

Inspired and expired air: limewater test

Investigate the differences in composition between inspired and expired air using limewater as a test for carbon dioxide

For Cambridge IGCSE Biology 0610 (and 0970, which has the same content). Teacher answers start on a new page.

Name

Date

Aim

To compare the carbon dioxide content of inspired air and expired air by finding how many breaths it takes to turn limewater cloudy.

Background

Inspired air is the air that is breathed in. **Expired air** is the air that is breathed out. Expired air contains less oxygen, more carbon dioxide and more water vapour than inspired air.

Limewater is a test for carbon dioxide. It is colourless, and it turns cloudy (milky) when carbon dioxide is bubbled through it. The more carbon dioxide there is in the gas, the faster the limewater turns cloudy.

Inspired air contains very little carbon dioxide (about 0.04%). Expired air contains about 4%.

Supplement: carbon dioxide is produced by the cells in respiration, carried to the lungs in the blood and diffuses into the alveoli.

Hypothesis

Fewer breaths of expired air than of inspired air are needed to turn limewater cloudy, because expired air contains more carbon dioxide.

Variables

Independent	The air tested: inspired air or expired air
Dependent	The number of breaths needed to turn the limewater cloudy
Control	• The same volume of limewater (20 cm³) in each tube • Fresh limewater from the same stock bottle in both tubes • The same size of boiling tube and the same depth of the long tube below the limewater surface • The same breaths: every breath in passes through tube A and every breath out passes through tube B • The same end-point: the first sign of cloudiness, compared with a tube of fresh limewater

Equipment

- Limewater, fresh from a stoppered bottle
- 3 boiling tubes (large test-tubes, 150 mm × 25 mm): two for the test and one of fresh limewater for comparison
- 2 bungs, each with two holes, fitted by the teacher with a long glass tube (reaching below the surface of the limewater) and a short glass tube (ending above it)
- Rubber tubing and a T-piece (or Y-piece) connector

- A new mouthpiece (or a new drinking straw) for each person
- Measuring cylinder, 25 cm³
- Test-tube rack
- Eye protection

Risk assessment

Hazard	Risk	Precaution
Limewater (calcium hydroxide solution)	Irritates the eyes; unpleasant and harmful if it is sucked or blown into the mouth.	Wear eye protection. Check that the tubes are connected the right way round before starting, and breathe gently, never sharply. Rinse any splashes off the skin or eyes with plenty of water.
Sharing a mouthpiece	Spread of infections.	Each person uses their own new mouthpiece or straw. Never share one, and throw it away afterwards.
Breathing through the apparatus for several minutes	Light-headedness.	Breathe at a normal, gentle rate and depth. Stop and rest if you feel dizzy.
Glass tubes in bungs	Cuts if the glass snaps.	The teacher fits the glass tubes into the bungs. Do not push or twist them.

Method

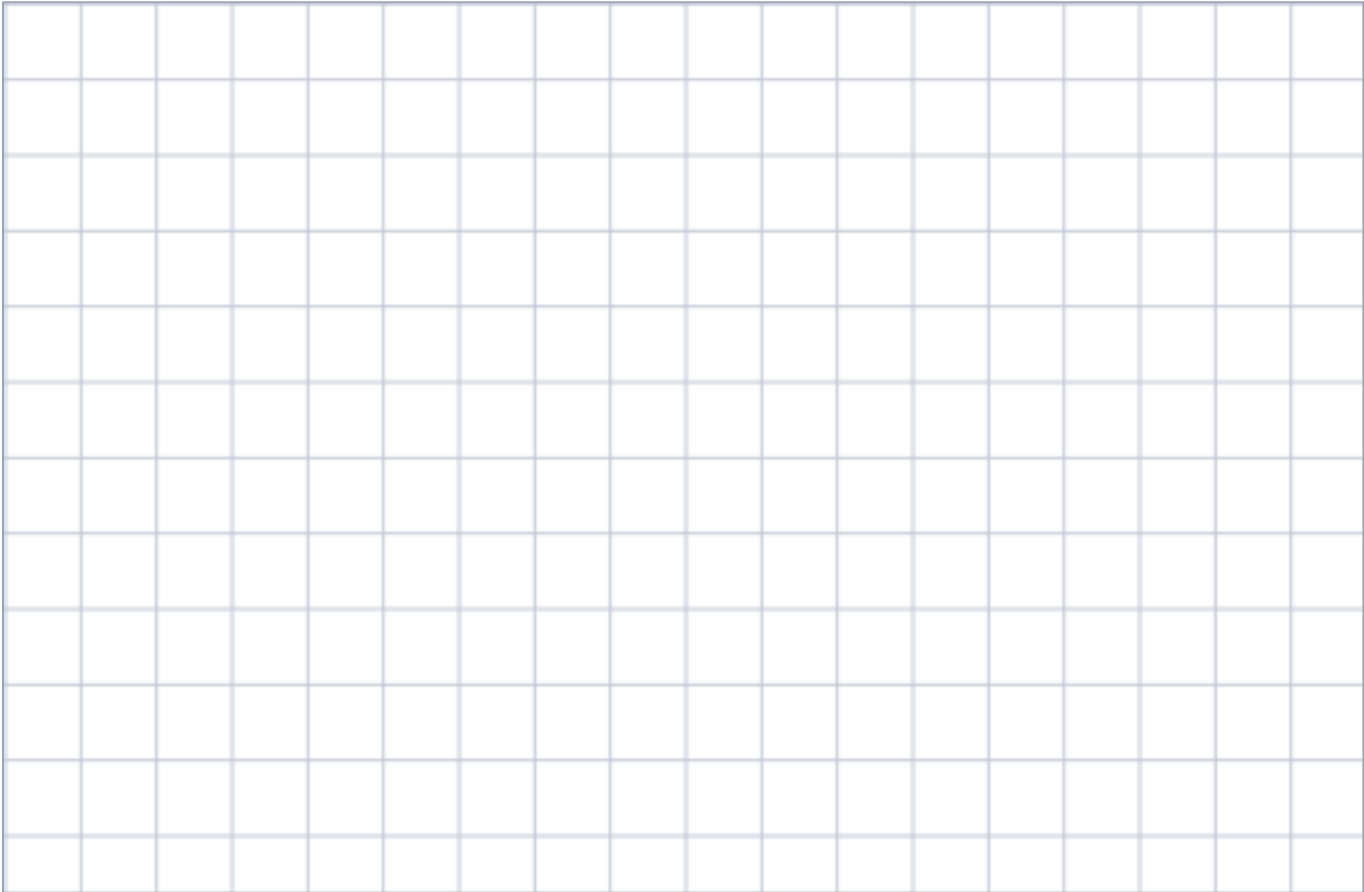
1. Put on eye protection.
2. Use the measuring cylinder to put 20 cm³ of fresh limewater into each of three boiling tubes. Label them A (inspired air), B (expired air) and C (comparison). Stand them in the rack.
3. Fit the bungs to tubes A and B. In tube A, the long tube is open to the room air and the short tube is joined to the T-piece. In tube B, the long tube is joined to the T-piece and the short tube is open to the air.
4. Fit a new mouthpiece to the T-piece. Ask your teacher to check that the tubes are connected the right way round.
5. Breathe in and out gently through the mouthpiece. Breathing in draws room air through the limewater in tube A. Breathing out blows your breath through the limewater in tube B.
6. Count the breaths (one breath = in and out). Record the number of breaths when the limewater in tube B first looks cloudy compared with tube C.
7. Carry on breathing gently and record the number of breaths when the limewater in tube A first looks cloudy. Stop after 60 breaths if it has not changed, and record 'more than 60'.
8. Record the appearance of the limewater in tubes A and B at the end.
9. Empty and rinse tubes A and B, add fresh limewater and repeat steps 5 to 8 twice more. Each person uses only their own mouthpiece.
10. Calculate the mean number of breaths needed to turn the limewater cloudy for inspired air and for expired air.
11. Compare the results and write a conclusion.

Results

Number of breaths needed to turn limewater cloudy					
air tested	number of breaths: 1	number of breaths: 2	number of breaths: 3	mean number of breaths	appearance of limewater at the end
inspired air (tube A)					
expired air (tube B)					

Graph

A bar chart with the air tested (inspired air, expired air) on the x-axis and mean number of breaths needed to turn limewater cloudy on the y-axis (title the axis: mean number of breaths). The two types of air are separate categories, so draw two bars of equal width that do not touch. Use a scale so that more than half of the grid is used and label both axes.



Exam questions 11 questions • 26 marks

1 State what limewater is used to test for and what is seen when the test is positive. [2 marks]

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- 2** The same volume of limewater is put into both tubes. Give one other variable that is kept the same in the investigation and explain why it is controlled. **[2 marks]**

- 3** A student uses the apparatus in the diagram to compare inspired air and expired air. (a) State the independent variable. [1] (b) State the dependent variable. [1] (c) After 44 breaths, the limewater in tube A also turned slightly cloudy. Suggest why. [1] **[3 marks]**

- 4** The table shows the number of breaths needed to turn the limewater cloudy for inspired air. Calculate the mean number of breaths. **[2 marks]**

Number of breaths needed to turn limewater cloudy (inspired air)			
air tested	number of breaths: 1	number of breaths: 2	number of breaths: 3
inspired air	41	47	44

Answer =

- 5** The mean number of breaths needed to turn the limewater cloudy was 44 for inspired air and 6 for expired air. State what these results show. **[2 marks]**

- 6** Supplement. Explain why expired air contains more carbon dioxide than inspired air. **[2 marks]**

7 In tube A, the long glass tube dips below the surface of the limewater and is open to the air. Explain why this tube must dip below the surface. **[2 marks]**

8 Describe two safety precautions that should be taken in this investigation. **[2 marks]**

9 Name another indicator that can be used to show that expired air contains carbon dioxide, and state the colour change that shows that carbon dioxide is present. **[2 marks]**

10 The student says that the method does not give accurate results. Suggest three improvements. **[3 marks]**

11 A student predicts that the limewater will turn cloudy in fewer breaths if the person has just done some exercise. Describe an investigation to test this prediction. **[4 marks]**

Teacher answers

Practical skill 11: Inspired and expired air: limewater test. The example results are practice data, not real measurements.

Example results

Example results (practice data)					
air tested	number of breaths: 1	number of breaths: 2	number of breaths: 3	mean number of breaths	appearance of limewater at the end
inspired air (tube A)	41	47	44	44	slightly cloudy
expired air (tube B)	6	5	7	6	milky

Conclusion

The limewater turned cloudy after a mean of 6 breaths with expired air but after a mean of 44 breaths with inspired air. The same breaths passed through both tubes, so expired air contains more carbon dioxide than inspired air, which supports the hypothesis. Inspired air contains a little carbon dioxide, so the limewater in tube A did turn slightly cloudy in the end. Supplement: carbon dioxide is produced by the cells of the body in respiration, carried to the lungs in the blood and diffuses into the air in the alveoli, so it is breathed out.

Errors and improvements

Error	Effect on the results	Improvement
The point at which the limewater first looks cloudy is judged by eye.	Different people stop at different degrees of cloudiness, so the number of breaths varies.	Compare with a tube of fresh limewater against a dark background, or note when a black cross on a card behind the tube can no longer be seen clearly.
The breaths are not all the same size.	Different volumes of air pass through the limewater, so the number of breaths needed varies between repeats.	Breathe as steadily as possible and repeat, or pump a measured volume of air through the limewater with a large syringe.
Limewater left open to the air absorbs carbon dioxide from the air.	It may already be slightly cloudy, so it turns cloudy in fewer breaths.	Use fresh limewater from a stoppered bottle for each repeat.
Only three repeats are done by one person.	One anomalous result has a large effect on the mean, and the results may not be typical.	Do more repeats and test several people, then ignore anomalous results when calculating the mean.

Mark scheme

One mark for each point unless a maximum is given. Words in brackets are not needed for the mark.

1. [2]

- carbon dioxide (1) allow CO₂
- limewater turns cloudy / milky (1) allow turns white; ignore from clear / colourless

2. [2]

- any one from: same concentration / fresh limewater / same size of tube / same depth of the long tube / same person / same breaths / same end-point (1) ignore 'same amount of air'
- so that any difference in the results is caused only by the type of air (1) allow so that it is a fair test

3. [3]

- (a) the type of air tested / inspired air or expired air (1)
- (b) the number of breaths needed to turn the limewater cloudy (1)
- (c) inspired air contains a small amount of carbon dioxide (1) reject inspired air contains no carbon dioxide

4. [2]

- $(41 + 47 + 44) \div 3$ (1)
- 44 (breaths) (1)

5. [2]

- the limewater turned cloudy in fewer breaths with expired air (1)
- so expired air contains more carbon dioxide than inspired air (1) reject inspired air contains no carbon dioxide

6. [2]

- carbon dioxide is produced by (body) cells in respiration (1)
- it is carried to the lungs in the blood and diffuses into the alveoli (1)

7. [2]

- so that the air breathed in bubbles through the limewater (1)
- so that the carbon dioxide in the inspired air reacts with / is tested by the limewater (1)

8. [2]

- wear eye protection (1)
- connect the tubes the right way round / breathe gently so that limewater is not sucked into the mouth (1)
- use your own new mouthpiece / do not share mouthpieces (1)
- stop if you feel dizzy (1)
- Max 2

9. [2]

- hydrogencarbonate indicator (1)
- orange / red to yellow (1)

10. [3]

- more repeats and calculate a mean (1)
- use a comparison tube of fresh limewater / a cross behind the tube to judge the same end-point (1)
- use fresh limewater from a stoppered bottle each time (1)
- pump the same volume of air through each tube, e.g. with a syringe (1)
- test more people (1)
- Max 3

11. [4]

- count the breaths needed to turn the limewater in tube B (expired air) cloudy when at rest (1)
- repeat straight after a set exercise, e.g. running on the spot for 2 minutes (1)
- same person / same volume of fresh limewater / same end-point (1)
- repeat each test and calculate a mean / allow full recovery between tests (1)

Exam tips

- Limewater turns cloudy (or milky) with carbon dioxide. Write 'cloudy' or 'milky', not 'clear to white'.
- When asked about the difference, compare: expired air contains more carbon dioxide than inspired air. Do not write only 'expired air has carbon dioxide', because inspired air contains a little as well.
- Controls to name: the same volume of fresh limewater, the same size of tube, the same person and the same end-point.
- Know the apparatus: in the inspired-air tube the long tube is open to the air; in the expired-air tube the long tube is joined to the mouthpiece. Air must bubble through the limewater.
- Know hydrogencarbonate indicator as an alternative test: it changes from red to yellow with more carbon dioxide.