Clarifying The Heat Pack Trigger

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Sections A08/B08

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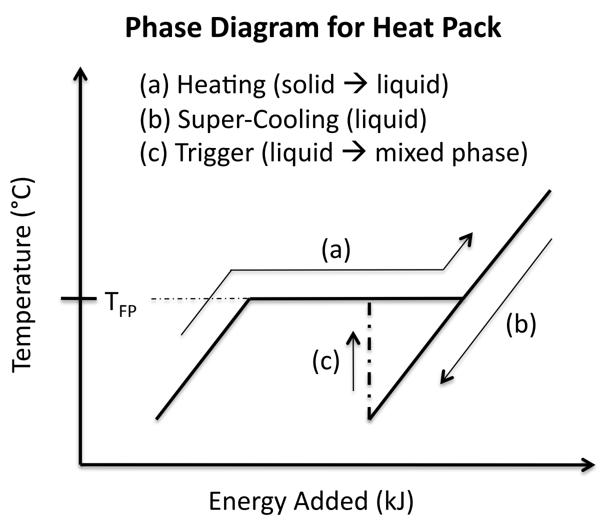
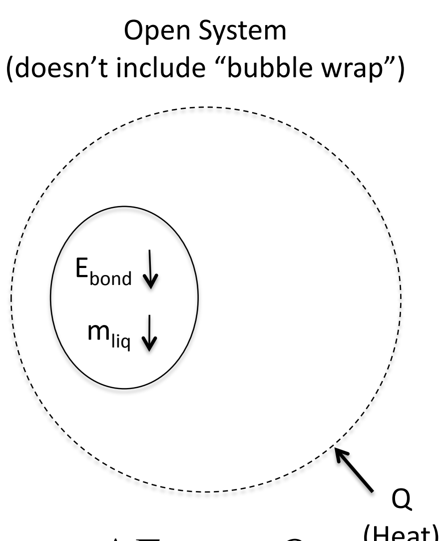
I wrote this to clarify some confusion about the energy diagrams we drew in DLM 2. In particular, I will demonstrate how to draw the correct diagram for the *triggering process* of the heat pack (the vertical line on the 3-Phase Model diagram).

First I will go over why some example energy diagrams are incorrect (given our assumptions), and use this to steer us toward the correct diagram.

Let's look at our "3-Phase Model" phase diagram for the heat pack from DL 2. Whether or not there is a phase transition depends on which direction we are going – we can heat our solid heat pack until it enters a phase transition, and then it liquifies. If we cool our packs (take energy *out* of the system), then the liquid *remains a liquid past the freezing point* (T_{FP} in the diagram).

Now, let's draw the EIM diagram for the (c) process from the diagram at right (triggering the heat pack). Namely, I want to see whether there is anything wrong with choosing my system to *exclude the insulation*.





$$\Delta E_{bond} = Q$$

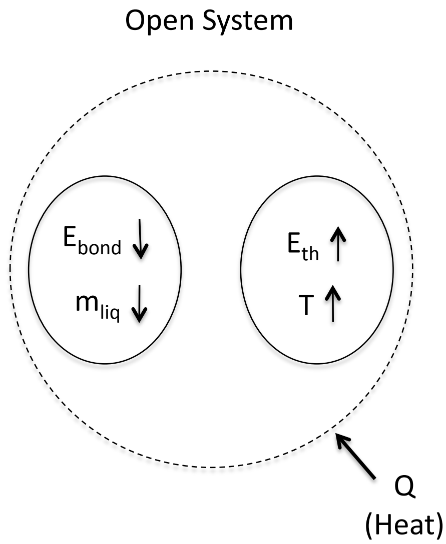
Interval: $23°C - 54°C$

If we are assuming the pack is insulated, can we choose the insulating material to be outside the system?

That would mean our system is open, and exchanges heat with the space between the pack and, say, our bubble wrap. Now, I draw the diagram on the left. Is it correct?

Right away, the first thing to spot is that our energy equation gives nonsense. Q is entering the system, so it's positive, but ΔE_b is negative (it's solidifying). So, we know we left out some energy. Also, remember to look at the phase diagram: *temperature is increasing*, which implies that E_{th} *must* be increasing.

Whoops! Let's add that thermal energy (see right). Are there still problems?

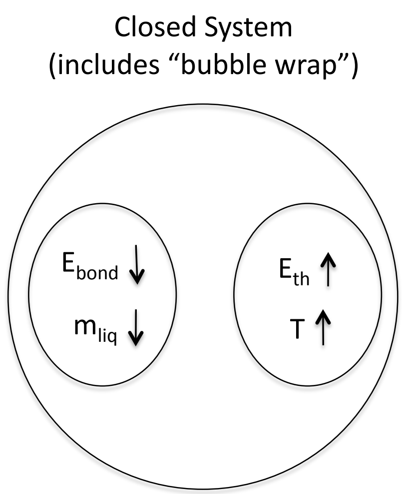


$$\Delta E_{bond} + \Delta E_{th} = Q$$

Well, this diagram says that Q is entering the system, which contradicts our phase diagram that says *no* energy was added! *The bottom line: if we said that no energy was added to our system (line is vertical in phase diagram), the system cannot be open.*

So, is there something wrong with choosing our system to exclude the insulation? **For the purposes of this class, yes.**

The key is to ask yourself: why does the temperature increase so rapidly? It is *not* due to energy transfer, but rather *the reaction that occurs when we click the trigger*. Triggering the heat pack almost instantly sends it to mixed phase, and no *heat transfer* was needed to do this.



$$\Delta E_{bond} + \Delta E_{th} = 0$$

On the left is the true diagram representing our heat pack *during the triggering process* (c). Why does it make sense?

In order to draw the phase diagram the way that we did (that is, with a vertical line for the triggering), *we must assume our system is closed for this process.*

Also, note that overall $\Delta E = 0$, so energy is conserved, as it should be for a closed system. E_{th} increases to compensate for E_b decreasing!

The take-aways from this are:

1. Always write your energy equations, and then *check that they make sense.*

2. When you define your system and interval, ask if it is communicating with the outside world *on this interval.* If it is closed, Q is not transferred into or out of the system.

3. When we say a system is **insulated**, we mean that the boundary of *that* system is an impenetrable barrier and so there is **no** heat transfer to/from that system.