Exercise 1

In an experiment conducted at 10°C below the melting point of iron, a vacancy concentration of 4.0 ppm is found and at T= 600°C a concentration of $2.0 \cdot 10^{-12}$ is found).

a) What is the vacancy formation enthalpy in Fe (in eV)?

b) What is the vacancy formation entropy in Fe (in k_B)?

c) How many vacancies are there per cm^3 at 300°C?

Exercise 2

In the experiment by Geiger and Marsden, 8 MeV α-particles were scattered against thin metal foils. The condition for Rutherford scattering to take place is that the projectiles are reaching close to the nucleus, compared to the size of the atom. Calculate the minimum distance in a head on collision, assuming the target is gold. Compare with the Bohr radius.

Exercise 2

a) Derive the scattering angle-dependent expression for the energy transfer, T, from an elastic collision, as a function of the kinetic energy of the incoming particle (E_i).

b) What is the maximal kinetic energy that a W atom in a fusion reactor divertor receives from 14.0 MeV neutrons coming from the fusion reactions in a tokamak?

Exercise 4

Proton or ion irradiation is often used to simulate neutron-induced damage in materials. We have a beam of 6 MeV protons that strike an Fe sample. Assume Rutherford scattering is dominating (Coulomb potential).

a) Calculate the energy transfer in a head-on collision.

b) Calculate the average energy transfer, and compare it to the case of 6 MeV neutrons.

Exercise 5

Focusing means that a chain of successive collisions in a crystalline solid eventually converges the collision angles to zero. It can occur when a PKA has a velocity vector close to a high-symmetry direction. Assume that the atoms scatter elastically as hard-spheres.

a) Using the nomenclature of the figure below, derive the criterion for focusing to occur.

b) In which direction is focusing most likely to occur, in **bcc** and in **fcc** lattices?