1. In steady state diffusion which of the following remains constant? (5%)

    a) Concentration gradient

    b) Kinetic energy of particles

    c) Potential energy of particles

    d) Change of concentration with respect to temperature

2. Which of the following are the two primary constituents of clays? (10%)

    (a) Alumina (Al_2O_3) and limestone ($CaCO_3$)

    (b) Limestone ($CaCO_3$) and cupric oxide (CuO)

    (c) Silica (SiO_2) and limestone ($CaCO_3$)

    (d) Alumina (Al_2O_3) and silica (SiO_2)

3. What is the name of the polymer represented by the following repeat unit? (10%)
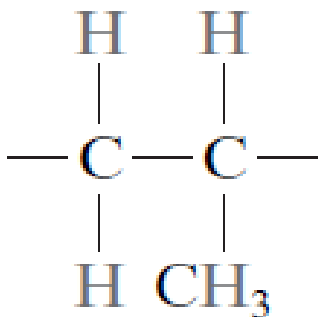
    (a) Poly(methyl methacrylate)

    (b) Polyethylene

    (c) Polypropylene

    (d) Polystyrene

4. The band gap of silicon is about (a) 0.6 (b) 1.1 (c) 2.5 (d) 6.7 eV (10%)

5. Visible light having a wavelength of 500 nm appears green. Compute the energy of a photon of this light. (10%)

   (a) 0.5 eV

   (b) 1.12 eV

   (c) 2.48 eV

   (d) 4.96 eV.

6. Which of the following pairs of materials displays ferromagnetic behavior? (10%)

   (a) Aluminum oxide and copper

   (b) Aluminum and titanium

   (c) MnO and Fe_3O_4

   (d) Iron (α-ferrite) and nickel

7. Explain why there is no face-centered tetragonal Bravais lattice. (10%)

8. Determine the indices for the directions (A&C) in the cubic unit cell shown below: (10%)
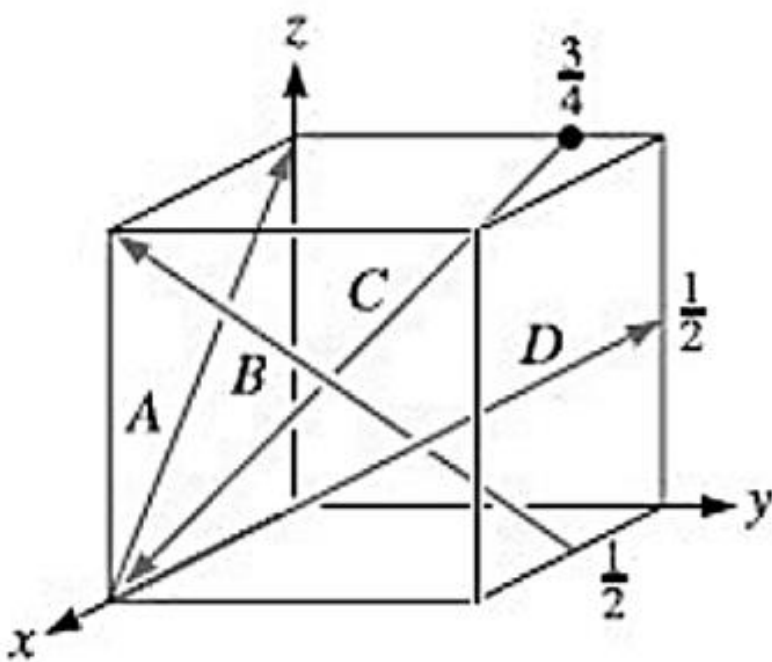
9. A diffracted X-ray beam is observed from the (311) planes of aluminum at a 2θ angle of 78.3° when X-rays of 0.15418 nm wavelength are used. Calculate the lattice parameter of the aluminum. (10%)

10. Write down the defect chemistry equation for introduction of $SrTiO_3$ in $BaTiO_3$ using the Kröger-Vink notation. (10%)

11. A steel part can be made by powder metallurgy (compacting iron powder particles and sintering to produce a solid) or by machining from a solid steel block. Which part is expected to have the higher toughness? Explain. (10%)

12. (A) At the eutectic in the Al-Si phase diagram, what phase(s) is (are) present? (5%) (B) Consider an Al–4% Si alloy. Determine (a) the amounts and compositions of each phase at 578°C; (5%) (b) the amounts and compositions of each phase at 576°C (5%), the amounts and compositions of each microconstituent at 576°C. (5%)
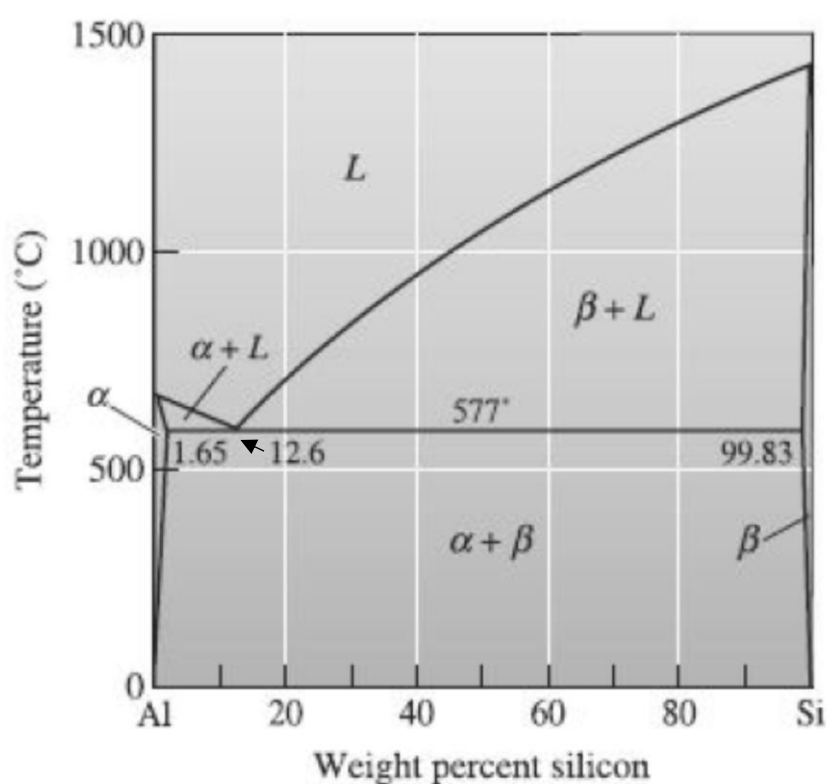
13. (A) Draw the eutectoid portion of the Fe-Fe$_3$C phase diagram. Be sure to indicate all the compositions and temperatures, and write the relevant reaction. (10%) (B) A steel contains 18% cementite and 82% ferrite at room temperature. Estimate the carbon content of the steel. (5%)

14. Compare thermoplastic and thermosetting polymers (a) on the basis of mechanical characteristics upon heating and (b) according to possible molecular structures. (10%)

15. An n-type semiconductor is known to have an electron concentration of 3×10^{18} m^{-3}. If the electron drift velocity is 100 m/s in an electric field of 500 V/m, calculate the conductivity of this material. (10%)

16. Compare the temperature dependence of the conductivity for metals and intrinsic semiconductors. Briefly explain the difference in behavior. (10%)

17. (a) Why is it so important to control the rate of drying of a ceramic body that has been hydroplastically formed or slip cast? (5%) (b) Cite three factors that influence the rate of drying, and explain how each affects the rate. (5%)

18. Briefly explain why metals are opaque to electromagnetic radiation having photon energies within the visible region of the spectrum. (10%)

19. (a) Briefly explain why thermal stresses may be introduced into a structure by rapid heating or cooling. (5%) (b) For cooling, what is the nature of the surface stresses? (5%)