國立成功大學
115學年度碩士班招生考試試題

編　號：110

系　所：生物醫學工程學系

科　目：材料科學

日　期：0203

節　次：第 2 節

注　意：1.可使用計算機
2.請於答案卷(卡)作答，於試題上作答，不予計分。

Define the following terms: (2 pts each, 40points total)

1. Bragg's law
2. Crystal vs glass
3. Draw edge vs. screw dislocation
4. Frenkel and Schottky defects
5. FCC vs BCC for structure of material
6. Interdiffusion vs. Interstitial diffusion
7. Tran and Cis structure
8. Critical fiber length:
9. Hydrogen embrittlement:
10. Pultrusion:
11. Crevice corrosion.
12. ASTM stands for:
13. Ductile-to-brittle transition:
14. Fatigue life and fatigue limit:
15. Hypereutectoid alloy:
16. Proeutectoid cementite
17. Critical resolve shear stress
18. Plane strain fracture toughness **(K_{IC}).**
19. Precipitation hardening:
20. Continuous-cooling transformation:

II. Essay and calculation (60 points total)

1. (6 points) **Sketch the repeat structure** for each of the following alternating polymers: (a) poly(tetrafluoroethlyene), (b) poly (methyl methacrylate) (c) polystyrene (d) poly (vinyl chloride)

2. (4 points) Within a cubic unit cell, **sketch the following directions**:
   (a) $[\bar{1}10]$, (b) $[\bar{1}\bar{1}1]$, (c) $[\bar{1}22]$, (d) $[1\bar{2}\bar{3}]$,

3. (6 points) Magnesium oxide has the rock salt crystal structure and a density of 3.58 g/cm^3.
   (a) Determine the unit cell edge length.
   (b) How does this result compare with the edge length as the radii of Mg^{2+} and O^{2-} ions are 0.072 and 0.140 nm respectively, assuming that the Mg^{2+} and O^{2-} ions just touch each other along the edges? (Mg: 24 g/mole; O: 16 g/mole)

4. (6 points) (a) If a rod of 1025 steel 1.0 m long is heated from 20°C to 100°C while its ends are maintained rigid, determine the type and magnitude of stress that develops. Assume that at 20°C the rod is stress free. (b) What will be the stress magnitude if a rod 2 m long is used? (c) If the rod in part (a) is cooled from 20°C to -20°C, what type and magnitude of stress will result? E=200 GPa, $\alpha=12.0\times10^{-6}$ $(^0C)^{-1}$

5. (6 points) A three-point transverse bending test is conducted on a cylindrical specimen of aluminum oxide having a reported flexural strength of 300 MPa. If the specimen radius is 2.0 mm and the support point separation distance is 28 mm, would you expect the specimen to fracture when a load of 500 N is applied? where $\sigma = My/I$; $M=FL/4$; $I=\pi R^4/4$

6. (6 points) A structural member 150 mm long must be able to support a load of 60,000 N without **fracture.** Given the following data for brass, steel, aluminum, and titanium, (A) calculate the required weight and (B) rank them from least to greatest **weight** in accordance with these criteria.

Alloy	Yield Strength (MPa)	Tensile Strength (MPa)	Density (g/cm^3)
Brass	415	520	8.5
Ductile Iron	276	310	7.1
Aluminum	310	389	2.7
Titanium	550	689	4.5

7. (6 points) What are main metal materials strengthening methods with brief explanation?

8. (12 points) Please draw a classic stress-stain curve of a ductile metal under tension, then draw another curve for true stress stain curve on it. Please define and point out on this curve for the following terms:
   a. stress (include unit), true stress
   b. strain (include unit), true strain
   c. Young's modulus (include unit)
   d. Yield stress
   e. Ultimate tensile stress.
   f. Ductility

9. (8 points)An FCC iron-carbon alloy initially **containing 0.30 wt% C** is exposed to an **oxygen-rich and virtually carbon-free** atmosphere at 1100°C. Under these circumstances the **carbon diffuses from the alloy** and reacts at the surface with the oxygen in the atmosphere; that is, the carbon concentration at the **surface position is maintained essentially at 0 wt% C**. (This process of carbon depletion is termed **decarburization.**) At what position will the carbon concentration be **0.15 wt%** after a **10-h treatment**? The value of D at 1400 K is 6.9 × 10^{-11} m^2/s.

$$\ln D_1 = \ln D_0 - \frac{Q_d}{R}\left(\frac{1}{T_1}\right) \qquad \frac{C_x - C_0}{C_s - C_0} = 1 - \operatorname{erf}\left(\frac{x}{2\sqrt{Dt}}\right)$$

Table 5.1 Tabulation of Error Function Values

z	$erf(z)$	z	$erf(z)$	z	$erf(z)$
0	0	0.55	0.5633	1.3	0.9340
0.025	0.0282	0.60	0.6039	1.4	0.9523
0.05	0.0564	0.65	0.6420	1.5	0.9661
0.10	0.1125	0.70	0.6778	1.6	0.9763
0.15	0.1680	0.75	0.7112	1.7	0.9838
0.20	0.2227	0.80	0.7421	1.8	0.9891
0.25	0.2763	0.85	0.7707	1.9	0.9928
0.30	0.3286	0.90	0.7970	2.0	0.9953
0.35	0.3794	0.95	0.8209	2.2	0.9981
0.40	0.4284	1.0	0.8427	2.4	0.9993
0.45	0.4755	1.1	0.8802	2.6	0.9998
0.50	0.5205	1.2	0.9103	2.8	0.9999

Tabulation of Diffusion Data

Diffusing Species	*Host Metal*	D_0 (m^2/s)	*Activation Energy Q_d*		*Calculated Values*	
			kJ/mol	*eV/atom*	*T(°C)*	D (m^2/s)
Fe	α-Fe (BCC)	2.8×10^{-4}	251	2.60	500	3.0×10^{-21}
					900	1.8×10^{-15}
Fe	γ-Fe (FCC)	5.0×10^{-5}	284	2.94	900	1.1×10^{-17}
					1100	7.8×10^{-16}
C	α-Fe	6.2×10^{-7}	80	0.83	500	2.4×10^{-12}
					900	1.7×10^{-10}
C	γ-Fe	2.3×10^{-5}	148	1.53	900	5.9×10^{-12}
					1100	5.3×10^{-11}
Cu	Cu	7.8×10^{-5}	211	2.19	500	4.2×10^{-19}
Zn	Cu	2.4×10^{-5}	189	1.96	500	4.0×10^{-18}
Al	Al	2.3×10^{-4}	144	1.49	500	4.2×10^{-14}
Cu	Al	6.5×10^{-5}	136	1.41	500	4.1×10^{-14}
Mg	Al	1.2×10^{-4}	131	1.35	500	1.9×10^{-13}
Cu	Ni	2.7×10^{-5}	256	2.65	500	1.3×10^{-22}

Source: E. A. Brandes and G. B. Brook (Editors), *Smithells Metals Reference Book*, 7th edition, Butterworth-Heinemann, Oxford, 1992.