

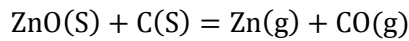
Lecture 7 Thermo chemistry: illustration

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Illustration- i

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



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

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

Substituting the values we get

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

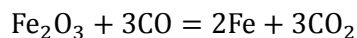
$$(\Delta H_f)_{1500} = (\Delta H_f^\circ)_{298} + \sum(H_{1500} - H_{298})_{\text{products}} - \sum(H_{1500} - H_{298})_{\text{reactant}}$$

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.



Component	$H_{1200} - H_{298}$ (kcal/kg mol)	ΔH_f° (kcal/kg mol)
Fe ₂ O 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 (Ni)_s = Ni(V).

Nickel undergoes phase transformation from α to β at 360°C.

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

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

$$\text{Latent heat of vaporization} = 87910 \text{ kcal/kg mol}$$

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

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

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) + (latent heat of transformation) +
 (Heat content in Ni from 360°C to 1455°C) + (latent heat of melting) +
 (Heat content in Ni from 1455°C to 2730°C) + (latent heat of vaporization) +
 (Heat content in Ni from 2730°C to 3500°C)

One has to calculate all the values to give heat content = $119217.5 \frac{\text{kcal}}{\text{kg mol}}$ in Ni vapour at 3500°C

which is equal to $2020 \frac{\text{kcal}}{\text{kg Ni}}$

Do yourself – ii

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

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

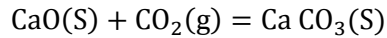
Find heat content of silver at 1235k.

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

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

Illustration iii

Find the enthalpy change at 900k for the reaction



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

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

$$\Delta C_P = C_{P_{\text{CaCO}_3}} - C_{P_{\text{CO}_2}}$$

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

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

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

Do yourself – iii

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

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

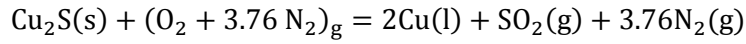
Enthalpy increment

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

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

Illustration iv

Calculate heat of reaction at 1100°C



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

$$C_P(\text{Cu}_2\text{S}) = 81.588 \frac{\text{J}}{\text{mol k}}$$

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

$$C_P(\text{Cu}_{\text{liquid}}) = 31.380 \frac{\text{J}}{\text{mol k}}$$

$$C_P(\text{SO}_2) = 43.430 + (10.62 \times 10^{-3}T) - (3.766 \times 10^5 T^{-2})$$

$$C_P(\text{N}_2) = 27.865 + (4.268 \times 10^{-3}T)$$

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

$$(\Delta H_{\text{Cu}_2\text{S}}^\circ)_{298} = -79496 \frac{\text{J}}{\text{mol}}, \Delta H_{\text{SO}_2}^\circ = -296810 \frac{\text{J}}{\text{mol}}$$

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

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