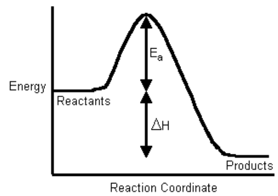
Thermochemistry Review

1. A reaction has a heat of reaction of +25 kJ/mol and an activation energy of 40 kJ/mol. What is the activation energy for the reverse reaction?

- Draw an enthalpy diagram, see that activation energy is 40kJ/mol
- Overall enthalpy of the reaction is 25kJ/mol
- The exothermic portion of the graph is therefore -15kJ/mol
- The reverse activation energy is the output of the forward reaction therefore 15kJ/mol

2. Determine the equation (including the enthalpy) of the formation of HF from its elements. Discuss the energy in and out.

$H_2 + F_2 \rightarrow 2HF$



$\Delta H = \Sigma(nH)_p - \Sigma(nH)_r$
$\Delta H = (2mol \times -273.3kJ/mol) - (0+0)$
$\Delta H = -546.6kJ$ = exothermic

3. Determine the equation (including enthalpy) of the decomposition of liquid sulfur trioxide into sulfur dioxide and oxygen. What is the energy of reacting 6.0g of Sulfur trioxide?

$2SO_3(l) + 288.4kJ \rightarrow 2SO_2(g) + O_2(g)$

$\Delta H = \Sigma(nH)_p - \Sigma(nH)_r$
$\Delta H = (2mol \times -296.6kJ/mol) - (2mol \times -441.0kJ/mol)$
$\Delta H = 288.4kJ$ (endothermic)

$\Delta H = nH_m$
$\Delta H = (6.0g \times 1mol/80.07g)(288.4kJ/2mol\ SO_3)$ ***remember to use Hrxn***
$\Delta H = 10.8kJ$

4. Determine the molar enthalpy of combustion of ethane. Compare it with the molar enthalpy of combustion of gasoline (octane)

$C_2H_6(g) + {}^{7/2}O2(g) \rightarrow 2CO_2(g) + 3H_2O(g)$

$\Delta H = \Sigma(nH)_p - \Sigma(nH)_r$
$\Delta H = -1428.4kJ$

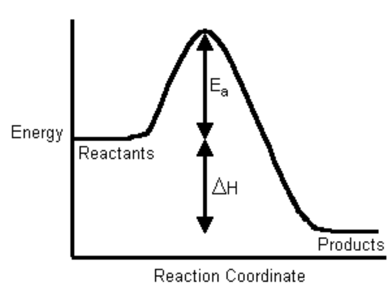
$C_8H_{18}(l) + 25O_2(g) \rightarrow 8CO_2(g) + 9H_2O(g)$

$\Delta H = \Sigma(nH)_p - \Sigma(nH)_r$
$\Delta H = -5074.2kJ$

5. What mass of acetylene, $C_2H_2(g)$, must be burned to release 1.00 MJ of energy.

$C_2H_2(g) + O_2(g) \rightarrow 2CO_2(g) + 1H_2O(g)$

$\Delta H = \Sigma(nH)_p - \Sigma(nH)_r$
$\Delta H = -1256.2kJ$



$\Delta H = nH_m$
$-1000kJ = n(-1256.2kJ/1mol)$
$n = 0.796mol$

$\#g = 0.796mol \times 26.04g/mol$
$\#g = 20.7g$

6. When a 50.0 g sample of an unknown metal is heated from −10.0°C to 60.0°C, 452 J of energy is absorbed. What is the specific heat capacity of the metal?

$Q = mc\Delta T$
452J = 50.0g **c** (70°C)
c = 0.129J/g°C

7. When 30.0g of propane is burned, it heats a copper pot (weighing 250g) filled with 1.5L of water from 25-35 degrees in 3 minutes. What is the experimental molar enthalpy of combustion determined by the heating of the water? How efficient is this burner?

$C_3H_8(l) + 5O_2(g) \rightarrow 3CO_2(g) + 4H_2O(g)$

Experimental molar enthalpy

$nH_m = -(mc\Delta T_{pot} + mc\Delta T_{water})$
$(30g \times 1mol/44.11g)H_m = (250g \times 0.385 J/g°C \times 10°C) + (1500g \times 4.19\ J/g°C \times 10°C)$
$H_m = -93825.64583J$
$H_m = -\ 93.826kJ/mol$ propane

Theoretical molar enthalpy

$\Delta H = \Sigma(nH)_p - \Sigma(nH)_r$
$\Delta H = -2043.9kJ = -2043.9kJ/mol$ propane

$\Delta H = nH_m$
$\Delta H = (30g \times 1mol/44.11g)(-2043.9kJ/mol)$
$\Delta H = -1390.09kJ$
****INPUT****

$$\text{Efficiency} = \frac{\text{output (heat} = mc\Delta T)}{\text{input (chem. Rxn} = nH_m)} \times 100\% \quad \text{or} \quad \frac{\text{experimental}}{\text{theoretical}} \times 100\%$$

$$\text{Efficiency} = \frac{mc\Delta T + mc\Delta T}{\Delta H} \times 100\%$$

$$\text{Efficiency} = \frac{(0.250kg \times 0.385kJ/kg°C \times 10°C) + (1.5kg \times 4.19\ kJ/kg°C \times 10°C)}{-1390.09kJ} \times 100\%$$

Efficiency = 4.59%

8. Find the ΔH for the reaction below, given the following reactions and subsequent ΔH values:
$N_2(g) + 2O_2(g) \rightarrow 2NO_2(g)$

$N_2(g) + 3H_2(g) \rightarrow 2NH_3(g)$	ΔH = -115 kJ keep
$2NH_3(g) + 4H_2O(l) \rightarrow 2NO_2(g) + 7H_2(g)$	ΔH = -142.5 kJ keep
$H_2O(l) \rightarrow H_2(g) + 1/2O_2(g)$	ΔH = -43.7 kJ **(174.8kJ)** flip and x4

ΔH = -82.7kJ

9. Find the ΔH for the reaction below, given the following reactions and subsequent ΔH values:
$CO_2(g) \rightarrow C(s) + O_2(g)$

$H_2O(l) \rightarrow H_2(g) + 1/2O_2(g)$	ΔH = 643 kJ **(-964.5)**(flip x 3/2)
$C_2H_6(g) \rightarrow 2C(s) + 3H_2(g)$	ΔH = 190.6 kJ **(95.3)**(x ½)
$2CO_2(g) + 3H_2O(l) \rightarrow C_2H_6(g) + 7/2O_2(g)$	ΔH = 3511.1 kJ **(1755.55kJ)** (x ½)

H = 886.35kJ

8. The combustion of ethane can be expressed through the equation below:

$$C_2H_6(g) + {}^{7/2}O_2(g) \rightarrow 2CO_2(g) + 3H_2O(g)$$

Using Hess' law, prove that the formation reactions of ethane, carbon dioxide and water can be used to calculated the same reaction enthalpy as using **products - reactant**

$\Delta H = \Sigma(nH)_p - \Sigma(nH)_r$
ΔH = -1428.4kJ