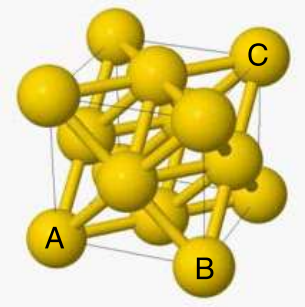
6. This question is about gold leaf

Gold atoms crystallise in the cubic arrangement shown in the figure on the right. The gold atoms, which are assumed to be spherical, are shown at half-radius size (rather than touching their neighbours) to illustrate the structure more clearly. The lattice structure can be built up from these cubic 'building blocks' – known as unit cells. Atoms are located at the corner positions and in the centre of the faces. The cube is shown as a thin outline; the thicker 'bonds' indicate which atoms are, in reality, in contact.



Avogadro's constant is 6.02×10^{23} mol^{-1}. Gold has only one isotope, which has a relative mass of 197. The density of gold is 19.3 g cm^{-3}.

(a) Calculate the mass (in g) of one gold atom.

The cube shown in wireframe in the figure has its corners at the centre of the atoms occupying those corner positions. The faces of the cube pass through the centre of the atoms found in the centre of the faces.

(b) By considering the fraction of each atom actually inside the unit cell, calculate the number of atoms within the unit cell.

(c) Bearing in mind that the atoms are in contact across the diagonal of a face of the cube, find expressions, in terms of the radius of the gold atom, *r*, for :

i) the length of the edge of the unit cell, i.e. the distance between the centres of atoms **A** and **B**;

ii) the volume of the unit cell;

iii) the length of the *unit cell body diagonal*, i.e. the distance between the centres of the atoms **A** and **C**.

(d) Calculate the molar volume of gold in cm^3 mol^{-1}.

(e) Given that the volume of a sphere is $4/3\ \pi r^3$, calculate what fraction of the volume of the unit cell is occupied by gold atoms.

(f) Bearing in mind your answer to part **(e)**, calculate the radius of a gold atom.

A small mass of gold can be hammered out to cover an extremely large area with gold foil. The most efficient way of stacking layers of gold atoms has three layers in the length of the unit cell body diagonal, i.e. the thickness of one layer is one third of the distance **A** to **C**.

(g) The great golden *Dome of the Rock* in Jerusalem is a hemisphere of diameter 21 m. The late King Hussein of Jordan donated 80 kg of gold to cover the outside of the dome.

i) Given that the surface area of a sphere is $4\pi r^2$, calculate the average thickness in cm of the gold on the dome.

ii) Hence calculate the average number of layers of gold atoms covering the surface of the dome.