

# 國立交通大學 104 學年度碩士班考試入學試題

科目：材料科學與工程導論(3142)

考試日期：104 年 2 月 7 日 第 4 節

系所班別：材料科學與工程學系

組別：材料系甲組

第 1 頁, 共 2 頁

【可使用計算機】\*作答前請先核對試題、答案卷(試卷)與准考證之所組別與考科是否相符!!

1. Explain why ceramic materials have smaller thermal expansion coefficient than metals? (7 points)

2. Explain the strengthening mechanism of solid-solution strengthening. (7 points)

3. The photo below shows an optical image for a Cu surface. (1) Explain why we can observe grain boundaries. (2) Explain why we see different contrast for different grains? (10 points)



4. For isothermal phase transformation from Austenite to pearlite in steels, explain why the phase transformation rate is lower at low temperatures. (7 points)

5. (a) Please show a diagram for triangular coordination (3 points)  
(b) Calculate the critical (minimum) radius ratio  $r/R$  for the triangular coordination (CN=3) of three anions of radii  $R$  surrounding a central cation of radius  $r$  in an ionic solid. (3 points)

6. (a) Predict the coordination number for the ionic solids CsCl. (3 points)  
(b) Calculate the ionic packing factor for CsCl. (3 points)  
Use the following radii:  $Cs^+ = 1.7 \text{ Angstrom}$ ;  $Cl^- = 1.81 \text{ Angstrom}$

7. (a) Please plot the crystal structure of NaCl. (3 points)  
(b) Calculate the density of NaCl from its crystal structure, the ionic radii of  $Na^+$  and  $Cl^-$  ions, and the atomic masses of Na and Cl. The ionic radius of  $Na^+ = 1.02 \text{ Angstrom}$  and that of  $Cl^- = 1.81 \text{ Angstrom}$ . The atomic mass of Na = 22.99 g/mol and that of Cl = 35.45 g/mol. (3 points)

8. For crack propagation in the ceramics, the crack-tip stress ( $\sigma_m$ ) needs to exceed a critical stress ( $\sigma_c$ ),

$$\sigma_c = \left( \frac{2E\gamma_s}{\pi a} \right)^{1/2}$$

where  $E$  = modulus of elasticity, and  $a$  = one half length of internal crack.

(a) What is  $\gamma_s$ ? (3 points)

(b) For ductile materials, how to modify the equation of  $\sigma_c$  by replacing  $\gamma_s$ ? (3 points)

9. (a) Please draw a plot of specific volume versus temperature for a glass and a crystalline solid, respectively. (5 points)

(b) Please identify the melting point ( $T_m$ ) (3 points)

(c) Please identify the glass transition point ( $T_g$ ) (3 points)



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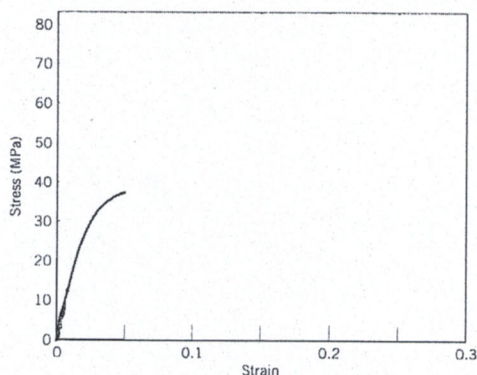
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第 2 頁, 共 2 頁

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10. (5 points) For ZnS and CdSe semiconductors, please decide which will have the smaller bandgap energy,  $E_g$  and cite the reason for your choice [Note: No point will be given without reasoning.]

11. (8 points) The stress-strain curve of poly(methyl methacrylate) (PMMA) at 35 °C is shown in the following plot. Please draw the stress-strain curves for PMMA measured at (a) -50 °C and (b) 70 °C in the same plot with proper labelling. You should take their relative elastic modulus (Young's modulus) and elongation-at-break into consideration.



12. (8 points) Which of the following oxide materials when added to fused silica ( $\text{SiO}_2$ ) will increase its index of refraction:  $\text{Al}_2\text{O}_3$ ,  $\text{TiO}_2$ ,  $\text{NiO}$ ,  $\text{MgO}$ ? Why?

Table Ionic Radii for Several Cations and Anions  
(for a Coordination Number of 6)

Cation	Ionic Radius (nm)	Anion	Ionic Radius (nm)
$\text{Al}^{3+}$	0.053	$\text{Br}^-$	0.196
$\text{Ba}^{2+}$	0.136	$\text{Cl}^-$	0.181
$\text{Ca}^{2+}$	0.100	$\text{F}^-$	0.133
$\text{Cs}^+$	0.170	$\text{I}^-$	0.220
$\text{Fe}^{3+}$	0.077	$\text{O}^{2-}$	0.140
$\text{Fe}^{2+}$	0.069	$\text{S}^{2-}$	0.184
$\text{K}^+$	0.138		
$\text{Mg}^{2+}$	0.072		
$\text{Mn}^{2+}$	0.067		
$\text{Na}^+$	0.102		
$\text{Ni}^{2+}$	0.069		
$\text{Si}^{4+}$	0.040		
$\text{Ti}^{4+}$	0.061		

13. (8 points) Please identify the polymer with lower  $T_m$  in the following pairs and explain why

(a) Polyethylene vs Polystyrene

(b) Atactic poly(vinyl chloride) vs Isotactic poly(vinyl chloride)

14. (5 points) Additives such as fillers, plasticizers, stabilizers, colorants, or flame retardants are widely used in the processing of polymer. How does the addition of a plasticizer influence the tensile strength of a polymer? Why?