

COLLEGE OF ENGINEERING PUNE
End Semester Exam
Metallurgical Thermodynamics

Class: S.Y.B.Tech. (Met.Engg)
F.Y.M.Tech.

Time: 3 hours
Marks: 50

Instructions:

- a) **Q1 is compulsory** and solve any **Four** from remaining questions
- b) Assume suitable data if necessary.
- c) Use of calculators is allowed.
- d) Assumptions and Figures will carry marks

Q1

State **True** or **False** and **Justify** to the point.

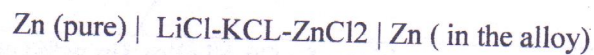
2 x5

- a. In an aqueous electrochemical cell, the free energy change of a dissolved species in presence of alloy metal can be represented as $\Delta G = RT \ln a$.
- b. Entropy of fusion of a metallic liquid solidifying at its melting point follows Richard' rule.
- c. A solution exhibits non-ideal behaviour if the activity coefficient is one.
- d. Solubility of Argon gas can be estimated if its partial pressure is known.
- e. In binary system containing two elements A and B, the atom % A is equal to wt % A.

Q2a

The following cell is set up for determination of the activity of zinc in a Zn-Sn-Cd-Pb alloy-

5



The reversible e.m.fs are as follows-

Temp.°C	441	484	532	569	604
E, mV	12.76	16.30	20.26	23.32	26.20

Calculate the activity of Zinc in the above alloy at these temperatures.

$$\text{One Faraday} = 96487 \text{ J/V/g-equivalent}$$

Q2b	The activity coefficient of copper in Cu-Zn alloys at 1027°C is given below-	5									
<table border="1"> <tr> <td>X_{Cu}</td> <td>0.9</td> <td>0.8</td> <td>0.7</td> <td>0.6</td> </tr> <tr> <td>γ_{Cu}</td> <td>0.981</td> <td>0.922</td> <td>0.837</td> <td>0.728</td> </tr> </table>			X_{Cu}	0.9	0.8	0.7	0.6	γ_{Cu}	0.981	0.922	0.837
X_{Cu}	0.9	0.8	0.7	0.6							
γ_{Cu}	0.981	0.922	0.837	0.728							
Calculate the integral molar free energy of mixing and excess integral molar free energy of solutions for an alloy containing 80 atom% and also confirm whether the given solution exhibits real behaviour or regular behaviour.											
Q3a	Determine the temperature above or below which the reduction of MgO by Al becomes thermodynamically feasible at 1 atm pressure (101325 N/m ²).	5									
$2 \{Al\} + \frac{3}{2} (O_2) = \langle Al_2O_3 \rangle \quad \Delta G^\circ = -1679876 + 321.79 T, J$ $(Mg) + \frac{1}{2} (O_2) = \langle MgO \rangle \quad \Delta G^\circ = -731154 + 205.39 T, J$											
Q3b	Will a blast furnace gas analyzing 28% CO, 13%CO ₂ and 58%N ₂ (by vol)reduce wustite (FeO) at 727 °C. How do you predict reduction of FeO from Ellingham diagram?	5									
$\langle Fe \rangle + \frac{1}{2} (O_2) = \langle FeO \rangle \quad \Delta G^\circ = -259617 + 62.55 T, J$ $(CO) + \frac{1}{2} (O_2) = (CO_2) \quad \Delta G^\circ = -282420 + 86.82 T, J$											
Q4	Calculate the equilibrium partial pressure of Zinc vapour and CO at 1200°C according to the following reaction-	10									
$\langle ZnO \rangle + \langle C \rangle = (Zn) + (CO) \quad \Delta G^\circ = 371\,204 + 42.30T \log T - 432.33 T, J$ <p>Assume that the reaction is carried out in a closed retort containing no air.</p>											
Q5	Calculate the equilibrium composition of a Cu-Ni alloy (in wt%) capable of existing in equilibrium with Cu ₂ O and NiO at 727°C from the following data- $\Delta G^\circ_{Cu_2O} = -76274 J/mol$; $\Delta G^\circ_{NiO} = -126\,148 J/mol$ Atomic weights of Cu and Ni are 63.54 and 58.7 respectively.	10									
Q6	At 1570°C liquid iron dissolves 0.039 wt% nitrogen in equilibrium with nitrogen at 1 atm (101325 N/m ²) pressure and 0.0025 wt% hydrogen in equilibrium with hydrogen at 1 atm pressure. Ammonia gas (NH ₃) was passed over iron at that temperature at such a rate that equilibrium was attained with fully dissociated ammonia at a net pressure of 1 atm. Calculate the hydrogen and nitrogen contents of the melt.	10									

-----The End-----