LA IMMACULADA CONCEPCION SCHOOL
SENIOR HIGH SCHOOL
GRADE 12 – STEM: GENERAL CHEMISTRY 2

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TOPIC: ENTHALPY OF A CHEMICAL REACTION: THERMOCHEMICAL EQUATIONS

Thermochemical equation

- A chemical equation that shows the value and direction of heat involved in a reaction.
- Energy changes which accompanies chemical reactions.
- It also indicates the physical state of the reactants and products involved in the reaction.

Enthalpy

- The amount of heat absorbed or released by a chemical reaction at constant atmospheric pressure.
- A form of chemical energy
- An extensive property

Enthalpy of a reaction

- The difference between the enthalpy of the product and the reactants.

$\Delta H = H_{products} - H_{reactants}$

+ ΔH – the chemical reaction is endothermic
−ΔH – the reaction is exothermic

Consider the exothermic combustion of methane (CH_4) into carbon dioxide and water.

$$\mathbf{CH_4\,(g) + 2O_2(g) \rightarrow CO_2(g) + 2H_2O_{(l)}\ \ \Delta H = -890.4kJ}$$

- ✓ This thermochemical equation means that 890.4 kJ of heat is released when one mole of gaseous methane and two moles of oxygen gas combust to form one mole of gaseous carbon dioxide and two moles of liquid water.
- ✓ Its magnitude is proportional to the amount of reactants and products in the reaction.
- ✓ For example , if the amount of reactants and products in a thermochemical equation is multiplied by 2, the value of the enthalpy is also multiplied by two.
- ✓ If multiplied by ½, the enthalpy is also reduced by half.

Original equation:	$\mathbf{CH_4\,(g) + 2O_2(g) \rightarrow CO_2(g) + 2H_2O_{(l)}}$	**ΔH= -890.4kJ**
Multiplied by 2:	$\mathbf{2CH_4\,(g) + 4O_2(g) \rightarrow 2CO_2(g) + 4H_2O_{(l)}}$	**ΔH= -1780.8.4kJ**
Multiplied by ½:	$\mathbf{1/2CH_4\,(g) + O_2(g) \rightarrow 1/2CO_2(g) + H_2O_{(l)}}$	**ΔH= -445.2kJ**

Standard molar enthalpy of formation ($\Delta H°_f$) of a compound is the change in enthalpy when the compound is formed from its elements under standard conditions (1 atm, 25°C

- The enthalpy of formation for an element in its stable from is zero under the same standard conditions.

Standard enthalpy of reaction ($\Delta H°_{rxn}$) can be calculated by subtracting the sum (∑) of the enthalpies of formation of the products and the sum of the enthalpies of formation of the reactants.

Consider the hypothetical equation:

$$\mathbf{aA\ \ bB \rightarrow cC + dD}$$

where a, b, c, and d are the respective coefficients of substances A, B, C and D in the balanced chemical equation. The sum of the enthalpies of formation of the products is calculated as:

$$\mathbf{\sum \Delta H°_f}(\text{products}) = \mathbf{\textit{c}\ \Delta H°_f(C) + \textit{d}\Delta H°_f(D)}$$

and for the reactants:

$$\mathbf{\sum \Delta H°_f}(\text{reactants}) = \mathbf{\textit{a}\ \Delta H°_f(A) + \textit{b}\Delta H°_f(B)}$$

Then the molar enthalpy of the hypothetical reaction is calculated as:

$$\mathbf{\Delta H°_{rxn} = \sum \Delta H°_f(products) - \sum \Delta H°_f(reactants)}$$

Consider the combustion of ethanol (C_2H_5OH) to produce carbon dioxide and water.

$$C_2H_5OH(l) + 3O_2(g) \rightarrow 2CO_2(g) + 3H_2O(g)$$

The standard molar enthalpies of each of the reactants and products are constant.

The standard enthalpy of the reaction is therefore:

$\Delta H°_{rxn} = [2\Delta H°_f(CO2) + 3\Delta H°_f(H2O)] - [\Delta H°_f(C_2H_5OH) + 3\Delta H°_f(O_2)]$

$= [2(-393.5\ kJ) + 3(-241.8)] – [-277.7) + 3(0)]$

= <u>- 1234.7kJ</u>

Table 3-2
ΔH_f° of Some Common Substances

Substance	Specific Heat ΔH_f° (kJ/mol)	Substance	Specific Heat ΔH_f° (kJ/mol)
C (graphite)	0	$H_2O(l)$	−285.8
$CO(g)$	−110.5	$N_2(g)$	0
$CO_2(g)$	−393.5	$NaCl(s)$	−411.2
$C_2H_5OH(l)$	−277.7	$NH_3(g)$	−46.3
$CaCO_3(s)$	−1206.9	$NO(g)$	90.29
$CaO(s)$	−635.6	$NO_2(g)$	33.85
$Fe_2O_3(s)$	−824.2	$N_2O(g)$	81.56
$H_2O(g)$	−241.8	$O_2(g)$	0

Hess' law

- States that the enthalpy of a sum of a series of reactions is equal to the sum of the enthalpies of those two reactions.
- The following rules must be considered:

Rule 1 : Enthalpy is an extensive property; it depends on the amount of reactants and products.

Rule 2 : The ΔH for a forward reaction is equal to the magnitude but opposite in sign to its reverse direction.

Rule 3 : the ΔH for a reaction is the same whether it occurs in one step or in a series of steps.

To do list

A. Look for 20 common substances (compound/ element) find its standard enthalpy.

Substances	Standard Enthalpy $\Delta H°_f$ (kJ/mol)
Ex. CO2	- 393.5