Enthalpy of Reaction (ΔH_{rxn})

1 a) **$2\ CO(g)\ +\ O_2(g) \rightarrow 2\ CO_2(g)$**

$$\Delta H_{rx} = (2\text{ mol})(\Delta H_f\ CO_2) - (2\text{ mol})(\Delta H_f\ CO) - (1\text{ mol})(\Delta H_f\ O_2)$$

$$\Delta H_{rx} = (2\text{ mol})(-393.5\text{ kJ/mol}) - (2\text{ mol})(-110.5\text{ kJ/mol}) - (1\text{ mol})(0\text{ kJ/mol})$$

$$\underline{\underline{\Delta H_{rx} = -566.0\text{ kJ}}}$$

b) **$Cu(s)\ +\ 2\ H_2SO_4(aq) \rightarrow CuSO_4(s)\ +\ SO_2(g)\ +\ 2\ H_2O(l)$**

$$\Delta H_{rx} = (1\text{ mol})(\Delta H_f\ CuSO_4) + (1\text{ mol})(\Delta H_f\ SO_2) + (2\text{ mol})(\Delta H_f\ H_2O(l)) - (1\text{ mol})(\Delta H_f\ Cu) - (2\text{ mol})(\Delta H_f\ H_2SO_4)$$

$$\Delta H_{rx} = (1\text{ mol})(-771.4\text{ kJ/mol}) + (1\text{ mol})(-296.8\text{ kJ/mol}) + (2\text{ mol})(-285.8\text{ kJ/mol}) - (1\text{ mol})(0\text{ kJ/mol}) - (2\text{ mol})(-814.0\text{ kJ/mol})$$

$$\underline{\underline{\Delta H_{rx} = -11.8\text{ kJ}}}$$

c) **$N_2(g)\ +\ 3\ H_2(g) \rightarrow 2\ NH_3(g)$**

$$\Delta H_{rx} = (2\text{ mol})(\Delta H_f\ NH_3) - (1\text{ mol})(\Delta H_f\ N_2) - (3\text{ mol})(\Delta H_f\ H_2)$$

$$\Delta H_{rx} = (2\text{ mol})(-46.1\text{ kJ/mol}) - (1\text{ mol})(0\text{ kJ/mol}) - (3\text{ mol})(0\text{ kJ/mol})$$

$$\underline{\underline{\Delta H_{rx} = -92.2\text{ kJ}}}$$

d) **$Fe_2O_3(s)\ +\ 3\ CO(g) \rightarrow 2\ Fe(s)\ +\ 3\ CO_2(g)$**

$$\Delta H_{rx} = (2\text{ mol})(\Delta H_f\ Fe) + (3\text{ mol})(\Delta H_f\ CO_2) - (1\text{ mol})(\Delta H_f\ Fe_2O_3) - (3\text{ mol})(\Delta H_f\ CO)$$

$$\Delta H_{rx} = (2\text{ mol})(0\text{ kJ/mol}) + (3\text{ mol})(-393.5\text{ kJ/mol}) - (1\text{ mol})(-824.2\text{ kJ/mol}) - (3\text{ mol})(-110.5\text{ kJ/mol})$$

$$\underline{\underline{\Delta H_{rx} = -24.8\text{ kJ}}}$$

e) **$2\ SO_2(g)\ +\ O_2(g) \rightarrow 2\ SO_3(g)$**

$$\Delta H_{rx} = (2\text{ mol})(\Delta H_f\ SO_3) - (2\text{ mol})(\Delta H_f\ SO_2) - (1\text{ mol})(\Delta H_f\ O_2)$$

$$\Delta H_{rx} = (2\text{ mol})(-395.7\text{ kJ/mol}) - (2\text{ mol})(-296.8\text{ kJ/mol}) - (1\text{ mol})(0\text{ kJ/mol})$$

$$\underline{\underline{\Delta H_{rx} = -197.8\text{ kJ}}}$$

f) **$4\ NH_3(g)\ +\ 5\ O_2(g) \rightarrow 4\ NO(g)\ +\ 6\ H_2O(l)$**

$$\Delta H_{rx} = (4\text{ mol})(\Delta H_f\ NO) + (6\text{ mol})(\Delta H_f\ H_2O(l)) - (4\text{ mol})(\Delta H_f\ NH_3) - (5\text{ mol})(\Delta H_f\ O_2)$$

$$\Delta H_{rx} = (4\text{ mol})(90.2\text{ kJ/mol}) + (6\text{ mol})(-285.8\text{ kJ/mol}) - (4\text{ mol})(-46.1\text{ kJ/mol}) - (5\text{ mol})(0\text{ kJ/mol})$$

$$\underline{\underline{\Delta H_{rx} = -1169.6\text{ kJ}}}$$

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

ΔH_{rx} = (2 mol)(ΔH_f NO_2) – (2 mol)(ΔH_f NO) – (1 mol)(ΔH_f O_2)

ΔH_{rx} = (2 mol)(33.2kJ/mol) – (2 mol)(90.2kJ/mol) – (1 mol)(0 kJ/mol)

ΔH_{rx} = –114.0 kJ

h) **$Ca(s) + 2\ H_2O(l) \rightarrow Ca(OH)_2(s) + H_2(g)$**

ΔH_{rx} = (1 mol)(ΔH_f $Ca(OH)_2$) + (1 mol)(ΔH_f H_2) – (1 mol)(ΔH_f Ca) – (2 mol)(ΔH_f $H_2O(l)$)

ΔH_{rx} = (1 mol)(–986.1 kJ/mol) +(1 mol)(0 kJ/mol) – (1 mol)(0 kJ/mol) – (2 mol)(–285.8 kJ/mol)

ΔH_{rx} = –414.5 kJ

2) Calculate the amount of heat released when 15.0 g of methanol burns.

$CH_3OH(l) + \frac{3}{2} O_2(g) \rightarrow CO_2(g) + 2H_2O(l)$

ΔH_{rxn} = (1 mol)($CO_2(g)$) + (2 mol)($2H_2O(l)$) – (1 mol)($CH_3OH(l)$) – ($\frac{3}{2}$ mol)($O_2(g)$)

ΔH_{rxn} = (1 mol)(-393.5 kJ/mol) + (2 mol)(-285.8 kJ/mol) – (1 mol)(-238.6 kJ/mol) - ($\frac{3}{2}$ mol)(0 kJ/mol)

ΔH_{rxn} = -726.5 kJ

$$n = \frac{\text{mass}}{\text{molar mass}} = \frac{15.0\ g}{32.04216\ g/mol} = 0.468 \text{ mol methanol}$$

$$\frac{0.468 \text{ mol}}{1 \text{ mol}} = \frac{x}{-726.5 \text{ kJ}}$$

$x = -340.$ kJ

3) Calculate the mass of ethanol that must be burned in order to produce 20.0 kJ.

$C_2H_5OH(l) + 3O_2(g) \rightarrow 2CO_2(g) + 3H_2O(l)$

ΔH_{rxn} = (2 mol)($CO_2(g)$) + (3 mol)($H_2O(l)$) – (1 mol)($C_2H_5OH(l)$) – (3 mol)($O_2(g)$)

ΔH_{rxn} = (2 mol)(-393.5 kJ/mol) + (3 mol)(-285.8 kJ/mol) – (1 mol)(-277.1 kJ/mol) – (3 mol)(0 kJ/mol)

ΔH_{rxn} = -1367.3 kJ

$$\frac{1 \text{ mol}}{x} = \frac{-1367.3 \text{ kJ}}{-20.0 \text{ kJ}}$$

$x = 0.0146$ mol

mass = (mol)(mol mass) = (0.0146 mol)(46.06904 g/mol) = 0.674 g ethanol

4) One teaspoon of sugar has a mass of 5.00g.

a) Calculate the energy change when a person consumes 2.00 teaspoons of sugar.

$C_{12}H_{22}O_{11}(s) + 12O_2(g) \rightarrow 12CO_2(g) + 11H_2O(l)$

ΔH_{rxn} = (12 mol)($CO_2(g)$) + (11 mol)($H_2O(l)$) – (1 mol)($C_{12}H_{22}O_{11}(s)$) – (12 mol)($O_2(g)$)

ΔH_{rxn} = (12 mol)(-393.5 kJ/mol) + (11 mol)(-285.8 kJ/mol) – (1 mol)(-2225.5 kJ/mol) – (12 mol)(0 kJ/mol)

ΔH_{rxn} = -5640.3 kJ

$$n = \frac{\text{mass}}{\text{mol mass}} = \frac{10.0\ g}{342.30008\ g/mol} = 0.0292\ mol$$

$$\frac{1\ mol}{0.0292\ mol} = \frac{-5640.3\ kJ}{x}$$

$$x = -164.8\ kJ$$

b) Energy obtained from food is often reported in food calories, or Calories 1 Calorie (1 Cal) = 1 kilocalorie (1 kcal) = 1000 calories (1000 cal) = 4.18 kJ Calculate the number of food calories contained in 2.00 teaspoons of sugar.

$$\frac{x}{} = \frac{4.18\ kJ}{165\ kJ}$$

$$x = 39.4\ Cal$$

c) A 150.0 lb person walking at a moderate speed will burn 40.0 Cal while walking for 15.0 minutes. How long would this person have to walk to burn the Calories in 2.00 teaspoons of sugar? $\overline{1Cal}$

$$\frac{x}{} = \frac{40.0\ Cal}{39.4\ Cal}$$

$$x = 14.8\ minutes$$

5) Which sugar compound is more stable, glucose or sucrose? Explain.

Glucose ΔH_f = -1273.1 kJ/mol

Sucrose ΔH_f = -2225.5 kJ/mol

Both glucose and sucrose are very stable as evidenced by their large negative enthalpies of formation. Sucrose is more stable than glucose based on the large negative enthalpy of formation. $\overline{15.0min}$

6) What mass of hydrogen gas should be burned (under standard conditions) to heat 1.00 L of water from 10.0°C to 80.0°C?

$q = mc\Delta t$
$q = (1.00\ kg)(4.18$
$J/g°C)(70.0°C)$ $q = 296.6\ kJ$
∴the water requires 292.6 kJ
∴the combustion of hydrogen must supply 292.6
kJ $2H_2(g) + O_2(g) \rightarrow 2H_2O(l)$

$\Delta H_{rxn} = (2\ mol)(\ H_2O(l)) - (2\ mol)(\ 2H_2(g)) - (1\ mol)(\ O_2(g))$
$\Delta H_{rxn} = (2\ mol)(-285.8\ kJ/mol) - (1\ mol)(0\ kJ/mol) - (1\ mol)(0\ kJ/mol)$
$\Delta H_{rxn} = -571.8\ kJ$

$$x = \frac{-571.8\ kJ}{-292.6\ kJ}$$

$$mass = (mol)(mol\ mass) = (1.02\ mol)(20.1588\ g/mol) = 2.06\ g\ hydrogen$$

7) What would be the final temperature of 885 g water, initially at 25.0°C, if it were heated by the burning of 20.0 g of sulfur in excess oxygen to produce sulfur dioxide?

$S(s) + O_2(g) \rightarrow SO_2(g)$

$\Delta Hrxn = (1\ mol)(-296.8\ kJ/mol) - (1\ mol)(0\ kJ/mol) - (1\ mol)(0$
$kJ/mol)$ $\Delta Hrxn = -296.8\ kJ$

$$n = \frac{mass}{molmass} = \frac{20.0g}{32.066g/mol} = 0.624 mol Sulfur$$

$$\frac{1\ mol}{0.624\ mol} = \frac{-296.8\ kJ}{x}$$
$x = -185\ kJ$
∴ when 20.0 g of sulfur burns, 185 kJ is released

$q = mc\Delta c$
$185\ kJ = (0.885\ kg)(4.18\ J/g°C)(T - 25.0°C)$
$$\frac{(185)(kJ)}{(0.885\ kg)(4.18\ J/g°C)} = T - 25.0°C$$
$50.0°C = T - 25.0°C$
$$T = 75.0°C$$

8) When 4.00 g of ammonium chloride is formed from its elements, 23.5 kJ of energy is released.

a) Write the thermochemical equation showing the formation of ammonium chloride.

$\frac{1}{2}N_2(g) + 2H_2(g) + \frac{1}{2}Cl_2(g) \rightarrow NH_4Cl(s)$

b) Calculate the standard heat of formation for ammonium chloride.

$$n = \frac{\text{mass}}{\text{mol mass}} = \frac{4.00\ g}{53.49146\ g/mol} = 0.0748\ mol$$

$$\frac{0.0748\ mol}{1\ mol} = \frac{-23.5\ kJ}{x}$$

$x = -314\ kJ$

$\therefore \Delta H_f\ NH_4Cl(s) = -314\ kJ/mol$

9) What volume of water would be needed to absorb the energy released in burning 1.00 g of magnesium and show a temperature increase (of the water) of 10.0°C?

$2Mg(s) + O_2(g) \rightarrow 2MgO(s)$

ΔH_{rxn} = (2 mol)(601.7 kJ/mol) – (2 mol)(0 kJ/mol) – (1 mol)(0 kJ/mol) ΔH_{rxn} = -1203.4 kJ

$$n = \frac{\text{mass}}{\text{mol mass}} = \frac{1.00\ g}{24.305\ g/mol} = 0.0411\ mol$$

$$\frac{2\ mol}{0.0411\ mol} = \frac{-1203.4\ kJ}{x}$$

$x = -24.5\ kJ$

$\therefore$24.8 kJ is released when 1.00 g of magnesium burns

$\therefore$24.8 kJ is absorbed by the water

$q = mc\Delta t$

$24.8\ kJ = m(4.18 kJ/kg°C)(10.0°C)$

$$m = \left(\frac{24.8kJ}{4.18kJ/kg°C}\right)\left(\frac{}{10.0°C}\right) = 0.592kg$$

$\therefore$0.592 L or 592 mL of water is needed

Hess' Law

A. **$CO_2(g) + H_2(g) \rightarrow H_2O(l) + CO(g)$**

$H_2(g) + \frac{1}{2}O_2(g) \rightarrow H_2O(l)$ $\Delta H = -285.9$ kJ

$CO(g) + \frac{1}{2}O_2(g) \rightarrow CO_2(g)$ $\Delta H = -393.5$ kJ

$CO_2(g) \rightarrow CO(g) + \frac{1}{2}O_2(g)$ $\Delta H = (-1)(-393.5 \text{ kJ})$

$\underline{H_2(g) + \frac{1}{2}O_2(g) \rightarrow H_2O(l)}$ $\Delta H = -285.9$ kJ

$CO_2(g) + H_2(g) \rightarrow H_2O(l) + CO(g)$ **$\Delta H = +107.6$ kJ**

B. **$2C_2H_5OH(l) + O_2(g) \rightarrow 2C_2H_4O(l) + 2H_2O(l)$**

$C_2H_5OH + 3O_2(g) \rightarrow 2CO_2(g) + 3H_2O(l)$ $\Delta H = -1370.7$ kJ

$C_2H_4O(l) + \frac{5}{2} O_2(g) \rightarrow 2CO_2(g) + 2H_2O(l)$ $\Delta H = -1167.3$ kJ

$2C_2H_5OH + 6O_2(g) \rightarrow 4CO_2(g) + 6H_2O(l)$ $\Delta H = (2)(-1370.7 \text{ kJ})$

$\underline{4CO_2(g) + 4H_2O(l) \rightarrow 2C_2H_4O(l) + 5O_2(g)}$ $\Delta H = (2)(-1167.3 \text{ kJ})$

$2C_2H_5OH(l) + O_2(g) \rightarrow 2C_2H_4O(l) + 2H_2O(l)$ $\Delta H =$ **-406.8 kJ**

C. **$2C(gr) + \frac{5}{2} H_2(g) + \frac{1}{2}Cl_2(g) \rightarrow C_2H_5Cl(g)$**

$H_2(g) + \frac{1}{2}O_2(g) \rightarrow H_2O(l)$ $\Delta H = -285.9$ kJ

$C(gr) + O_2(g) \rightarrow CO_2(g)$ $\Delta H = -393.5$ kJ

$C_2H_4(g) + HCl(g) \rightarrow C_2H_5Cl(g)$ $\Delta H = -72.0$ kJ

$H_2(g) + Cl_2(g) \rightarrow 2HCl(g)$ $\Delta H = -184.6$ kJ

$C_2H_4(g) + 3O_2(g) \rightarrow 2CO_2(g) + 2H_2O(l)$ $\Delta H = -1410.8$ kJ

$2C(gr) + 2O_2(g) \rightarrow 2CO_2(g)$ $\Delta H = (2)(-393.5 \text{ kJ})$

$C_2H_4(g) + HCl(g) \rightarrow C_2H_5Cl(g)$ $\Delta H = (-72.0 \text{ kJ})$

$2CO_2(g) + 2H_2O(l) \rightarrow C_2H_4(g) + 3O_2(g)$ $\Delta H = (-1)(-1410.8 \text{ kJ})$

$\frac{1}{2}H_2(g) + \frac{1}{2}Cl_2(g) \rightarrow HCl(g)$ $\Delta H = (\frac{1}{2})(-184.6 \text{ kJ})$

$\underline{2H_2(g) + O_2(g) \rightarrow 2H_2O(l)}$ $\Delta H = (2)(-285.9 \text{ kJ})$

$2C(gr) + \frac{5}{2} H_2(g) + \frac{1}{2}Cl_2(g) \rightarrow C_2H_5Cl(g)$ **$\Delta H = -112.3$ kJ**

D. **$Na(s) + \frac{1}{2}Cl_2(g) \rightarrow NaCl(s)$**

$2Na(s) + 2HCl(g) \rightarrow 2NaCl(s) + H_2(g)$ $\Delta H = -637.4\ kJ$

$H_2(g) + Cl_2(g) \rightarrow 2HCl(g)$ $\Delta H = -184.6\ kJ$

$Na(s) + HCl(g) \rightarrow NaCl(s) + \frac{1}{2}H_2(g)$ $\Delta H = (\frac{1}{2})(-637.4\ kJ)$

$\underline{\underline{\frac{1}{2}H_2(g) + \frac{1}{2}Cl_2(g) \rightarrow HCl(g)}}$ $\Delta H = (\frac{1}{2})(-184.6\ kJ)$

$Na(s) + \frac{1}{2}Cl_2(g) \rightarrow NaCl(s)$ **$\Delta H = -411\ kJ$**

E. **$2XO_2(s) + CO(g) \rightarrow X_2O_3(s) + CO_2(g)$**

$XO_2(s) + CO(g) \rightarrow XO(s) + CO_2(g)$ $\Delta H = -83.7\ kJ$

$X_3O_4(s) + CO(g) \rightarrow 3XO(s) + CO_2(g)$ $\Delta H = +25.1\ kJ$

$3X_2O_3(s) + CO(g) \rightarrow 2X_3O_4(s) + CO_2(g)$ $\Delta H = -50.2\ kJ$

$2XO_2(s) + 2CO(g) \rightarrow 2\ XO(s) + 2CO_2(g)$ $\Delta H = (2)(-83.7\ kJ)$

$\cancel{2}/_3\ X_3O_4(s) + \cancel{1}/_3\ CO_2(g) \rightarrow X_2O_3(s) + \cancel{1}/_3\ CO(g)$ $\Delta H = (-\cancel{1}/_3)(-50.2\ kJ)$

$\underline{\underline{2XO(s) + \cancel{2}/_3 CO_2(g) \rightarrow \cancel{2}/_3 X_3O_4(s) + \cancel{2}/_3 CO(g)}}$ $\Delta H = (-\cancel{2}/_3)(+25.1\ kJ)$

$2XO_2(s) + CO(g) \rightarrow X_2O_3(s) + CO_2(g)$ **$\Delta H = -167.4\ kJ$**

F. **$2MnO_2(s) + CO(g) \rightarrow Mn_2O_3(s) + CO_2(g)$**

$MnO_2(s) + CO(g) \rightarrow MnO(s) + CO_2(g)$ $\Delta H = -150.6\ kJ$

$Mn_3O_4(s) + CO(g) \rightarrow 3MnO(s) + CO_2(g)$ $\Delta H = -54.4\ kJ$

$3Mn_2O_3 + CO(g) \rightarrow 2Mn_3O_4(s) + CO_2(g)$ $\Delta H = -142.3\ kJ$

$2MnO_2(s) + 2CO(g) \rightarrow 2MnO(s) + 2CO_2(g)$ $\Delta H = (2)(-150.6\ kJ)$

$\cancel{2}/_3\ Mn_3O_4(s) + \cancel{1}/_3\ CO_2(g) \rightarrow Mn_2O_3 + \cancel{1}/_3\ CO(g)$ $\Delta H = (-\cancel{1}/_3)(-142.3\ kJ)$

$\underline{\underline{2MnO(s) + \cancel{2}/_3 CO_2(g) \rightarrow \cancel{2}/_3 Mn_3O_4(s) + \cancel{2}/_3 CO(g)}}$ $\Delta H = (-\cancel{2}/_3)(-54.4\ kJ)$

$2MnO_2(s) + CO(g) \rightarrow Mn_2O_3(s) + CO_2(g)$ **$\Delta H = -217.5\ kJ$**

G. **$3V_2O_3(s) \rightarrow V_2O_5(s) + 4VO(s)$**

$2V(s) + \frac{3}{2} O_2(g) \rightarrow V_2O_3(s)$	$\Delta H = -1213$ kJ
$2V(s) + \frac{5}{2} O_2(g) \rightarrow V_2O_5(s)$	$\Delta H = -1561$ kJ
$V(s) + \frac{1}{2}O_2(g) \rightarrow VO(s)$	$\Delta H = -418$ kJ
$V(s) + O_2((g) \rightarrow VO_2(s)$	$\Delta H = -720$ kJ

$3V_2O_3(s) \rightarrow 6V(s) + \frac{9}{2} O_2(g)$	$\Delta H = (-3)(-1213\text{ kJ})$
$2V(s) + \frac{5}{2} O_2(g) \rightarrow V_2O_5(s)$	$\Delta H = -1561$ kJ
$4V(s) + 2O_2(g) \rightarrow 4VO(s)$	$\Delta H = (4)(-418\text{ kJ})$
$3V_2O_3(s) \rightarrow V_2O_5(s) + 4VO(s)$	**$\Delta H = 406$ kJ**

H. **$V_2O_5(s) + 3V(s) \rightarrow 5VO(s)$**

Data as in G.

$V_2O_5(s) \rightarrow 2V(s) + \frac{5}{2} O_2(g)$	$\Delta H = (-1)(-1561\text{ kJ})$
$5V(s) + \frac{5}{2}O_2(g) \rightarrow 5VO(s)$	$\Delta H = (5)(-418\text{ kJ})$
$V_2O_5(s) + 3V(s) \rightarrow 5VO(s)$	**$\Delta H = -529$ kJ**

I. **$Fe_2O_3(s) + 3CO(g) \rightarrow 2Fe(s) + 3CO_2(g)$**

$Fe_2O_3(s) + CO(g) \rightarrow 2FeO(s) + CO_2(g)$	$\Delta H = -2.9$ kJ
$Fe(s) + CO_2(g) \rightarrow FeO(s) + CO(g)$	$\Delta H = +11.3$ kJ

$Fe_2O_3(s) + CO(g) \rightarrow 2FeO(s) + CO_2(g)$	$\Delta H = -2.9$ kJ
$2FeO(s) + 2CO(g) \rightarrow 2Fe(s) + 2CO_2(g)$	$\Delta H = (-2)(+11.3\text{ kJ})$
$Fe_2O_3(s) + 3CO(g) \rightarrow 2Fe(s) + 3CO_2(g)$	**$\Delta H = -25.5$ kJ**

J. **$2C(gr) + H_2(g) \rightarrow C_2H_2(g)$**

$CaO(s) + H_2O(l) \rightarrow Ca(OH)_2(s)$	$\Delta H = -65.3$ kJ
$CaO(s) + 3C(gr) \rightarrow CaC_2(s) + CO(g)$	$\Delta H = +462.3$ kJ
$CaC_2(s) + 2H_2O(l) \rightarrow Ca(OH)_2 + C_2H_2(g)$	$\Delta H = -125.5$ kJ
$2C(gr) + O_2(g) \rightarrow 2CO(g)$	$\Delta H = -220.9$ kJ
$2H_2O(l) \rightarrow 2H_2(g) + O_2(g)$	$\Delta H = +571.5$ kJ

$CaC_2(s) + 2H_2O(l) \rightarrow Ca(OH)_2 + C_2H_2(g)$	$\Delta H = -125.5$ kJ
$Ca(OH)_2(s) \rightarrow CaO(s) + H_2O(l)$	$\Delta H = (-1)(-65.3\text{ kJ})$
$CaO(s) + 3C(gr) \rightarrow CaC_2(s) + CO(g)$	$\Delta H = +462.3$ kJ
$H_2(g) + \frac{1}{2}O_2(g) \rightarrow H_2O(l)$	$\Delta H = (-\frac{1}{2})(+571.5\text{ kJ})$
$CO(g) \rightarrow C(gr) + \frac{1}{2}O_2(g)$	$\Delta H = (-\frac{1}{2})(-220.9\text{ kJ})$
$2C(gr) + H_2(g) \rightarrow C_2H_2(g)$	**$\Delta H = 226.8$ kJ**

K. **$Cu(s) + \frac{1}{2}O_2(g) \rightarrow CuO(s)$**

$Cu_2O(s) + \frac{1}{2}O_2(g) \rightarrow 2CuO(s)$ $\Delta H = -143.9$ kJ

$CuO(s) + Cu(s) \rightarrow Cu_2O(s)$ $\Delta H = -11.3$ kJ

$Cu_2O(s) + \frac{1}{2}O_2(g) \rightarrow 2CuO(s)$ $\Delta H = -143.9$ kJ

$\underline{CuO(s) + Cu(s) \rightarrow Cu_2O(s)}$ $\underline{\Delta H = -11.3 \text{ kJ}}$

$Cu(s) + \frac{1}{2}O_2(g) \rightarrow CuO(s)$ **$\Delta H = -155.2$ kJ**