1. An x-ray diffractometer recorder chart for an element which has either the BCC or the FCC crystal structure shows diffraction peaks at the following 2θ angles: 40, 58, 73, 86.8, 100.4 and 114.7. The wavelength of the incoming x-ray used was 0.154 nm.
a. Determine the cubic structure of the element.
b. Determine the lattice constant of the element. (10%)

2. Consider the gas carburizing of a gear of 1020 steel at 927°C (1700°F), Calculate the time in minutes necessary to increase the carbon content to 0.40% at 0.50 mm below the surface. Assume that the carbon content at the surface is 0.90% and that the steel has a nominal carbon content of 0.20 %. (10%)

3. Describe the structure of a grain boundary. How does it form in a solid metal? Why are grain boundaries favorable sites for the nucleation and growth of precipitates? (10%)

4. Construct a phase diagram from the following information: element A melts at 1200°C and element B melts at 1000°C; element B has a maximum solubility of 10wt% in element A, and element A has a maximum solubility of 20wt% in element A; the number of degree of freedom from the phase rule is zero when the temperature is 800°C and there is 45wt%B present; at room temperature 3wt%A is soluble in B and 0wt%B is soluble in A. Describe the microstructural development upon slow cooling of a) 15wt% A from 1400°C. b) 5wt% B from 1000°C. (40%)

5. In a laboratory creep experiment at 1000°C, a steady-state creep rate of 5x 10^{-1} % per hour is obtained. The creep mechanism for this alloy is known to be dislocation climb with an activation energy of 200 kJ/mol. Predict the creep rate at a service temperature of 600 °C. What assumptions need to be made for this result to be validated? (10%)

PART II

1. On the basis of crystal structure, compute the theoretical density for sodium chloride if

　ionic wt of Na^+ = 22.99g/mol

　ionic wt of Cl^- = 35.45g/mol

　ionic radius of Na^+ = 0.102nm

　ionic radius of Cl^- = 0.181nm

　Avogadro's number = 6.023×10^{23}

10%

2. Briefly explain the difference in characteristics between thermoplastic and thermosetting polymers. Which one is comparably beneficial in the viewpoint of environmental protection? Explain why.　　10%

3. For a concentration cell, briefly explain why corrosion occurs at that region having the lower concentration. Give an example.　10%

4. Phosphorus is added to high-purity silicon to give a concentration of 10^{23} m^{-3} of charge carriers at room temperature.

(a) Is this material n-type or p-type

(b) Calculate the room-temperature conductivity of this material, assuming that electron and hole mobilities are the same as for the intrinsic material, if

　$e = 1.6 \times 10^{-19}$ c

　$u_e = 0.14 m^2/v\text{-}s$

10%

5. Cite the factors that affect the toughness of steels in impact test. The "Titanic" was hit by floating iceberg and suddenly split in half and sank, please propose the possible reasons from the viewpoint of materials performance of steels for the ship.　10%