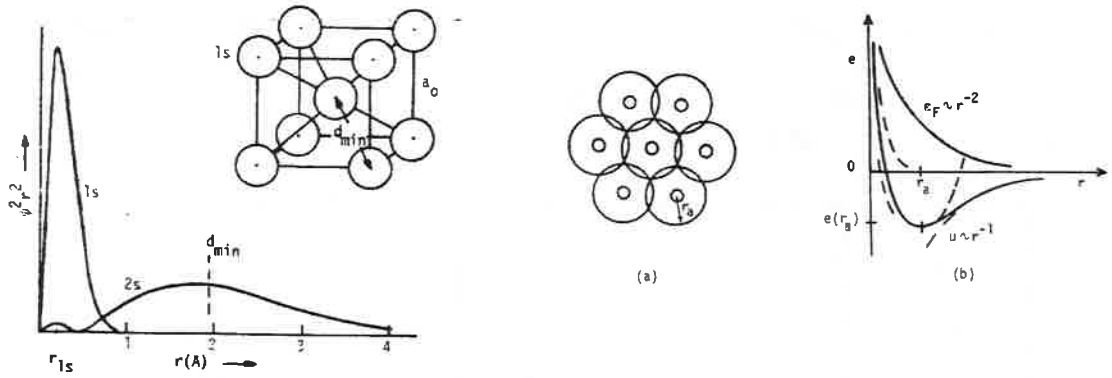
ELEC-D8710 Principles of materials science **Intermediate Exam I**
6.3.2019

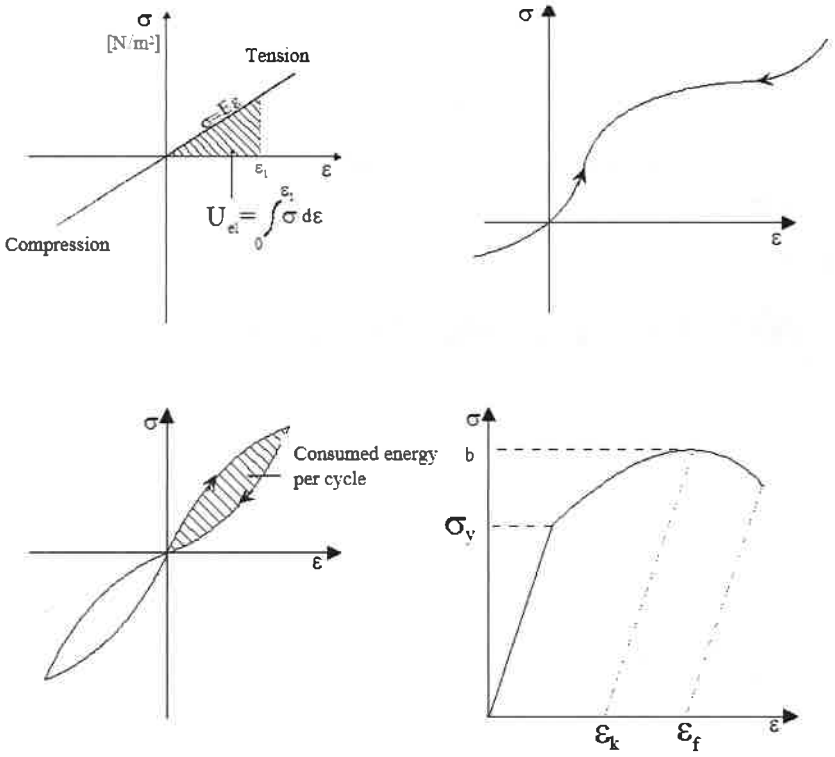
1. a) Explain the formation of a metallic bond by utilizing the below given diagrams. Explain, by utilizing the typical properties of metallic bonds, why closed packed structures are typical for metals (2 p)



b) Give electron configurations for quicksilver (Hg) and tin (Sn). Determine also their valences (number of electrons and configuration). Atomic number of Hg is 80 and that of Sn is 50. The inner energy levels are filled except for empty 5f and 5g orbitals for Hg and empty 4f orbital for Sn. (2p)

c) A material has a high melting point, high Young's modulus, it is a hard but brittle and an electrical insulator (even as melted). What kind of bonding the material is likely to have? (1p)

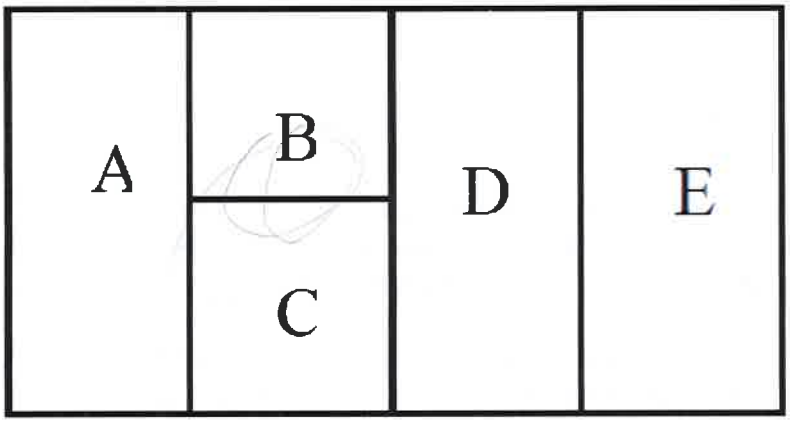
2. (a) Explain the stress-strain behavior of the four different material types shown in the figure below and give an example material out of each group (2p)



b) A polymer has a fracture toughness of 1.8 MPa m½. During its use 25 MPa stress is applied on the material. What is the largest crack size tolerated a) inside and b) on the surface of the polymer? (2p).

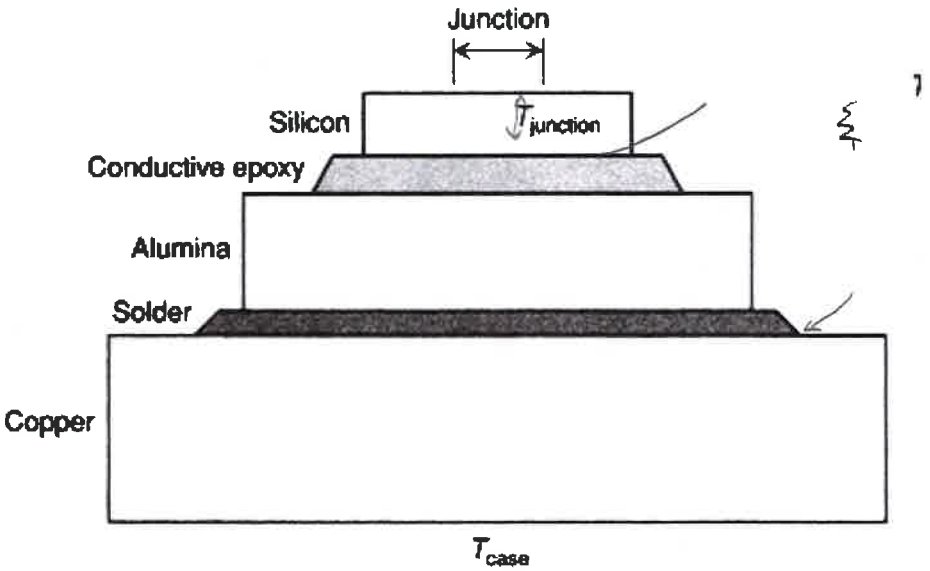
c) Explain why the use of linear elastic fracture mechanics is not particularly suitable for plastic materials like polymers in the example above. (1p)

3. (a) Determine the heat transfer through the composite wall shown in the figure below. Take the thermal conductivities of A, B, C, D & E as 50, 10, 6.67, 20 & 30 W/mK respectively and assume one dimensional heat transfer. Take area of to be A =D= E = 1m^2 and B=C=0.5 m^2. Temperature entering at wall A is 800 °C and leaving at wall E is 100 °C (2p)



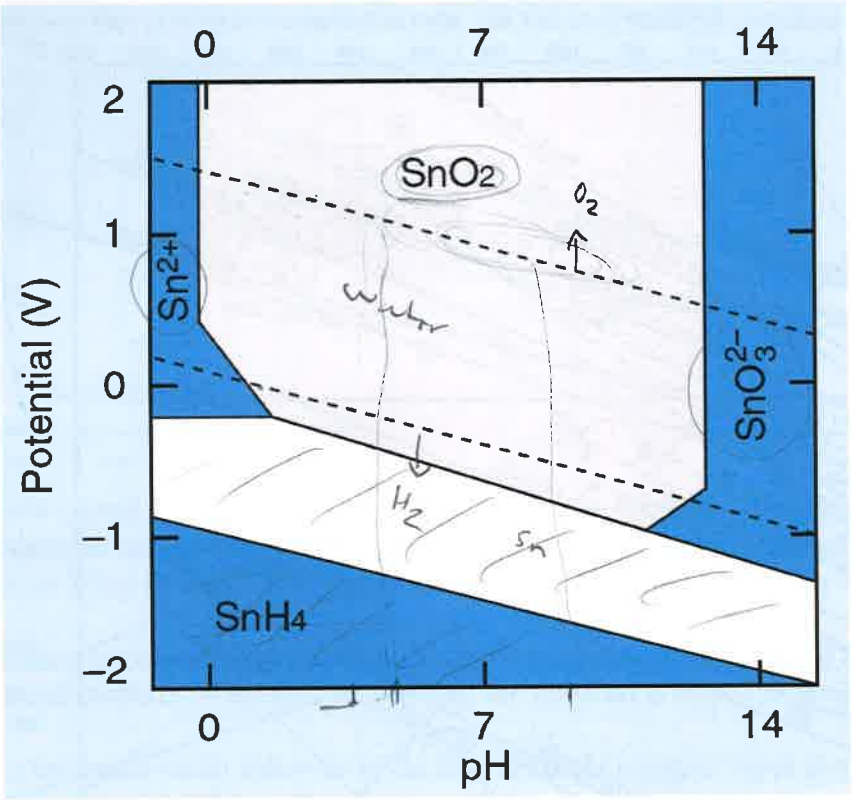
b) By which mechanisms heat is conducted in solids, liquids and in gases? (1p)

c) Establish the equivalent thermal circuit for the system shown in figure below starting from the T-junction and ending to T-case (1p).



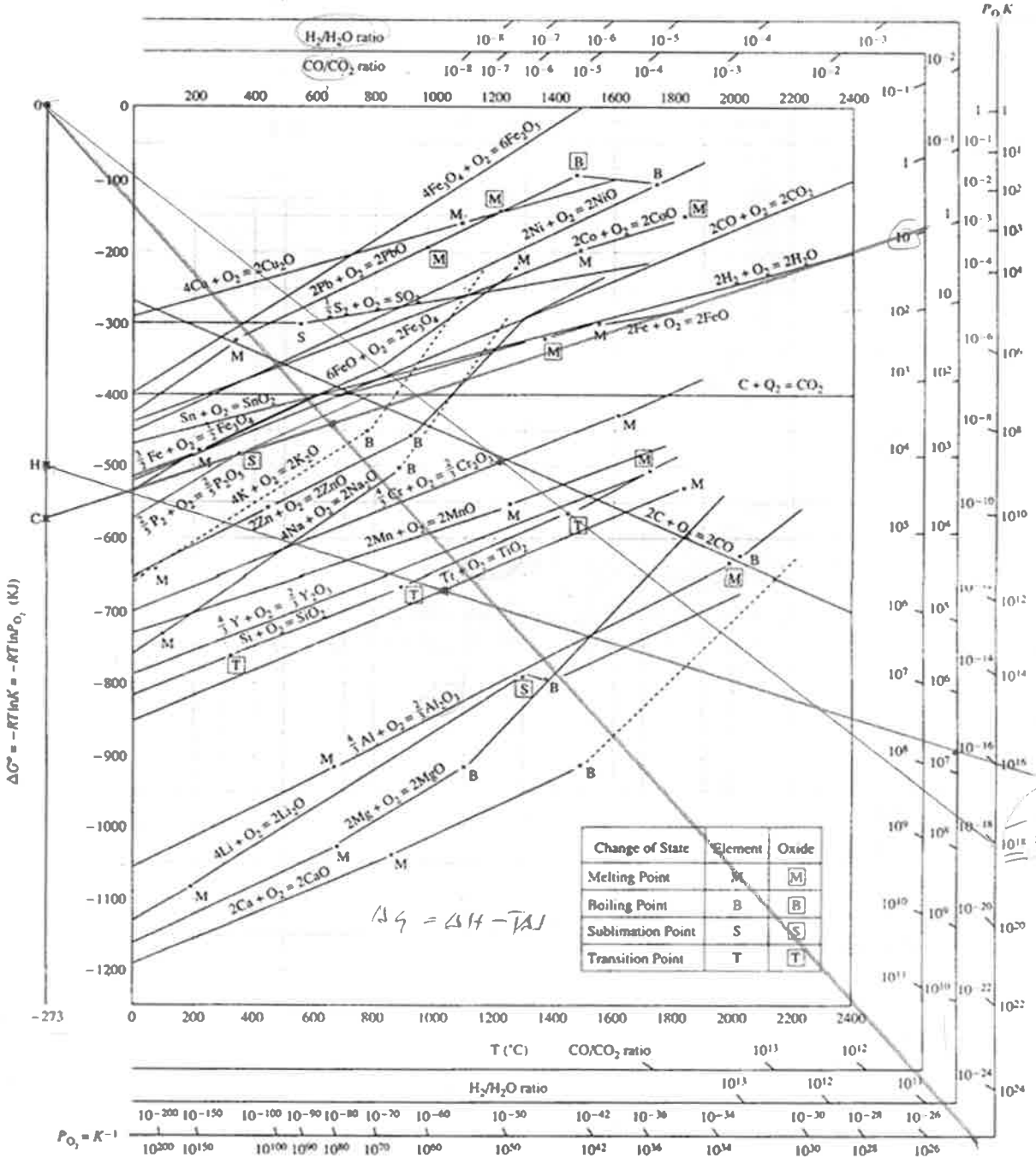
d) What is meant by the thermal contact resistance and what is its significance from the thermal management point of view? (1p)

4. a) Pourbaix diagram for Sn is shown below. Explain what are the dashed lines in the figure and when Sn is in immune, active and in passive stage. In the pH region 4 to 8 what form of Sn you would use to catalyze oxygen evolution and why? (2p) (You can disregard SnH_4)



b) Based on the Ellingham diagram (see figure below) 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 (1p)

c) What is the partial pressure of oxygen for gas mixture with CO/CO_2 ratio of 10^4 at 1200 °C based on the same diagram? (2p)



$\Delta G = \Delta H - T\Delta S$

10^{-25} atm