Condensed Matter Physics: Weekly Problem 1

These problems are to be formatively self-assessed by you, the student. Students taking part in the peer-marking pilot scheme will also be required to mark one of their peer's weekly problems. A mark scheme, out of 10, will be provided with each solution to aid your assessment before your timetabled weekly workshop.

Summary: These problems review properties of solids from Level 1 and also explore different aspects of symmetry, lattices and crystal structure using material covered in Lectures 2 and 3.

a. Describe, with the aid of a simple sketch, a model of a crystalline solid which allows the molar heat capacity at constant volume to be determined. State the equipartition theorem and use it to show that $C_V = 3R$ where R is the ideal gas constant. **[3 marks]**

b. Miller Indices:

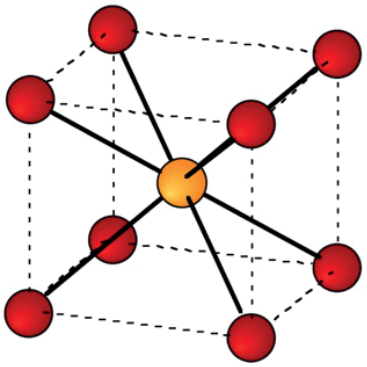
i. For a primitive cubic lattice draw a sketch illustrating planes with the Miller indices (011) and (120). **[1 mark]**

ii. The lattice constant a is 0.5 nm. For each set of indices above determine the spacing between the planes. **[1 mark]**

c. A crystal structure is composed of a lattice and a basis, as described in lectures. The figure shows a unit cell for the salt caesium chloride (CsCl). Each Cs^+ ion is bonded to 8 Cl^- ions; each Cl^- ion is bonded to 8 Cs^+ ions.

i. Determine the lattice and basis, justify your answer. **[1 mark]**

ii. Illustrate your answer with a sketch. **[1 mark]**



d. A lattice is a mathematical construct for filling space. Determine the maximum percentage of available space that can be filled in 3D by a face centred cubic lattice with a single atom basis. You will need to make some sensible assumptions to determine the solution. **[3 marks]**