A2.2 Chemistry

Chemistry in Medicine 5.11.

- You will be expected to be able to explain the use of indigestion remedies to cure excess hydrochloric acid in the stomach stating the types of compounds used and writing equations for their reactions.
- You will be expected to be able to use a back titration to determine the percentage of an active ingredient in an indigestion remedy and perform various calculations on the titration.
- You will be expected to be able to explain how to deal with variations in the pH values of skin, explain the role of fatty acids in skin pH and explain the use of corrosive chemicals in removing warts.
- You will be expected to be able to recall and explain the use of silver nitrate in the treatment of eye diseases.
- You will be expected to be able to explain the action of anticancer drugs, for example cisplatin in preventing DNA replication in cancer cells and how varying the structure of cisplatin affects the efficiency of anticancer activity
- You will be expected to be able to carry out titrations to determine the concentration of aspirin in solution and carry out associated calculations.
- You will be expected to be able to recall the synthesis of aspirin from salicylic acid and ethanoic anhydride and compare it with the use of ethanoic acid and ethanoyl chloride and explain why the sodium salt of aspirin is often used rather than aspirin.
- You will be expected to be able to explain the use of GLC linked to MS to identify drugs and to determine their purity.
- You will be expected to be able to explain the role of iron (II) in haemoglobin in the transportation of oxygen in blood and the poisonous nature of carbon monoxide.
- You will be expected to be able to explain the role of edta in sequestering calcium ions in preventing the clotting of blood.

There is a problem with the English language that the word chemist is frequently used when the word should be pharmacist. This “mistake” is not made in other countries e.g. in Germany the word is Apotheke which reminds you of the English word apothecary (a person who prepared and sold medicines or drugs).

Digestion Remedies

http://www.nhs.uk/Conditions/Indigestion/Pages/Treatment.aspx A good general medical background on what indigestion is from the NHS and how to treat it.

http://www.rsc.org/learn-chemistry/resource/res00000698/using-indigestion-tablets-to-neutralise-an-acid?cmpid=CMP00005978 An RSC experiment which guides you how to compare indigestion tablets.

https://www.pearsonschoolsandfecolleges.co.uk/Secondary/Science/14-16forEdexcel/EdexcelGCSEScience2011/Samples/TeacherBookSamples/ChemistryC110TeacherBookSample.pdf Edexcel shows you how to do it!

Stomach problems are often caused by an excess of hydrochloric acid. Indigestion tablets contain chemicals that neutralise the excess acid. There are many names for indigestion such as dyspepsia, hyperacidity and heartburn. There can be other serious reasons for indigestion but if the indigestion is cured by taking a simple remedy the cause was probably a reaction to the food or drink consumed.

The chemicals which react with the hydrochloric acid are called “antacids” although chemists would describe them as bases. It would not be feasible to take alkalis such as sodium hydroxide. They would cause more damage than the indigestion. The chemicals used are usually oxides, hydroxides and carbonates. Magnesium oxide, hydroxide and carbonate are frequently used. The corresponding calcium compounds calcium oxide and hydroxide would not be used because they are too alkaline, but calcium carbonate is used.

Rennie contains calcium carbonate and magnesium carbonate

Milk of Magnesia contains magnesium hydroxide; 5 cm^3 contains 415 mg of $Mg(OH)_2$; magnesium hydroxide is not very soluble (0.64 mg dissolve in 100 cm^3 of water) and it is called “milk” of magnesia (magnesium oxide) because it appears white because of the insoluble magnesium hydroxide. In 2013 the EU banned it because it contained too much magnesium sulfate (0.5%). Try testing a bottle for sulfate ions. You could filter it off and weigh it. Milk of magnesia also acts as a very mild laxative.

Gaviscon from Reckitts contains sodium alginate, sodium or potassium hydrogencarbonate and calcium carbonate. The sodium alginate acts as a gum and with the gas released from the carbonates forms a layer on the stomach which prevents the acid reaching the oesophagus.

Gaviscon from Glaxo Smith Kline contains aluminium hydroxide, magnesium carbonate or magnesium trisilicate

Bisodol contains sodium hydrogencarbonate (64 mg), calcium carbonate (522 mg) and magnesium carbonate (68 mg)

The Use of Back Titrations to Determine the Active Ingredients in an Indigestion Remedy.

The pH of Skin and the Removal of Warts

http://skincarerx.com/article-ph A general article on skin care which contains some chemistry

http://www.ncbi.nlm.nih.gov/pubmed/18489300 Difficult to know what the best skin pH is in terms of bacteria!

The pH of skin is acidic and whilst the pH quoted is usually 5.5 it can range from 4.5 to 5.5, The acidity is caused by free fatty acids and by lactic acid and amino acids from sweat. Sweat itself has a pH range of 4.5 to 7.0. The layer of acid on the skin is often described as the "acid mantle". Skin has an acidic pH which is protective because bacteria are killed in acidic conditions. If the pH of the skin is not maintained at an acidic pH its condition changes. At alkaline pHs it becomes dry and sensitive.

Soap is the sodium (or potassium) salt of a long chain fatty acid. Fatty acids are weak acids and sodium hydroxide is a strong base this means that the salt formed from such a combination is alkaline. This means that washing with soap removes the acidic layer although it can be replaced. This has led to cosmetic products such as pHisoderm (pH equals skin) which are used to clean skin and leave the skin acidic as before.

Warts are caused by the human papillovirus. They can be removed using several methods. One is cryotherapy with liquid nitrogen another is actual surgery. The chemical method is to add salicylic acid.

The acid is not used in its pure state as it would be too corrosive.; 10-60% solutions or creams etc. are used. It is regarded as being less painful than the other methods. It softens the hard outer layers of the wart.

Many corrosive chemicals have been used over the years for removing warts such as concentrated nitric and sulfuric acids. The main danger is that such chemicals can damage healthy skin around the wart.

The Use of Silver Nitrate in Eye Diseases

http://www.avocamedical.com/usage/medical-uses/ A general coverage of the uses of silver nitrate in medicine.

https://en.wikipedia.org/wiki/Caustic_pencil Silver nitrate used as a "pencil".

https://en.wikipedia.org/wiki/Silver_nitrate This article is on silver nitrate generally. Look at the medical section.

Silver nitrate has been known since the days of the alchemists. Its alchemical name was *lunar caustic* (caustic moon). Its melting point is very low at 217 ^{o}C and it was melted to form sticks. In this form it was used in surgery as a caustic. The older meaning of caustic was "able to burn or corrode organic tissue by chemical action" which explains its use in treating warts. Both the aqueous solution and the solid oxidise organic matter. The silver nitrate is reduced to silver which is deposited in a black finely divided metallic state.

Silver nitrate when heated decomposes to produce the metal and nitrogen (IV) oxide.

$$2AgNO_3 \rightarrow 2Ag + 2NO_2 + O_2$$

If you spill silver nitrate solution (of a certain strength) or the solid on your hand it will turn black and stay black for days or weeks. The only way to prevent this is to wash the skin with sodium chloride solution to try and form silver chloride before the silver nitrate oxidises the flesh. Colloidal silver was used to treat many diseases and was taken daily by many people. This led to argyria (argyros = silver) which led to the body turning blue-grey because of silver deposited in the skin. All of this disappeared when penicillin was discovered, and antibiotics were used to treat many diseases.

A major use of dilute silver nitrate solution was in treating babies' eyes at birth. If the birth canal was contaminated with venereal disease especially gonorrhoea the babies' eyes became infected. Adding a few drops of 1% silver nitrate solution killed the gonorrhoea bacterium. Silver ions are very toxic to bacteria. Like many other heavy metal ions, they react with the –SH groups on amino acids and change the structure of a protein i.e. they denature it.

With the mass production of penicillin in 1944 the use of silver nitrate became redundant with bacterial disease being treated with antibiotics. Silver is today being looked at again with the development of nanotechnology.

The Use of Cisplatin in treating Cancer

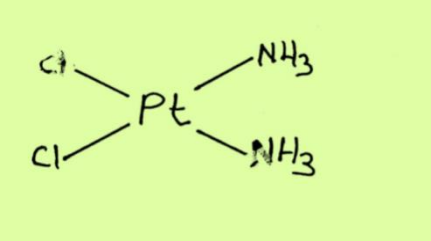

Fig 65cisplatin

https://en.wikipedia.org/wiki/Cisplatin Although this is Wikipedia the level of coverage is quite reasonable, not too excessive.

http://scienceblog.cancerresearchuk.org/2015/08/26/cisplatin-the-story-of-a-platinum-selling-life-saver/ The history of cisplatin and its role in cancer treatment.

http://www.chm.bris.ac.uk/motm/cisplatin/htmlonly/ A brief summary of cisplatin.

The word cis has disappeared from GCE chemistry and has been replaced by Z (zusammen). Cisplatin has a curious history. It was well known as Peyrone's salt and discovered in 1845 by the Italian Michela Pyrene. Its structure was elucidated in 1893 by Werner. The chemical name for it is cis-diamminedichloroplatinum(II). It came into prominence in the 1960s when Rosenberg was investigating the effect of electricity on bacteria using platinum electrodes. He noticed that the bacteria had grown but that they had not divided. Cancer cells are rapidly dividing cells as the cells that produce hair. That is why chemotherapy usually results in people losing their hair because the drugs used stop the growth of rapidly dividing cells.

The mechanism of the action of cisplatin in curing cancer is to attack the DNA molecule. Protein structure has mentioned the coiled α-helix. DNA also has a coiled structure but in the case of DNA amino acids are not in the chain they are organic bases instead.

The organic base guanine is one of four bases that exist in DNA.

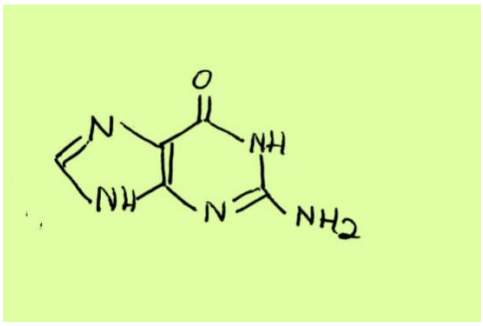

Fig 66 Guanine

The two chlorine atoms on the cisplatin are lost and bonds are formed (known as cross links because they link across two guanine molecules on the same chain) with adjacent guanines on the same strand of DNA. This is just like a complex forming being N atoms and a transition metal. The lone pairs on the nitrogen atoms fit into the empty d-orbitals in the metal. This causes a kink in the DNA helix. The cell is unable to repair this damage. The strands are then unable to uncoil and separate.

Eventually this results in the death of the cell because with inactive DNA the cell cannot survive. Transplatin works in a similar way to cisplatin but the cross links are repaired more effectively. They cannot be repaired with cisplatin.

Cisplatin has quite a few unpleasant side effects, but it is still one of the most effective drugs in chemotherapy. It has been replaced in some cases by carboplatin and oxaliplatin.

The Synthesis of Aspirin using Ethanoic Anhydride

http://www.rsc.org/learn-chemistry/content/filerepository/CMP/00/000/045/Aspirin.pdf This is the definitive treatment of aspirin for GCE. It is well worth reading and perhaps you could print it. Although it does wander off the point at times the material fits in well with the CCEA course. There is lots of information about the history of aspirin and how it developed from the use of salicylic acid for the treatment of pain. Bear in mind that salicylic acid was/is used to remove warts and you can see the problem!

https://en.wikipedia.org/wiki/History_of_aspirin This is the history of aspirin. It is a long story and there is little chemistry in it for GCE, but it is an interesting read and shows you how drugs were developed in the past.

http://www.rsc.org/learn-chemistry/resources/screen-experiment/aspirin/experiment/1 Aspirin "screen experiment" from the RSC. You get "points" when you do it! See if you like it; you have to log in.

Ethanoic Anhydride

Ethanoic anhydride is an acid anhydride formed from the dehydration (removal of a molecule of water) of ethanoic acid.

$$2CH_3COOH \rightarrow (CH_3CO)_2O + H_2O$$

It is a colourless liquid with an irritating smell. It is neutral when pure. It is slightly soluble in water whereas ethanoic acid is miscible and ethanoyl chloride reacts very quickly. Ethanoic anhydride reacts in a similar way to ethanoyl chloride but much less vigorously. Hence it is preferred to ethanoyl chloride and it is also cheaper to make.

Salicylic acid

The systematic name for salicylic acid is 2-hydroxybenzoic acid. It is a white crystalline solid with a melting point of 159 ^oC sparingly soluble in water but readily soluble in hot water and in ethanol. The –OH group attached to a benzene ring acts as a phenol. This was seen in the section that dealt with diazotisation. The diazonium ion was reacted with a solution of sodium phenoxide, $C_6H_5O^-Na^+$. The –OH group is acidic enough to react with sodium hydroxide but not enough to react with $NaHCO_3$ or Na_2CO_3. In other words, the –OH group is similar to the –OH group in ethanol it acts like an alcohol, but it is also slightly acidic.

With sodium hydroxide *both* the –OH group and the –COOH group react.

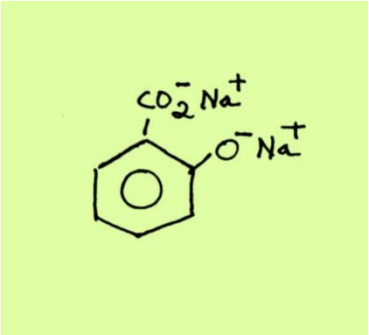

Fig 67 of disodium compound

With sodium carbonate or sodium hydrogencarbonate *only* the –COOH group reacts.

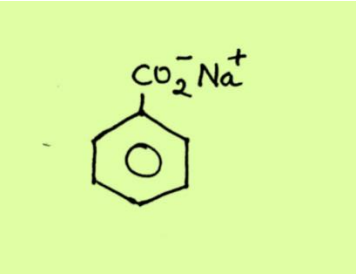

Fig 68 of monosodium compound

So, salicylic acid can be esterified but only because the –OH group reacts with an acid. The -COOH group does not react with acids; it is too acidic itself.

Salicylic acid will react with acetic acid (ethanoic acid) to produce acetylsalicylic acid. This is a typical reaction between an acid and an alcohol to form an ester. The problem in making aspirin is that this is equilibrium. The yield of aspirin could be improved by increasing the concentration of one of the reactants, preferably ethanoic acid (it's cheaper). But the improvement in yield still means that there is unreacted salicylic acid and the reaction is slow. The reaction is speeded up by the addition of concentrated sulfuric acid. But all is in vain because the reaction worth ethanoic anhydride is far better.

The Reaction of Salicylic Acid with Ethanoic Anhydride to Make Aspirin

Aspirin is acetylsalicylic acid (2-ethanoyloxybenzenecarboxylic acid). It's manufactured by the reaction of ethanoic anhydride with salicylic acid.

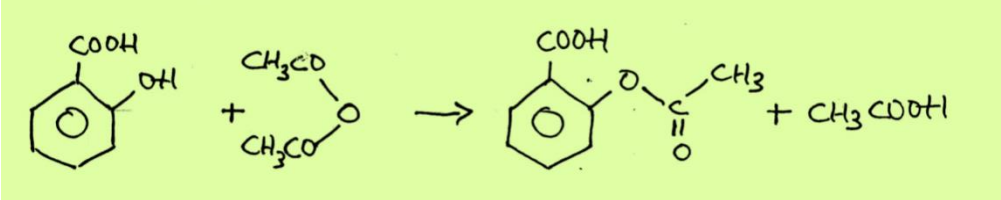

Fig 69for the formation of aspirin with ethanoic anhydride

The reaction is irreversible and no equilibrium is formed. There are numerous preparations to be found on the internet and in organic practical books. The preparation uses a catalyst of either concentrated phosphoric acid or concentrated sulfuric acid. There is no need to use a catalyst and the reaction should take about the same time without one!

The Preparation of Aspirin

The following is an adaption of the RSC method of making aspirin (shown in the website at the start of the topic) with a rolling commentary which poses questions about the preparation and asks you to do some partial calculations:

1 g of salicylic acid is added to a pear-shaped flask.

This is a small-scale method with the use of 1 g. The RMM of the acid is 138. Confirm this by calculating the molecular formula. 1 g = 0.0076 mol; check the calculation is this OK re significant figures? The pear-shaped flask could be round bottomed! Depends what you have in your laboratory. Some methods use a conical flask. Doesn't matter, the temperature does not go that high. See if your teacher knows the answer to this point. Not a point that is often taught today.

2 cm^3 of ethanoic anhydride are added.

The density of ethanoic anhydride is 1.08 g cm^{-3}. Its RMM is 102. Calculate the mass of ethanoic anhydride. Confirm the number of moles is 0.0211. Is this OK in terms of significant figures? Is this an excess? ~How would you measure out the ethanoic anhydride? Is this done in the lab or the fume cupboard? Check your HAZCARDS. Can you add the anhydride quickly or slowly, explain?

8 drops of concentrated phosphoric acid are added.

How will you add the acid? What is the role of the acid? Not a lot is added, would it be better to add more? Concentrated sulfuric acid is an alternative, why? This is different to the formation of a normal ester, why? This means that concentrated sulfuric acid is not carrying out one of its normal functions, which one is that?

The mixture is warmed for 5 minutes in a hot water bath in fume cupboard.

The reaction is starting already but slowly. The warming is to dissolve the salicylic acid. Why is this done in a fume cupboard? Indeed, all the previous preparation could have been done in a fume cupboard.

The mixture is warmed for a further 10 minutes in the hot water bath.

The hot water bath could be a boiling water bath. The boiling point of the ethanoic anhydride is 140 ^{o}C so what does it matter?! This is to complete the reaction but what does it matter with the concentrated acid as a catalyst.

While the flask is in the hot water bath slowly add 4 cm^3 of water.

This is to decompose the excess ethanoic anhydride. It was proved to be an excess earlier. It is added whilst the water is hot because it decomposes slowly at room temperature.

Add 5 cm^3 of cold water to the flask and cool it in iced water. As it cools crystals of aspirin appear. It may be necessary to stir with a glass rod to start the precipitation process. Stand the flask in iced water to precipitate out all the aspirin.

Aspirin has a very low solubility in water at room temperature. Only 0.33g of aspirin dissolves in 100 $cm^3$of water at 20 ^{o}C. The ice cools the water well below room temperature and the solubility of aspirin is even less.

The aspirin is filtered off using a Buchner funnel with a vacuum i.e. a filter pump.

There is no need to use gravity filtration. It's a cold mixture and although vacuum filtration cools the mixture it makes no difference its cold already.

The crude aspirin is washed with a little cold water and left overnight to dry

Impurities which might be present on the aspirin are ethanoic acid from the hydrolysis of ethanoic anhydride, traces of diluted inorganic acid either sulfuric or phosphoric acid. The crude aspirin contained a lot of water up to about 40%. It could be dried in an oven. It could be dried in a desiccator. Overnight is recommended by RSC.

The product is weighed.

1 g of salicylic acid produces 0.9 g of crude aspirin. The RMM of salicylic acid is 138 and that of aspirin is 180. Use these figures to show that the % yield is 69%.

The crude aspirin is pretty pure. You can do the following tests on it some of which will determine the purity.

Checking the Purity of Aspirin using TLC

Plastic plates can be purchased for TLC or they could be made by dipping microscope slides into alumina or silica slurry and then drying them. The aspirin and salicylic acid and aspirin from a tablet (not the soluble variety) are dissolved in ethanol or dichloromethane. Aspirin does dissolve in hot water but is partially hydrolysed and the water does not evaporate off as well when the spot is created on the TLC plate.

Using a capillary tube, solutions of aspirin, salicylic acid and aspirin from a tablet (not the soluble variety) are applied to the TLC plate. The plate is run in ethyl ethanoate.

Diagram TLC

The spots are developed using either UV light or iodine. The slide/plate is placed in a beaker containing iodine crystals.

It depends on the material used to make the plate but the R_f value for aspirin using ethyl ethanoate as a solvent is 0.45. The use of salicylic acid is to show whether there is any present as an impurity in the crude. Commercial aspirin is used to show that the aspirin made is the same as that used commercially.

Checking the Purity of Aspirin using Melting Point

The aspirin prepared in the laboratory is relatively pure.

Reactions of aspirin

1. Shake a small amount of the prepared aspirin with deionised water. Prepare a similar solution of salicylic acid. Each solution is tested with a drop of iron (III) chloride solution. Salicylic acid gives an immediate purple colour with the iron (III) ion because of the formation of a complex. Aspirin gives no colour, if it is pure because there is no free –OH group. If the aspirin gives a colour it should be recrystallised, and a comparison made with the purified product. The reaction of salicylic acid with ethanoic anhydride is relatively simple and salicylic acid should be the only impurity.

2. Boil a mixture of 1 g of aspirin with 15 cm^3 of 2M sodium hydroxide solution in a flask under reflux for 20 min. Cool the solution thoroughly answer and then add dilute sulfuric acid until the precipitation of salicylic acid is finished. Filter off the salicylic acid and recrystallize it from hot water. Its identity can be confirmed by the iron (III) chloride test, and, also by its melting point, which should be 156 - 7 ^{0}C. Sulfuric acid has been added to just neutralise the sodium salt, but the remaining solution will be acidic because of the ethanoic acid and should smell of vinegar.

The Use of TLC and GLC/MS to Identify Drugs

http://www.bbc.co.uk/schools/gcsebitesize/science/add_aqa/atomic_structure/analysing_substancerev2.shtml Avery simple but useful explanation.

http://www.scientific.org/tutorials/articles/gcms.html An unusual account of what GLC/MS can or can't do.

TLC has limited use in identifying drugs because one spot in a one-dimensional TLC can be as many as 10 separate compounds when analysed by GLC. However, it is very quick to compare simple drugs especially when an unknown drug can be compared with a known sample of a drug. TLC is pretty useless at determining the amount of a substance present largely because of the uncertainty in the value and the fact that GLC can do this far more accurately.

The battle to identify drugs goes on. One thing is sure, all chemicals can be identified, and they can all be detected no matter what they are. The problem is that some are more difficult to identify and if they have not been identified before they are even more difficult. There many possible chemical compounds that can exist. Indeed, there are an infinite number of compounds. Today it is estimated that there are 10 million known compounds.; 9 million of them organic and the rest consisting of other elements.

Allow me to let you into a secret! The best poison is deuterated water(D_2O). It is said that isotopes do not have different chemical properties. Indeed, they do not but they alter the speed of reactions. The process is known as the "kinetic isotope effect". If a person ingests deuterated water (i.e. water containing a high percentage of D_2O) the sequence of enzyme catalysed reactions is disturbed, so much that the person dies. Yet who would look for deuterium in GLC-MS? Yes, it could be found but you would have to look very carefully indeed. But if you did not suspect it you would not even look. The only problem is getting hold of the deuterated water!

Laboratories that are dealing with drugs all the time, set up their GLCs to deal with the drugs they expect to see. If it is a narrow range of drugs, then perhaps one chromatography column is used. A greater variety will require a greater range of columns. Using a specific column enables the drug to be identified based on retention time only. Many laboratories can't afford mass spectrometers despite the price constantly getting lower.

There is the problem of designer drugs or legal highs developing all the time and a "dedicated" GLC machine will produce signals that are unknown.

Although a GLC trace can determine what a substance is there is always the possibility of a "false positive" being noted. However, from a legal point of view, conclusive evidence is required. This is provided by GLC-MS.

The following areas now use GLC-MS:

- Sports antidoping agencies
- Organic pollutants in the environment
- Explosives detection
- Analysis of fire debris
- Astrochemistry several probes carrying GLC-MS have left the Earth
- Medicine investigating metabolic disorders via minor compounds in urine
- Food, beverage and perfume analysis
- Chemical warfare agent detection

The Role of Iron (II) in Haemoglobin (link with section 2.3)

http://chemed.chem.purdue.edu/genchem/topicreview/bp/1biochem/blood3.html A few facts about haemoglobin.

http://www.chemistry.wustl.edu/~edudev/LabTutorials/Hemoglobin/MetalComplexinBlood.html This develops into a very complicated account of how haemoglobin transports oxygen, but it shows you that it is not as simple as it first appears!

Max Perutz and John Kendrew of Cambridge University were awarded the Noble prize in 1962 for their discovery of the structure of haemoglobin. It was and probably still is the most studied protein. Haemoglobin has an RMM of about 68,000 and its empirical?? Formula is $(C_{759}H_{1208}N_{210}S_2O_{204}Fe)_4$. An adult has 4g of iron of which 2/3 are contained in haemoglobin. The body needs a means of transporting oxygen around the body and of absorbing it from air. Simpler animals just absorb oxygen from the air others need lungs and gills. Hence the existence of haemoglobin. It is a globular protein which dissolves in water. Just like enzymes globular proteins need to dissolve so that their active sites which are either used for catalytic or for transport purposes.

No need to remember this complicated structure! A structure of haemoglobin is shown in the section on transition metals. It is a simplification of the overall structure of haemoglobin being a haem molecule and occurs in red blood cells.

There are four peptide chains each of which contains a haem group which contains iron in an oxidation state of +2. Each haem group contains iron as a tetradentate ligand in a four-coordinate planar structure. The iron is contained din what is called a porphyrin ring. Oxygen molecules have numerous lone pairs. It only needs one of them to form a bond to the iron (II) atom. Because there are four porphyrin rings in a haemoglobin molecule there will be four oxygen molecules attached to each haemoglobin molecule.

Oxygen combines with haemoglobin to form oxyhaemoglobin.

$$\text{oxygen} + \text{haemoglobin} \rightleftharpoons \text{oxyhaemoglobin}$$

In the lungs there is a high concentration of oxygen. In the body tissues there is a low concentration of oxygen. Hence the equilibrium moves appropriately from left to right and vice versa.

Carbon monoxide competes with oxygen in coordinating with the iron (II) in haemoglobin. Unfortunately, it is 200x more strongly bound with the iron (II) than oxygen which is bad news for those who suffer from carbon monoxide poisoning. The carbon monoxide is often formed from faulty boilers which because of a lack of oxygen result in fuels burning with incomplete combustion and forming carbon and carbon monoxide.

$$\text{carbon monoxide} + \text{haemoglobin} \rightleftharpoons \text{carboxyhaemoglobin}$$

Oxygenated blood is red and deoxygenated blood is blue allegedly because some observers say that the blood in veins is blue. Many believe that the skin layers obscure this colour. The blood is always red. In veins it is dark red. Blood from arteries is bright red.

There are also deaths caused by the carbon monoxide in car exhausts, again because of incomplete combustion. With the fitting of catalytic converters this should be far rarer than it was.

Much is made of the fact that carbon monoxide poisoning is always fatal. But chemistry disagrees with this. If the reaction between carbon monoxide is reversible, then a large excess (concentration) of oxygen should reverse the process. The good news is that doctors do not abandon those suffering from carbon monoxide poisoning.

The Role of Edta in Sequestering Calcium ions (see the link with section 5.5.7)

The word sequester means “to remove or set apart”. In chemistry an ion may remain in solution when it is sequestered but it is no longer available for reaction. When edta is added to a solution of calcium ions they are sequestered. A calcium ion is surrounded by an edta molecule which forms coordinate bonds.

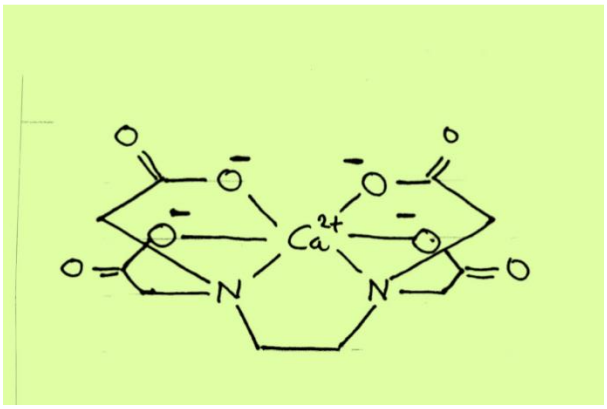

Fig 70

The equation for the reaction is.

$$Ca^{2+}_{(aq)} + edta^{4-}_{(aq)} \rightarrow Ca(edta)^{2-}_{(aq)} + nH_2O_{(l)}$$

nH_2O are the water molecules surrounding the calcium ion. The number of molecules on the right-hand side of the equation is much greater than the number on the left-hand side which means that the forward reaction is favoured by entropy.

What is the connection of all of this with the prevention of clotting of blood? Calcium ions are essential for the successful clotting of blood. It is very difficult to explain the exact role of calcium ions because they have so many functions in the complex process of blood clotting. Without writing a biological essay all that can be said is that calcium ions are co-factors in the action of several proteins.

In a blood bank citric acid is added to prevent clotting.

Edta can also be used to remove calcium ions from hard water as well as magnesium ions both of which cause permanent harness. It competes with many other substances that also remove calcium ions.

Quick Questions

1 Explain the meaning of the terms: back titration, digestion remedy, cisplatin, DNA, haemoglobin, GLC-MS, sequestering and edta.

2 Explain how you would use a back titration to determine the mass of active ingredients in in an indigestion remedy.

3 Draw the structures of cisplatin and transplatin. How does cisplatin act as an anti-cancer drug and why does transplatin not work as effectively?

4 Explain the role of haemoglobin in transporting oxygen in the body and why carbon monoxide is poisonous.

5 Describe how aspirin is prepared in the laboratory. Explain how you would compare your prepared sample with aspirin sold commercially.

Past Paper Questions

Past paper questions are not included in this section of the eBook. They can be readily obtained by going to the section on the CCEA website which deals with past papers and their mark schemes. The papers for several previous years are available together with detailed mark schemes.

END