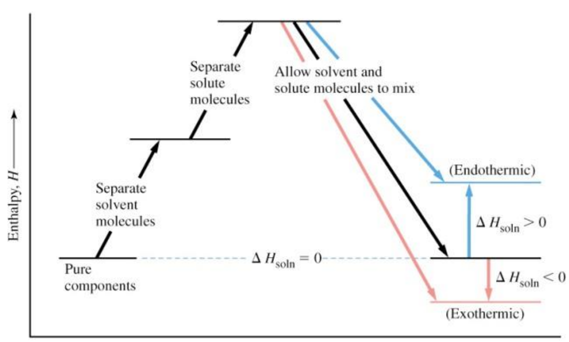
Figure 1

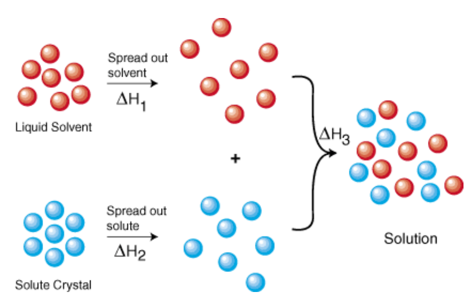
2. What physical conditions are required for heat to flow? $\Delta T = T_{outside} - T_{inside}$





3. What is happening on the molecular level?
   (heat energy is required to break bonds)





4. Are all materials equivalent for heat flow? $q = k (T_{outside}-T_{inside})$ (thickness) = $k\Delta T$ t

k is thermal conductivity W/m ^oK. The value of k depends upon the specific material

Other units for k that are encountered:[W/(cm^2 ^oC/cm), kJ/(h m^2 K/m), J/(s m^2 ^oC/m),kcal/(h m^2 ^oC/m),cal/(s cm^2 ^oC/cm)]

Thermal Conductivities of Selected Materials, W/m.K (values at 20°C, unless otherwise stated)					
Good Conductors		*Average conductors*		*Poor conductors (good insulators)*	
Diamond	2,000	Ice (0°C)	2.20	Brick, insulating	0.150
Silver	429	Concrete	1.70	Asbestos	0.090
Copper	400	Soil	1.50	Fiberglass	0.040
Aluminum	220	Glass	1.00	Glass wool	0.040
Iron	80	Water	0.60	Styrofoam	0.033
Lead	35	Epoxy	0.59	Air (dry)	0.026
Stainless steel	14	Body fat	0.20	Silica aerogel	0.004
Granite	3	Snow	0.16	Vacuum	0

5. Identify examples of both convective and conductive heat transfer in the room. Which method (conductive or convective) can be influence by outside conditions.

What is the effect of agitation on the transfer of heat (a) in the solution and (b) through the container walls.

In this project, when is convective heat transfer to your benefit? When is the effect negative? How will this affect your design>

Heating Principles Self-Evaluation **(Revised 2/27/13)**

Complete this assignment without referring to any notes, references, or class materials.

Quantitative (Show all steps in the calculations, including set-up, units, and significant figures.)

Complete the problems on the review sheet and laboratory sheet

Compare the conductive heat flow rates through 1 cm thickness of glass and 1 cm thickness of steel at a temperature difference of 30^{o}C.

Repeat for the same thicknesses of aluminum and styrofoam

Molecular level

Make a diagram showing all of the steps of dissolution

Also, show the dissolution process on the molecular level

Carefully define heat of solution ΔH_{soln}

What is similar/different between the calorimeter and the equipment required for the project?

Make a diagram of both the calorimeter and your proposed equipment for this project.

Show materials of construction and other fabrication details

Write clear direct statements of all of the differences and similarities

What are the requirements for heat flow/materials?

State the difference between heat and temperature.

Distinguish between heat capacity and thermal conductivity. Show the units for both quantities.

Make a schematic diagram for heat flow. Label all resistances. Show the overall heat flow equation.