Topic 5 Energetics (SL)

Syllabus:

5.1 Measuring the enthalpy changes

Heat is a form of energy

Temperature is a measure of the average kinetic energy of the particles

Conservation of energy

Endothermic and Exothermic involve the transfer of the heat between the system and the surroundings.

The unit of enthalpy change ΔH^{θ} is $kJ\ mol^{-1}$, which is measured under standard conditions.

5.2 Hess's Law

Definition of Hess's Law

Calculation ΔH of reactions using ΔH^{θ}_{f} data.

Calculation ΔH of reactions using multiple reaction with known enthalpy change.

5.3 Bond enthalpies

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

Definition of average bond enthalpy

Understand the bond strength in ozone relative to oxygen in its importance to the atmosphere.

The mechanism of ozone depletion catalyzed by CFCs and NOx.

5.1Measureing the enthalpy changes

(A) Conservation of energy

- Law of conservation of energy: Energy can neither be created or destroyed. It can be transformed to or exchanged between the system and its surroundings.
- Energy can be converted from one form to another.
- Forms of energy: Chemical, Electrical, Nuclear, Radiant, Sound

(B) Define ΔH, endothermic and exothermic reaction

- **Enthalpy (H)**, is an indication of a substance's total energy content and it cannot be measured directly.

- The **standard enthalpy change of a reaction ΔH^{θ}** is the enthalpy change when the molar quantities of reactants as stated in the balanced equation completely react together to give the products under standard conditions (298K, 100kPa).

- **Standard enthalpy change of formation ΔH^{θ}_{f}** is the enthalpy change when **1 mole of compound is formed** from its constituent elements in their standard states under standard conditions.

  For example,

  1. Standard enthalpy change of formation of carbon dioxide

  $C(s) + O_2(g) \rightarrow CO_2(g)$ $\Delta H^{\theta}_{f} = -393.5 \text{ kJ mol}^{-1}$

  2. Standard enthalpy change of formation of ethane

  $2C(s) + 2H_2(g) \rightarrow C_2H_4(g)$ $\Delta H^{\theta}_{f} = +52.0 \text{ kJ mol}^{-1}$

- **Standard enthalpy change of combustion ΔH^{θ}_{c}** is the enthalpy change when **1 mole of element or compound is burnt completely** under standard conditions.

  For example,

  1. Standard enthalpy change of formation of combustion of graphite

  $C(s) + O_2(g) \rightarrow CO_2(g)$ $\Delta H^{\theta}[C(s)] = -393.5 \text{ kJ mol}^{-1}$

  2. Standard enthalpy change of formation of combustion of aluminium

  $Al(s) + \frac{3}{4}O_2 \rightarrow \frac{1}{2}Al_2O_3\ (s)$ $\Delta H^{\theta}[Al(s)] = -837.8 \text{ kJ mol}^{-1}$

- **Exothermic reaction, ΔH < 0**

  It gives out heat to the surroundings.

  Energy is released in the reaction

  Energy of products < Energy of reactants.

  Product is more stable than reactant.

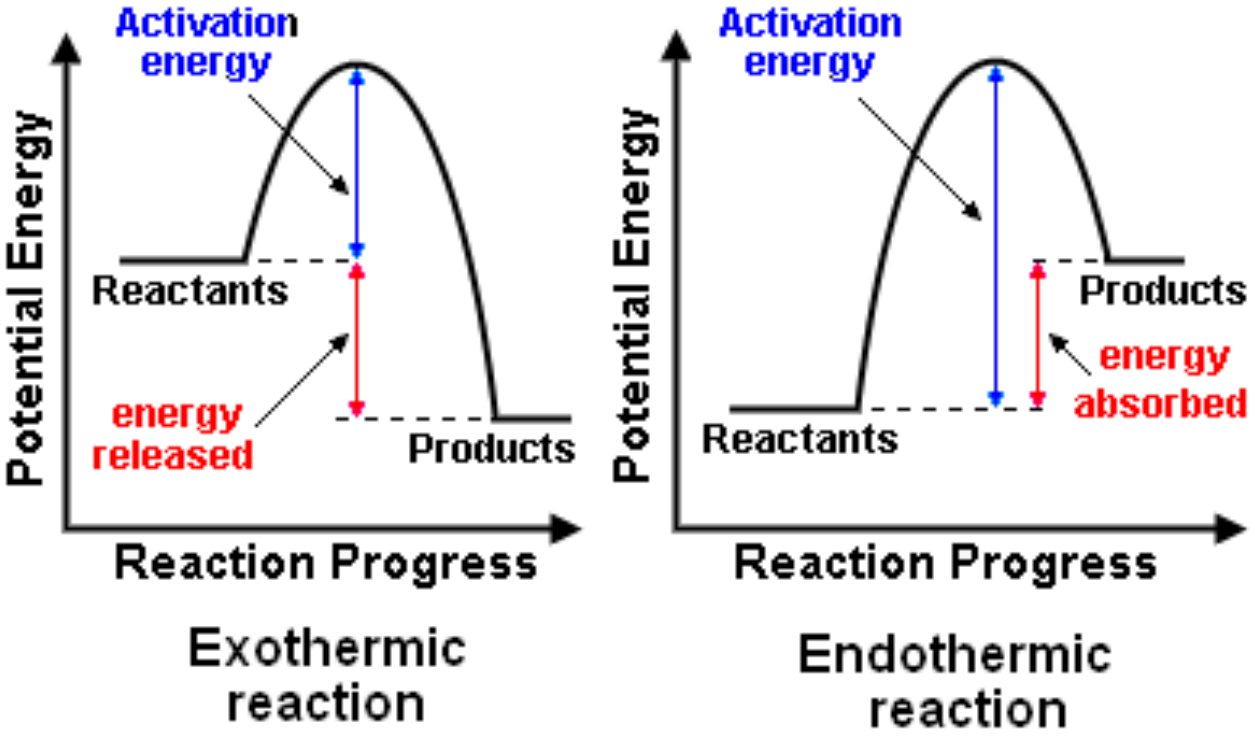
- **Endothermic reaction, ΔH > 0**

  It absorbs heat from the surroundings.

  Energy is used up in the reaction

  Energy of products > Energy of reactants.

  Reactant is more stable than product



- The compound with lower energy is more stable.
- For exothermic reaction, products are more stable than reactants because products have lower potential energy.
- For endothermic reaction, reactants are more stable than products because reactants have lower potential energy.

Question

1. Write the equation for the standard enthalpy change of formation of ethanol, $C_2H_5OH(l)$.

2. Write the equation for the standard enthalpy change of formation of ethanol, $C_3H_6(g)$.

3. Write the equation for the standard enthalpy change of combustion of ethanol, $CH_3OH(l)$.

4. Write the equation for the standard enthalpy change of combustion of ethanol, $C_2H_2(g)$.

Question 5

Sketch the labeled potential energy diagram for exothermic and endothermic reaction

Exothermic reaction	**Endothermic reaction**

MCQ

1. Which processes are exothermic?

   I. Ice melting
   II. Neutralization
   III. Combustion

   A. I and II only
   B. I and III only
   C. II and III only
   D. I, II and III

2. Which process is endothermic?

   A. $CH_4(g) + 2O_2(g) \rightarrow CO_2(g) + 2H_2O(g)$
   B. $HCl(g) + NaOH(aq) \rightarrow NaCl(aq) + H_2O(l)$
   C. $CaCO_3(s) \rightarrow CaO(s) + CO_2(g)$
   D. $H_2O(g) \rightarrow H_2O(l)$

3. Which statements are correct for an exothermic reaction?

   I. The products are more stable than the reactants.
   II. The enthalpy change, $\Delta H°$, is negative.
   III. The temperature of the surroundings increases.

   A. I and II only
   B. I and III only
   C. II and III only
   D. I, II and III

4. Which processes are exothermic?

I. $CH_3CH_2CH_3(g) + 5O_2(g) \rightarrow 3CO_2(g) + 4H_2O(g)$

II. $Cl_2(g) \rightarrow 2Cl(g)$

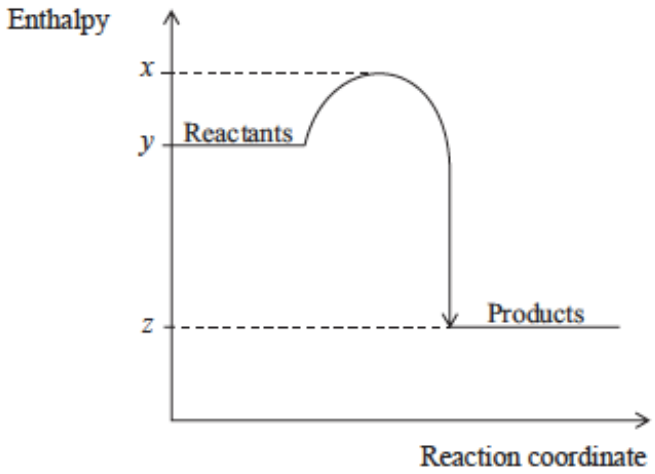
III. $CH_3CH_2COOH(aq) + NaOH(aq) \rightarrow CH_3CH_2COONa(aq) + H_2O(l)$

A. I and II only
B. I and III only
C. II and III only
D. I, II and III

5. The enthalpy change for the reaction between zinc metal and copper(II) sulfate solution is –217 $kJmol^{-1}$. Which statement about this is correct?

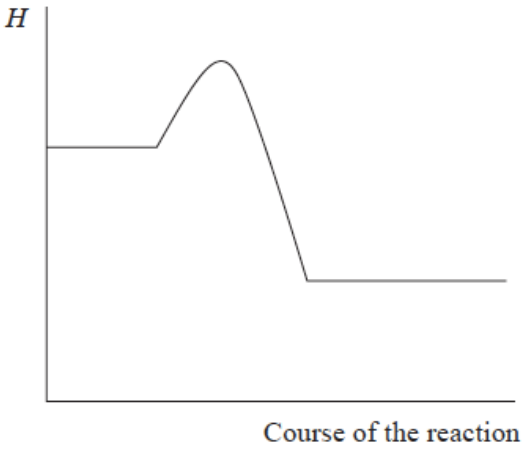
A. The reaction is endothermic and the temperature of the reaction mixture initially rises.
B. The reaction is endothermic and the temperature of the reaction mixture initially drops.
C. The reaction is exothermic and the temperature of the reaction mixture initially rises.
D. The reaction is exothermic and the temperature of the reaction mixture initially drops.

6. What is the value of ΔH for the exothermic reaction represented by the diagram below?



A. y – z
B. z – y
C. x – z
D. z – x

7. Which statement is correct given the enthalpy level diagram below?



A. The reaction is endothermic and the products are more thermodynamically stable than the reactants.
B. The reaction is exothermic and the products are more thermodynamically stable than the reactants.
C. The reaction is endothermic and the reactants are more thermodynamically stable than the products.
D. The reaction is exothermic and the reactants are more thermodynamically stable than the products.

8. Which combination is correct for the exothermic reaction that occurs between zinc and copper sulfate solution.

	Temperature of solution	Heat released to surroundings	Enthalpy of products greater than enthalpy of reactants
A.	Increases	Yes	Yes
B.	Decreases	No	No
C.	Increases	Yes	No
D.	Decreases	No	Yes