B. E. Part IV (Met. Eng.) (7th Sem.) Examination, November/December 2013

SUB: COMPOSITES AND CERAMIC MATERIALS

(Code: MT 701)

Time: 3 hours | Full Marks: 70

Use **single** answer script.
Answer any **Seven** questions.
Figures on the right hand side margin indicate full marks.

1. State true or false and justify. (Any four) 2.5 × 4
   (a) The most widely used fibre is made of polymer for polymer matrix composite (PMC).
   (b) The creep curve of a metal reinforced with continuous ceramic fibres approaches almost a zero creep rate.
   (c) Sol-gel processing usually requires low processing temperature.
   (d) In a composite, the matrix is never a ceramic.
   (e) Melt stirring is not a preferred route for MMCs.
   (f) Carbon fibre is usually used to improve the thermal deformation resistance in a magnesium alloy.

2. (a) Distinguish between an alloy and a composite material.
   (b) What do you mean by polymer pyrolysis?
   (c) The fracture toughness, K_{IC} of magnesia stabilised zirconia is 8 MPa-$\sqrt{m}$. The tensile strength is 150 GPa. If a centre cracked panel of this material is loaded to this level of stress without failure, determine the maximum flaw size that could have been present. (Assume constant parameter is unity).

   3+3+4

3. (a) While graphite has poor strength, carbon fibres exhibit very high strength. Explain.
   (b) Define the terms isostress and isostrain as associated with continuous fibre composites.
   (c) A silicon carbide fibre reinforced glass composite contains 60% SiC fibre by volume. Calculate the elastic modulus of the composite under isostress and isostrain conditions. The elastic modulus of the SiC fibre is 420 GPa and that of the glass is 100 GPa.

   3+3+4

4. (a) Why many metals are reinforced with strong fibre materials to produce composites though there are many other mechanisms of strengthening?
   (b) What composite would you select for conveyor belt material and why?
   (c) Explain why interfacial reactions are of major concern in composite?

   4+3+3

5. (a) A soda-lime glass has a viscosity of $10^{14.6}$ P at 560°C. What will be its viscosity at 675°C if the activation energy for viscous flow is 430 kJ/mol?
   (b) Briefly discuss about one insitu chemical technique for processing of composite. Why the process is named so?
   (c) Why is fatigue crack growth rate in PEEK matrix composite slower compared to monolithic PEEK?

   4+3+3

6. (a) What is sintering? What is its driving force?
(b) What are the disadvantages of uniaxial compaction in ceramic processing?
(c) What should be the ideal morphology of the powder particles for conventional compaction?
(d) Distinguish between "Cold Isostatic Pressing" and "Hot Isostatic Pressing".

3+2+2+3

7. (a) What are the different polymorphs of ZrO_2? How high temperature phase/phases of ZrO_2 can be retained at room temperature? How does transformation toughening occur in ZrO_2?
(b) Why do compounds with perovskite structure show ferroelectricity?
(c) Why do some compounds exist in both zincblende and wurtzite structures?

5+3+2

8. (a) Schematically show the variation of the following energy terms with inter-ionic distance in case of an ionic crystal and mark the crystal energy associated with most stable inter-ionic separation:
(i) Energy due to electrostatic attraction, (ii) Repulsive energy and (iii) total energy of an ionic crystal.
(b) Explain all the terms in the following expression for Madelung constant (α):

$$\alpha = -\sum_i \frac{\left(\frac{Z_i}{|Z_i|}\right)\left(\frac{Z_j}{|Z_j|}\right)}{X_{ij}}$$

7+3

9. (a) State five statements of Pauling's rule for determining crystal structure of ionic crystal.
(b) Calculate the radius of the largest cation that can fit into an octahedral and a tetrahedral void formed by anions with radius R_a ($R_a = 0.14$ nm).
(c) Draw a unit cell of MgO and show that Pauling's first and second rules apply to the compound. (Ionic radius of $Mg^{2+} = 0.072$ nm and ionic radius of $O^{2-} = 0.14$ nm)

5+2+3

10. (a) Distinguish between Frenkel and Schottky defects in ionic crystal.
(b) Complete the following defect reactions-
(i) $null = V_{Na} + V_{Cl}$ for NaCl
(ii) $null = V_{Mg} + V_O$ for MgO
(iii) $Ti_{Ti}^{x} = Ti^{\bullet\bullet\bullet\bullet} + V_{Ti}$ for TiO_2
(iv) $O_O^{x} = O_i + V_O$ for Oxygen
(v) $null = (\quad) V_{Al} + (\quad) V_O$ for Al_2O_3

2.5+7.5

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