Code No: RR311804 **Set No. 1**

**III B.Tech I Semester Regular Examinations, November 2006**
**METALLURGICAL THERMO DYNAMICS**
**(Metallurgy & Material Technology)**

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

**Answer any FIVE Questions**
**All Questions carry equal marks**

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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 $500^oC$ (Al is Fcc and lattice constant is $4.05^oA$). ($D_o = 0.15 \times 10^{-4} m^2/sec$, Q = 30,200 cal/mole; $E = 0.210 \times 10^{-18} J/atom$.[8]

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 $1020^oC$. If temperature is decreased to $880^oC$, calculate the time required so that at same depth same composition can be achieved. [10]

3. (a) What is the importance of Ellingham diagram & its limitation? [8]
   (b) Explain the interpretation of two or more free energy change vs temperature lines of oxide reactions. [8]

4. (a) Discuss the asymmetric potential energy curve for a material as a function of distance of separation between the atoms. [8]
   (b) A metallic strip is constructed from strips of two different metals that are bonded along their lengths. Explain how such a device may be used in a thermostat to regulate temperature. [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) Explain the difference of crystal imperfect as on the stability of crystal disorders. [8]
   (b) What is the importance of Gibbs Duhem equation on Metallurgical processes? [8]

7. (a) What is the importance of chemical potential? [4]
   (b) Derive the Gibb's phase rule & explain its importance. [12]

8. Define the following: [2+8=16]

(a) Half cell potential
(b) Decomposition potential
(c) Standard electrode potential
(d) Sign convention of electrode potentials
(e) Nernst equation.
(f) Electrical energy
(g) Electrolysis
(h) Cell representation

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Code No: RR311804 **Set No. 2**

**III B.Tech I Semester Regular Examinations, November 2006**
**METALLURGICAL THERMO DYNAMICS**
**(Metallurgy & Material Technology)**

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

**Answer any FIVE Questions**
**All Questions carry equal marks**

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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 $500^oC$ (Al is Fcc and lattice constant is $4.05^oA$). ($D_o = 0.15 \times 10^{-4} m^2/sec$, Q = 30,200 cal/mole; $E = 0.210 \times 10^{-18} J/atom$.[8]

2. (a) What is kirkendall effect? How will you explain the mass flow of metal or gases with this effect? [8]
   (b) The activation energy for the diffusion of carbon in alpha iron is 20.1kcal/mol. If $D_o$ is $2 \times 10^{-6} m^2/sec$, calculate the diffusion constant at $27^oC$ and at $527^oC$ and show that at the elevated temperature the rate of diffusion is much higher than at the room temperature. [8]

3. (a) What is the importance of Ellingham diagram & its limitation? [8]
   (b) Explain the interpretation of two or more free energy change vs temperature lines of oxide reactions. [8]

4. (a) Discuss the meaning of partial molal heat capacity at constant pressure. Explain the equations which relate this quantity to [10]
      i. the heat capacity Cp and
      ii. the enthalpy H of the solution.
   (b) A glass rod and a steel rod of equal lengths at 273 k, differ in length by 1.2 mm at 373 k. If the coefficients of linear expansion of glass rod and the steel are $8 \times 10^{-6}/0^oC$ and $12 \times 10^{-6}/0^oC$ respectively, calculate the lengths of the rods at $0^oC$. [6]

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) Explain the difference of crystal imperfect as on the stability of crystal disorders. [8]
   (b) What is the importance of Gibbs Duhem equation on Metallurgical processes? [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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Code No: RR311804 **Set No. 3**

**III B.Tech I Semester Regular Examinations, November 2006**
**METALLURGICAL THERMO DYNAMICS**
**(Metallurgy & Material Technology)**

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

**Answer any FIVE Questions**
**All Questions carry equal marks**

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1. (a) What is the concept of diffusion? Discuss the diffusion mechanisms responsible for movement of atoms. [8]
   (b) Write the equation for Fick's first law of diffusion, define and explain each of the terms in SI units [8].
2. (a) Compare interstecial and vacancy atomic mechanisms for diffusion. [8]
   (b) Cite 2 reasons why interstecial 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) Explain what is anharmonicity and its effects on thermal expansion. [8]
   (b) Estimate the value of $C_v$ at 60 k for Cu if the value of $C_v$ 0.38 J. $mol.k^{-1}$ at 20k. Calculate the $\theta_D$ of copper. [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) Differentiate between electrochemical cells & electrolytic cells. [8]
   (b) Explain in detail about the concentration cells. [8]

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Code No: RR311804 **Set No. 4**

**III B.Tech I Semester Regular Examinations, November 2006**
**METALLURGICAL THERMO DYNAMICS**
**(Metallurgy & Material Technology)**

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

**Answer any FIVE Questions**
**All Questions carry equal marks**

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1. Define and explain the following: [4X4=16]
   (a) Diffusion
   (b) Solid state diffusion
   (c) Self diffusion
   (d) Hetero diffusion.

2. (a) Explain 'Carburizing' and 'decarburizing' processes with special reference to diffusion. Give their concentration profile. [8]
   (b) Assume that the surface concentration to be constant having 1.2% carbon. Calculate the time required to carburize a steel component having original composition of 0.4% carbon to 0.9% carbon at a depth of 0.15mm at $1000^oC$. [8]

3. (a) What is the importance of Ellingham diagram & its limitation? [8]
   (b) Explain the interpretation of two or more free energy change vs temperature lines of oxide reactions. [8]

4. (a) Discuss the classical; Einstein and Debye's models of specific heats of solids. [8]
   (b) The measured specific heat of pure Nickle as a function of temperature is given below. Find the electronic specific heat coefficient $\gamma$ and the lattice specific heat coefficient $\beta$ from the above data. Plot $C_v$ (electronic) and $C_v$ (lattice) against T and compare the two calculated specific heat curve. Find the value of $Q_D$ for Ni

| T(k) | $C_v in 10^{-4} Calculate.mol^{-1} deg^{-1}$ |
|---|---|
| 1.776 | 30.99 |
| 1.843 | 32.23 |
| 1.894 | 33.24 |
| 1.993 | 35.29 |
| 2.057 | 36.56 |
| 2.139 | 38.15 |
| 2.235 | 39.81 |
| 2.346 | 41.95 |
| 2.438 | 43.86 |
| 2.508 | 45.48 |
| 2.603 | 47.18 |
| 2.728 | 49.34 |
| 2.889 | 52.51 |
| 3.201 | 59.20 |
| 3.436 | 64.03 |
| 3.752 | 71.12 |
| 3.990 | 76.00 |
| 4.114 | 79.62 |

[8]

5. (a) Given that Henry's law holds for the solute of a dilute real solution, derive Raoult's law for the solvent. [8]

   (b) Assume that, in a binary solution A-B, the activity coefficients can be expressed as

   $1_n \lambda_A = \alpha_1 X_B + 1/2 \alpha_2 X_B{}^2 + 1/3 \alpha_3 X_B{}^3$

   $1_n \lambda_B = \beta_1 X_A + 1/2 \beta_2 X_A{}^2 + 1/3 \beta_3 X_A{}^3$

   in the entire composition. Prove.

   i. $\alpha_1 = \beta_1 = 0$

   ii. if only the quadratic terms retained, $\alpha_2 = \beta_2$. [8]

6. (a) Explain the difference of crystal imperfect as on the stability of crystal disorders. [8]

   (b) What is the importance of Gibbs Duhem equation on Metallurgical processes? [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 electrochemical cells & its classification. [8]

   (b) How chemical / electrical energy can be calculated for any electrochemical cells. [8]

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