Reactivity 1.2

IB CHEMISTRY SL

25	16		6	2	25
Mn	S	J	C	He	Mn
Manganese	Sulfur		Carbon	Helium	Manganese
54.938045	32.065		12.0107	4.002602	54.938045

Reactivity 1.2.1

Understandings:

- Bond-breaking absorbs energy and bond-forming releases energy.

Learning outcomes:

- Calculate the enthalpy change of a reaction from given average bond enthalpy data.

Additional notes:

- Include explanation of why bond enthalpy data are average values and may differ from those measured experimentally.
- Average bond enthalpy values are given in the data booklet.

Linking questions:

- Structure 2.2 How would you expect bond enthalpy data to relate to bond length and polarity?
- Reactivity 3.4 How does the strength of a carbon– halogen bond affect the rate of a nucleophilic substitution reaction?

Bond enthalpy and average bond enthalpies

- Average bond enthalpy is the energy needed to break one mole of bonds in a gaseous molecule averaged over similar compounds.
- Bond breaking is endothermic (requires energy).
- Bond making is exothermic (releases energy).

$$\Delta H = \sum \text{(bonds broken)} - \sum \text{(bonds formed)}$$

Example: Calculate the enthalpy change for the following reaction.

$$C_3H_8(g) + 5O_2(g) \rightarrow 3CO_2(g) + 4H_2O(g)$$

Exercises:

1. Propane can be formed by the hydrogenation of propene.

$$CH_3CH{=}CH_2(g) + H_2(g) \rightarrow CH_3CH_2CH_3(g)$$

Determine a value for the hydrogenation of propene using information from Table 11 of the Data Booklet. State and explain if the reaction is exothermic or endothermic.

2. Use the information from Table 11 of the Data Booklet to calculate the enthalpy change for the following reaction.

$$N_2H_4(g) + O_2(g) \rightarrow N_2(g) + 2H_2O(g)$$

3. State three reasons why enthalpy changes calculated using average bond enthalpies can be inaccurate.

Reactivity 1.2.2

Understandings:

- Hess's law states that the enthalpy change for a reaction is independent of the pathway between the initial and final states.

Learning outcomes:

- Apply Hess's law to calculate enthalpy changes in multistep reactions.

Calculating the enthalpy change of a reaction that is the sum of multiple reactions with known enthalpy changes

- Applying Hess's law, the enthalpy change for a reaction can be calculated using multiple reactions with known enthalpy changes.

Example:

$2C_2H_6(g) + 7O_2(g) \rightarrow 4CO_2(g) + 6H_2O(l) \quad \Delta H = -3120 \text{ kJ}$

$2H_2(g) + O_2(g) \rightarrow 2H_2O(l) \quad \Delta H = -572 \text{ kJ}$

$C_2H_4(g) + 3O_2(g) \rightarrow 2CO_2(g) + 2H_2O(l) \quad \Delta H = -1411 \text{ kJ}$

Calculate the enthalpy change for the following reaction:

$C_2H_6(g) \rightarrow C_2H_4(g) + H_2(g)$

Exercises:

1. Using the equations below:

$C(s) + O_2(g) \rightarrow CO_2(g)$ ΔH = -390 kJ
$Mn(s) + O_2(g) \rightarrow MnO_2(s)$ ΔH = -520 kJ

Determine the ΔH (in kJ) for the following reaction.

$MnO_2(s) + C(s) \rightarrow Mn(s) + CO_2(g)$

2. Using the equations below:

$Cu(s) + ½O_2(g) \rightarrow CuO(s)$ ΔH = -156 kJ
$2Cu(s) + ½O_2(g) \rightarrow Cu_2O(s)$ ΔH = -170 kJ

Determine the ΔH (in kJ) for the following reaction.

$2CuO(s) \rightarrow Cu_2O(s) + ½O_2(g)$

3. Calculate the enthalpy change, ΔH, for the reaction:

$C(s) + 2H_2(g) + ½O_2(g) \rightarrow CH_3OH(l)$

using Hess's Law and the following information.

$CH_3OH(l) + 1½O_2(g) \rightarrow CO_2(g) + 2H_2O(l)$ ΔH_1 = -676 kJ
$C(s) + O_2(g) \rightarrow CO_2(g)$ ΔH_2 = -394 kJ
$H_2(g) + ½O_2(g) \rightarrow H_2O(l)$ ΔH_3 = -242 kJ