Lecture 7 Thermo chemistry: illustration

Content:

Illustration- i

Calculate heat of the following reaction/ mole at 550K.

$$ZnO(S) + C(S) = Zn(g) + CO(g)$$

Given:

Component	H_{1500} -H_{298} (kcal/kg mol)	ΔH_f° (kcal/kg mol)
ZnO(s)	14800	-83310
C(s)	9291	-
Zn(g)	37150	-
CO(g)	5480	- 29160

For the reaction 1

$$\left(\Delta H_f^\circ\right)_{298} = \left(\Delta H_f^\circ\right)_{CO} - \left(\Delta H_f^\circ\right)_{ZnO}$$

Substituting the values we get

$$\left(\Delta H_f^\circ\right)_{298} = +54150 \text{ k cal/kg mol.}$$

$$(\Delta H_f)_{1500} = \left(\Delta H_f^\circ\right)_{298} + \sum(H_{1500} - H_{298})_{\text{products}} - \sum(H_{1500} - H_{298})_{\text{reactant}}$$

Substituting the value we get

$$(\Delta H_f)_{1500} = 72689 \text{ kcal/kg mol}$$

Do you self –i

Calculate heat of the following reaction at 1200K.

$$Fe_2O_3 + 3CO = 2Fe + 3CO_2$$

Component	H_{1200} - H_{298} (kcal/kg mol)	ΔH_f° (kcal/kg mol)
Fe_2O_3	30870	-198500
CO	6798	-29160
CO_2	10650	-97200
Fe	8370	-

Illustration –ii

Calculate heat content in 1 kg mol nickel at 3500°C.

At 3500°C $(\mathrm{Ni})_s = \mathrm{Ni(V)}$.

Nickel undergoes phase transformation from α to β at360°C.

Melting point of Ni = 1455°C, boiling point is 2730°C

Latent heat of melting $= 4248 \frac{\mathrm{kcal}}{\mathrm{kg\ mol}}$

Latent heat of vaporization $= 87910$ kcal/kg mol

$$(C_P)_{Ni}\alpha = 12.535 + (35.815 \times 10^{-3}T) - (6.95x10^5 T^{-2}) \frac{\mathrm{KJ}}{\mathrm{kg\ mole\ K}}$$

$$(C_P)_{Ni}\ \beta = 25.104 + (7.531 \times 10^{-3}T) - \frac{\mathrm{KJ}}{\mathrm{kg\ mole\ K}}$$

Latent heat of transformation from α to β = 0

Solution

Heat content in 1 kg mol nickel vapour

$$(Heat\ content\ in\ Ni\ from\ 25°C\ to\ 360°C) + (\text{latent heat of transformation}) +$$
$$(\text{Heat content in Ni from 360°Cto 1455°C}) + (\text{latent heat of melting}) +$$
$$(\text{Heat content in Ni from 1455°Cto 2730°C}) + (\text{latent heat of vaprization}) +$$
$$(\text{Heat content in Ni from 2730°Cto 3500°C})$$

One has to calculate all the values to give heat content $= 119217.5 \frac{\mathrm{kcal}}{\mathrm{kg\ mol}}$ in Ni vapour at 3500°C which is equal to $2020 \frac{\mathrm{k\ cal}}{\mathrm{kg\ Ni}}$

Do yourself – ii

For a solid silver, the molar heat capacity at constant pressure

$$C_P = 21.3 + (8.535 \times 10^{-3}T) + (1.506 \times 10^5\ T^{-3})\mathrm{J/g\ mol\ k}$$

Find heat content of silver at 1235k.

Latent heat $= 111\frac{\text{kj}}{\text{kg}}$, melting print of $\text{Ag } 962°\text{C}$.

Answer: $37582\frac{\text{j}}{\text{g mol}}$.

Illustration iii

Find the enthalpy change at 900k for the reaction

$\text{CaO(S)} + \text{CO}_2\text{(g)} = \text{Ca CO}_3\text{(S)}$

Component	$-\Delta H_f^\circ(\text{KJ})$	C_p J/mol K.
CaO(s)	634.3	$49.62+(4.52\text{x}10^{-3}T)-(6.95\text{x}10^{5}T^{-2})$
CO_2(g)	393.5	$44.14+(9.04\text{x}10^{-3}T)-(8.54\text{x}10^{5}T^{-2})$
Ca CO_3(s)	1206.7	$104.52+(21.9\ 2\text{x}10^{-3}T)-(25.94\text{x}10^{5}T^{-2})$

$\Delta H_{298}^\circ = 178900\text{J}$ for reaction 1.

$\Delta CP = C_{P_{CaCO_3}} - C_{P_{CO2}}$

$= 10.76 + (8.36 \times 10^{-3}T) - (10.45 \times 10^5\ T^{-2})$

$\Delta H_{900} = \Delta H^\circ + \int_{298}^{900} 10.76 + (8.36 \times 10^{-3}T) - (10.45 \times 10^5 T^{-2})dT$

$\Delta H_{900} = -171748$ joules.

Do yourself – iii

Calculate enthalpy of copper at 950K and the enthalpy increment for heating copper from 298 K to 950K.

$C_P = 5.41 + 1.5 \times 10^{-3}T\ \text{cal/mol K}$

Enthalpy increment

$H_{(950K,1atm\ pressure)} - H_{(950K,1atm\ )} = \int_{298}^{950} C_P\ dT$

Ans. enthalpy of $\text{Cu} = 4137.6\ \text{cal/mol}$ since $H_{(298K,1atm\ )}$ for Cu is zero.

Illustration iv

Calculate heat of reaction at $1100°C$

$Cu_2S(s) + (O_2 + 3.76\ N_2)_g = 2Cu(l) + SO_2(g) + 3.76N_2(g)$

Reactants and products are at $1100°C$. Air is supplied at $25°C$. Melting point of copper is $1084°C$.

$C_P(Cu_2s) = 81.588 \frac{J}{mol\ k.}$

$C_P(Cu_{solid}) = 22.635 + (6.27 \times 10^{-3}T) \frac{J}{mol\ k}.$

$C_P(Cu_{liquid}) = 31.380 \frac{j}{mol\ k}$

$C_P(SO_2) = 43.430 + (10.62 \times 10^{-3}T) - (3.766 \times 10^5 T^{-2})$

$C_P(N_2) = 27.865 + (4.268 \times 10^{-3}T)$

$\text{Latent heat of copper} = 11193\ \frac{j}{mol}$

$(\Delta H^\circ_{Cu_2s})_{298} = -79496 \frac{j}{mol}, \Delta H^\circ_{SO_2} = -296810\ \frac{j}{mol}$

$\Delta H_R(1373) = \Delta H^\circ_R + \sum(H_{1373} - H_{298})_P - \sum(H_{1373} - H_{298})_R$

On solving $\Delta H_R(1373) = -40405$ joule