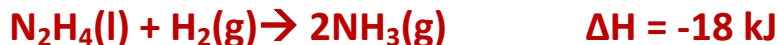


Hess's Law & Standard Enthalpy of Formation

Honors Chemistry

Use Hess's Law for Questions 1-4:

1. Calculate the ΔH for the following reaction using the equations below: $N_2H_4(l) + H_2(g) \rightarrow 2NH_3(g)$
- | | | |
|---|---|------------------------------------|
| a. $N_2H_4(l) + CH_4O(l) \rightarrow CH_2O(g) + N_2(g) + 3H_2(g)$ | $\Delta H = -37 \text{ kJ}$ | Flip C
Add: a+b+d |
| b. $N_2(g) + 3H_2(g) \rightarrow 2NH_3(g)$ | $\Delta H = -46 \text{ kJ}$ | |
| c. $CH_4O(l) \rightarrow CH_2O(g) + H_2(g)$ | $\Delta H = -65 \text{ kJ}$ | |
| d. $CH_2O(g) + H_2(g) \rightarrow CH_4O(g)$ | $\Delta H = +65 \text{ kJ}$ | |



2. Calculate the ΔH for the following reaction using the equations below: $PbCl_2(s) + Cl_2(g) \rightarrow PbCl_4(l)$
- | | | |
|--|--|----------------------------------|
| a. $Pb(s) + Cl_2(g) \rightarrow PbCl_2(s)$ | $\Delta H = -359.4 \text{ kJ}$ | Flip a
Add: b+c |
| b. $Pb(s) + 2Cl_2(g) \rightarrow PbCl_4(l)$ | $\Delta H = -329.3 \text{ kJ}$ | |
| c. $PbCl_2(s) \rightarrow Pb(s) + Cl_2(g)$ | $\Delta H = +359.4 \text{ kJ}$ | |



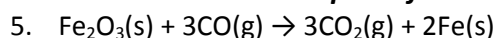
3. Calculate the ΔH for the following reaction using the equations below: $CS_2(l) + 3O_2(g) \rightarrow CO_2(g) + 2SO_2(g)$
- | | | |
|--|--|---|
| a. $C(s) + O_2(g) \rightarrow CO_2(g)$ | $\Delta H = -393.5 \text{ kJ}$ | Flip c
Multiply bx2
Add: a+d+e |
| b. $S(s) + O_2(g) \rightarrow SO_2(g)$ | $\Delta H = -296.8 \text{ kJ}$ | |
| c. $C(s) + 2S(s) \rightarrow CS_2(l)$ | $\Delta H = +87.9 \text{ kJ}$ | |
| d. $2S(s) + 2O_2(g) \rightarrow 2SO_2(g)$ | $\Delta H = -593.6 \text{ kJ}$ | |
| e. $CS_2(l) \rightarrow C(s) + 2S(s)$ | $\Delta H = -87.9 \text{ kJ}$ | |



4. Calculate the ΔH for the following reaction using the equations below: $4NH_3(g) + 5O_2(g) \rightarrow 4NO(g) + 6H_2O(g)$
- | | | |
|--|--|--|
| a. $N_2(g) + O_2(g) \rightarrow 2NO(g)$ | $\Delta H = 180.5 \text{ kJ}$ | Multiply ax2
Flip b and multiply it x 2
Multiply cx3
Add: d+e+f |
| b. $N_2(g) + 3H_2(g) \rightarrow 2NH_3(g)$ | $\Delta H = 91.8 \text{ kJ}$ | |
| c. $2H_2(g) + O_2(g) \rightarrow 2H_2O(g)$ | $\Delta H = -483.6 \text{ kJ}$ | |
| d. $2N_2(g) + 2O_2(g) \rightarrow 4NO(g)$ | $\Delta H = -361 \text{ kJ}$ | |
| e. $4NH_3(g) \rightarrow 2N_2(g) + 6H_2(g)$ | $\Delta H = +183.6 \text{ kJ}$ | |
| f. $6H_2(g) + 3O_2(g) \rightarrow 6H_2O(g)$ | $\Delta H = -1450.8 \text{ kJ}$ | |



Use the Standard Enthalpies of Formation below to find the $\Delta H^\circ_{\text{rxn}}$ for questions 5 – 9:



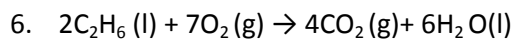
$$\Delta H^\circ_{\text{rxn}} = \sum \Delta H^\circ_{\text{f}}(\text{products}) - \sum \Delta H^\circ_{\text{f}}(\text{reactants})$$

$$\Delta H^\circ_{\text{rxn}} = [(3) \Delta H^\circ_{\text{f}}(\text{CO}_2) + (2) \Delta H^\circ_{\text{f}}(\text{Fe})] - [(1) \Delta H^\circ_{\text{f}}(\text{Fe}_2\text{O}_3) + (3) \Delta H^\circ_{\text{f}}(\text{CO})]$$

$$\Delta H^\circ_{\text{rxn}} = [(3) \Delta H^\circ_{\text{f}}(-394) + (2) \Delta H^\circ_{\text{f}}(0)] - [(1) \Delta H^\circ_{\text{f}}(-824) + (3) \Delta H^\circ_{\text{f}}(-111)]$$

$$\Delta H^\circ_{\text{rxn}} = [-1182 + 0] - [-824 + -333]$$

$$\Delta H^\circ_{\text{rxn}} = -25 \text{ kJ}$$



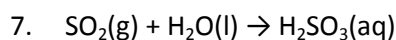
$$\Delta H^\circ_{\text{rxn}} = \sum \Delta H^\circ_{\text{f}}(\text{products}) - \sum \Delta H^\circ_{\text{f}}(\text{reactants})$$

$$\Delta H^\circ_{\text{rxn}} = [(4) \Delta H^\circ_{\text{f}}(\text{CO}_2) + (6) \Delta H^\circ_{\text{f}}(\text{H}_2\text{O})] - [(2) \Delta H^\circ_{\text{f}}(\text{C}_2\text{H}_6) + (7) \Delta H^\circ_{\text{f}}(\text{O}_2)]$$

$$\Delta H^\circ_{\text{rxn}} = [(4) \Delta H^\circ_{\text{f}}(-394) + (6) \Delta H^\circ_{\text{f}}(-285)] - [(2) \Delta H^\circ_{\text{f}}(-85) + (7) \Delta H^\circ_{\text{f}}(0)]$$

$$\Delta H^\circ_{\text{rxn}} = [-1576 + (-1710)] - [-170 + 0]$$

$$\Delta H^\circ_{\text{rxn}} = -3116 \text{ kJ}$$



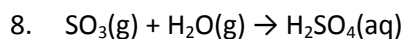
$$\Delta H^\circ_{\text{rxn}} = \sum \Delta H^\circ_{\text{f}}(\text{products}) - \sum \Delta H^\circ_{\text{f}}(\text{reactants})$$

$$\Delta H^\circ_{\text{rxn}} = [(1) \Delta H^\circ_{\text{f}}(\text{H}_2\text{SO}_3)] - [(1) \Delta H^\circ_{\text{f}}(\text{SO}_2) + (1) \Delta H^\circ_{\text{f}}(\text{H}_2\text{O})]$$

$$\Delta H^\circ_{\text{rxn}} = [(1) \Delta H^\circ_{\text{f}}(-609)] - [(1) \Delta H^\circ_{\text{f}}(-297) + (1) \Delta H^\circ_{\text{f}}(-285)]$$

$$\Delta H^\circ_{\text{rxn}} = [-609] - [(-297) + (-285)]$$

$$\Delta H^\circ_{\text{rxn}} = -27.0 \text{ kJ}$$



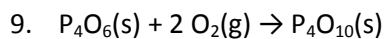
$$\Delta H^\circ_{\text{rxn}} = \sum \Delta H^\circ_{\text{f}}(\text{products}) - \sum \Delta H^\circ_{\text{f}}(\text{reactants})$$

$$\Delta H^\circ_{\text{rxn}} = [(1) \Delta H^\circ_{\text{f}}(\text{H}_2\text{SO}_4)] - [(1) \Delta H^\circ_{\text{f}}(\text{SO}_3) + (1) \Delta H^\circ_{\text{f}}(\text{H}_2\text{O})]$$

$$\Delta H^\circ_{\text{rxn}} = [(1) \Delta H^\circ_{\text{f}}(-814)] - [(1) \Delta H^\circ_{\text{f}}(-396) + (1) \Delta H^\circ_{\text{f}}(-242)]$$

$$\Delta H^\circ_{\text{rxn}} = [(-814)] - [(-396) + (-242)]$$

$$\Delta H^\circ_{\text{rxn}} = -176.0 \text{ kJ}$$



$$\Delta H^\circ_{\text{rxn}} = \sum \Delta H^\circ_{\text{f}}(\text{products}) - \sum \Delta H^\circ_{\text{f}}(\text{reactants})$$

$$\Delta H^\circ_{\text{rxn}} = [(1) \Delta H^\circ_{\text{f}}(\text{P}_4\text{O}_{10})] - [(1) \Delta H^\circ_{\text{f}}(\text{P}_4\text{O}_6) + (2) \Delta H^\circ_{\text{f}}(\text{O}_2)]$$

$$\Delta H^\circ_{\text{rxn}} = [(1) \Delta H^\circ_{\text{f}}(-2984)] - [(1) \Delta H^\circ_{\text{f}}(-1640) + (2) \Delta H^\circ_{\text{f}}(0)]$$

$$\Delta H^\circ_{\text{rxn}} = [(-2984)] - [(-1640) + (0)]$$

$$\Delta H^\circ_{\text{rxn}} = -1344.0 \text{ kJ}$$

Compound	$\Delta H^\circ_{\text{f}}$ (kJ/mol)	Compound	$\Delta H^\circ_{\text{f}}$ (kJ/mol)	Compound	$\Delta H^\circ_{\text{f}}$ (kJ/mol)	Compound	$\Delta H^\circ_{\text{f}}$ (kJ/mol)
H ₂ S(g)	-21	CCl ₄ (l)	-128	C ₂ H ₅ OH(l)	-278	KCl(s)	-436
SO ₂ (g)	-297	CaO	-635	glucose(s)	-1274	KClO ₃ (s)	-391
SO ₃ (g)	-396	H ₂ SO ₄ (aq)	-814	O ₃ (g)	-396	P ₄ O ₁₀	-2984
HF(g)	-273	CO(g)	-111	N ₂ O(g)	+82	I ₂ (g)	+62
SF ₆ (g)	-1220	H ₂ O(l)	-285	PCl ₅ (g)	-375	P ₄ O ₆	-1640
Fe ₂ O ₃ (s)	-824	H ₂ O(g)	-242	PCl ₃ (g)	-287	H ₂ SO ₃ (aq)	-609
CO ₂ (g)	-394	NaHCO ₃ (s)	-951	Al ₂ O ₃ (s)	-1680	CH ₄ (g)	-75
CaCO ₃ (s)	-1207	Na ₂ CO ₃ (s)	-1131	NaOH(s)	-427	NO ₂ (g)	+33
NO(g)	+90	FeS(s)	-100	HI(g)	+27	C ₂ H ₂	+227
NH ₃ (g)	-46	H ₂ O ₂ (l)	-188	C ₂ H ₆ (g)	-85	NH ₄ NO ₃ (s)	-356