Preview for tomorrow

Read ahead on the following topics either in a textbook or articles provided by the teacher and/or the department.

Topics:

1. Calorimetry
2. Using a Calorimeter
3. Using a Calorimeter to Determine the Enthalpy of a Rxn

Make notes using the following note taking strategies:

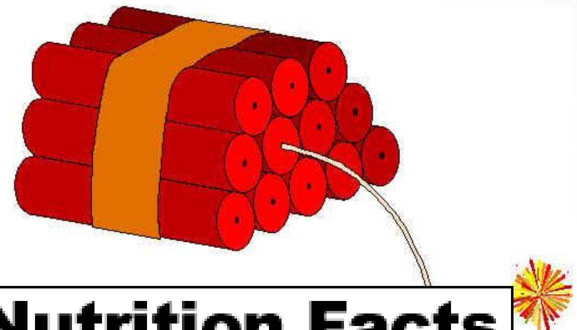
1. Cornell
2. Mind map/flow chart
3. Chart

Due at the beginning of next class
Formative

The Technology of Heat Measurement

- Why do we need to measure heat (transfer of kinetic energy, Ek)?

- 1 calorie = 4.2 joules



Nutrition Facts

Serving Size 125g

Amount Per Serving

Calories 65	Calories from Fat 2
	% Daily Value*
Total Fat 0g	0%
Saturated Fat 0g	0%
Trans Fat	
Cholesterol 0mg	0%
Sodium 1mg	0%
Total Carbohydrate 17g	6%
Dietary Fiber 3g	12%
Sugars 13g	
Protein 0g	

Vitamin A	1%	Vitamin C	10%
Calcium	1%	Iron	1%

*Percent Daily Values are based on a 2,000 calorie diet. Your daily values may be higher or lower depending on your calorie needs.

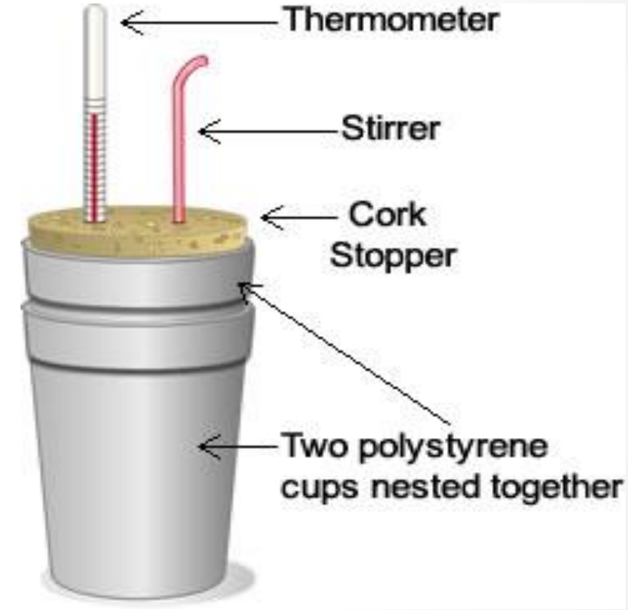
NutritionData.com

Calorimeter

- Instrument used to measure changes in Ek.

Basic components:

- Water
- Thermometer
- Isolated system (no flow of energy or matter



Calorimetry:

- The process of measuring changes in Ek

Using a Calorimeter

- A known mass of water is inside
- The water, surrounds and in direct contact with the process (undergoing energy change)
- Energy transfer between the chemical rxn (system) and the water (surrounding) is monitored by **measuring ΔT of water**
- $\mathbf{q_{system} = -q_{surrounding}}$
- $\mathbf{q_{rxn} = -q_{water}}$

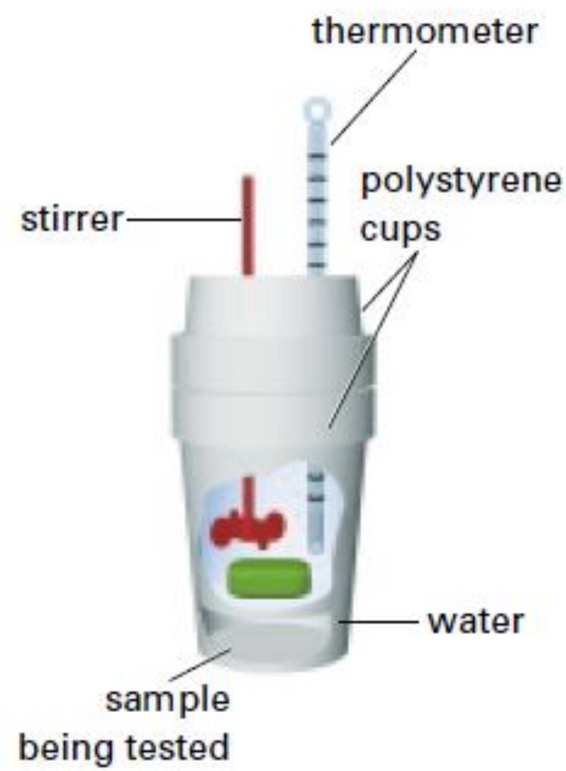


Figure 17.1 A coffee-cup calorimeter usually consists of two nested polystyrene cups with a polystyrene lid, to provide insulation from the surroundings.

Using a Calorimeter

Assumptions for, $q_{rxn} = -q_{water}$:

- System is completely isolated
- No heat is exchanged between the system and the calorimeter
- The reactants have the same properties as water:
    - Density of water (1.00g/mL)
    - Specific heat capacity (4.184 J/g°C)
        - It is because the solution is dilute enough
- Temperature change of water is monitored, thus… $q_w = mc\,\Delta T$

Inside a Calorimeter

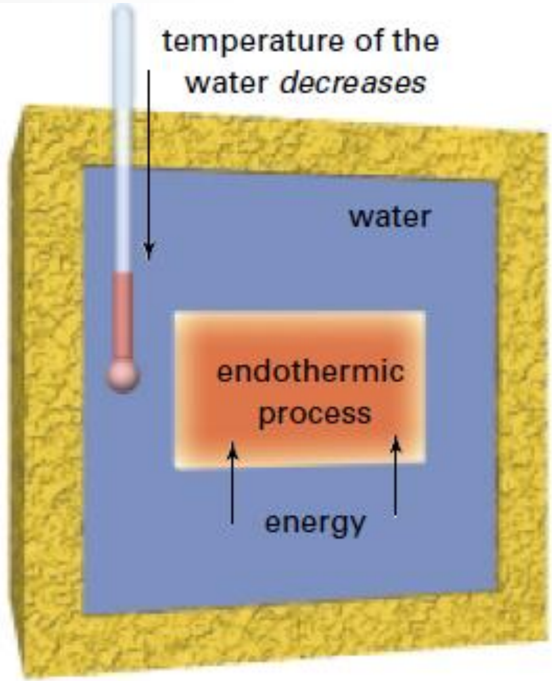


Figure 17.2 An endothermic process, such as ice melting

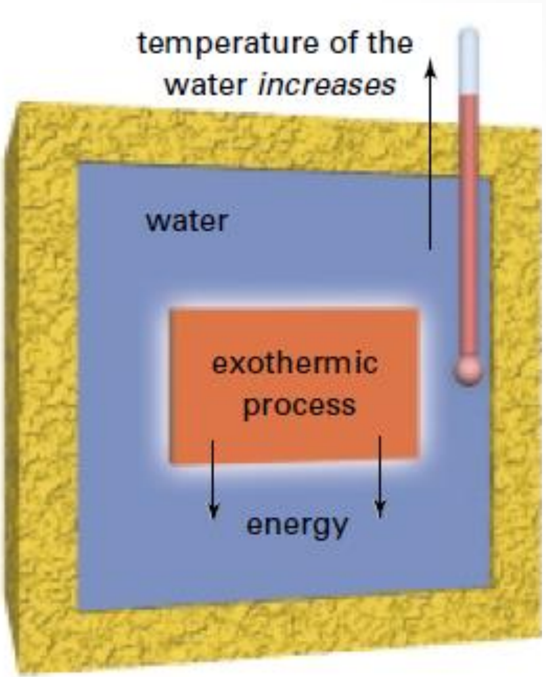
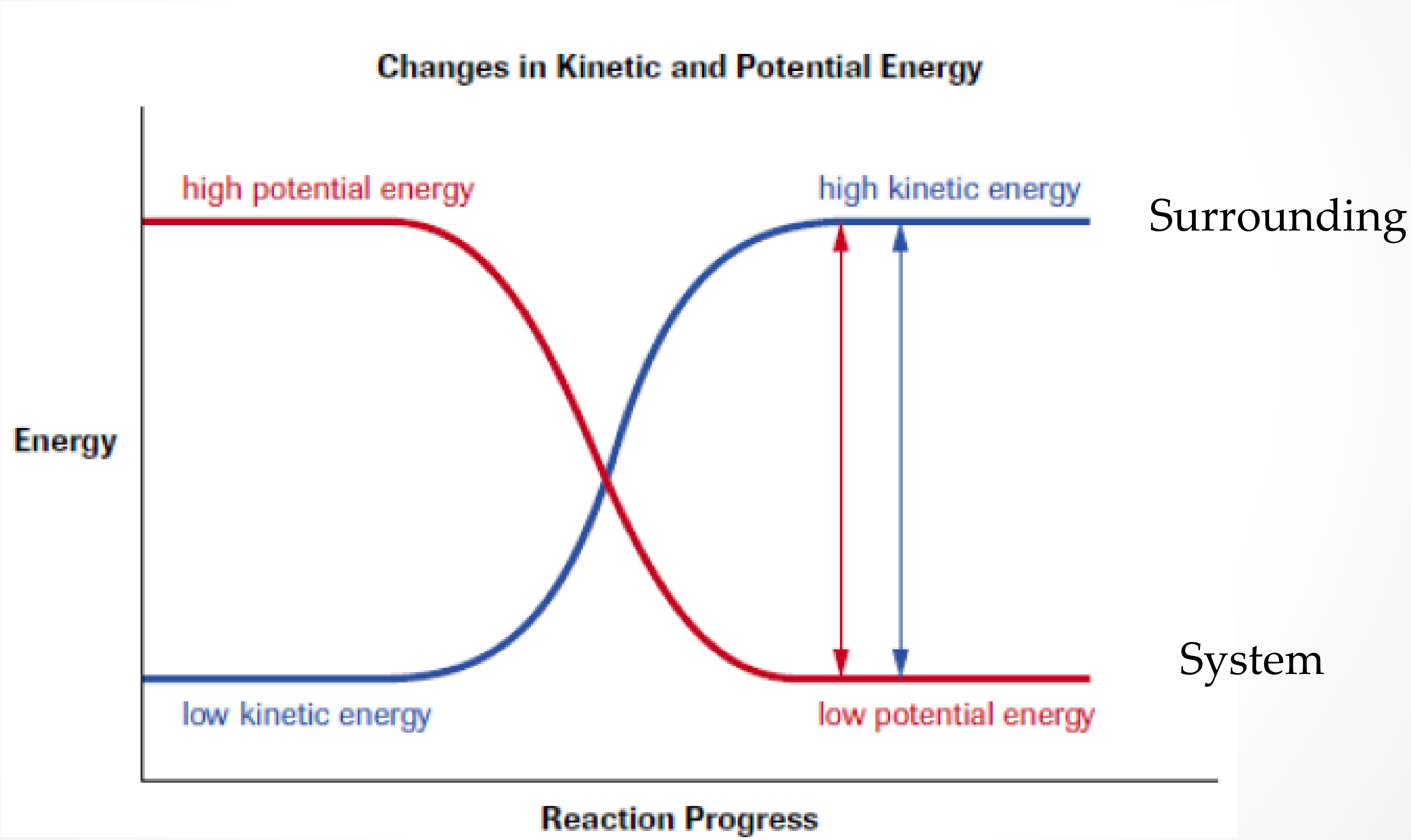


Figure 17.3 An exothermic process, such as a neutralization reaction

Using a Calorimeter to measure ΔHrxn

Recall:



Using a Calorimeter to measure ΔHrxn

Steps:

1. Observe changes in temperature
2. Determine $q_{surrounding}$(Ek)…= m c ΔT
3. **Law of conservation of energy**: energy changes into different forms, but it cannot be created or destroyed.
4. $q_{surrounding}$ (Ek) = $-q_{system}$(Ep)

5. q_{system} (Ep) = n ΔH

Recall:

Assume the **reactants** have the same density and specific heat capacity as **water**.

Example

Copper(II) sulfate, $CuSO_4$, reacts with sodium hydroxide, NaOH, in a double displacement reaction. A precipitate of copper(II) hydroxide, $Cu(OH)_2$, and aqueous sodium sulfate, Na_2SO_4, is produced.

$$CuSO_{4(aq)} + 2NaOH_{(aq)} \rightarrow Cu(OH)_{2(s)} + Na_2SO_{4(aq)}$$

50.0 mL of 0.300 mol/L $CuSO_4$ solution is mixed with an equal volume of 0.600 mol/L NaOH. The initial temperature of both solutions is 21.4°C. After mixing the solutions in the coffee-cup calorimeter, the highest temperature that is reached is 24.6°C. Determine the enthalpy change of the reaction. Then write the thermochemical equation.

- Copy the chemical equation, and values only

Given:

- $V_{CuSO_4} = 50.0\ mL$
- $[c]_{CuSO_4} = 0.300\ mol/L$
- $V_{NaOH} = 50.0\ mL$
- $[c]_{NaOH} = 0.600\ mol/L$
- $T_i = 21.4\ ^{o}C$
- $T_f = 24.6\ ^{o}C$
- $D = 1.00\ g/mL$
- $c = 4.184\ J/g^{o}C$

Required:

- $\Delta H_{rxn} = ?$

Analysis:

- $m = D \times V_T$
- $q_{surrounding}$ (Ek) $= m\,c\,\Delta T$
- $n_{CuSO4} = [c] \times V$
- $n_{NaOH} = [c] \times V$
- $q_{system} = -q_{surrounding}$
- q_{system} (EP) $= n\,\Delta H$

Solution:

- $m = 1.00\text{g/m}\cancel{\text{L}} \times (50.0 + 50.0)\text{m}\cancel{\text{L}}$

  $= 1.00 \times 10^2$ g
- $n_{CuSO4} = 0.300\ \text{mol/}\cancel{\text{L}} \times 5.00 \times 10^{-2}\ \cancel{\text{L}}$

  $= 0.0150$ mol
- $n_{NaOH} = 0.600\ \text{mol/}\cancel{\text{L}} \times 5.00 \times 10^{-2}\cancel{\text{L}}$

  $= 0.0300$ mol

- $-(mc\,\Delta T) = n_{CuSO4}\,\Delta H_{rxn}$

$[-(1.00 \times 10^2\ \cancel{g})(4.184\ J/\cancel{g}\cancel{°C})(24.6 - 21.4)\cancel{°C}] / 0.0150\ mol = \Delta H_{rxn}$

$\Delta H_{rxn} = -8.92 \times 10^4\ J/mol\ (-89.2\ kJ/mol)$

The thermochemical equation is

$CuSO_{4(aq)} + 2NaOH_{(aq)} \rightarrow Cu(OH)_{2(s)} + Na_2SO_{4(aq)} + 89\ kJ$

Paraphrase:

- The enthalpy change of the reaction is -89.2 kJ/mol of $CuSO_4$

Check:

The surrounding gained heat (increase in Temp.)→ system lost heat (exothermic process)

Homework

Complete practice problems on Worksheet # 3