Acids, alkalis and indicators

Science, grade 8 - by Claude Opus 5.5 - status: written (unreviewed)

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Grade 8 Science — Acids, alkalis and indicators: reading the colour of a liquid

> **Unreviewed AI draft.** Written by Claude Opus 5.5 (an AI agent) on 2026-11-04. No teacher has checked it yet. Read it fully, adapt it to your class and local rules, and test any practical work yourself before using it with students.

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Big idea

Many liquids are acidic, alkaline or neutral, and we cannot tell which by looking. An indicator is a dye that changes colour depending on how acidic or alkaline a liquid is, so it lets us "read" a liquid safely without tasting or touching it. The pH scale (usually 0 to 14) puts this on a number line: below 7 is acidic, 7 is neutral, above 7 is alkaline. When an acid and an alkali are mixed in the right amounts they cancel each other out (neutralisation), making a salt and water. People use this every day, from indigestion tablets to farmers adding lime to sour soil.

Outcomes

By the end of the unit, students can:

1. Make a red cabbage indicator and use it to sort everyday liquids into acidic, neutral and alkaline, recording colours in a table.
2. Place liquids on the pH scale using universal indicator, and explain that below 7 is acidic, 7 is neutral and above 7 is alkaline.
3. Write the word equation acid + alkali → salt + water, and explain that adding a carbonate or hydrogencarbonate (such as baking soda) to an acid also gives off carbon dioxide.
4. Carry out a repeated, fair comparison of how much alkali is needed to neutralise two acids, and use the median of repeats.
5. Explain two real uses of neutralisation (antacids for indigestion; lime for acidic soil) and what "ocean acidification" does and does not mean.
6. Correct the common ideas that "all acids burn", "alkalis are safe", "neutral means no chemicals" and "an indicator turns a liquid into an acid".

Prior knowledge

- Some substances dissolve to make solutions; mixtures can be separated; some changes make new materials, and a gas given off is a sign of this (grade 5).
- Bromothymol blue changes colour when carbon dioxide dissolves in water (grade 7).
- Fair tests: change one thing, keep the rest the same, repeat, use the median (grades 3–7).

Lessons (about 50 minutes each)

#	Lesson	Practical?
1	Can you tell by looking? Making a red cabbage indicator	Make indicator; test 8 liquids
2	The pH scale and universal indicator	Universal indicator paper; rank liquids

#	Lesson	Practical?
3	Cancelling out: neutralisation by drops	Count drops of baking soda solution to neutralise vinegar and lemon juice
4	Neutralisation at work: stomachs, soils and seas	Test soil samples; antacid demonstration; ocean pH data
5	Acids and alkalis in the world + unit check	Discussion and written assessment

Materials (whole unit)

- Eye protection for everyone in every practical lesson.
- Lesson 1: red cabbage (about a quarter of a head per class); a kettle (teacher only); a heatproof jug; a sieve; clear plastic cups or spotting tiles; droppers; labelled test liquids (see lesson 1): lemon juice, white vinegar, fizzy (carbonated) water, tap water, salt solution, baking soda (sodium hydrogencarbonate) solution, milk of magnesia, and washing soda (sodium carbonate) solution made up dilute by the teacher.
- Lesson 2: universal indicator paper and its colour chart (or universal indicator solution); the same liquids; tweezers or glass rods.
- Lesson 3: cabbage indicator; white vinegar; lemon juice; baking soda solution (1 level teaspoon in 100 ml water, made up fresh); 10 ml plastic syringes or measuring cylinders; droppers; white tiles.
- Lesson 4: three soil samples (for example garden soil, a peat-free compost and soil from under conifers, or whatever is available); distilled or deionised water; filter paper and funnels; universal indicator paper; one antacid tablet or milk of magnesia (teacher demonstration only).
- Student record sheets (tables are given in each lesson).

Assessment

- Ongoing: closing check questions at the end of each lesson (answers included).
- Lesson 3: the results table, medians and conclusion are a practical skills task.
- Lesson 5: a 10-question unit check (20 marks) with an answer guide and marking notes.

Sources

These are general references that a teacher can use to check facts. Links were checked to load on 2026-11-04.

- Wikipedia, "PH": https://en.wikipedia.org/wiki/PH
- Wikipedia, "Acid": https://en.wikipedia.org/wiki/Acid
- Wikipedia, "Base (chemistry)": https://en.wikipedia.org/wiki/Base_(chemistry)
- Wikipedia, "Alkali": https://en.wikipedia.org/wiki/Alkali
- Wikipedia, "PH indicator": https://en.wikipedia.org/wiki/PH_indicator
- Wikipedia, "Universal indicator": https://en.wikipedia.org/wiki/Universal_indicator
- Wikipedia, "Litmus": https://en.wikipedia.org/wiki/Litmus
- Wikipedia, "Phenolphthalein": https://en.wikipedia.org/wiki/Phenolphthalein
- Wikipedia, "Red cabbage" (pH indicator section): https://en.wikipedia.org/wiki/Red_cabbage
- Wikipedia, "Anthocyanin": https://en.wikipedia.org/wiki/Anthocyanin
- Wikipedia, "Neutralization (chemistry)": https://en.wikipedia.org/wiki/Neutralization_(chemistry)
- Wikipedia, "Sodium bicarbonate": https://en.wikipedia.org/wiki/Sodium_bicarbonate

- Wikipedia, "Sodium hydroxide": https://en.wikipedia.org/wiki/Sodium_hydroxide
- Wikipedia, "Magnesium hydroxide": https://en.wikipedia.org/wiki/Magnesium_hydroxide
- Wikipedia, "Antacid": https://en.wikipedia.org/wiki/Antacid
- Wikipedia, "Citric acid": https://en.wikipedia.org/wiki/Citric_acid
- Wikipedia, "Acetic acid": https://en.wikipedia.org/wiki/Acetic_acid
- Wikipedia, "Vinegar": https://en.wikipedia.org/wiki/Vinegar
- Wikipedia, "Soil pH": https://en.wikipedia.org/wiki/Soil_pH
- Wikipedia, "Ocean acidification": https://en.wikipedia.org/wiki/Ocean_acidification
- Wikipedia, "Acid rain": https://en.wikipedia.org/wiki/Acid_rain

Known gaps and cautions

- **Not reviewed** by a teacher or a science technician. Check every practical against your school's or region's chemical safety guidance before use.
- **Only household-strength chemicals** are used by students. Laboratory acids and alkalis (such as hydrochloric acid or sodium hydroxide solution) are left out on purpose; a teacher who wants them should follow local guidance for concentrations.
- **Colours vary.** Red cabbage colours depend on the cabbage, the water and how strong the extract is. Test every liquid yourself the day before and use your own results as the answer key. The colours given here are typical, not guaranteed.
- **Tap water varies** from place to place and may not read exactly 7.
- **Simplifications:** "acid + alkali → salt + water" is taught as a word equation only. Hydrogen ions, the logarithmic pH scale (one pH step is a tenfold change) and weak versus strong acids are introduced only as stretch ideas and are covered properly in grades 9–10.
- The ocean pH figures (about 8.15 in 1950 to about 8.05 now) come from Wikipedia's "Ocean acidification" article; check a current scientific source before quoting them as exact.

Lesson 1 — Can you tell by looking? Making a red cabbage indicator

Back to unit

Goal

Students see that acidic, neutral and alkaline liquids can look the same, make a natural indicator from red cabbage, and use it to sort eight everyday liquids into three groups.

Materials

- Eye protection for everyone.
- Red cabbage extract, made by the teacher before the lesson or as a demonstration: chop about a quarter of a red cabbage, cover it with just-boiled water from a kettle in a heatproof jug, leave 10–15 minutes until the water is deep purple, then sieve and cool. Store covered in a fridge for up to two days.
- Per group: 8 clear cups or a spotting tile, a dropper of cabbage extract, a white sheet of paper underneath, a record table.
- Eight labelled liquids, about 20 ml each per group:
- A lemon juice
- B white vinegar
- C fizzy (carbonated) water, freshly opened
- D tap water
- E salt solution (1 teaspoon table salt in 100 ml water)
- F baking soda solution (1 teaspoon sodium hydrogencarbonate in 100 ml water)
- G milk of magnesia (shake well, then dilute 1 part to 4 parts water)
- H washing soda solution (made up dilute by the teacher: 1 teaspoon sodium carbonate in 200 ml water)

Steps

✎ Opening (5 min)

Hold up two cups of clear liquid: one of tap water and one of white vinegar diluted to look the same. Ask: "Which one is safe to drink? How could we find out without tasting or touching?" Take ideas. Establish the rule for the whole unit: **in science we never taste or touch unknown liquids.** We need a safe way to "read" a liquid.

✎ Main activity (30 min)

1. **The cabbage changes colour (teacher demo, 5 min).** Pour a little purple cabbage extract into three cups. Add a few drops of vinegar to one (it turns pink-red) and a pinch of baking soda to another (it turns blue-green). Leave the third alone. Ask: "What made the colour change? Did the cabbage turn the vinegar into something else?" Explain: the cabbage contains a coloured pigment (an anthocyanin) that is one colour

in acidic liquids, another in neutral ones and others in alkaline ones. A dye like this is called an **indicator**.
2. **Predict (5 min).** Groups look at the eight liquids and predict each one: acid, neutral or alkali. They write predictions in pen before testing.
3. **Test (15 min).** Put about 1 cm of each liquid in a cup (or a few drops in a spotting tile well). Add 5 drops of cabbage extract. Swirl. Record the colour against the white paper.

Liquid	Prediction	Colour with cabbage	Group (acid / neutral / alkali)
A lemon juice			
B vinegar			
C fizzy water			
D tap water			
E salt solution			
F baking soda			
G milk of magnesia			
H washing soda			

1. **Build the colour key (5 min).** As a class, line the cups up from red through purple to green-yellow. The typical pattern:
2. **red / pink / magenta** = acidic (lemon juice, vinegar; fizzy water is usually a paler pink-purple)
3. **purple** = about neutral (salt solution; tap water is usually purple or close to it)
4. **blue / green** = alkaline (baking soda, milk of magnesia)
5. **green-yellow** = more strongly alkaline (washing soda)

Teacher: use your own results from testing the day before. Colours vary with the cabbage and water.

✓ Discussion questions (10 min)

1. **Were any of your predictions wrong? Which ones surprised you?** Example answer: "We thought fizzy water would be neutral because it's just water, but it went pinkish so it's slightly acidic." (Carbon dioxide dissolves in water and makes it slightly acidic — the same idea as the bromothymol blue tubes in grade 7.)
2. **Salt solution and tap water look the same as vinegar. Why can't we use our eyes?** Example answer: "Acids and alkalis are often colourless; you can only tell with a test."
3. **Is lemon juice dangerous? Is washing soda safe?** Example answer: "Lemon juice is an acid but we eat it, so not all acids are dangerous. Washing soda is an alkali and it can hurt your eyes and skin, so alkalis are not automatically safe." (Strength and concentration matter more than the label "acid" or "alkali".)
4. **Did the cabbage turn the vinegar into an acid?** Example answer: "No. The vinegar was already an acid. The cabbage just shows it by changing colour."

✓ Closing check (5 min, answers below)

1. What is an indicator?

2. A liquid turns cabbage indicator green. Is it acidic, neutral or alkaline?
3. Name one acidic and one alkaline liquid from today.

Answers: 1. A substance (often a dye) that changes colour depending on whether a liquid is acidic, neutral or alkaline. 2. Alkaline. 3. Acidic: lemon juice, vinegar or fizzy water. Alkaline: baking soda solution, milk of magnesia or washing soda solution.

Vocabulary

acid, alkali, neutral, indicator, pigment, anthocyanin, prediction

Differentiation

- **Support:** give a printed colour strip (red → purple → green → yellow) with "acid", "neutral" and "alkali" labels to match against. Reduce to five liquids (A, B, D, F, H).
- **Stretch:** try other coloured plant juices the teacher has prepared (for example blueberry juice) and compare them with cabbage. Blueberry juice also turns redder with acid and more blue-violet with alkali. Which indicator shows the difference more clearly?

⚠ Safety

- Eye protection on throughout. If anything goes in an eye, rinse with plenty of clean water and tell the teacher.
- **Never taste** any liquid in the lab, even ones that are food at home.
- The teacher handles the kettle and hot water. Let the extract cool before students use it.
- Washing soda solution is an irritant: the teacher makes it up dilute, students wear eye protection, and spills are wiped up straight away. Wash hands after the lesson.
- **Never use bleach, oven cleaner or drain cleaner** in this lesson. Drain cleaners often contain sodium hydroxide, which is highly corrosive. Never mix household cleaning products.
- Cabbage extract stains clothes and benches; use trays.

Teacher notes and misconceptions

- **"All acids burn."** Many acids are weak or dilute and are in food (citric acid in lemons, acetic acid in vinegar). Strong, concentrated acids are dangerous.
- **"Alkalis are safe because they're not acids."** Strong alkalis such as sodium hydroxide are as dangerous as strong acids.
- **"Neutral means no chemicals in it."** Salt solution is neutral and is full of dissolved salt. Neutral describes acidity, not purity.
- **"The indicator makes the liquid acidic."** The indicator only shows what is already there.
- Fizzy water loses its carbon dioxide once opened, so it may drift towards purple over a lesson. Open it just before use.
- Milk of magnesia is cloudy; let it settle a moment and look at the colour of the liquid above, or dilute it more.

Lesson 2 — The pH scale and universal indicator

Back to unit

Goal

Students use universal indicator to give liquids a pH number, place them on the 0–14 scale, and compare three indicators (cabbage, litmus, universal indicator) to see what each can and cannot tell us.

Materials

- Eye protection for everyone.
- Per group: universal indicator paper cut into 1 cm strips (or universal indicator solution and a spotting tile), the colour chart supplied with it, tweezers or a glass rod, a white tile.
- Red and blue litmus paper (a few strips per group).
- The eight liquids from lesson 1 (A–H), freshly poured.
- A long paper strip or masking tape line across the board, marked 0 to 14.
- "pH cards" for the closing sort (see Main activity part 4).

Steps

✎ Opening (5 min)

Show last lesson's cabbage results. Ask: "Lemon juice and fizzy water were both 'acid'. Are they equally acidic? How could we tell?" Take ideas. Explain that scientists use a number scale, the **pH scale**, which usually runs from 0 to 14:

- below 7 = **acidic** (the lower the number, the more acidic)
- 7 = **neutral** (pure water at room temperature)
- above 7 = **alkaline** (the higher the number, the more alkaline)

✎ Main activity (30 min)

1. **Universal indicator (15 min).** Universal indicator is a mixture of several indicators, so it changes through many colours instead of two or three. Show the colour chart: red, orange and yellow mean acidic; green means neutral; blue and violet mean alkaline. For each liquid, dip a rod in and touch it onto a fresh strip of paper (or add 2 drops of indicator solution to a few drops of liquid). Match the colour to the chart **within 30 seconds** and record the pH number.

Liquid	Cabbage group (lesson 1)	Universal indicator colour	pH (from chart)
A lemon juice			
B vinegar			
C fizzy water			

Liquid	Cabbage group (lesson 1)	Universal indicator colour	pH (from chart)
D tap water			
E salt solution			
F baking soda			
G milk of magnesia			
H washing soda			

1. **Line them up (5 min).** Each group sends one person to stick a label for each liquid on the class 0–14 line. Discuss disagreements: "Why might two groups get different numbers for the same liquid?" (Reading colours is a judgement; strips can be left too long; liquids were poured at different times.) Agree a class value for each liquid and mark ranges where groups disagree.
2. **Litmus: a yes/no indicator (5 min).** Give red and blue litmus paper. Students test lemon juice, salt solution and baking soda solution. Blue litmus turns red in acid; red litmus turns blue in alkali; in a neutral liquid neither changes much. Ask: "What can universal indicator tell you that litmus can't?" (How acidic or alkaline: a number, not just acid or alkali.)
3. **pH cards (5 min).** Groups place these cards on the class line. The values are typical figures from reference sources:
4. pure water: 7
5. human blood: about 7.4 (slightly alkaline)
6. seawater: about 8.05 (slightly alkaline)
7. most drinking water: between 6.5 and 8.5
8. acid rain: on average about 4 to 5
9. citrus fruit and vinegar: below 4.6

✓ Discussion questions (10 min)

1. **Which indicator would you choose to check whether a swimming pool is slightly too acidic, and why?** Example answer: "Universal indicator, because it gives a number. Litmus would only say acid or not."
2. **Blood is about 7.4. Is blood acidic, neutral or alkaline?** Example answer: "Slightly alkaline, because it's just above 7."
3. **Acid rain has a pH of about 4 to 5. Why might that harm a lake?** Example answer: "It makes the lake water more acidic than normal, and the living things there are used to water around neutral." (Acid rain is linked to harm to fish, forests and soils.)
4. **Some indicators have only two colours (litmus; phenolphthalein, which is colourless in acid and pink in alkali). Why might a scientist still use them?** Example answer: "When you only need to know if you've gone past a certain point, like when an acid has been neutralised, a sharp change from one colour to another is easier to see."

✓ Closing check (5 min, answers below)

1. A liquid has pH 3. Another has pH 6. Which is more acidic?
2. What colour would universal indicator turn in a neutral liquid?

3. Give one advantage of universal indicator over litmus.

Answers: 1. pH 3 (lower number = more acidic). 2. Green. 3. It shows how acidic or alkaline something is (a pH number), not just whether it is acidic or alkaline.

Vocabulary

pH, pH scale, universal indicator, litmus, phenolphthalein, colour chart, range

Differentiation

- **Support:** give a pre-printed 0–14 line coloured like the universal indicator chart, with "acid", "neutral" and "alkali" bands. Students stick small coloured dots for each liquid.
- **Stretch:** the pH scale is not like a ruler. Each step of 1 means a **tenfold** change in acidity. So pH 3 is 10 times more acidic than pH 4, and 100 times more acidic than pH 5. How many times more acidic is acid rain at pH 4 than water at pH 6? (100 times.) This is a simplified introduction; the reason (hydrogen ion concentration and logarithms) comes in later grades.

⚠ Safety

- Eye protection on throughout.
- Never taste the liquids. Universal indicator solution is often made in alcohol, which is flammable: keep it away from flames.
- Universal indicator and cabbage stain skin; use tweezers or a rod, not fingers. Wash hands at the end.
- Dispose of used strips in the bin, not the sink.

Teacher notes and misconceptions

- **"pH 7 always means water."** pH 7 means neutral; salt solution is also about 7.
- **"A higher pH number means more acid."** It is the opposite. Many students think "higher = more". Use the line repeatedly.
- **"The pH scale stops at 0 and 14."** It is usually drawn from 0 to 14, but very concentrated strong acids and alkalis can go beyond it. Mention only if students ask.
- Universal indicator paper keeps changing colour if left; reading quickly matters.
- Tap water results vary by area. Accept your own measured value.

Lesson 3 — Cancelling out: neutralisation by drops

Back to unit

Goal

Students neutralise an acid by adding an alkaline solution drop by drop, watching the indicator change, and carry out a repeated, fair comparison of two acids (vinegar and lemon juice) using the median number of drops.

Materials

- Eye protection for everyone.
- Per group: two clear cups or small beakers; a white tile or paper underneath; two 10 ml plastic syringes (no needles) or small measuring cylinders; one dropper used only for the baking soda solution; cabbage indicator from lesson 1; a stirring rod or spoon; a record table.
- White vinegar and lemon juice (bottled lemon juice gives more consistent results than fresh lemons).
- Baking soda solution: 1 level teaspoon (about 5 g) sodium hydrogencarbonate stirred into 100 ml water, made up fresh. Make one large batch for the whole class so every group uses the same solution.
- Water for diluting.

Teacher trial: do the whole method the day before. With 1 ml of acid, expect something in the region of 20–40 drops, but the number depends on your vinegar (vinegar can contain anywhere from about 4% to 18% acetic acid), your lemon juice, your teaspoon and your dropper. Adjust the acid volume so groups need roughly 15–40 drops.

Steps

✎ Opening (5 min)

Recap: acids are below 7, alkalis above 7. Ask: "What do you think happens if you mix an acid and an alkali?" Take predictions ("they explode", "they fizz", "you get something in the middle"). Tell students they will find out, and count exactly how much it takes.

✎ Main activity (30 min)

1. **Watch it happen (teacher demo, 5 min).** Put 1 ml of vinegar and 10 ml of water in a cup with 10 drops of cabbage indicator: it is pink-red. Add baking soda solution a few drops at a time, swirling. Students see:
2. **fizzing** — a gas is given off (carbon dioxide; links to grade 5's bicarbonate and vinegar balloon);
3. the colour moving from pink towards **purple** (neutral);

4. if you keep going, it turns **blue-green** (now alkaline: too much has been added).

Explain: the acid and the alkali **cancel each other out**. This is called **neutralisation**. The general word equation is:

acid + alkali → salt + water

Baking soda is a hydrogencarbonate, so here there is also a gas:

acid + hydrogencarbonate → salt + water + carbon dioxide

("Salt" is a family of substances; table salt is only one of them.)

1. **The question (2 min).** "Which needs more baking soda solution to neutralise it: 1 ml of vinegar or 1 ml of lemon juice?" Students predict and give a reason.
2. **Plan it fairly (3 min).** Ask what must stay the same: the volume of acid (1 ml, measured with a syringe), the added water (10 ml), the number of indicator drops (10), the same dropper, the same baking soda batch, and the same end point (**the first time the colour stays purple for 10 seconds after swirling**). What changes: the type of acid. What we measure: the number of drops.
3. **Do it (15 min).** Each group does **three repeats for each acid**, rinsing the cup between runs. Add one drop at a time, swirl, wait, then add the next.

Acid	Run 1 (drops)	Run 2	Run 3	Median
Vinegar				
Lemon juice				

Example results (made-up numbers to show the method, not a prediction):

Acid	Run 1	Run 2	Run 3	Median
Vinegar	31	29	30	**30**
Lemon juice	25	27	41	**27**

Point out the 41: it is far from the other two. The group probably overshot the purple and went into blue. The median (27) is not dragged up by the mistake, which is why we use it.

1. **Conclude (5 min).** Each group writes one sentence: "The ___ needed more drops of baking soda solution (median ___ drops compared with ___), so 1 ml of it contained more acid to cancel out." Compare across groups. Do all groups agree on which needs more?

✓ Discussion questions (10 min)

1. **Why do we count drops instead of just saying "a bit more"?** Example answer: "Numbers let us compare fairly and check if other groups got the same result."
2. **Why did we use the same baking soda batch and the same dropper for everyone?** Example answer: "If one group's solution was stronger or their drops were bigger, they'd need fewer drops, and it wouldn't be a fair comparison."
3. **When the mixture is purple, are there still chemicals in it?** Example answer: "Yes. There's water and a salt dissolved in it. Neutral doesn't mean empty."

4. **Where did the fizz come from, and where did it go?** Example answer: "Carbon dioxide gas was made when the baking soda reacted with the acid, and it escaped into the air."

✓ Closing check (5 min, answers below)

1. Complete: acid + alkali → _____ + _____.
2. A group's results for one acid are 18, 19 and 33 drops. What is the median, and which result is probably a mistake?
3. What colour shows that the cabbage-indicator mixture has just been neutralised?

Answers: 1. Salt + water. 2. Median 19; the 33 is probably a mistake (overshooting the end point). 3. Purple.

Vocabulary

neutralisation, salt, word equation, end point, hydrogencarbonate, carbon dioxide, median, repeat

Differentiation

- **Support:** give a step card with pictures (measure 1 ml → add 10 ml water → add 10 drops indicator → add baking soda one drop at a time → stop at purple). Do two repeats instead of three.
- **Stretch:** name the salts. Vinegar contains acetic acid, so the salt is sodium acetate; lemon juice contains mainly citric acid, so the salt is sodium citrate. Why might two acids need different amounts even if they are the same volume? (They may be different concentrations, and different acids can cancel out different amounts of alkali per molecule. This is covered properly in grades 9–10.)

⚠ Safety

- Eye protection on throughout.
- Syringes have **no needles**.
- Never taste any mixture, even though the ingredients come from a kitchen.
- Wipe spills straight away; the fizzing mixture can bubble over if baking soda is added too fast.
- Mixtures can go down the sink with plenty of water. Wash hands at the end.

Teacher notes and misconceptions

- **"Neutralisation destroys the chemicals."** It makes new substances (a salt and water, plus carbon dioxide here). Mass is not lost; the carbon dioxide escapes into the air.
- **"Acid + alkali always fizzes."** Only acids with carbonates or hydrogencarbonates give carbon dioxide. Acid + an alkali such as sodium hydroxide gives no gas.
- **"Purple means pure water."** It means neutral.

- Overshooting is the most common error: insist on one drop at a time near the end, and swirling. The colour change near neutral can be gradual; agree as a class what "purple" looks like by keeping one neutral cup (salt solution + indicator) as a reference.
- Results differ between brands of vinegar and lemon juice, so the class answer is "which needed more with our bottles", not a general rule.

Lesson 4 — Neutralisation at work: stomachs, soils and seas

Back to unit

Goal

Students measure the pH of real soil samples, watch a model of how an antacid works, and use real data to explain what "ocean acidification" means and what it does not mean.

Materials

- Eye protection for everyone.
- Three soil samples, labelled X, Y and Z, collected by the teacher (for example: garden or field soil, peat-free compost, and soil from under conifers or from a heather or rhododendron bed if available). About 2 tablespoons of each per group.
- Per group: three clear cups or jars with lids, distilled or deionised water (tap water can change the result), filter paper and a funnel (or a coffee filter), universal indicator paper and chart, a teaspoon, a record table.
- Teacher demonstration: a clear jug or large beaker, white vinegar diluted about 1 part to 10 parts water, cabbage indicator, and either one antacid tablet or 1–2 teaspoons of milk of magnesia.
- Printed ocean pH card (see part 3).

Steps

✎ Opening (5 min)

Ask: "Where outside a lab might people want to neutralise something?" Take ideas. Introduce the three places in today's lesson: **inside your stomach, in the soil, and in the sea.**

✎ Main activity (30 min)

1. **Soil pH (15 min).**
2. Put 1 heaped teaspoon of soil in a cup. Add about 50 ml of distilled water. Put the lid on and shake for 30 seconds. Leave it to settle for 5 minutes.
3. Filter the cloudy water into a clean cup (it does not have to be perfectly clear).
4. Test the liquid with universal indicator paper. Record the colour and pH.
5. Repeat for all three soils.

Soil	Where it came from	Indicator colour	pH
X			
Y			
Z			

Then share some facts about soils: - Soil pH matters because it controls which nutrients plants can take up. Most plants grow best between about **pH 5.5 and 7.5**. - Some plants prefer **acidic** soil: rhododendrons, heathers (Erica), Scots pine. Others prefer **limey (alkaline)** soil: ash trees, lilac, clematis. - Farmers and gardeners can **neutralise acidic soil** by adding lime (calcium hydroxide) or crushed limestone (calcium carbonate). Soil that is too alkaline can be made more acidic with sulfur.

Ask: "Which of our soils would suit a rhododendron? Which would a farmer want to lime?"

1. **A model of an antacid (teacher demo, 7 min).** Explain: your stomach makes acid to help digest food. Sometimes it causes discomfort (heartburn, indigestion). An **antacid** is a medicine that neutralises some of the stomach acid. Many contain an alkaline substance such as magnesium hydroxide (milk of magnesia) or a carbonate.
2. Pour the dilute vinegar into the jug and add cabbage indicator: pink-red. "This is our pretend stomach acid." (Real stomach acid is hydrochloric acid and much more acidic. Vinegar is only a safe stand-in.)
3. Crush and add the antacid tablet, or stir in the milk of magnesia. Stir and wait. The colour moves towards purple, or beyond into blue. If the tablet contains a carbonate, it fizzes.

4. Ask: "Which word equation from last lesson is this?" (acid + alkali → salt + water; with a carbonate, also carbon dioxide.)

5. **What is happening to the sea? (8 min).** Hand out the ocean pH card:

   Between 1950 and today, the average pH of the ocean surface fell from about **8.15** to about **8.05**. The main cause is carbon dioxide from human activities: some of the extra carbon dioxide in the air dissolves in the sea and makes it slightly more acidic. Seawater is **still alkaline** (above pH 8). This change is called **ocean acidification**. Animals that build shells or skeletons from calcium carbonate, such as corals and molluscs, are especially at risk.

Link to grade 7: the bromothymol blue tubes turned yellow when students breathed carbon dioxide into them. The same thing happens, very slowly, to the ocean.

Ask: "Is the sea now acidic?" (No. It is still alkaline, just less alkaline than before. "Acidification" means moving towards the acidic end, not arriving there.)

✓ Discussion questions (10 min)

1. **Why did we shake the soil with distilled water instead of tap water?** Example answer: "Tap water has its own pH, which might change the result. Distilled water doesn't add anything."
2. **A gardener's soil is pH 4.5 and her vegetables grow badly. What could she do, and why does it work?** Example answer: "Add lime. It's alkaline, so it neutralises some of the acid in the soil and raises the pH towards the 5.5 to 7.5 that most plants like."
3. **Why is vinegar only a model of stomach acid?** Example answer: "Real stomach acid is a different, stronger acid. Vinegar is safe to use in class, but it doesn't behave exactly the same."

4. **A headline says "The oceans are turning to acid." What is right and wrong about it?** Example answer: "Right: the pH is going down, so the sea is becoming more acidic. Wrong: the sea is still alkaline, above 8, not an acid."

✓ Closing check (5 min, answers below)

1. What type of substance is used to treat soil that is too acidic?
2. What does an antacid do in the stomach?
3. The ocean's surface pH went from about 8.15 to about 8.05. Did it become more acidic or more alkaline? Is it acidic now?

Answers: 1. An alkaline substance or a carbonate, such as lime or crushed limestone. 2. It neutralises some of the stomach acid. 3. More acidic (the pH went down); no, it is still alkaline (above 7).

Vocabulary

soil pH, lime, limestone, antacid, indigestion, ocean acidification, calcium carbonate, model

Differentiation

- **Support:** test two soils instead of three; give a sentence frame for the ocean question ("The pH went ___, so the sea became more ___. It is still ___ because its pH is above 7.").
- **Stretch:** the ocean's pH fell by only 0.1. Using the "each step of 1 is ten times" rule from lesson 2, a drop of 0.1 is about a 26% increase in acidity (because 10 to the power 0.1 is about 1.26). Why might a small-looking change in pH still matter to sea life? Acid rain (lesson 2) has been reduced in Europe and North America since the 1970s by laws cutting sulfur dioxide and nitrogen oxide emissions. What would cutting ocean acidification need?

⚠ Safety

- Eye protection on throughout.
- **Students do not handle antacid tablets or other medicines.** The teacher does the antacid demonstration and disposes of any leftover tablet safely. Students should never take medicine without an adult's permission.
- Wear gloves or wash hands well after handling soil. Collect soil only from places free of animal droppings, sharp objects and garden chemicals. Cover cuts.
- Never taste any of the mixtures.

Teacher notes and misconceptions

- **"Ocean acidification means the sea is acid."** The sea is still alkaline; the pH is falling.
- **"Plants all like neutral soil."** Many plants are adapted to acidic or alkaline soils; the "best" pH depends on the plant.
- **"Antacids get rid of all the acid."** They neutralise some of it; the stomach needs acid to digest food.

- Soil results depend on the soil-to-water ratio and on the soil itself. A cheap soil-testing kit from a garden centre can be used instead of indicator paper.
- If compost results look surprising, that is a good discussion point: many composts and potting mixes are deliberately adjusted by the manufacturer.

Lesson 5 — Acids and alkalis in the world + unit check

Back to unit

Goal

Students pull the unit together by sorting real-life situations, then complete a 10-question unit check (20 marks).

Materials

- A set of 10 situation cards per group (listed below).
- Three large labels per group: ACIDIC, NEUTRAL, ALKALINE, plus a fourth: NEUTRALISATION.
- Printed unit check (questions below), one per student.

Steps

✎ Opening (5 min)

Quick-fire recall: teacher calls out a colour and an indicator ("green with universal indicator", "pink with cabbage", "red litmus turns blue") and students hold up A (acid), N (neutral) or K (alkali) cards.

✎ Main activity: situation sort (15 min)

Groups place each card under ACIDIC, NEUTRAL, ALKALINE or NEUTRALISATION and write one reason on a sticky note.

1. Lemon juice in a salad dressing. (Acidic: citric acid.)
2. A bottle of drain cleaner containing sodium hydroxide. (Alkaline, and highly corrosive.)
3. Salt dissolved in pure water. (Neutral.)
4. A person takes an antacid for indigestion. (Neutralisation.)
5. Rain with a pH of 4.5 falling on a forest. (Acidic: acid rain.)
6. A farmer spreading crushed limestone on a field. (Neutralisation of acidic soil.)
7. Human blood at pH about 7.4. (Slightly alkaline.)
8. Vinegar used to pickle vegetables. (Acidic: acetic acid.)
9. Seawater at pH about 8.05. (Alkaline, though becoming less so.)
10. Baking soda added to a cake mixture with an acidic ingredient so that it fizzes and rises. (Neutralisation, giving carbon dioxide.)

Discuss: card 2 and card 1 are both "chemicals from home", but one is food and one is dangerous. What makes the difference? (Strength and concentration, not whether it is an acid or alkali.)

✓ Unit check (25 min)

Students work alone. Calculators are not needed.

Q1. What is an indicator? (2 marks)

Q2. Red cabbage indicator turns: red/pink in liquid P, purple in liquid Q, green in liquid R. Label each as acidic, neutral or alkaline. (2 marks)

Q3. Put these in order from most acidic to most alkaline: blood (pH about 7.4), lemon juice (pH about 2.2), pure water (pH 7), acid rain (pH about 4.5 to 5), washing soda solution (strongly alkaline). (2 marks)

Q4. Give one advantage of universal indicator over litmus paper. (2 marks)

Q5. Complete the word equations. (2 marks) (a) acid + alkali → _____ + _____ (b) acid + hydrogencarbonate → salt + water + _____

Q6. A group neutralised 1 ml of vinegar with baking soda solution three times. They needed 22, 24 and 37 drops. (a) What is the median? (1 mark) (b) Which result is probably a mistake, and what might have caused it? (1 mark)

Q7. In the neutralisation investigation, name two things that must be kept the same to make it a fair comparison. (2 marks)

Q8. A gardener tests her soil and finds it is pH 4.5. Most of her plants grow best between pH 5.5 and 7.5. What could she add, and why does it work? (2 marks)

Q9. A student says: "Alkalis are safe, it's acids you have to be careful with." Do you agree? Explain with an example. (2 marks)

Q10. A news article says: "Ocean acidification means the sea has become an acid." The ocean's average surface pH has fallen from about 8.15 to about 8.05. Explain what is right and what is wrong in the article. (2 marks)

Answer guide and marking notes

Q1. 1 mark: a substance that changes colour. 1 mark: depending on whether a liquid is acidic, neutral or alkaline (or depending on pH). "A colour" alone = 0.

Q2. All three correct (P acidic, Q neutral, R alkaline) = 2 marks; two correct = 1 mark.

Q3. Correct order: lemon juice, acid rain, pure water, blood, washing soda solution. 2 marks for the full order; 1 mark if only one adjacent pair is swapped. (Lemon juice at about pH 2.2 is clearly more acidic than acid rain at about 4.5 to 5. The 2.2 figure is from the Wikipedia "PH" article; real lemons vary a little.)

Q4. 1 mark: universal indicator gives a pH number / shows how acidic or alkaline. 1 mark: litmus only shows acid or alkali (or a full comparison sentence).

Q5. (a) salt + water (1 mark for both). (b) carbon dioxide (1 mark).

Q6. (a) 24. (b) 37; overshooting the end point / adding too many drops past purple / adding drops too quickly (any sensible cause).

Q7. Any two, 1 mark each: volume of acid; volume of added water; number of indicator drops; same dropper; same baking soda solution / batch; same end point colour. "The amount" without saying of what = 0.

Q8. 1 mark: lime / crushed limestone / an alkali or a carbonate. 1 mark: it neutralises some of the acid in the soil and raises the pH (towards 5.5–7.5).

Q9. 1 mark: disagree. 1 mark: an example, such as sodium hydroxide / drain cleaner is a highly corrosive alkali; or washing soda can irritate eyes and skin. Accept "it depends on strength and concentration" with an example.

Q10. 1 mark (right): the pH has fallen, so the sea has become more acidic. 1 mark (wrong): seawater is still alkaline (pH above 7, about 8), so it is not an acid.

Total: 20 marks. No pass mark is set; use the results to see which ideas need revisiting. Common gaps to look for: thinking a higher pH means more acidic (Q3); thinking neutralisation needs no measuring (Q6–Q7); thinking "acidification" means "acidic" (Q10).

Vocabulary review

acid, alkali, neutral, indicator, pH scale, universal indicator, litmus, neutralisation, salt, antacid, lime, ocean acidification

Differentiation

- **Support:** read questions aloud; provide the word bank above; allow Q3 to be done by placing labelled cards on a pH line.
- **Stretch:** add a bonus question (not marked out of 20): "Acid rain at pH 4 is how many times more acidic than water at pH 6?" (100 times.)

⚠ Safety

- No practical work in this lesson.

Teacher notes

- Card 10 (baking soda in a cake) links to the sodium bicarbonate fact that baking powder contains an acid ingredient so that the reaction happens without adding vinegar.
- Card 9's pH figure and Q10's figures come from the Wikipedia "Ocean acidification" article (see unit sources); check a current scientific source before quoting them as exact.
- If students did not get clear results in lesson 3, let them use the example data table from lesson 3 for Q6–Q7 discussion afterwards.