Science Starter

If a substance required 2,364 Joules to melt 2.9 grams of the substance, determine the heat of fusion of the substance in J/g.

The substance has a molar mass of 36.87g/mol, determine the molar heat of fusion.

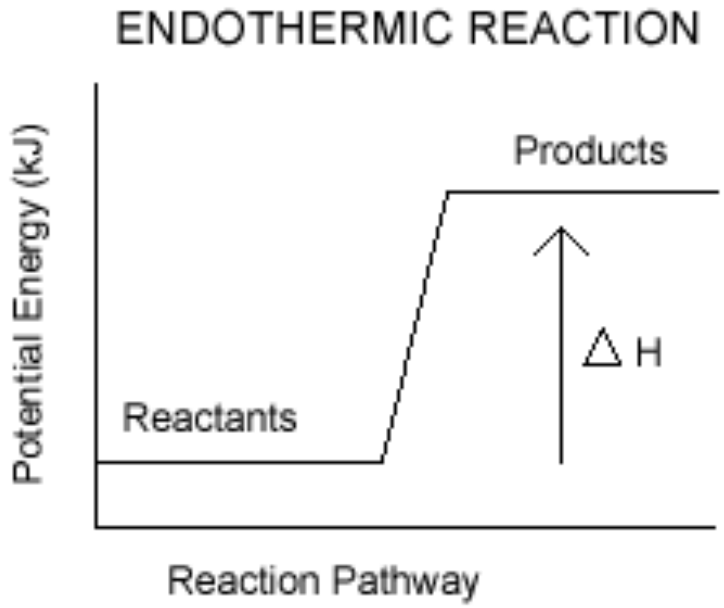
Thermochemical Equations & Heats of Formation

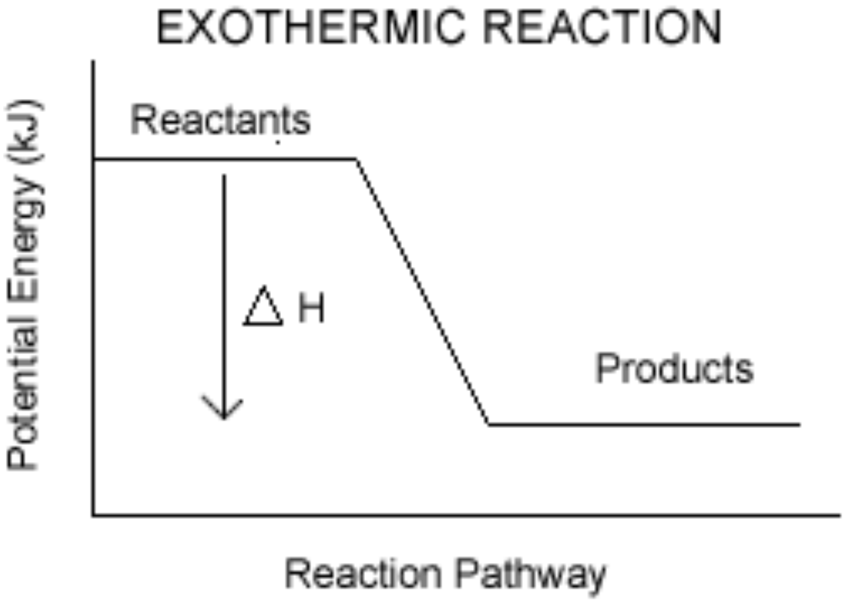
Arbor Prep Chemistry

Energies with Reactions

- For a change to occur, a system must either obtain or release energy in respect to it’s surroundings.
  - A car cannot move unless it uses the energy released from the combustion of gasoline.
  - No Coffee → Grumpy Teacher

Endothermic vs. Exothermic





Thermochemical Equations

- A chemical equation can have the energy associated in the reaction as a reactant or a product.
  - If the reaction has energy as a reactant, is it endothermic or exothermic?
  - If the reaction has energy as a product, is it endothermic or exothermic?

$$CaO(s) + H_2O(l) \longrightarrow Ca(OH)_2(s) + 65.2\ kJ$$

- The above reaction has energy in the equation itself. This is known as a thermochemical equation.

Heat of a Reaction

- Heat of a reaction = Enthalpy shown for the reaction
  - This reaction releases 65.2 KJ for every mole of CaO and H_2O that reacts. Write the thermochemical equation of this reaction.

$$CaO(s) + H_2O(l) \longrightarrow Ca(OH)_2(s) \qquad \Delta H = -65.2\ kJ$$

- How about the decomposition of sodium bicarbonate?

$$2NaHCO_3(s) \longrightarrow Na_2CO_3(s) + H_2O(g) + CO_2(g) \qquad \Delta H = 129\ kJ$$

But the Whopper or the Slider?

- Energy is an extensive property, which means that it depends on the amount of matter that is present.
  - A whopper from BK is going to have more energy than a slider from WC.
- Therefore the amount of energy is solely dependent on the amount of either reactants or products that is in needed in the chemical reaction.

Simple Energy Calculations

- If it takes 12 KJ to react one mole of something, how much energy does it take to react 3 moles of that item?

- How about 0.5 moles?

Practice with Thermochemical Reactions

How much heat will be absorbed when 13.7 g of Nitrogen reacts with excess O_2 according to the following equation?

$N_2 + O_2 \rightarrow 2NO \quad \Delta H° = -180kJ$

How much heat will be transferred when 14.9 g of ammonia reacts with excess O_2 according to the following equation? $4NH_3 + 5O_2 \rightarrow 4NO + 6H_2O \quad \Delta H° = -1170kJ$

Heat of Formation Values

- To produce a compound a standard heat of formation is the change in enthalpy that accompanies the formation of 1 mole of the compound from its elements. (ΔH_f)

Standard Heats of Formation (ΔH_f^0) at 25°C and 101.3 kPa

Substance	ΔH_f^0 (kJ/mol)	Substance	ΔH_f^0 (kJ/mol)
$Al_2O_3(s)$	−1676.0	$H_2O_2(l)$	−187.8
$Br_2(g)$	30.91	$I_2(g)$	62.4
$Br_2(l)$	0.0	$I_2(s)$	0.0
C(*s*, diamond)	1.9	$N_2(g)$	0.0
C(*s*, graphite)	0.0	$NH_3(g)$	−46.19
$CH_4(g)$	−74.86	$NO(g)$	90.37
$CO(g)$	−110.5	$NO_2(g)$	33.85
$CO_2(g)$	−393.5	$NaCl(s)$	−411.2
$CaCO_3(s)$	−1207.0	$O_2(g)$	0.0
$CaO(s)$	−635.1	$O_3(g)$	142.0
$Cl_2(g)$	0.0	P(*s*, white)	0.0
$Fe(s)$	0.0	P(*s*, red)	−18.4
$Fe_2O_3(s)$	−822.1	S(*s*, rhombic)	0.0
$H_2(g)$	0.0	S(*s*, monoclinic)	0.30
$H_2O(g)$	−241.8	$SO_2(g)$	−296.8
$H_2O(l)$	−285.8	$SO_3(g)$	−395.7

Heats of Combustion

Heat of combustion if the amount of energy associated with combusting one mole of the reactant.

Heats of Combustion at 25°C		
Substance	**Formula**	**ΔH (kJ/mol)**
Hydrogen	$H_2(g)$	−286
Carbon	$C(s)$, graphite	−394
Methane	$CH_4(g)$	−890
Acetylene	$C_2H_2(g)$	−1300
Ethanol	$C_2H_5OH(l)$	−1368
Propane	$C_3H_8(g)$	−2220
Glucose	$C_6H_{12}O_6(s)$	−2808
Octane	$C_8H_{18}(l)$	−5471
Sucrose	$C_{12}H_{22}O_{11}(s)$	−5645

But Wait!

Think of an element in its natural state. Does it need energy to form from it's naturally occuring state?

No, therefore any element in its natural state has a Heat of Formation of 0.

Change

- To determine the heat of a reaction you must account for the reaction's change in heat.
- Change is always final (products) - initial (reactants)
- Make sure your equation is balanced ☺
- Little details make a HUGE difference!
    - Check the physical states of compounds.
    - Also check the amount of each compound. This can make a difference too!

So let's try this together...

Calculating the Standard Heat of Reaction:

What is the standard heat of reaction for the reaction of CO (*g*) with O_2(*g*) to form CO_2(*g*)?

Calculate the heat of reaction for the following reactions:

$Br_2(g) \rightarrow Br_2(l)$

$CaCO_3(s) \rightarrow CaO(s) + CO_2(g)$

$2NO(g) + O_2(g) \rightarrow 2NO_2(g)$

Cumulative Practice

When Aluminum Oxide is formed from its elements, heat is released. Calculate the amount of heat released when 5.66 g of Aluminum Oxide is formed.

(hint: first write a balanced chemical equation. Once you have that-determine how much energy is associated with the "perfect world" amounts. Then use that to assist you in determining the amounts that are actually given)