Chapter 15 Part 2

Warm Up

- How much energy is required to raise 50 g of water by 10.5 °C?

- If you were told that it required 44.7 kJ/mol for NaOH to dissolve in water and you were supplied with 0.5 mols of NaOH. Can you figure out how to find the energy required?

Today's Agenda

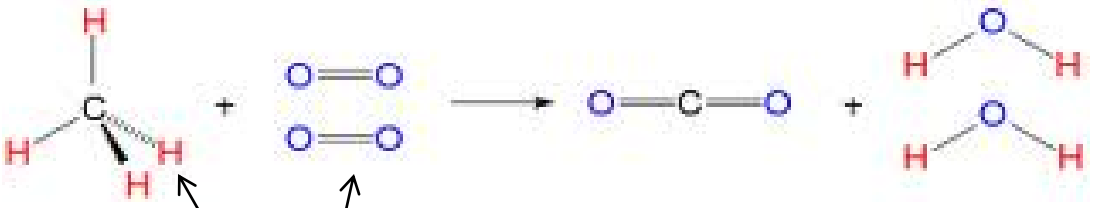
- QOTD: What is enthalpy and how do we calculate the energy associated with a chemical reaction?

- Enthalpy
- Calculating ΔH

- Homework – Chapter 15 80-94 evens

Chemical Potential Energy

- Energy that is stored in a substance because of its chemical composition.



Energy is stored in bonds

Breaking bonds COSTS energy

Forming bonds RELEASES energy

Enthalpy (H)

- Heat content of a system at a constant pressure.

- Change in enthalpy for a reaction – ΔH_{rxn}
  - ΔH_{rxn} represents the energy that is either **REQUIRED** or **RELEASED** in order to break bonds and form new ones

Enthalpy of Formation (H_f)

- Energy change during the formation of substance from the elements.

- ΔH_f for elements = 0 kJ/mol

Examples include C, O_2, Cl_2 all have ZERO enthalpy of formation!

We can use tablulated values of ΔH_f to find enthalpy for reactions!

Endothermic vs. Exothermic Reactions

- Remember, chemical reactions are EITHER:

- Endothermic – energy **REQUIRED**
  - The reactants need energy. Heat is a reactant!
  - $H_{products} > H_{reactants}$
- Exothermic – energy **RELEASED**
  - The reactants release energy. Heat is a product!
  - $H_{products} < H_{reactants}$

Calculating ΔH_{rxn}

- Equation:

$$\Delta H_{rxn} = \Sigma n \Delta H_{products} - \Sigma n \Delta H_{reactants}$$

Stoichiometric coefficients from balanced equation!

The total energy for the reaction is the difference between the enthalpy of forming products and breaking up reactants.

Sign of ΔH

- If energy is left over after a reaction has completed:
  - Reaction is EXOTHERMIC and ΔH_{rxn} is negative!
  - Heat is a product.
- If energy must be added to reactants for the reaction to proceed
  - Reaction is ENDOTHERMIC and ΔH_{rxn} is positive!
  - Heat is a reactant.

Calculating ΔH_{rxn}

$$H_2S + 4F_2 \rightarrow 2HF + SF_6$$

ΔH_{H2S} = -21 kJ/mol

ΔH_{HF} = -273 kJ/mol

ΔH_{SF6} = -1220 kJ/mol

ΔH_{F2} = 0 kJ/mol (remember its elemental!)

Your Turn

ΔH_{C8H18} = -49.8 kJ/mol

ΔH_{CO2} = -393.5 kJ/mol

ΔH_{H2O} = -241.8 kJ/mol

ΔH_{O2} = 0 kJ/mol (remember its elemental!)

What is the ΔH_{rxn} for the combustion of octane?

$$2C_8H_{18} + 25\ O_2 \rightarrow 16\ CO_2 + 18\ H_2O$$

Use ΔH_{rxn} to solve for ΔH_f

$CaCO_3 \rightarrow CaO + CO_2$ $\Delta H_{rxn} = 178.1$ kJ/mol

$\Delta H_{CaO} = -635.5$ kJ/mol

$\Delta H_{CO2} = -393.5$ kJ/mol

What is ΔH_{CaCO3}?

Warm Up!

- Identify the products and reactants

$$C_2H_{4\,(g)} + H_{2\,(g)} \rightarrow C_2H_{6\,(g)}$$

- Find ΔH_{rxn}

ΔH_{C2H4} = 52.3 kJ/mol

ΔH_{H2} = 0 kJ/mol

ΔH_{C2H6} = -84.7 kJ/mol

Today's Agenda

- QOTD: How can we use enthalpy as a conversion factor to determine energy output?

- Enthalpy of solution
- Energy conversion problems

- Molarity Lab Due today (worksheet only)

Molar Heat of Solution (ΔH_{soln})

- As a compound dissolves, energy is released or absorbed in the solvation process.

Example:

$$NaOH \rightarrow Na^{+} + OH^{-}$$

Practice Problem

- What is the heat change when 80 g of NaOH dissolves in water (ΔH_{soln} = -44.5 kJ/mol)?

$$NaOH \rightarrow Na^{+} + OH^{-} + 44.5\ kJ/mol$$

Use enthalpy as a conversion factor:

1. 80g → convert to moles!
2. Use moles and convert to kJ with enthalpy!

Your Turn!

- What is the heat change when 25 g of HCl is solvated (ΔH_{soln} = -74.84 kJ/mol)?

- How much heat energy is created when 380 g of CH_3OH combusts if ΔH_{comb} = -726.5 kJ/mol?

Calorimetry of Solvation

- If you dissolve 5 g of KOH (ΔH_{soln} = -57.61 kJ/mol) in 35 g of water in a calorimeter. What temperature change should you observe?

- Find q for solvation
- $q_{solvation} = mc\Delta T$ (**You must ADD masses of solid and water!**)
- Solve for ΔT

Practice Problems

- An aqueous ammonia (NH_3) solution is created by adding 8 g of NH_3 to 100 g of water. What is the temperature change observed if the ΔH_{soln} = -30.5 kJ/mol?

- How many grams of table salt (NaCl) were added to water to change the temperature by 5 °C if the total mass is 23 g (ΔH_{soln} = 3.88 kJ/mol)?

Mixed Review Warm Up

- Write and balance the combustion of C_3H_8
- Find ΔH_f for C_3H_8 using the following info:

ΔH_{H2O} =-241.8 kJ/mol, ΔH_{CO2} = -393.5 kJ/mol, ΔH_{O2} = 0 kJ/mol, and ΔH_{rxn} = 2200 kJ/mol.

What is the temperature change associated with the solvation of 10 g of NaOH in 300 g of water? ΔH_{soln} = -44.7 kJ/mol)

How many grams of C_3H_8 must you use to heat 105 L of water from 20 – 600 °C? ΔH_{rxn} = 2200 kJ/mol

Agenda for Monday

- Review for Quiz!

- Quiz tomorrow – using Enthalpy as a conversion factor, using heat as fuel, and $\Delta H_{rxn} = \Sigma n \Delta H_{products} - \Sigma n \Delta H_{reactants}$
- Quiz Review worksheet due tomorrow.

Energy for Fuel

- Ethanol is considered as an alternative fuel source. How much energy does it output??
- You use ethanol (C_2H_6O) as fuel to heat 50 L of water from 18 °C to 86 °C (ΔH_{comb} = -726.5 kJ/mol for ethanol). How much ethanol must you burn?

- Find energy needed for water and then use ΔH as a conversion factor.

Compare to Octane

- Now you use octane (C_8H_{18}) as a fuel to heat 50 L of water from 15 °C to 83 °C (ΔH_{comb} = -5074.2 kJ/mol for octane). How much octane must you burn?

- Now try propane C_3H_8 (ΔH_{comb} = -2200 kJ/mol for propane)…

- Which fuel is most efficient? Why