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FREE EBOOK

SCIENCE PROJECTS AND KITS

Safe Chemistry Projects for School

Experiments and models with kitchen materials and proper safety

INSIDE THIS BOOK

- Safety first
- Acids, bases and natural indicators
- The pH scale and neutralisation
- The fizzing volcano and other gas reactions
- Growing crystals
- ...and 6 more chapters, practice questions and a glossary

Beginner to intermediate

Students of class 6 to 12 and teachers

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Safe Chemistry Projects for School

Safe, clear chemistry experiments with things from the kitchen and the chemist's shop, from natural indicators and the pH scale to crystals, chromatography, rusting, splitting water with a 9 V battery and simple food adulteration tests. Every project gives the science, numbered steps, what you should see and the safety rules, with tips for writing a strong project report.

WHO IT IS FOR	Students of class 6 to 12 and teachers
LEVEL	Beginner to intermediate
SUBJECT AREA	Science projects and kits
WHAT IS INSIDE	11 chapters, practice questions with answers, and a glossary

HOW TO USE IT

Read one chapter at a time and try the examples as you go: on a computer, at your workbench or in your notebook. The boxes give tips, safety points and short activities. When you finish, test yourself with the practice questions and check your answers at the end. Words you may not know are explained in the glossary.



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Safety first

Chemistry is the study of substances: what they are made of, how they change and why. You do not need a big laboratory to explore it. Your kitchen already holds acids, bases, salts and crystals. This book shows you how to use them in experiments that are safe, clear and good enough for a school exhibition.

Rules for every experiment

1. Work with an adult nearby. Students of class 6 to 8 need an adult beside them for anything hot, sharp or chemical.
2. Wear old clothes or an apron, and tie back long hair. Wear safety goggles when you mix, heat or stir anything that can splash.
3. Never taste anything in an experiment, even if it came from the kitchen. To smell something, hold it away from your face and wave the air towards your nose with your hand. This is called **wafting**.
4. Label every jar. Never keep an experiment liquid in a drinking-water bottle or a cup someone might drink from.
5. Use small amounts. A spoonful shows the same science as a bucketful.
6. Wipe spills at once, and wash your hands with soap after every experiment.
7. An adult does all the heating, on a stove or with water from a kettle.
8. If anything splashes into your eyes, rinse them with plenty of clean running water for at least 15 minutes and tell an adult.

Household-safe materials

Material	Used for	Take care
Vinegar (sirka), lemon juice	Acids	Keep out of eyes
Baking soda (meetha soda)	A weak base	Safe with normal care
Washing soda	A stronger base	Wear gloves; it irritates skin
Salt, sugar, alum (phitkari)	Crystals	Do not eat experiment samples

Material	Used for	Take care
Turmeric, red cabbage, china rose (gudhal)	Natural indicators	Turmeric stains clothes
Soap and detergent	Bases, cleaning tests	Keep out of eyes
Tincture of iodine (from a chemist)	Starch test	Poisonous if swallowed; an adult handles it
Chuna (the lime used in paan)	Lime water	Burns eyes and skin; an adult handles it

SAFETY

Never use drain cleaner, toilet cleaner, bleach, battery acid, kerosene or petrol in a project. Never mix cleaning products: some mixtures, such as bleach with a toilet cleaner, give off poisonous gases.

EXAMPLE

Kavya from Pune planned four experiments for her science week. She bought a red cabbage (! 40), a packet of alum (! 20), a box of iron nails (! 30) and safety goggles (! 90). Everything else came from her kitchen. Her total was ! 180.

CHAPTER 2

Acids, bases and natural indicators

Many foods taste sour because they contain **acids**. Lemon juice has citric acid, vinegar has acetic acid, curd has lactic acid and tamarind (imli) has tartaric acid. **Bases** are the chemical opposites of acids. They taste bitter and feel soapy. Baking soda, washing soda, soap and lime water are bases. A base that dissolves in water is called an **alkali**.

We know the taste of acids from food. In an experiment, though, we never taste. Instead we use an **indicator**: a substance that shows one colour in an acid and a different colour in a base.

Turmeric paper

1. Mix half a teaspoon of turmeric with a few drops of water to make a paste.
2. Spread it thinly on strips of white blotting paper or filter paper.
3. Let the strips dry in the shade.
4. Dip one strip in lemon juice and another in soap solution.

Turmeric stays yellow in acids and in neutral water. It turns reddish-brown in a base such as soap solution or washing soda solution. Baking soda is a weak base, so it may change the colour only a little.

DID YOU KNOW

A turmeric stain on a white kurta turns reddish-brown when it is washed with soap. The soap is a base, and the stain is acting as an indicator.

Red cabbage indicator

1. Chop four or five red cabbage leaves into small pieces and put them in a steel bowl.
2. An adult pours hot water over them, just enough to cover.
3. Leave it for 30 minutes, then strain the purple liquid into a clean bottle and label it.
4. Keep it in the fridge and use it within two or three days.

Red cabbage is a superb indicator because it shows many colours: red or pink in acids, purple in neutral liquids, blue to green in bases and yellow in very strong bases.

China rose indicator

Soak the petals of a few red china rose flowers in warm water for about 20 minutes and strain the liquid. China rose indicator turns acids dark pink (magenta) and bases green.

Testing kitchen liquids

Put two spoons of each liquid in a row of small cups, label them, and add a few drops of each indicator in turn.

Liquid	Turmeric	Red cabbage	China rose
Lemon juice	Yellow	Red	Dark pink
Vinegar	Yellow	Pink-red	Dark pink

Liquid	Turmeric	Red cabbage	China rose
Tap water	Yellow	Purple	Little change
Baking soda solution	Little change	Blue	Green
Washing soda solution	Reddish-brown	Green	Green

TRY THIS

Paint a sheet of paper with turmeric paste and let it dry. Write a message on it with a cotton bud dipped in soap solution. Red letters appear, as if by magic.

CHAPTER 3

The pH scale and neutralisation

Some liquids are strongly acidic and some only mildly. Scientists measure how acidic or basic a liquid is on the **pH scale**, which runs from 0 to 14.

- pH 7 is **neutral**: neither acid nor base. Pure water is pH 7.
- Below 7 is acidic. The lower the number, the more acidic.
- Above 7 is basic. The higher the number, the more basic.

Each whole step on the scale is a change of ten times. A liquid at pH 3 is ten times more acidic than one at pH 4, and a hundred times more acidic than one at pH 5.

Substance	Approximate pH
Lemon juice	2
Vinegar	3
Milk	a little below 7
Pure water	7
Baking soda solution	8
Soap solution	9 to 10
Washing soda solution	11

These are rough values. To measure pH properly, use **pH paper** (also called universal indicator paper), sold in science shops. You dip a strip and match its colour against the chart on the packet.

A red cabbage colour chart

Add the same amount of red cabbage indicator to six cups: lemon juice, vinegar, tap water, baking soda solution, soap solution and washing soda solution. Arrange them from red to green, photograph them and write the approximate pH under each.

Neutralisation

When an acid and a base react, they cancel each other. This is called **neutralisation**:

acid + base → salt + water

The word **salt** here means any substance made when an acid and a base react, not only table salt.

1. Pour two tablespoons of vinegar into a glass and add red cabbage indicator. It turns pink.
2. Add baking soda solution with a dropper, a few drops at a time, stirring after each.
3. Count the drops until the colour turns purple. The liquid is now neutral.
4. Add a few more drops and watch it turn blue: now the base is in excess.

You will also see fizzing. That is carbon dioxide gas, which you will meet in the next chapter.

EXAMPLE

Arjun from Bhopal neutralised two tablespoons of vinegar with baking soda solution. It took 42 drops. Then he mixed vinegar with an equal amount of water and tested two tablespoons of that. It took about 21 drops, half as many, because each spoonful now held half as much acid. It was a fair test: the same amount of liquid, the same dropper and the same baking soda solution.

Neutralisation in daily life

- An ant bite injects formic acid. Rubbing a little baking soda paste on it helps neutralise the acid.
- Antacid tablets contain mild bases that react with extra acid in the stomach.

- Farmers add lime to soil that is too acidic for their crops.
- Toothpaste is basic. It helps neutralise the acids that mouth bacteria make, which cause tooth decay.

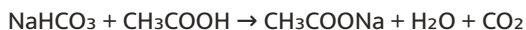
CHAPTER 4

The fizzing volcano and other gas reactions

The baking soda volcano is a favourite at school fairs. It is also a real chemical reaction, so be ready to explain it.

The science: Baking soda (sodium hydrogen carbonate) reacts with vinegar (acetic acid). A new substance forms, and so does a gas, carbon dioxide. The gas makes the bubbles.

baking soda + vinegar → sodium acetate + water + carbon dioxide



Making the volcano

You need: a small plastic bottle, a tray, newspaper, flour paste or clay, paints, baking soda, vinegar, liquid dish soap and red food colour.

1. Stand the bottle in the middle of the tray.
2. Build a cone around it with clay, or with newspaper strips dipped in flour paste (papier-mâché). Keep the bottle's mouth open.
3. Let papier-mâché dry for a day or two, then paint it brown and grey.
4. To erupt: put two teaspoons of baking soda, a few drops of dish soap and a drop of food colour into the bottle.
5. Pour in about half a cup of vinegar and step back.

The soap traps the gas in bubbles, so you get a thick red foam instead of a quick fizz.

REMEMBER

Your volcano is a model of how an eruption looks, not of how it works. A real volcano erupts molten rock called **magma**, pushed up by heat and gases from deep inside the earth.

Testing for carbon dioxide

Carbon dioxide turns **lime water** milky. Lime water is a clear solution of calcium hydroxide. An adult makes it by stirring a teaspoon of chuna into a glass of water, leaving it overnight, and pouring off the clear liquid on top.

Blow gently into a little lime water through a straw. Your breath contains carbon dioxide, so the lime water turns milky. The milky appearance is tiny grains of calcium carbonate, the same substance as limestone and marble. Blow out only, and never suck through the straw.

The balloon that blows itself up

Pour a quarter cup of vinegar into an empty plastic bottle. Using a paper funnel, put two teaspoons of baking soda inside a balloon. Stretch the balloon over the bottle neck, then lift it so the soda falls into the vinegar. The balloon fills with carbon dioxide.

TRY THIS

Turn the volcano into a fair test. Change only the amount of baking soda (one, two, then three teaspoons), keeping the vinegar the same, and measure how high the foam rises each time.

SAFETY

Carbon dioxide is heavier than air and puts out flames. A teacher can show this by tipping the gas from a glass onto a small candle flame. Students do not light candles for this experiment.

CHAPTER 5

Growing crystals

A **crystal** is a solid whose tiny particles are arranged in a regular, repeating pattern. That pattern gives crystals their flat faces, straight edges and sharp corners.

To grow crystals, you first make a **saturated solution**: a solution in which so much has dissolved that no more will dissolve. When water evaporates from it, or when it cools, the extra substance comes out as crystals.

Salt crystals

1. Stir common salt into a cup of warm water, a spoonful at a time, until no more dissolves.
2. Pour the clear liquid into a shallow dish, leaving any undissolved salt behind.
3. Keep the dish in a warm, sunny, dust-free place.
4. As the water evaporates over a few days, small cube-shaped crystals appear.

Salt dissolves almost equally well in hot and cold water, so cooling does not help. Evaporation is the method that works.

DID YOU KNOW

In the Little Rann of Kutch in Gujarat, salt workers let brine (very salty water) evaporate in shallow pans under the sun. The salt crystals they rake up are made in exactly the same way as yours.

Sugar crystals (mishri)

1. An adult heats one cup of water and stirs in about two and a half to three cups of sugar, a little at a time, until it all dissolves.
2. Let the syrup cool for about 20 minutes and pour it into a clean glass jar.
3. Tie a clean cotton thread to a pencil. Wet the thread, roll it in dry sugar and let it dry. These grains are starting points for crystals.
4. Rest the pencil across the jar so the thread hangs in the syrup without touching the sides or bottom.
5. Cover the jar with paper and leave it undisturbed for a week or more.

Hot sugar syrup sticks to skin and causes very bad burns, so an adult does steps 1 and 2.

Alum crystals

Alum grows the most beautiful crystals, shaped like two pyramids joined at their bases. This eight-faced shape is called an **octahedron**.

1. An adult dissolves alum powder in hot water until no more will dissolve.
2. Let it cool. By the next day, small crystals will form at the bottom.
3. Pick out the best-shaped one. This is your **seed crystal**.

4. Tie it to a thin nylon thread, such as fishing line.
5. Make a fresh saturated solution, let it cool, and hang the seed crystal in it.
6. Check every day. Remove any small crystals that form on the bottom so they do not steal from your seed.

TIP

Use nylon thread for alum, not cotton. Crystals grow all along the hairy fibres of cotton, so your seed gets crowded by dozens of small ones.

Crystal	Shape	Best method	Time
Salt	Cubes	Evaporation	3 to 7 days
Sugar	Slanted, prism-like crystals	Cooling a very strong syrup	1 to 2 weeks
Alum	Octahedrons	Seed crystal in a cooled solution	1 to 2 weeks

CHAPTER 6

Separating mixtures and chromatography

A **mixture** is two or more substances mixed together but not chemically joined. Because they are not joined, they can be separated using differences in size, weight, magnetism or how well they dissolve.

Method	How it works	Everyday example
Handpicking	Remove big pieces by hand	Stones from dal
Sieving	Small particles pass through holes	Bran from atta with a chalni
Winnowing	Wind blows away light parts	Husk from grain
Magnet	Iron is attracted, others are not	Iron filings from sand
Sedimentation and decantation	Heavy parts settle; pour off the liquid	Muddy water left to stand
Filtration	A filter holds back solids	Tea leaves in a strainer

Method	How it works	Everyday example
Evaporation	Water leaves, dissolved solid stays	Salt from seawater

Project: separate a four-part mixture

Mix one spoon each of sand, salt, sawdust and iron filings (from a science shop). Now get them all back.

1. Put a magnet inside a small plastic bag and pass it over the mixture. The iron filings cling to the bag. Hold the bag over a paper and pull the magnet out: the filings drop off cleanly.
2. Pour the rest into a glass of water and stir. Sawdust floats. Skim it off with a spoon and dry it.
3. The salt dissolves. The sand sinks.
4. Pour the water through filter paper in a funnel. The sand stays in the paper.
5. Leave the salty water in a dish in the sun, or let an adult heat it gently. When the water has gone, the salt is left behind.

Paper chromatography

Black ink looks like one colour, but it is often a mixture of several dyes.

Chromatography separates them. Water climbs up a strip of paper and carries each dye with it. Some dyes dissolve well and cling to the paper only a little, so they travel far. Others cling more, so they stay low.

You need: a strip of filter paper, coffee filter or white blotting paper about 2 cm wide and 15 cm long, a pencil, black water-based sketch pens of different brands, a glass and water.

1. Draw a pencil line across the strip, 2 cm from the bottom.
2. Put a small, strong dot of black sketch pen on the line.
3. Pour water into the glass to a depth of about 1 cm.
4. Hang the strip from a pencil laid across the glass, so the bottom dips in the water but the dot stays above it.
5. Wait 10 to 15 minutes. Take the strip out before the water reaches the top.
6. Mark how far the water rose with pencil, and let the strip dry.

The dot spreads into bands of blue, purple, yellow or pink. Use pencil for the start line because graphite does not dissolve in water. A pen line would run.

Measuring the result

Scientists compare dyes using the **Rf value**:

$Rf = \text{distance moved by the dye} \div \text{distance moved by the water}$

EXAMPLE

On Faizan's strip in Hyderabad, the water rose 10 cm from the pencil line. A blue band moved 7 cm and a yellow band moved 3 cm. The Rf of blue was $7 \div 10 = 0.7$, and of yellow, $3 \div 10 = 0.3$. An Rf value is always between 0 and 1.

CHAPTER 7

Rusting: an investigation

Rust is the reddish-brown, flaky layer that forms on iron. Rusting is a slow chemical change: iron reacts with oxygen from the air and with water to form a new substance, a kind of iron oxide.

iron + oxygen + water $\rightarrow$ rust

Only iron, and steel (which is mostly iron), rusts. Other metals change in their own ways. Copper turns green, and silver turns black.

The four-jar experiment

This experiment proves that iron needs both air and water to rust.

You need: four small glass jars with lids, four plain iron nails, sandpaper, cooking oil, salt, two or three silica gel sachets (the small packets that come with new shoes and bags), labels and water.

1. Rub each nail with sandpaper until it is shiny. Plain iron nails work best. Shiny galvanised nails have a zinc coating that stops rust.
2. **Jar A (air and water):** put a nail in and add tap water to half its height.

3. **Jar B (water, no air):** an adult boils some water for a few minutes to drive out the dissolved air. Let it cool, put a nail in, cover it fully with the boiled water and pour a thin layer of oil on top so air cannot get back in. Close the lid.
4. **Jar C (air, no water):** put a nail and the silica gel sachets in a dry jar and close the lid tightly. Silica gel soaks up moisture from the air. Do not open the sachets, and keep them away from small children.
5. **Jar D (salt water):** put a nail in water with two teaspoons of salt dissolved in it.
6. Label each jar and look at the nails every day for a week.

Jar	Conditions	What you should see after a week
A	Air and water	Clear rust
B	Water, no air	Little or no rust
C	Air, no water	No rust
D	Air and salt water	The most rust

Jar D shows that salt speeds up rusting. That is why iron rusts faster in coastal cities such as Mumbai and Chennai, where the air carries salt from the sea.

REMEMBER

This is a fair test. The only thing that changes from jar to jar is the condition you are testing. Each nail, each jar and the time are kept the same.

Preventing rust

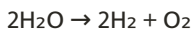
Rust is prevented by keeping air and water away from the iron: **paint** on gates and grills, **oil or grease** on tools and bicycle chains, and a coat of zinc, called **galvanising**, on water tanks and roofing sheets. Food tins are steel coated with tin. **Stainless steel**, used for kitchen utensils, is iron mixed with other metals such as chromium and nickel, so it resists rust.

DID YOU KNOW

The Iron Pillar in the Qutub complex in Delhi is more than 1,600 years old and has hardly rusted. Scientists explain this by its unusual make-up, including a high amount of phosphorus, which helps a thin protective layer form on its surface.

Splitting water with a 9 V battery

Water is a compound of hydrogen and oxygen. An electric current can split it back into these two gases. Breaking a compound apart with electricity is called **electrolysis**.



The equation shows two molecules of water giving two molecules of hydrogen and one of oxygen. So you should collect about twice as much hydrogen as oxygen.

Pure water carries electricity very poorly. Adding a little washing soda or baking soda lets the current flow.

SAFETY

Do not use common salt for this experiment. With salt water, the gas made at the positive side is chlorine, a poisonous gas that smells like bleach.

What you need

- One 9 V battery and a battery snap (a clip with two wires)
- Two pencils sharpened at both ends. Their graphite is used because it does not dissolve during the experiment
- A clear plastic cup
- One teaspoon of washing soda stirred into two cups of water
- Two small transparent tubes, such as test tubes or clean medicine-sample tubes
- Clay or hot glue, and two wires with crocodile clips

Steps

1. An adult makes two small holes, about 3 cm apart, in the bottom of the cup and pushes a pencil up through each, so that 2 cm of each point is inside.
2. Seal around the pencils with clay, or with hot glue applied by an adult, so the cup does not leak.
3. Rest the cup on two books placed a little apart, so the lower ends of the pencils hang free between them.
4. Fill the cup about two-thirds with the washing soda solution.

5. Fill each tube with the solution, cover its mouth with your finger, turn it upside down and lower it over one pencil point. Try not to let any air in.
6. Clip one wire to the lower end of each pencil and join the wires to the battery snap. Fit the snap on the battery. Bubbles rise from both points at once.
7. Leave it for 20 to 30 minutes and compare the gas in the two tubes.

On a 9 V battery, the smaller round terminal is positive (+) and the larger six-sided one is negative (-). On most battery snaps, the red wire is positive and the black wire is negative.

What you should see

More gas collects over the point joined to the negative terminal. This is **hydrogen**. The gas at the positive side is **oxygen**. The volume of hydrogen should be about twice the volume of oxygen. With pencil electrodes you often see even less oxygen than that, because oxygen dissolves in water more easily than hydrogen, and some of it reacts with the graphite.

SAFETY

Use only a 9 V battery or cells, never a charger, an adapter or a wall socket. Hydrogen burns: the amounts here are tiny, but work near an open window and keep flames away. Never touch the two wires together, because that short circuit makes the battery hot. Wear gloves with washing soda, and disconnect the battery when you finish. The gas tests use a lighted or glowing splint, so only a teacher does them.

DID YOU KNOW

Many countries, including India, are building plants that split water this way on a giant scale. When the electricity comes from the sun or the wind, the hydrogen made is called **green hydrogen**, a clean fuel.

Simple tests for food adulteration

Adulteration means adding a cheaper or harmful substance to food, or removing something valuable from it, to make more money. India's food safety authority, FSSAI, publishes simple tests that families can do at home. Here are some of the safest.

REMEMBER

These are screening tests. They give a sign, not proof. A proper food laboratory confirms the result. If you suspect a product, tell an adult, who can report it to the local food safety office. Never taste any sample.

Water in milk

Put a drop of milk on a clean, polished, sloping surface such as a steel plate held at a slant. Pure milk flows slowly and leaves a white trail behind it. Milk with added water runs down quickly and leaves almost no trail.

Starch in milk or paneer

1. Take two teaspoons of milk in a steel bowl. For paneer, mash a small piece in a little water.
2. An adult boils it and lets it cool.
3. An adult adds two or three drops of tincture of iodine.

A blue colour means starch has been added. Pure milk shows only the brownish colour of the iodine. Iodine is poisonous if swallowed, so throw the sample away and wash the bowl.

Chalk in sugar or salt

Stir a teaspoon of sugar or salt into a glass of water. Pure sugar and pure salt dissolve and leave the water clear. Chalk powder makes the water white and settles at the bottom.

Artificial colour in chilli powder

Sprinkle a little chilli powder on the surface of water in a glass. Added colour runs down at once in coloured streaks. Brick powder or sand sinks quickly to the bottom. Keep your hands away from your eyes, and wash them afterwards.

Chicory in coffee powder

Sprinkle coffee powder gently on water. Coffee floats for a while. Chicory, which is cheaper, starts sinking within a few seconds and leaves a brown trail.

Is the salt iodised?

Cut a potato in half. Sprinkle a little salt on the cut face, wait a minute, then add two drops of lemon juice. Iodised salt gives a blue colour. Salt without iodine gives no blue.

Colour on green peas

Soak a handful of green peas in a glass of water for half an hour and stir. If the water turns green, colour has been added.

EXAMPLE

Neha from Lucknow tested milk from three sources for a class project. Sample A left a white trail, sample B left a white trail, and sample C ran down fast with no trail. She reported that sample C needed a proper laboratory test. She did not claim it was adulterated, because a single home test is not proof.

CHAPTER 10

Soap and how it cleans

How soap is made

Soap is made by a reaction called **saponification**. Oils or fats react with a strong alkali called sodium hydroxide, also known as **caustic soda** or lye.

oil or fat + sodium hydroxide $\rightarrow$ soap + glycerol

Glycerol (also called glycerine) is a thick, sweet, harmless liquid that keeps skin soft.

SAFETY

Caustic soda is dangerous. It burns skin, can blind if it splashes into eyes, and makes water hot when it dissolves. Junior students never handle it. Senior students may see it used only in a school laboratory, with a teacher, goggles and gloves. This book does not give a recipe that uses it.

How soap cleans

A soap particle is long and thin. One end, the head, loves water. The other end, the tail, loves oil and grease. When you wash a greasy plate, the tails push into the grease and the heads stay in the water. The grease is broken into tiny droplets, each surrounded by soap, and the water carries them away.

The pepper test

1. Fill a plate with water and sprinkle black pepper over the surface.
2. Dip a toothpick in liquid soap and touch the middle of the water.
3. The pepper rushes to the edges at once.

Water has a stretchy "skin" on its surface, called **surface tension**. Soap weakens it where it touches, and the stronger pull from the edges drags the pepper away.

Hard and soft water

Hard water contains dissolved calcium and magnesium salts. With soap, it forms a white, curdy scum and very little lather. **Soft water**, such as rainwater, lathers easily.

Take equal amounts of rainwater and tap or borewell water in two identical bottles. Add five drops of liquid soap to each, close the lids, shake each bottle ten times and measure the height of the foam.

Less foam and a cloudy scum mean harder water. Detergents lather well even in hard water, which is one reason they are used in washing machines.

Melt-and-pour soap for juniors

You can still make your own soap, safely. **Melt-and-pour soap base** is soap that a factory has already made by saponification. You only melt it, colour it and shape it.

1. An adult cuts the soap base into cubes and melts them in a bowl over a pan of hot water.

2. Stir in a drop of food colour and a few drops of fragrance.
3. Pour the liquid into small moulds, such as silicone moulds or small paper cups.
4. Leave it for one to two hours to set, then press the soap out.

TIP

When you present this, explain clearly that saponification happened in the factory. You changed the soap's shape and colour, which is a physical change, not a chemical one.

CHAPTER 11

Molecular models and your project report

Ball-and-stick models

Atoms join together to make **molecules**. In a ball-and-stick model, each ball is an atom and each stick is a **bond**, the link that holds two atoms together. Each kind of atom forms a fixed number of bonds:

Atom	Bonds it forms	Usual colour
Hydrogen (H)	1	White
Oxygen (O)	2	Red
Nitrogen (N)	3	Blue
Carbon (C)	4	Black

Chemists everywhere use these colours, so follow them.

You need: thermocol balls in two sizes (small for hydrogen, larger for the others), poster paints and toothpicks or short pieces of broomstick.

1. Paint the balls and let them dry.
2. Push the sticks in at the right angles.
3. Where two atoms share two bonds, called a **double bond**, use two sticks side by side.

Molecule	Formula	Shape	Angle between bonds
Water	H ₂ O	Bent, like a wide V	About 104.5°
Carbon dioxide	CO ₂	Straight line, O=C=O	180°
Methane	CH ₄	Tetrahedron	About 109.5°
Ammonia	NH ₃	Low pyramid	About 107°
Oxygen gas	O ₂	Two atoms, double bond	Not applicable

TIP

For methane, push three sticks into the carbon ball so it stands on its three hydrogens like a tripod, then add the fourth stick pointing straight up. That gives the **tetrahedron** shape, a pyramid with four triangle faces.

DID YOU KNOW

Common salt is not made of molecules. It is a huge, regular stack of sodium and chloride particles, side by side. You can model a small piece with 27 balls in two colours, arranged in a 3 by 3 by 3 cube so that no two balls of the same colour touch.

Writing your project report

A neat report makes a simple experiment shine. Use these headings:

- 1. Title and aim:** what you wanted to find out.
- 2. Hypothesis:** what you expected to happen, and why.
- 3. Materials and method:** numbered steps that someone else could follow.
- 4. Observations:** a table with dates, measurements and photographs.
- 5. Result and conclusion:** what happened and what it shows.
- 6. Precautions and sources of error:** what you did to stay safe and accurate, and what could have affected the result.
- 7. Uses in daily life and references.**

Keep a logbook with the date on every page, and write what you saw, not what you hoped to see. In a fair test, change only one thing at a time.

EXAMPLE

Rohan from Kochi wrote a rusting report. His hypothesis was "Iron rusts fastest in salt water, because salt helps the reaction." His table showed all four jars on days 1, 3, 5 and 7, with a photo of each. Under sources of error he noted that one nail was slightly thicker than the others.

REMEMBER

Judges ask "why?" more than "what?". Be ready to explain the science behind every step.

CHECK YOURSELF

Practice questions

1. What is wafting, and why do we use it?
2. Name the acid found in each: lemon, vinegar, curd and tamarind.
3. What is an indicator? Name three natural indicators.
4. What colour does red cabbage indicator show in a strong base like washing soda solution?
5. A liquid has pH 4 and another has pH 6. Which is more acidic, and by how many times?
6. Write the word equation for neutralisation.
7. Why does rubbing baking soda on an ant bite help?
8. Which gas makes the bubbles in the baking soda volcano? How can you test for it?
9. What is a saturated solution?
10. Why is evaporation, not cooling, used to grow salt crystals?
11. Why should alum crystals be grown on nylon thread rather than cotton?
12. How would you separate a mixture of sand, salt and iron filings?
13. Why is the start line in chromatography drawn in pencil?

14. A dye moved 4.5 cm while the water moved 9 cm. Find its Rf value.
15. What are the two conditions iron needs in order to rust?
16. Why is the water in jar B boiled and then covered with oil?
17. Why must common salt not be used in the electrolysis of water?
18. Which gas collects at the negative terminal in electrolysis, and why is there more of it?
19. Describe a home test for starch in milk.
20. Why is caustic soda not used by junior students?
21. How many bonds does a carbon atom form? Name a molecule that shows this.
22. Give three headings you would use in a science project report.

ANSWER KEY

Answers

1. Wafting means waving the air above a container towards your nose with your hand. It lets you smell a substance safely, without breathing in a strong dose.
2. Lemon: citric acid. Vinegar: acetic acid. Curd: lactic acid. Tamarind: tartaric acid.
3. An indicator is a substance that shows one colour in an acid and another in a base. Turmeric, red cabbage and china rose are natural indicators.
4. Green. In very strong bases it can turn yellow.
5. The pH 4 liquid is more acidic. It is $10 \times 10 = 100$ times more acidic, because each pH step is ten times.
6. Acid + base $\rightarrow$ salt + water.
7. An ant bite injects formic acid. Baking soda is a base, so it neutralises the acid.
8. Carbon dioxide. It turns lime water milky.
9. A solution in which no more of the substance can dissolve at that temperature.
10. Salt dissolves almost equally well in hot and cold water, so cooling releases very little salt. Evaporation removes the water and leaves the salt behind.
11. Crystals grow all over the fibres of cotton, crowding the seed crystal. Smooth nylon lets one large crystal grow.

12. Remove the iron filings with a magnet in a plastic bag, dissolve the salt in water, filter out the sand, then evaporate the water to get the salt back.
13. Graphite does not dissolve in water, so the line stays put. Ink would run and mix with the sample.
14. $R_f = 4.5 \div 9 = 0.5$.
15. Air (oxygen) and water.
16. Boiling drives out dissolved air, and the oil layer stops air from getting back in. So the nail has water but no air.
17. With salt water, chlorine, a poisonous gas, forms at the positive side.
18. Hydrogen. Each water molecule has two hydrogen atoms and one oxygen atom, so splitting water gives about twice as much hydrogen as oxygen.
19. An adult boils a little milk with water, cools it and adds two or three drops of iodine tincture. A blue colour shows added starch.
20. It burns skin, can blind if it splashes into the eyes, and heats up when dissolved in water.
21. Four bonds. Methane, CH_4 , shows a carbon atom joined to four hydrogen atoms.
22. Any three of these: aim, hypothesis, materials, method, observations, result, conclusion, precautions, sources of error, references.

WORD LIST

Glossary

Acid

a substance that tastes sour and turns blue litmus red; it has a pH below 7.

Adulteration

adding a cheaper or harmful substance to food, or removing something valuable from it.

Base

the chemical opposite of an acid; it tastes bitter, feels soapy and has a pH above 7.

Chromatography

a method of separating a mixture of dyes as a liquid carries them across paper.

Crystal

a solid whose particles are arranged in a regular, repeating pattern.

Electrolysis

breaking a compound apart by passing an electric current through it.

Fair test

an experiment in which only one thing is changed at a time.

Hard water

water containing dissolved calcium and magnesium salts, which forms scum with soap.

Indicator

a substance that shows different colours in acids and bases.

Lime water

a clear solution of calcium hydroxide that turns milky with carbon dioxide.

Mixture

two or more substances mixed together but not chemically joined.

Molecule

a group of atoms joined together by bonds.

Neutralisation

the reaction of an acid with a base to form a salt and water.

pH scale

a scale from 0 to 14 that shows how acidic or basic a substance is.

Rf value

the distance moved by a dye divided by the distance moved by the water in chromatography.

Rust

the reddish-brown substance formed when iron reacts with oxygen and water.

Saponification

the reaction of oils or fats with a strong alkali to make soap.

Saturated solution

a solution in which no more of a substance can dissolve.

Surface tension

the stretchy "skin" effect on the surface of water.

Wafting

waving air towards your nose to smell something safely.



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