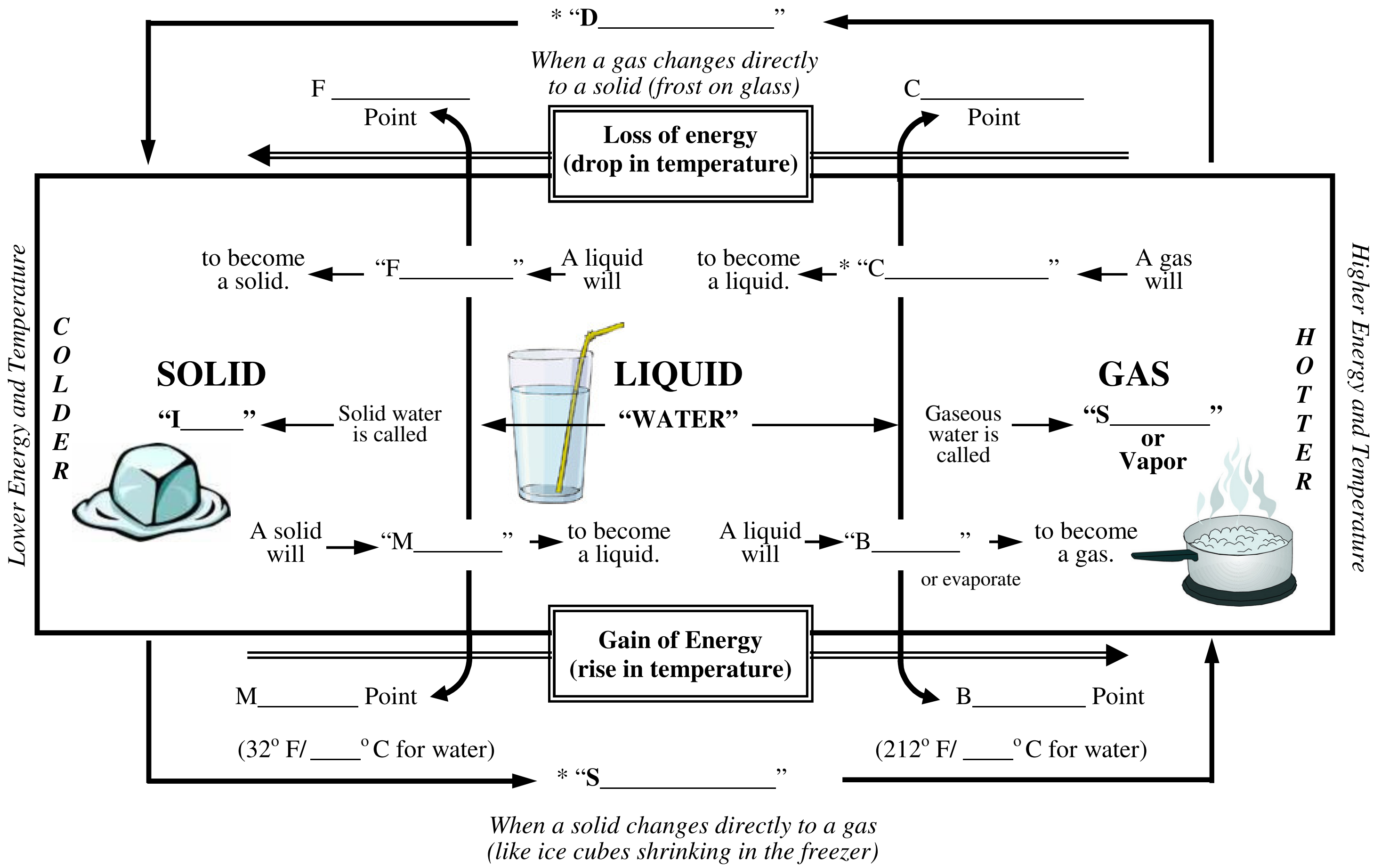
Heat and Thermo 1

1. The following diagram will help you remember the terms we use for water. These terms are often the same for other substances. Follow the arrows to fill in the blanks.



2. Gain or loss of energy?

   A. ____ When water freezes.
   B. ____ During sublimation.
   C. ____ When water boils.
   D. ____ When ice melts.
   E. ____ During condensation.
   F. ____ When water turns to steam.

3. Solid, Liquid, or Gas?

   A. _____Water at 50° C.
   B. _____Water at 120°C.
   C. ____ Water at 10° F.
   D. ____ Water at –5°C.
   E. ____ Water at 100°C.
   F. ____ * Water at 285 K.

Understanding the heat equation ($Q = mc_p\Delta T$) and specific heat (c_p):

4. Steam has a specific heat of 2010 J/kg•C°.
   A. * How much heat (in J) is necessary to raise 1 kg of steam 1 degree Celsius?

   B. * How much heat is necessary to raise 1 kg of steam 2 degrees Celsius?

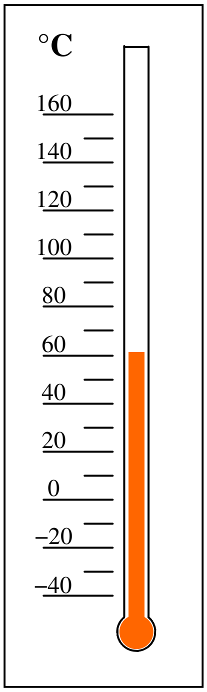
5. Ice has a specific heat of 2090 J/kg•C°. How much heat is necessary to raise 1 kg of ice 1 degree Celsius?

6. Water has a specific heat of 4186 J/kg•C°. How much heat is necessary to raise 1 kg of water 1 degree Celsius?

7. So, if the specific heat of a substance is bigger it requires _______ heat (in J) to raise its temperature.

8. Which phase of water required the most heat to change temperature?
9. * Why can't you use the same equation (do one single calculation) to calculate the energy needed to heat liquid water and steam?

10. The Celsius thermometer below is used to measure the temperature of 3 kg of water. We will assume that the water is at normal atmospheric pressure. (*See footnote below.)*



A. Label the boiling point of water. Use an arrow and a label.
B. Mark and label the freezing point of water.
C. Label the three most common phases of water on the thermometer. Label them ice, liquid water, and steam (since they are all still water).
D. Label the Cp's for the different phases of water. These were given on the previous page.
E. Label the present reading as T_1.
F. In what phase is the water at this temperature?

We want to lower the 3 kg of water to −30° C.

G. Mark the desired temperature as T_2.
H. What is the lowest temperature water will stay liquid?
I. What will be the change of temperature during its liquid phase (ΔT_{liquid})?
J. Calculate the heat removed from the water to lower it to 0°C.

A. 100° C
B. 0°C
C. Figure it out.
D. See front
E.
F. Liquid (between 0 and 100°C)
G.
H. 0°C
I. −60°C
J. $Q = mc_{p\ water}\,\Delta T$ $= 3(4186)(-60)$ $= -7.53E5$ J

Now the 3 kg of water is at 0°C. At this point heat must be removed to it to fuse it into ice. This heat is known as the "latent heat of fusion". The equation is $\boldsymbol{Q = mL_{fusion}}$ *and* $\boldsymbol{L_{fusion\ for\ ice} = \pm 3.33\times10^5\ J/kg}$. *It is + when melting (since ice gains heat to become liquid water) and −when freezing (since water must lose heat to become ice).*

K. How much heat must be removed to fuse the water into ice?

L. What will be the initial temperature of this water when it has turned to ice?

M. What will be the change of temperature of this water during its solid (ice) phase (ΔT_{ice})?

N. Calculate the heat removed from the ice to lower it to −30°C.

O. Calculate the total heat removed from the water to lower it from 60° to −30°C.

K. 3(-3.33E5) = −9.99E5 J (− since freezing)
L. 0°C
M. −30°C
N. $Q = mc_{p\ ice}\,\Delta T$ = −1.88E5J
O. Add em all up: −1.94E6J

1. Condensation/ Sublimation/ Deposition 3F: Liquid (0°C = 273K) 4A: 2010 J
4B: 2(2010) = 4020 J 9. Steam and water have different Cps.

Footnote: if not at standard pressure (1 atmosphere) the freezing point and boiling point change. Greater pressures (like a pressure cooker) can cause water to stay liquid at much higher temperatures than 100°C.