PENANG SANGAM HIGH SCHOOL

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LESSON NOTES

WEEK 16

Year/Level: 13A/B **Subject:** Chemistry

Strand 3	**Reactions**
Sub Strand 3.2	**Thermochemistry**
Content Learning Outcome	By the end of this lesson students should be able: • Define standard heat of reaction, standard heat of formation and standard heat of combustion. • Explain Hess's law an use Hess's law to calculate the enthalpy of formation.

Thermochemical Equations

- Equations in which enthalpy change is also made a part of the equation.
- The physical state of the reactants and products is included.

Example:

$$1/2\ N_2(g) + 3/2 H_2(g) \rightarrow NH_3(g) \qquad \Delta H^\circ = -46.2\ kJ$$

Standard Heat of Formation (ΔH°_f)

- Amount of heat absorbed or released when one mole of the substance is formed at 25°C and one atmosphere pressure from its elements in their standard states.
- Most stable physical state. E.g. solid, liquid, gas.

Standard Heat of Combustion (ΔH_c)

- Enthalpy change when 1 mole of a substance is completely burned in oxygen under standard conditions.

Hess's Law

- States that in going from a particular set of reactants to a particular set of products, the change in enthalpy is same whether the reaction takes place in one step or in a number of steps.

For example:

Combustion of carbon to form carbon dioxide can occur in one step or in two steps, as shown below.

One step

$$C(s) + O_2(g) \rightarrow CO_2(g) \qquad \Delta H^\circ = -393.5\ kJ$$

Two steps

$$C(s) + \tfrac{1}{2}O_2(g) \rightarrow CO(g) \qquad \Delta H^\circ = -110.5\ kJ$$
$$CO(g) + \tfrac{1}{2}O_2(g) \rightarrow CO_2(g) \qquad \Delta H^\circ = -283.0\ kJ$$

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$$C(s) + O_2(g) \rightarrow CO_2(g) \qquad \Delta H^\circ = -393.5\ kJ$$

- ΔH° comes out to be the same in both the cases.

Hess's law allows us to calculate enthalpy changes for those reactions which are not convenient to carry out, or for those reactions for which $\Delta H°$ values are not known or cannot be measured.

* Thermochemical equations can be added, including their $\Delta H°$ values, to obtain a desired chemical equation and its H°.

Rules for manipulating thermochemical equations

1. When a thermochemical equation is reversed, the sign of H° must be changed.
2. If all the coefficients of an equation are multiplied or divided by a factor, the value of $\Delta H°$ must be multiplied or divided by the same factor.

Example 1:

Calculate the enthalpy change for the reaction from the following thermochemical equations

$$C(s) + 2S(s) \rightarrow CS_2(\ell)$$

(i) $C(s) + O_2(g) \rightarrow CO_2(g)$	$\Delta H° = -393.3$ kJ
(ii) $S(s) + O_2(g) \rightarrow SO_2(g)$	$\Delta H° = -293.7$ kJ
(iii) $CS_2(\ell) + 3O_2(g) \rightarrow CO_2(g) + 2SO_2(g)$	$\Delta H° = -1108.7$ kJ

Solution:

If we multiply equation (ii) by 2, add this to equation (i) and then subtract equation (iii), we get the required equation

$C(s) + O_2(g) \rightarrow CO_2(g)$	$\Delta H° = -393.3$ kJ
$2S(s) + 2O_2(g) \rightarrow 2SO_2(g)$	$\Delta H° = 2 \times -293.7$ kJ
$CO_2(g) + 2SO_2(g) \rightarrow CS_2(\ell) + 3O_2(g)$	$\Delta H° = 1108.7$ kJ
$C(s) + 2S(s) \rightarrow CS_2(\ell)$	$\Delta H° = 128.02$ kJ

EXERCISE

1. Calculate the heat of formation of acetic acid from the following data:

$CH_3COOH(\ell) + 2O_2(g) \rightarrow 2CO_2(g) + 2H_2O(\ell)$	$\Delta H = -869.0$ kJ
$C(s) + O_2(g) \rightarrow CO_2(g)$	$\Delta H = -393.5$ kJ
$H_2(g) + 1/2O_2(g) \rightarrow H_2O(\ell)$	$\Delta H = -285.8$ kJ