ELEC-D8710 Principles of materials science

Extra exam 26.4.2017

1. Answer following questions based on Figure 1, which shows the binary Al-O phase diagram.

a) What is the melting temperature and evaporation temperature of Al_2O_3 (p=1atm)? Explain the phase transformations (what phases are in equilibrium, what is their composition and amount) from 4000K down to 300K when x_O=0.2. (5p)

b) What is the state of the surface when pure aluminum metal plate is in contact with air at room temperature? (1p)

c) It is known that Al_2O_3 phase grows parabolically (under NTP conditions). What can you say about the protecting properties of Al_2O_3? What is generally required an oxide to be protective? (2p)

d) Based on the Ellingham diagram (See Fig. 2) what is the oxygen partial pressure, in which pure Al_2O_3 can be reduced to pure Al at T=1000°C? Give also the corresponding equilibrium constant for the reaction (2p)

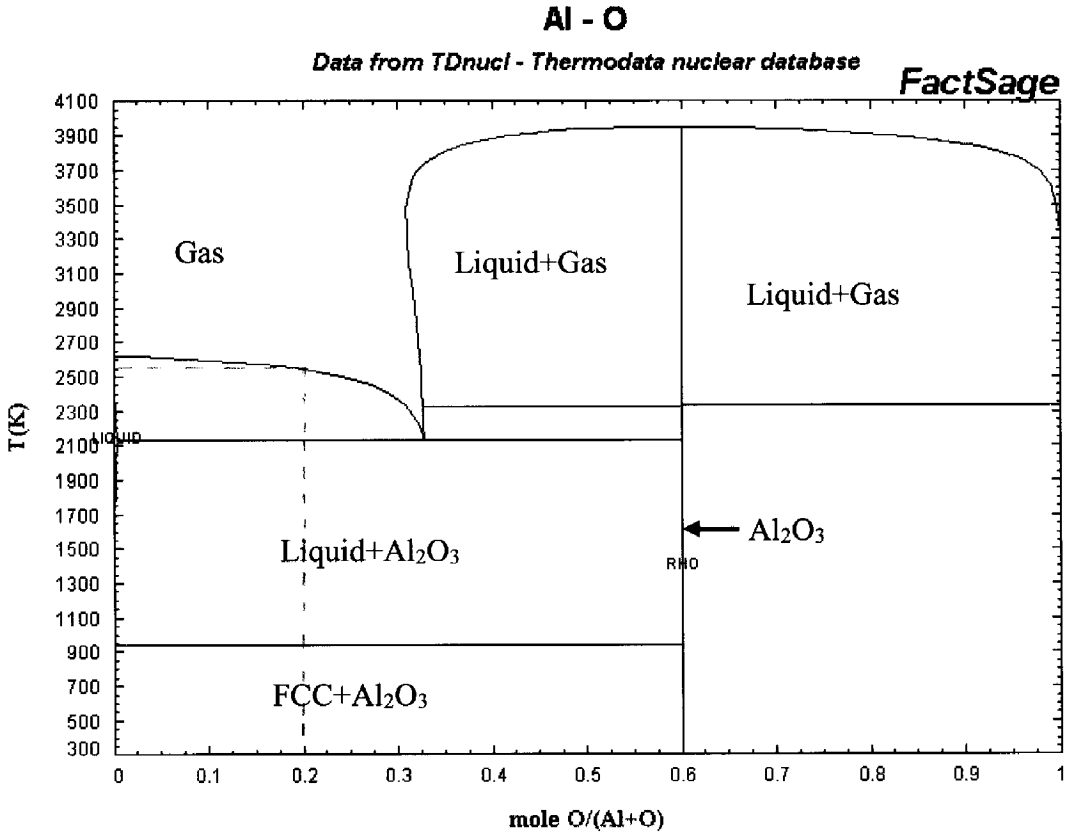


Figure 1 Binary Al-O phase diagram

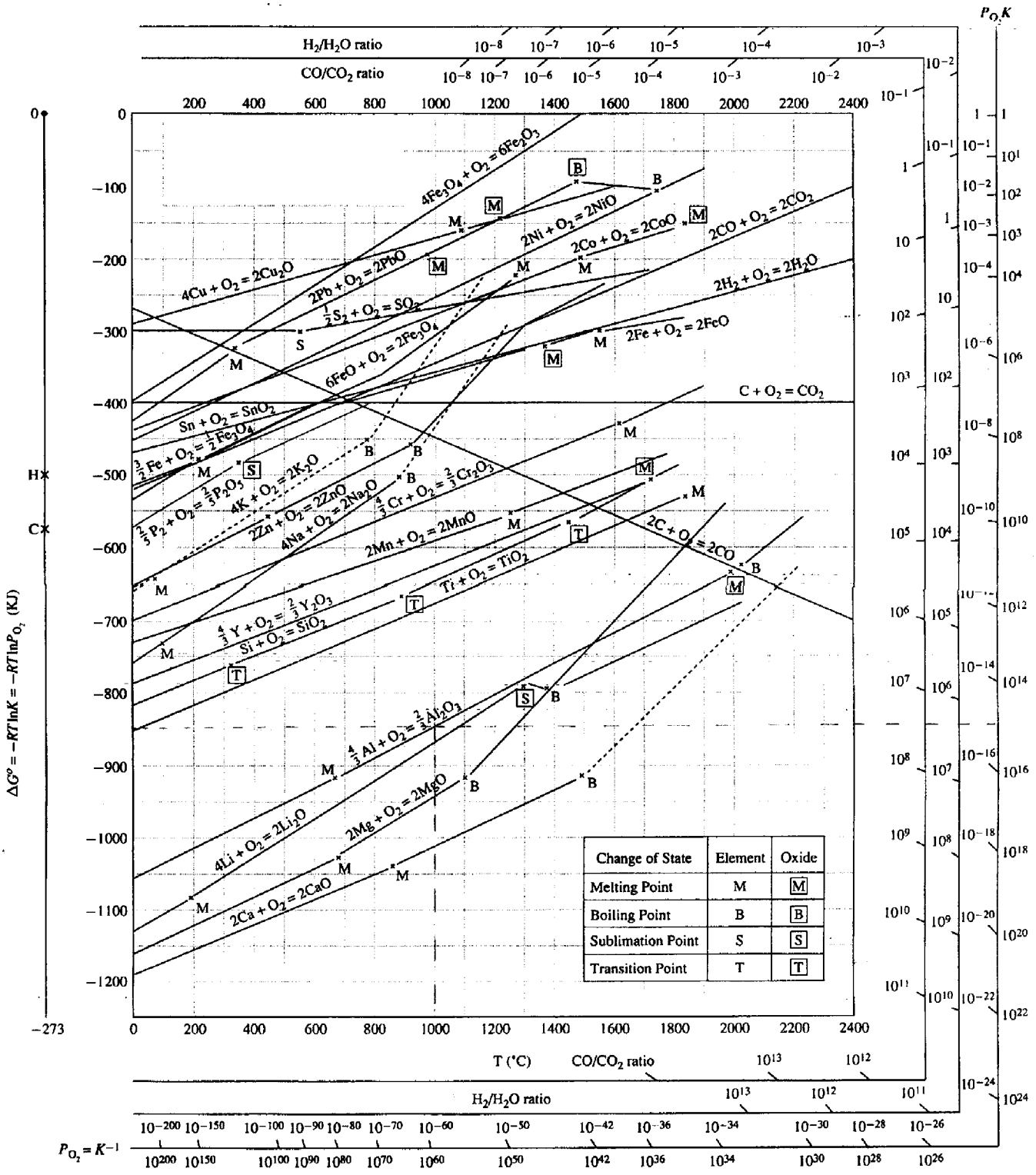


Figure 2 Ellingham diagram

2. a) Identify the type of primary bonding in LiF shown in Figure 3. Justify your answer based on the electron density distribution shown in Figure 3 (2p).

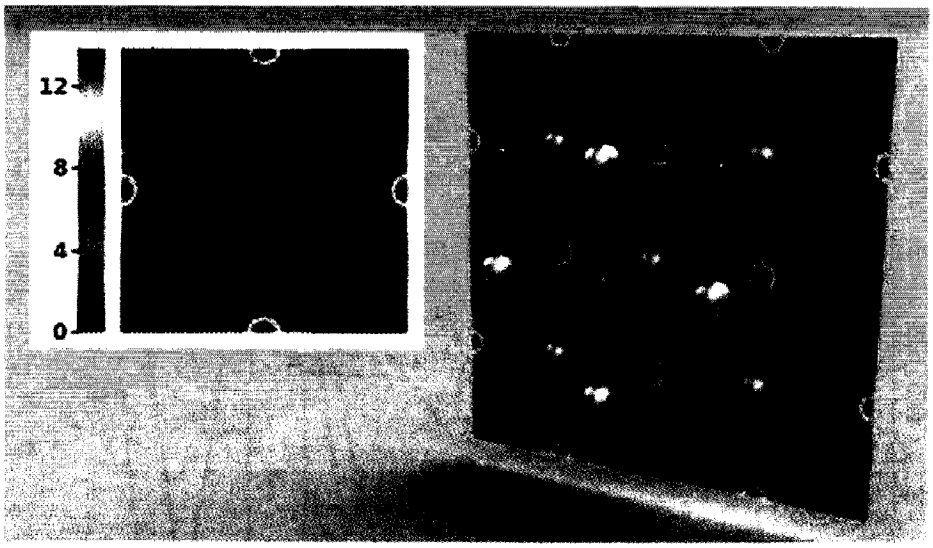
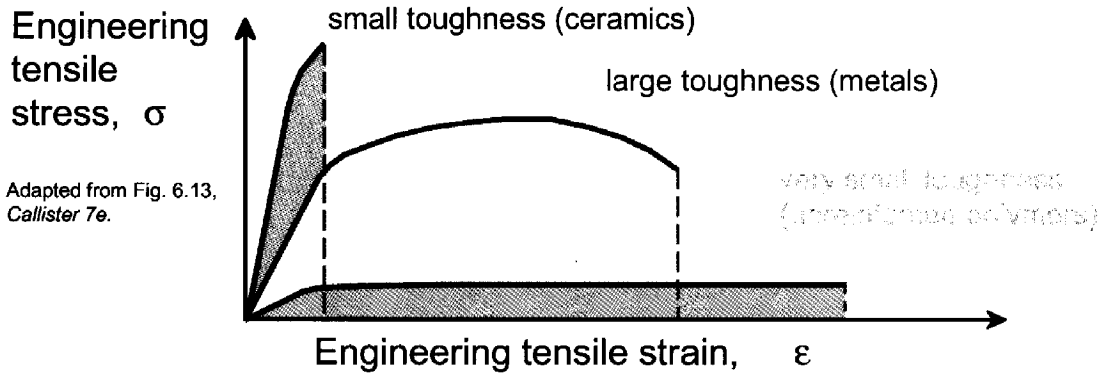


Figure 3.

b) Based on different types of bonding between atoms, explain the stress-strain behavior of ceramics, metals and unreinforced polymers shown in Figure 4. Which one of the three material types you would choose to fabricate a hammer and why? (2p)



Adapted from Fig. 6.13, *Callister 7e.*

Figure 4.

c) Which one of the following materials: silver, diamond and polyethene you would expected to be the best conductor of (i) electricity and (ii) heat. Justify your answer based on the bonding experienced by the above listed materials. (1p)

3. Thick aluminum (Al) and copper (Cu) metal plates are attached against each other (=semi-infinite diffusion couple) at the temperature of 300°C. Based on the phase diagram (see Fig. 5) draw the structure of the diffusion couple and the composition profiles for both components, when sufficient amount of time has elapsed so that local equilibria is achieved in all interfaces. (NB. Mark clearly the compositions of the phases at all interfaces!) (5p)

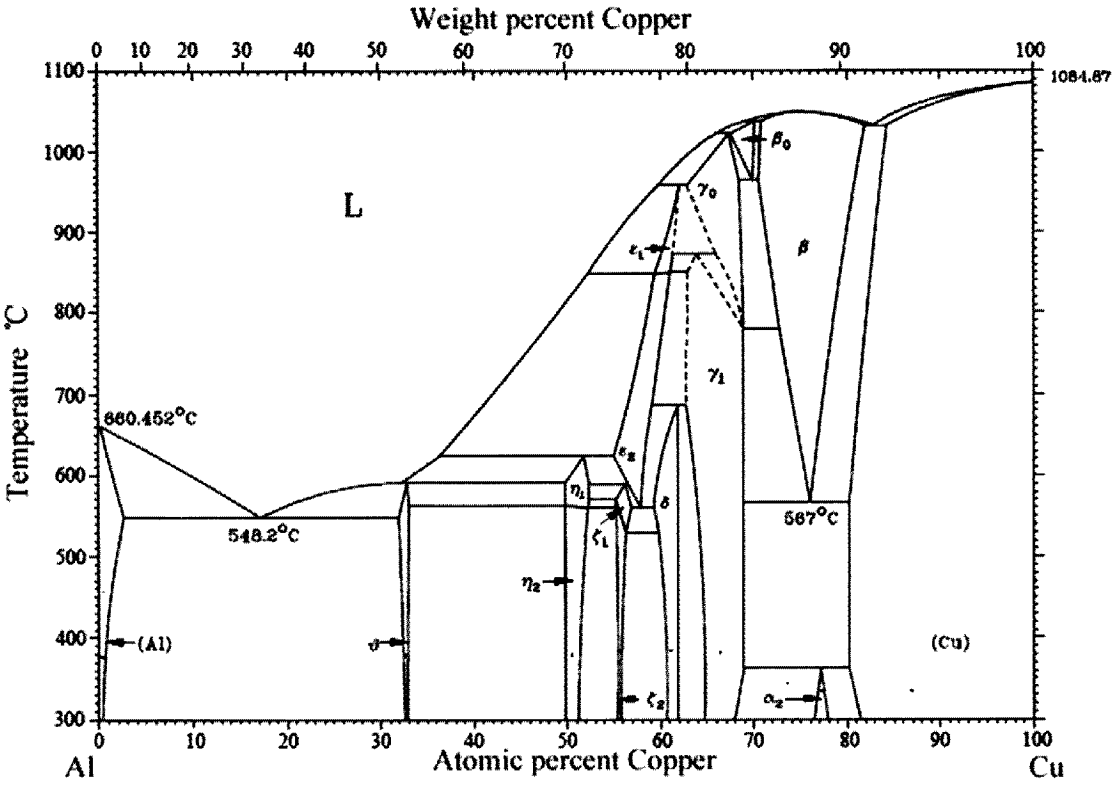


Figure 3 Al-Cu binary phase diagram