Hess's Law

- Hess's Law: the overall enthalpy change in a reaction is equal to the sum of the enthalpy changes of the individual steps.

- Example:

> $2S(s) + 2O_2 \rightarrow 2SO_2(g)$ $\Delta H = -594$ kJ
>
> $2SO_2(g) + O_2(g) \rightarrow 2SO_3(g)$ $\Delta H = 198$ kJ

$2S(s) + 3O_2(g) \rightarrow 2SO_3(g)$ $\Delta H = -396$ kJ

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Standard Heat of Formation

ΔH_f: the amount of energy released when a compound is formed from its elements.

- The standard heat of formation for water, $\Delta H_f = -285.83$ kJ/mol
- Page 975 in your book has a table of standard heats of formation
- We use this information to determine the heat of formation for any reaction.

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

(sum) (sum)

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Heat of Formation (pg. 975)

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

Table R-11 Heat of Formation Values

ΔH_f° (kJ/mol) (concentration of aqueous solutions is 1*M*)

Substance	ΔH_f°	Substance	ΔH_f°	Substance	ΔH_f°	Substance	ΔH_f°
Ag(s)	0	CsCl(s)	−443.0	H_3PO_4(aq)	−1271.7	NaBr(s)	−361.1
AgCl(s)	−127.0	Cs_2SO_4(s)	−1443.0	H_2S(g)	−20.6	NaCl(s)	−411.2
AgCN(s)	146.0	CuI(s)	−67.8	H_2SO_3(aq)	−608.8	$NaHCO_3$(s)	−950.8
Al_2O_3	−1675.7	CuS(s)	−53.1	H_2SO_4(aq)	−814.0	$NaNO_3$(s)	−467.9
$BaCl_2$(aq)	−855.0	Cu_2S(s)	−79.5	$HgCl_2$(s)	−224.3	NaOH(s)	−425.8
$BaSO_4$	−1473.2	$CuSO_4$(s)	−771.4	Hg_2Cl_2(s)	−265.4	Na_2CO_3(s)	−1130.7
BeO(s)	−609.4	F_2(g)	0	Hg_2SO_4(s)	−743.1	Na_2S(s)	−364.8
$BiCl_3$(s)	−379.1	$FeCl_3$(s)	−399.49	I_2(s)	0	Na_2SO_4(s)	−1387.1
Bi_2S_3(s)	−143.1	FeO(s)	−272.0	K(s)	0	NH_4Cl(s)	−314.4
Br_2	0	FeS(s)	−100.0	KBr(s)	−393.8	O_2(g)	0
CCl_4(l)	−128.2	Fe_2O_3(s)	−824.2	$KMnO_4$(s)	−837.2	P_4O_6(s)	−1640.1
CH_4(g)	−74.6	Fe_3O_4(s)	−1118.4	KOH	−424.6	P_4O_{10}(s)	−2984.0
C_2H_2(g)	227.4	H(g)	218.0	LiBr(s)	−351.2	$PbBr_2$(s)	−278.7
C_2H_4(g)	52.4	H_2(g)	0	LiOH(s)	−487.5	$PbCl_2$(s)	−359.4
C_2H_6(g)	−84.0	HBr(g)	−36.3	Mn(s)	0	SF_6(g)	−1220.5
CO(g)	−110.5	HCl(g)	−92.3	$MnCl_2$(aq)	−555.0	SO_2(g)	−296.8
CO_2(g)	−393.5	HCl(aq)	−167.159	$Mn(NO_3)_2$(aq)	−635.5	SO_3(g)	−395.7
CS_2(l)	89.0	HCN(aq)	108.9	MnO_2(s)	−520.0	SrO(s)	−592.0
Ca(s)	0	HCHO	−108.6	MnS(s)	−214.2	TiO_2(s)	−944.0
$CaCO_3$(s)	−1206.9	HCOOH	−425.0	N_2(g)	0	Tl(s)	−123.8
CaO(s)	−634.9	HF(g)	−273.3	NH_3(g)	−45.9	UCl_4(s)	−1019.2
$Ca(OH)_2$(s)	−985.2	HI(g)	26.5	NH_4Br(s)	−270.8	UCl_6(s)	−1092.0
Cl_2(g)	0	H_2O(l)	−285.8	NO(g)	91.3	Zn(s)	0
Co_3O_4(s)	−891.0	H_2O(g)	−241.8	NO_2(g)	33.2	$ZnCl_2$(aq)	−415.1
CoO(s)	−237.9	H_2O_2(l)	−187.8	N_2O(g)	81.6	ZnO(s)	−350.5
Cr_2O_3(s)	−1139.7	H_3PO_2(l)	−595.4	Na(s)	0	$ZnSO_4$(s)	−982.8

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Standard Heat of Formation

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

- Page 975 in Textbook

- All elements in their standard states (example: oxygen gas, solid copper, liquid mercury) will have an Enthalpy of formation of zero.

Practice:

$= -2436.\text{KJ}$

$$4FeS(s) + 7O_2(g) \rightarrow 2Fe_2O_3(s) + 4SO_2(g);\ \Delta H_{rxn} = ?$$

$$[2(-824.2\text{KJ}) + 4(-296.8\text{KJ})] - [4(-100\text{KJ}) + 7(0)]$$

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PRACTICE

Calculate the ΔH_{rxn} for the following using the heats of formation on pg. 975 in your book.

$$CH_{4\,(g)} + 2Cl_{2\,(g)} \longrightarrow CCl_{4\,(l)} + 2H_{2\,(g)}$$

$$[-128.2\text{KJ} + 2(0)] - [-74.6\text{KJ} + 2(0)]$$

$$= -53.6\text{KJ}$$

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