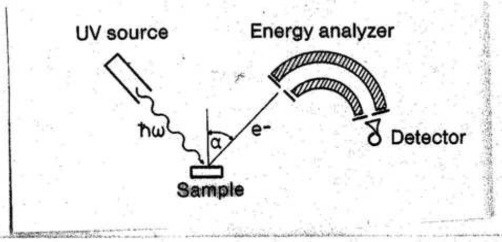
Please return by Monday 26.4.2010 12:00. The exercise session will be held at Physicum D115 on the same day at 16:15. You can contact the the teaching assistant at tuomas.pylkkanen@helsinki.fi.

1. Photoelectron spectroscopy. The target crystal is irradiated with photons of a relatively high energy. This causes electrons to be excited from occupied (band) states into empty states above the vacuum energy level. (Vacuum energy level can be defined as Fermi energy + work function.) Discuss qualitatively what information can be obtained by measuring the kinetic energy distribution of the electrons that are observed in the detector.



2. Calculate the photon energies at which you would expect onset of absorption to occur for the 140 and 210 Å GaAs layers, and compare your answer with the observed values (see Fig. 1). The simplest approach is to assume that the bound state energies approximate to those of infinite square potential wells. Take the energy gap of GaAs to be 1.519 eV and the effective masses of electrons and holes to be $0.0665m$ and $0.45m$ respectively, where m is the bare electron mass.

   Also obtain more accurate values of the photon energies by allowing for the finite depth of the potential wells. The wells in the conduction and valence band edges are 0.220 and 0.028 eV respetively.

3. Explain briefly what is a spallation neutron source and how it differs from the conventional reaction neutron source.

4. Neutrons of energy 0.03 eV are scattered at an angle of 12° from solid He (speed of sound = 300 m/s) with emission of a phonon. Estimate the energy loss of the neutrons. What is the time of flight over a 10 m path of unscattered and scattered neutrons?

5. Identify, with respect to (a) the magnetic and (b) the chemical unit cell, the Miller indices of the magnetic reflections at 11.9°, 30.2°, and 36.4° in Fig. 2.

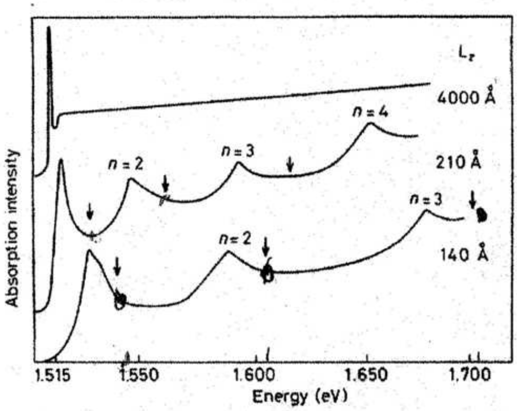


Figure 1: Absorption intensities for GaAs layers of various thicknesses. (Figure from Hook & Hall, Fig. 14.5).

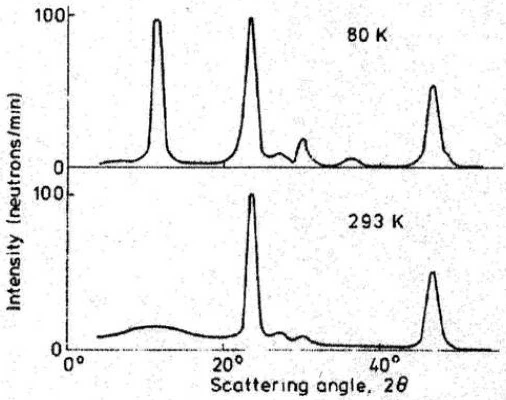


Figure 2: Neutron diffraction data from powdered MnO. (Figure from Hook & Hall, Fig. 12.8.)