

# **Chapter 6: Quantities in Chemical Reactions**

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October 10, 2022

Chemistry Department, Cypress College

# Class Annoucements

## Lab

- Experiment 12 - Single Displacement Reactions
- Recall indications for chemical reaction (color, solids, temp, etc.)
- Reminder - Need 70% of laborator points to pass the course

## Lecture

- Finally graded homework 3 and go over homework 4 (EC for students who present)
- Finish up Ch 6 and worksheet 7; begin discussion on Ch 7 - Electronic Structure of the Atom
- Quiz and Homework assignment released Fri, Oct 14th at 3pm

# Outline

Review: Chemical Equations. Limiting Reagent and Percent Yield

Energy Changes

Law of Conservation of Energy

Endothermic and Exothermic Reactions

Calorimetry

# Meaning of a Balanced Equation

## Photosynthesis Chemical Equation



- Balanced chemical equation satisfies the conservation of mass
- Coefficients in front of the molecules represent the relative moles of reactants and products

## Approaching Limiting Reactant Problems



- Given a certain amount of each reagents ( $R_1$  and  $R_2$ ) to produce  $P_1$ , determine how much the  $R_2$  is needed to completely react with  $R_1$
- Based on that calculated value, determine whether there is enough  $R_2$  to completely react with  $R_1$
- If the amount of  $R_2$  is less than what is needed, then  $R_2$  is the limiting
- If the amount of  $R_2$  is more than what is needed, then  $R_2$  is the excess

## Percent Yield, Theoretical Yield, and Actual

**Percent Yield** - describes how much product has been produced

$$\% = \frac{\text{actual yield}}{\text{theoretical yield}} \times 100\% \quad (3)$$

**Actual Yield** - the amount produced in the lab (potential errors)

**Theoretical Yield** - the maximum amount predicted from a given amount of reagents

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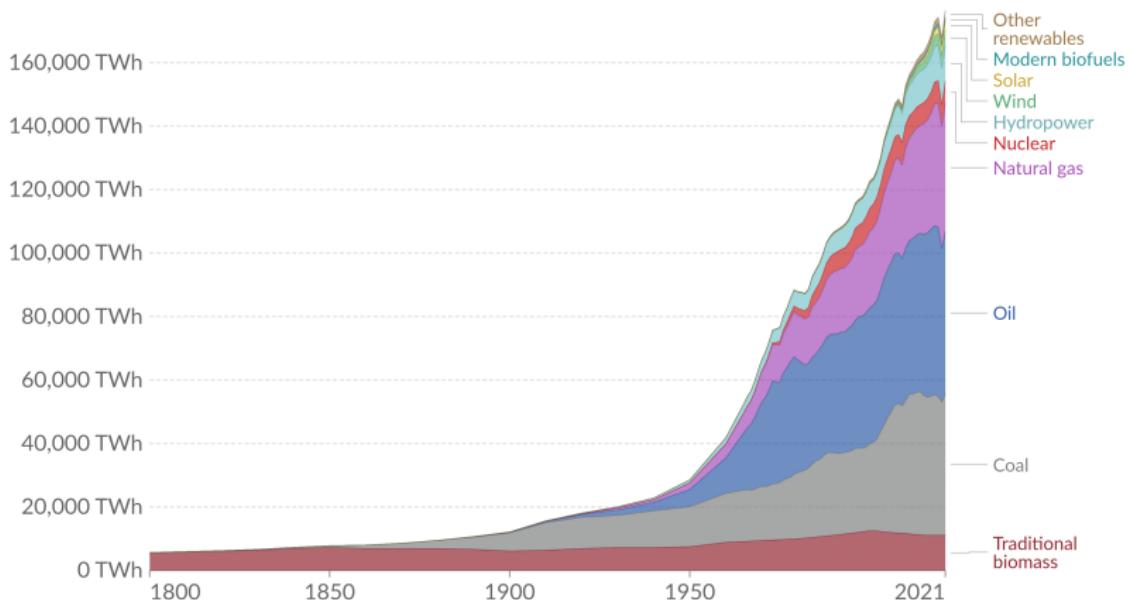
Calorimetry

# Global Energy Consumption

Our World  
in Data

## Global primary energy consumption by source

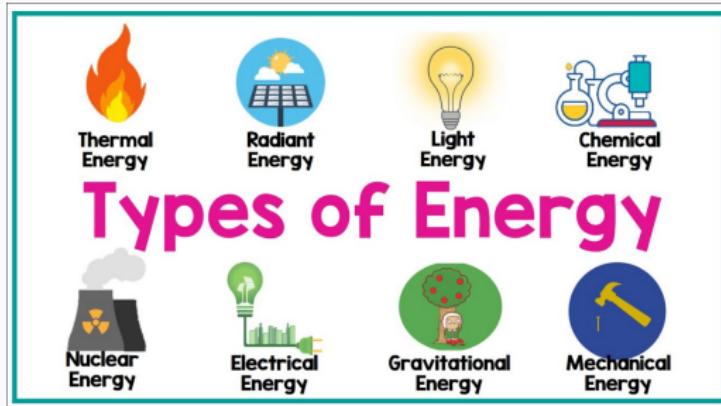
Primary energy is calculated based on the 'substitution method' which takes account of the inefficiencies in fossil fuel production by converting non-fossil energy into the energy inputs required if they had the same conversion losses as fossil fuels.



Source: Our World in Data based on Vaclav Smil (2017) and BP Statistical Review of World Energy

OurWorldInData.org/energy • CC BY

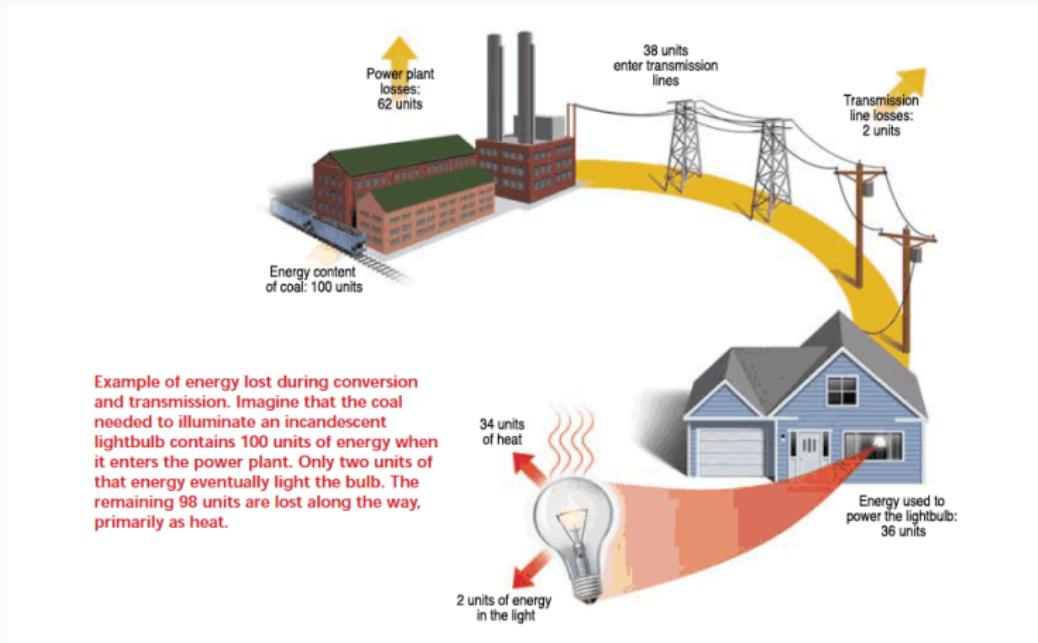
# Law of Conservation of Energy



**Energy is neither created nor destroyed**

- Energy can be converted from form to another e.g. mechanical, chemical, thermal, nuclear, electrical and vibrational energy
- Converting from one energy form to another is never 100% efficient; there is always a loss of energy

# Context: Energy Loss



Approximately only  $\sim 30\%$  efficiency

# Endothermic and Exothermic Reactions



**EXOTHERMIC**

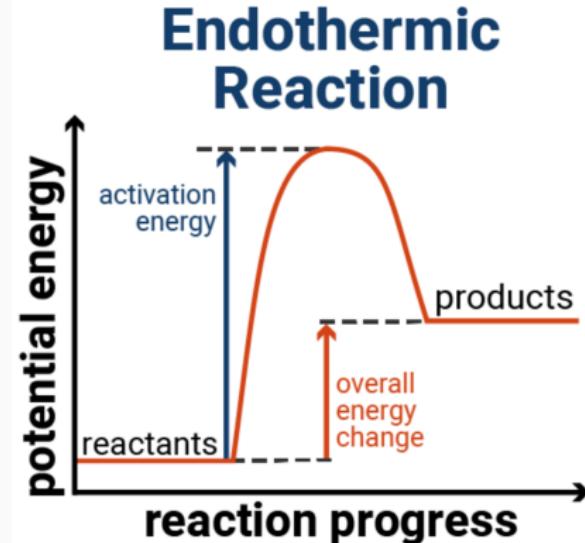


**ENDOTHERMIC**

**Exo** - external; exothermic reactions give off heat

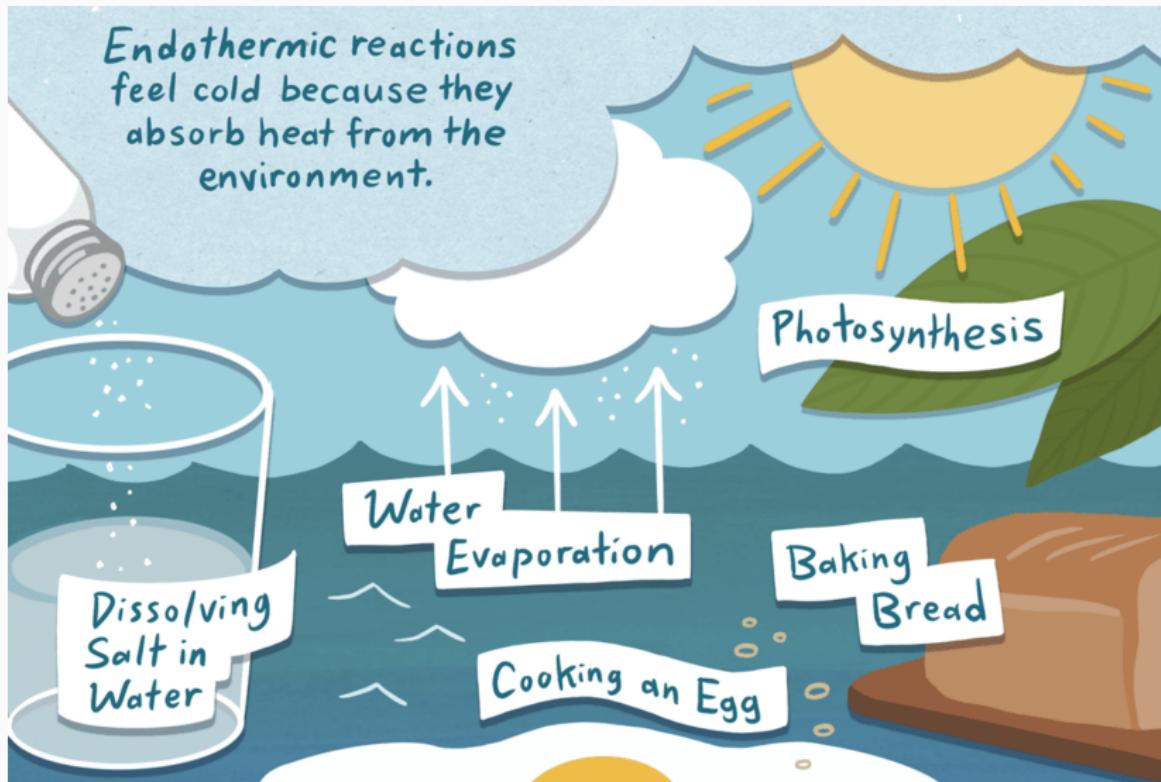
**Endo** - internal; endothermic reactions absorb heat

# Endothermic Reaction Diagram

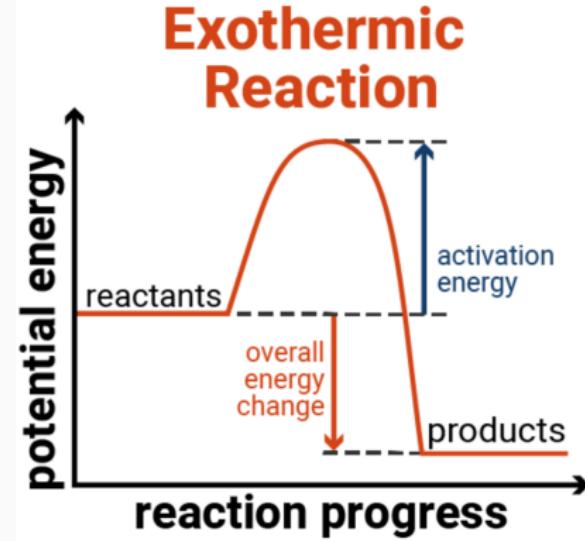


- Recall **Potential energy** - ability to do work;  
 $\Delta E_{\text{products}} > \Delta E_{\text{reactants}}$
- **Activation energy** - minimum energy to start the reaction;  
determines the rate at which the reaction undergoes

# Examples of Endothermic Reactions



# Exothermic Reaction Diagram



- Potential energy -  $\Delta E_{\text{products}} < \Delta E_{\text{reactants}}$
- Products are more stable than reactants since preference for lower energy state

# Examples of Exothermic Reactions



Water and  
Acid  
Reaction



Rusting



Campfire

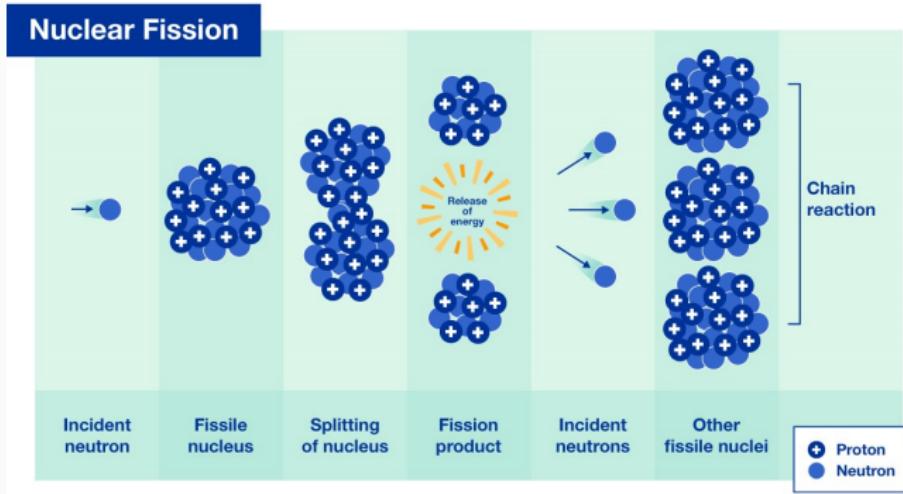


Freezing  
Water  
Into Ice



Nuclear Fission

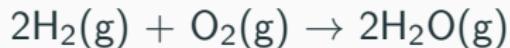
# Nuclear Fission



- **Nuclear fission** - releases energy where the nucleus of an atom splits into two or smaller nuclei
- U-235 atoms breaking down to release up to 200 million eV ( $4.6 \times 10^9$  kcal/mol)
- **Context** - 9.71 kcal/mol to boil water

## Practice: Endothermic and Exothermic Reactions

Consider the following reaction:



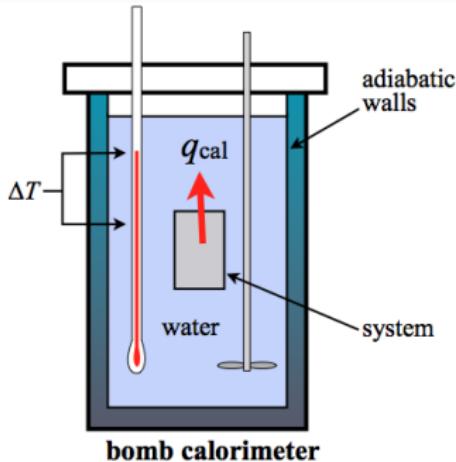
- a) Is this reaction endothermic or exothermic?
- b) Is the reverse reaction endothermic or exothermic?
- c) For the products or reactants, which ones have the higher potential energy?

## Familiarize: Units of Energy

$$4.184 \text{ J} = 1 \text{ Cal}$$

- “Calories” used on food items should not be confused with the “calorie” used in chemistry
- $1 \text{ Cal} = 1000 \text{ cal}$

# Calorimetry

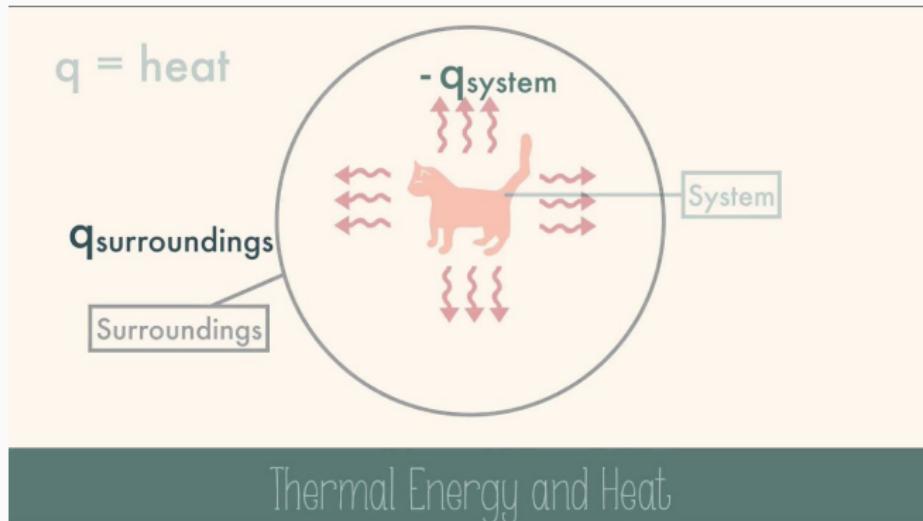


$$q = mC\Delta T \quad (4)$$

where  $q$  is heat,  $m$  is the mass (g),  $C$  is specific heat capacity ( $^{\circ}\text{C/g}$ ) and  $T$  is temperature ( $^{\circ}\text{C}$ )

- Performed at constant-pressure (atmospheric pressure)
- Bomb Calorimeter is Insulated where the heat evolved by the reaction is absorbed by the water
- **Specific Heat Capacity** - the amount of heat ( $q$ ) required to heat an object  $1^{\circ}\text{C/g}$

# Relating Conservation of Energy



$$q_{\text{system}} + q_{\text{surrounding}} = 0 \text{ where } q \text{ is the heat}$$

Negative sign indicate released heat and positive sign indicates absorbed heat

## Example: Calorimetry

A brick is placed in an insulated calorimeter containing 5,000 kg of water. The temperature of the water decreases from  $25.0^{\circ}\text{C}$  to  $19.4^{\circ}\text{C}$  when thermal equilibrium is reached

- Was the initial temperature of the brick greater than or less than the initial temperature of the water? Explain.
- What is the heat change  $q$  of the brick? Specific heat capacity of water is  $4.184 \text{ J}/(\text{g } ^{\circ}\text{C})$ .

## Practice: Heating Metal Alloy

A sample of metal alloy is heated and then placed in 125.0g of water held in a calorimeter at  $22.5^{\circ}\text{C}$ . The final temperature of the water is  $29.0^{\circ}\text{C}$ . Assume heat exchange only occurs between the water and alloy.

- a) Was the initial temperature of the alloy  $>$  or  $<$  the initial temperature of the water? Explain
- b) What is the heat change of the alloy? Specific heat capacity of water is  $4.184 \text{ J}/(\text{g } ^{\circ}\text{C})$ .

## Example: Relating to Chemical Reactions

Ethanol ( $\text{CH}_3\text{CH}_2\text{OH}$ ) burns in excess oxygen. The heat change  $q$  for the reaction is  $-1367 \text{ kJ/mol}$ .

- Is this reaction endothermic or exothermic?
- What is the heat change when  $0.200 \text{ mol}$  of  $\text{CH}_3\text{CH}_2\text{OH}$  burns?

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  - b) What is the heat change when 0.200 mol of  $\text{CH}_3\text{CH}_2\text{OH}$  burns?
- a)** Exothermic

## Example: Relating to Chemical Reactions

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- Is this reaction endothermic or exothermic?
  - What is the heat change when  $0.200 \text{ mol}$  of  $\text{CH}_3\text{CH}_2\text{OH}$  burns?
- a) Exothermic  
b)

$$0.200\text{mol } \text{CH}_3\text{CH}_2\text{OH} \times \frac{-1367\text{kJ}}{1\text{mol } \text{CH}_3\text{CH}_2\text{OH}} = -273\text{kJ}$$

## Practice: Combination Reaction

Consider the combination reaction of hydrogen gas and solid iodine. The heat change  $q$  for this reaction is +53.00 kJ/mol.

- Is this reaction endothermic or exothermic?
- What is the heat change when 2.50 mol of  $I_2$  reacts?