國立臺灣海洋大學九十九學年度研究所碩士班暨碩士在職專班入學考試試題

考試科目： 材料科學導論(含英文科學論文閱讀)

系所名稱： 材料工程研究所碩士班金屬材料組

＊可使用計算器

1.答案以橫式由左至右書寫。2.請依題號順序作答。

1. Many reactions and processes that are important in the treatment of materials rely on the transfer of mass either within a specific solid (ordinarily on a microscopic level) or from a liquid, a gas, or another solid phase. This is necessarily accomplished by diffusion, the phenomenon of material transport by atomic motion. Please answer the following question:

(a) Rank the magnitudes of the diffusion coefficients from greatest to least for the following systems and explain why.

N in α-Fe at 700°C
Cr in γ-Fe at 700°C
N in α-Fe at 900°C
Cr in α-Fe at 700°C (6 pts)

(b) Consider the self-diffusion of two hypothetical metals A and B. On a schematic graph of ln D versus 1/T, plot (and label) lines for both metals given that D_0 (A) > D_0 (B) and Q_d (A) > Q_d (B). (4 pts)

2. Please answer the following question:

(a) Explain the differences in grain structure for a metal that has been cold worked and one that has been cold worked and then recrystallized. (4 pts)

(b) What is the driving force for recrystallization? (2 pts)

(c) For grain growth? (2 pts)

3. (a) Please describe the meanings of Schottky defect and Frenkel defect. (2 pts)

(b) Suppose that CaO is added as an impurity to Li_2O. If the Ca^{2+} substitutes for Li^{+}, what kind of vacancies would you expect to form? How many of these vacancies are created for every added? (4 pts)

(c) Suppose that CaO is added as an impurity to $CaCl_2$. If the O^{2-} substitutes for Cl^{-}, what kind of vacancies would you expect to form? How many of these vacancies are created for every added? (4 pts)

4. Corrosion is defined as the destructive and unintentional attack of a metal; it is electrochemical and ordinarily begins at the surface. The problem of metallic corrosion is one of significant proportions. At this time, please answer the following questions:

(a) Briefly describe the phenomenon of passivity. (3 pts)

(b) Why does chromium in stainless steels make them more corrosion resistant in many environments than plain carbon steels? (3 pts)

(c) Briefly explain why cold-worked metals are more susceptible to corrosion than noncoldworked metals. (3 pts)

(d) For a concentration cell, by means of the standard emf series, briefly explain why corrosion occurs at that region having the lower concentration. (4 pts)

5. Please answer the following question:

(a) What is the purpose of a spheroidizing heat treatment? (3 pts)

(b) On what classes of alloys is it normally used? (2 pts)

(c) What influence does the presence of alloying elements (other than carbon) have on the shape of a hardenability curve? Briefly explain this effect. (4 pts)

6. A specimen of magnesium having a rectangular cross section of dimensions 3.2 mm × 19.1 mm (1/8 in. × 3/4 in.) is deformed in tension. Using the load–elongation data tabulated as Table 1, complete parts (a) through (e).

(a) Plot the data as engineering stress versus engineering strain. (5 pts)

(b) Compute the modulus of elasticity. (2 pts)

(c) Determine the yield strength at a strain offset of 0.002. (2 pts)

(d) Determine the tensile strength of this alloy. (1 pt)

(e) Please state the meaning of the resilience. (2 pts)

(f) Compute the modulus of resilience. (2 pts)

(g) What is the ductility, in percent elongation? (2 pts)

7. Figure 1 shows the first five peaks of the x-ray diffraction pattern for tungsten, which has a BCC crystal structure, and the five first-order diffraction peaks are occurred at the following diffraction angles: 40.2, 58.4, 73.3, 87, and 100.7. Here monochromatic x-radiation having a wavelength of 0.1542 nm was used.

(a) Index (i.e., give *h*, *k*, and *l* indices) for each of these peaks. (5 pts)

(b) Determine the interplanar spacing for each of the peaks. (5 pts)

(c) For each peak, please evaluate the lattice parameter and determine the standard deviation. (4 pts)

Hint:

2θ	**40.2**	**58.4**	**73.3**	**87.0**	**100.7**
Sin(θ)	**0.3437**	**0.4879**	**0.5969**	**0.6884**	**0.7700**

8. Figure 2 shows the continuous cooling transformation diagram for a 0.35 wt% C iron–carbon alloy. Make a copy of this figure and then sketch and label continuous cooling curves to yield the following microstructures:

(a) Fine pearlite and proeutectoid ferrite. (2 pts)

(b) Martensite. (2 pts)

(c) Martensite and proeutectoid ferrite. (2 pts)

(d) Coarse pearlite and proeutectoid ferrite. (2 pts)

(e) Martensite, fine pearlite, and proeutectoid ferrite. (2 pts)

9. English essay reading -- Piezoelectric Ceramics (10 pts)

A few ceramic materials (as well as some polymers) exhibit the unusual phenomenon of piezoelectricity—electric polarization (i.e., an electric field or voltage) is induced in the ceramic crystal when a mechanical strain (dimensional change) is imposed on it. Electric polarization is the alignment of electric dipoles in a common direction, which gives rise to an electric field that is oriented in this same direction. Moreover, the inverse piezoelectric effect is also displayed by this group of materials; that is, a mechanical strain results from the imposition of an electrical field.

Piezoelectric materials may be utilized as transducers between electrical and mechanical energies. One of the early uses of piezoelectric ceramics was in sonar, wherein underwater objects (e.g., submarines) are detected and their positions determined using an ultrasonic emitting and receiving system. A piezoelectric crystal is caused to oscillate by an electrical signal, which produces high-frequency mechanical vibrations that are transmitted through the water. Upon encountering an object, these signals are reflected back, and another piezoelectric material receives this reflected vibrational energy, which it then converts back into an electrical signal. Distance from the ultrasonic source and reflecting body is determined from the elapsed time between sending and receiving events.

More recently, the utilization of piezoelectric devices has grown dramatically as a consequence of increases in automatization and consumer attraction to modern sophisticated gadgets. Applications that employ piezoelectric devices are found in the automotive, computer, commercial/ consumer, and medical sectors. Some of these applications are as follows: automotive—wheel balances, seat belt buzzers, tread-wear indicators, keyless door entry, and airbag sensors; computer—microactuators for hard disks and notebook transformers; commercial/consumer—ink-jet printing heads, strain gauges, ultrasonic welders, and smoke detectors;medical—insulin pumps, ultrasonic therapy, and ultrasonic cataract-removal devices.

Commonly used piezoelectric ceramics include barium titanate ($BaTiO_3$), lead titanate ($PbTiO_3$), lead zirconate–titanate (PZT) [$Pb(Zr,Ti)O_3$], and potassium niobate ($KNbO_3$).

According to the foregoing essay, please answer the following question <u>in Chinese</u>. (用英文回答者，將以零分計算)

(a) Sonar is one of the early uses of piezoelectric ceramics. Please describe how to work for the use of piezoelectric ceramics in sonar. (4 pts)

(b) Please briefly describe the phenomenon of piezoelectricity. (2 pts)

(c) Please briefly describe the electric polarization. (2 pts)

(d) Please give four application examples employing piezoelectric devices. (2 pts)

Table - 01

Load		*Length*	
lb_f	*N*	*in.*	*mm*
0	0	2.500	63.50
310	1380	2.501	63.53
625	2780	2.502	63.56
1265	5630	2.505	63.62
1670	7430	2.508	63.70
1830	8140	2.510	63.75
2220	9870	2.525	64.14
2890	12,850	2.575	65.41
3170	14,100	2.625	66.68
3225	14,340	2.675	67.95
3110	13,830	2.725	69.22
2810	12,500	2.775	70.49
	Fracture		

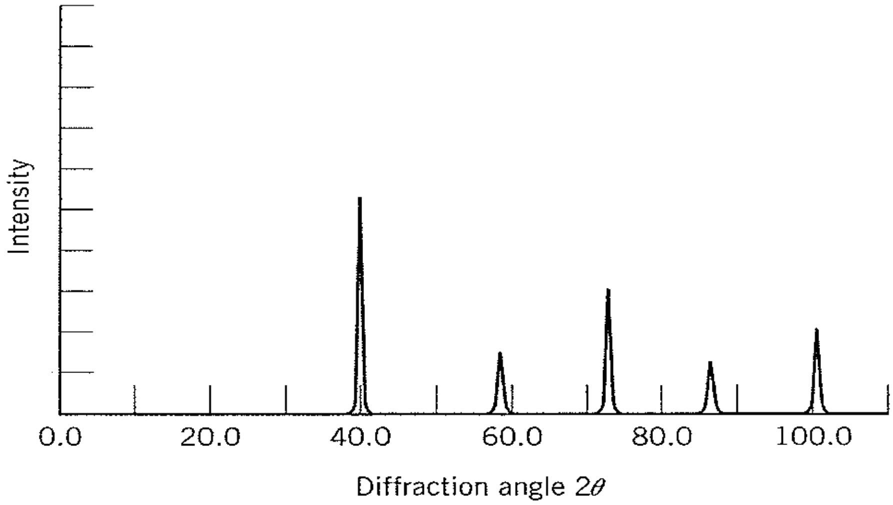

Figure 1 Diffraction pattern for powdered tungsten. (Courtesy of Wesley L. Holman.)

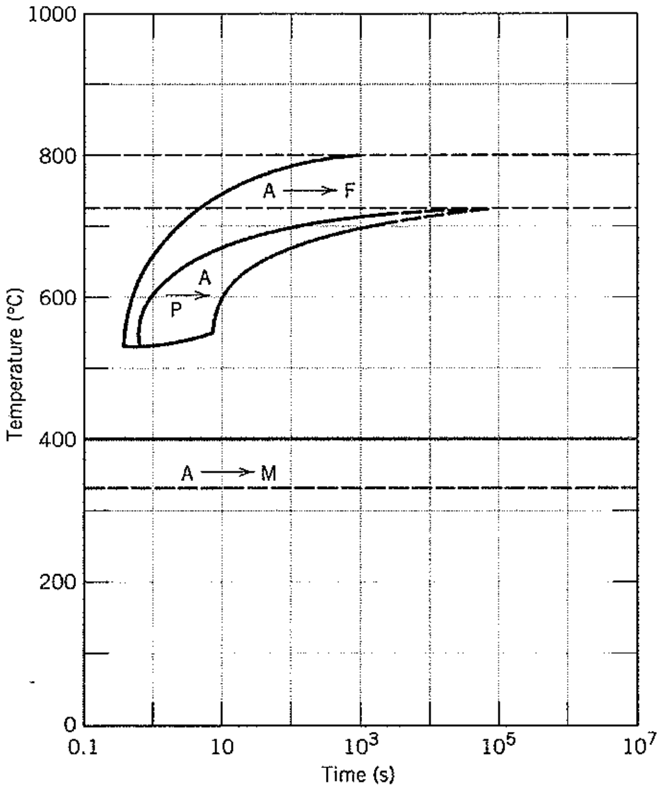

Figure 2 Continuous cooling transformation diagram for a 0.35 wt% C iron-carbon