**Materials Science and Engineering**

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**Polymers, Ceramics, and Composites**

**Polymers**

1. Differentiate between addition and condensation polymerization.
2. What is polydispersity index of a polymer?
3. Why is the density of HDPE different from LDPE?
4. Why is teflon highly chemical resistant?
5. Why is PVC soft and flexible but bakelite is hard and brittle?
6. Write short notes on
7. addition polymerization
8. condensation polymerization
9. thermoplastic and thermosetting plastics
10. number average and weight average molecular weight.
11. Define and give examples for

(i) Monomer (ii) Functionality (iii) Degree of polymerization (iv) Co-polymer.

1. Define tacticity of polymers. Explain the difference between isotactic, syndiotactic, and atactic polymers.

**Ceramics**

1. Discuss the characteristics of ceramics, nature of bonding, and applications of ceramics.
2. Cite one reason why ceramic materials are, in general, harder yet more brittle than metals.
3. For a ceramic compound, what are the two characteristics of the component ions that determine the crystal structure?
4. Show that the minimum cation-to-anion radius ratio for a coordination number of 4 is 0.225 in a cubic structure.
5. On the basis of ionic charge and ionic radii given in Table, predict crystal structures for the following materials: Justify your selections.

(a) CsI,

(b) NiO,

(c) KI, and

(d) NiS.

1. Iron sulfide (FeS) may form a crystal structure that consists of an HCP arrangement of S2- ions. rS2- = 0.184 nm and rFe2+= 0.077 nm

(a) Which type of interstitial site will the Fe2+ ions occupy?

(b) What fraction of these available interstitial sites will be occupied by Fe2+ ions?

1. Calculate the density of FeO, given that it has the rock salt (NaCl) crystal structure. rFe2+ = 0.077 nm and rO2- = 0.140 nm

**Composites**

1. For a polymer-matrix fiber-reinforced composite,

(a) List three functions of the matrix phase.

(b) Compare the desired mechanical characteristics of matrix and fiber phases.

(c) Cite two reasons why there must be a strong bond between fiber and matrix at their interface.

**Answer:**

(a) For polymer-matrix fiber-reinforced composites, three functions of the polymer-matrix phase are: (1) to bind the fibers together so that the applied stress is distributed among the fibers; (2) to protect the surface of the fibers from being damaged; and (3) to separate the fibers and inhibit crack propagation.

(b) The matrix phase must be ductile and is usually relatively soft, whereas the fiber phase must be stiff and strong.

(c) There must be a strong interfacial bond between fiber and matrix in order to: (1) maximize the stress transmittance between matrix and fiber phases; and (2) minimize fiber pull-out, and the probability of failure.

1. (a) What is the distinction between matrix and dispersed phases in a composite material?

(b) Contrast the mechanical characteristics of matrix and dispersed phases for fiber-reinforced composites.

**Answer:**

(a) The matrix phase is a continuous phase that surrounds the noncontinuous dispersed phase.

(b) In general, the matrix phase is relatively weak, has a low elastic modulus, but is quite ductile. On the other hand, the fiber phase is normally quite strong, stiff, and brittle.

1. (a) What is a hybrid composite?

(b) List two important advantages of hybrid composites over normal fiber composites.

**Answer:**

(a) A hybrid composite is a composite that is reinforced with two or more different fiber materials in a single matrix.

(b) Two advantages of hybrid composites are: (1) better overall property combinations, and (2) failure is not as catastrophic as with single-fiber composites.

1. Classify the composite materials based on the matrix phase. Give one example of each kind of composite.
2. Classify the composite material based on the dispersed phase. Give one example of each kind of composite material.