

Preparation of Aluminium Oxide

Aluminium oxide, Al_2O_3 , is a white crystalline solid with many uses. It is a useful material that can be used in abrasives, refractories and ceramics. It's used to manufacture electrical insulators, catalysts, paper, spark plugs, laboratory equipment, gas adsorbers, chromatography plates and columns, light bulbs, artificial gems, heat resistant fibres, food additives, water desalination and haemodialysis.

What you need to do

You must follow the procedure given below to prepare a pure, dry sample of aluminium oxide. You must also measure the yield, and work out the cost of making your product.

Equipment and materials

Read through the procedure and make a list of the apparatus you need. Check it with your teacher. You are also provided with the following chemicals:

- aluminium chloride-6-water (**IRRITANT**)
- 2 mol dm⁻³ sodium hydroxide solution (**CORROSIVE**).

Health and safety

- Wear eye protection.
- A risk assessment must be carried out before starting work.

Procedure

- Weigh out accurately about 2.5 g of aluminium chloride-6-water in a 100 cm³ beaker. Record the mass.
- Add about 25 cm³ of distilled water and stir with a glass rod until the solid has dissolved.
- Warm to about 40 °C and, while still stirring with a glass rod, add 15 cm³ of 2 mol dm⁻³ sodium hydroxide solution. Use a thermometer to check the temperature, but do not stir the solution with it. A white solid will form.
- Allow the solid to settle and add a further 1 cm³ of the 2 mol dm⁻³ sodium hydroxide solution. Once again allow to settle. Repeat this process, 1 cm³ at a time, until the addition of sodium hydroxide solution does not give a white precipitate.
- Set up a filter funnel with a fluted filter paper. Carefully pour the white mixture into the filter.
- Using the wash bottle, wash the white solid from the beaker until it is completely transferred to the filter paper. When filtration is complete, gently squirt distilled water over the aluminium hydroxide in the filter paper to rinse it. Again, allow the liquid to filter away completely.

- Carefully remove the filter paper from the funnel and place it on a piece of paper slightly larger than the filter paper. Put it in an oven at 105 °C to dry.
- Weigh a crucible. Scrape the solid into the crucible and heat over a small non-luminous Bunsen flame for 10 minutes.
- Put the crucible and contents in a desiccator to cool. Weigh the cooled crucible with the dried aluminium oxide in it.
- Put the solid into a suitably labelled sample tube.

Questions

1. Chemical formulae of the reactants are

sodium hydroxide solution NaOH (aq)

aluminium chloride solution AlCl₃ (aq)

and of the products for the first reaction are:

aluminium hydroxide Al(OH)₃ (s)

sodium chloride solution NaCl (aq)

What type of reaction is this? Write a word equation and a balanced chemical equation.

2. When the aluminium hydroxide is heated strongly it forms:

aluminium oxide Al₂O₃ (s)

steam (gaseous water) H₂O (g)

What type of reaction is this? Write a word equation and a balanced chemical equation.

3. Calculate the actual yield of aluminium oxide using

actual yield of aluminium oxide = (mass of crucible + dried product) – (mass of crucible)

4. Now calculate the theoretical yield.

241.5 g of aluminium chloride-6-water produces 51 g of aluminium oxide

Therefore, 1 g would produce $\frac{51}{241.5}$ g

So, m g would produce $\frac{51}{241.5} \times m$ g

where m = the mass of aluminium chloride-6-water used

This is the theoretical yield of aluminium oxide you could obtain from the mass of aluminium chloride-6-water you used.

5. Calculate the percentage yield in the preparation you carried out using

percentage yield = $\frac{\text{actual yield}}{\text{theoretical yield}} \times 100\%$

6. Using a chemical supplier's catalogue, find the costs of the chemicals used. Calculate the total cost of the chemicals used to make the sample of aluminium oxide.
7. Calculate the cost in chemicals to make 1 kg (1000 g) of aluminium oxide. What other things need to be taken into account when working out the true cost of making the aluminium oxide?
8. It's not possible to obtain a 100% percentage yield. For various reasons it is always less. Give some of these reasons.

Precipitation reactions take place almost instantly, unlike the reaction between a solid and a liquid. Explain why this is.

Preparation of Magnesium Oxide

Magnesium oxide, MgO, is a white crystalline solid. It is the starting point for the production of other magnesium salts such as magnesium sulfate and magnesium nitrate. Special grades of magnesium hydroxide, oxide and carbonate are used in antacids, cosmetics, toothpaste and ointments. Magnesium oxide is used as a pigment extender in paint and varnish, in the construction industry and to make semi-conductors. It is also found in some fertilisers where it is a source of essential magnesium for plants. It is used in glass manufacture, insulation, refractory materials and ceramics. The list goes on: rubber and plastics manufacture, steel industry, sugar refining, wood pulping and waste water treatment. Magnesium oxide is a versatile and useful chemical.

What you need to do

You must follow the procedure given below to prepare a pure, dry sample of magnesium oxide. You must also measure the yield, and work out the cost of making your product.

Equipment and materials

Read through the procedure and make a list of the apparatus you need. Check it with your teacher. You are also provided with the following chemicals:

- magnesium sulfate crystals
- 1 mol dm⁻³ sodium hydroxide solution (**CORROSIVE**).

Health and safety

- Wear eye protection.
- A risk assessment must be carried out before starting work.

Procedure

- Weigh out accurately between 6.2 and 6.8 g of magnesium sulfate crystals in a 100 cm³ beaker. Record the mass.
- Add about 25 cm³ of distilled water and stir with a glass rod until the solid has dissolved.
- Warm to about 40 °C and, while still stirring with a glass rod, add 45 cm³ of 1 mol dm⁻³ sodium hydroxide solution. Use a thermometer to check the temperature, but do not stir the solution with it. A white solid will form.
- Allow the solid to settle and add a further 1 cm³ of the 1 mol dm⁻³ sodium hydroxide solution. Once again allow to settle. Repeat this process, 1 cm³ at a time, until the further addition of sodium hydroxide solution does not give a white precipitate.
- Set up a filter funnel with a fluted filter paper. Carefully pour the white mixture into the filter.

- Using the wash bottle, wash the white solid from the beaker until it is completely transferred to the filter paper. When filtration is complete, gently squirt distilled water over the magnesium hydroxide in the filter paper to rinse it. Again, allow the liquid to filter away completely.
- Carefully remove the filter paper from the funnel and place it on a piece of paper slightly larger than it is. Put it in an oven at 105 °C to dry.
- Weigh a crucible. Scrape the solid to the crucible and heat over a small non-luminous Bunsen flame for 10 minutes.
- Put the crucible and contents in a desiccator to cool. Weigh the cooled crucible with the dried magnesium oxide in it.
- Put the solid into a suitably labelled sample tube.

Questions

1. Chemical formulae of the reactants are

sodium hydroxide solution NaOH (aq)

magnesium sulfate solution MgSO₄ (aq)

and of the products for the first reaction are:

magnesium hydroxide Mg(OH)₂ (s)

sodium sulfate solution Na₂SO₄ (aq)

What type of reaction is this? Write a word equation and a balanced chemical equation.

2. When the magnesium hydroxide is heated strongly it forms:

magnesium oxide MgO (s)

steam (gaseous water) H₂O (g)

What type of reaction is this? Write a word equation and a balanced chemical equation.

3. Calculate the actual yield of magnesium oxide using

actual yield of magnesium oxide = (mass of crucible + dried product) – (mass of crucible)

4. Now calculate the theoretical yield.

246 g of magnesium sulfate crystals produces 40 g of magnesium oxide

Therefore, 1 g would produce $\frac{40}{246}$ g

So, m g would produce $\frac{40}{246} \times m$ g

where m = the mass of magnesium sulfate crystals used

This is the theoretical yield of magnesium oxide you could obtain from the mass of magnesium sulfate crystals you used.

5. Calculate the percentage yield in the preparation you carried out using
percentage yield = $\frac{\text{actual yield}}{\text{theoretical yield}} \times 100\%$
6. Using a chemical supplier's catalogue, find the costs of the chemicals used cost. Calculate the total cost of the chemicals used to make the sample of magnesium oxide.
7. Calculate the cost of the chemicals to make 1 kg (1000 g) of magnesium oxide. What other things need to be taken into account when working out the true cost of making the magnesium oxide?
8. It is not possible to obtain a 100% percentage yield. For various reasons it is always less. Give some of these reasons.
9. Precipitation reactions take place almost instantly, unlike the reaction between a solid and a liquid. Explain why this is.

Preparation of Zinc Sulfate Crystals

Zinc sulfate tablets, lotion and paste

Your body contains about 2 g of zinc. Zinc deficiency (in other words, not enough zinc in your diet) slows growth and wounds don't heal as quickly as they should. Most people get enough zinc in their normal food. However, if more is needed, a mineral supplement can be bought at a pharmacy or supermarket. It contains zinc sulfate. Often mineral supplements consist of a number of essential minerals, of which zinc is one.

A paste of zinc sulfate and zinc oxide is spread on bandages. These are used to treat acne, a skin disease that causes lots of pimples. Zinc sulfate is an astringent; it closes up the pores of the skin to keep out bacteria. A lotion is a liquid that is put on the skin for a medical purpose, for example, to cure a skin disease, or prevent sunburn.

What you need to do

You must follow the procedure given below to prepare a pure, dry sample of zinc sulfate crystals. You must also measure the yield, and work out the cost of making your product.

Equipment and materials

Read through the procedure and make a list of the apparatus you need. Check it with your teacher. You are also provided with the following chemicals:

- zinc oxide
- 1 mol dm⁻³ sulfuric acid (**IRRITANT**)

Health and safety

- Wear eye protection.
- A risk assessment must be carried out before starting work.

Procedure

- Weigh out between 4.4 g and 5 g of zinc oxide into a weighing bottle or small beaker. You do not need to record the actual mass.
- Measure out 50 cm³ of 1.0 mol dm⁻³ sulfuric acid into a 250 cm³ beaker.
- Warm the acid to about 50 °C and add the zinc oxide, stirring gently. Most of the zinc oxide should react, leaving only a little.
- Allow the reaction mixture to cool and filter the solution into an evaporating basin.
- Gently boil the solution in the evaporating basin to evaporate the water, until only about one-third of the volume is left.

- the sulfuric acid had been 0.1 mol dm^{-3} instead of 1 mol dm^{-3} ?
- the sulfuric acid used had been cooled to about $5 \text{ }^{\circ}\text{C}$ in an ice-bath before the zinc oxide was added?

Explain your answers.

Preparation of Sodium Citrate

Additive E331

Citric acid, like all acids, forms salts. For example, it reacts with sodium hydroxide to make sodium citrate. But it is complicated by the fact that there are three 'sodium citrates' that can be made: mono-, di- and tri-sodium citrate. These are made using different proportions of acid and alkali. Each type helps to keep the acidity of food at a constant value. They are known as acidity regulators (you will see this expression on some food labels). Each type regulates to a different pH value, so they are used in different types of food. Only allowed substances may be added to food. They can be recognised on a label by their E-number. The three sodium citrates all have the same number – E331.

You will prepare tri-sodium citrate. It is used in processed cheese.

What you need to do

Follow the procedure given below to prepare a pure, dry sample of tri-sodium citrate. You must measure the yield, and work out the cost of making your product.

Equipment and materials

Look at the procedure and write a list of apparatus you need. Check this with your teacher. You are also provided with the following chemicals:

- citric acid crystals (monohydrate) (**IRRITANT**)
- 1 mol dm⁻³ sodium hydroxide solution (**CORROSIVE**).

Health and safety

- Wear eye protection.
- A risk assessment must be carried out before starting work.
- The tri-sodium citrate you will make is not pure enough for food use. You must **not** taste it.

Procedure

- Weigh out accurately 3.50 g of citric acid crystals into a beaker.
- Using a pipette and safety filler, add 50.0 cm³ of 1.0 mol dm⁻³ sodium hydroxide solution to the beaker. Stir gently, but thoroughly, until all the crystals have dissolved.
- Gently boil the solution to evaporate the water until only about one-third of the volume is left.
- Transfer the basin to a hot water bath. Continue heating until all the water in the basin has evaporated; beware of spitting. Remove the basin from the bath to cool.

- Label a sample tube with the name of the product, your name and the date. Weigh the labelled sample tube and record its mass.
- Carefully scrape your product from the basin onto a piece of paper. Then carefully tip the product into the sample tube. Weigh the tube again. Record its mass.
- Calculate and record the yield of your product in your notebook and on the sample tube.

Questions

1. The chemical formula for citric acid is $C_3H_5O(COOH)_3$. Is it an organic or inorganic acid? How can you tell?
2. Citric acid is a natural product. Where is it found in nature?
3. Sodium hydroxide is an alkali. What type of chemical reaction occurs when citric acid reacts with sodium hydroxide?

4. The reactants are:

citric acid solution $C_3H_5O(COOH)_3$ (aq)

sodium hydroxide solution NaOH (aq)

and the products are:

tri-sodium citrate solution $C_3H_5O(COONa)_3$ (aq)

water H_2O (l)

Write a word equation and a balanced chemical equation for the reaction.

5. Use the following steps to calculate the theoretical yield (the mass of tri-sodium citrate that could be obtained from the mass of citric acid you used).

Step 1 210 g of citric acid crystals produces 294 g of tri-sodium citrate

Step 2 Therefore, 1 g of citric acid crystals would produce $\frac{294}{210}$ g

Step 3 So, m g would produce $\frac{294}{210} \times m$ g

Step 4 Replace m with the mass of citric acid crystals you used and calculate the theoretical yield of tri-sodium citrate from your preparation.

6. Using this theoretical yield and your actual yield (the mass of tri-sodium citrate you obtained), calculate the percentage yield using:

percentage yield = $\frac{\text{actual yield}}{\text{theoretical yield}} \times 100\%$

7. 50 cm³ of the alkali solution contained 2 g of sodium hydroxide.

- From a chemical supplier's catalogue, find out the cost of the chemicals you used.
- How much would the chemicals cost to make 1 kg (1000 g) tri-sodium citrate?

- What other costs must be included in working out the total cost of making tri-sodium citrate?
8. It is not possible to obtain a 100% percentage yield. For various reasons it is always less. Give some of these reasons.
 9. Predict the effect on the rate of reaction between citric acid crystals and sodium hydroxide solution if the following were changed from the conditions you used for the preparation:
 - the citric acid crystals had been powdered first, using a mortar and pestle?
 - the sodium hydroxide solution had been 0.1 mol dm^{-3} instead of 1 mol dm^{-3} ?
 - the sodium hydroxide solution had been cooled to about $5 \text{ }^{\circ}\text{C}$ in an ice-bath before adding to the citric acid crystals? Explain your answers.
 10. The chemical formula for citric acid is $\text{C}_3\text{H}_5\text{O}(\text{COOH})_3$ and the formula for tri-sodium citrate is $\text{C}_3\text{H}_5\text{O}(\text{COONa})_3$. Suggest the formulae for mono-sodium citrate and di-sodium citrate.
 11. All three sodium citrates (E331), calcium citrate (E332) and potassium citrate (E333) are used as acidity regulators (also called 'buffers'). What is the purpose of an acidity regulator?
 12. Look at food labels at home and in shops. Make a list of food additives, noting which types of foods contain which type of additives. Their E-numbers indicate their purpose, for example acids and acidity regulators have numbers in the E300 range. From your list, what is the other main use of additives in the E300 range?

Preparation of Calcium Benzoate

Additive E213

Benzoic acid is a carboxylic acid. Like all acids it reacts with alkalis to form a salt and water. It also reacts with carbonates to make a salt, carbon dioxide and water. Calcium benzoate (E213) is used as a preservative. It may be made from the reaction between benzoic acid and calcium carbonate.

What you need to do

Follow the procedure given below to prepare a pure, dry sample of calcium benzoate. You must measure the yield, and work out the cost of making your product.

Equipment and materials

Look at the procedure and write a list of apparatus you need. Check this with your teacher. You are also provided with the following chemicals:

- Benzoic acid (**HARMFUL and IRRITATING TO EYES**)
- Calcium carbonate.

Health and safety

- Wear eye protection.
- A risk assessment must be carried out before starting work.
- The calcium benzoate you will make is not pure enough for food use. You must **not** taste it.

Procedure

- Weigh out about 2 g of powdered calcium carbonate into a small beaker.
- Weigh out accurately about 3.0 g of benzoic acid into another beaker. Record the actual mass of acid.
- Add about 50 cm³ of distilled water to the benzoic acid. Heat gently and stir until all the acid has dissolved. Remove from the heat.
- Add 1 spatula of powdered calcium carbonate to the warm solution of benzoic acid. Stir gently with the glass rod until the reaction almost stops.
- Add more calcium carbonate, 1 spatula measure at a time, until no more will dissolve.
- Filter the reaction mixture through a fluted filter paper into an evaporating basin.
- Gently boil the solution to evaporate the water until only about one-third of the volume is left.
- Transfer the basin to a hot water bath. Continue heating until all the water in the basin has evaporated; beware of spitting. Remove the basin from the bath to cool.

- Label a sample tube with the name of the product, your name and the date. Weigh the labelled sample tube and record its mass.
- Carefully scrape your product from the basin onto a piece of paper. Then carefully tip the product into the labelled sample tube and weigh the tube again. Record its mass.

Questions

- Calculate the actual yield of calcium benzoate obtained using
 actual yield of calcium benzoate = (mass of sample tube + product) - (mass of sample tube)
- The chemical formula for benzoic acid is C_6H_5COOH . Is it an organic or inorganic acid? How can you tell?
- What type of chemical reaction occurs when benzoic acid reacts with calcium carbonate?

The reactants are:

benzoic acid solution C_6H_5COOH (aq)

calcium carbonate $CaCO_3$ (s)

and the products are:

calcium benzoate solution $(C_6H_5COO)_2Ca$ (aq)

water H_2O (l)

carbon dioxide CO_2 (g)

Write a word equation and a balanced chemical equation for the reaction.

- Why did the mixture fizz when you added calcium carbonate to the benzoic acid solution?
- Calculate the theoretical yield of calcium benzoate in your preparation:

Step 1 244 g of benzoic acid produces 336 g of calcium benzoate

Step 2 Therefore, 1 g would produce $\frac{336}{244}$ g

Step 3 and m g would produce $\frac{336 \times m}{244}$ g

Step 4 Replace m with the mass of benzoic acid you used to calculate the theoretical yield of calcium benzoate in the preparation.
- Use the theoretical yield and actual yield to calculate the percentage yield using:
 percentage yield = $\frac{\text{actual yield}}{\text{theoretical yield}} \times 100\%$

7. From a chemical supplier's catalogue, find out the cost of the chemicals you used. How much would the chemicals cost to make 1 kg (1000 g) of calcium benzoate? What other costs must be included in working out the total cost of making calcium benzoate?
8. Explain why you did not need to weigh the quantity of calcium carbonate used.
9. It's not possible to obtain a 100% percentage yield. For various reasons it is always less. Give some of these reasons.
10. Predict the effect on the rate of reaction between calcium carbonate and benzoic acid solution if the following were changed from the conditions you used for the preparation:
 - the calcium carbonate had been in the form of marble chips instead of powder
 - the benzoic acid had been dissolved in 100 cm³ rather than 50 cm³ of distilled water
 - the benzoic acid solution had been cooled to room temperature before the calcium carbonate was added

Explain your answers.

Preparation of Copper

An important metal

Copper is unusual. It is one of the very few metals that is not silvery. It is reddish-orange. It has many uses, because it is a good conductor of electricity and heat, and can be easily worked and drawn into wire. Copper wires are used in electrical circuits and copper cookware may be found in kitchens. It is also used to make coins.

The method used here is not how copper is manufactured industrially. However, the method illustrates how a metal can be displaced from a solution of its salts by a more reactive metal.

What you need to do

You must follow the procedure given below to prepare a pure, dry sample of copper. You must also measure the yield, and work out the cost of making your product.

Equipment and materials

Read through the procedure and make a list of the apparatus you need. Check it with your teacher. You are also provided with the following chemicals:

- zinc powder (**FLAMMABLE**)
- copper sulfate crystals (**HARMFUL**).

Health and safety

- Wear protective clothing and eye protection.
- A risk assessment must be carried out before starting work.

Procedure

- Weigh about 6 g of copper sulfate crystals in a 250 cm³ beaker.
- Add 100 cm³ of distilled water and stir until the copper sulfate has dissolved.
- Weigh accurately between 1.1 and 1.3 g of powdered zinc and add it to the copper sulfate solution.
- Stir the mixture for several minutes. When the reaction is complete the solution should be blue (you will only see this when the copper has settled).
- Allow the reaction mixture to settle and filter the solution through a fluted filter paper. Wash the product well on the filter paper with distilled water.
- When the distilled water has drained through the filter paper completely, open the filter paper and place it on a watch glass. Put the watch glass, wet filter paper and product into an oven at 105 °C. Leave it to dry for 2 hours.
- Label a sample tube with the name of the product, your name and the date. Weigh the labelled sample tube and record its mass.

Preparation of Ethyl Butanoate

Pineapple flavouring

Ethyl butanoate is a colourless liquid. It is used to give a pineapple flavour to sweets and drinks such as milk shake. It is a type of organic compound called an ester. Esters can be made by reacting an alcohol with a carboxylic acid. Esters are not salts, so these are not acid-base reactions. The reaction between an alcohol and a carboxylic acid is called an esterification.

Although it is used as a food flavouring, ethyl butanoate does not have an E-number. Food labels usually just say "flavourings", without saying which ones. This is because most flavourings are mixtures of many different compounds.

What you need to do

Follow the procedure given below to prepare a pure, dry sample of ethyl butanoate. You must measure the yield, and work out the cost of making your product. You will need to work **very carefully** in this experiment. Quickfit apparatus is expensive and the main chemicals used are hazardous. Your teacher may show you how to assemble the Quickfit apparatus.

You must also know how to use a separating funnel correctly.

Read the procedure through carefully before beginning any practical work.

Equipment and materials

- Quickfit apparatus for reflux and distillation: 50 cm³ pear-shaped flask; condenser; thermometer holder; adaptors; stands, clamps
- 250 °C or 360 °C thermometer
- 50 cm³ conical flask
- separating funnel
- butanoic acid (**CORROSIVE**)
- ethanol (**HIGHLY FLAMMABLE**)
- concentrated sulfuric acid (**CORROSIVE**)
- 2 mol dm⁻³ sodium carbonate solution
- anhydrous calcium chloride granules (**IRRITANT**)
- calcium chloride solution (5 g anhydrous CaCl₂ dissolved in 5 cm³ water).

Health and safety

- Protective clothing and eye protection should be used.
- A risk assessment must be carried out before starting work.
- Your ethyl butanoate is not pure enough for food use. You may smell it, but you must **not** taste it.

Procedure

- Set up the apparatus for reflux, as shown in figure 1. Remove the condenser temporarily.



Figure 1

- Measure 10 cm³ of butanoic acid into a 10 cm³ measuring cylinder. Weigh the measuring cylinder and acid.
- Pour the butanoic acid into the pear-shaped flask. Reweigh the measuring cylinder. Calculate and record the mass of butanoic acid added to the flask.
- In another 10 cm³ measuring cylinder, measure 7 cm³ of ethanol. Add the ethanol to the flask.
- Carefully add 2 cm³ of concentrated sulfuric acid to the flask, swirling gently to mix the three liquids. Take care that separate layers do not remain.
- Replace the condenser, making sure the joint is firm. Turn on the water through the condenser (in at the bottom, out at the top).
- Boil the mixture in the flask gently for 10 minutes.
- Stop heating and turn off the water. Rearrange the apparatus as shown in Figure 2. Make sure that the thermometer bulb is opposite the condenser.

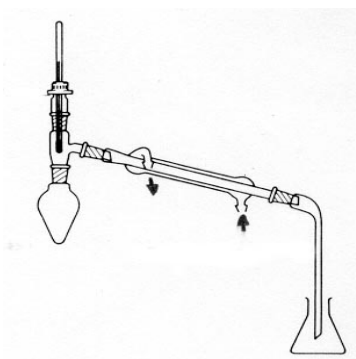


Figure 2

- Put a test-tube at the end of the condenser to collect the low boiling point distillates. Have a small conical flask ready to collect your product. Pass water through the condenser again, and heat the pear-shaped flask **very gently**.
- Watch the thermometer. When the temperature reaches 110 °C put a small conical flask under the end of the condenser instead of the test-tube.
- Continue heating gently, collecting the distillate in the conical flask. Stop heating when the temperature rises above 130 °C. The liquid in the conical flask is your impure product.

Purification of ethyl butanoate

- Pour your impure product into a separating funnel (remember to close the tap first). Add 5 cm³ of 2 mol dm⁻³ sodium carbonate solution. Put the stopper in the top.
- Turn the funnel so the stopper is at the bottom and hold it in place with the palm of your hand. Give the funnel one shake. Carefully open the tap to release any gas and close it again. Repeat this twice more.
- Repeat the shaking procedure again – but shake more vigorously – until no more gas is given off.
- Turn the funnel so that the stopper is at the top and clamp it. Allow the liquids to separate into two layers. Remove the stopper and carefully run off the lower layer into a test-tube. Stop when the line between the two layers reaches the tap. If any of the top layer runs through, pour all the liquid back into the funnel and try again.
- Your product is in the separating funnel. Add 5 cm³ of calcium chloride solution. Replace the stopper, and hold it in while shaking for 1 minute. This removes unreacted ethanol from the impure product. Allow the liquids to separate and run off the lower layer as before, leaving your product in the funnel.
- Run off your product into the small conical flask. It is cloudy because it contains a small amount of water. Add a few anhydrous calcium chloride granules. Stopper the flask. Label it with your name and the name of the product. Leave the flask overnight. Note: the calcium chloride absorbs water, leaving your purified ethyl butanoate dry.
- Next practical session, check that your product is clear. If it is cloudy, it is still wet. Add more anhydrous calcium chloride and swirl gently until it clears.
- Label a sample tube with the name of the product, your name and the date. Weigh the labelled sample tube and record its mass
- When your ethyl butanoate is clear and dry, carefully pour it into the sample tube. Make sure the calcium chloride does not get into the sample tube. Weigh the tube again and record its mass.
- Calculate and record the yield of your product in your notebook and on the sample tube.

Questions

- The chemical formula for butanoic acid is $\text{C}_3\text{H}_7\text{COOH}(\text{l})$, and for ethanol is $\text{C}_2\text{H}_5\text{OH}(\text{l})$. Are these organic or inorganic chemicals? How can you tell?
- Ethanol is an alcohol. What type of chemical reaction occurs when an acid reacts with an alcohol? (Note: an alcohol is **not** an alkali.)
- The products of the reaction are:

ethyl butanoate $\text{C}_3\text{H}_7\text{COOC}_2\text{H}_5(\text{l})$

water $\text{H}_2\text{O}(\text{l})$

Write a balanced chemical equation for the reaction.

- Use the following steps to calculate the theoretical yield (the mass of ethyl butanoate that could be obtained from the mass of butanoic acid you used).
 - 88 g of butanoic acid produces 116 g of ethyl butanoate
 - Therefore, 1 g would produce $\frac{116}{88}$ g
 - So, m g would produce $\frac{116}{88} \times m$ g
 - Replace m with the mass of butanoic acid you used and calculate the theoretical yield of ethyl butanoate from the mass of butanoic acid you used
- Using this theoretical yield and your actual yield (the mass of ethyl butanoate you obtained), calculate the percentage yield.
- From a chemical supplier's catalogue, find out the cost of the butanoic acid and ethanol you used. How much would these chemicals cost to make 1 kg (1000 g) ethyl butanoate? What other costs must be included in working out the total cost of making ethyl butanoate?
- Ethyl butanoate occurs naturally in pineapples. However, suggest why pure ethyl butanoate neither smells nor tastes like real pineapple.
- Try to find the names of some other esters that are used as food flavourings, and which flavour each ester gives. There are many different esters, but most of them are **not** used as flavourings. Do not include these in your list.
- You used sodium carbonate to remove acids from your impure product. What gas is produced when a carbonate reacts with an acid?
- The reaction in this preparation is reversible.

Explain what this means. Find out what factors affect the yield of product in a reversible reaction and how quickly the reaction takes place.