1. The phase diagram of the copper-antimony system is shown below. The phase diagram contains an intermetallic compound marked "**X**" on the diagram. Determine the chemical formula of this compound. The atomic weight of copper and antimony are 63.54 and 121.75, respectively. **(5%)**

2. The copper-antimony phase diagram shown below contains two eutectic reactions and one eutectoid reaction. For each reaction, identify the phases involved, give the compositions of the phases, and give the temperature of the reaction. **(15%)**
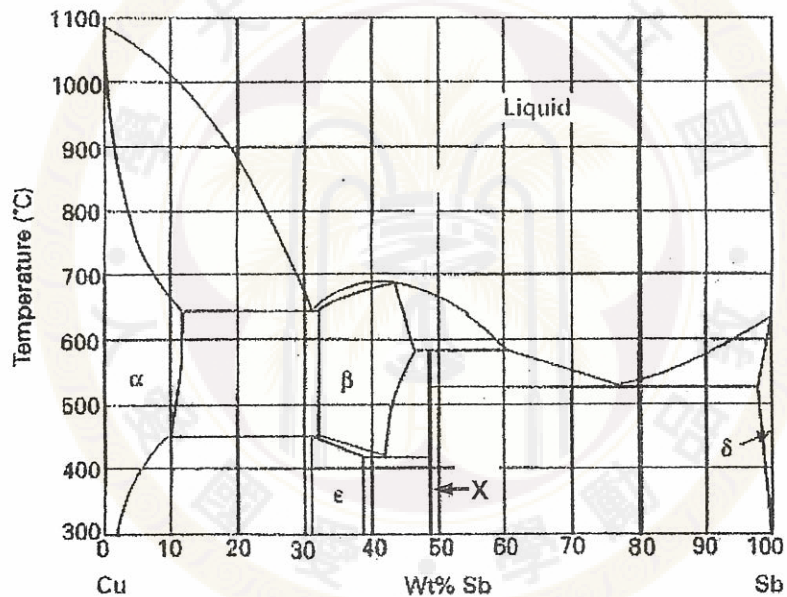
3. If the true stress (σ) – true strain (ε) curve for a material can be defined as: $\sigma = A\varepsilon^n$, where A and n are constants; for a nickel alloy, $n = 0.2$ and $A = 800$ MN·m^{-2}. Evaluate **(i)** the tensile strength (σ_{TS}) of the nickel alloy, and **(ii)** the true stress in the nickel alloy specimen when loaded to σ_{TS}. **(15%)**

4. Three-point and four-point bending tests were carried out on samples of silicon carbide, and the median values of the flexural strength were 350 and 300 MPa, respectively. A tensile test was also carried out using a sample of identical material and dimensions, but loaded in tension along its length. The median value of the tensile strength was only 230 MPa. Explain why there is a difference between the three measures of strength. **(10%)**

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5. A *1050* steel is held at 800 °C for 1 h, quenched to 700 °C and held for 50 s, quenched to 400 °C and held for 20 s, and finally quenched to room temperature. What is the final microstructure of this steel? The TTT diagram for a *1050* steel is shown below. (15%)
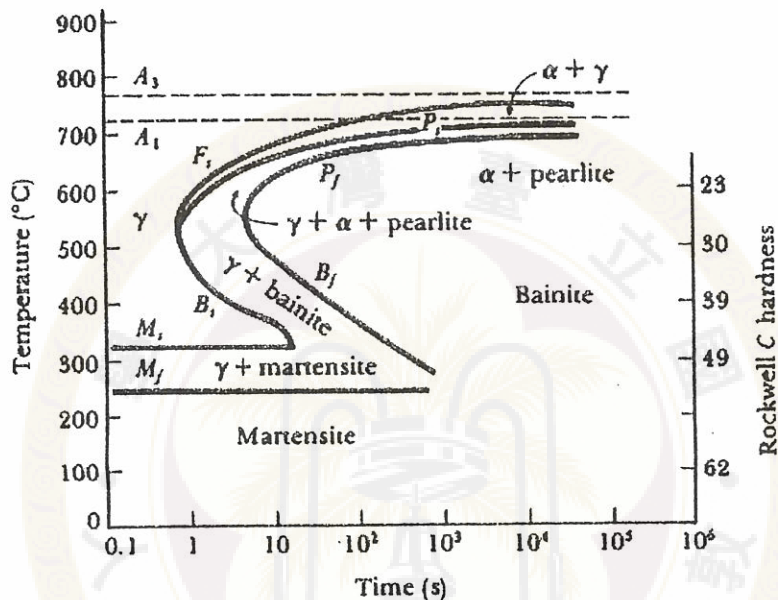
6. Calculate the density of the compound BeO (one of the best electrical insulators in existence) if it crystallizes in the zinc blende structure. (The ionic radii for Be^{2+} and O^{2-} are 0.35 Å and 1.32 Å, respectively. The atomic masses for Be^{2+} and O^{2-} are 9 amu and 16 amu, respectively.) (10%)

7. A thermosetting polyester can be produced by combining adipic acid, ethylene glycol and maleic acid to produce a linear condensation polymer chain containing an unsaturated carbon bond. By drawing polymer structures, show (i) how this linear chain develops, and (ii) how styrene can provide cross-linking of the chains into a framework structure. (Additional information: maleic acid, $C_4H_4O_4$, is a molecule with two carboxyl groups.) (15%)

8. In terms of defect chemistry using Kroger and Vink notation, describe the possible types of defects generated when a $BaTiO_3$ ceramic is doped with Y_2O_3. Some of these defects could make $BaTiO_3$ (an excellent dielectric material) becoming semiconductive. Please relate the types of defects you proposed with the likely semiconductor characteristics of the doped $BaTiO_3$ ceramic. (15%)

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