Workshop Tutorials for Physics

PR7: **Solids II – Crystals and Bonding**

A. Qualitative Questions:

1. The three types of strong bonds that form between atoms are ionic, covalent and metallic bonds.
a. In which regions of the periodic table are the elements that form ionic bonds? Why?
b. Why do covalent solids not have long range interactions, but ionic solids do?
c. Why is it that solids which have ionic bonds, like salt, tend to be brittle, but metals are usually quite plastic?
d. Why are metals like copper such good conductors compared to ionic and covalent solids like salt and chalk?

2. Why is it that metals tend to be more dense than ionic or covalent solids? Explain your answer in terms of bond type and packing.

B. Activity Questions:

1. Lenard - Jones potential
The graph shows a plot of potential as a function of inter-atomic distance.
a. Where is the potential energy positive and where is it negative for this pair of atoms?
b. Where is the force between them repulsive? Where is it attractive? How do you know?
c. What is the equilibrium distance for this pair of atoms?
d. Explain what the term binding energy means. How would you find the maximum binding energy for this pair of atoms?

2. Crystal structures
Can you identify the basis cell for the crystal structures shown?
What is the coordination number for each lattice?

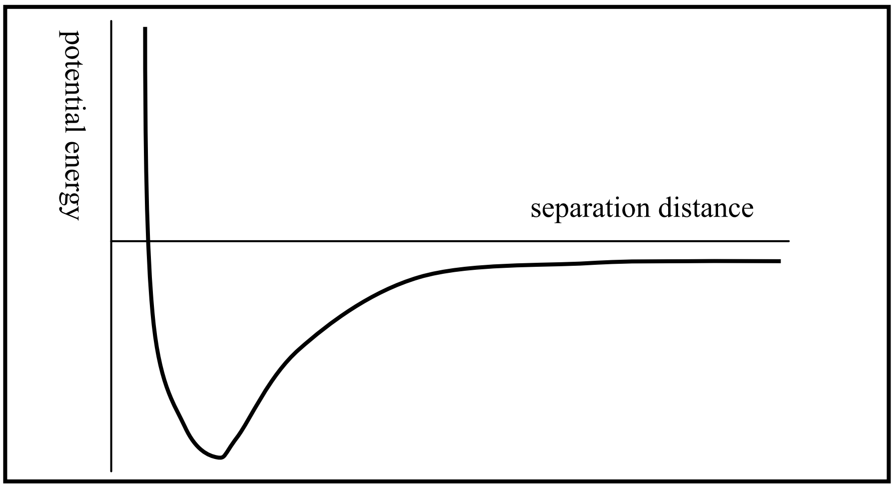
3. Bend and Stretch
What sort of bond holds the atoms together in chalk?
Can you break the chalk by compressing or stretching it?
What about by bending or twisting it? What is the easiest way to break it and why?
Now try to break the piece of metal.
How do the metallic bonds affect its elastic properties?

C. Quantitative Question:

1. The potential energy function for two ions, one with a charge of $+e$ and the other with a charge of $-e$ is given by

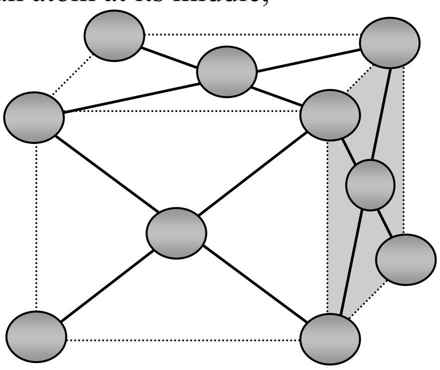
$$V(r) = -\frac{Ae^2}{r} + \frac{B}{r^9}.$$

which looks like this:



Find an expression for the equilibrium separation distance, r_o, for these two ions.

2. A face centred cubic crystal has atoms arranged as shown.
Each face of the cubic unit cell has an atom at its middle,
and one at each corner.



Modelling the atoms as rigid spheres sitting up against their nearest neighbours, calculate the packing density in the face centred cubic structure.