國立臺灣科技大學 111 學年度碩士班招生試題

系所組別：機械工程系碩士班戊組

科　　目：材料原理

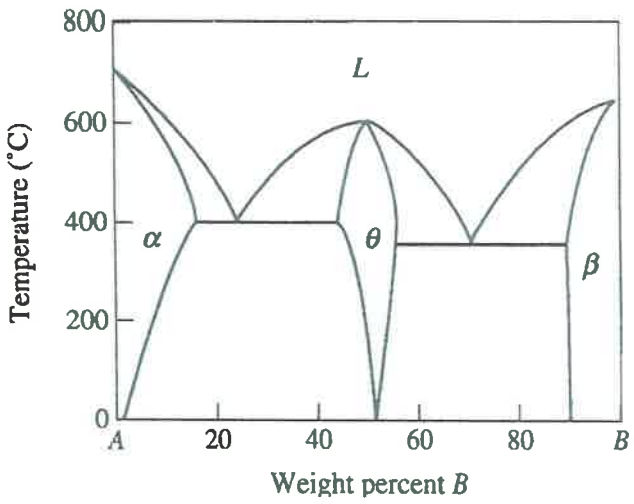
(總分為 100 分；所有試題務必於答案卷內頁依序作答，否則不予計分)

1.(10%) Diffraction angles obtained from an x-ray diffraction experiment of a metal are as following: 25.5°, 36.5°, 44.5°, 51.5°, 58.5°, 64.5°, 70.5° and 75.5°. The wavelength of x-ray is 0.15418 nm. Determine the crystal structure of the metal. Is it SC, FCC, or BCC?

2. (15%) A hypothetical binary phase diagram for A-B alloy is shown in the figure.

(a) What is the three phase reaction at 400 °C? Write down the name of the reaction, the reaction in equation form, and the composition of each phase. **(5%)**

(b) Precipitation hardening is a commonly-used method for strengthening metallic materials. Among the alloys A-10wt%B, A-55wt%B, and A-95wt%B, find the best candidate for precipitation hardening and justify your answer. **(10%)**



3. (10%) Both of titanium and magnesium appear at the anodic end of the galvanic series. However, only titanium is safe to use as a permanent biomedical implant. Why?

4. (15%)

(a) Define "thermal shock". **(5%)**

(b) Name five factors that affect thermal shock of a material and explain briefly how thermal shock behavior is affected by these factors. **(10%)**

5. (20%) Use the TTT diagram below to estimate the range of cooling rates required to achieve a certain phase transform starting from the eutectoid steel. Typically, the transformation is done by rapidly cooling the eutectoid steel to a pre-selected temperature, and then hold it for a certain amount of time to complete the transformation.

(a) Name the A, P, B and M in the diagram shown below and describe their microstructures. Some answers are already given as examples. **(15%)**

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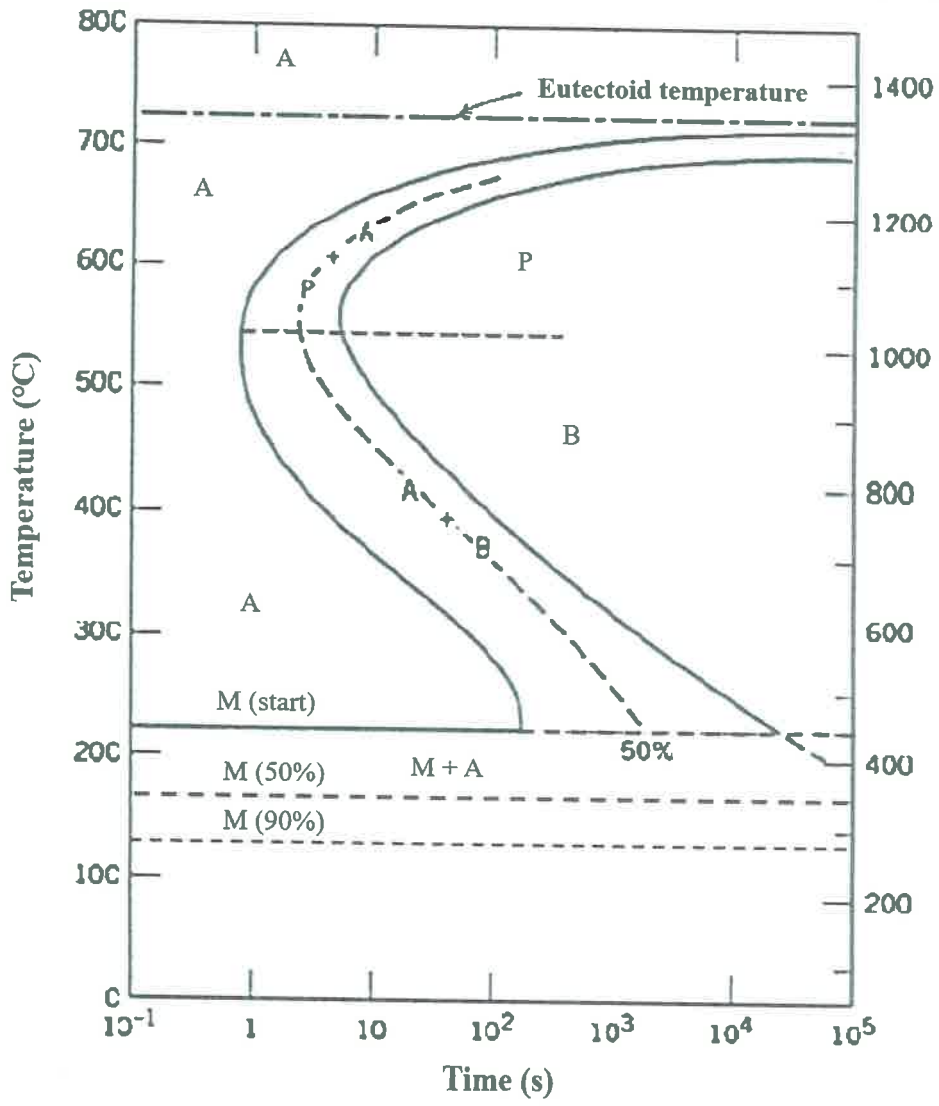
	Name	Number of phases	Microstructures
A	Austenite	1	Single phase
P			
B			
M			
Annealed P or B			
Annealed M			

(b) Use the TTT diagram to estimate the minimum cooling rate (in degrees per second) required to fully transform A to M from 800 °C. Show your work. **(5%)**



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6. (30%) Select one or more correct answers to the following questions. (**Points are awarded for all correct.**)

A. **(3%)** Through an ion exchange process, Na^+ ions (ionic radius = 0.098 nm) on the surface of glass can be replaced with K^+ ions (ionic radius = 0.133 nm). The glass becomes significantly more scratch-resistant after this process. The reason for this surface toughening is that:

(a.) These larger potassium ions create a surface compressive stress to inhibit crack opening

(b.) Potassium has a lower coefficient of thermal expansion such that it creates a surface compressive stress

(c.) All the vacant sites in glass are filled by the larger potassium ions

(d.) Internal stress is relieved by the ion exchange process

B. **(3%)** Cold work on a metal can decrease its

(a.) Tensile strength

(b.) Ductility

(c.) Yield strength

(d.) Electrical conductivity

C. **(3%)** Suppose a phase transformation obeys the Avrami relation with n=1. If you heat at a temperature T for 1 hour, you find the transformation is 40.0% complete. If you heat for another two hours at T (for a total of 3 hours), what is the percentage of transformed phase? (You may assume that the nucleation period is essentially zero in this problem.)

(a.) 80.0%; (b.) 78.4%; (c.) 93.6%; (d.) None of the above

D. **(3%)** Which of the following has a thermally-activated (Arrhenius-type) behavior?

(a.) Diffusion

(b.) Phase transformation rate

(c.) Fatigue life

(d.) Vacancy formation

E. **(3%)** GaAs is a compound semiconductor. Ga has valence 3 and As valence 5. Consider adding sulfur impurities to GaAs. Sulfur has valence equal to 6 and occupies As sites.

(a.) GaAs forms more positive ion vacancies

(b.) GaAs forms more negative ion vacancies

(c.) GaAs becomes an N-type semiconductor

(d.) GaAs becomes a P-type semiconductor

F. **(3%)** Silicon's electrical conductivity increases rapidly above room temperature because

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(a.) Thermal expansion increases the average time between electron collisions and hence the electrical conductivity

(b.) Electron thermal velocity increases with temperature so that electrons travel further between collisions

(c.) Thermal excitation of valence electrons into the conduction band increases conduction electron concentration

(d.) Higher temperature results in increased vacancy concentration

G. **(3%)** Which material would you expect to have the largest yield strength?

(a.) 1 cm^3 cube of polycrystalline Al-4wt% Cu alloy with average grain size of 10 microns

(b.) 1 cm^3 cube of polycrystalline Al with average grain size of 10 microns

(c.) 1 cm^3 cube of single crystal Al

(d.) They all have the same yield stress

H. **(3%)** Which statement is true regarding dislocations and grain boundaries?

(a.) Atom diffusion is faster along grain boundaries than through the bulk of the crystal

(b.) Amorphous solids have dislocations and grain boundaries

(c.) Impurity atoms tend to segregate to dislocation, but not grain boundaries

(d.) Impurity atoms tend to segregate to grain boundaries, but not dislocation

I. **(3%)** Which statement is correct about metal fatigue?

(a.) Mechanical structures subjected to fluctuating stresses can fail at levels below the ultimate tensile strength

(b.) Fatigue life is independent of the environment

(c.) For all metals, there is a stress level below which the fatigue life is infinite

(d.) As long as there are no initial cracks, sharp corners do not affect fatigue life

J. **(3%)**Cesium iodide (Cs^+I^-) has a body-centered crystal structure, in which Cs^+ sits at the cube corners and I^- at the center of the cube. The radius of Cs^+ is 0.169 nm, and that of I^- is 0.216 nm. What is the lattice constant (side length of the cube)?

(a.) 0.385 nm; (b.) 0.445 nm; (c.) 0.544 nm; (d.) 0.770 nm