Marks
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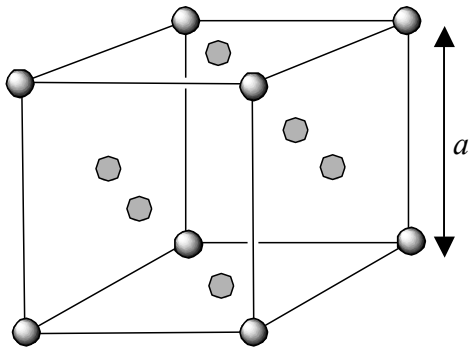
• The diagram below shows the structure of an alloy of copper and gold with a gold atom at each of the corners and a copper atom in the centre of each of the faces. The unit cell dimension (edge length, *a*) for this alloy is 0.36 nm.



= Au = Cu

What is the chemical formula of the alloy?

There are 8 Au atoms on the corners. Each of these contribute 1/8 to the unit cell:

number of Au atoms = 8 × 1/8 = 1

There are 6 Cu atoms on the face. Each of these contribute 1/2 to the unit cell:

number of Cu atoms = 6 × 1/2 = 3

The ratio of Cu to Au atoms is therefore 3 : 1 and the formula is Cu_3Au.

Answer: **Cu_3Au**

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 Cu_3Au is:

molar mass = (3 × 63.55 (Cu) + 1 × 196.97 (Au)) g mol^{-1} = 387.62 g mol^{-1}.

1 mol of Cu_3Au contains 1 mol of Au, the percentage by weight of gold in Cu_3Au is:

$$\textbf{percentage by weight} = \frac{196.97}{387.62} \times 100\ \% = 50\ \%$$

As a 100 % alloy is 24 carat and a 75% alloy is 18 carat, a 50 % alloy is 12 carat.

Answer: **12 carat**

What is the volume (in cm^3) of the unit cell?

As the unit cell is cubic:

volume = (side length)^3 = a^3 = (0.36 × 10^{-9} m)^3 = 4.7 × 10^{-29} m^3

= 4.7 × 10^{-23} cm^3

Answer: **4.7 × 10^{-23} cm^3**

ANSWER CONTINUES ON THE NEXT PAGE

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

From above, the unit cell contains 1 Au atom and 3 Cu atoms:

mass of gold = 196.97 g mol^{-1} / 6.022 × 10^{23} mol^{-1} = 3.271 × 10^{-22} g

mass of copper = 3 × 63.55 g mol^{-1} / 6.022 × 10^{23} mol^{-1} = 3.166 × 10^{-22} g

mass of unit cell = (3.271 × 10^{-22} + 3.166 × 10^{-22}) g = 6.437 × 10^{-22} g

The density is therefore:

density = mass / volume

= 6.437 × 10^{-22} g / 4.7 × 10^{-23} cm^3 = 1.4 × 10^{1} g cm^{-3}

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