THERMODYNAMICS

Chapter 15

INTERNAL ENERGY

- If you look at a rock or a pool of water or a tree, if they aren't moving and are on the ground they look like they don't have any energy.
- But they actually have a great deal of energy. We have learned that their temperature is their mean kinetic energy per particle. In addition they have energy in the bonds that hold a solid or liquid together that we have learned about as latent heat. They can have other forms of energy too, based on their structure or possibility for chemical reactions.
- All of these types of energy are collectively refereed to as internal energy and given the symbol U.
- In practice we can never really measure the internal energy of a substance but we can see when it changes. Thus we only measure ΔU.

FIRST LAW OF THERMODYNAMICS

- The first law of thermodynamics is that the change of internal energy to a system is equal to the heat that flows into it minus any work it does.

$$\Delta U = Q - W$$

- This is just energy conservation but focusing on the most common energies that change internal energy.

EXAMPLE

- A 5.0g bullet is fired through a tree. Before entering the tree the bullet has a speed of 400 m/s, when it leaves the tree its speed is only 200m/s. What is the change of internal energy to the tree?

m = 5g = 0.005kg

v_1 = 400 m/s

v_2 = 200 m/s

$$\Delta U = Q - W$$

$$W = \Delta KE$$

$$\Delta U = -\Delta KE = \frac{1}{2}m(v_1^2 - v_2^2) = \frac{1}{2}(0.005kg)((400m/s)^2 - (200m/s)^2) = 300J$$

EXAMPLE

- An internal combustion engine works by heating gas so that it pushes on a cylinder. If you transfer 20J of heat to the gas and it pushes the cylinder with a force of 500N for 2cm, what is the change to the internal energy of the gas?

Q = 20J

F = 500N

d = 2cm = 0.02m

$$\Delta U = Q - W$$

$$W = Fd\sin\theta$$

$$\Delta U = Q - Fd \quad = 20J - (500N)(0.02m) = 10J$$

2ND LAW OF THERMODYNAMICS

- Heat always flows from hotter systems to colder systems.
- The 2nd law can also be understood as entropy always increases.
- Entropy is a measure of disorder in a system. So the 2nd law says that things always become more disordered.
- We can calculate the entropy change ΔS by $\Delta S = \frac{Q}{T}$

EXAMPLE 15.6

- **Entropy Increases in an Irreversible (Real) Process:** Spontaneous heat transfer from hot to cold is an irreversible process. Calculate the total change in entropy if 4000 J of heat transfer occurs from a hot reservoir at T_h=600 K(327° C) to a cold reservoir at T_c=250 K(−23° C), assuming there is no temperature change in either reservoir.

Q = 4000J

T_h = 600K

T_c = 250K

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

$$\Delta S_h = \frac{Q_h}{T_h} = \frac{-4000J}{600K} = -6.67J/K$$

$$\Delta S_c = \frac{Q_c}{T_c} = \frac{4000J}{250K} = 16.0J/K$$

$$\Delta S = \Delta S_h + \Delta S_c$$

$$= -6.67J/K + 16.0J/k = 9.33J/K$$

Notice entropy increases

EXAMPLE 15.8

- **Entropy Associated with Disorder:** Find the increase in entropy of 1.00 kg of ice originally at 0° C that is melted to form water at 0° C.

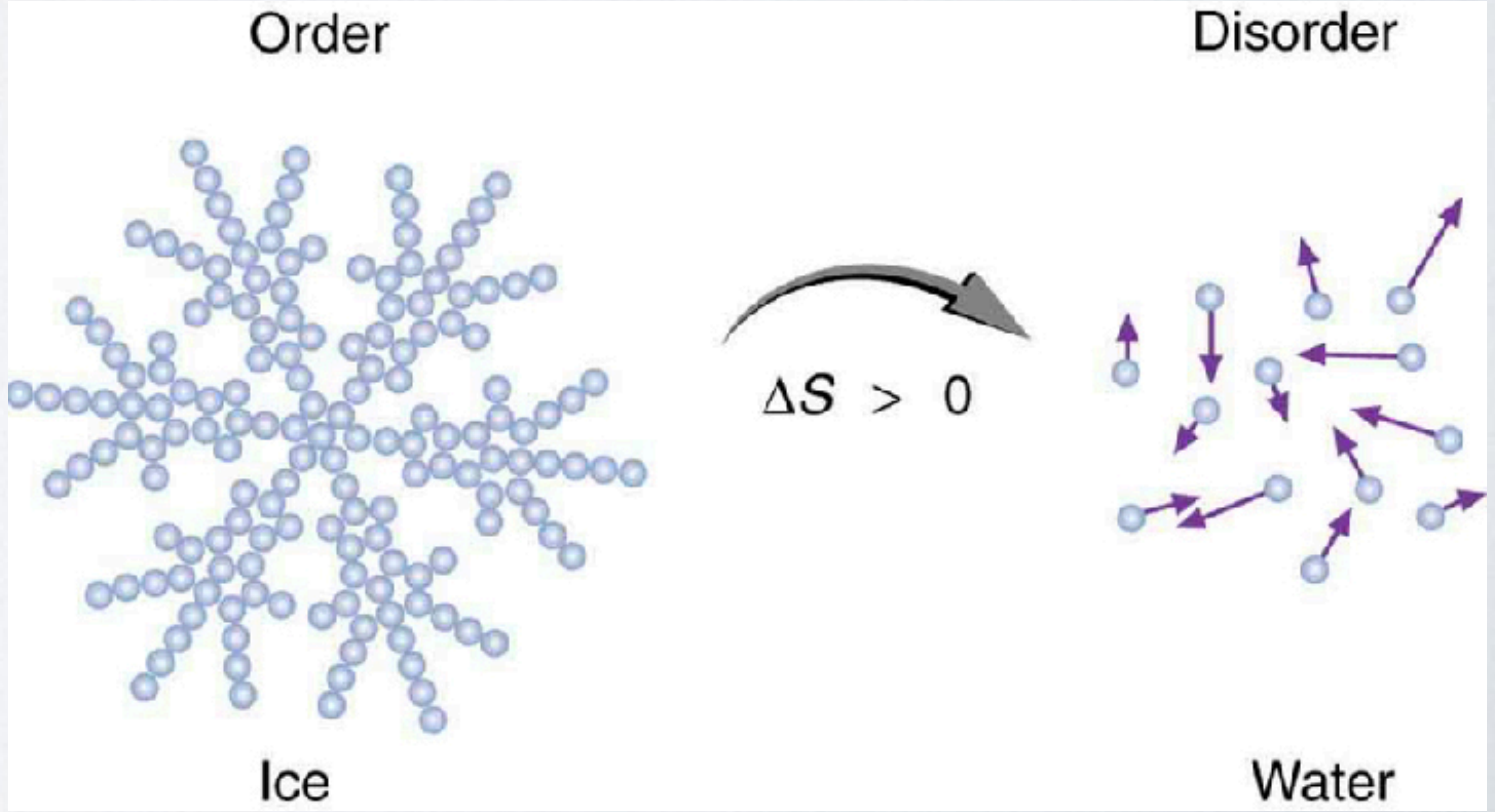
m = 1.00 kg
T = 0° C = 273K

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

$$Q = mL_{f,ice}$$

$$Q = 1.00kg(334kJ/kg) = 334kJ = 334,000J$$

$$\Delta S = \frac{334,000J}{273K} = 1,220J/K$$



HOME WORK

- Chap 15 - 2, 3, 47, 53