Supplemental Activities

Module: Thermodynamics

Section: Hess's Law

Thermochemical Equations

ACTIVITY 1

A thermochemical equation is a chemical reaction written with the corresponding enthalpy change. The purpose of this activity is to recall information about thermochemical equations.

1. Here is a thermochemical equation for the combustion of cyclohexane at room temperature:

   C_6H_{12} (l) + $9O_2$ (g) → $6CO_2$ (g) + $6H_2O$ (l) ΔH = –3920 kJ $mol^{-1}rxn^{-1}$

   What would happen to the value of the enthalpy if you reversed the chemical process (switched reactants and products)? What would happen to the value of the enthalpy if you reduced each of the stoichiometruc coefficients by a factor of 3?

2. Do you think the value of the change in enthalpy for the thermochemical equation is temperature dependent? Why or why not?

ACTIVITY 2

The purpose of this activity is to recall using thermochemical equations in a different format.

1. Here is the same thermochemical equation:

   C_6H_{12} (l) + $9O_2$ (g) → $6CO_2$ (g) + $6H_2O$ (l) ΔH = –3920 kJ $mol^{-1}rxn^{-1}$

   How could you write this thermochemical equation differently but still provide the value for the change in enthalpy of the reaction?

2. For the two formats of thermochemical equations, how can you determine if the reaction is endothermic or exothermic?

ACTIVITY 3

The purpose of this activity is to practice using thermochemical data and reaction stoichiometry to answer quantitative questions given a thermochemical equation.

1. How much heat is released when 8.40 g of C_6H_{12} is combusted according to the equation below?

   C_6H_{12} (l) + 9O_2 (g) → 6CO_2 (g) + 6H_2O (l) ΔH = –3920 kJ $mol^{-1}rxn^{-1}$

Hess's Law

ACTIVITY 1

An application of Hess's law is the ability to algebraically manipulate and then add thermochemical equations to net out a desired reaction. The method is similar to combining linear equations to solve for variables. The purpose of this activity is to recall how Hess's law allows us to manipulate thermochemical equations.

1. State Hess's Law and discuss its implication when calculating the change in enthalpy of a reaction.

2. Show how you would manipulate the listed thermochemical equations to get the desired reaction for the synthesis of anhydrous aluminum chloride, which is written:

   2Al (s) + 3Cl_2 (g) → 2$AlCl_3$ (s)

ΔH_1	2Al (s) + 6HCl (aq) → 2$AlCl_3$ (aq) + 3H_2 (g)	–149 kJ $mol^{-1}rxn^{-1}$
ΔH_2	HCl (g) → HCl (aq)	–74 kJ $mol^{-1}rxn^{-1}$
ΔH_3	H_2 (g) + Cl_2 (g) → 2HCl (g)	–185 kJ $mol^{-1}rxn^{-1}$
ΔH_4	$AlCl_3$ (s) → $AlCl_3$ (aq)	–323 kJ $mol^{-1}rxn^{-1}$

3. Calculate the reaction enthalpy for the synthesis of anhydrous aluminum chloride using the thermochemical data provided with the thermochemical equations.

ACTIVITY 2

Another application of Hess's law is to use formation reaction data for the reactants and compounds in a given chemical change to calculate the change in enthalpy for the desired reaction. The purpose of this activity is to recall information about formation reactions.

1. A formation reaction is a chemical reaction that produces __________ mole of a substance from its __________.

2. How is a value calculated for standard conditions noted in its abbreviation?

3. Was the reaction given for the synthesis of anhydrous aluminum chloride in the previous activity (question#2) a formation reaction? Why or why not? If not, please correct the equation so that it is a formation reaction.

ACTIVITY 3

The purpose of this activity is to practice using Hess's Law with enthalpy of formation data to calculate the standard change in enthalpy for a given reaction.

1. Write the formation reaction for hydrogen sulfide gas (assume standard conditions) from solid sulfur (monatomic) and hydrogen gas.

2. Look up the value for the enthalpy of formation for hydrogen sulfide from a thermodynamic data table.

3. Use the enthalpies of formation from a thermodynamic data table to calculate the enthalpy for the combustion of hydrogen sulfide gas in oxygen when the products are sulfur dioxide gas and gaseous water.

ACTIVITY 4

Another method that can be used to estimate the change in enthalpy for a reaction is to use bond energy (enthalpy) data. The purpose of this activity is to practice using bond energy data to estimate the change in enthalpy for a reaction.

1. Bond energy is the energy required to break the bonds in __________ mole of a substance in the __________ phase.

2. __________ bonds is an endothermic process while __________ bonds is an exothermic process.

3. Use a bond energy table to ***set-up*** the change in enthalpy for the combustion of hydrogen sulfide as you wrote it in the previous activity (question #3). Don't actually solve! Consider both resonance structures of SO_2. What does that mean for the bond energy of the sulfur–oxygen bonds?

4. What are the three methods discussed in this supplemental worksheet that allow you to calculate the change in enthalpy of a reaction? Which two give the most similar answers and why does the third method sometimes provide a different value than the other two?