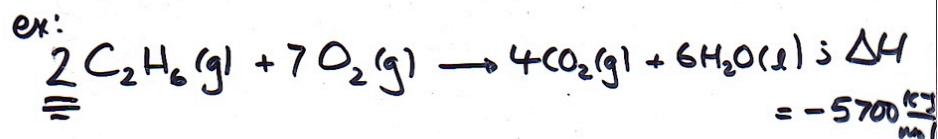


ΔH is a conversion factor!

moles \leftrightarrow q_p \leftarrow heat
 \leftarrow constant P.



What's q_p is 12.5g of C_2H_6 react?

$\Delta H = -5700 \frac{\text{kJ}}{\text{mol}}$ \leftarrow per mole of RXN

$-5700 \text{ kJ} = 2 \text{ mol C}_2\text{H}_6$

C_2H_6

$$\begin{array}{r} 2 \times \text{C} = 2 \times 12.01 \\ 6 \times \text{H} = 6 \times 1.01 \\ \hline 30.08 \end{array}$$

exothermic

1200 kJ of heat
is RELEASED

$$\frac{12.5 \text{g C}_2\text{H}_6}{\underbrace{30.08 \text{g C}_2\text{H}_6}_{\text{MOLAR MASS}}} \times \frac{1 \text{ mol C}_2\text{H}_6}{\underbrace{2 \text{ mol C}_2\text{H}_6}_{\Delta H}} \times (-5700 \text{ kJ}) = -1200 \text{ kJ}$$

Predicting ΔH of chemical rxns!

involves the use of standard enthalpies of formation.

ΔH_f° \leftarrow formation \leftarrow STD

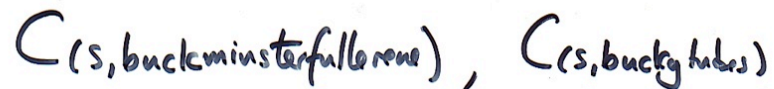
- all gases are under a std. pressure of 1 atm
- all solids are at a std. conc. of 1 M
- all solids + liquids are pure.

ΔH_f° of a substance is equal to ΔH for the reaction where we form 1 mol of substance from its elements in their most stable forms.

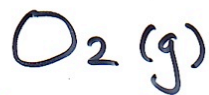
ex: $\Delta H_f^\circ(\text{C}_6\text{H}_6(l)) = +49.04 \frac{\text{kJ}}{\text{mol}}$



Carbon exists in several forms.... Allotropes

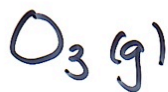


Oxygen exists in several forms...



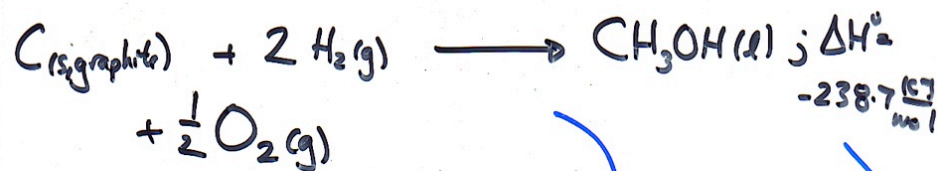
"oxygen"

dioxygen

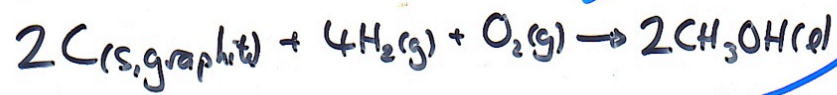


ozone

ex: $\Delta H_f^\circ(\text{CH}_3\text{OH}(l)) = -238.7 \frac{\text{kJ}}{\text{mol}}$



if we doubled up this rxn...



$$\Delta H^\circ = -477.4 \frac{\text{kJ}}{\text{mol}}$$

There are tables in back of Chany that list hundreds of substances + their ΔH_f° values.

WHY? We can use them to predict ΔH for ANY chemical rxn.

Table 6.4 Standard Enthalpies of Formation of Some Inorganic Substances at 25°C

Substance	ΔH_f° (kJ/mol)	Substance	ΔH_f° (kJ/mol)
Ag(s)	0	H ₂ O ₂ (l)	-187.6
AgCl(s)	-127.04	Hg(l)	0
Al(s)	0	I ₂ (s)	0
Al ₂ O ₃ (s)	-1669.8	HI(g)	25.94
Br ₂ (l)	0	Mg(s)	0
HBr(g)	-36.2	MgO(s)	-601.8
C(graphite)	0	MgCO ₃ (s)	-1112.9
C(diamond)	1.90	N ₂ (g)	0
CO(g)	-110.5	NH ₃ (g)	-46.3
CO ₂ (g)	-393.5	NO(g)	90.4
Ca(s)	0	NO ₂ (g)	33.85
CaO(s)	-635.6	N ₂ O ₄ (g)	9.66
CaCO ₃ (s)	-1206.9	N ₂ O(g)	81.56
Cl ₂ (g)	0	O(g)	249.4
HCl(g)	-92.3	O ₂ (g)	0
Cu(s)	0	O ₃ (g)	142.2
CuO(s)	-155.2	S(rhombic)	0
F ₂ (g)	0	S(monoclinic)	0.30
HF(g)	-268.61	SO ₂ (g)	-296.1
H(g)	218.2	SO ₃ (g)	-395.2
H ₂ (g)	0	H ₂ S(g)	-20.15
H ₂ O(g)	-241.8	ZnO(s)	-347.98
H ₂ O(l)	-285.8	ZnS(s)	-202.9

†In thermodynamics, the standard pressure is defined as 1 bar, where 1 bar = 10⁵ Pa = 0.987 atm. Because 1 bar differs from 1 atm by only 1.3 percent, we will continue to use 1 atm as the standard pressure. Note that the normal melting point and boiling point of a substance are defined in terms of 1 atm.

One little point...

$$\Delta H_f^\circ (\text{elements in most stable form}) = 0 \frac{\text{kJ}}{\text{mol}}$$

ex: $\Delta H_f^\circ (\text{O}_2(\text{g})) = 0$

WHY?



For any chemical rxn...

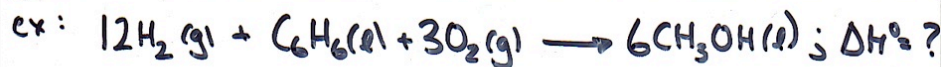


$$\text{then } \Delta H^\circ = [c \times \Delta H_f^\circ(C) + d \times \Delta H_f^\circ(D)]$$

$$\ominus [a \times \Delta H_f^\circ(A) + b \times \Delta H_f^\circ(B)]$$

$$\text{OR } \Delta H^\circ = \sum_i n \cdot \Delta H_f^\circ(\text{Products}) - \sum_j m \cdot \Delta H_f^\circ(\text{Reactants})$$

↑ stoich. coefficients
↑
↑



given... $\Delta H_f^\circ(\text{C}_6\text{H}_6(\text{l})) = +49.04 \text{ kJ/mol}$

$\Delta H_f^\circ(\text{CH}_3\text{OH}(\text{l})) = -238.7 \text{ kJ/mol}$

then $\Delta H_{\text{rxn}}^\circ = [6 \times \Delta H_f^\circ(\text{CH}_3\text{OH}(\text{l}))]$

$\ominus [12 \times \cancel{\Delta H_f^\circ(\text{H}_2(\text{g}))} + 1 \times \Delta H_f^\circ(\text{C}_6\text{H}_6(\text{l})) + 3 \times \cancel{\Delta H_f^\circ(\text{O}_2(\text{g}))}]$

$= [6 \times -238.7 \frac{\text{kJ}}{\text{mol}}] - [1 \times +49.04 \frac{\text{kJ}}{\text{mol}}]$

$= -1481.2 \text{ kJ/mol}$

ex: What's $\Delta H_{\text{rxn}}^\circ$ for...



if $\Delta H_f^\circ(\text{N}_2\text{O}_4(\text{g})) = +9.66 \text{ kJ/mol}$

if $\Delta H_f^\circ(\text{NO}_2(\text{g})) = +33.85 \text{ kJ/mol}$

$\Rightarrow \Delta H_{\text{rxn}}^\circ = [2 \times \Delta H_f^\circ(\text{NO}_2(\text{g}))] - [1 \times \Delta H_f^\circ(\text{N}_2\text{O}_4(\text{g}))]$

$= (2 \times 33.85 \frac{\text{kJ}}{\text{mol}}) - (1 \times 9.66 \frac{\text{kJ}}{\text{mol}})$

$= +58.0 \text{ kJ/mol}$

$\Delta(x) = X_{\text{final}} - X_{\text{initial}}$
 $= \text{Prods} - \text{Reactants}$

Calculate $\Delta H_{\text{rxn}}^{\circ}$ for....



if

$$\begin{aligned}\Delta H_f^{\circ}(\text{Al}_2\text{O}_3(\text{s})) &= -1669.8 \text{ kJ/mol} \\ \text{" } (\text{CO}(\text{g})) &= -110.5 \text{ kJ/mol} \\ \text{" } (\text{CO}_2(\text{g})) &= -393.5 \text{ kJ/mol}\end{aligned}$$

$$\Delta H_{\text{rxn}}^{\circ} = [2 \times \Delta H_f^{\circ}(\text{Al}(\text{s})) + 3 \times \Delta H_f^{\circ}(\text{CO}_2(\text{g}))] \ominus$$

$$[1 \times \Delta H_f^{\circ}(\text{Al}_2\text{O}_3(\text{s})) + 3 \times \Delta H_f^{\circ}(\text{CO}(\text{g}))]$$

$$= [2 \times 0 + 3 \times -393.5 \frac{\text{kJ}}{\text{mol}}] \ominus$$

$$[1 \times -1669.8 \frac{\text{kJ}}{\text{mol}} + 3 \times -110.5 \frac{\text{kJ}}{\text{mol}}]$$

$$= [-1180.5 \frac{\text{kJ}}{\text{mol}}] - [-2001.3 \frac{\text{kJ}}{\text{mol}}]$$

$$= +820.8 \text{ kJ/mol} \quad \text{endothermic}$$