國立高雄大學一百學年度研究所碩士班招生考試試題

科目：材料科學導論
考試時間：100 分鐘

系所：化學工程及材料工程學系
（乙組）
本科原始成績：100 分

是否使用計算機：是

（所有答案均作答於答案紙上）

I. part A. Select a correct answer. (15%)

( )1. The strength and hardness of some metal alloys may be enhanced by the formation of extremely small uniformly dispersed particle of a second phase within the original phase matrix; this can be accomplished by appropriate heat treatments. The process is called (a) working hardening (b) annealing (c) calcinations (d) precipitation hardening (e) recovery

( )2. For the process of a ceramic material, during firing the formed piece shrinks and experiences a reduction of porosity and improvement in mechanical integrity, the process is termed (a) drying (b) vitrification (c) sintering (d) quench

( )3. Regarding the fiber-reinforced composites, which one of the following is WRONG (a) longer fibers carry stress more efficiently (b) the transverse modulus is larger than the longitudinal modulus (c) elastic modulus depends on fiber direction

( )4. Which one of the following is WRONG for intergranular corrosion of a stainless steel? (a) depletion of Cr at the region near the grain boundary (b) formation of SiC at grain boundary (c) increasing carbon concentration in steel is good to prevent the phenomenon (d) adding Ti or Nb is good to prevent the phenomenon

( ) 5. ZnO has a band gap of 3.3 eV. What wavelength will its near-band edge excitation correspond to? (plank's constant: 4.13×10^{-15}eV-s, c: 3×10^{8} m/s)) (a) 325 nm (b) 375 nm (c) 425 nm (d) 520 nm (e) 650 nm (f) 750 nm

Part B. Answer the following questions in detail. (85%)

1. (10%)

Consider a single crystal of BCC iron oriented such that a tensile stress is applied along a [010] direction.

(a) Compute the resolved shear stress along a (110) plane and in a $[\bar{1}11]$ direction when a tensile stress of 52 MPa is applied.

(b) If slip occurs on a (110) plane and in a $[\bar{1}11]$ direction, and the critical resolved shear stress is 30 Mpa, calculate the magnitude of the applied tensile stress necessary to initiate yielding.

2. (25 %)

(a) Plot the Fe-Fe_3C phase diagram and describe the eutectic, eutectoid, and peritectic reaction in the system

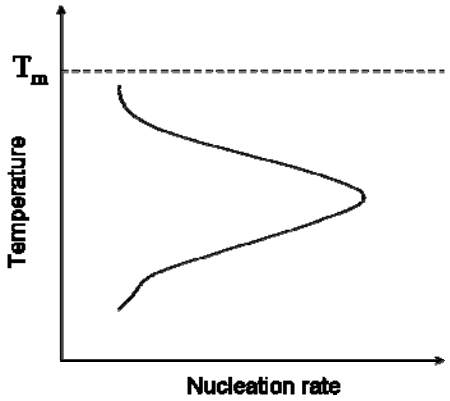
(b) For a 99.68 wt% Fe-0.32 wt% C alloy at a temperature jut below the eutectoid, determine the following

1. the fraction of total ferrite and cementite phases
2. the fraction of the proeutectoid ferrite and pearlite
3. For such an alloy, make schematic sketches of the microstructures that would be observed for conditions of very slow cooling just **above** and **below** eutectoid temperatures, respectively. Label all phases and indicate their approximate compositions.

(Hint: the solubility limit of C in iron is around 0.022 wt % at eutectoid temperatures)

3. (10%)

A schematic plot of nucleation rate vs. temperature for solidification is shown in the figure. Note that, with a lowering temperature from below Tm, the nucleation rate first increases, achieves a maximum, and subsequently diminishes. Explain possible mechanisms. (10 %)



4. (20%)

An extrinsic p-type silicon material is designed having a room-temperature conductivity of 50 $(\Omega\text{-m})^{-1}$.

(a) Specify an acceptor impurity that may be used.

(b) Determine its concentration in atomic percent to yield the electrical characteristic.

(Hint: hole mobilities at impurity concentration of 10^{21} m^{-3} and 10^{22} m^{-3} are 0.045 and 0.04 m^2/V-s, respectively; the electrical charge on an hole is 1.6×10^{-19} C).

(c) If you have fabricated the material by some processes, how to verify its p-type conductivity? Illustrate one possible method and explain its principles.

5. (20 %)

The wear resistance of a steel is to be improved by hardening its surface. This is to be accomplished by increasing the carbon content within an outer surface layer as a result of carbon diffusion into the steel; the carbon is to be supplied from an external carbon-rich gaseous atmosphere at an elevated and constant temperature. Consider one such steel that initially has a uniform carbon concentration of 0.20 wt% and is to be treated at an elevated temperature. The concentration of carbon at the surface is suddenly brought to and maintained at 1.0 wt%. If after 5.3 h the concentration of carbon is 0.60 wt% at a position 0.75 mm below the surface, determine (a) the diffusion coefficient D (b) the temperature at which the treatment was carried out.

z	erf(z)
0.45	0.4755
0.50	0.5205
0.55	0.5633

(**Available data:** preexponintial $D_o = 2.3\times10^{-5}$ m^2/s, activiation energy Q_d = 148,000 *J/mol*, gas constant *R= 8.314 J/mol-K*, ln $(7.03\times10^5) = 13.45$)