1001 Inventions

United Nations Educational, Scientific and Cultural Organization

2019 IYPT International Year of the Periodic Table of Chemical Elements

ROYAL SOCIETY OF CHEMISTRY

1001 Inventions

Journeys from Alchemy to Chemistry

Educational Workshops

Acknowledgments

This educational guide is part of *"1001 Inventions: Journeys from Alchemy to Chemistry"* - a global initiative produced by 1001 Inventions, in partnership with UNESCO, to celebrate the United Nations proclaimed International Year of the Periodic Table of Chemical Elements (IYPT2019). For more information and resources, visit: www.1001inventions.com and www.iypt2019.org

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Introduction

This document includes a range of hands-on workshops and science demonstrations to help children between ages 7 and 14 improve their understanding of chemistry and its numerous applications. The activities introduce children to the fascinating journey from alchemy to chemistry, across the ages, undertaken by lesser-known pioneers from ancient cultures and civilisations that still influence our world today.

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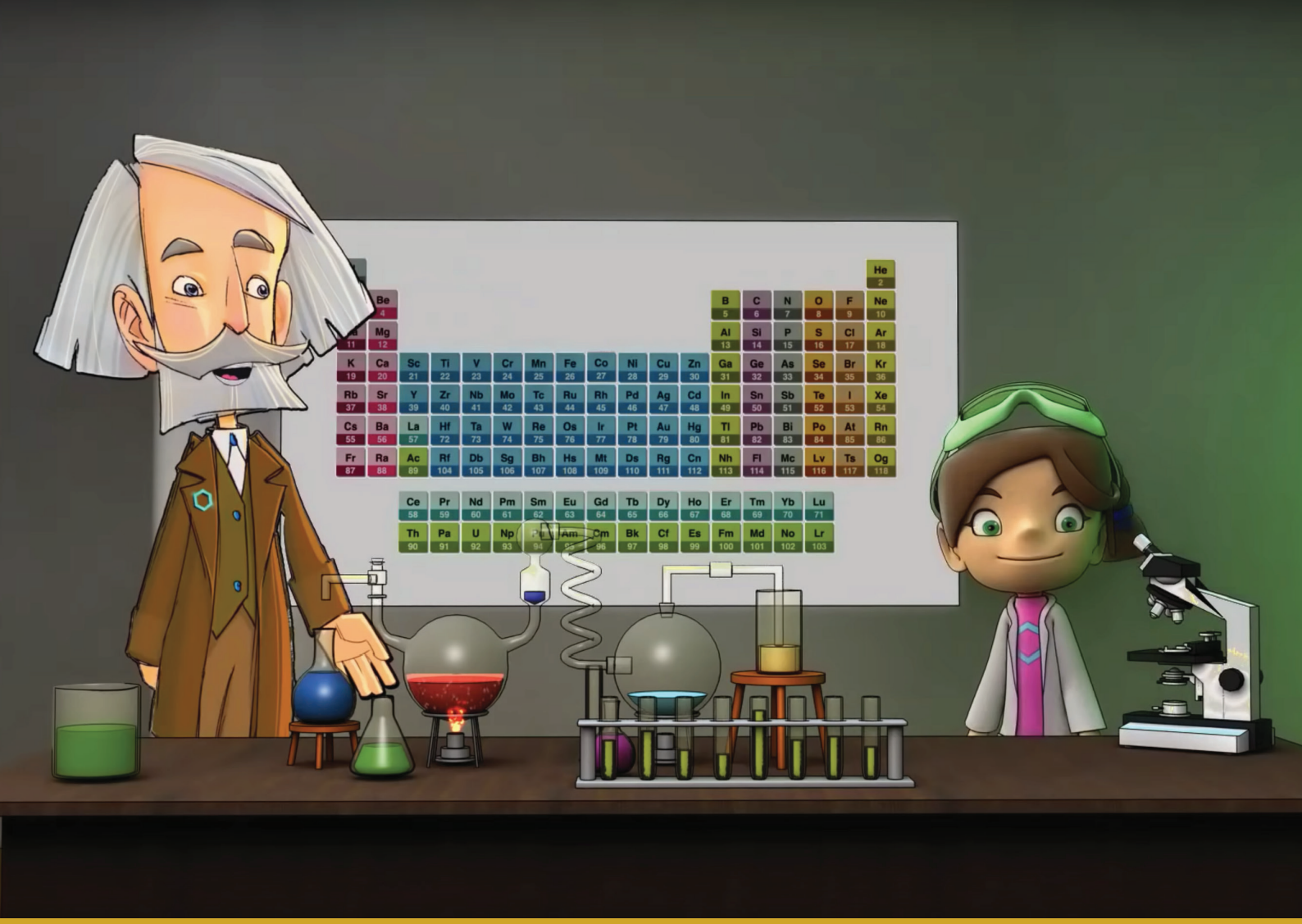
Journeys from Alchemy to Chemistry

"1001 Inventions: Journeys from Alchemy to Chemistry" is a public engagement with science initiative produced by 1001 Inventions in partnership with UNESCO to celebrate the International Year of the Periodic Table of Chemical Elements (IYPT2019).

Through live events, short films, science theatre, hands-on workshops, and educational resources, this global initiative aims to promote science education for all and to raise awareness of the importance of chemistry and its applications, while promoting diversity and intercultural appreciation.

For more information, please visit:
www.1001inventions.com/chemistry



Short Animated Video

Celebrate science, chemistry and diversity by running the workshops and demonstrations in this document with your children and pupils! Spark their imagination and creativity and help foster a new generation of explorers and experimenters! Complement the activities by first watching “1001 Inventions: Journeys from Alchemy to Chemistry” short animated video and join a wondrous journey through an exciting world of science from over one thousand years ago.

The short animated video is narrated by Professor Jim Al-Khalili, renowned scientist, author and broadcaster. It brings to life the contributions made by lesser-known pioneers from ancient cultures and civilisations to the foundations of modern chemistry. It includes the remarkable work of the 8th century pioneering polymath Jabir ibn Hayyan.

You can find the video on YouTube, using this link:
https://bit.ly/34hmVwd

Jabir ibn Hayyan

The 8th century pioneer Jabir ibn Hayyan, also known as Geber, spent most of his life in Kufa, Iraq. This was the height of the **golden age of Arabic science** — a creative era that spanned a thousand years from the 7th century onwards, from Spain to China, bringing forth many far-reaching advances in science and technology by men and women of different faiths and cultures. They collected, translated, corrected, and added to knowledge of ancient civilisations in the Arabic language, enabling it to become the lingua franca of the time. Arabic served as the language of science, poetry, literature, governance, and art.Such contributions added crucial value to the accumulation of scientific knowledge that still shape our world today.

Jabir ibn Hayyan, a remarkable polymath, who made significant contributions to chemistry, devised and perfected sublimation, liquefaction, crystallization, distillation, purification, amalgamation, oxidation, evaporation, and filtration. He developed precise measuring equipment and discovered sulfuric, nitric, and nitromuriatic acids, all of which are vital to the chemical industry nowadays. His research and publications, including the *Great Book of Chemical Properties, The Weights and Measures, The Chemical Combination,* and *The Dyes*, opened the way for modern chemistry and guided scientists during the centuries that followed.

Activity 1

Make a liquid change colour

Suggested age group

- 5-14

Learning objectives

- To investigate the chemical properties of common everyday substances.
- To learn that acids and alkalis play an important role in chemistry and react differently in indicator solutions.
- To learn that substances like vinegar are acidic, while substances like baking powder (bicarbonate of soda) are alkaline.
- To learn how scientists from the golden age of Arabic science contributed to our knowledge of acids and alkalis.

About this activity

- Acids and alkalis are types of chemicals. When they are very strong, they can be dangerous. But you can find weaker acids and alkalis in everyday substances, such as lemon juice and bicarbonate of soda.
- Red cabbage juice is an acid-base indicator (pH indicator). Acidic substances should make the cabbage juice turn bright pink. Alkalis should turn it a bluish colour.
- In this activity you will investigate common everyday substances and identify which ones are acids and which ones are alkalis using red cabbage juice.

Time

- 1 hour

Activity 1

Make a liquid change colour

Kit list

- A red cabbage
- A wooden spoon
- Clear cups/glasses
- A bowl
- A sharp knife
- A jug of water
- Different substances to test (including water, lemon juice, bicarbonate of soda, tomato ketchup, cola, liquid soap, washing powder…)

Watch out!

- You will need an adult to help you cut and mash up the red cabbage.
- Don't test dangerous liquids/substances – always check with a responsible adult first.

Instructions

1. Finely slice ¼ of a red cabbage.
2. Put all the chopped-up cabbage into a bowl and add a cup of water (roughly 250 mL).
3. Take the wooden spoon and mash up the cabbage in the water.
4. When the water in the bowl has turned a vibrant purple colour, sieve it into a pouring jug.
5. Pour approximately 1 cm of purple liquid into some clear cups or glasses.
6. Choose one of the substances and add some of it to one of the cups (vinegar is a good one to start with). Observe what happens.

Activity 1

Make a liquid change colour

7. Choose another substance and add it to a different cup. Observe what happens. Continue until you've tested all the substances.
8. Sort the cups into two groups. Acids will have turned the cabbage juice a reddish, pink colour. Alkalis a bluish, purple colour.

Did you know?

- The word "alkali" is derived from the Arabic word *al-qali* and refers to an early source of alkalis, the ashes of burnt plants. These were used during the golden age of Arabic science to make soap.
- The 8th-century pioneering polymath Jabir ibn Hayyan, vastly increased the possibilities of chemical experiments by discovering sulfuric, nitric, and nitromuriatic acids, all now vitally important in the chemical industry.

Next steps

- What other substances could you test? What happens if you add milk to red cabbage juice? Or orange juice?

Activity 2

Make metal rust

Suggested age group

- 7-14

Learning objectives

- To learn that oxidation is an irreversible chemical reaction in which oxygen reacts with other substances.
- To learn that rusting is a type of oxidation reaction.
- To learn how scientists during the golden age of Arabic science contributed to our understanding of chemical reactions like oxidation.

About this activity

- When substances break apart or join together to form new substances, this is known as a chemical reaction. Most chemical reactions are irreversible – they only go one way. Oxidation is an irreversible chemical reaction in which oxygen reacts with other substances. When metal rusts, this is a type of oxidation reaction.
- In this activity, you will observe an oxidation reaction taking place.

Time

- 1 hour

Kit list

To make metal rust quickly, you will need:

- Wire wool
- Vinegar
- A glass jar or a glass

Activity 2

Make metal rust

- A bowl
- A thermometer
- Cardboard
- Scissors
- Clingfilm/cloth

Watch out!

- Be careful when handling the wire wool and make sure you clear up any spillages.

Instructions

1. Wrap the wire wool around the thermometer and record the temperature.
2. Put the wire wool in a bowl and pour vinegar over it so that it is completely covered. Let it sit for a minute.
3. Remove the wire wool and shake it dry.
4. Put the wire wool into a glass jar. Push the thermometer into the middle of the wire wool and cover the top of the jar with a cloth or clingfilm.
5. After 20 minutes, check the thermometer – has the temperature risen?
6. Remove the wire wool. You will find that it has gone rusty.

Did you know?

- Wire wool is covered by a protective coating which the vinegar strips away, exposing it to the oxygen in the air. The iron in the wire wool reacts with the oxygen to form a new substance, iron oxide (rust). The temperature increased because this is an exothermic reaction, which is a chemical reaction that releases energy in the form of heat.

Activity 2

Make metal rust

- Jabir ibn Hayyan was born in 722 and spent most of his life in Kufa, Iraq. He studied many chemical processes, including oxidation, and devised the ancestor of anti-rust paint. He wrote many famous books including *The Great Book of Chemical Properties, The Weights and Measures, The Chemical Combination,* and *The Dyes*.

Next steps

- What other types of oxidation reaction can you find out about?

Notes

Activity 3

Make your own filter

Suggested age group

- 5-14

Learning objectives

- To experiment with different materials to make a filter.
- To learn that insoluble solids do not dissolve in liquids and can be separated by the process of filtration.
- To learn that soluble solids do dissolve in liquids and can't be separated by the process of filtration.
- To learn how scientists during the golden age of Arabic science contributed to the development of filtration.

About this activity

- Throughout history, access to clean drinking water has been a vital requirement for any civilisation. The process of filtration can clean dirty water.
- Filtration is used to separate an insoluble solid from a liquid. Insoluble solids do not dissolve in liquids. Soluble solids do dissolve in liquids.
- In this activity, you will make your own filter and use it to clean dirty water.

Time

- 1 hour

Kit list

To build a filter, you will need:

Activity 3

Make your own filter

- A large clear plastic bottle
- Two clear jars or beakers
- Cotton wool
- Clean, washed sand
- Clean, washed gravel
- Paper/kitchen towels
- Garden soil
- An old spoon
- Scissors

Watch out!

- Be careful when you cut the bottom off of the bottle.
- Make sure you wash your hands after handling the soil and gravel.

Instructions

1. Carefully cut the bottom of the bottle, turn the top half of the bottle upside down and plug the neck with the cotton wool.
2. Put a good thick layer of sand on top of the cotton wool.
3. Spoon in a deep layer of gravel.
4. Cut out a disc of kitchen/paper towel big enough to cover the gravel and place it on top.

   You have now constructed your filter and are nearly ready to test it. All you need to do is stand the filter (with the cotton wool at the bottom!) on top of the beaker.
5. Take three spoonfuls of the garden soil and mix it in with some water so that you have a beaker containing a runny, muddy water solution.
6. Carefully pour the muddy water solution into your filter, on top of the paper towel disc and wait to see what comes out at the other end. Is the filtered water cleaner?

Activity 3

Make your own filter

7. Replace the paper towel. Dissolve some salt in water. Then carefully pour the salty water into your filter – has the salt been removed?

Did you know?

- Rivers and lakes supply us with most of the water we need for drinking, cooking, washing, and cleaning. Before we use river or lake water it has to be cleaned – you have just made a water filter that will clean dirty water.
- The filter process allows the water to flow slowly through a granular bed (or filter) of varying grades – in this case, the paper towel, followed by the sand, then the gravel and finally, the cotton wool. These filters hold onto most of the solid matter (the mud, small stones etc.) and allow the water to pass through.
- When a soluble solid (like salt) is dissolved in a liquid it forms a solution. Filters can't separate solutions because the soluble solid particles in the solution are too small.
- Jabir ibn Hayyan, the pioneering polymath who flourished during the golden age of Arabic science, devised and perfected many of these processes in the 8th century, including filtration. He wrote many famous books including *The Great Book of Chemical Properties, The Weights and Measures, The Chemical Combination,* and *The Dyes*.

Next steps

- Once you've made your filter, how could you improve it? What other materials could you use? Do they make the water even cleaner?

Activity 4

Burning paper

Suggested age group

- 7-14

Learning objectives

- To learn about the properties of different liquids.
- To learn that mixtures of liquids can behave in surprising ways.
- To learn how scientists during the golden age of Arabic science contributed to the development of our understanding of combustion.

About this demonstration

- The 8th century pioneering polymath Jabir ibn Hayyan carried out many experiments, including attempts to make paper that would not burn. In this demonstration, you will set paper on fire but it will not burn because of the solution it has been soaked in.

Time

- 15 minutes

Kit list

For this demonstration, you will need:

- Water
- Salt
- A saucer
- Alcohol (70% vol. or 90% vol.)
- A small piece of paper
- Tongs
- Matches or an electronic gas lighter
- A fire extinguisher/fire blanket

Activity4

Burning paper

Watch out!

- Only a responsible adult should attempt this demonstration. Great care must be taken when handling alcohol and matches/a lighter. When attempting this demonstration wear protective gloves and make sure you have a fire extinguisher or fire blanket. Also ensure that the audience is at a safe distance.

Instructions

1. Mix 3 teaspoons of water and 1 teaspoon of salt together in the saucer and stir until it dissolves.
2. Mix in 4 teaspoons of alcohol (3 teaspoons are enough if using 90% vol. alcohol).
3. Soak your small piece of paper in the mixture then pick it up with the tongs.
4. Hold it well away from yourself or anyone else, then set it on fire.

Did you know?

- The paper will burn if you dip it into a pure alcohol solution. Here, the water in the mixture evaporates and absorbs much of the heat energy that is generated when you ignite the paper. The water is first heated to its boiling point and then vaporized by the heat of combustion from the burning alcohol. The evaporation of the water keeps the temperature below the ignition temperature of paper, which is 233°C. If you reduce the amount of water in the mixture, the piece of paper is likely to char or even catch on fire.

Next steps

- You can make this demonstration more exciting by using money instead of paper.

Activity 5

Make your own paper

Suggested age group

- 7-14

Learning objectives

- To learn how paper is made.
- To learn about the importance of paper and paper-making during the golden age of Arabic science.
- To learn how pioneers during the golden age of Arabic science contributed to the development of paper-making.

About this activity

- Thanks to Chinese scholars who passed on the technology of paper-making, books could be written to spread scientific ideas during the golden age of Arabic science.
- Paper is often made of thousands of tiny, long, thin strands of wood, squashed together. These strands, or fibres, can be separated out and reused to make new, homemade paper. In this activity, you will make your own recycled paper.

Time

- 2 hours to make the paper. 3 days for the paper to fully dry.

Kit list

To make paper, you will need:

- A coat hanger
- An old pair of tights
- A tray
- Newspaper

Activity 5

Make your own paper

- Kitchen towels
- PVA glue
- Cotton wool balls
- A mixing bowl
- A cup
- Food dye (optional)
- A plastic bag
- A rolling pin

Watch out!

- Making your own paper can be quite messy. Make sure you cover the area that you're working in and clean up afterwards.

Instructions

1. Bend the wire coat hanger to make it into a square. Pull one leg of an old pair of tights over it to make a 'screen'.
2. Spread several layers of newspaper on a tray. Cover them with a layer or two of kitchen towels.
3. Tear some scrap paper into small pieces. Put the pieces in the mixing bowl until you have about four cupfuls.
4. Add enough water to cover the paper (add more if the paper soaks it all up). Leave it to soak for an hour. Then, add a tablespoon of PVA glue.
5. Use your fingers to break up the paper in to smaller pieces. After ten minutes or so, it will be a thick mixture.
6. To make the paper stronger, stir in torn-up cotton wool balls. Add food dye for colour (optional).
7. Put the screen on top of the towels in the tray. Spoon the mixture onto it and spread it out in a thin layer.

Activity 5

Make your own paper

8. Lay a plastic bag on top. Roll over it with the rolling pin to even out the pulp and squeeze out the water.
9. Peel off the plastic bag and lift out the screen. Lay it on some fresh newspaper and paper towels. Leave it to dry.
10. After about three days, the pulp should be dry. Peel it off the screen. You will have a piece of recycled paper.

Did you know?

- Papermakers during the golden age of Arabic science pioneered the use of the trip hammer, a tool for beating linen rags or tree roots into the pulp used to make paper.
- All the hand mixing and mashing that went into making paper in China was done by mills in the Arab world. Mills started in Baghdad and spread to other cities to meet the demand. Damascus - where Arabian paper was made (suitably known in Europe as charta damascena- Damascus paper) became the main supplier of paper to Europe until the 15th century.

Next steps

- How good is the paper that you've made? What is the best use for it? You could devise tests to find out how strong or absorbent it is.
- You could also find out what happens to paper in a paper recycling factory.

Activity 6

Make your own soap

Suggested age group

- 7-14

Learning objectives

- To learn how soap is made.
- To learn that soap is made by a chemical reaction between an alkali and an oil.
- To learn how scientists during the golden age of Arabic science contributed to the development of soap.

About this activity

- During the golden age of Arabic science, personal hygiene was considered important. Chemists refined soap-making methods and soap was used in the *hammams* or bathhouses. It was made on an industrial scale, especially in Nablus, Fes, Damascus, and Aleppo. To make soap, a mixture of oil, *al-qali* (an alkaline substance), and sweet or spicy smelling ingredients were boiled and left to harden in a mould.
- In this activity, you will colour and perfume some soap in a way described in a 700-year-old recipe.

Time

- 15 minutes

Kit list

To make soap, you will need:

- Safety glasses
- Clear soap base (meltable soap blocks)

Activity 6

Make your own soap

- A pan (preferably with a pouring spout) and access to a hob for melting, or a jug and access to a microwave
- A wooden spoon
- Saffron
- Thyme oil
- Silicone moulds (or equivalent – the moulds will need to be able to withstand a high temperature and be slightly flexible to remove the hardened soap)

Watch out!

- Wear safety goggles at all times while heating the soap base.
- Take care when stirring and pouring the mixture – it will be extremely hot.

Instructions

1. Place small blocks of the soap base into the pan or jug and carefully and slowly heat. The soap will need to reach a temperature of around 120°C before it fully melts, so take great care. If using a microwave, heat for short bursts at a time and stir in between.
2. Remove the soap from the heat once it is completely melted.
3. Sprinkle in strands of saffron and stir. Watch the colour develop.
4. Pour in thyme oil (the oil is strong but you may need a significant number of drops to achieve a good perfume). Stir and smell the mixture as you add the drops.
5. Carefully pour the mixture into moulds.
6. Leave the soap to set (refrigerating it will speed up the process).

Activity 6

Make your own soap

Did you know?

- Perfumed, coloured liquid and solid soaps were all made by chemists during the golden age of Arabic science and used widely. Making soap requires a strong alkali or basic substance to be mixed with oil.
- In the 9th century, a basic substance named *al-qali* (which has the same derivation as our word alkali) was obtained by leaching ashes, and reacted with olive oil to produce soap.
- Over time, people managed to produce caustic soda (sodium hydroxide, a strong base) from wood ashes and burnt lime (calcium oxide). Nowadays, we still use strong base chemicals like sodium hydroxide, but they are produced with extremely different processes.

Next steps

- How does the soap that you've made compare to different types of soap you can buy from a shop? How could you test which is best at cleaning your hands? Or which has the nicest smell?
- You could also research why using soap to stay clean is so important.

Activity 7

Make your own crystals

Suggested age group

- 5-14

Learning objectives

- To grow crystals and observe the process of crystallisation.
- To learn that a crystal is a solid that contains particles joined together in a regular arrangement or repeating pattern.
- To learn what a saturated solution is.
- To learn how scientists during the golden age of Arabic science contributed to our understanding of crystals and crystallisation.

About this activity

- A crystal is a solid containing particles (atoms, molecules or ions) joined together to form a regular arrangement or repeating pattern. Crystals are formed by the process of crystallisation.
- In this activity, you will grow your own crystals and observe the process of crystallisation.

Time

- 40 minutes to make the salt solution. 2 - 3 days for the salt crystals to grow.

Kit list

To make crystals, you will need:

- 8-10 tbsp of salt flakes
- An empty jam jar
- A heatproof jug
- 300 mL boiling water
- 2 pipe cleaners

Activity 7

Make your own crystals

- 1 pencil
- Blue food colouring

Watch out!

- This activity involves boiling water – ask an adult to help you and be careful!

Instructions

1. Cut one pipe cleaner into quarters.
2. Take three pieces and wrap them together at the centre. Pull the ends into a six-pointed star shape.
3. Wrap one end of the other pipe cleaner around the middle of the star. Twist the other end around the centre of the pencil. Balance the pencil on the edges of the jar so the star hangs in the salt solution - the star must hang freely in the solution, not touching any sides.
4. Pour the boiling water into the heatproof jug.
5. Add the salt flakes gradually and stir until dissolved. Repeat until the solution is saturated (this is when no more salt can be dissolved in the water).
6. Stir in a couple of drops of blue food colouring.
7. Pour carefully into the jar so it covers all of the star.
8. Leave it for a couple of days and watch the crystals grow.

Did you know?

- As you stir salt into the hot water, it dissolves until you reach the point where no more salt can be dissolved into the solution called a saturated solution. When the saturated solution starts to evaporate, there's more salt in the solution than it can hold, so the salt starts to come out little by little. It starts to form

crystals on the rough surface of the pipe cleaners and the crystals slowly grow and grow.

- Jabir ibn Hayyan was born in 722 and spent most of his life in Kufa, Iraq. He devised and perfected many chemical processes, including crystallisation, and wrote many famous books including *The Great Book of Chemical Properties, The Weights and Measures, The Chemical Combination,* and *The Dyes*.

Next Steps

- Once you've grown some crystals, remove them from the liquid and examine them using a magnifying glass or microscope. Are they all the same?

Activity 8

Make your own dye

Suggested age group

- 5-14

Learning objectives

- To experiment with different ingredients to make dyes.
- To learn that a dye is a mixture of a solvent and solute. The solute dissolves in the solvent to form a solution.
- To learn about the history of dyeing.
- To learn how scientists during the golden age of Arabic science contributed to the development of dyeing.

About this activity

- People have been dyeing textiles since Neolithic times. Throughout most of history, dyes were made using natural materials like roots, berries, bark, leaves, wood, fungi, and lichens. The first man-made (synthetic) dye, mauveine, was discovered by accident by a British chemist called William Henry Perkin in 1856 (he was actually searching for a cure to malaria). Since his discovery, thousands of synthetic dyes have been developed. A vast array of colourful, natural dyes was produced during the golden age of Arabic science. In the city of Fez alone, there were 116 dye works.
- In this activity, you will make dyes using a range of natural ingredients and then use them to dye fabrics.

Time

- 1 hour

Kit list

To make your own dye, you will need:

Activity 8

Make your own dye

- A small saucepan
- A strainer
- Water
- A hob
- Beakers or glass jars
- White fabric/a white t-shirt
- A sharp knife
- Different natural ingredients including blackberries, blueberries, red cabbage, raspberries, orange/lemon peel, spinach, onion skins. You could also try different flower petals.

Watch out!

- You will need a responsible adult to help you to chop up the ingredients and to heat your dye mixture.

Instructions

1. Select one of the natural ingredients and finely chop it. You will need a cupful.
2. Add the chopped ingredient to a small saucepan and cover with twice as much water as the fruit or vegetable.
3. Place over a medium heat, and bring to a simmer for one hour.
4. Turn off the heat, and let the water cool down to room temperature.
5. Strain the cooled dye into a plastic container.
6. To create long-lasting coloured fabrics, place the material that you want to dye in a fixative. For fruit dyes, simmer the fabric in ¼ cup of salt and 4 cups of water. For vegetable dyes, simmer in one cup vinegar and four cups water. Boil for one hour.
7. Rinse the article of clothing in cold water, and then soak it in the natural dye until it reaches the desired colour.

Activity 8

Make your own dye

8. Repeat with a different natural ingredient – what coloured dye do you want to make this time?

Did you know?

- A solvent is a liquid that dissolves substances. The substance that dissolves is called the solute and the mixture formed by a solvent and solute is called a solution. A dye is a coloured substance that sticks to the material to which it is being applied. The dye is normally added to an aqueous solution which is a solution in which the solvent is water.
- During the golden age of Arabic science, yellows were made from saffron extracted from a crocus flower. Reds came from qirmiz, an insect that produced a brilliant red colour. Today, foods with red colouring, like strawberry milk, often contain the extract of cochineal bugs, another form of dye introduced during the golden age of Arabic science.

Next steps

- Once you've used the different natural ingredients to make dyes, try mixing them together. What new colours can you make?

Activity 9

Make your own ink

Suggested age group

- 5-14

Learning objectives

- To experiment with different ingredients to make and test ink.
- To learn about the importance of ink during the golden age of Arabic science.

About this activity

- During the golden age of Arabic science, thousands of books and manuscripts were produced. At one point, Baghdad had 36 libraries and more than one hundred book dealers. The library of the Zaytuna Mosque in Tunisia had more than 100,000 books.
- Ink was produced on a vast scale. Gold and silver inks were used on blue paper to create impressive front pages for books. Artists used reed pens called qalams and different colours of ink to write on paper in a decorative script known as Arabic calligraphy.
- In this activity you will make and test your own ink using ingredients similar to those that were used over one thousand years ago.

Time

- 1 hour

Kit list

To make ink, you will need:

Activity 9

Make your own ink

- Crushed charcoal
- Egg yolks
- Egg whites
- Olive oil
- Water
- 4 Beakers (other plastic containers or cups could also be used)
- A stirring stick/spoon
- Paint brushes
- White paper

Watch out!

- Check that no one is allergic to eggs before you make the ink.
- When you make the ink, ensure that it is not too runny and not too thick. Slowly add the crushed charcoal and keep checking the thickness.

Instructions

1. Get 4 beakers. Fill one with some egg yolks (4 – 5 should be enough), one with some egg whites, one with olive oil (approximately 1cm deep) and one with water (approximately 1cm deep).
2. Add some crushed charcoal to each container and stir until you have a thick paste.
3. Use paint brushes to write with each ink on a piece of white paper. Which ink is easiest to write with?

Did you know?

- In 953, the Ruler of Egypt, tired of having ink stain his hands and clothes, asked for a leak-proof pen that held its own ink. What he got was much like today's fountain pen.

Activity 9

Make your own ink

Next steps

- Once you've made your ink, can you use it to write in an Arabic style? Research Arabic calligraphy and copy some of the patterns.

Activity 10

Make the perfect cup of coffee

Suggested age group

- 7-14

Learning objectives

- To investigate what factors affect how quickly substances dissolve.
- To learn that some solids are soluble, while others are insoluble.
- To learn about the history of coffee.

About this activity

- More than 1.5 billion cups of coffee are drunk worldwide every day – enough to fill nearly 300 Olympic-size swimming pools. Coffee is a global industry and most high streets have at least one coffee shop.
- People in parts of the Muslim world were sipping coffee as early as the 9th century. The drink didn't catch on in Europe for another 700 years.
- One way of making coffee is by adding 'instant' coffee powder to hot water and stirring it. In this activity, you will investigate what factors affect how quickly the coffee powder dissolves.

Time

- 1 hour

Activity 10

Make the perfect cup of coffee

Kit list

To investigate coffee, you will need:

- Instant coffee powder
- Spoons
- 4 Beakers (other plastic containers or cups could also be used)
- Timer

Watch out!

- This investigation involves using hot water. Make sure a responsible adult helps you.

Instructions

1. Fill 4 beakers with water at different temperatures (icy cold, room temperature, lukewarm, and hot – but not boiling).
2. Add 2 spoonfuls of coffee to the beaker which contains icy cold water. Stir and time how long it takes for all of the coffee powder to dissolve.
3. Repeat for the other beakers.
4. Did the temperature of the water affect how quickly the coffee powder dissolved?

Did you know?

- A solvent is a liquid that dissolves substances. The substance that dissolves is called the solute and the mixture formed by a solvent and solute is called a solution. The components of a solution are mixed together completely and do not separate out.
- Substances that can dissolve in a particular solvent are soluble. Substances that cannot dissolve in a particular solvent are insoluble. Coffee powder is a soluble substance.

Activity 10

Make the perfect cup of coffee

- It is believed that an Abyssinian goat herder in what is now Ethiopia discovered coffee 1200 years ago when his goats got an energy boost after eating some red berries. People soon began boiling the berries to make coffee.
  Travel and trade spread the popular drink to Yemen, Mecca, Damascus, Baghdad, Istanbul, and to Europe and beyond.

Next steps

- Once you've tested the 'instant' coffee powder, you could test other soluble solids like sugar or salt. Do they dissolve more quickly than coffee powder?

Activity 11

Make your own bath bomb

Suggested age group

- 5-14

Learning objectives

- To experiment with different ingredients to make bath bombs.
- To learn about the history of cosmetics.
- To learn that when an acid (like citric acid) is mixed with a carbonate (like bicarbonate of soda), they react to form carbon dioxide gas.
- To learn how scientists during the golden age of Arabic science contributed to the development of cosmetics.

About this activity

- Cosmetics have been in use for thousands of years. Since Ancient Egyptian times, people have made products to make them look and smell better. During the golden age of Arabic science, people went to great lengths to keep up their appearance and many parts of the modern cosmetic industry began and were developed during this time.
- In this activity, you will make and test your own cosmetic product – bath bombs!

Time

- 1 hour to make the bath bombs. 3 – 4 days for the bath bombs to set.

Activity 11

Make your own bath bomb

Kit list

To make bath bombs, you will need:

- Food colouring
- Sweet almond oil or another light vegetable oil
- An essential oil (make sure it is suitable to put in bath bombs and that it's not for oil burners or candles)
- 10 tablespoons of bicarbonate of soda
- 3 tablespoons of solid citric acid (you can buy this from chemists and some supermarkets)
- Large mixing bowls - glass works best
- A muffin tray or other mould
- A small glass jar
- A mixing spoon
- A whisk

Watch out!

- Make sure you wash your hands before and after making the bath bombs.
- Don’t eat any of the ingredients!

Instructions

1. Use the almond oil to lightly grease the muffin tray or mould.
2. Mix the citric acid and bicarbonate of soda together in a glass bowl. Make sure you get any lumps out.
3. Mix together 12 drops of your essential oil, 10 teaspoons of sweet almond oil and 15-20 drops of food colouring. Don't use any more food colouring, otherwise it will turn your bath a funny colour!
4. Gradually pour the oil mixture into the dry mixture, stirring well. If the mixture starts to foam, you're adding the oil too quickly.

Activity 11

Make your own bath bomb

The mixture is ready when it has the consistency of damp sand.

5. Spoon the mixture into the muffin tray and press down firmly. It should make 2-4 bath bombs, depending on the size of your muffin tray.
6. Leave the bath bombs to set for a few days. Then drop them into water and see what happens.

Did you know?

- When you drop your bath bomb into water, this sets off a chemical reaction between the citric acid and the bicarbonate of soda. During the reaction, carbon dioxide is made, which causes the fizzing. The almond oil moisturises your skin and the essential oils smell nice.
- Al-Zahrawi was a physician and surgeon from 10th century Al-Andalus whose ideas and discoveries revolutionised medicine. He considered cosmetics to be a branch of medicine that he called 'the medicine of beauty'. In his book, *The Method of Medicine,* he dedicated a whole chapter to cosmetics, in which he wrote about nasal sprays, mouthwashes, hand creams, hair dyes, and moulded perfume sticks which may be the earliest versions of lipstick and roll-on deodorant.

Next steps

- Once you've made some bath bombs, experiment by changing the quantities of the different ingredients. Can you make an even fizzier bath bomb?

Activity 12

Make your own simple distillation still

Suggested age group

- 7-14

Learning objectives

- To learn that the process of distillation separates substances with different boiling points through a process of heating them and then collecting the condensation.
- To learn that a soluble solid (e.g. salt) can be separated from a liquid (like water) through a process of heating and cooling (distillation).
- To learn how scientists during the golden age of Arabic science contributed to the development of our understanding of distillation.

About this activity

- Distillation is the process of heating substances with different boiling points to separate them, then collecting the condensation, which should be relatively "pure". Without distillation, we would have no gasoline, kerosene, asphalts, or plastics. It has been known to chemists during the golden age of Arabic science since the 8th century. Its first and most renowned application was in the production of rose water and “essential oils”.
- In this activity, you will make your own simple distillation still and use it to separate salt from water.

Time

- 1 hour

Activity 12

Make your own simple distillation still

Kit list

To make an Alembic still, you will need:

- Salt
- A cooking pot or crucible
- A heat source like an oven hub or tea light
- A bowl
- Water

Watch out!

- You will need to use an oven hob to boil water for this activity. Make sure a responsible adult helps you at all times.

Instructions

1. Fill the cooking pot half full with tap water.
2. Add salt to the water and stir it so that it dissolves. Keep adding salt until it stops dissolving (this is called the water's saturation point). Provided the equipment that you have used is clean, you can taste it – it will taste very salty, like sea water.
3. Turn on the heat and bring the water to a boil. You want the water to simmer. Some of the water will start to evaporate.
4. Balance a lid on the pot so that part of it is hanging over the rim. Try to arrange the lid so that the portion hanging off of the edge is the lowest point on the lid. Watch as condensation forms on the bottom of the lid and starts to trickle down it.
5. Since water runs downhill, the condensation on the underside of the lid will naturally gather at the lowest point of the lid. Once enough condensation gathers here, it will start to form drops and fall. Place a bowl under this spot to catch the drops of distilled water as they fall.

Activity 12

Make your own simple distillation still

6. Provided the equipment that you have used is clean, you can taste the water in the bowl (make sure it has cooled down). It will no longer be salty. This is because when the water evaporated it left the salt behind in the cooking pot.

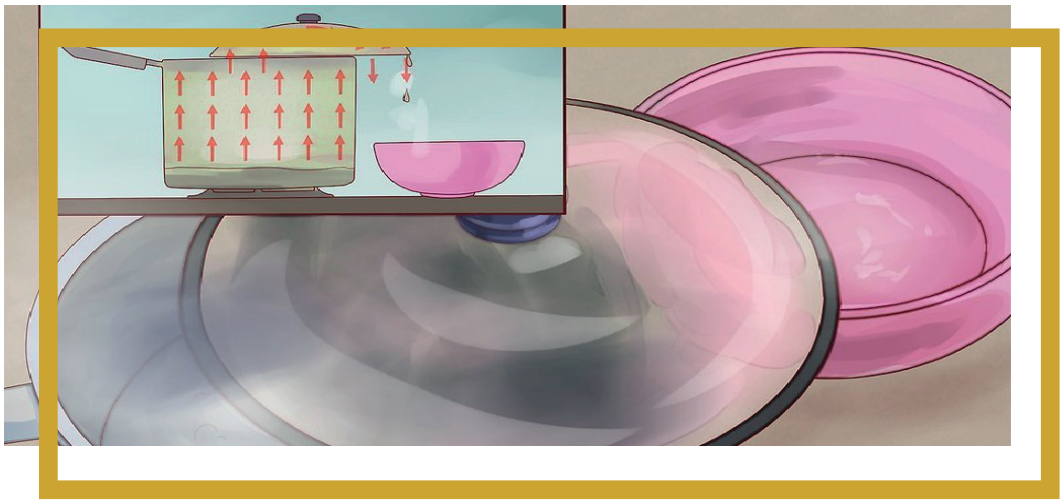
   Note: You could make your own still on a smaller scale using a tea light as the heat source and a crucible to contain the salty water.

Did you know?

- Jabir ibn Hayyan, a chemist who flourished during the golden age of Arabic science, developed the process of distillation. He invented a piece of equipment called the Alembic still. In this curiously shaped glass vessel, a liquid could be boiled down, allowing its separate pure parts to be collected as they condensed and trickled down the spout. It is still used in distillation laboratories today.

Next steps

- Once you've used your distillation still to separate salt from water, what else could you use it to separate? You could dissolve salt, sugar, or coffee powder in water and see if you can separate them using your still.



Activity 13

Make your own toothpaste

Suggested age group

- 5-14

Learning objectives

- To experiment with different ingredients to make toothpaste.
- To learn about the history of toothpaste.
- To learn how scientists during the golden age of Arabic science contributed to the development of toothpaste.

About this activity

- People have been making toothpaste for thousands of years. Experts believe that the first toothpastes originated in India, Egypt, and China around 7000 years ago. Toothpaste recipes used to have some strange ingredients. The ancient Egyptians, for example, used to put burnt egg shells and dried iris flowers into theirs. A number of effective toothpaste recipes were developed during the golden age of Arabic science.
- In this activity, you will make toothpaste using ingredients that are similar to those used to make modern toothpastes. You will decide on your toothpaste's colour, flavour, and smell.

Time

- 1 hour

Kit list

To make the toothpaste, you will need:

- Baking soda (sodium bicarbonate, NOT baking powder)
- Cornflour
- Salt
- Glycerine

Activity 13

Make your own toothpaste

- Peppermint flavouring
- Food colouring
- Water
- Teaspoons
- Yoghurt pots or plastic beakers
- Extra flavours and colours (optional)

Watch out!

- All ingredients must be new and equipment clean. Toothpaste should only be tasted if you are certain it has been prepared hygienically. You must request adult approval and supervision if you will taste the toothpaste.

Instructions

1. Mix together the baking soda, cornflour, and salt in a container.
2. Add the glycerine and peppermint flavouring, and mix to form a thick paste.
3. Add a few drops of water at a time until the mixture is at the correct thickness.
4. You can add colouring as well.

Did you know?

- People during the golden age of Arabic science used a basic toothbrush called a *miswak*. They also used mouthwash and understood that rotting food trapped between teeth causes tooth decay. Dentists were able to remove broken teeth and wire loose teeth together using gold wire.
- More than a thousand years ago, a musician and gastronome from Baghdad called Ziryab introduced toothpaste to Al-Andalus (modern day Spain). The exact ingredients of Ziryab's toothpaste are unknown, but it is said to have been both 'functional and pleasant to taste'.

Activity 13

Make your own toothpaste

Next steps

- Once you've made your toothpaste, how can you test its effectiveness ? How could you test how good it is at removing stains?
- You could experiment by changing the quantities of the different ingredients and seeing what effect this has.

Activity 14

The magic kettle

Suggested age group

- 7-14

Learning objectives

- To investigate the chemical properties of common everyday substances.
- To learn that acids and alkalis play an important role in chemistry and react differently in indicator solutions.
- To learn that substances like vinegar are acidic, while substances like baking powder (bicarbonate of soda) are alkaline (or basic).
- To learn how scientists during the golden age of Arabic science contributed to our knowledge of acids and alkalis.

About this demonstration

- The 8th century pioneer Jabir ibn Hayyan introduced the word alkali, which derives from the Arabic al-qali, or ashes, which is where you find potassium carbonate. He also discovered sulfuric, nitric, and nitromuriatic acids.
  This demonstration is a fun way of introducing acids, alkalis, and the periodic table.

Time

- 15 minutes

Kit list

For this demonstration, you will need:

- A kettle
- A red cabbage/red cabbage juice
- 4 clear glasses

Activity 14

The magic kettle

- 2 acids and 2 alkalis – everyday household items can be used e.g. clear vinegar, lemonade, liquid soap etc.

Watch out!

- An adult is needed to help cut and mash up the red cabbage.
- Don't use dangerous liquids/substances in this demonstration. Many acids and alkalis are very corrosive and should not be used – always check with a responsible adult first.

Instructions

Before the demonstration

1. Finely chop up ½ of the red cabbage. Place it in a bowl and cover it with water. Mash up the red cabbage until the water has turned a vivid purple colour.
2. Using a strainer, pour the red cabbage juice into a kettle.
3. Put a different acid or alkali into each cup and note the colour change that it will cause when the red cabbage juice is added. Only put a very small amount of the acid/alkali into the cup. For the 'magic' to work, it is vital that the audience can't see the liquid in each container. Clear acids/alkalis are best.

When doing the demonstration

1. Make sure you know what colour each cup will make the red cabbage juice turn.
2. Explain to the audience that you have a magic kettle – it will pour whatever colour water you tell it to.
3. Say the colour and pour the red cabbage juice into the first cup. Repeat for each of the cups.
4. Once you've finished, explain the science behind what has happened.

Activity 14

The magic kettle

Did you know?

- Red cabbage juice is an ‘acid-base indicator’ (or pH indicator). When it mixes with acidic substances it will turn a yellowy or reddish/pink colour depending on how strong the acid is. Alkalis will turn the red cabbage juice a purple or bluish colour.

Next steps

- How many different acids and alkalis can you use in your demonstration (see the ‘watch out’ safety section and make sure you don’t use any dangerous substances)? What are the brightest colours that you can make?

Activity 15

Make your own perfume

Suggested age group

- 7-14

Learning objectives

- To learn how to make perfume.
- To learn that a perfume is a mixture of different oils that gives it its scent.
- To learn how scientists during the golden age of Arabic science contributed to our understanding of distillation – a vital process in the manufacture of perfumes.
- To learn how scholars during the golden age of Arabic science contributed to the development of perfume.

About this activity

- All through history, people have found ways to make perfumes. Perfume-making was particularly popular during the golden age of Arabic science. In this activity, you will make a perfume from essential oils adapted from a recipe from over a thousand years ago.

Time

- 1 hour

Kit list

To make perfume, you will need:

- Small bottles with lids for the perfume (1 per person or group making perfume)
- Almond oil/olive oil/grape seed oil
- Jasmine oil
- Orange oil

Activity 15

Make your own perfume

- Thyme oil
- Sandalwood oil
- Vanilla extract
- Pipettes for the vanilla extract and if the essential oil bottles do not have droppers

Watch out!

- Avoid contact between any essential oils and eyes. Rinse thoroughly if accidental contact occurs.
- Wash hands thoroughly after this activity.

Instructions

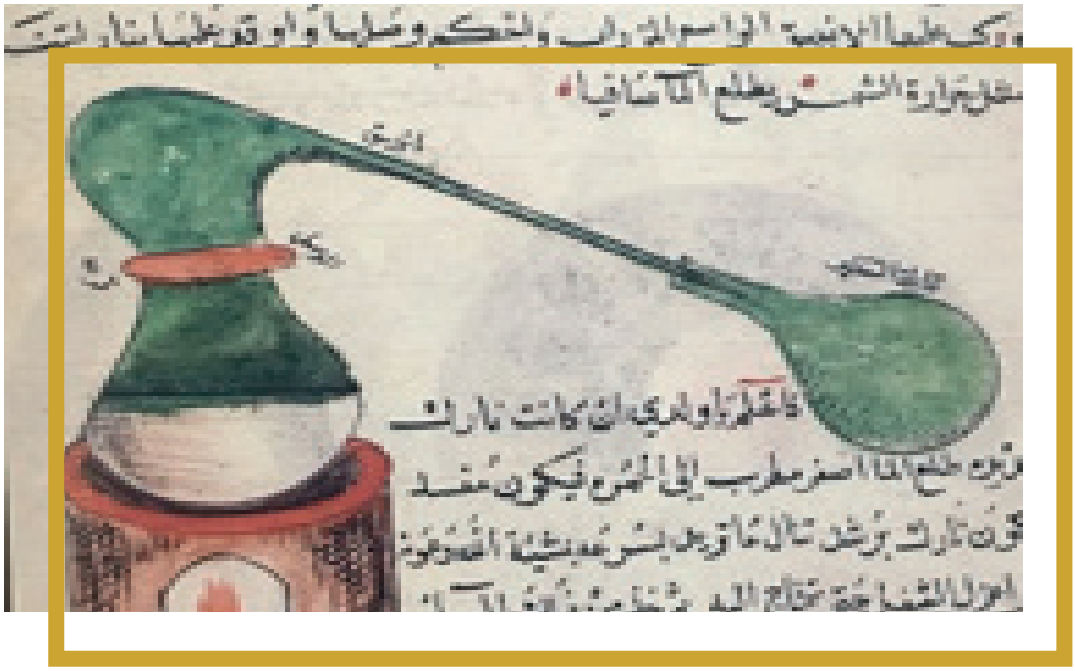
1. Get a bottle to use for your perfume.
2. Drop 60 drops of almond oil into your bottle.
3. Drop 5 drops of vanilla extract into your bottle.
4. Prepare the other oil bottles – jasmine, orange, thyme, and sandalwood– and drop 1 drop of each oil into their bottle.
5. Put the lid on each bottle and shake the perfume vigorously.
6. You can now dab the perfume onto their skin.

Did you know?

- For centuries, people used primitive apparatus like this to distil (separate out) plant essences for perfumes.
- Over a thousand years ago in modern day Iraq, a chemist called Jabir ibn Hayyan felt sure he could improve on the process. After much experimentation, he developed the alembic still which extracted the essences far more effectively.

Activity 15

Make your own perfume



- Over the two hundred years which followed, physicians and scientists such as Al-Kindi, Al-Razi, and Al-Zahrawi perfected the alembic still. As well as extracting essences for perfume, they used it to distil alcohol as a hospital disinfectant, extract essences for new medicines, and separate lamp oil from crude black oil.
- Al-Kindi even wrote a book on the chemistry of perfumes which contained 107 recipes for different scents using many essential plant oils, which can still be extracted through distillation today.

Next steps

- Once you've made the perfume, experiment by changing the quantities of the different oils – what effect does this have?You could also research how perfumes work. How are we able to smell them?

Activity 16
Make inks split (Chromatography)

Suggested age group

- 5-14

Learning objectives

- To investigate the composition of different inks.
- To learn that paper chromatography is a method for separating dissolved substances from one another.
- To observe the process of chromatography.

About this activity

- Crystallisation, distillation, evaporation, and filtration are all chemical processes that use different techniques to separate substances. Jabir ibn Hayyan, a chemist who flourished during the golden age of Arabic science, devised and perfected many of these processes in the 8th century.
- Another way of separating substances is paper chromatography. This is a method for separating dissolved substances from one another. It is often used when the dissolved substances are coloured, such as inks, food colourings and plant dyes.
- In this activity, you will use chromatography to separate inks into their different substances.

Time

- 1 hour

Kit list

To split inks, you will need:

- Filter paper (e.g. a coffee filter) or kitchen roll

Activity 16

Make inks split (Chromatography)

- A plastic bowl
- Washable felt tip pens (including the colour black)
- A cup of cold tap water

Watch out!

- Make sure that none of the pens that you're going to experiment with are 'permanent'.

Instructions

1. Draw a spot in the middle of the filter paper (start with the black pen).
2. Rest the filter paper on the bowl to catch any drips.
3. Dip your finger in the water to get a drop on the end and let it fall onto the spot (use a pipette if you have one).
4. Watch what happens to the black ink – is it really black?
5. Repeat the process with different coloured pens – use a different piece of filter paper each time.

Did you know?

- Although some inks often only appear to be made up of one colour, they are usually composed of a number of different pigments. As the water moves outwards through the filter paper, the different pigments are carried through the paper at varying speeds. Pigments which are more soluble in water move through the filter paper at a faster rate and will travel further from the centre than those which are less soluble; this should cause a series of concentric, differently coloured circles to form on the paper.

Activity 16

Make inks split (Chromatography)

Next steps

- Once you've split different colours of ink, you could try food colourings or plant dyes. Are they made of different pigments as well? Do they contain more or less pigments than the inks?

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About the International Year of the Periodic Table of Chemical Elements (IYPT2019)

Organisation des Nations Unies pour l'éducation, la science et la culture

2019 IYPT

Année internationale du tableau périodique des éléments chimiques

The United Nations General Assembly proclaimed 2019 as the International Year of the Periodic Table of Chemical Elements to highlight the contributions of chemistry and other basic sciences to the implementation of the 2030 Agenda for Sustainable Development.

For more information, please visit the official website of IYPT2019: www.iypt2019.org

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