

Chemistry
Step up work
2023

Making L-Dopa

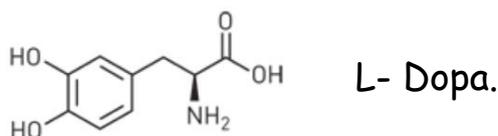
Name _____

Making L-Dopa

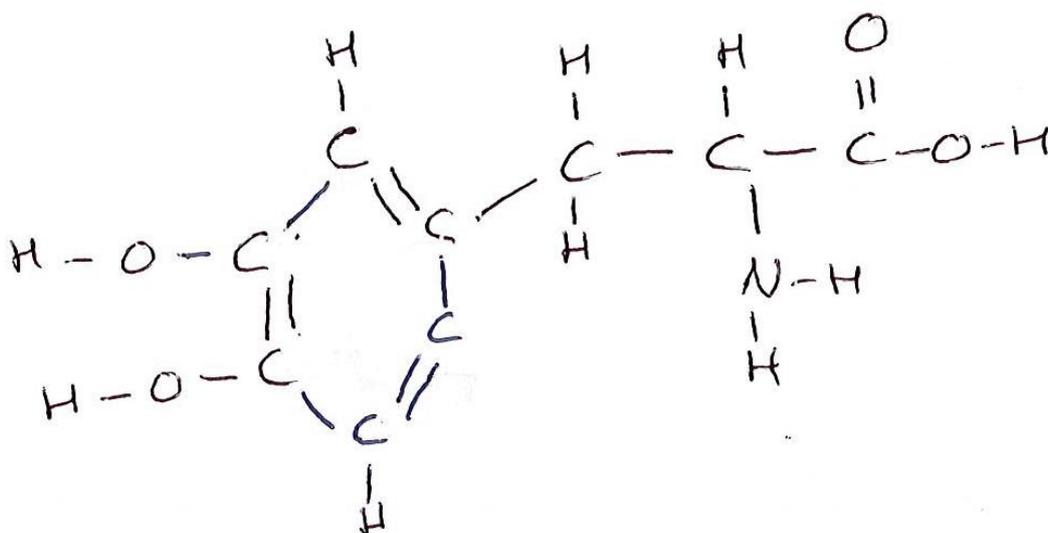
Read through the booklet completing all tasks

Scenario:

A North-East pharmaceutical company has been asked to manufacture Sinemet_{TM}. This is the brand name for the drug L-Dopa (Full name 3,4-dihydroxyphenylalanine) L-Dopa is a medication used for the treatment of Parkinson's disease.



It can be drawn out in full as seen below.



Work out the molecular formula for L-Dopa.

One of the first steps in manufacturing a new medicine is for research chemists to identify the functional groups (this will help indicate how the medicine will work)

On the diagram above circle the carboxylic acid functional group.

L-Dopa also contains a phenol group.

Draw a phenol group (you will need to research this)

How could this be identified using a chemical test?

Manufacture:

The next step is to determine how L-Dopa can be made.

Other research chemists work out that it can be made in a two step process:

In the first step a molecule is reacted with hydrogen using an enzyme catalyst.

What type of bonding must be present for a substance to be called a molecule?

What is a catalyst?

Why are enzymes the preferred choice for a catalyst?

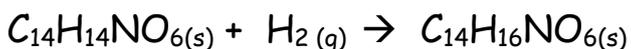
The second step uses an acid catalyst.

What ion is present in all acids?

Below are the two equations (unbalanced) - can you balance the second one.

Step one is often referred to as an addition reaction - explain why.

Step 1:



Step 2:

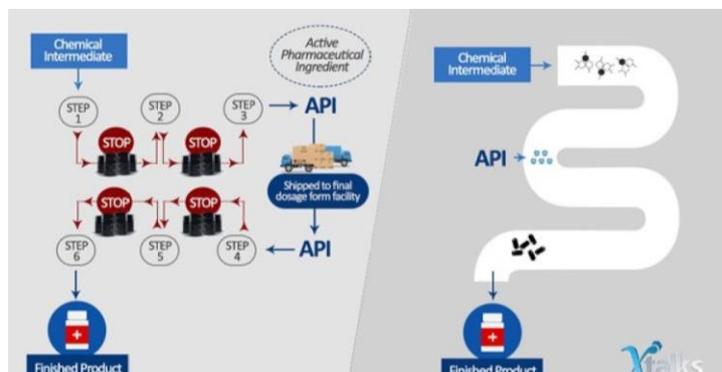
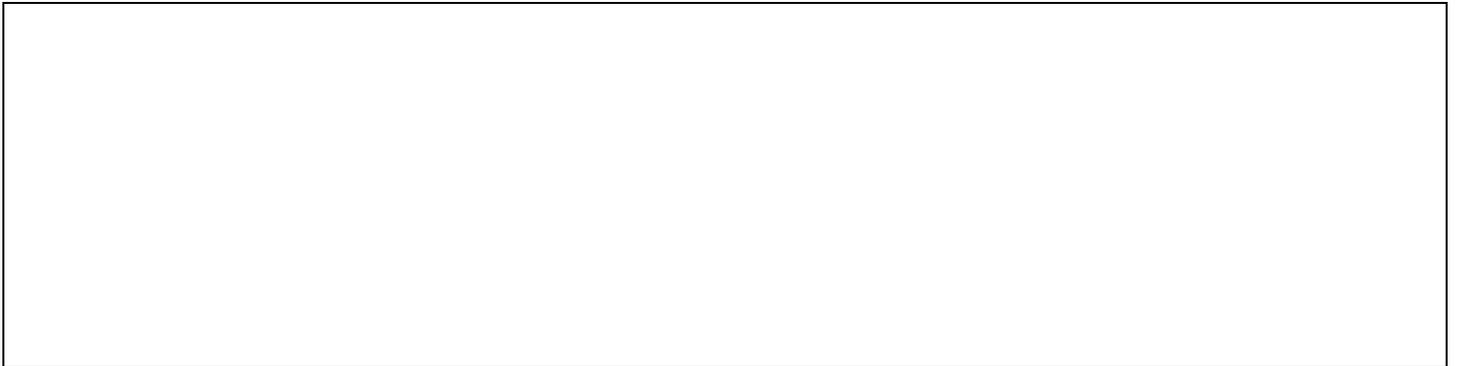


What do each of the state symbols in the above equations indicate?

g	s
l	aq

Step 1 can be carried out as a continuous process but step 2 has to be done as a batch process.

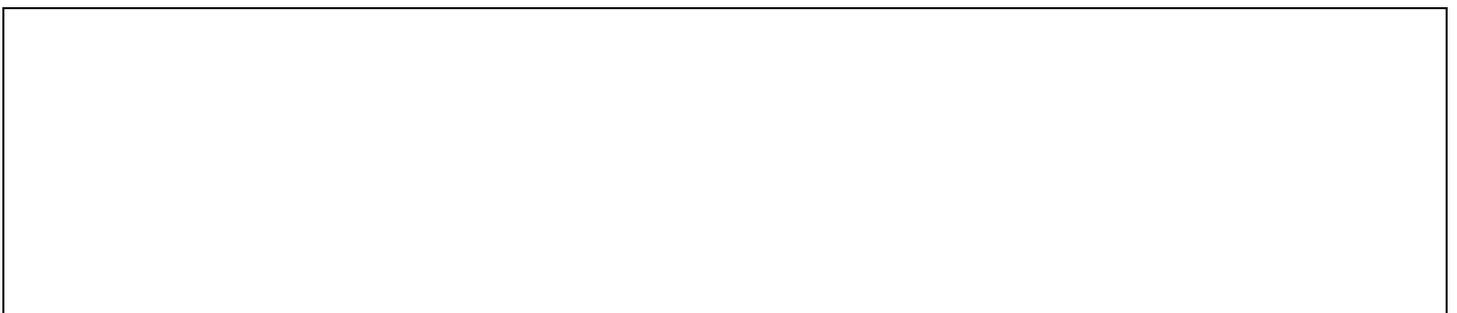
Use the diagram to describe the difference between batch and continuous processes in industry.



Raw materials and Health and Safety

Once the manufacture route has been determined the raw materials need to be sourced and costed; then the Health and Safety executives will assess and advise on how to ensure the transportation, handling and manufacture is done in as safe a way as possible. The correct safety symbols must be worked out and used appropriately.

Why is it important we use hazard symbols and not just rely on written warnings?

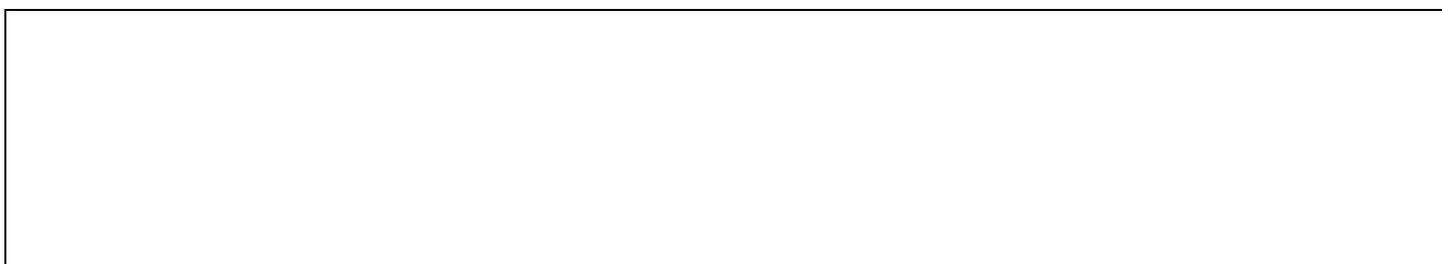


Hydrogen is used in the first step, it is a flammable gas.

What hazard symbol should be used when transporting and storing hydrogen?



What precautions should be taken when storing and handling hydrogen?



Hydrogen is a covalent molecule.

What is a covalent bond?



Draw a dot-cross diagram for a hydrogen molecule.

(Hydrogen has an atomic number of 1)



What are the properties of simple covalent molecules, like hydrogen?
Link each one to the structure.

An acid catalyst is used in the second step.

What hazard symbol should be used when storing and handling the acid?

What precautions should be taken when storing and handling acids?

The acid that is used is a concentrated acid, describe how this differs from a dilute acid.

The acid is also classed as a strong acid. Describe, with equations how this differs from a weak acid.

Risks and Benefits (Life Cycle Assessment)

Once all the risks have been assessed and a process has been proposed. An LCA consultant will carry out a life cycle assessment.

Describe what this would involve.

Planning the synthesis

The company have been asked to make 1 million tablets. Each tablet weighs 500mg (0.4g)

The 'pure' tablet contains, L-Dopa mixed with binding agents (These make sure the chemical stays in tablet form), and other chemicals to make the tablet easy to swallow.



Why would a chemist say that the tablet is not 'pure'? (ie what is the chemical definition of pure)

Each tablet will actually only contain 0.4g of L-Dopa. ($C_9H_{10}NO_4$)

Calculate the number of moles of L-Dopa in each tablet and in total in 1,000,000 tablets.

The first step has a percentage yield of 95%

How is percentage yield calculated?

The second step has a percentage yield of 75%

What would the overall percentage yield be?

Why is it not possible to get a 100% yield? Give 3 reasons.

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-

-

If the two step process is combined the overall synthesis equation can be given as:



Using the overall percentage yield that you calculated earlier work out the mass in kg of $C_{14}H_{14}NO_6$ need to make 400kg of L-Dopa.

Mass in g of L-Dopa if x%

Mass of L-Dopa if 100%

Moles of L-Dopa if 100%

Moles of $C_{14}H_{14}NO_6$ needed

Mass in g of $C_{14}H_{14}NO_6$ needed

Mass in kg of $C_{14}H_{14}NO_6$ needed

Hydrogen is one of the reactants. Using the moles of $C_{14}H_{14}NO_6$ calculated. Calculate the volume of hydrogen gas that will be needed to make the required amount of product.

(1 mole of gas occupies 24dm^3 at room temperature and pressure)

The hydrogen is added in excess.

Why is this important?

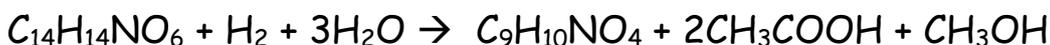
Green chemistry

When devising a new method of producing a product, lots of factors are looked at to make sure the process is as green as possible.

One of these factors is atom economy.

Define the term Atom economy.

Calculate the atom economy for the overall process of making L-Dopa.



The company have people looking at ways of making the atom economy greater. One proposal is that they sell the methanol to a company that makes antifreeze. Calculate the new atom economy if this proposal goes ahead.

Draw the full structural formula of methanol.

Methanol is a covalent molecule, can you do the dot-cross diagram for methanol?

The rate of the reaction is also considered by environmental scientists.

How can the chemists make the rate as fast as possible?

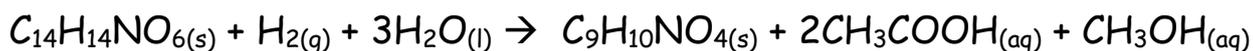
How does the use of an enzyme as a catalyst help keep costs down as well as ensuring that the process is better for the environment?

Separation and purification

Once the product has been made it then needs to be isolated from the reaction mixture.

Looking at the state symbols in the overall process, what would be the best method of removing the product? Use diagrams and keywords to describe how this could be done on a laboratory (small) scale.

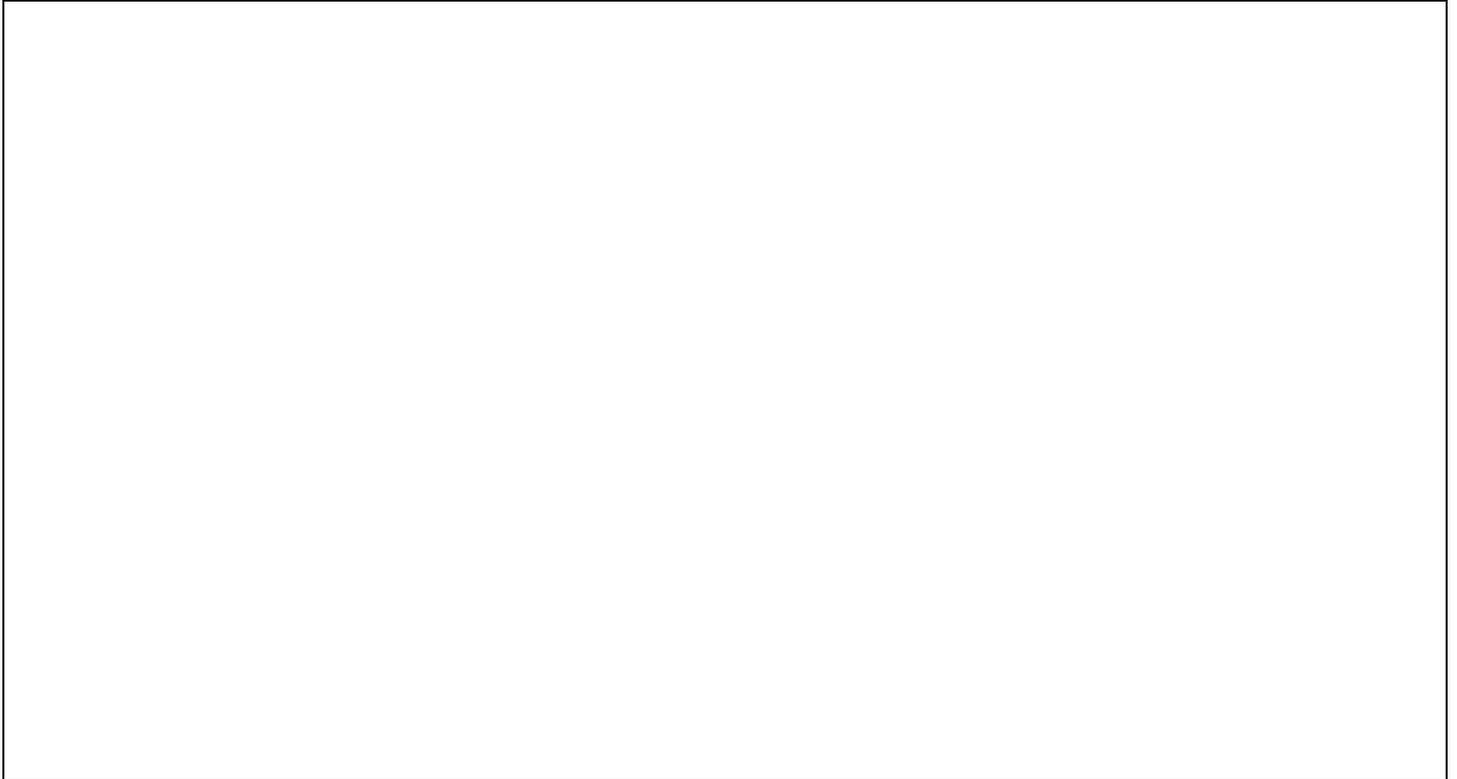
Overall process.



Once the product is isolated it is sent to the labs for testing to make sure that the product is pure enough to be used as a medicine.

One method that is used to test purity is chromatography.

Describe how chromatography is carried out in a lab and how the chromatogram is analysed to assess purity.



Once the product has been tested to make sure it is pure, it is then packaged and sent to the distributors.

