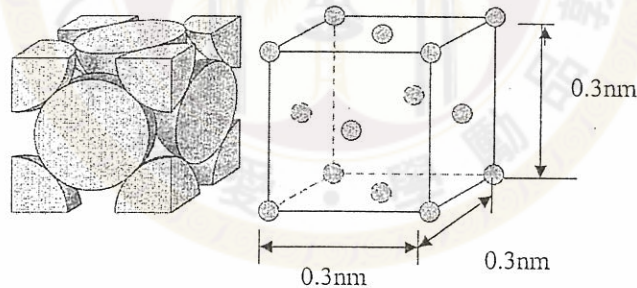


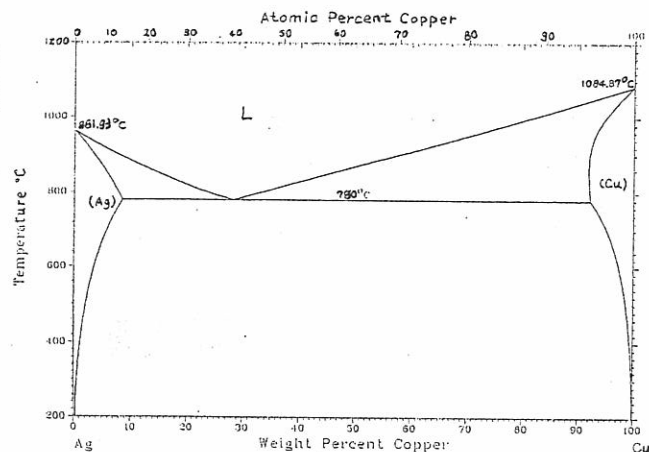
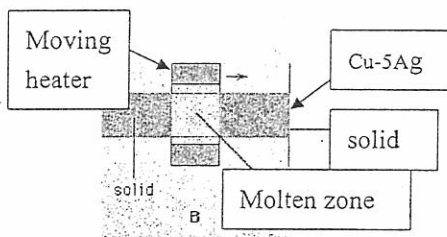
- (8%) A 300 Kg steel plate is hanging on a medium carbon steel wire of 1mm in diameter.
  - What is the tensile stress (MPa) applied to the wire? (4%)
  - Do you think the wire will break or not? Why? (2%)
  - About 500 years ago, da Vinci (達文西) measured the tensile strength of many short wires and long wires with the same wire diameter. He observed that the long wire had a lower average tensile strength. Why? (2%)
- (8%) A low carbon steel was heated to 900°C for 1 hour in a CO (carbon monoxide)-containing atmosphere. The steel surface was carburized and hardened after quenching. To save time, you want to heat the steel to 930°C.
  - How many hours do you need to get similar degree of carburization, ie, similar surface hardness and carburized depth after quenching? You may select the preexponential diffusion constant ( $D^0$ ) and activation energy (Q) you need from the table shown below. The gas constant is 8.31J/mole-K.
  - Give a reason why you select that  $D_0$  and Q.

Diffusing species	Matrix structure	$D^0, m^2/s$	Activation energy, kJ/mole
Carbon	$\alpha$ -Fe	$6.2 \times 10^{-7}$	80
Carbon	$\gamma$ -Fe	$2.3 \times 10^{-5}$	148

- (8%) A material has the structure shown below. What is the diffraction angle of the slip plane? Assume that monochromatic radiation having a wavelength of 0.18nm is used and the order of reflection is 1.

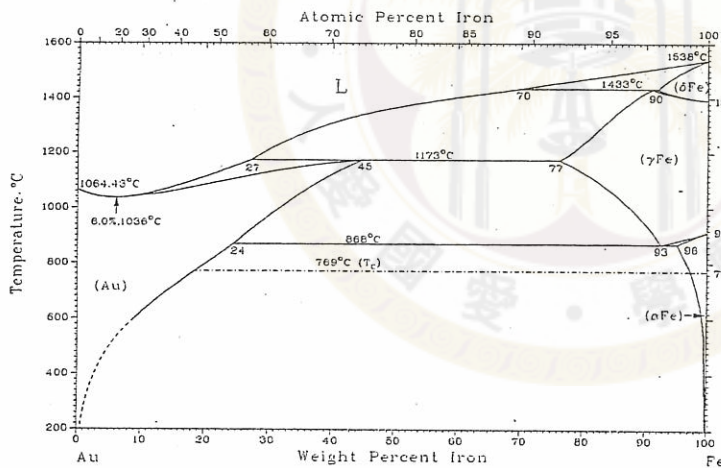
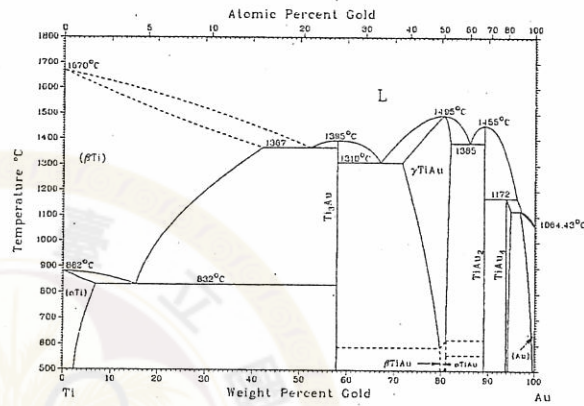
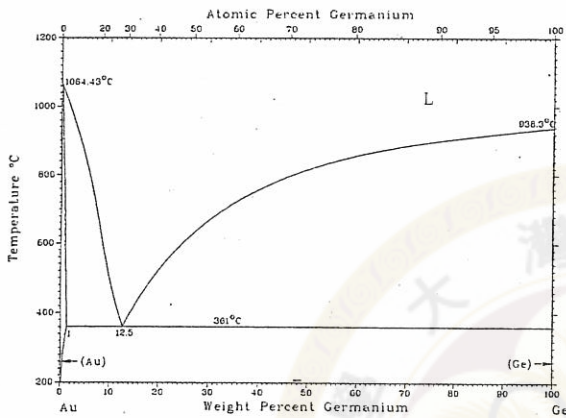


- (8%) A Cu-5Ag is melted and re-solidified as the heater (shown below) travels slowly from left to right. Assuming that the zone melting (zone refining) technique can purify Cu from this Cu-5Ag alloy, estimate the percentages of the silver at the very left end and at the very right end after the alloy has been melted and re-solidified three times (3 cycles) by the traveling heater.



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5. (8%) About 6 years ago, Hong-Kong held a competition of hard jewelry that must have a high gold content and a high hardness. Which gold alloy shown below will you choose if you want to use a precipitation hardened gold alloy? (a) Describe the alloy composition you use, (b) what is the precipitated material, (c) describe the process including time and temperature, (d) explain why the other two gold alloys are less effective for precipitation hardening.



6. (10%)
- (a) For the anionic polymerization, what properties are generally required of the initiator and the monomer? Give one set of example (initiator + monomer). (5 %)
- (b) For the cationic polymerization, what properties are generally required of the initiator and the monomer? Give one set of example (initiator + monomer). (5 %)

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7. (10%)
- (a) Based on what property can one predict whether a particular solvent would be a good solvent for a particular polymer? Explain your answer. (5 %)
- (b) Define the term “ $\theta$  (theta) temperature”. (5 %)
8. (8%) How much kaolinite clay must be added to 100 g of quartz to produce a  $\text{SiO}_2$ -30%  $\text{Al}_2\text{O}_3$  fireclay brick after firing? (The molecular weights of  $\text{SiO}_2$ ,  $\text{Al}_2\text{O}_3$  and  $\text{H}_2\text{O}$  are 60.08, 101.96 and 18 g/g-mole, respectively.)
9. (6%) Draw a cubic close packing of oxygen ions, locate all the tetrahedral interstitial sites, and fill them up with cations. What structure do you obtain? If the anions are oxygen, what must be the charge on the cation for charge neutrality to be maintained?
10. (6%) Explain the toughening mechanism in partially stabilized zirconia.
11. (10%) The base semiconducting material used in most of modern integrated circuits devices is silicon. However, silicon has some limitations and restrictions. Please write an essay comparing the properties and applications of silicon and gallium arsenide.
12. (10%) Consider the manufacture process of optical fibers and materials used. Please describe what factors would reduce attenuation in an optical communication system.

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