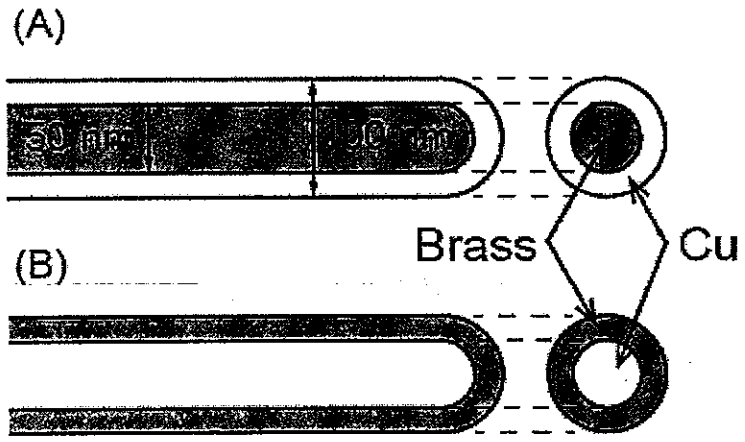
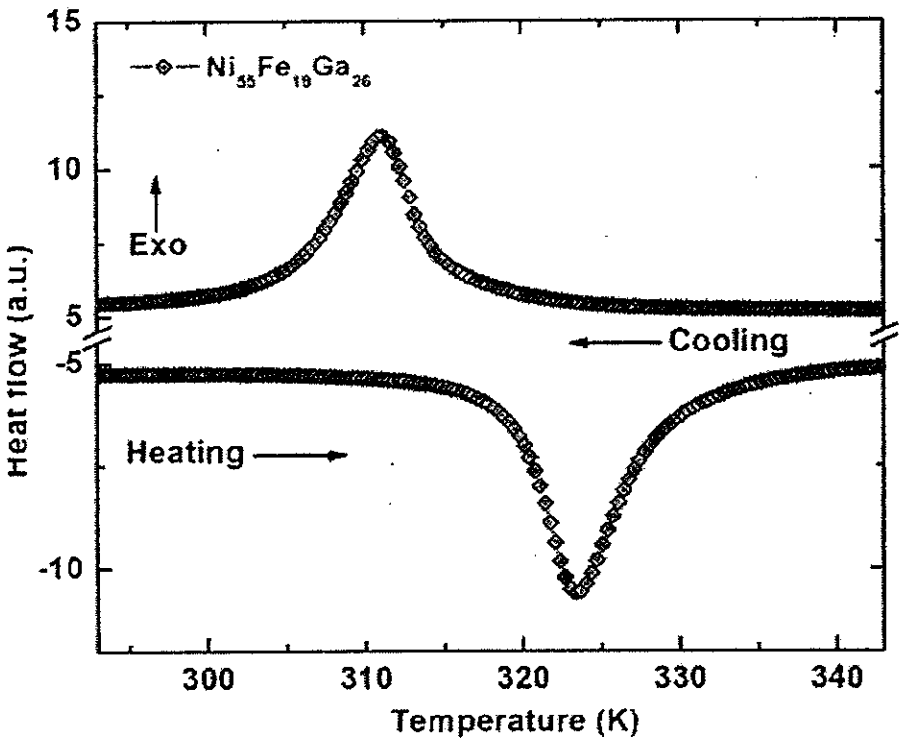
1. Dislocations in Metals (10%):
   (a) Please list all slip systems in face-centered cubic (FCC) crystal. (2%)
   (b) Please list all slip systems in body-centered cubic (BCC) crystal. (2%)
   (c) Compared with FCC metal, why does BCC metal usually has a clear ductile-to-brittle transition temperature (DBTT)? (2%)
   (d) Please describe an approach to increase the DBTT of BCC metal. (2%)
   (e) Will this approach also increase the elongation during tensile test at room temperature? (2%)
2. Essentials of Stainless Steels (10%):
   (a) What is the minimum content of Cr in stainless steels? (2%)
   (b) What is the mechanism for Cr to protect steel from corrosion? (2%)
   (c) Please briefly describe the essentials of sensitization. (2%)
   (d) How do you prevent sensitization when you anneal the stainless steels. (2%)
   (e) People might replace Ni by Mn in austenitic stainless steels. What are the advantages and disadvantages by doing so? (2%)
3. Materials Kinetics (10%): There are two nanowires as shown below: (A) Brass in core and Cu in shell and (B) Cu in core and Brass in shell. (melting point of Cu: 1085 °C and melting point of Zn: 420 °C) Please schematically draw the morphologies of these nanowires after annealing at 600 °C and explain the reasons.



4. Experiment (10%): You now work on the martensitic transformation in $Ni_{55}Fe_{19}Ga_{26}$ alloy. The figure below shows the measurement from differential scanning calorimeter (DSC) for TiNi alloy.



   (a) Based on the figure above, how does the atomic volume change when martensitic transformation occurs in cooling? (2%)
   (b) Please suggest a method to determine the M_s and M_f temperatures of martensitic transformation in the figure above. (2%)
   (c) When one deforms the alloy at 60 °C, how can he/she make the deformation recovered? (6%)

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5. (a) What is the vulcanization? (5%)
   (b) Is it necessary to be vulcanized for thermoplastic elastomer? Why? (5%)
6. Sketch chemical structures for poly(hexamethylene adipamide) (nylon 6,6) and styrene-butadiene rubber. (10%)
7. Please schematically plot the electrical resistivity (ρ) of a (a) metallic conductor (b) semiconductor and (c) superconductor as a function of temperature. (10%)
8. (a) What is the origin of magnetic moments in materials? (b) For a ferromagnetic material, what does its Curie temperature (T_c) mean? (c) Please schematically plot the saturation magnetization (M_s) as a function of temperature for a ferromagnetic material. (10%)
9. Perovskite is a family of materials that has attracted lots of interests recently due to its potential application in solar cell industry. In the 80s, it was also popular due to the discovery of high-T_c cuprate superconductors. (a) What is the general formula for a material with perovskite structure? (b) Please plot a representative unit cell for the perovskite crystal structure and carefully indicate the positions of cations and anions. (c) What are the coordination numbers for each ion? (10%)
10. Please plot the specific volume as a function of temperature for (a) a crystalline solid and (b) a non-crystalline (amorphous) material that can be considered as glass at low temperature. Indicate the melting temperature (T_m) and the glass transition temperature (T_g) on your plots. (10%)

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