Marks 5

- Complete the following table. Give, as required, the formula, the systematic name and the principal ions present in a solution prepared by adding the substance to water. For the substances that do not form ions in solution, write N/A in this column.

FORMULA	SYSTEMATIC NAME	PRINCIPAL IONS IN WATER SOLUTION
$MgCl_2$	magnesium chloride	**$Mg^{2+}(aq)$, $Cl^-(aq)$**
Na_2CrO_4	sodium chromate	**$Na^+(aq)$, $CrO_4^{2-}(aq)$**
CO	**carbon monoxide**	**N/A**
HIO	**hypoiodous acid**	$H^+(aq)$, $IO^-(aq)$
$Fe(NO_3)_3.6H_2O$	iron(III) nitrate-6-wate	**$Fe^{3+}(aq)$, $NO_3^-(aq)$**

- Electron configurations are governed by three rules: the 'Aufbau Principle', the 'Pauli Exclusion Principle' and 'Hund's Rule of Maximum Spin Multiplicity'. The ground state electron configurations of He, N and O have been written INCORRECTLY, as shown below. For each element, name the electron configuration rule that has been broken.

Element	Electronic configuration (1s 2s 2p 2p 2p)	Name of rule that has been broken
He	☐ ↑↓ ☐ ☐ ☐	**Aufbau principle**
N	↑↓ ↑↓ ↑↓ ↑ ☐	**Hund's Rule**
O	↑↓ ↑↓ ↑↑ ↑ ☐	**Pauli Exclusion Principle**

Write the electron configuration of Fe^{2+} **$1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6\ 3d^6$**

What property of iron makes it useful for biological systems?

Stability of two oxidation states, Fe^{2+} and Fe^{3+}.

Marks 4

- Complete the following table. Give, as required, the formula, the systematic name, the oxidation number of the underlined atom and, where indicated, the principal ions present in a solution prepared by adding the substance to water.

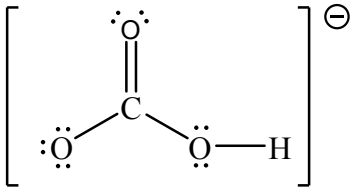
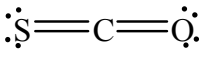
FORMULA	SYSTEMATIC NAME	OXIDATION NUMBER	PRINCIPAL IONS IN WATER SOLUTION
$\underline{N}O_2$	**nitrogen dioxide**	**+IV**	N/A
$\underline{Pb}(CH_3CO_2)_2$	**lead(II) acetate**	**+II**	**Pb^{2+}(aq), $CH_3CO_2^-$(aq)**
$Mg(\underline{Cl}O_4)_2$	**magnesium perchlorate**		Mg^{2+}(aq); $\underline{Cl}O_4^-$(aq)

Write the full electron configuration of the As^{3+} ion.

$1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6\ 3d^{10}\ 4s^2$

5

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

HCO_3^-	COS	CN^-
		
Resonance: **YES** / NO	Resonance: YES / **NO**	Resonance: YES / **NO**

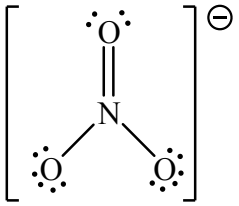
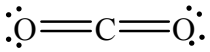
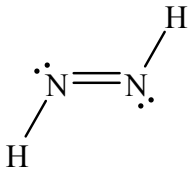
- Complete the following table. Give, as required, the formula, the systematic name, the oxidation number of the underlined atom and, where indicated, the number of *d* electrons for the element in this oxidation state.

Marks 5

FORMULA	SYSTEMATIC NAME	OXIDATION NUMBER	NUMBER OF *d* ELECTRONS
$\underline{S}O_3$	**sulfur trioxide**	**+IV**	**0**
$K\underline{Mn}O_4$	**potassium permanganate**	**+VII**	**0**
$\underline{Co}Cl_2 \cdot 6H_2O$	**cobalt(II) chloride-6-water**	**+II**	**7**
NH_4SO_4	ammonium sulfate		

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

4

NO_3^-	CO_2	N_2H_2
		
Resonance: **YES** / NO	Resonance: YES / **NO**	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?

2

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:

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

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

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

Answer: **3.42×10^4 g mol^{-1}**

Marks 5

- 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.

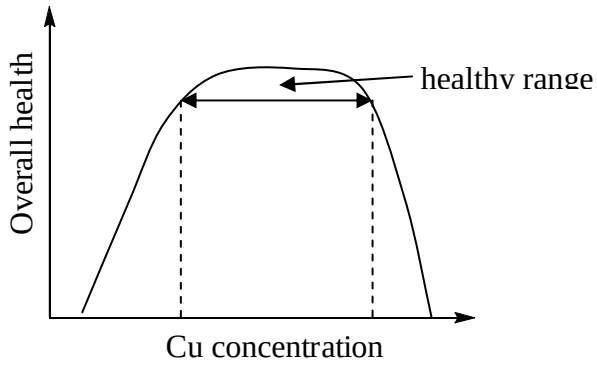
Formula	Systematic name	Oxidation number	Number of *d* electrons
$\underline{C}O_2$	**carbon dioxide**	**+IV or +4**	**0**
$Na_2\underline{Cr}O_4$	**sodium dichromate**	**+VI or +6**	**0**
$\underline{Fe}Cl_3 \cdot 3H_2O$	**iron(III) chloride-3-water**	**+III or +3**	**5**
	potassium sulfate		

- Complete the following table, giving either the systematic name or the molecular formula as required.

Marks 2

Formula	Systematic name
SO_2	**sulfur dioxide**
$CoCl_2 \cdot 6H_2O$	**cobalt(II) chloride-6-water**
Ag_2CrO_4	silver chromate
$KHCO_3$	potassium hydrogencarbonate

- Copper is an essential element in human biology, deficiencies leading to blood disorders. Excess copper can occur in cases of poisoning or in Wilson's disease. Draw a graph showing the relationship between overall health and the level of copper in the body and identify the 'healthy' range. **4**



Describe one biological function of copper.

Copper enzymes are involved in electron transport systems due to the ability of copper to change its oxidation state.

In some organisms, copper enzymes are involved in oxygen transport.

Suggest one approach for treating an excess level of copper.

Treatment with a complexing agent such as EDTA leads to the formation of stable water-soluble complex that can be excreted from the body.

• Complete the following table, giving either the systematic name or the molecular formula as required.

Marks 2

Formula	Systematic name
$NaHSO_4$	**sodium hydrogensulfate**
$AsCl_3$	arsenic(III) chloride
$CrCl_3 \cdot 6H_2O$	**chromium(III) chloride-6-water**
$Ag_2Cr_2O_7$	silver dichromate

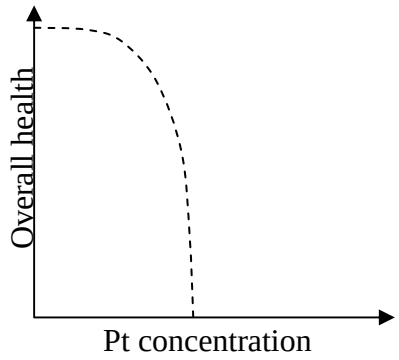
- Like most medicines, the platinum complex, cisplatin, *cis*-$[PtCl_2(NH_3)_2]$, is both effective and toxic. What is cisplatin used to treat? **4**

Cisplatin is used to treat a number of cancers, including testicular and ovarian cancer.

What does the cisplatin react with in the body to cause most of the toxicity?

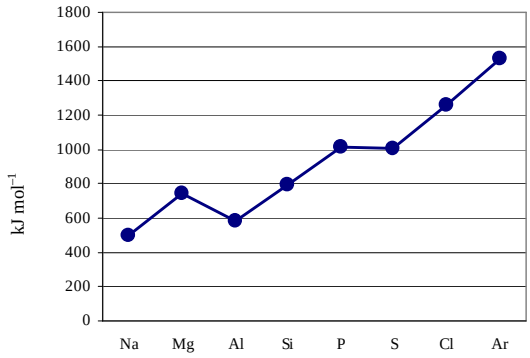
Sulfur containing enzymes in the kidneys

Draw a graph showing the relationship between overall health and the level of platinum in the body of a healthy person.



Marks 3

- The diagram below shows the general trend for the first ionisation energy for some *s* and *p* block elements.



How will the general trend differ for the second ionisation energy of these elements (*i.e.* $X^+(g) \rightarrow X^{2+}(g) + e^-$)? Explain.

The second ionisation of Na will be off the scale as a core electron is ionised. (Actual value > 4500 kJ mol^{-1})

Mg^+ is isoelectronic with Na, Al^+ is isoelectronic with Mg, *etc*., so the second ionisations of the other elements follow the same trends as the first ionisations (for exactly the same reasons), but displaced one atomic number to the right and at a slightly higher energy (as Z_{eff} is greater).