Registration No. :

Total number of printed pages – 3

Third Semester Regular Examination – 2014
METALLURGICAL THERMODYNAMICS AND KINETICS
BRANCH(S) : MM, MME
QUESTION CODE : H 412
Full Marks – 70
Time – 3 Hours

Answer Question No. **1** which is compulsory and any **five** from the rest.
The figures in the right-hand margin indicate marks.

1. Answer the following questions :   2 × 10

    (a) What do you mean by Extensive and intensive properties ?

    (b) Define Reversible and irreversible process.

    (c) Define Activation energy and Internal energy.

    (d) What is the basic principle of Differential Thermal Analysis (DTA) ?

    (e) What do you mean by standard state of a system ?

    (f) What is Electro Chemical Equivalent ?

    (g) What is Limiting Current Density ?

    (h) What is Henry's law ?

    (i) What is phase rule ?

    (j) State second law of thermodynamics.

2. Write short notes on any two :   5 × 2

    (a) One weight percentage standard state

    (b) Thermal Analysis

    (c) Excess function

    (d) Partial molal quantities

    (e) Auxiliary functions.

P.T.O.

3. (a) Derive Gibbs Helmholtz equation $\left[\dfrac{\partial(\Delta G/T)}{\partial T}\right]_P = -\Delta H/T^2$ 5

   (b) Calculate the standard heat of formation of solid PbO produced from liquid Pb and O_2 gas at 800 K. The melting point of Pb is 600 K and its latent heat of fusion is 4.81 kJ/mol.   5

   Given :

   $\Delta H^\circ_{f}, 298, Cr_2O_{3(s)} = -1120.3$ kJ/mol,

   $\Delta H^\circ_{f}, 298, Al_2O_{3(s)} = -1674.0$ kJ/mol

   $Cp, Al_{(s)} = 20.7 + 12.4 \times 10^{-3}$ J/K/mol

   $Cp, Al_2O_{3(s)} = 106.6 + 17.8 \times 10^{-3}T - 28.5 \times 10^5T^{-2}$ J/K/mol
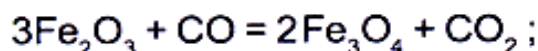
   $Cp, Cr_{(s)} = 24.4 + 9.87 \times 10^{-3}T - 3.7 \times 10^5T^{-2}$ J/K/mol

   $Cp, Cr_2O_{3(s)} = 119.4 + 9.2 \times 10^{-3}T - 15.6 \times 10^5T^{-2}$ J/K/mol

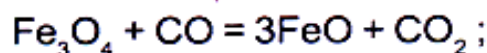4. (a) What is an ideal solution ? Explain the important characteristics of an ideal solution in terms of :   5

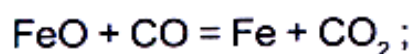   (i) Thermodynamic chemical potential

   (ii) Enthalpy.

   (b) Calculate the standard heat of reaction of $Fe_2O_3 + 3CO = 2Fe + 3CO_2$ from the following data :   5

   $3Fe_2O_3 + CO = 2Fe_3O_4 + CO_2$;

   $\Delta H^\circ_{298} = -12.7$ k.Cal

   $Fe_3O_4 + CO = 3FeO + CO_2$;

   $\Delta H^\circ_{298} = +9.8$ k.Cal

   $FeO + CO = Fe + CO_2$;
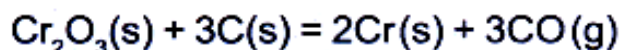
   $\Delta H^\circ_{298} = -4.4$ k.Cal

5. (a) Discuss topo-chemical pattern of iron ore reduction. Discuss the significance of activation energy in a chemical reaction.   6

   (b) Calculate the entropy of liquid iron at its melting point, 1808 K, given that for iron :   4

   $L_f = 15.4$ KJ/mol, $S^\circ_{298, Fe(s)} = 27.9$ J/K/mol and $Cp = 25.2$ J/K/mol.

   OR (of b.)

Calculate the standard entropy change for the reaction

$Cr_2O_3(s) + 3C(s) = 2Cr(s) + 3CO(g)$

Given :

$S°_{298}, Cr_2O_{3(s)} = 83.17$ J/K/mol

$S°_{298}, C_{(s)} = 5.69$ J/K/mol

$S°_{298}, Cr_{(s)} = 23.76$ J/K/mol

$S°_{298}, CO_{(g)} = 197.90$ J/K/mol

6. (a) What is fugacity ? What do you mean by standard state of a system.?   5

    (b). State Henry's Law. Justify "the fugacity of the solute in real dilute solution is proportional to its mole fraction".   5

7. Derive the following thermodynamic relations (any two) :   5×2

    (a) $Cp - Cv = R$

    (b) $P_1(RT_1/P_1)^\gamma = P_2(RT_2/P_2)^\gamma = Constant$

    (c) $dU = T.dS - P.dV$

    (d) $\left(\dfrac{\partial y}{\partial x}\right)_z \left(\dfrac{\partial y}{\partial z}\right)_x \left(\dfrac{\partial z}{\partial x}\right)_y = -1$

8. What is entropy ? Discuss important characteristics of entropy. Derive expression for entropy of a perfect gas ($S = Cp \ln V + Cv \ln P + constant$).   2+4+4

<div align="center">OR</div>

Derive Maxwell's Relations. From the following data determine which metal has greater probability of oxidation in presence of steam at 827°C and 1 atm pressure.   6+4

    (a) $NiO(s) + H_2(g) = Ni(s) + H_2(g)$, $\Delta G° = (-2301 - 42.59\,T)$ J

    (b) $1/3\,Cr_2O_3(s) + H_2(g) = 2/3\,Cr(s) + H_2O(g)$, $\Delta G° = (126{,}566 - 30.67T)$ J