

## Enthalpy of Formation ( $\Delta H_f^\circ$ )

### Calculating Enthalpy Changes of Reactions from Heat of Formation

**Standard enthalpy (heat) of formation ( $\Delta H_f^\circ$ ):** change in enthalpy that accompanies the formation of 1 mole of the compound in its standard state from its component elements their standard states.

Note: The naught,  $^\circ$ , simply indicates **standard conditions (1 atm and 25°C)**.

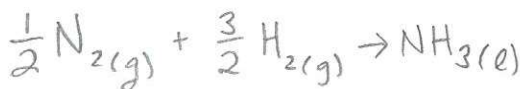
#### Examples



Note: you will see fractional coefficients to ensure only 1 mole of compound is formed.

The  $\Delta H_f^\circ$  for elements (in their standard state) is always  $\phi$  kJ/mol<sub>rxn</sub>!

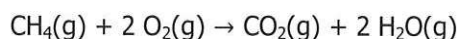
**Now you try!** Write the formation reaction of  $NH_3$ :



The enthalpy change for a chemical reaction, or amount of heat released or absorbed, can be determined by the following formula, which is known as Big Momma's Equation:

$$\Delta H_{rxn}^\circ = \Sigma [n\Delta H_f^\circ(\text{products})] - \Sigma [n\Delta H_f^\circ(\text{reactants})] \quad \left. \vphantom{\Delta H_{rxn}^\circ} \right] \text{ on F.C!}$$

#### Example:



$$\Delta H_{rxn}^\circ = \Delta H_{comb}^\circ = [ \Delta H_f^\circ(CO_2) + 2 \cdot \Delta H_f^\circ(H_2O) ] - [ \Delta H_f^\circ(CH_4) + 2(\phi) ]$$

### Enthalpy Changes of Different Types of Reactions

You will encounter a variety of Subscripts following the  $\Delta H$ , however, they are simply indicating a reaction type of reaction or change of state.

#### Examples

$\Delta H_{comb}^\circ$  = Enthalpy of Combustion (Heat Energy Released during Combustion Reactions)

$\Delta H_{neut}^\circ$  = Enthalpy of Neutralization (Heat Energy Released during Acid-Base Neutralization Reactions)

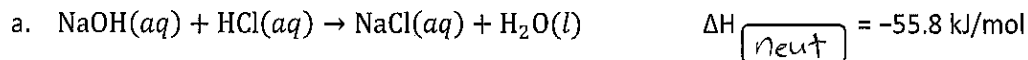
$\Delta H_{soln}^\circ$  = Enthalpy of Solution (Heat Energy Released/Absorbed Dissolving a Solute in Water)

$\Delta H_{vap}^\circ$  = Enthalpy of Vaporization (Heat Energy Absorbed to Convert from Liquid to Gas Phase)

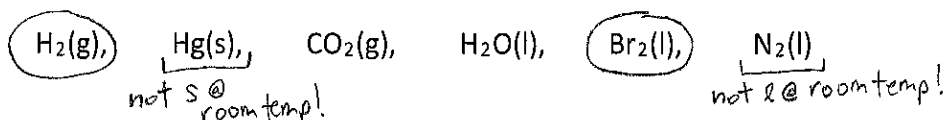
$\Delta H_{fus}^\circ$  = Enthalpy of Fusion (Heat Energy Absorbed to Convert from Solid to Liquid Phase)

## Let's Practice!

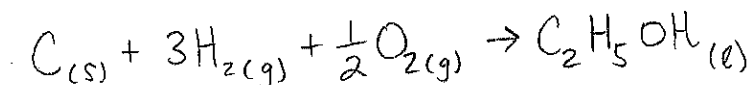
1. For each reaction below, fill in the box with a subscript that specifies the type of reaction:



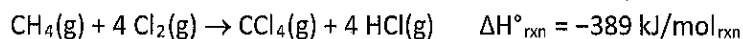
2. Circle each of the following which will have a standard heat of formation equal to zero.



3. Write a balanced molecular equation representing the enthalpy for standard heat of formation reaction of ethanol,  $\text{C}_2\text{H}_5\text{OH}(l)$ .



4. Use the information provided and the balanced equation to determine  $\Delta H_f^\circ$  of carbon tetrachloride.



Substance	$\Delta H_f^\circ$
$\text{CH}_4(g)$	-75 kJ/mol <sub>rxn</sub>
$\text{HCl}(g)$	-92 kJ/mol <sub>rxn</sub>

$$\begin{aligned} \Delta H^\circ_{\text{rxn}} &= -389 \frac{\text{kJ}}{\text{mol}_{\text{rxn}}} = \sum n \Delta H_f^\circ(\text{pr}) - \sum n \Delta H_f^\circ(\text{re}) \\ &= [\text{CCl}_4 + 4\text{HCl}] - [\text{CH}_4 + 4\text{Cl}_2] \\ &= [\text{CCl}_4 - 4(-92)] - [-75 + 4(\emptyset)] \end{aligned}$$

$$-389 = \text{CCl}_4 - 293 \Rightarrow \Delta H_f^\circ(\text{CCl}_4) = \boxed{-96 \text{ kJ/mol}_{\text{rxn}}}$$