Complete the following table. Give, as required, the formula, the systematic name, the oxidation number of the underlined atom and, where indicated, the number of $d$ electrons for the element in this oxidation state.

<table>
<thead>
<tr>
<th>FORMULA</th>
<th>SYSTEMATIC NAME</th>
<th>OXIDATION NUMBER</th>
<th>NUMBER OF $d$ ELECTRONS</th>
</tr>
</thead>
<tbody>
<tr>
<td>SO$_3$</td>
<td>sulfur trioxide</td>
<td>+IV</td>
<td>0</td>
</tr>
<tr>
<td>KMnO$_4$</td>
<td>potassium permanganate</td>
<td>+VII</td>
<td>0</td>
</tr>
<tr>
<td>CoCl$_2$·6H$_2$O</td>
<td>cobalt(II) chloride-6-water</td>
<td>+II</td>
<td>7</td>
</tr>
<tr>
<td>NH$_4$SO$_4$</td>
<td>ammonium sulfate</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Draw the Lewis structures, showing all valence electrons for the following species. Indicate which of the species have contributing resonance structures.

- NO$_3^-$
- CO$_2$
- N$_2$H$_2$

Resonance: **YES** / **NO**

A sample of carboxypeptidase (an enzyme) was purified and found on analysis to contain 0.191% by weight of zinc. What is the minimum molecular weight of the enzyme if we assume it is a monomer?

The minimum molecular weight corresponds to the enzyme containing only one zinc atom per molecule, or one mole of the enzyme contains one mole of zinc. The percentage of zinc is given by:

$$\text{percentage zinc} = \frac{\text{atomic mass of zinc}}{\text{molar mass of enzyme}} \times 100 = 0.191$$

As the atomic mass of zinc is 65.39 g mol$^{-1}$, this can be rearranged to give the molar mass of the enzyme:

$$\text{molar mass of enzyme} = \frac{65.39}{0.00191} = 3.42 \times 10^4 \text{ g mol}^{-1}$$

Answer: $3.42 \times 10^4$ g mol$^{-1}$
Given that haemoglobin contains 4 Fe atoms per molecule and its concentration in blood is 15 g per 100 mL, calculate the total mass of Fe in the patient’s blood before being treated with Desferal. (The molar mass of haemoglobin is \(6.45 \times 10^4\) g mol\(^{-1}\).)

In 5.04 L, the total mass of haemoglobin is \((15 \text{ g}) \times (5.04 \times 10^3 \text{ mL} / 100 \text{ mL}) = 756 \text{ g}\). If the molar mass is \(6.45 \times 10^4\) g mol\(^{-1}\), this corresponds to

\[
\text{moles of haemoglobin} = \frac{\text{mass}}{\text{molar mass}} = \frac{756 \text{ g}}{6.45 \times 10^4 \text{ g mol}^{-1}} = 0.0117 \text{ mol}
\]

As haemoglobin contains 4 Fe atoms, the number of moles of Fe is \(4 \times 0.0117\) mol = 0.0469 mol. There is also \(3.2105 \times 10^{-3}\) mol of free Fe\(^{3+}\) present (from 2004-J-3) so the total number of moles of Fe is \((0.0469 + (3.2105 \times 10^{-3}) \text{ mol}) = 0.050 \text{ mol}\).

The mass of Fe is given by moles × atomic mass:

\[
\text{mass of Fe} = (0.050 \text{ mol}) \times (55.85 \text{ g mol}^{-1}) = 2.80 \text{ g}
\]

ANSWER: \(2.8 \text{ g}\)

THE REMAINDER OF THIS PAGE IS FOR ROUGH WORKING ONLY
Siderophores (from the Greek meaning ‘iron carriers’) are organic molecules produced by microorganisms to provide essential Fe$^{3+}$ required for growth. The functional group (the group which binds Fe$^{3+}$) of siderophores is shown below as tautomers I and II. Complete the table below, relating to the molecular geometry about the specified atoms in I and II.

<table>
<thead>
<tr>
<th>Atom</th>
<th>Geometric arrangement of the electron pairs around the atom</th>
<th>Hybridisation of atom</th>
<th>Geometry of bonding electron pairs around atom</th>
</tr>
</thead>
<tbody>
<tr>
<td>$^1$C</td>
<td>tetrahedral</td>
<td>sp$^3$</td>
<td>tetrahedral</td>
</tr>
<tr>
<td>$^2$N</td>
<td>tetrahedral</td>
<td>sp$^3$</td>
<td>trigonal pyramidal</td>
</tr>
<tr>
<td>$^3$C</td>
<td>trigonal planar</td>
<td>sp$^2$</td>
<td>trigonal planar</td>
</tr>
<tr>
<td>$^4$O</td>
<td>tetrahedral</td>
<td>sp$^3$</td>
<td>bent</td>
</tr>
<tr>
<td>$^5$N</td>
<td>trigonal planar</td>
<td>sp$^2$</td>
<td>bent</td>
</tr>
</tbody>
</table>

Desferal is a siderophore-based drug that is used in humans to treat iron-overload. One molecule of Desferal (molecular formula: C$_{25}$H$_{48}$O$_8$N$_6$) can bind one Fe$^{3+}$ ion. A patient with iron-overload had an excess of 0.637 mM Fe$^{3+}$ in his bloodstream. Assuming the patient has a total blood volume of 5.04 L, what mass of Desferal would be required to complex all of the excess Fe$^{3+}$?

In 5.04 L, the number of moles of Fe$^{3+}$ is given by the concentration $\times$ volume:

$$\text{moles of Fe}^{3+} = (0.637 \times 10^{-3} \text{ mol L}^{-1}) \times (5.04 \text{ L}) = 3.2105 \times 10^{-3} \text{ mol}$$

As each desferal molecule binds one Fe$^{3+}$, this is also the number of moles of desferal that is required. The molar mass of desferal is:

$$\text{molar mass} = (25\times12.01 \text{ (C)} + 48\times1.008 \text{ (H)} + 8\times16.00 \text{ (O)} + 6\times14.01 \text{ (N)}) \text{ g mol}^{-1}$$
$$= 560.964 \text{ g mol}^{-1}$$

The mass of desferal required is then the number of moles $\times$ molar mass:

$$\text{mass of desferal} = (3.2105 \times 10^{-3} \text{ mol}) \times (560.964 \text{ g mol}^{-1}) = 1.80 \text{ g}$$

ANSWER: 1.80 g
The partial Lewis structure of lactic acid, the molecule that forms in muscle during exercise, is shown below. Complete the Lewis structure of lactic acid by drawing the non-bonded electron pairs around the relevant atoms.