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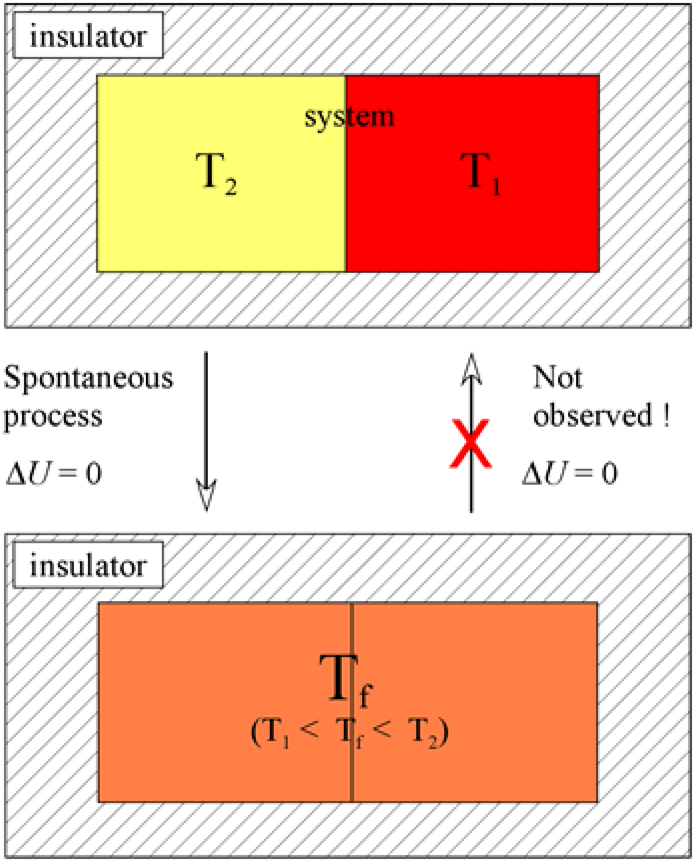
Entropy



http://guweb2.gonzaga.edu/faculty/cronk/chemistry/images/spontaneous-example1.gif

Spontaneous Change

Spontaneous changes are changes that have a **natural tendency to occur**.

Spontaneous changes move a system from a less stable state **to a more stable state**.

Spontaneous changes are those in which **energy** and/or **matter are spread out**.

http://en.wikivisual.com/images/a/a0/Hydrochloric_acid_ammonia.jpg

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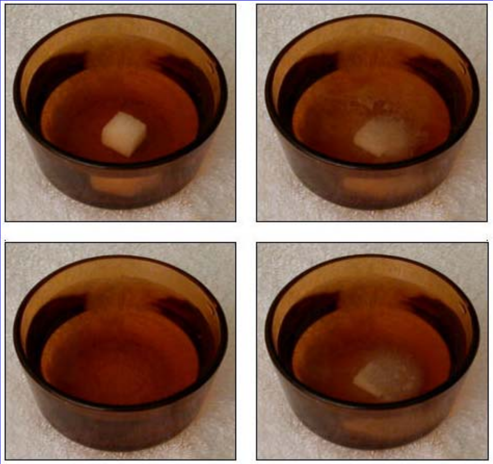
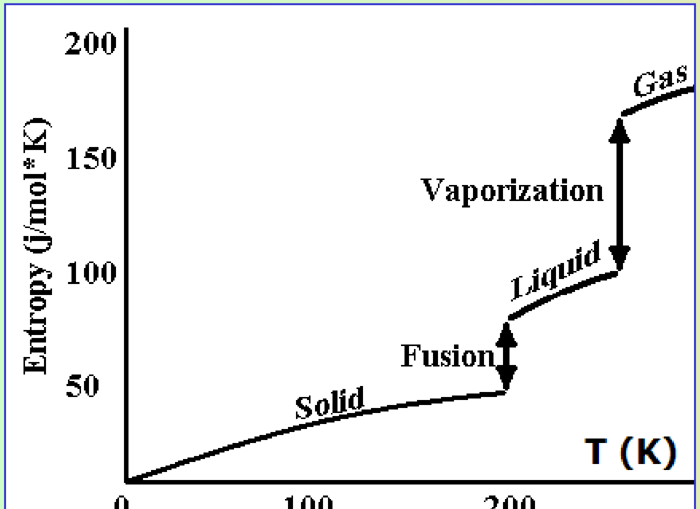


http://www.vectorsite.net/tpecp_09_04.jpg



http://www.chem.uic.edu/marek/apintropage/ap_notes/chapter20/Image126.gif

Entropy and Disorder

Entropy (**S**) is a measure of the disorder of a system.

The entropy of a system increases when the **matter** or **energy** in the system **spreads out** or becomes **more random** in its arrangement.

For example, entropy increases when a solid melts to produce a liquid, when a liquid vaporizes to produce a gas, or when substances dissolve or mix together.

Entropy also increases when a substance is heated but no change of state is produced.

http://i222.photobucket.com/albums/dd53/hawk2833/ice_cube.jpg

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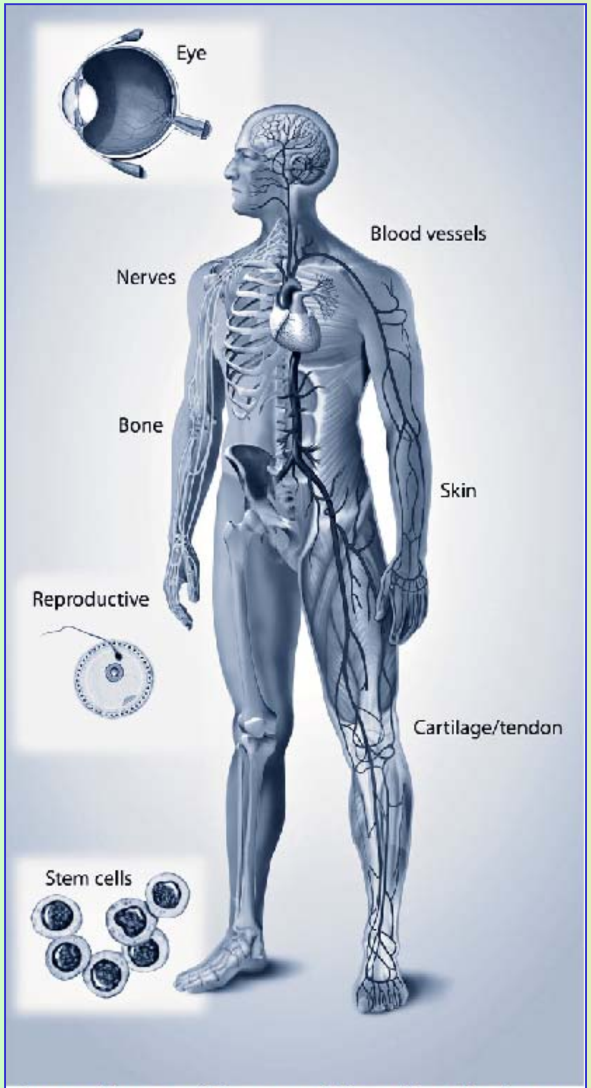


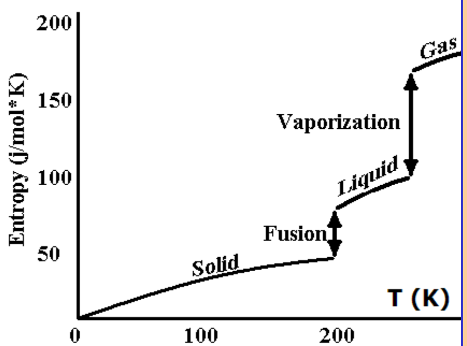
http://www.fda.gov/Cber/inside/annrpt1.jpg

Entropy and Disorder

There are some processes in which heat flow occurs without an important change in temperature:

- a substance changes its phase at a constant temperature
- chemical reactions in which temperature is held constant, as in human body
- the surroundings are so large that they can absorb heat without significantly changing its temperature

http://i222.photobucket.com/albums/dd53/hawk2833/ice_cube.jpg



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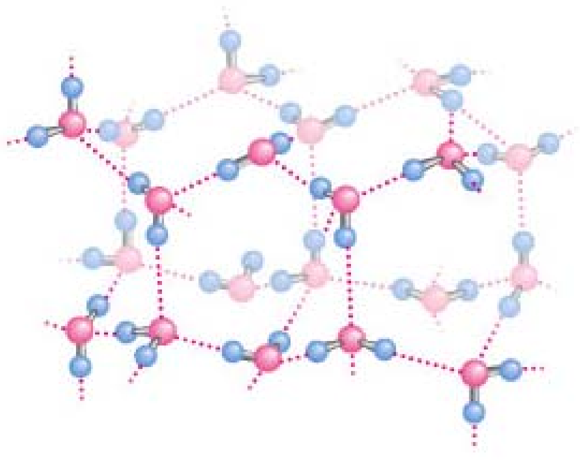

Hydrogen bonds in ice

http://web.virginia.edu/Heidi/chapter2/Images/8883n02_02.jpg

Entropy: numerical values

Entropy is given the symbol S.

The entropy change in a system is defined as:

$$\Delta S = \frac{q}{T}$$

where q is the heat added to the system from the surroundings and T is the temperature in Kelvin.

When ice melts, the heat added to the system does not increase its temperature; the energy just makes the matter more disordered.

http://i222.photobucket.com/albums/dd53/hawk2833/ice_cube.jpg

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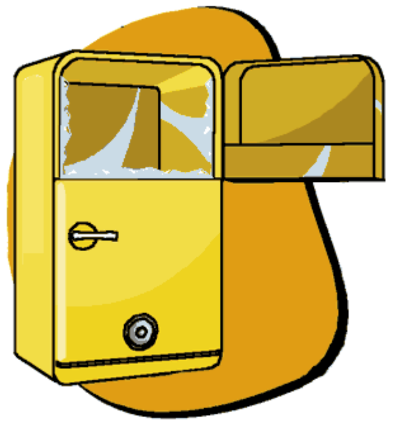

http://gloriana.files.wordpress.com/2007/01/freezer.gif

Entropy changes during freezing

EXERCISE:

What is the total entropy change when 2.00 mol of liquid water at 0ºC freezes in a freezer compartment whose temperature is –15 ºC?

ΔH_{fus} = 6.01 kJ/mol for water

SOLUTION:

The amount of heat lost by the water is:

$$q_{water} = -2\ \text{mol} * 6010\ \frac{J}{mol} = -12020\ J$$

The change in entropy for the water is:

$$\Delta S_{water} = \frac{q_{water}}{T_{water}} = \frac{-12020\ J}{273\ K} = -44\ \frac{J}{K}$$

The freezer absorbs the heat release by the water:

$$\Delta S_{freezer} = \frac{q_{freezer}}{T_{freezer}} = \frac{12020\ J}{258\ K} = +46.6\ \frac{J}{K}$$

The total entropy change is the sum of these changes in entropy:

$$\Delta S_{total} = \Delta S_{water} + \Delta S_{freezer} = -44\ \frac{J}{K} + 46.6\ \frac{J}{K}$$

$$\Delta S_{total} = +2.6\ \frac{J}{K}$$

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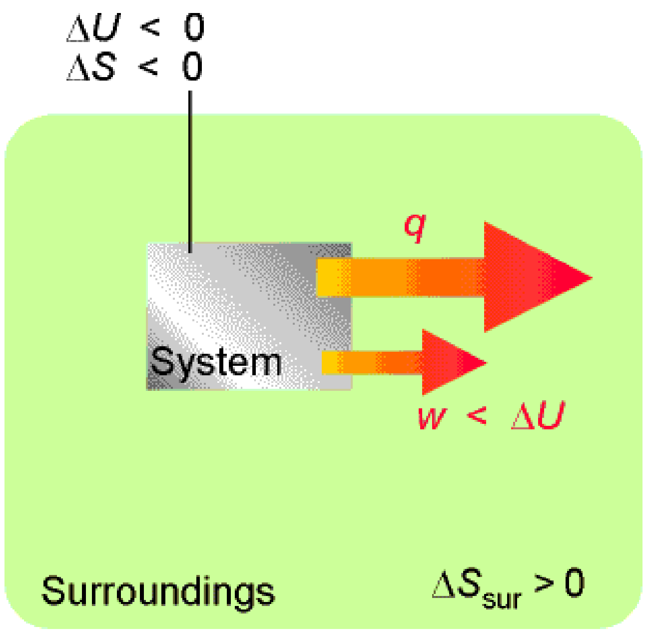

http://staff.um.edu.mt/jgri1/teaching/che2372/notes/04/g_a/F4_12.gif

System and surroundings

The total entropy change for any process can be broken down into the entropy change in the system plus the entropy change in the surroundings.

$$\Delta S_{total} = \Delta S_{sys} + \Delta S_{surr}$$

In terms of entropy change (or disorder) the significance of the heat released by an exothermic reaction (**ΔH**) into the surroundings depends on how hot the surroundings are. The hotter they are, the less effect the transfer of heat will have.

$$\Delta S_{surr} = \frac{-\Delta H_{reaction}}{T}$$

$$\Delta S_{total} = \Delta S_{sys} - \frac{\Delta H_{reaction}}{T}$$

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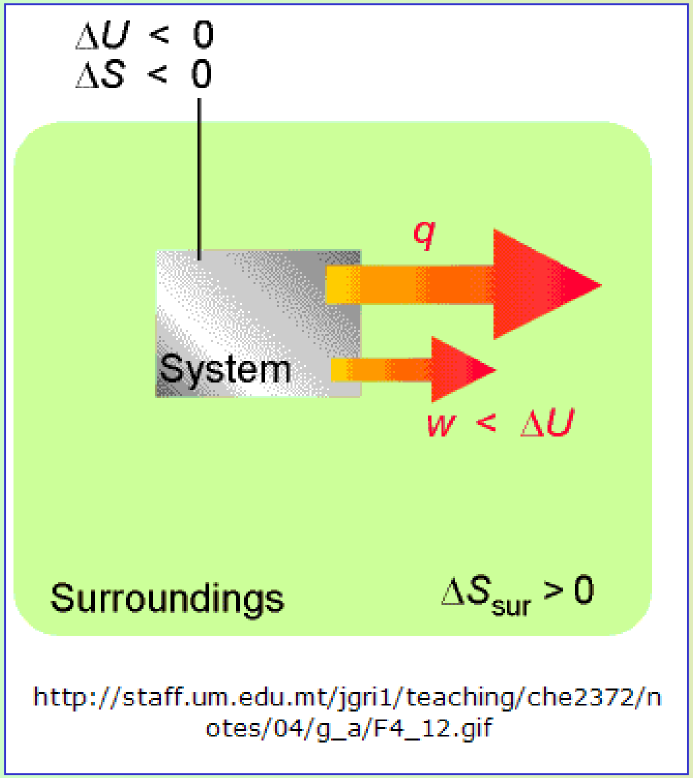

The second law of thermodynamics

The system plus the surroundings constitute the Universe.

When any change takes place, the total entropy of the Universe tends to increase:

the total entropy of the Universe always tends to increase; it never goes down.

As a result:

$$\Delta S_{tot} > 0$$

$$\Delta S_{total} = \Delta S_{sys} - \frac{\Delta H_{reaction}}{T} > 0$$

$$T * \Delta S - \Delta H > 0$$