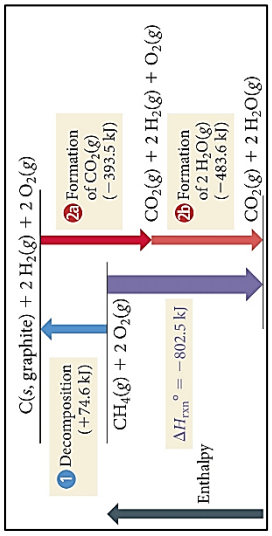
N4 – Thermochemistry – Heat of Formation

Practice #1 - Calculate ΔH for the combustion of methane, CH_4 **$CH_4(g) + 2O_2(g) \rightarrow CO_2(g) + 2H_2O(l)$**

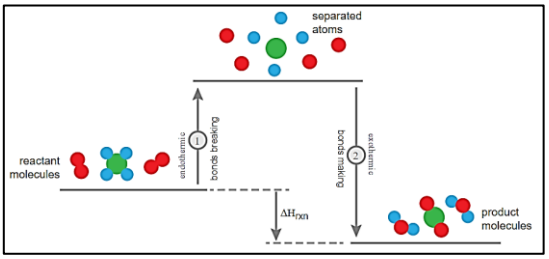
Formula	ΔH_f (kJ)
CH_4	-74.80
O_2	0
CO_2	-393.50
H_2O	-285.83



Practice #2 - Ethanol is used as an additive in many fuels today. What is ΔH°_{rxn} (kJ) for the combustion of ethanol?

$2\ C_2H_5OH\ (l) + 6\ O_2\ (g) \rightarrow 4\ CO_2\ (g) + 6\ H_2O\ (l)$

Formula	ΔH°_f
C_2H_5OH (*l*)	–277.6
CO_2 (*g*)	–393.5
H_2O (*g*)	–241.8
H_2O (*l*)	–285.8



Practice #3 – What is the enthalpy of formation for the equation below, using the table of bond energies provided.

Single Bond Energies (kJ/mol of bonds)

	H	C	N	O	S	F	Cl	Br	I
H	436								
C	413	346							
N	391	305	163						
O	463	358	201	146					
S	347	272	—	—	226				
F	565	485	283	190	284	155			
Cl	432	339	192	218	255	253	242		
Br	366	285	—	201	217	249	216	193	
I	299	213	—	201	—	278	208	175	151

Multiple Bond Energies (kJ/mol of bonds)

C=C 602	C=N 615	C=O 799
C≡C 835	C≡N 887	C≡O 1072
N=N 418	N=O 607	
N≡N 945	O=O 498	

N3 – Thermochemistry – Hess's Law

Definitions

Hess's Law

"In going from a particular set of reactants to a particular set of products, the change in enthalpy is the same whether the reaction takes place in one step or a series of steps."

Add Reactions *+ ΔH's*
Multiplying a Rxn by a factor *x ΔH by the factor*
Reversing a Rxn *- ΔH*
(opposite sign, not necessarily a negative value)

Standard State

- Pure gas at 1 atm pressure
- Pure solid or liquid in its most stable form at 1 atm, and temp of interest (usually 25°C)
- Substances in a solution with a [ ] of 1M

Hess's Law #1

#	Reaction	ΔH°
1	$C + 2H_2 \rightarrow CH_4$	-74.80 kJ
2	$C + O_2 \rightarrow CO_2$	-393.50 kJ
3	$H_2 + ½\ O_2 \rightarrow H_2O$	-285.83 kJ

Hess's Law #2

Rxn #1) **$½\ N_2\ (g) + ½\ O_2\ (g) \rightarrow NO\ (g)$**
$\Delta H = 90.3$ kJ

Rxn #2) **$NO\ (g) + ½\ Cl_2\ (g) \rightarrow NOCl\ (g)$**
$\Delta H = -38.6$ kJ

Hess's Law #3

Rxn #1) **$3Fe_2O_3 + CO\ (g) \rightarrow 2Fe_3O_4 + CO_2\ (g)$**
$\Delta H^{\circ} = -47$ kJ

Rxn #2) **$Fe_2O_3 + 3CO\ (g) \rightarrow 2Fe\ (s) + 3CO_2\ (g)$**
$\Delta H^{\circ} = -25$ kJ

Rxn #3) **$Fe_3O_4 + CO\ (g) \rightarrow 3FeO\ (s) + CO_2\ (g)$**
$\Delta H^{\circ} = 19$ kJ

You should notice that I put these in backwards order. That makes it easier to cut them out without the whole thing falling out of your binder!

N2 – Thermochemistry – A Review

Some Background Knowledge Definitions
Not all the definitions from the notes – you still have to take notes!
Energy – capacity to do work or produce heat
Potential Energy – due to position or composition
Kinetic Energy - due to motion
Electrical Energy – flow of electrical charge
Thermal Energy – molecular motion
Light/Radiant Energy – energy transitions in an atom
Nuclear Energy – potential energy in atomic nuclei
Chemical Energy – due to structure of atoms/bonds
Law of Conservation of Energy – cannot create or destroy energy
1st Law of Thermodynamics – total energy content of universe is constant
State Function – depends only on present state, not pathway to get there

Endothermic	
System absorbs energy	Surroundings release energy
System energy increases	Surrounding energy decreases
$+ q_{system}$	$- q_{surroundings}$
If you touch the container YOU feel cold – the system is taking heat away from YOU! Your thermometer is in the SURROUNDINGS so the temperature it reads decreases!	

Exothermic	
System releases energy	Surroundings gain energy
System energy decreases	Surrounding energy increases
$- q_{system}$	$+ q_{surroundings}$
If you touch the container YOU feel hot – the system is releasing heat towards YOU! Your thermometer is in the SURROUNDINGS so the temperature it reads increases!	

Q#1 Identical amounts of heat are applied to 50 g blocks of lead, silver, and copper, all at an initial temp of 25°C. Which block will have the largest increase in temp?

Q#2 Determine the energy required to convert 21.1 grams of ice at -6°C to steam at 100°C

Q#3 A sample of barium chloride is increased in temperature by 3.8C when the sample absorbed 2.4×10^2J of heat energy. Calculate the number of mole sof barium chloride in the sample if its molar heat capacity is 75.1 J/mol•K

Q#4 The temperature of a 700.0-g bar of iron decreases by 10.0°C when the iron is plunged into 500.0 g of water. What is the temperature increase of the water, assuming that no heat is lost in the transfer? (C_{Fe} = 0.45 J/g°C)

Q#5 50.0 g of water at 22 °C is mixed with 125 g of water initially at 36 ° C. What is the final temperature of the water after mixing, assuming no heat is lost to the surroundings?