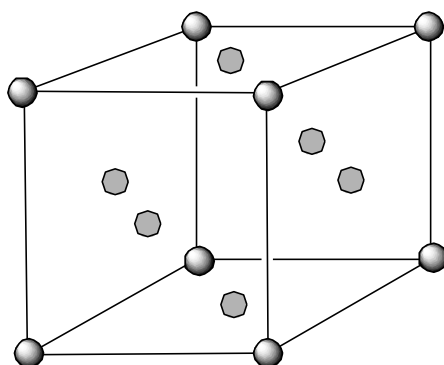


Marks
6

- The diagram below shows the structure of an alloy of copper and gold with a gold atom at each of the corners and a copper atom in the centre of each of the faces. The length of the side of the cubic unit cell is 0.36 nm.



= Au

= Cu

What is the chemical formula of the alloy?

There are 8 Au atoms and each is on a corner so contributes 1/8 to the unit cell:

$$\text{total number of Au atoms} = 8 \times 1/8 = 1$$

There are 6 Cu atoms and each is on a face so contributes 1/2 to the unit cell.

$$\text{total number of Cu atoms} = 6 \times 1/2 = 3$$

Answer: **AuCu₃ or Cu₃Au**

Pure gold is 24 carat, whilst gold alloys consisting of 75 % gold by weight are termed 18 carat gold. What carat gold is this alloy?

The molar mass of Cu₃Au is:

$$\text{molar mass} = (3 \times 63.55 \text{ (Cu)} + 196.97 \text{ (Au)}) \text{ g mol}^{-1} = 387.62 \text{ g mol}^{-1}$$

The percentage gold is therefore:

$$\text{percentage gold} = 196.97 / 387.82 \times 100\% = 50\%$$

As 100% gold is 24 carat and 75% gold is 18 carat, this corresponds to 12 carat.

Answer: **12 carat**

What is the volume (in cm³) of the unit cell?

The length of the side of the unit cell is 0.36 nm. This corresponds to 0.36×10^{-9} m or 0.36×10^{-7} cm. As the unit cell is cubic, its volume, V , is given by:

$$V = (0.36 \times 10^{-7})^3 \text{ cm}^3 = 4.7 \times 10^{-23} \text{ cm}^3$$

Answer: **$4.7 \times 10^{-23} \text{ cm}^3$**

ANSWER CONTINUES ON THE NEXT PAGE

What is the density (in g cm^{-3}) of the alloy?

From above, the mass of a mole of Cu_3Au is $387.62 \text{ g mol}^{-1}$. As this corresponds to Avogadro's number of formula units, the mass of the unit cell is:

$$\text{mass of unit cell} = (387.62 \text{ g mol}^{-1}) / (6.022 \times 10^{23} \text{ mol}^{-1}) = 6.43673 \times 10^{-22} \text{ g}$$

The density of the unit cell is therefore:

$$\begin{aligned} \text{density} &= \text{mass} / \text{volume} \\ &= (6.43673 \times 10^{-22} \text{ g}) / (4.7 \times 10^{-23} \text{ cm}^3) \\ &= 14 \text{ g cm}^{-3} \end{aligned}$$

Answer: **14 g cm^{-3}**