

## In your notes:

Write just the variables, not the entire question

- ▶ A sample of unknown metal of mass 0.550 kg has an initial temperature of 75.0°C. It is placed into a calorimeter that contains 0.500 kg of water in a 0.100 kg aluminum inner cup, both of which are initially at 15.5°C. The equilibrium temperature of the calorimeter and metal is 18.8°C. What is the specific heat of the metal?

## Warm-up Answer:

- ▶ Specific heat of the unknown metal =

$$\begin{aligned}\Delta Q_{\text{lost}} &= \Delta Q_{\text{gained}} \\ (m \cdot c \cdot \Delta T)_{\text{unknown}} &= (m \cdot c \cdot \Delta T)_{\text{H}_2\text{O}} + (m \cdot c \cdot \Delta T)_{\text{Al}} \\ (0.550)(c)(75.0 - 18.8) &= (0.500)(4186)(18.8 - 15.5) + (0.100)(920)(3.3) \\ 30.91(c) &= 6906.9 + 303.6 \\ c &= \frac{7210.5}{30.91}\end{aligned}$$

$$c = 233 \text{ J} \cdot \text{kg}^{-1} \cdot \text{C}^{-1}$$

## Phase Changes and Latent Heat

Read: Section 11.3 (pp. 393+)

## Kinetic Theory of Matter

### ▶ Basic Assumptions:

- All matter is composed of extremely small particles
- All particles are in constant motion
- If particles collide with neighboring particles, kinetic energy is conserved
- A mutual attractive force exists between particles

## Brownian Motion

- ▶ Small particles suspended on a surface of a fluid, such as pollen grains on the surface of water, move in erratic, seemingly unpredictable patterns
- ▶ This gives evidence that particles in substances are in constant motion
- ▶ Demo: [Click Here](#) and watch, in the "microscope" on the right, what happens to the "dust particle" (blue dot) as a result of collisions with the other molecules (red dots)

### ▶ Macroscopic Properties

- All the *observable behaviors* of that material such as the shape, volume, and compressibility

### ▶ Microscopic Properties

- Properties that are indicative of what is occurring at the atomic level of a substance

*Print off the handout "Macro- and Micro-characteristics" from the website...*

*Keep the handout in your notes and make sure your review it!*

## Phase Changes

- ▶ As thermal energy is added to a substance, there are two possible outcomes for that substance:
  - Its temperature will increase (an increase in internal kinetic energy)
- OR
- It will change phases (states) of matter (an increase in the internal potential energy)

## Phase Changes— *a qualitative approach*

- ▶ Imagine a solid block of ice, beginning at a temperature of  $-4.0\text{ }^{\circ}\text{C}$ ...
  - What happens as thermal energy is added at a constant rate?**
- 1. As thermal energy is added, the molecules in the solid will vibrate at a faster rate, increasing the ice's kinetic energy, and, therefore, the temperature of the solid

### What happens as thermal energy is added at a constant rate?

- 2. Soon, however, the solid reaches a temperature at which the particles have enough energy to break free from their fixed positions and begin to slide over each other...
  - It has now reached the **melting point**—all thermal energy added is allowing the potential energy to increase
  - The temperature will **remain constant** until the entire substance has changed from the solid to the liquid state

### What happens as thermal energy is added at a constant rate?

- 3. As soon as the substance is completely in the liquid state, the thermal energy that is still being added will once again increase the kinetic energy of the particles, causing...
  - **An increase in temperature...again!**

### What happens as thermal energy is added at a constant rate?

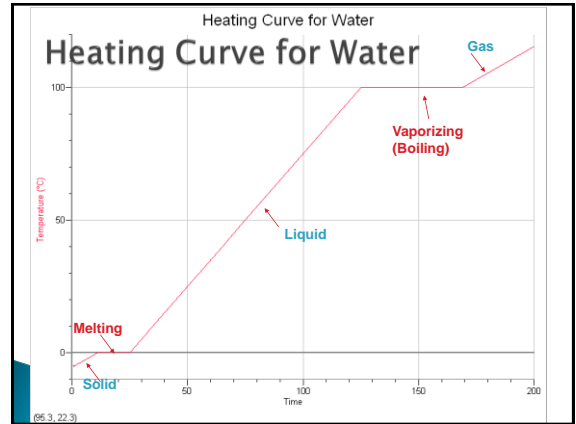
- 4. The temperature will continue to increase until the liquid reaches its **boiling point**, at which time the molecules have sufficient energy to overcome the forces of attraction between other molecules.
  - The molecules are now able to "escape" into the gaseous state

### What happens as thermal energy is added at a constant rate?

- 5. If it were possible to contain the liquid and gas as the liquid was boiling, as soon as all of the liquid particles gained enough energy to become gaseous particles the gas would also follow the trend and increase in kinetic energy (and, therefore, temperature) as long as heat was added.

## Phase Changes— a quantitative approach

- ▶ Heating Curves:
  - A graphical analysis of the phase changes and temperature changes of a substance as thermal energy is added at a steady rate.



## Phase Changes— a quantitative approach

- ▶ It is possible to calculate specific heats, as well as **Latent Heats**:
  - **Latent Heat of Fusion ( $L_f$ )** = the amount of thermal energy required to MELT OR FREEZE 1 kg of a substance
  - **Latent Heat of Vaporization ( $L_v$ )** = the amount of thermal energy required to VAPORIZE OR CONDENSE 1 kg of a substance

## Latent Heat of Fusion

- ▶ A certain amount of heat is required to melt or freeze a substance:
  - Melting: energy is added
  - Freezing: energy is removed (released)
- ▶ The amount of energy required depends on the mass of the substance and on the Latent Heat of Fusion:

$$Q = mL_f$$

## Latent Heat of Vaporization

- ▶ A certain amount of heat is also required in order to vaporize or condense a substance
  - Remember, to **vaporize** refers to a liquid changing into the gas phase at its boiling point!
  - Vaporizing: energy is added
  - Condensing: energy is removed
- ▶ The amount of energy required depends on the mass of the substance and on the Latent Heat of Vaporization:

$$Q = mL_v$$