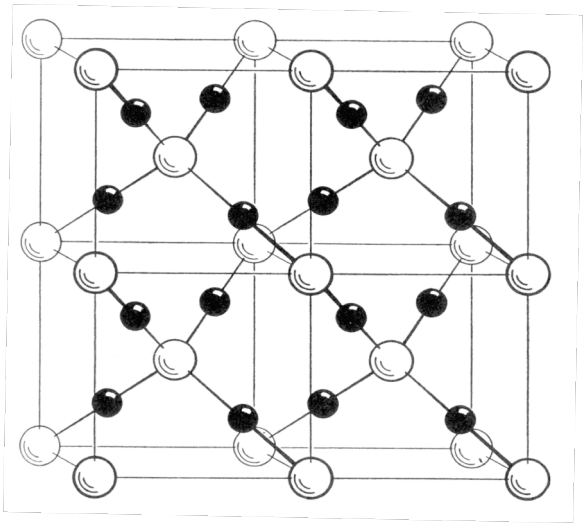
**Marks 7**

- Copper oxide is used as a photovoltaic material in solar cells and it crystallizes with the structure shown below. The large white spheres represent the oxygen atoms and the smaller black spheres represent copper atoms.



How many unit cells are represented in the above diagram? Explain your answer.

**There are 4 unit cells represented.**

**A unit cell is the simplest repeating unit of a lattice. Each of the 4 cubes are identical and translation of any one of them will generate the overall structure.**

From the solid-state structure shown above, determine the empirical formula for copper oxide.

**There are 8 O on the corners plus 1 O in the centre. The O on the corners are shared with 8 other cells so contribute 1/8 to the cell. The O at the centre is unshared so contributes only to this cell. The net contribution is 8 × 1/8 + 1 = 2.**

**The 4 Cu are completely within the cell so only contribute to this cell. The net contribution from Cu is 4.**

**With a Cu : O ratio of 4 : 2, the formula is $Cu_2O$.**

What is the oxidation state of copper in this compound?

**With $O^{2-}$, it must be Cu(I) (i.e +1).**

Use the box notation to predict whether the copper ions are paramagnetic.

**$Cu^+$ has 10 electrons in its 3*d* subshell. They are all paired as shown, so $Cu^+$ is diamagnetic, not paramagnetic.**

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**ANSWER CONTINUES ON THE NEXT PAGE**

Silver oxide is another Group 11 metal oxide and its solid-state structure is identical to that of copper oxide even though the ionic radius for the copper ion (118 pm) is smaller than that of the silver ion (139 pm). Account for this observation.

**The anionic radius of $O^{2-}$ is the main factor determining the solid state structure of the oxides. The cations ($Ag^{+}$ or $Cu^{+}$) fit in the holes within the $O^{2-}$ lattice.**