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MIDSEMESTER EXAMINATION AUTUMN 2019-2020

MATERIAL SCIENCE AND ENGINEERING ME F213

Closed book Examination. Time 90 mins. Max marks. 60 **Date: 30-09-2019; Time: 11.00 am to 12.30 pm**

Answer to a new question should be on a fresh page, answer continuously & split answers won't be evaluated
Avoid leaving spaces, and use neat figures whenever necessary.
You may make necessary assumptions if any, and the same shall be justified clearly

Cheat sheet of 10 cm X8 cm shall only contain equations

Part A 2x3 = 6 Marks

1. You have two metals in your custody, determine the crystal structure of both. Metal A has a_o = 4.9489 Å, r = 1.75 Å and one atom per lattice point; and metal B has a_o = 0.42906 nm, r = 0.1858 nm and one atom per lattice point.

2. Determine the planar density and packing fraction for FCC nickel in the (100), (110), and (111) planes. Which of these planes is close-packed? Assume a_o=3.5167 Å

Part B 3x8 Marks

3. For both FCC and BCC crystal structures, there are two different types of interstitial sites. In each case, one site is larger than the other, and is normally occupied by impurity atoms. For FCC, this larger one is located at the centre of each edge of the unit cell; it is termed an octahedral interstitial site. On the other hand, with BCC the larger site type is found at 0, 1/2 , 1/4 positions that is, lying on {100} faces, and situated midway between two-unit cell edges on this face and one-quarter of the distance between the other two-unit cell edges; it is termed a tetrahedral interstitial site. For both FCC and BCC crystal structures, compute the radius r of an impurity atom that will just fit (touch each other with host and impurity atom) into one of these sites in terms of the atomic radius R of the host atom.

4. You need to cast a part as shown in figure 1, for which two options of hypothetical metals (say A&B) are available to you. The energy vs interatomic spacing graphs for both metals (super imposed) is shown in the figure 2. Based on the graph, briefly explain 3 points* that you may observe during the casting process (State the observation you made and then explain). Assume that you need to perform a cold-chamber die casting process for the part.

** Strictly not more than 1 page*

Figure 1

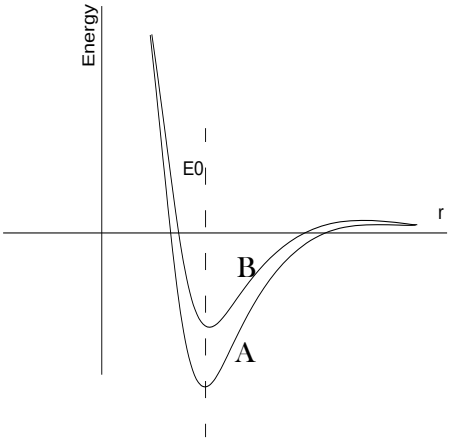

Figure 2

5. The net potential energy EN between two adjacent ions is sometimes represented by the expression $En = -\frac{C}{r} + D * \exp(-\frac{r}{\rho})$ in which r is the interionic separation and C, D, and ρ are constants whose values depend on the specific material. Derive an expression for the bonding energy E_0 in terms of the equilibrium interionic separation r_0 and the constants D and ρ

Part C 2x15=30 Marks

6. Derive (a) the relationship connecting concertation in wt% and atomic wt% for an alloy consisting of 2 elements. (b) an equation for mass of component 1 per unit volume (kg/m^3) of an alloy and (c) an equation for calculating A_{avg}

**Clearly define the notations used*

7. During a design process, you need to find yield stress of a single crystal of a hypothetical alloy for slip to occur while the stress was applied along [010] direction. The alloy was composed of 12.5 wt% of metal A and 87.5 wt% of metal B. The densities of metals A and B are 4.27 and 6.35 g/cm^3, respectively, whereas their respective atomic weights are 61.4 and 125.7 g/mol. From the x-ray diffraction data, that you have performed it is known to you that the unit cell edge length as 0.395 nm for cubic lattice. You also know that resolved shear stress for this alloy is 1.12 MPa. Also, show the diffraction pattern(intensity Vs. 2θ) you might have observed during your diffraction technique using a 1st order x-ray having a wave length of 0.1542 nm.

** The most favoured slip system(s) is (are) the one(s) that has (have) the largest τR value*