**Chemistry 120**
**Hess's Law Worksheet**

1. Calculate $\Delta H$ for the reaction $C_2H_4\ (g) + H_2\ (g) \rightarrow C_2H_6\ (g)$, from the following data.

| | |
|---|---|
| $C_2H_4\ (g) + 3\ O_2\ (g) \rightarrow 2\ CO_2\ (g) + 2\ H_2O\ (l)$ | $\Delta H = -1411.$ kJ/mole |
| $C_2H_6\ (g) + 7/2\ O_2\ (g) \rightarrow 2\ CO_2\ (g) + 3\ H_2O\ (l)$ | $\Delta H = -1560.$ kJ/mole |
| $H_2\ (g) + 1/2\ O_2\ (g) \rightarrow H_2O\ (l)$ | $\Delta H = -285.8$ kJ/mole |

2. Calculate $\Delta H$ for the reaction $4\ NH_3\ (g) + 5\ O_2\ (g) \rightarrow 4\ NO\ (g) + 6\ H_2O\ (g)$, from the following data.

| | |
|---|---|
| $N_2\ (g) + O_2\ (g) \rightarrow 2\ NO\ (g)$ | $\Delta H = -180.5$ kJ |
| $N_2\ (g) + 3\ H_2\ (g) \rightarrow 2\ NH_3\ (g)$ | $\Delta H = -91.8$ kJ |
| $2\ H_2\ (g) + O_2\ (g) \rightarrow 2\ H_2O\ (g)$ | $\Delta H = -483.6$ kJ |

3. Find $\Delta H_f^0$ for acetic acid, $HC_2H_3O_2$, using the following thermochemical data.

| | |
|---|---|
| $HC_2H_3O_2\ (l) + 2\ O_2\ (g) \rightarrow 2\ CO_2\ (g) + 2\ H_2O\ (l)$ | $\Delta H = -875.$ kJ/mole |
| $C\ (s, \text{graphite}) + O_2\ (g) \rightarrow CO_2\ (g)$ | $\Delta H = -394.51$ kJ/mole |
| $H_2\ (g) + 1/2\ O_2\ (g) \rightarrow H_2O\ (l)$ | $\Delta H = -285.8$ kJ/mole |

4. Calculate $\Delta H$ for the reaction $CH_4\ (g) + NH_3\ (g) \rightarrow HCN\ (g) + 3\ H_2\ (g)$, from the reactions.

| | |
|---|---|
| $N_2\ (g) + 3\ H_2\ (g) \rightarrow 2\ NH_3\ (g)$ | $\Delta H = -91.8$ kJ |
| $C\ (s, \text{graphite}) + 2\ H_2\ (g) \rightarrow CH_4\ (g)$ | $\Delta H = -74.9$ kJ/mole |
| $H_2\ (g) + 2\ C\ (s, \text{graphite}) + N_2\ (g) \rightarrow 2\ HCN\ (g)$ | $\Delta H = +270.3$ kJ |

5. Calculate $\Delta H$ for the reaction $2\ Al\ (s) + 3\ Cl_2\ (g) \rightarrow 2\ AlCl_3\ (s)$ from the following data.

| | |
|---|---|
| $2\ Al\ (s) + 6\ HCl\ (aq) \rightarrow 2\ AlCl_3\ (aq) + 3\ H_2\ (g)$ | $\Delta H = -1049.$ kJ |
| $HCl\ (g) \rightarrow HCl\ (aq)$ | $\Delta H = -74.8$ kJ/mole |
| $H_2\ (g) + Cl_2\ (g) \rightarrow 2\ HCl\ (g)$ | $\Delta H = -1845.$ kJ |
| $AlCl_3\ (s) \rightarrow AlCl_3\ (aq)$ | $\Delta H = -323.$ kJ/mole |

**Solutions**

Reactions that were reversed or multiplied by a constant are shown in italics.

1. D**H = -137. kJ**

| | |
|---|---|
| $C_2H_4$ (g) + 3 $O_2$ (g) → 2 $CO_2$ (g) + 2 $H_2O$ (l) | ΔH = -1411. kJ |
| *2 $CO_2$ (g) + 3 $H_2O$ (l) ® $C_2H_6$ (g) + 7/2 $O_2$ (g)* | *DH = +1560. kJ* |
| $H_2$ (g) + 1/2 $O_2$ (g) → $H_2O$ (l) | ΔH = -285.8 kJ |

2. D**H = -1628. kJ**

| | |
|---|---|
| *2 $N_2$ (g) + 2 $O_2$ (g) ® 4 NO (g)* | *DH = 2 x (-180.5 kJ)* |
| *4 $NH_3$ (g) ® 2 $N_2$ (g) + 6 $H_2$ (g)* | *DH = 2 x (+91.8 kJ)* |
| *6 $H_2$ (g) + 3 $O_2$ (g) ® 6 $H_2O$ (g)* | *DH = 3 x (-483.6 kJ)* |

3. D**$H_f^0$ = -486. kJ**

Reaction defining $\Delta H_f^0$ ($HC_2H_3O_2$) is: 2 C(s, graphite) + 2 $H_2$ (g) + $O_2$ (g) → $HC_2H_3O_2$ (l).

| | |
|---|---|
| *2 $CO_2$ (g) + 2 $H_2O$ (l) ® $HC_2H_3O_2$ (l) + 2 $O_2$ (g)* | *DH = +875. kJ* |
| *2 C (s, graphite) + 2 $O_2$ (g) ® 2 $CO_2$ (g)* | *DH = 2 x (-394.51 kJ)* |
| *2 $H_2$ (g) + $O_2$ (g) ® 2 $H_2O$ (l)* | *DH = 2 x (-285.8 kJ)* |

4. D**H = +256.0 kJ**

| | |
|---|---|
| *$NH_3$ (g) ® 1/2 $N_2$ (g) + 3/2 $H_2$ (g)* | *DH = 1/2 x (+91.8 kJ)* |
| *$CH_4$ (g) ® C (s, graphite) + 2 $H_2$ (g)* | *DH = +74.9 kJ* |
| 1/2 $H_2$ (g) + C (s, graphite) + 1/2 $N_2$ (g) → HCN (g) | ΔH = 1/2 x (+270.3 kJ) |

5. D**H = -6387. kJ**

| | |
|---|---|
| 2 Al (s) + 6 HCl (aq) → 2 $AlCl_3$ (aq) + 3 $H_2$ (g) | ΔH = -1049. kJ |
| *6 HCl (g) ® 6 HCl (aq)* | *DH = 6 x (-74.8 kJ)* |
| *3 $H_2$ (g) + 3 $Cl_2$ (g) ® 6 HCl (g)* | *DH = 3 x (-1845. kJ)* |
| *2 $AlCl_3$ (aq) ® 2 $AlCl_3$ (s)* | *DH = 2 x (+323. kJ)* |