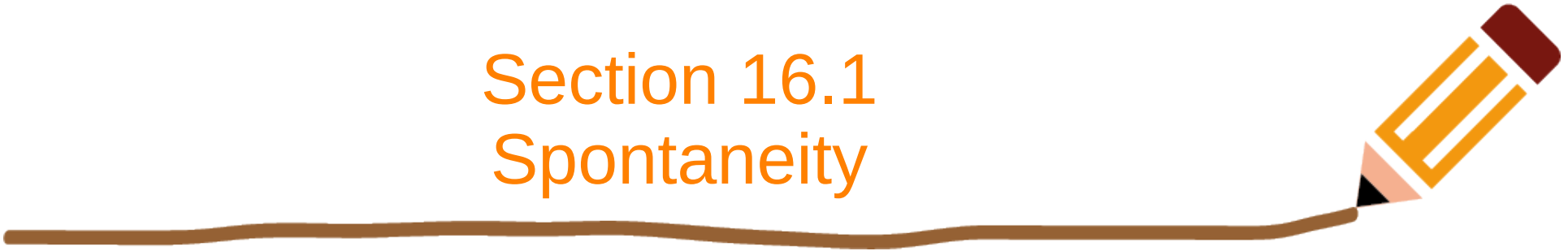
Section 16.1
Spontaneity



Michael Stogsdill

Mott Community College

Learning Objectives

- Distinguish between spontaneous and nonspontaneous processes
- Describe the dispersal of matter and energy that accompanies certain spontaneous processes

Spontaneity

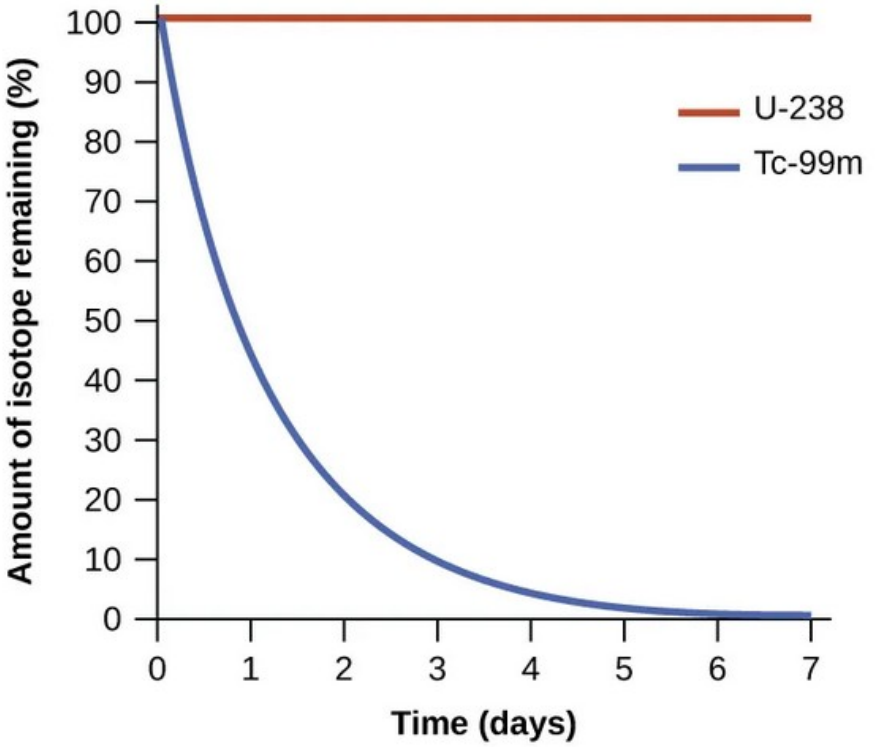
- Processes have a natural tendency to occur in one direction under a given set of conditions.
  - Water will naturally flow downhill, but uphill flow requires a pump.
  - Iron exposed to air will corrode, but rust is not converted to iron requires smelting
- A **spontaneous process** is one that occurs naturally under certain conditions.
- A **nonspontaneous process** will not take place without the continual input of energy from an external source.

Reversible Processes

- A process that is spontaneous in one direction under a particular set of conditions is nonspontaneous in the reverse direction.
- At room temperature and typical atmospheric pressure, ice will spontaneously melt, but water will not spontaneously freeze.

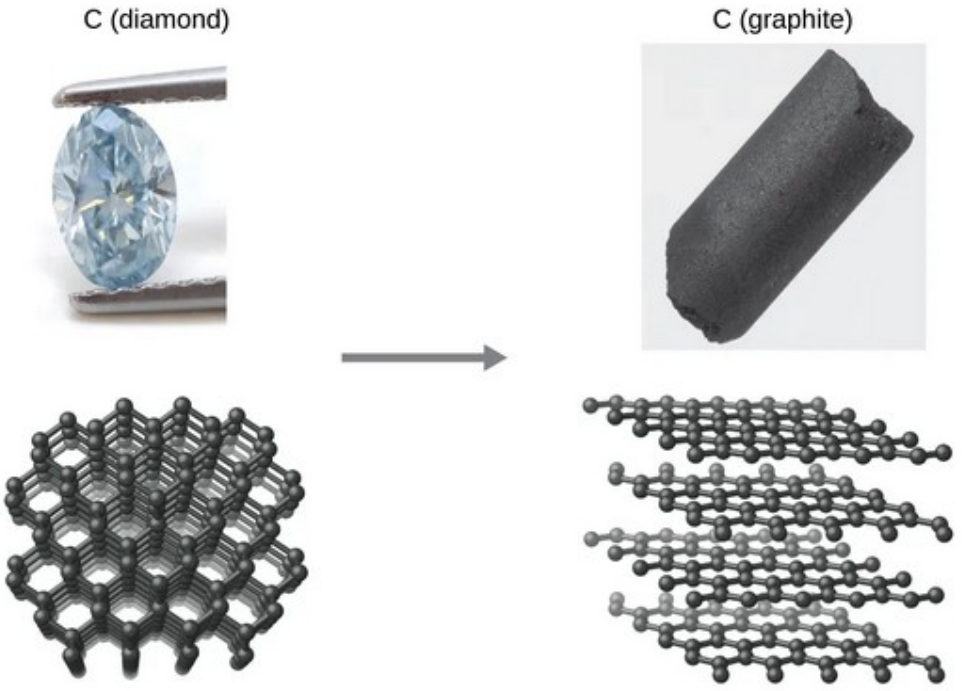
Spontaneity and Rates

- The spontaneity of a process is *not* correlated to the speed of the process.
- A spontaneous change may be so rapid that it is essentially instantaneous or so slow that it cannot be observed over any practical period of time.



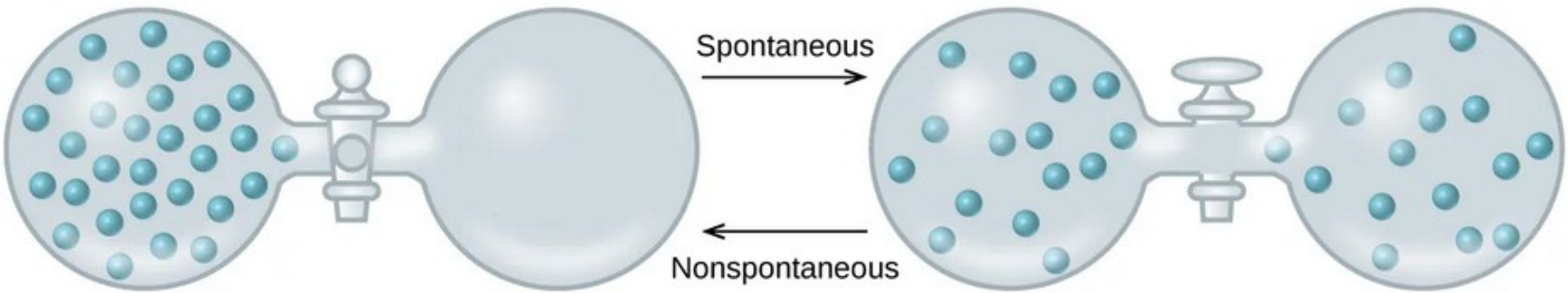
Spontaneity and Rates

- Graphite is the stable form of carbon under ambient atmospheric pressure.
- Diamond is the stable allotrope at very high pressures.
- Yet diamonds are observed to exist, and persist, under ambient conditions.



Dispersal of Matter and Energy

- Consider an isolated system consisting of two flasks connected with a closed valve.
  - Initially there is an ideal gas in one flask and the other flask is empty (P = 0).
  - When the valve is opened, the gas spontaneously expands to fill both flasks equally. But why?



Considering Internal Energy

- No work has been done because the pressure in a vacuum is zero.

$$w = -P\Delta V = 0 \qquad (P = 0 \text{ in a vacuum})$$

- Since the system is isolated, no heat has been exchanged with the surroundings (q = 0).
- The first law of thermodynamics confirms that there has been no change in the system's internal energy

$$\Delta U = q + w = 0 + 0 = 0$$

Dispersal of Matter is Spontaneous

- The spontaneity of this process is not a consequence of any change in energy.
- Instead, the driving force is related to the *greater, more uniform dispersal of matter* that results when the gas is allowed to expand.
- After the spontaneous expansion took place, the matter was distributed both more widely and more uniformly.
  - Occupying twice its original volume
  - Present in equal amounts in each flask

Dispersal of Energy is Spontaneous

- Consider two objects at different temperatures
- When these objects come into contact, heat spontaneously flows from the hotter object to the colder one.
  - One object loses energy and the other gains it.
  - There was no net gain or loss of thermal energy
  - The available thermal energy was redistributed among the two objects.