Metal atoms participate in many biological processes. The following table shows a number of metals, one property of each metal and the biological function for which the metal is important. Complete the table.

<table>
<thead>
<tr>
<th>Metal</th>
<th>Property which is important for biological activity</th>
<th>Biological function to which this property is relevant</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cu</td>
<td>Can exist in two oxidation states, +I and +II</td>
<td>Electron transport</td>
</tr>
<tr>
<td>Pt</td>
<td>Forms square-planar co-ordination compounds</td>
<td>Cancer chemotherapy</td>
</tr>
<tr>
<td>Fe</td>
<td><strong>Forms complexes with molecular oxygen.</strong></td>
<td>Oxygen transport in blood</td>
</tr>
</tbody>
</table>
• Calcium oxalate is a major constituent of kidney stones. Calculate the solubility product constant for calcium oxalate given that a saturated solution of the salt can be made by dissolving 0.0061 g of CaC\textsubscript{2}O\textsubscript{4}·H\textsubscript{2}O(s) in 1.0 L of water.

The molar mass of CaC\textsubscript{2}O\textsubscript{4}·H\textsubscript{2}O is:
\[
40.08 \text{ (Ca)} + 2 \times 12.01 \text{ (C)} + 5 \times 16.00 \text{ (O)} + 2 \times 1.008 \text{ (H)} = 146.116.
\]

Hence, 0.0061 g corresponds to \[
\frac{0.0061}{146.116} = 4.2 \times 10^{-5} \text{ mol}.
\]
As this amount dissolves in 1.0 L, the molar solubility = \( S = 4.2 \times 10^{-5} \) M.

The dissolution equilibrium is:
\[
\text{CaC}_2\text{O}_4\cdot\text{H}_2\text{O(s)} \rightarrow \text{Ca}^{2+}(\text{aq}) + \text{C}_2\text{O}_4^{2-}(\text{aq}) + \text{H}_2\text{O(l)}.
\]

As one mol of cation and one mol of anion is produced, the solubility product is:
\[
K_{sp} = [\text{Ca}^{2+}(\text{aq})][\text{C}_2\text{O}_4^{2-}(\text{aq})] = (S)(S) = S^2 = (4.2 \times 10^{-5})^2 = 1.7 \times 10^{-9}
\]

Answer: \(1.7 \times 10^{-9}\)

• A sample of 2.0 mg of Cu(OH)\textsubscript{2} is added to 1.0 L of a solution buffered at a pH of 8.00. Will all of the Cu(OH)\textsubscript{2} dissolve? Show all working.
(The \(K_{sp}\) of Cu(OH)\textsubscript{2} is \(4.8 \times 10^{-20}\) M\textsuperscript{3}.)

As pH + pOH = 14.00, pOH = 14.00 − 8.00 = 6.00. Hence, [\text{OH}^-(\text{aq})] = 10^{-6} \text{ M}.

The dissolution equilibrium is: Cu(OH)\textsubscript{2}(s) \rightarrow \text{Cu}^{2+}(\text{aq}) + 2\text{OH}^-(\text{aq})

Hence, if \( S \) is the molar solubility, \( K_{sp} = [\text{Cu}^{2+}(\text{aq})][\text{OH}^-(\text{aq})]^2 = S \times [\text{OH}^-(\text{aq})]^2 \).

As \( K_{sp} = 4.8 \times 10^{-20} \), \( S = \frac{4.8 \times 10^{-20}}{(10^{-6})^2} = 4.8 \times 10^{-8} \text{ M} \)

The molar mass of Cu(OH)\textsubscript{2} is 63.55 (Cu) + 2 \times (16.00 (O) + 1.008 (O)) = 97.566.
The solubility in g L\textsuperscript{-1} is therefore \( (4.8 \times 10^{-8}) \times 97.566 = 4.7 \times 10^{-6} \).

Hence, only \(4.7 \times 10^{-3}\) mg will dissolve.

Answer: NO
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.

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 \( 8 \times \frac{1}{8} = 1 \) atom. The atoms touch along the edges of the cube.
- The body centred cubic form has 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 \( 8 \times \frac{1}{8} \) (corner) + \( 6 \times \frac{1}{2} \) (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.

Teeth are made from hydroxyapatite, \( \text{Ca}_5(\text{PO}_4)_3\text{OH} \). Why does an acidic medium promote tooth decay? Use chemical equations where appropriate.

Hydroxyapatite dissolves in water according to the equation:

\[
\text{Ca}_5(\text{PO}_4)_3\text{OH}(s) \rightleftharpoons 5\text{Ca}^{2+}(aq) + 3\text{PO}_4^{3-}(aq) + \text{OH}^-(aq)
\]

In a non-acidic medium, the equilibrium lies to the left. In acidic media, \( \text{H}^+ \) reacts with both \( \text{PO}_4^{3-} \) and \( \text{OH}^- \) to form the conjugate acids (\( \text{HPO}_4^{2-} \) and \( \text{H}_2\text{O} \), 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 \( \text{OH}^- \) forming \( \text{Ca}_5(\text{PO}_4)_3\text{F}(s) \). This is less soluble than hydroxyapatite - it does not react with \( \text{H}^+ \) to the same extent as \( \text{OH}^- \).