Indian Institute of Science Education and Research, Kolkata
Mid-semester examination, Spring 2019
Mineral Physics (ID4213)

Time : 90 minutes **Full Marks : 30**

Q1. Answer any **two :**

a) Consider two systems having energies E1 and E2 respectively that are in thermal contact with each other, but thermally isolated from their surroundings. Consider that the the first system can be in any one of Ω_1(E1) microstates and the second system can be in any one of Ω_2(E2) microstates. Show that when the two systems are in thermal equilibrium :

$$\frac{\mathrm{d}\ln\Omega_1}{\mathrm{d}E_1} = \frac{\mathrm{d}\ln\Omega_2}{\mathrm{d}E_2}.$$

[5 Marks]

b) Starting from the Clausius inequality :

$$\oint \frac{đQ}{T} \leq 0$$

Prove that the entropy of an isolated system tends to a maximum. [5 Marks]

c) For a monoatomic ideal gas the internal energy per mole, U = 3/2 RT. Prove that C_P-C_V = R. Where C_P is specific heat at constant pressure and C_V is specific heat at constant volume.
[5 Marks]

Q2). a) A Fe^{2+} ion sitting in an undistorted octahedral environment is found in its low spin state. Calculate the corresponding electronic entropy. Calculate the entropy if the Fe ion is found in +3 charge state and high spin state. The electronic configuration of Fe is $[Ar]3d^64s^2$. [5 Marks]

b) Inspite of the fact that creation of defects in crystal lattice costs energy, explain(invoking the concept of free energy) why all crystals at temperatures above absolute zero contain some amount of point defects. [5 Marks]

Q3) Let us consider the substitution of two elements A and B on a simple cubic lattice which forms a solid solution. A and B are supposed to be completely randomly mixed. Let the fraction of A atoms be X_A and the fraction of B atoms be X_B such that $X_A + X_B = 1$.
The corresponsing change in Gibb's free energy associated with the formation of a solid solution is given by

$\Delta G_{mix} = \Delta H_{mix} - T\Delta S_{mix}$

a) (a) Draw a ΔG_{mix} vs X_B curve for the case when $\Delta H_{mix} = 0$. Plot and explain the effect of temperature on the curve. [3 Marks]

b) Plot the ΔG_{mix} vs X_B for a situation when ΔH_{mix} is greater than 0. Explain the effect of temperature by appropriately redrawing the ΔG_{mix} vs X_B plot. Explain the behaviour of the curve as a function of temperature. Plot the locus of the minima of the ΔG_{mix} curves (as a function of temperature) vs X_B on a plot having temperature on the y-axis and X_B on the x-axis. What you obtain is called the solvus curve. What happens if the composition of a certain solid solution at a given temperature lies within the area enclosed by the solvus curve. [7 Marks]