Module 2: Thermodynamics of Combustion

Lecture 9: Heat of Combustion

The Lecture Contains:

- Heat of combustion

- Hess Law

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Heat of Combustion

Heat of formation	Heat of reaction per mole of a particular species formed isothermally from elements in their standard state
Heat of reaction	Enthalpy change due to chemical reaction
Heat of Combustion	One of the reactant should be fuel

For the reaction : $CH_4 + 2O_2 \rightarrow CO_2 + 2H_2O$

Heat of reaction is given by : $\Delta H^0_{R,298} = \left(n_{CO_2}\, h^0_{f,CO_2} + n_{H_2O}\, h^0_{f,H_2O}\right) - \left(n_{CH_4}\, h^0_{f,CH_4} + n_{O_2}\, h^0_{f,O_2}\right)$

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Heat of formation of important species at 25 °C and 0.1 MPa

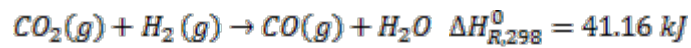| Species	Formula	State	Heat of formation (kJ/mol)
Oxygen	O_2	Gas	0
Hydrogen	H_2	Gas	0
Hydroxyl	OH	Gas	42.3
Water	H_2O	Gas	-242
Water	H_2O	Liquid	-286
Carbon monoxide	CO	Gas	-110.5
Carbon dioxide	CO_2	Gas	-394
Methane	CH_4	Gas	-74.5
Propane	C_3H_8	Gas	-103.8
Butane (n)	C_4H_{10}	Gas	-124.7
Kerosene	$CH_{1.842}$	Liquid	-51.6
Nitrogen dioxide	NO_2	Gas	33.9
Nitric acid	NO	Gas	90.4

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Hess Law

Hess Law	In a chemical reaction, the resultant heat is same, irrespective of the number of steps

The net heat of reaction depends only on the initial and final states

Illustration: Determine the heat of reaction for water gas shift reaction

$$CO_2(g) + H_2(g) \rightarrow CO(g) + H_2O \quad \Delta H^0_{R,298} = 41.16 \ kJ$$

Intermediate Reactions:

$$CO_2 \rightarrow C + O_2 \qquad\qquad \Delta H^0_{R,298} = 393.51 \ kJ$$

$$C + \left(\frac{1}{2}\right) O_2 \rightarrow CO \qquad\qquad \Delta H^0_{R,298} = -110.59 \ kJ$$

$$H_2 + \left(\frac{1}{2}\right) O_2 \rightarrow H_2O \qquad\qquad \Delta H^0_{R,298} = -241.82 \ kJ$$

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$$CO_2 + H_2 \rightarrow CO + H_2O \qquad \Delta H^0_{R,298} = -41.16 \ kJ$$

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