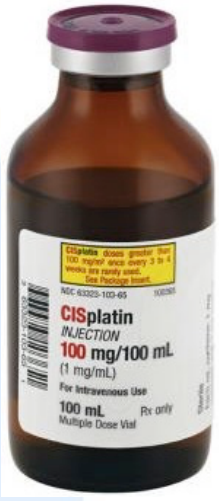
HL Paper 3 Section A Data Response (9) with worked answers



Cis-platin, $Pt(NH_3)_2Cl_2$, is used to treat a variety of cancers including testicular and ovarian cancer. The compound was discovered in 1845. It is manufactured from potassium tetrachloroplatinate, K_2PtCl_4. The process goes through several stages to give an overall yield of cis-platin of 63%.

(a) Calculate the mass of potassium tetrachloroplatinate required to produce 100.0 g of cis-platin. ***[2]***

$M(Pt(NH_3)_2Cl_2) = 195.08 + (2 \times 14.01) + (6 \times 1.01) + (2 \times 35.45) = 300.06$ g mol^{-1}
Amount of K_2PtCl_4 required = $(100 \div 300.06) \times (100 \div 63) = 0.5290$ mol ***[1]***
$M(K_2PtCl_4) = (2 \times 39.10) + 195.08 + (4 \times 35.45) = 415.08$ g mol^{-1}
Mass of K_2PtCl_4 required = $0.5290 \times 415.08 = 220$ g ***[1]***

(Underlying chemistry concepts can be found in 1.2 The mole & Avogadro's constant.)

(b) Cis-platin contains four monodentate ligands.

(i) Deduce the oxidation state of platinum in cis-platin. ***[1]***

+ 2 ***[1]***
Note: II, +II, 2+ or 2 are not acceptable.

(Underlying chemistry concepts can be found in 9.1 Oxidation & reduction.)

(ii) State the meaning of the term *monodentate ligand* with reference to cis-platin. ***[2]***

A *ligand,* such as NH_3 or Cl^-, contains a non-bonding pair of electrons that can form a coordinate bond with a transition metal or ion. ***[1]***
Monodentate ligands utilise one pair of electrons to form one coordinate bond. ***[1]***

(Underlying chemistry concepts can be found in 9.1 Oxidation & reduction and 13.1 First-row d-block elements.)

(iii) Show how the name cis-platin leads to the deduction that the shape of the compound is square planar. ***[1]***

The four ligands can either be arranged in a square planar shape or a tetrahedral shape. If the shape is tetrahedral then optical activity would be possible but they would not show cis/trans isomerism. In the cis- isomer the two NH_3 ligands (or the two Cl^- ligands) will be at 90° to each other, in the trans isomer they will be at 180° to each other in the square planar complex. ***[1]***

(Underlying chemistry concepts can be found in 4.3 Covalent structures (2) and in 20.3 Stereoisomerism.)

(c) The pharmaceutical properties of cis-platin were only discovered accidently in 1965 when scientists at Michigan State University were investigating the effect of electric fields on bacteria cell division. They realised that when a platinum electrode was used a compound was formed (later shown to be cis-platin) that stopped the bacteria dividing.

State the single word used to describe a chance happening that leads to a discovery. ***[1]***

Serendipity ***[1]***

(Underlying chemistry concept can be found in The Nature of Science.)

(d) Cis-platin has no overall charge so it can diffuse through the membrane of cancer cells. Once inside the cell it exchanges a chloride ion for a water molecule to form a new square planar species. This new species can enter the cell nucleus where it exchanges another chloride ion and also the water molecule so that it can bind to the nitrogen atoms on two different guanine molecules in the cell's DNA. This alters the cancer cell's DNA and prevents it from reproducing.

(i) Deduce the formula of the new square planar species formed when one of the chloride ions on cis-platin is exchanged for a water molecule. ***[1]***

$[Pt(NH_3)_2(H_2O)Cl]^+$ ***[1]***

Note that there must be square brackets and a positive sign to gain the mark.

(Underlying chemistry concepts can be found in 9.1 Oxidation & reduction and 13.1 First-row d-block elements.)

(ii) Suggest one reason why trans-platin is ineffective as a treatment against cancer. ***[1]***

Because the sites on the platinum in the trans isomer are 180° apart the two N atoms from the two guanine bases on the same strand of DNA in the cancer cell are not able to fit around the platinum so the cancer cell's DNA is not altered. ***[1]***

(Underlying chemistry concepts can be found in 20.3 Stereoisomerism.)