

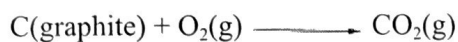
10/08/25

Calculating Enthalpy

What are the steps for calculating Hess' Law?

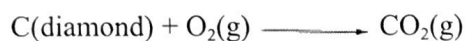
- 1) If rxn is reversed, sign ΔH is reversed
- 2) Make coefficients the same for the same element.
 - ↳ Multiply ΔH value by integer amount for coefficients

keep



$$\Delta H = -393.5 \text{ kJ}$$

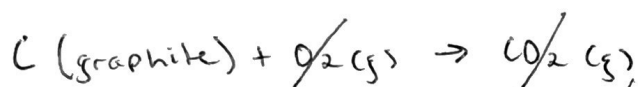
flip



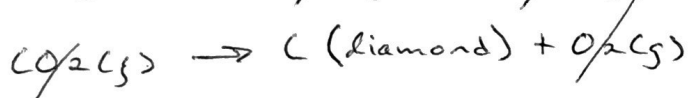
$$\Delta H = -395.4 \text{ kJ}$$

Calculate ΔH for the conversion of graphite to diamond:

$$\Delta H = ?$$



$$\Delta H = -393.5 \text{ kJ}$$



$$\Delta H = +395.4 \text{ kJ}$$

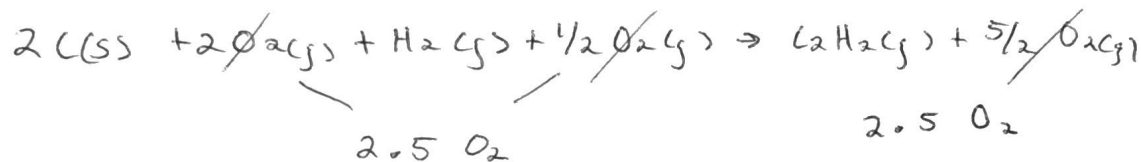
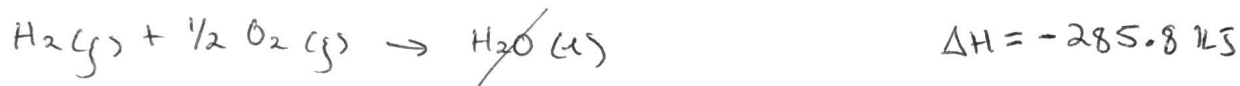
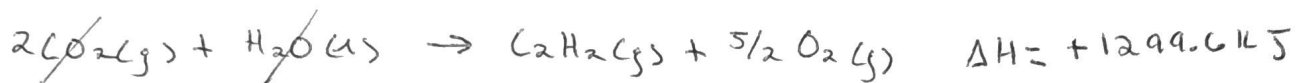
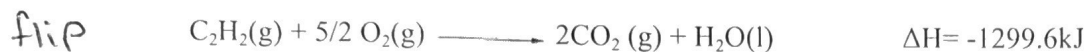


$$\Delta H = 1.9 \text{ kJ}$$

Calculate ΔH for the reaction



given the following chemical equations:



$\Delta H = 226.8 \text{ kJ}$

How is enthalpy of formation depicted as a sign (its abbreviation)?

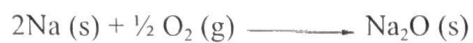


Standard enthalpies of formation are measured under what conditions?

Measured under conditions of $25^\circ\text{C} + 1.00 \text{ atm}$ pressure

- Gases = pressure = 1 atm
- Substance in solution = 1 M concentration
- Standard state is the pure liquid or solid
- Any element exists as $\Delta H_f^\circ = 0$

Is either of the following chemical equations a standard enthalpy formation?



standard enthalpy formation

↑ In solid elemental form



Not in standard enthalpy formation

↑ Not in most stable elemental form

- Supposed to be a solid

What is the equation for standard enthalpy of formation?

$$\Delta H^\circ_{\text{reaction}} = \sum n \Delta H_f^\circ \text{ products} - \sum n \Delta H_f^\circ \text{ reactants}$$

Products - reactants

Σ = sum of

ΔH_f° = standard enthalpy of formation

TABLE 5.3 • Standard Enthalpies of Formation, ΔH_f° , at 298 K

Substance	Formula	ΔH_f° (kJ/mol)	Substance	Formula	ΔH_f° (kJ/mol)
Acetylene	$C_2H_2(g)$	226.7	Hydrogen chloride	$HCl(g)$	-92.30
Ammonia	$NH_3(g)$	-46.19	Hydrogen fluoride	$HF(g)$	-268.60
Benzene	$C_6H_6(l)$	49.0	Hydrogen iodide	$HI(g)$	-25.9
Calcium carbonate	$CaCO_3(s)$	-1207.1	Methane	$CH_4(g)$	-74.80
Calcium oxide	$CaO(s)$	-635.5	Methanol	$CH_3OH(l)$	-238.6
Carbon dioxide	$CO_2(g)$	-393.5	Propane	$C_3H_8(g)$	-103.85
Carbon monoxide	$CO(g)$	-110.5	Silver chloride	$AgCl(s)$	-127.0
Diamond	$C(s)$	1.88	Sodium bicarbonate	$NaHCO_3(s)$	-947.7
Ethane	$C_2H_6(g)$	-84.68	Sodium carbonate	$Na_2CO_3(s)$	-1130.9
Ethanol	$C_2H_5OH(l)$	-277.7	Sodium chloride	$NaCl(s)$	-410.9
Ethylene	$C_2H_4(g)$	52.30	Sucrose	$C_{12}H_{22}O_{11}(s)$	-2221
Glucose	$C_6H_{12}O_6(s)$	-1273	Water	$H_2O(l)$	-285.8
Hydrogen bromide	$HBr(g)$	-36.23	Water vapor	$H_2O(g)$	-241.8

Calculate the enthalpy for the following reaction using the table above:



products - reactants

$$\begin{aligned} & \left[(3 \times -393.5 \text{ kJ/mol}) + (4 \times -285.8 \text{ kJ/mol}) \right] - \left[(1 \times -103.85 \text{ kJ/mol}) + (0) \right] \\ & \quad \text{CO}_2 \quad \quad \quad \text{H}_2\text{O} \quad \quad \quad \text{C}_3\text{H}_8 \quad \quad \quad \text{O}_2 \\ & \quad -2323.7 \quad \quad \quad -103.85 \\ & = \boxed{-2427.6 \text{ kJ}} \end{aligned}$$

Calculate the enthalpy for the following reaction using the table above:



products - reactants

$$\begin{aligned} & \left[(1 \times -393.5 \text{ kJ}) + (2 \times -285.8 \text{ kJ}) \right] - \left[(1 \times -74.80 \text{ kJ}) + (2 \times 0 \text{ kJ}) \right] \\ & \quad \text{CO}_2 \quad \quad \quad \text{H}_2\text{O} \quad \quad \quad \text{CH}_4 \quad \quad \quad \text{O}_2 \\ & \quad -965.1 \quad \quad \quad -74.80 \\ & \quad \quad \quad -74.80 \end{aligned}$$

$$\Delta H^\circ_{\text{rxn}} = \boxed{-890.3 \text{ kJ}}$$

What is bond enthalpy?

Enthalpy associated w/ breaking 1 mole of a certain bond in a gaseous substance

Are bonds breaking endothermic or exothermic? Are bonds forming endothermic or exothermic?

Bond breaking = endothermic

- Requires energy

Bonds forming = exothermic

- Releases energy

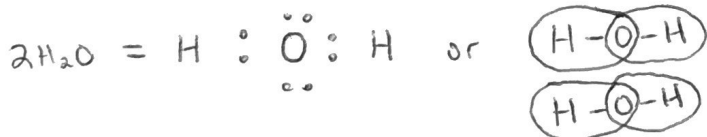
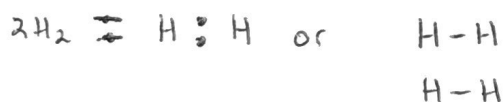
What is the equation for bond enthalpy?

$$\Delta H_{rxn} = \sum (\text{bond enthalpies of bonds broken}) - \sum (\text{bond enthalpies of bonds formed})$$

Reactants - Products

Average Bond Energies					
Bond	Bond Energy (kJ/mol)	Bond	Bond Energy (kJ/mol)	Bond	Bond Energy (kJ/mol)
H-H	436	C-C	347	O-O	142
H-C	414	C=C	611	O=O	498
H-N	389	C≡C	837	O-F	190
H-O	464	C-N	305	O-Cl	203
H-Cl	431	C=N	615	O-I	234
H-Br	364	C≡N	891	F-F	159
H-I	297	C-O	360	Cl-Cl	243
C-F	485	C=O	736*	F-F	159
C-Cl	339	C≡O	1072	Cl-F	253
C-Br	276				
C-I	240	*799 in CO ₂			

What is the enthalpy for the following reaction using the table above?



Reactants - products

$$\left[\begin{array}{c} \text{H}_2 \\ (2 \times 436 \text{ kJ}) \end{array} + \begin{array}{c} \text{O}_2 \\ (1 \times 498 \text{ kJ}) \end{array} \right] - \left[\begin{array}{c} \text{H}_2\text{O} \\ (4 \times 464 \text{ kJ}) \end{array} \right]$$

1370 kJ - 1856 kJ

$$= \boxed{-486 \text{ kJ}}$$