Marks

- Many elemental metals crystallise in one of three cubic forms, either with a face-centred cubic, a body-centred cubic or a simple cubic unit cell. Explain the main differences and similarities between these different crystalline forms. **3**

All three are based on a cubic unit cell:

- **The simple cubic form has atoms on each corner so that the atoms are stacked directly one on top of the other. As the 8 atoms are shared with eight other cubes, each contributes 1/8 to the cell so that the cell contains 8 × 1/8 = 1 atom. The atoms touch along the edges of the cube.**
- **The body centred cubic form has at an additional atom in the cube centre, giving a total of 2 atoms in the cell. The atoms touch along the cube diagonal.**
- **The face centred cubic form has atoms on each corner and atoms at the centre of each face (with no atom at the centre of the cube). The atoms on the face centres are shared with two other cubes and so contribute 1/2 to the cell. The cell contains 8 × 1/8 (corner) + 6 × 1/2 (face) = 4. The atoms touch along the face diagonals.**
- **The face centred cubic form is the only close packed structure and is the most dense.**
- **In a face centred cubic structure, 74% of the space is occupied. In a body centred cubic, 68% is occupied. In a simple cubic structure, 52% is occupied.**

- Teeth are made from hydroxyapatite, $Ca_5(PO_4)_3OH$. Why does an acidic medium promote tooth decay? Use chemical equations where appropriate. **3**

Hydroxyapatite dissolves in water according to the equation:

$$Ca_5(PO4)_3OH(s) \rightleftharpoons 5Ca^{2+}(aq) + 3PO_4^{3-}(aq) + OH^-(aq)$$

In a non-acidic medium, the equilibrium lies to the left. In acidic media, H^+ reacts with both PO_4^{3-} and OH^- to form the conjugate acids (HPO_4^{2-} and H_2O, respectively) and this shifts the equilibrium to the right and the tooth dissolves..

How does the fluoridation of drinking water aid the prevention of tooth decay?

Fluoridation can replace OH^- forming $Ca_5(PO_4)_3F(s)$. This is less soluble than hydroxyapatite - it does not react with H^+ to the same extent as OH^-.