School of Maths and Physics
PHY2002 Physics of the Solid State

Assignment 1

Deadline for Submission of Answers: Wed Feb 18th (10pm)
Feedback will be given through Canvas and an analysis of the questions and answers will be provided in the class on: TBD
Note: Your assignment scores contribute 20% to the PHY2002 module
Please make sure your name is on your submitted script!

- In recent years, students have sometimes found the solid-state physics exams to be challenging. To try to help, the following questions are adapted from past paper questions.

Section A

1) Consider the structure 'A' in Fig. 1 (in 2D), indicate and list the symmetry operations present in the molecule shown below, indicate the direction of the symmetry operation and the corresponding point group. **[4]**

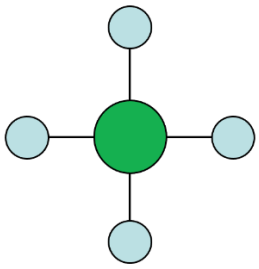


Figure 1. Structure 'A'.

2) Sketch a hexagonal unit cell in real space (either in 3D or 2D) and demonstrate that the hexagonal lattice can be represented by an alternative (and smaller) primitive unit cell. **[3]**

3) Show that the packing efficiency for a BCC structure is 68%. **[3]**

4) Edgarite ($FeNb_3S_6$) belongs to the hexagonal crystal system with the following lattice parameters: a =4.77Å, c=10.19Å.

a) Sketch the primary lattice vector sets of the real and the reciprocal lattices and determine values for: a *, b*, c* and gamma*. **[4]**

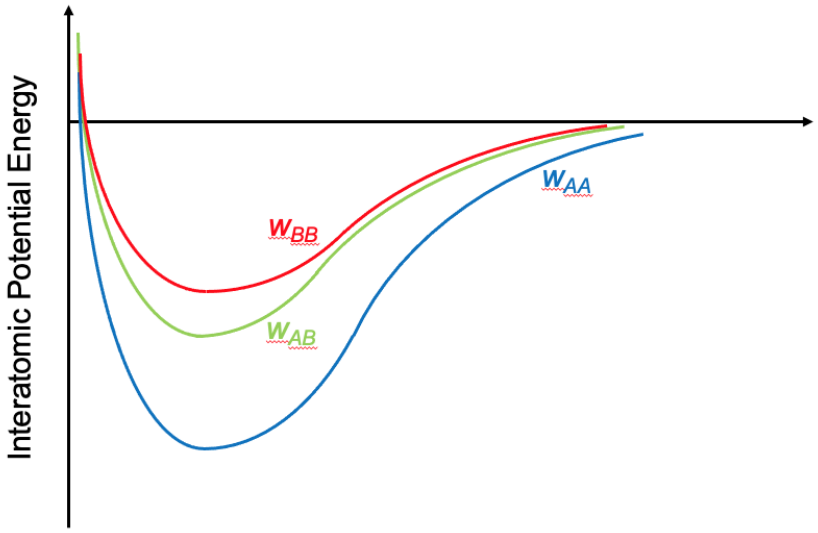
b) By plotting an appropriate section of the reciprocal lattice, determine the (120) interplanar spacing. **[3]**

c) Use the reciprocal lattice to determine the angle at which the (120) and (020) planes intersect. **[3]**

Section B

4. Consider the three interatomic potential energy functions given in the diagram below, where w_{AA} is the energy function associated with the formation of bonds between two "A" atoms, w_{BB} is the energy function associated with the formation of bonds between two "B" atoms and w_{AB} is the energy function associated with the formation of bonds between an "A" and a "B" atom.

(a) Given these interatomic potential energy functions, if we were to force a solid solution (randomly bonded crystalline array) between A atoms and B atoms initially, perhaps at elevated temperature, what would tend to happen in time at lower temperatures. Fully justify your answer. **[4]**



(b) Explain, in terms of free energy, why the influence of differences in the interatomic potential energies become relatively unimportant at high temperatures. **[4]**

(c) Discuss briefly whether exsolution and ordering are mutually exclusive and explain your reasoning (HINT: consider the change in enthalpy on mixing, ΔH_{mix}, needed for exsolution as opposed to ordering). **[4]**

5. In the figure on the right, the Free Energy of Mixing (ΔG_{mix}) is presented, as a function of composition and temperature, for a solid system composed of A and B atoms. Using the information in the figure, discuss the behaviour of the 50%A - 50%B composition as it cools under equilibrium from 1100°C to 500°C. **[8]**