1. (a) Determine the Miller indices for the plane in the cubic unit cell shown in fig.1(a), and the Miller-Bravais indices for the plane in the hexagonal unit cell shown in fig. 1(b). (10%)
(b) Three different types of primary atomic bond and a secondary bonding are found in solids. List and briefly describe these bonds and give for each bond (or bonding) an example. (10%)

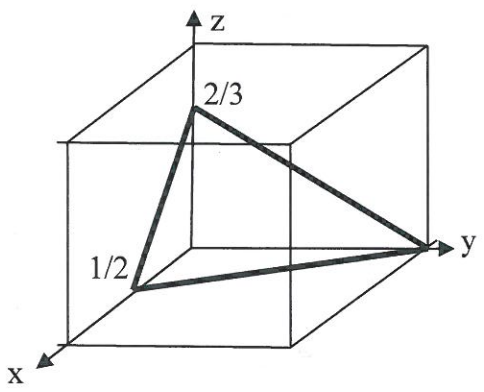

Fig. 1(a)

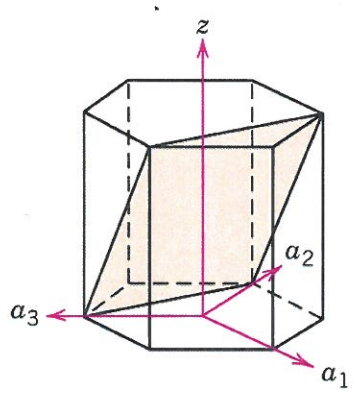

Fig. 1(b)

2. Copper (Cu) has a Face-centered cubic (FCC) crystal structure. The atomic radius of copper is 0.128 nm.
(a) Determine the lattice constant ***a*** of copper. (5 %)
(b) Determine the interplanar spacing d_{111} for the (111) set of planes for copper. If you could not solve 2(a), then assume lattice constant ***a*** = 0.4nm. (5 %)
(c) For X-ray diffraction (XRD) on crystalline copper powder specimen, determine the expected diffraction angle 2θ for the first order (n=1) diffraction from the (111) set of planes. The wavelength of the X-ray is 0.1542 nm. (5 %)
(d) List the Miller indices of the first four peaks of XRD for copper in correct sequence. (5 %)

3. For a body-centered cubic (BCC) crystal structure, (a) sketch the unit cell including the atomic sites; (b) determine the number of atoms per unit cell; (c) what is the coordination number (CN) of a BCC structure? (d) Give any two metallic elements which belongs to BCC crystal structure. (10%)

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4. Solid solution. Atomic radius, crystal structure, electronegativity, and the most common valence, are tabulated on the right for several elements; for those that are nonmetals radii are indicated. Which of these elements would you expect to form the following with nickel and justify your choice: (a) a substitutional solid solution having complete solubility, (b) a substitutional solid solution of incomplete solubility, and (c) an interstitial solid solution. (20 %)

Element	Atomic Radius (nm)	Crystal Structure	Electro-negativity	Valence
Ni	0.1246	FCC	1.8	+2
C	0.071			
H	0.046			
O	0.06			
Ag	0.1445	FCC	1.9	+1
Al	0.1431	FCC	1.5	+3
Co	0.1253	HCP	1.8	+2
Cr	0.1249	BCC	1.6	+3
Fe	0.1241	BCC	1.8	+2
Pt	0.1387	FCC	2.2	+2
Zn	0.1332	HCP	1.6	+2

5. Describe (a) Fick's first law (state-state diffusion) and (b) Fick's second law (nonsteady-state diffusion). Rank the followings in order of decreasing diffusivity and give a brief explanation justifying your choice. (c) H (diffusing species) in Fe (host material) at 600°C and H in Fe at 800°C, (d) H in BCC Fe (800°C) and H in FCC Fe (1000°C), (e) C (carbon) in FCC Fe and H in FCC Fe, (f) C in BCC Fe and Fe in BCC Fe, (g) Fe in BCC Fe and C in graphite, and (h) Carbon in the bulk, grain boundary, and along the surface of Fe. (16%)

6. Briefly explain the principle of (a) Scanning Electron Microscope (SEM), (b) Transmission Electron Microscope (TEM) and (c) Scanning Probe Microscope (SPM). (14%)

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