Problem #1
Define a slip system. Write down the slip system for face-centered cubic (FCC) metals.

(8%)

Problem #2
The atomic diameter of an atom of nickel is 0.2492 nm. Calculate the lattice constant of FCC nickel.

(5%)

Problem #3
The diffusion coefficients for iron in nickel are given at two temperatures.

<table>
<thead>
<tr>
<th>$T$ (°K)</th>
<th>$D$ (m$^2$/sec)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1273</td>
<td>9.4×10$^{-6}$</td>
</tr>
<tr>
<td>1473</td>
<td>2.4×10$^{-14}$</td>
</tr>
</tbody>
</table>

(a) Determine the values of pre-exponential factor $D_0$ and the activation energy, $Q_a$.

(7%)

(b) What is the magnitude of the diffusion coefficient at 1300°K?

(The gas constant $R = 8.31$ J/mole°K).

(5%)

Problem #4
What are the important limitations of plain-carbon steels for engineering applications?

(10%)

Problem #5
How can the tendency to stress-corrosion cracking be reduced?

(15%)

Problem #6
Describe the electrical conduction of pure Si crystal including the effect of temperature by giving: (a) a physical picture of the electrons moving in the crystal lattice and (b) an energy-band diagram.

(12%)

Problem #7
What is laser? Describe the mechanism involving in laser action.

(13%)
Problem #8

A hypothetical \( AX \) type of ceramic material is known to have a density of \( 2.65 \text{ g/cm}^3 \)
and a unit cell of cubic symmetry with a cell edge length of 0.43 nm. The atomic
weights of the \( A \) and \( X \) elements are 86.6 and 40.3 \( \text{g/mol} \), respectively. On the basis
of this information, which of the following crystal structures is (are) possible for this
material: rock salt, cesium chloride, or zinc blende? Justify your choice(s). (7%)

Problem #9

(a) Suppose that \( \text{CaO} \) is added as an impurity to \( \text{Li}_2\text{O} \). If the \( \text{Ca}^{2+} \) substitutes for \( \text{Li}^+ \),
what kind of vacancies would you expect to form? How many of these vacancies
are created for every \( \text{Ca}^{2+} \) added? (2%)

(b) Suppose that \( \text{CaO} \) is added as an impurity to \( \text{CaCl}_2 \). If the \( \text{O}^2- \) substitutes for \( \text{Cl}^- \),
what kind of vacancies would you expect to form? How many of these vacancies
are created for every \( \text{O}^2- \) added? (2%)

Problem #10

(a) What is the distinction between glass transition temperature and melting
temperature? (3%)

(b) On the basis of the answer given in (a), explain why glass may be drawn into
fibers whereas crystalline aluminum oxide may not. (3%)

Problem #11

(a) Compare the crystalline state in metals and polymers. (4%)

(b) Compare the non-crystalline state as it applies to polymers and ceramic glasses. (4%)