1. Calculate the radius of a tantalum (Ta) atom, given that Ta has a BCC crystal structure, a density of 16.6 g/cm^3, and an atomic weight of 180.9 g/mol.

2. On the basis of ionic charge and ionic radii given in the following table, predict crystal structures for the following materials:

(a) CaO

(b) KBr

Cation	*Ionic Radius (nm)*	*Anion*	*Ionic Radius (nm)*
Al^{3+}	0.053	Br^-	0.196
Ba^{2+}	0.136	Cl^-	0.181
Ca^{2+}	0.100	F^-	0.133
Cs^+	0.170	I^-	0.220
Fe^{2+}	0.077	O^{2-}	0.140
Fe^{3+}	0.069	S^{2-}	0.184
K^+	0.138		
Mg^{2+}	0.072		
Mn^{2+}	0.067		
Na^+	0.102		
Ni^{2+}	0.069		
Si^{4+}	0.040		
Ti^{4+}	0.061		

3. Calculate the theoretical density of NiO, given that it has the rock salt crystal structure.

(Ni: 58.69 g/mol, O: 16.00 g/mol, Ni ionic radius: 0.069 nm, O ionic radius: 0.140 nm)

4. Calculate the linear density of atoms along the [111] direction in (a) bcc iron and (b) fcc nickel.

(Fe atomic radius: 0.124 nm, Ni atomic radius: 0.125 nm)

5. Calculate the planar density of atoms in the (111) plane of (a) bcc iron and (b) fcc nickel.

(Fe atomic radius: 0.124 nm, Ni atomic radius: 0.125 nm)

6. The following table lists diffraction angles for the first three peaks (first-order) of the x-ray diffraction pattern for some metal. Monochromatic x-radiation having a wavelength of 0.0711 nm was used.

(a) Determine whether this metal's crystal structure is FCC, BCC or neither FCC or BCC and explain the reason for your choice.

Peak Number	*Diffraction Angle* (2θ)
1	*18.27°*
2	*25.96°*
3	*31.92°*

7. For some hypothetical metal, the equilibrium number of vacancies at 900°C is 2.3 x 10^{25} m^{-3}. If the density and atomic weight of this metal are 7.40 g/cm^3 and 85.5 g/mol, respectively, calculate the fraction of vacancies for this metal at 900°C.

8. Calculate the energy for vacancy formation in nickel (Ni), given that the equilibrium number of vacancies at 850°C (1123 K) is 4.7 × 10^{22} m^{-3}. The atomic weight and density (at 850°C) for Ni are, respectively, 58.69 g/mol and 8.80 g/cm^3

9. What is the composition, in atom percent, of an alloy that consists of 5.5 wt% Pb and 94.5 wt% Sn?

10. Nitrogen from a gaseous phase is to be diffused into pure iron at 675°C. If the surface concentration is maintained at 0.2 wt% N, what will be the concentration 2 mm from the surface after 25 h? The diffusion coefficient for nitrogen in iron at 675°C is 2.8 × 10^{-11} m^2/s

The Error Function			
z	$\mathrm{erf}(z)$	z	$\mathrm{erf}(z)$
0.00	0.0000	0.70	0.6778
0.01	0.0113	0.75	0.7112
0.02	0.0226	0.80	0.7421
0.03	0.0338	0.85	0.7707
0.04	0.0451	0.90	0.7969
0.05	0.0564	0.95	0.8209
0.10	0.1125	1.00	0.8427
0.15	0.1680	1.10	0.8802
0.20	0.2227	1.20	0.9103
0.25	0.2763	1.30	0.9340
0.30	0.3286	1.40	0.9523
0.35	0.3794	1.50	0.9661
0.40	0.4284	1.60	0.9763
0.45	0.4755	1.70	0.9838
0.50	0.5205	1.80	0.9891
0.55	0.5633	1.90	0.9928
0.60	0.6039	2.00	0.9953
0.65	0.6420		

11. The steady-state diffusion flux through a metal plate is 7.8×10^{-8} kg/m^2.s at a temperature of 1200°C (1473 K) and when the concentration gradient is –500 kg/m^4. Calculate the diffusion flux at 1000°C (1273 K) for the same concentration gradient and assuming an activation energy for diffusion of 145,000 J/mol.

12. An aluminum bar 125 mm long and having a square cross section 16.5 mm on an edge is pulled in tension with a load of 66,700 N and experiences an elongation of 0.43 mm. Assuming that the deformation is entirely elastic, calculate the modulus of elasticity of the aluminum

13. A steel alloy to be used for a spring application must have a modulus of resilience of at least 2.07 MPa. What must be its minimum yield strength?

14. Consider a single crystal of nickel oriented such that a tensile stress is applied along a [001] direction. If slip occurs on a (111) plane and in a [101] direction and is initiated at an applied tensile stress of 13.9 MPa, compute the critical resolved shear stress.