Chapter 1

1. Endothermic and Exothermic Reactions

- Thermo chemistry is the study of heat changes that accompany chemical reactions and phase changes.

- In chemical reactions energy is either absorbed or released. According to this there are two types of reactions; endothermic and exothermic.

a. ***Endothermic Reactions***

- Energy is absorbed by reactants and total potential energy of reactants is smaller than that of products.

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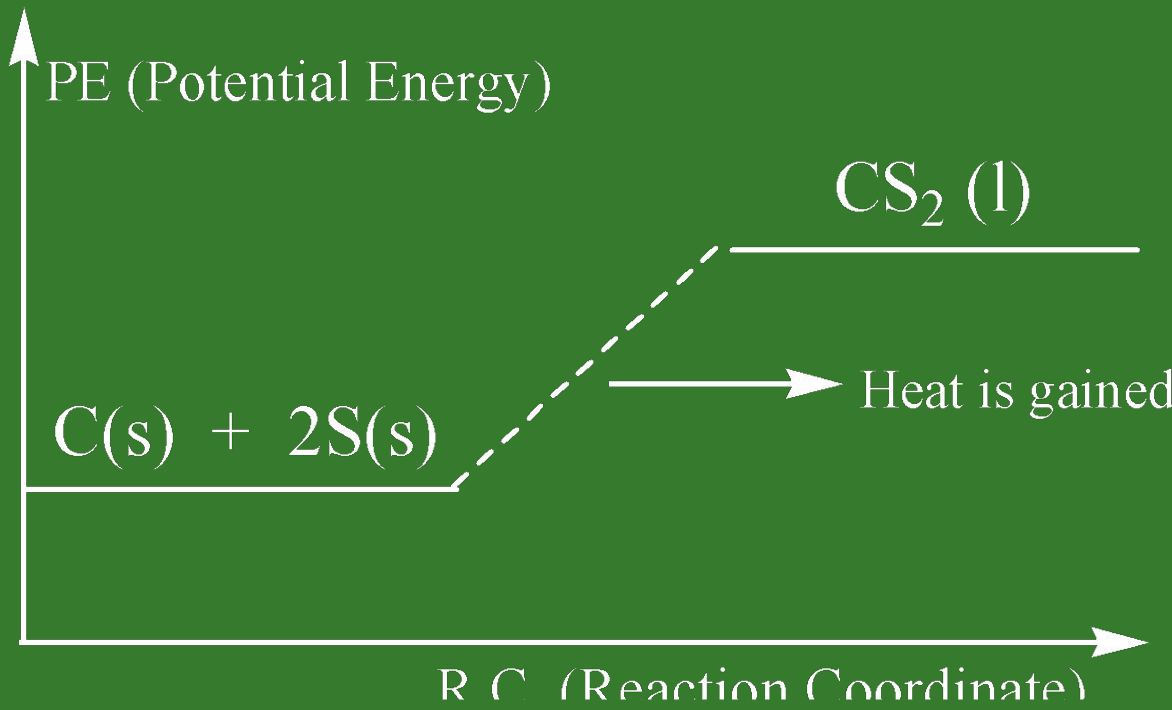
1. Endothermic and Exothermic Reactions

$$87.9\ kJ + C(s) + 2S(s) \longrightarrow CS_2\,(l)$$

The reaction above is an example for endothermic reactions.



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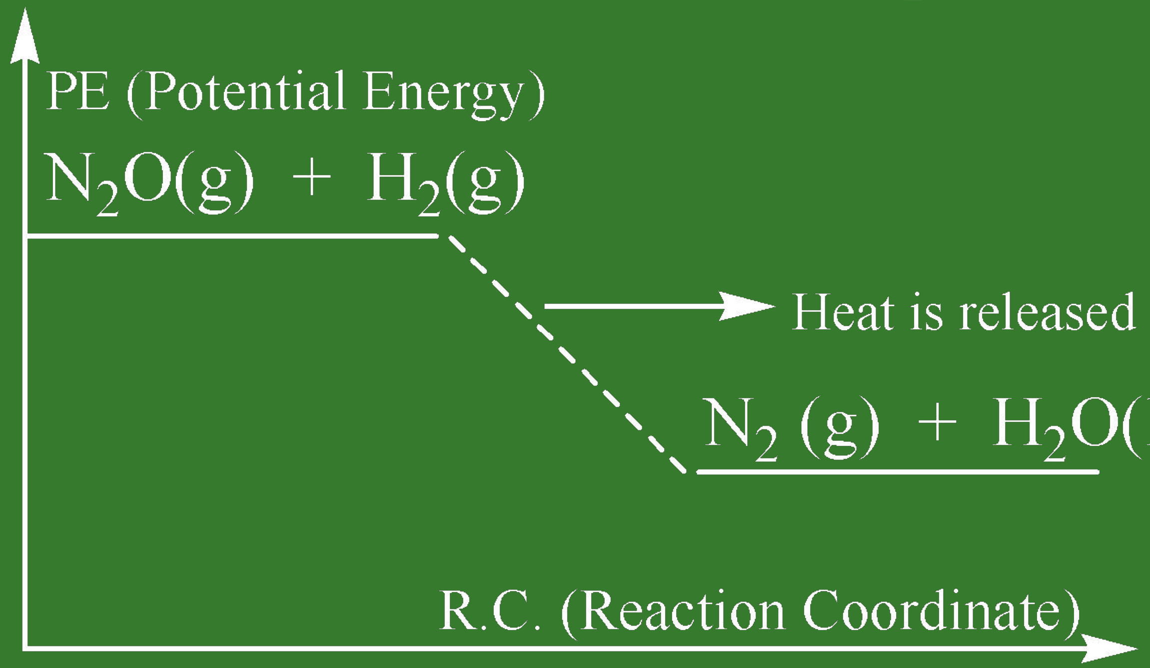
1. Endothermic and Exothermic Reactions

b. Exothermic Reactions

- Energy is released by reactants and total potential energy of reactants is greater than that of products.

$$N_2O(g) + H_2(g) \longrightarrow N_2(g) + H_2O(l) + 368\ kJ$$



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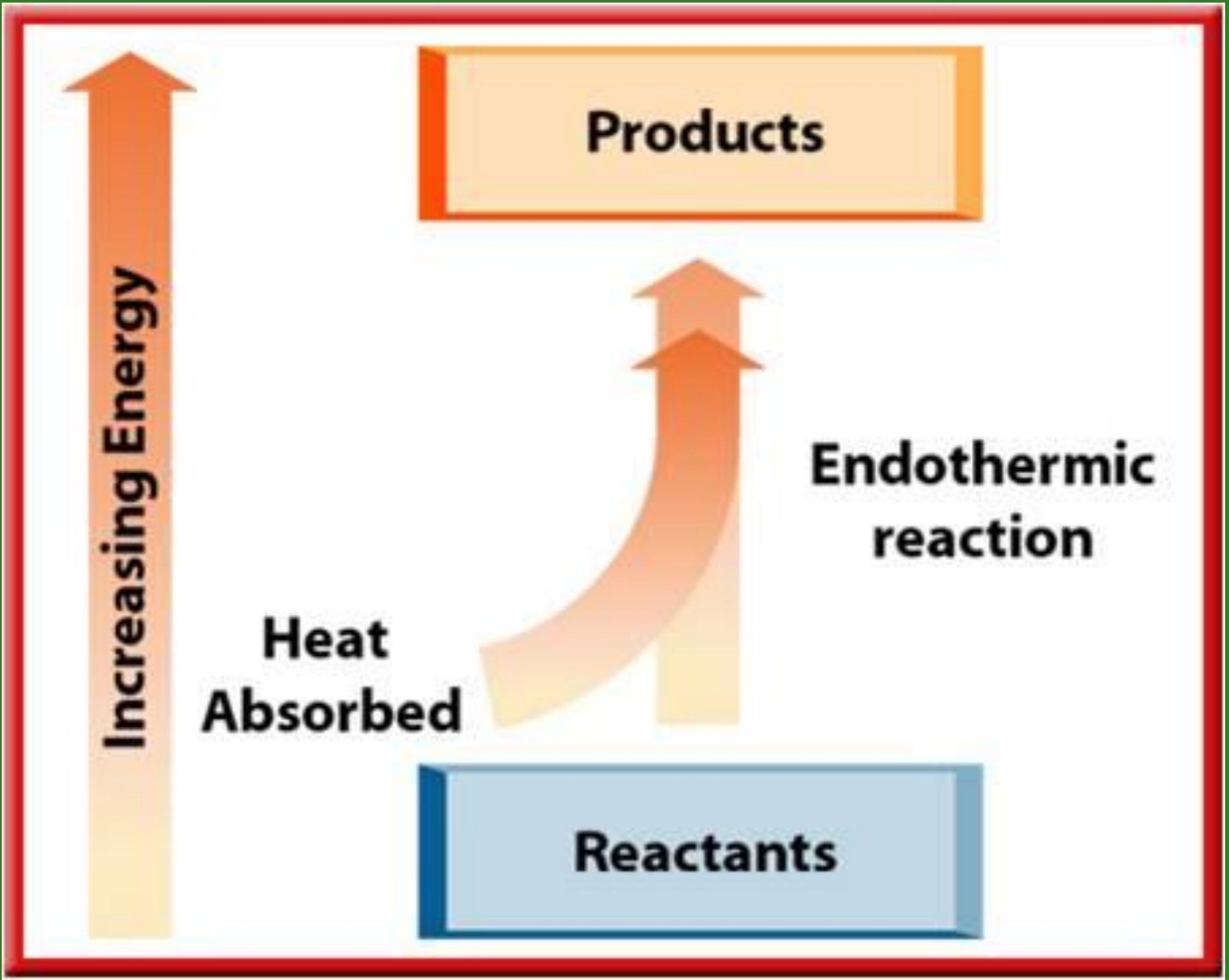
1. Endothermic and Exothermic Reactions



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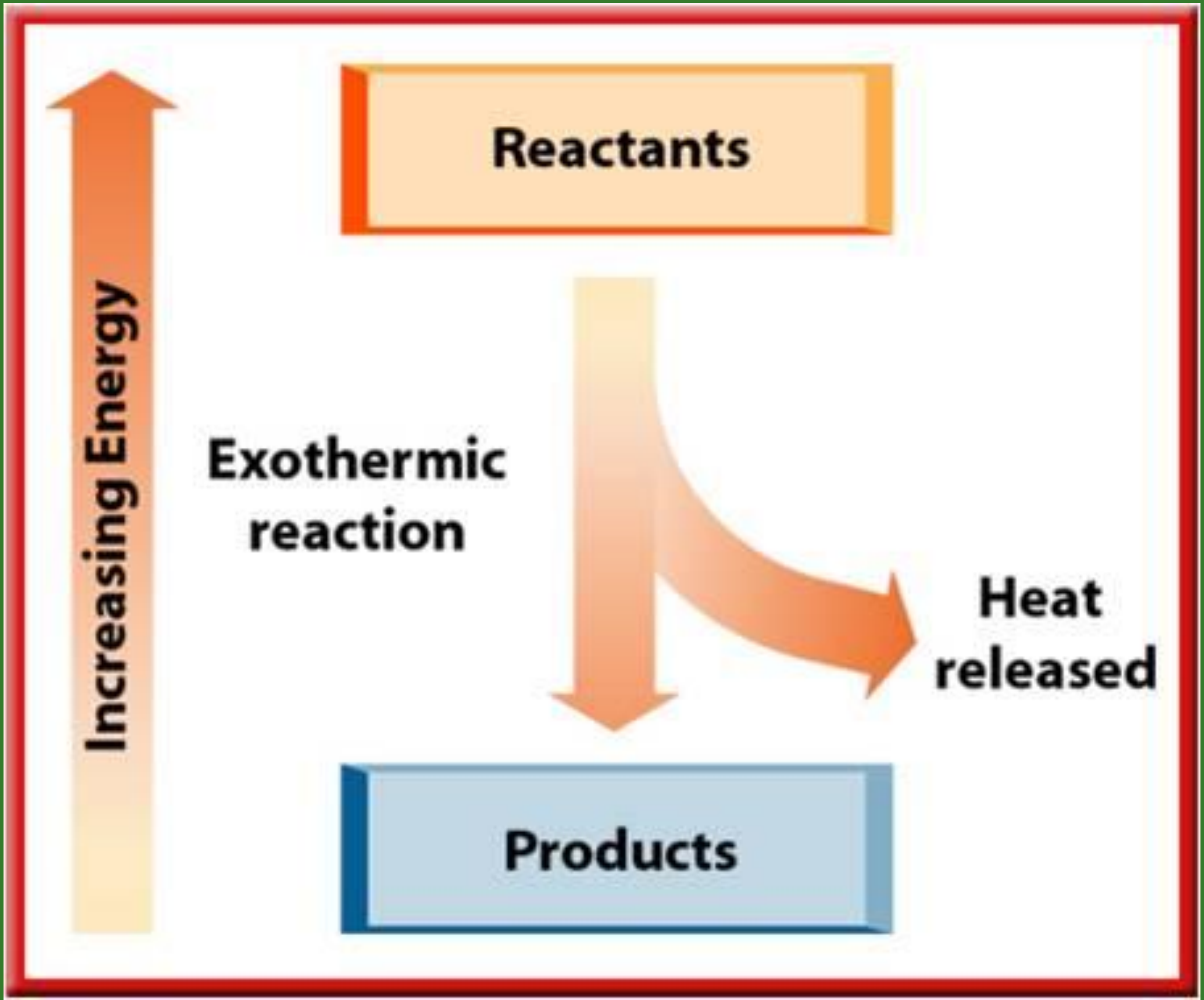
1. Endothermic and Exothermic Reactions



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2. Enthalpy Change of Reactions (ΔH)

- Enthalpy (H) is the heat content of a substance at constant pressure.
- The change in enthalpy for a reaction is called the enthalpy of reaction (ΔH).

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

- If $\Sigma H_{products} > \Sigma H_{reactants}$, then $\Delta H > 0$ so the reaction is endothermic. Similarly,
- If $\Sigma H_{products} < \Sigma H_{reactants}$, then $\Delta H < 0$ so the reaction is exothermic.

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2. Enthalpy Change of Reactions (ΔH)

Enthalpy Changes for Exothermic and Endothermic Reactions

Type of reaction	Sign of ΔH_{rxn}
Exothermic	Negative
Endothermic	Positive

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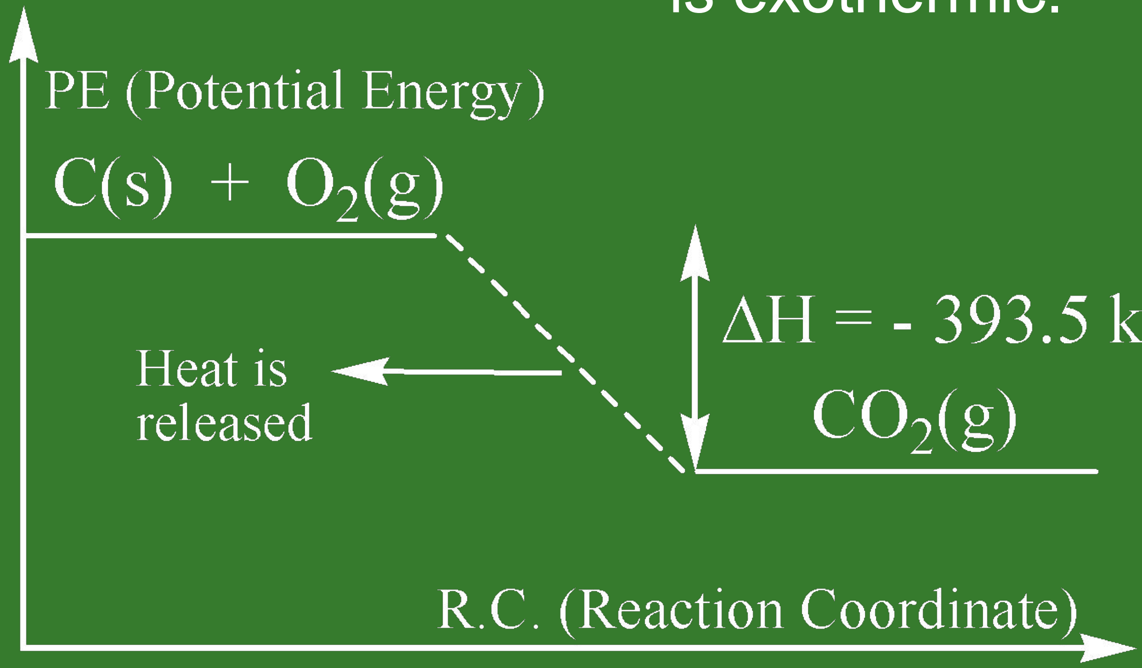
2. Enthalpy Change of Reactions (ΔH)

Example 1

$$C(s) + O_2(g) \longrightarrow CO_2(g) + 393.5\ kJ$$

$\Delta H = -393.5$ kJ < 0 then the reaction is exothermic.



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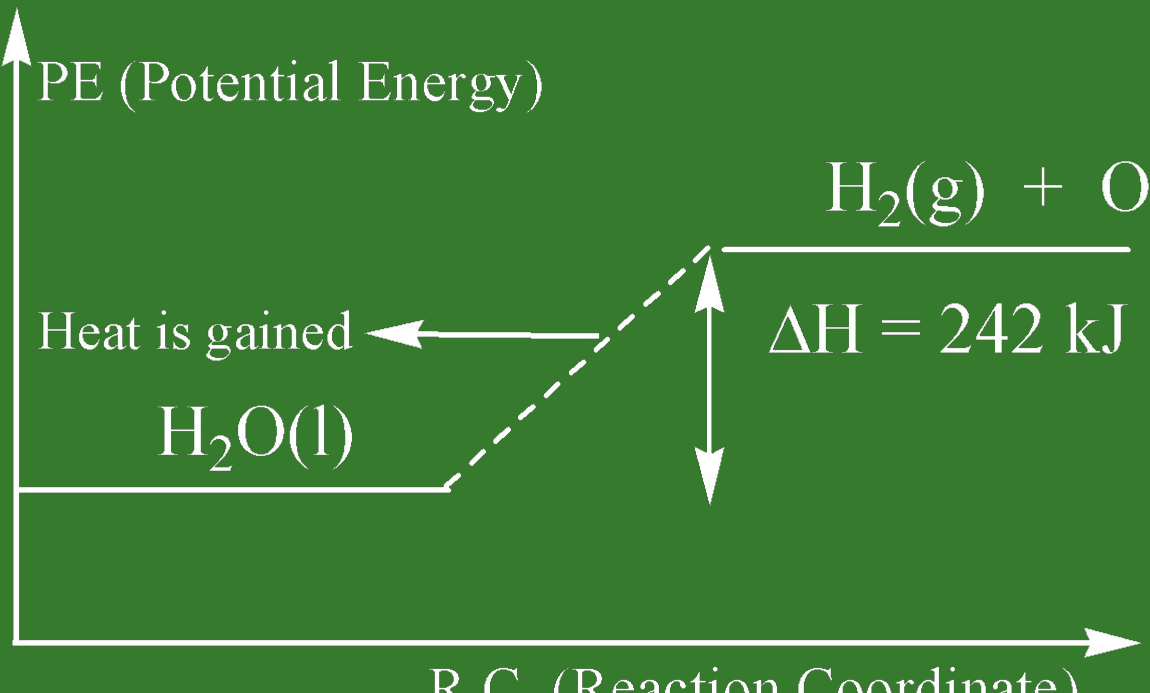
2. Enthalpy Change of Reactions (ΔH)

Example 2

$$H_2O(l) + 242\ kJ \longrightarrow H_2(g) + O_2(g)$$

ΔH = 242 kJ > 0 then the reaction is endothermic.



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2. Enthalpy Change of Reactions (ΔH)

Standard Heat of Formation (ΔH^o_f)

- The heat change when 1 mole compound is produced from its elements in their most stable states (under 1 atm pressure and at 25^{o}C is called as standard heat of formation, and shown by ΔH^o_f.
- ΔH^o_f of the free atoms (K, Fe, Na, S, P, Cu…etc) and free simple molecules (O_2, N_2, Cl_2, P_4, …etc) are accepted as zero.

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2. Enthalpy Change of Reactions (ΔH)

Heat of a reaction, ΔH^o can be calculated by using ΔH^o_f values.

$$\Delta H^o = \Sigma H^o_{f(products)} - \Sigma H^o_{f(reactants)}$$

Example 3

Find the heat of the reaction (ΔH^o)

$SO_2(g) + \frac{1}{2} O_2(g) \rightarrow SO_3(g)$

by using ΔH^o_f of the compounds given

$\Delta H^o_{f(SO2)} = -297$ kJ/mol, $\Delta H^o_{f(SO3)} = -396$ kJ/mol

$\Delta H^o_{f(O2)} = 0$ kJ/mol

2. Enthalpy Change of Reactions (ΔH)

Solution

$\Delta H^o = \Sigma H^o_{f(products\ )} - \Sigma H^o_{f(reactants)}$

$\Delta H^o = \Delta H^o_{f(SO3)} – [\Delta H^o_{f(SO2)} + ½\ \Delta H^o_{f(O2)}]$

$\Delta H^o = (-396) – [(-297)+ ½ \times (0)]$

$\Delta H^o = -99$ kJ

Example 4

When 2.4 g of graphite burnt with O_2 completely, 78.70 kJ heat is released. What is the molar enthalpy of the formation of CO_2 ?

2. Enthalpy Change of Reactions (ΔH)

Solution

$C_{(graphite)} + O_2(g) \rightarrow CO_2(g)$

2.4 g C releases 78.70 kJ

12 g (1mol) C releases x

x = 393.5 kJ

$$\Delta H^o = \Sigma H^o_{f(products)} - \Sigma H^o_{f(reactants)}$$

$$\Delta H^o = \Delta H^o_{f(CO2)} – [\Delta H^o_{f(C)} + \Delta H^o_{f(O2)}]$$

$$-393.5 = \Delta H^o_{f(CO2)} – [(0)+ (0)]$$

$$\Delta H^o_{f(CO2)} = -393.5 \text{ kJ}$$

2. Enthalpy Change of Reactions (ΔH)

Example 5

The combustion reaction of propane is

$C_3H_8(g) + 5O_2(g) \rightarrow 3CO_2(g) + 4H_2O(l) \quad \Delta H^o = -2220.3$ kJ

If $\Delta H^o_{f(CO2)}$ and $\Delta H^o_{f(H2O)}$ values are -393.5 kJ/mol and -286 kJ/mol respectively find $\Delta H^o_{f(C3H8)}$?

Example 6

$Fe_2O_3(s) + 3CO(g) \rightarrow 2Fe(s) + 3CO_2(g)$

If $\Delta H^o_{f(Fe2O3)}$, $\Delta H^o_{f(CO)}$ and $\Delta H^o_{f(CO2)}$ values are -826 kJ/mol, -110.5 kJ/mol and -393.5 kJ/mol respectively find ΔH^o for the reaction.