※ 注意：請於試卷上「非選擇題作答區」標明大題及小題題號，並依序作答。

1. (18%)

(a) Calculate the atomic packing factors for the HCP and BCC crystals, respectively. (6%)

(b) Calculate the planar density and planar packing fraction for the (010) and (020) planes in the simple cubic polonium, which has a lattice parameter of 0.334 nm. (6%)

(c) The lattice constant for diamond is 0.357 nm. What percent of volume change occurs when it transforms to graphite ($\rho_{graphite} = 2.25$ g/cm^3)? (6%)

2. (20%)

(a) Explain why HCP metals are typically more brittle than FCC and BCC metals. (2%)

(b) Explain why we need to describe the hexagonal metals using Miller indices containing four digits instead of three. (3%)

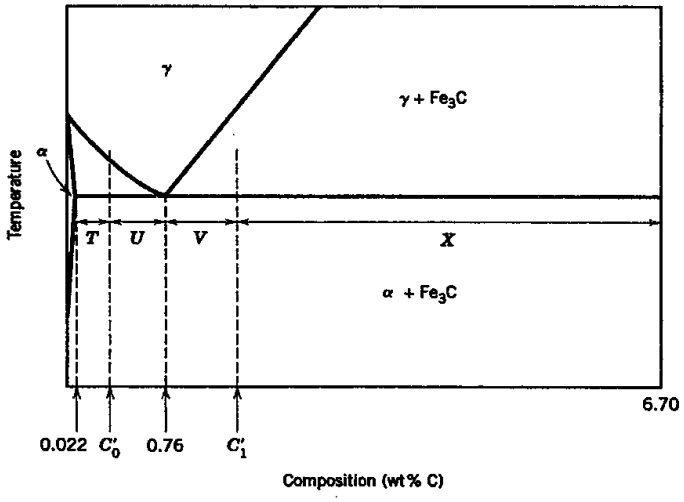
(c) Explain whether the planes (110) and $(1\bar{2}0)$ in the three-digit system for a hexagonal crystal are equivalent in the four-digit system. (4%)

(d) What are the <111> directions lying in the (101) planes of iron? (2%)

(e) Explain why face-centered tetragonal is not included in the 3-D Bravais lattices. (3%)

(f) Indicate the slip systems as a FCC metal is subjected to the [110] and [111] uniaxial compressions, respectively. (6%)

3. (7%) Is it possible to have an iron-carbon alloy for which the mass fractions of total cementite and proeutectoid ferrite are 0.057 and 0.36, respectively? Why or why not? A portion of the Fe–Fe_3C phase diagram is shown below.



4. (15%) (a) A random poly(styrene-butadiene) copolymer (styrene: C_6H_6–$CH{=}CH_2$; butadiene: $CH_2 = CH{-}CH = CH_2$) has a weight-average molecular weight of 350,000 g/mol and a weight-averaged degree of polymerization of 5000. Compute the fraction

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of styrene and butadiene mers in this copolymer. (6%)

(b) The density and associated percent crystallinity for two polyethylene materials are as follows:

ρ (g/cm^3)	Crystallinity (%)
0.965	76.8
0.925	46.6

What are the densities of totally crystalline and totally amorphous polyethylene, respectively? (6%) Please determine the percent crystallinity of a specimen having a density of 0.950 g/cm^3 (3%).

5. (12%)

(a) Demonstrate that the minimum cation-to-anion radius ratio for an ionic compound like CsCl with a coordination number 8 is 0.732. (4%)

(b) Would you expect Frenkel defect for anions to exist in ionic ceramics in relatively high concentrations? Why or Why not? (4%)

(c) Briefly explain why there may be significant scatter in the fracture strength for some given ceramic materials and why fracture strength increases with decreasing the specimen size. (4%)

6. (8%) The zinc blende crystal structure is one that may be generated from close-packed planes of anions.

(a) Will the stacking sequence for this structure be FCC or HCP? (4%)

(b) Will cations fill tetrahedral or octahedral positions? (2%)

(c) What is the fraction of the positions being occupied? (2%)

7. (20%)

(a) Please briefly describe definition of polarization and polarizability, respectively. (4%)

(b) Please describe three different types of polarization found in dielectric materials. Which type of polarization does it have the highest relaxation frequency upon an alternating electric field? Which type of polarization can it only be found in substances that possess permanent dipole moment? (5%)

(c) Both silica glass and quartz are composed of SiO_2 tetrahedra and neither material possesses a center of symmetry. Why is silica glass not a piezoelectric, whereas quartz is? (3%)

(d) Most ceramics are electrical insulators. Describe the factors that would allow a ceramic to be classified as a ferroelectric rather than just an insulator. (3%)

(e) Dielectric constants of polymers are greatest at intermediate temperatures. Why is so? How does the dielectric constant differ between **ac** and **dc**. (5%)

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