Top of the Bench 2025 Practical Challenge

AIR

The second most abundant gas in air is oxygen.

Oxygen is a non-metal element and is found in air as the molecule O_2.

Oxygen is a colourless, odourless gas and as such is hard to detect.

In this year's practical challenge you will investigate a famous demonstration used to show that oxygen is present in the air.

The demonstration is called '**The Blue Bottle experiment**.'

In this activity your team will:

- investigate how three factors affect the rate of colour change in the Blue Bottle experiment
- set up your own demonstration in which a set of three bottles change colour after 100, 150 and 200 s

The Blue Bottle experiment

In the Blue bottle experiment a bottle containing a solution of glucose, sodium hydroxide and an indicator is changed from colourless to blue with shaking.

On standing the blue colour disappears.

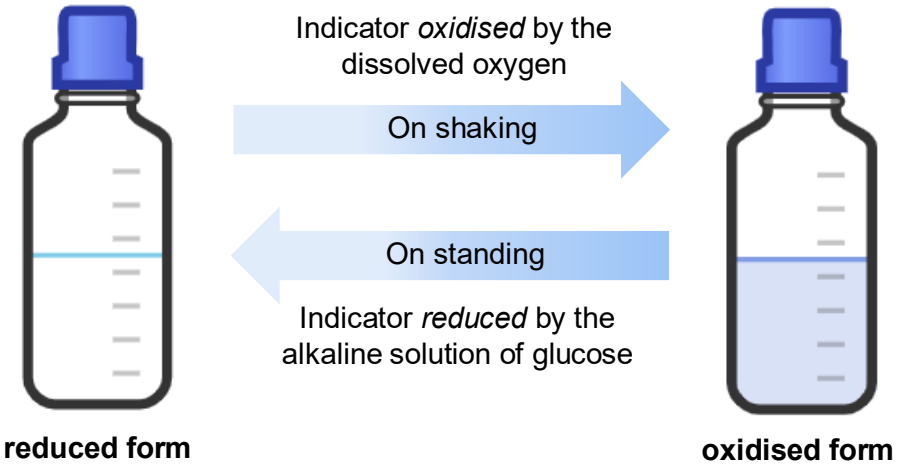


Figure 1

The indicator is called **methylene blue**.

It is a redox indicator. Oxidising or reducing it changes its colour.

The alkaline solution of glucose acts as a reducing agent and reduces the methylene blue from a blue to a colourless form.

Shaking the solution raises the concentration of oxygen in the mixture and this oxidises the methylene blue back to its blue form.

When all the dissolved oxygen has been used up, the methylene blue is slowly reduced back to its colourless form by the remaining glucose, and the cycle can be repeated many times by further shaking.

In this activity you will investigate how three factors affect the time it takes for the blue colour to disappear. The factors are;

- the number of times the bottle is shaken
- the concentration of the sodium hydroxide solution
- the mass of glucose

You will use the results of these investigations to put together a set of three bottles which change from blue to colourless sequentially after 100 s, 150 s and 200 s.

Instructions

All results and answers should be written in the Answer booklet

A basic method for each investigation is given on the following pages.

You should;

1. Read the instructions carefully.
2. Carry out each investigation.
3. Record the results of each investigation in a suitable table in the **Answer booklet**.
4. Analyse your results by following the instructions given.
5. Set up the bottles as outlined in the **Challenge** ready to run the demonstration in front of your demonstrator.

You can separate the pages of the instruction and **Answer booklets** if helpful.

The pages of the **Answer booklet** must be stapled back together in the correct order ready to hand in at the end of the challenge.

NOTE The results of **Investigation 1** are required before **Investigations 2** and **3** can be completed.

Health and safety

- Wear eye protection throughout
- Take care to avoid skin contact with the solution
- Ensure the lid is fastened securely on the bottle before shaking

Investigation 1

How does the number of shakes affect the blue bottle experiment?

1. Add 50 cm^3 of 0.4 mol dm^{-3} sodium hydroxide solution into a clean reagent bottle.
2. Add 1.5 g of glucose to the bottle and gently **swirl** until the glucose is dissolved.
3. Add 0.5 cm^3 of methylene blue solution using a syringe.
4. Gently swirl the mixture until the methylene blue is fully dispersed.
5. Fasten the lid on the bottle securely and leave the bottle to stand until it has turned colourless.

You are now ready to time how long it takes for the indicator to turn back to colourless once oxidised.

6. Give the bottle a single good shake. Start the stop clock.
7. Time how long it takes for the bottle to turn colourless.
   Record your results in a suitable table in the **Answer booklet**.
8. Repeat steps 6 and 7 giving the bottle 5, 10, 15 and 20 shakes.

Analysis

Plot a graph of **Number of shakes** on the x-axis against **Time taken to turn colourless in s** on the y-axis.

Draw a line of best fit.

Based on your results choose how many shakes you wish to give the bottle each time in Investigation 2 and 3.

Investigation 2

How does the concentration of sodium hydroxide affect the blue bottle experiment?

1. Carefully measure 1.5 g of glucose into 5 clean reagent bottles.
2. Label the bottles **1** to **5** using the permanent marker pen.
3. Into bottle **1** add 50 cm^3 of 0.4 mol dm^{-3} sodium hydroxide solution.
4. Gently **swirl** the mixture until the glucose is dissolved.
5. Repeat steps 3-4 to make up bottles **2-5** with concentrations of sodium hydroxide between 0.36 and 0.24 mol dm^{-3} using the information given in **Table 1**. Add the required volume of 0.4 mol dm^{-3} sodium hydroxide first followed by the required volume of water.

Bottle	Volume of 0.4 mol dm^{-3} NaOH solution in cm^3	Volume of water in cm^3	Concentration of NaOH solution in mol dm^{-3}
1	50	0	0.40
2	45	5	0.36
3	40	10	0.32
4	35	15	0.28
5	30	20	0.24

Table 1

6. To each bottle add 0.5 cm^3 of methylene blue solution using a syringe.
7. Gently swirl the mixture until the methylene blue is fully dispersed.
8. Fasten the lid on the bottle securely and leave the bottles to stand until they have turned colourless.

You are now ready to time how long it takes for the indicator to turn back to colourless once oxidised.

9. Give each bottle the number of shakes you have decided as a result of **Investigation 1**.
10. Record in a suitable table in the **Answer booklet** the time it takes for each bottle to change from blue back to colourless

Analysis

Plot a graph of **Concentration of sodium hydroxide solution in mol dm^{-3}** on the x-axis against **Time taken to turn colourless in s** on the y-axis.

Draw a line of best fit.

Investigation 3

How does the mass of glucose affect the blue bottle experiment?

1. Add 50 cm^3 of 0.4 mol dm^{-3} sodium hydroxide solution into 5 clean reagent bottles.
2. Label the bottles **6** to **10** using the permanent marker pen.
3. Add 2.0 g of glucose to bottle **6** and gently **swirl** until the glucose is dissolved.
4. Repeat step 3 to make up bottles **7**-**10** by adding the amount of glucose to each bottle in turn as outlined in **Table 2**.

Bottle	Mass of glucose added in g
6	2.0
7	1.6
8	1.2
9	0.8
10	0.4

Table 2

5. To each bottle add 0.5 cm^3 of methylene blue solution using a syringe.
6. Gently swirl the mixture until the methylene blue is fully dispersed.
7. Fasten the lid on the bottle securely and leave the bottles to stand until they have all turned colourless.

You are now ready to time how long it takes for the indicator to turn back to colourless once oxidised.

8. Give each bottle the number of shakes you have decided as a result of **investigation 1**.
9. Record in a suitable table in the **Answer booklet** the time it takes for each bottle to change from blue back to colourless

Analysis

Plot a graph of **Mass of glucose added in g** on the x-axis against **Time taken to turn colourless in s** on the y-axis.

Draw a line of best fit.

Challenge

You are now to demonstrate what you have learnt to your demonstrator.

As a team you are to prepare a set of three bottles;

Bottle A is to turn colourless after 100 s

Bottle B is to turn colourless after 150 s

Bottle C is to turn colourless after 200 s

Clearly label each bottle using the glass marker pen.

The bottles will all need to be started at the same time.

Marks will be awarded for how close the time each bottle changes colour is to the specified time.

TOP OF THE BENCH 2025 PRACTICAL CHALLENGE

Answer Booklet

School name: _____ **Score** _____

Investigation 1: How does the number of shakes affect the blue bottle experiment?

Results

Record your results in a suitable table below;

Investigation 1: Analysis

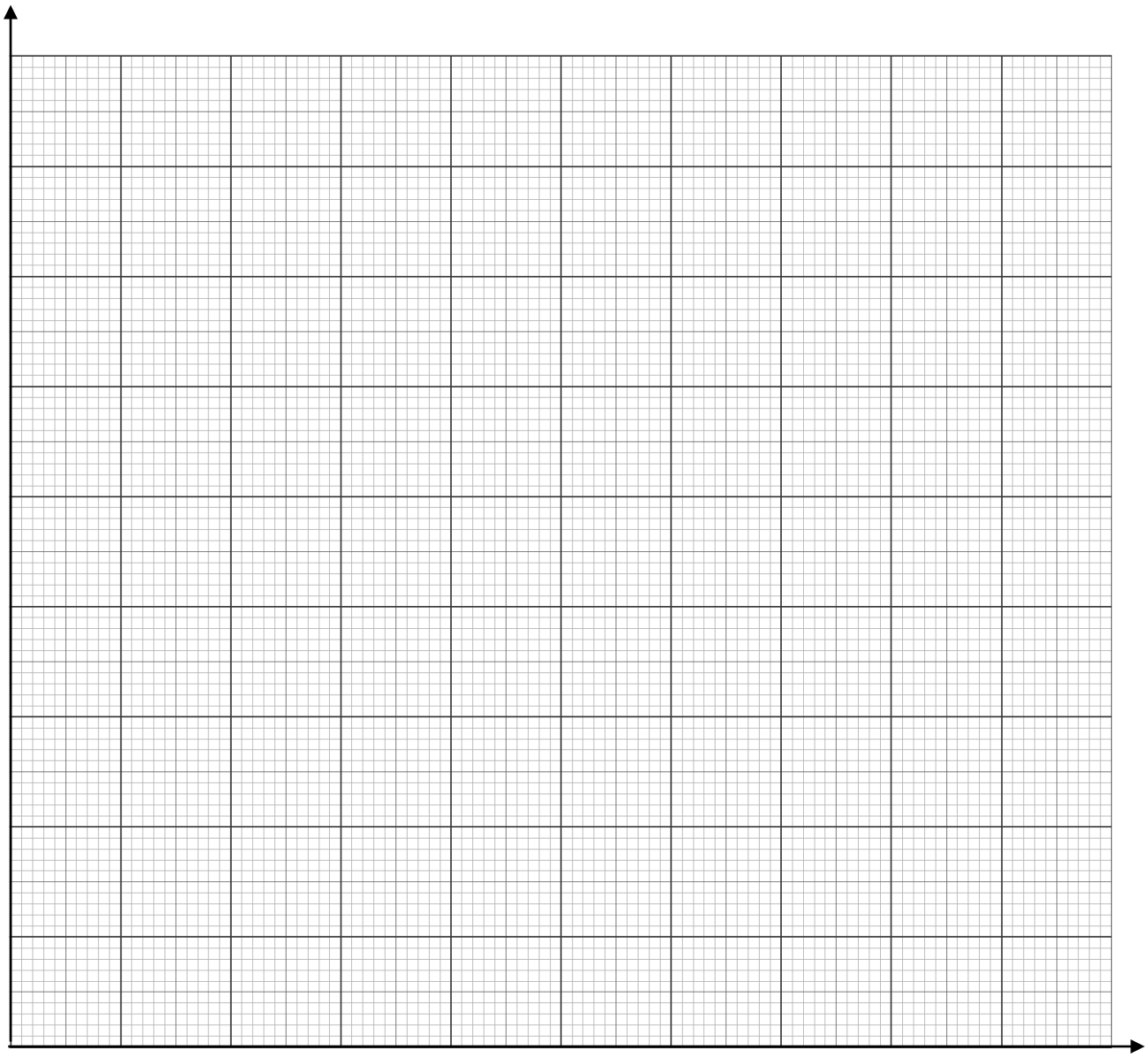
On **Graph 1** plot the **Number of shakes** on the x-axis against **Time taken to turn colourless in s** on the y-axis.

Draw a line of best fit.

Based on the results of investigation 1, state below how many times you have chosen to shake each bottle in investigation 2 and 3.

_____

Graph 1: Results of investigation 1



Investigation 2: How does the concentration of sodium hydroxide affect the blue bottle experiment?

Results

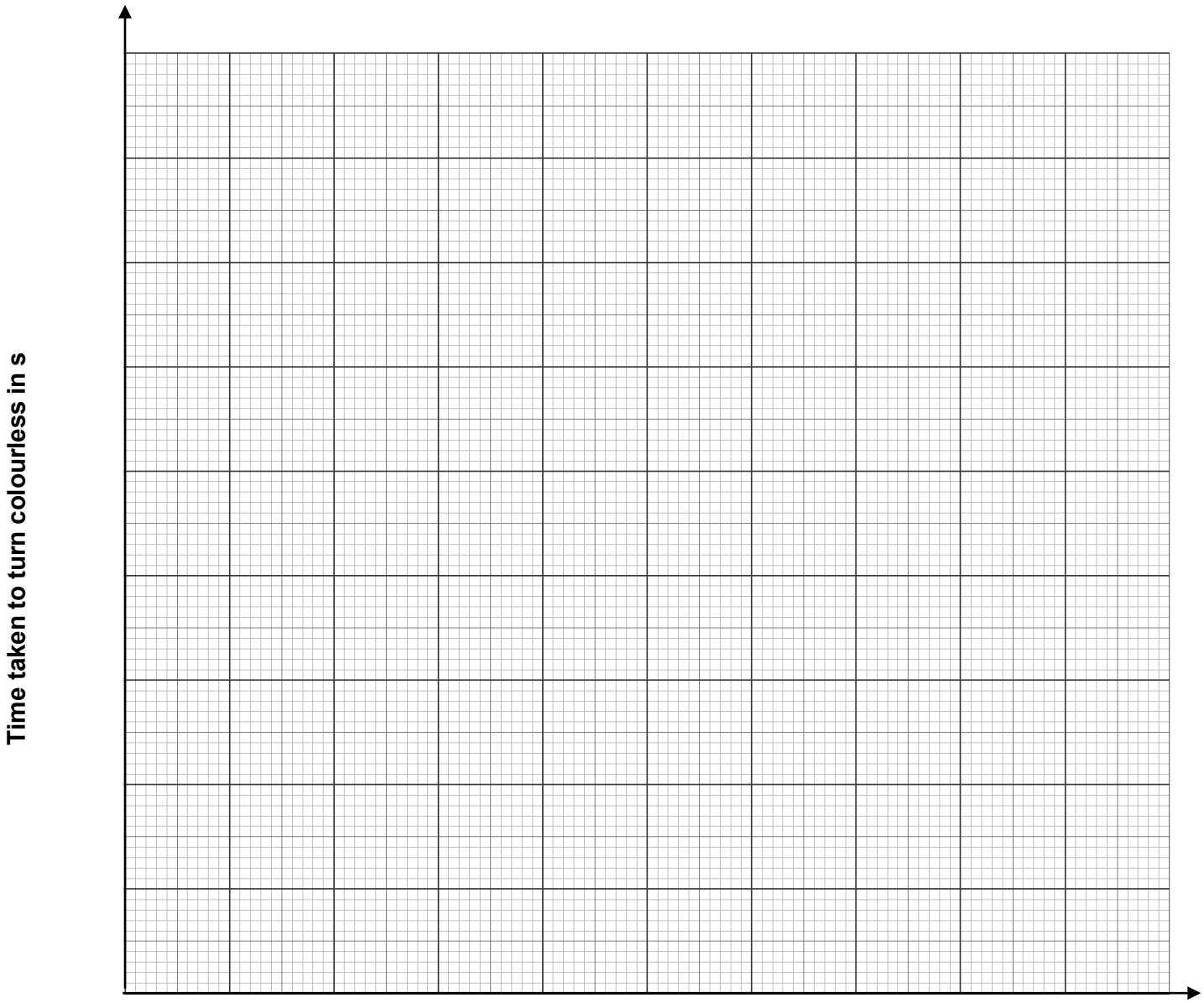
Record your results in a suitable table below;

Investigation 2: Analysis

On **Graph 2** plot the **Final concentration of sodium hydroxide solution in mol dm^{-3}** on the x-axis against **Time taken to turn colourless in s** on the y-axis.

Draw a line of best fit.

Graph 2: Results of investigation 2



Investigation 3: How does the mass of glucose affect the blue bottle experiment?

Results

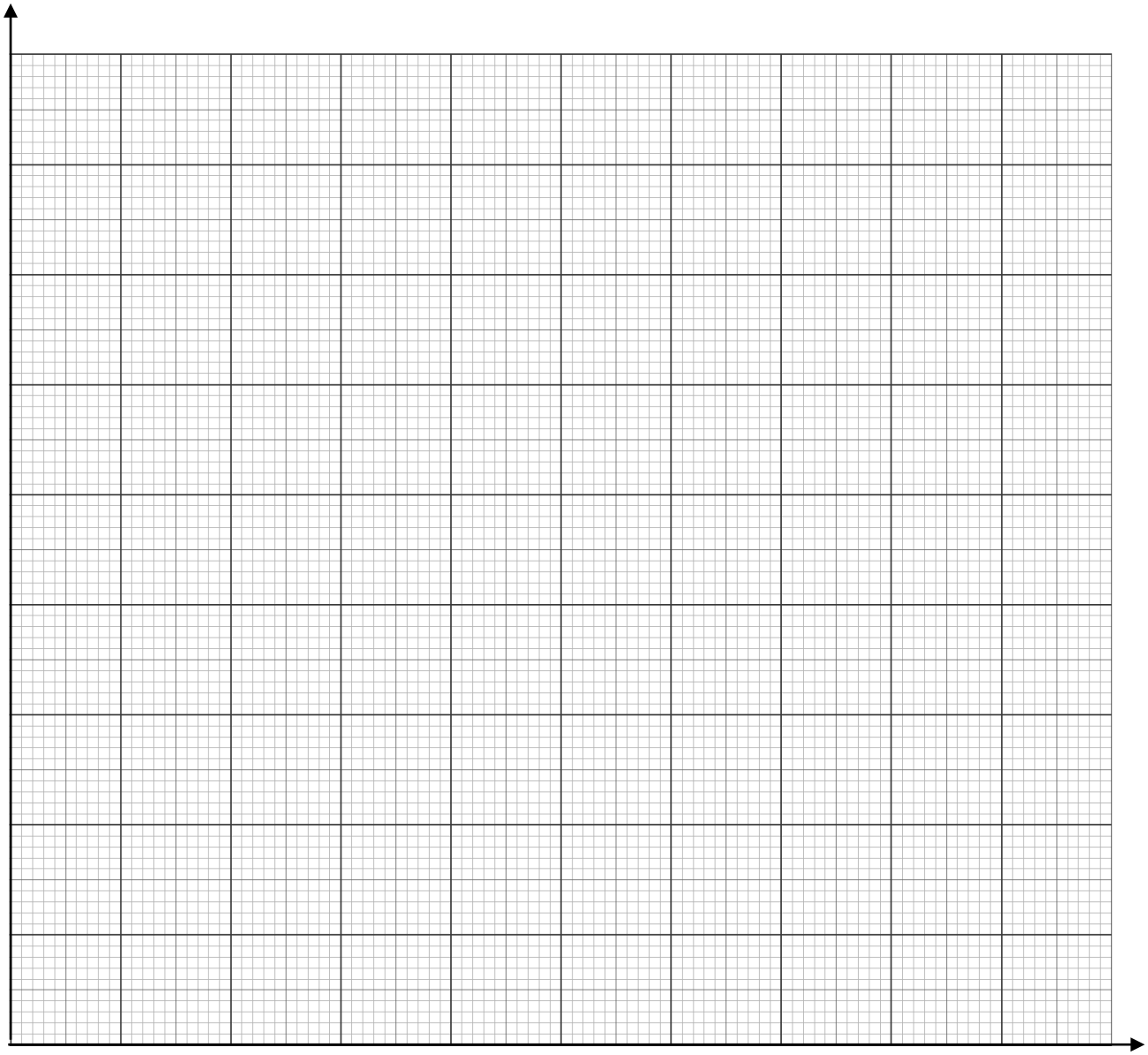
Record your results in a suitable table below;

Investigation 3: Analysis

On **Graph 3** plot **Mass of glucose added in g** on the x-axis against **Time taken to turn colourless in s** on the y-axis.

Draw a line of best fit.

Graph 3: Results of investigation 3



Challenge results *To be completed by your demonstrator*

Time taken for **Bottle A** to turn colourless = _____ s

Time table for **Bottle B** to turn colourless = _____ s

Time table for **Bottle C** to turn colourless = _____ s