

III B.Tech. I Semester Regular Examinations, November -2005
METALLURGICAL THERMO DYNAMICS
(Metallurgy & Material Technology)

Time: 3 hours**Max Marks: 80**

Answer any FIVE Questions
All Questions carry equal marks

1. (a) Define the term 'diffusion'. Explain the engineering importance of diffusion. Explain the various applications of diffusion. [8]
(b) There is 0.19% of Cu at the surface of some aluminium and 0.18% copper, 1.2 mm underneath the surface. What will be the flux of copper atoms be from the surface inward at 500°C (Al is Fcc and lattice constant is 4.05°\AA).
($D_o = 0.15 \times 10^{-4} \text{m}^2/\text{sec}$, $Q = 30,200 \text{ cal/mole}$; $E = 0.210 \times 10^{-18} \text{ J/atom}$). [8]
2. (a) Compare interstitial and vacancy atomic mechanisms for diffusion. [8]
(b) Cite 2 reasons why interstitial diffusion is normally more rapid than vacancy diffusion. [8]
3. (a) What is the importance of equilibrium constant & how this can be calculated from standard free energy changes? [8]
(b) Define equilibrium constant & how this can be influenced on the extraction process. [8]
4. (a) Discuss Einstein's theory of specific heats. Point out its limitations. Explain how these were overcome by Debye's approach. [9]
(b) Calculate the temperature if 1500 calories are introduced to 500 gms of a metal at 25°C which has a specific heat of 0.025 cal/gm/k . [7]
5. (a) State and explain Raoult's law and Henry's laws. [6]
(b) What is a solution. Compare and contrast ideal solutions and regular solutions. [6]
(c) Explain the conversion of composition for weight percentage and to atomic percentage. [4]
6. (a) What are the properties of solution that can be studied with the help of Gibbs Duhem equation? Explain them in detail. [8]
(b) Write a short notes on Sievert's law [8]
7. (a) What is the importance of chemical potential? [4]
(b) Derive the Gibb's phase rule & explain its importance. [12]
8. (a) Explain about the Galvanic cell & its sign convention & representation. [8]
(b) What are the reversible and irreversible cells, Explain any one cell. [8]

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1. (a) Explain the effect of the following factors on diffusion coefficient. [3X3=9]
 - i. Temperature
 - ii. Grain size
 - iii. Concentration.
- (b) The inward flux of carbon atoms in FCC iron is $10^{19} m^2/sec$. at $1000^\circ C$. What is the concentration gradient. ($D_o = 0.2 \times 10^{-4} m^2/sec$; $Q = 34,000$ cal/mol, $E = 0.236 \times 10^{-18} J/atom$). [7]
2. (a) Give some applications of diffusion which are used in modern industries, along with their advantages. [6]
- (b) It is found that in a specimen of Iron the carbon percentage is 0.8 at a depth of 0.15 mm after $1\frac{1}{2}$ hours, when it is subjected to carburization at a temperature of $1020^\circ C$. If temperature is decreased to $880^\circ C$, calculate the time required so that at same depth same composition can be achieved. [10]
3. (a) What is the importance of equilibrium constant & how this can be calculated from standard free energy changes? [8]
- (b) Define equilibrium constant & how this can be influenced on the extraction process. [8]
4. (a) Describe 'Debye's theory' of specific heats of solids. Explain the concept of Debye's temperature. [8]
- (b) Discuss the merits and defects of Debye's model in comparison with Einstein's model in explaining specific heats of solids. [8]
5. (a) Explain how the composition of a solution can be expressed. [6]
- (b) One mole of solid Cr at 1873 K is added to a large quantity of liquid Fe-Cr solution at 1873 K with $X_{cr} = 0.24$. If Fe and Cr form ideal solution, Calculate the heat and entropy change in the system resulting from the addition. Ignore the difference of C_p between solid and liquid chromium. [10]
6. (a) What are the properties of solution that can be studied with the help of Gibbs Duhem equation? Explain them in detail. [8]
- (b) Write a short notes on Sievert's law [8]
7. (a) What is the importance of chemical potential? [4]
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8. (a) Explain about the Galvanic cell & its sign convention & representation. [8]
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1. (a) Explain the following diffusion mechanisms. [3X3=9]
 - i. Vacancy mechanism
 - ii. Interstitial mechanism
 - iii. Direct interchange mechanism.
- (b) At the surface of a steel bar there is one carbon atom per 20 unit cells of iron. At 1mm behind the surface, there is one carbon atom per unit cells. The diffusivity at $1000^{\circ}C$ is $3 \times 10^{-11} m^2/sec$. The structure is FCC at $1000^{\circ}C$ is (lattice constant: $3.65^{\circ}A$). How many carbon atoms diffuse through each unit cell per minute? [7]
2. (a) Explain Gauss error function (probability function) and its significance. [8]
- (b) In a kirkendall diffusion experiment analysed by the Matano method the following data are obtained for the metal at the cross section containing the markers.
 Diffusion time = 200 Hrs.
 Markers movement $x = 0.0144$ cm
 Interdiffusion coefficient $D = 10^{-7} sq.cm/sec$.
 Slope of the penetration curve $\frac{\partial NA}{\partial x} = 20cm^{-1}$ at the markers
 Atom Fraction of component A, $N_A = 0.4$
 Compute the intrinsic diffusivities. [8]
3. (a) What is the importance of equilibrium constant & how this can be calculated from standard free energy changes? [8]
- (b) Define equilibrium constant & how this can be influenced on the extraction process. [8]
4. (a) Describe 'Debye's theory' of specific heats of solids. Explain the concept of Debye's temperature. [8]
- (b) Discuss the merits and defects of Debye's model in comparison with Einstein's model in explaining specific heats of solids. [8]
5. (a) State and explain Sievert's law. [6]
- (b) Define activity of a substance. Indicate the relationship between activity and mole fraction for an ideal solution. [10]
6. (a) How Gibbs Duhem (Integration) equation related with the ideal & non-ideal solutions? [8]

- (b) Derive the Gibbs Duhem equation & Integration of Gibbs Duhem equation. [8]
7. (a) What is the importance of chemical potential? [4]
(b) Derive the Gibb's phase rule & explain its importance. [12]
8. (a) How thermodynamics is useful to electrochemical cells? [6]
(b) Discuss in detail about the following: [5+5=10]
 i. Concentration cells
 ii. Galvanic cells.

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(b) Define equilibrium constant & how this can be influenced on the extraction process. [8]
4. (a) Explain what is the difference in heat capacities ($C_p - C_v$) of a solid crystalline material in thermal equilibrium at absolute zero temperature. [8]
(b) Calculate the expected specific heat of Aluminium, Copper; Iron and silicon based on classical model if the atomic weights are 26.98, 63.54, 55.85 and 28 respectively. [8]
5. (a) State and explain Sievert's law. [6]
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