The required practicals are examined in the written papers: at least 15% of the marks are about experiments. For each one, know the method in order, the variables and how each control is kept the same, what the results show, and one specific improvement. : 、 、

Working scientifically – the words the questions use

Independent / dependent / control variable / / – the one you change; the one you measure; the ones you keep the same – and say HOW: 'keep the temperature at 35 °C with a water bath'

Hypothesis – a testable idea with a reason: 'as light intensity increases the rate of photosynthesis increases, because light provides the energy for the reaction'

Valid – the method measures what it claims to, because only the independent variable changed

Repeatable / reproducible / – you get similar results again / someone else, or another method, gets similar results

Resolution – the smallest change an instrument shows: 1 mm on a ruler, 0.01 g on a balance

Living things vary. Use several individuals (cylinders, seedlings, people) for each condition, and calculate a mean leaving out anomalies.

Uncertainty: half the range of the repeats. Times of 24 s, 30 s and 27 s give 27 s ± 3 s.

RP1 – Microscopy

Aim: use a light microscope to observe, draw and label plant and animal cells, with a magnification scale.

1. Peel a thin layer of onion epidermis with forceps and lay it flat on a drop of water on a slide. A thin layer lets light through.
2. Add a drop of iodine solution to stain the cells, and lower a coverslip at an angle with a mounted needle so no air bubbles are trapped.
3. Start with the lowest-power objective, focus with the coarse focus, then move to a higher power and use only the fine focus.
4. Draw a few cells with a sharp pencil: clear unbroken lines, no shading, labelled with ruled label lines.

Total magnification = eyepiece × objective: a ×10 eyepiece with a ×40 objective gives ×400.

Magnification = image size ÷ real size. A cell 40 mm long in a drawing at ×400 is 40 ÷ 400 = 0.1 mm = 100 µm long. Convert first: 1 mm = 1000 µm.

RP2 – Microbiology (biology only)

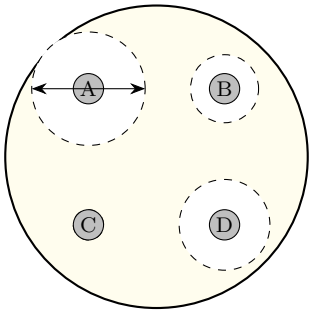
Aim: compare how well different antiseptics or antibiotics stop bacteria growing, by measuring the clear zone around each.

1. Sterilise the inoculating loop by heating it in a Bunsen flame until red hot, and let it cool. Sterile glassware and agar have been autoclaved.
2. Lift the Petri dish lid only slightly, spread the bacteria evenly over the agar, and close it – near a Bunsen flame, which draws air up and away.

3. Place paper discs soaked in each antiseptic (and one in sterile water as a control) on the agar with sterile forceps.

4. Tape the lid with two strips (not all the way round, so oxygen gets in and harmful anaerobic bacteria do not grow), and store it upside down so condensation does not drip on the agar.

5. Incubate at 25 °C (no higher in school) for 48 hours, then measure the diameter of each clear zone.



clear zone: no bacteria grow around disc A (diameter 15 mm)

bacteria grow over the rest of the agar (a cloudy lawn)

disc C: sterile water, the control — no clear zone beyond the disc

The larger the clear zone, the more effective the antiseptic against this bacterium.

Area of a clear zone = πr^2. A diameter of 15 mm gives r = 7.5 mm and an area of $3.14 \times 7.5^2 = 177$ mm^2.

RP3 – Osmosis

Aim: find how the concentration of a salt or sugar solution affects the mass of plant tissue.

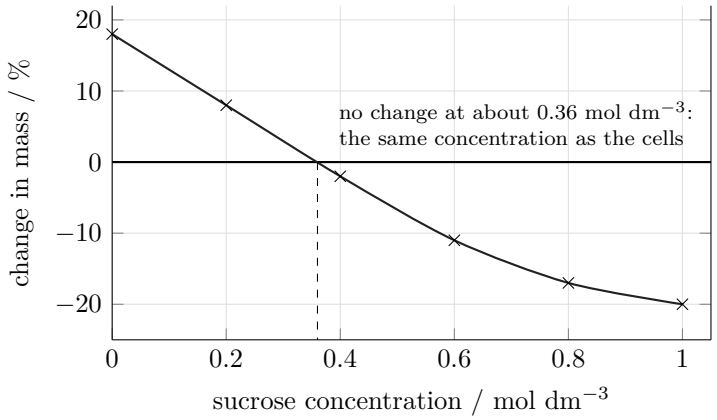
1. Cut potato cylinders with a cork borer and trim them to the same length. Blot dry and weigh each one.

2. Put each cylinder in a tube with the same volume of a different sucrose concentration (0.0, 0.2, 0.4, 0.6, 0.8 and 1.0 mol/dm^3), and leave them for the same time.

3. Remove, blot in the same way, reweigh, and calculate the percentage change in mass.

4. Plot percentage change in mass against concentration. Where the line crosses zero, the solution has the same concentration as the potato cells.

Percentage change = (final mass − starting mass) ÷ starting mass × 100. It is used because the cylinders do not start at exactly the same mass.



Where the curve crosses 0%, there is no net movement of water: read down to the concentration axis.

In dilute solutions the cylinders gain mass (water moves in by osmosis); in concentrated ones they lose mass. Blotting each one the same way is the main control – extra surface water adds mass.

RP4 – Food tests

Reducing sugars – Benedict's test – add Benedict's solution and heat in a water bath at about 80 °C for 5 minutes: blue → green → yellow → brick red as the amount of sugar increases

Starch – iodine test – add iodine solution: orange-brown → blue-black

Protein – Biuret test – add Biuret solution: blue → purple (lilac)

Lipids – Sudan III test – add Sudan III stain and shake: a red-stained oily layer forms on top

Grind the food with a little water using a pestle and mortar first, and filter it if it is cloudy. Heat Benedict's in a water bath, never over a flame – it can boil over.

RP5 – Enzymes

Aim: find how pH affects the rate at which amylase breaks down starch.

1. Put one drop of iodine solution in each well of a spotting tile.
2. In a test tube, mix amylase solution with a buffer of one pH, and keep it in a water bath at 35 °C with the starch solution for 5 minutes.
3. Add the starch, mix and start the stopwatch. Every 30 seconds, put a drop of the mixture on a fresh drop of iodine.
4. When the iodine stays orange, the starch has all been broken down: record the time. Repeat with each pH.

pH	**4**	**5**	**6**	**7**	**8**
Time for starch to disappear / s	over 300	150	90	60	120
Rate = 1000 ÷ time / s^{-1}	below 3.3	6.7	11	17	8.3

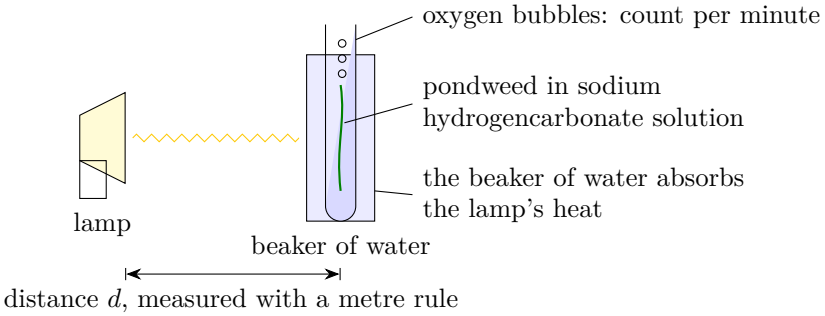
Typical results: the optimum here is about pH 7. With samples every 30 s, each time has an uncertainty of up to 30 s.

Rate = 1 ÷ time (multiplied by 1000 to give convenient numbers). At pH far from the optimum the active site changes shape, the starch no longer fits, and the enzyme is denatured.

Improvement: sample every 10 seconds instead of 30 for a more precise time, or use a colorimeter to measure the colour change.

RP6 – Photosynthesis

Aim: find how light intensity affects the rate of photosynthesis in pondweed.



Move the lamp to change the light intensity; leave the pondweed 5 minutes at each new distance before counting.

Distance / cm	10	20	30	40	50
Mean bubbles per minute	48	30	15	9	6

The rate falls as the lamp moves away. Between 10 and 20 cm it does not fall four-fold: close to the lamp, another factor (carbon dioxide or temperature) limits the rate.

Higher tier: light intensity $\propto 1 \div d^2$. Doubling the distance quarters the light intensity.

Bubbles vary in size, so counting them is imprecise. Improvement: collect the gas in a gas syringe or a capillary tube and measure its volume. An LED lamp gives off less heat than a filament lamp.

RP7 – Reaction time

Aim: find the effect of a factor (practice, caffeine, the hand used) on human reaction time.

1. The subject sits with their forearm on the edge of a table and thumb and finger apart at the 0 cm mark of a ruler held by a partner.

2. The partner drops the ruler without warning; the subject catches it as quickly as possible. Record the distance at the top of the thumb.

3. Repeat ten times, convert each distance to a time with a conversion table, and calculate the mean.

4. Change one factor – drink a caffeinated drink and wait 10 minutes – and repeat.

Control: the same person dropping, the same hand, the same starting height, and no warning or countdown. People improve with practice, so give a few trial catches before recording.

Ethics: no one should be made to take caffeine; anyone with a heart condition should not.

RP8 – Plant responses (biology only)

Aim: find the effect of light (or gravity) on the growth of seedlings.

1. Grow cress or mustard seedlings on damp cotton wool in three Petri dishes.

2. Put one in a box lit from one side, one in full light and one in the dark, at the same temperature and with the same volume of water each day.

3. After a few days, measure the length of each shoot and note the direction it grows.

Shoots grow towards light (positive phototropism): auxin collects on the shaded side and makes those cells elongate more. Shoots in the dark grow tall, thin and yellow: their cells elongate fast and they make no chlorophyll.

Measure several seedlings per dish and take the mean; one seedling tells you very little.

RP9 – Field investigations

Aim: estimate the population of a plant species, and investigate how a factor affects its distribution.

Random quadrats – lay two tape measures at right angles and use random numbers as coordinates for each quadrat, so the choice of position cannot be biased

Transect – a line along which quadrats are placed at regular intervals, to see how a species changes across a habitat – from a hedge into a field, or away from a path. Measure a factor (light, soil moisture) at each quadrat too

Population estimate = mean number per quadrat × (total area ÷ quadrat area). A mean of 3.2 dandelions in 1 m^2 quadrats across a 2400 m^2 field gives $3.2 \times 2400 \approx 7700$ dandelions.

More quadrats give a more representative mean. Count a plant as 'in' only if more than half of it is inside the quadrat, and use the same rule every time.

RP10 – Decay (biology only)

Aim: find how temperature affects the rate of decay of fresh milk, measured by the change in pH.

1. Mix milk, sodium carbonate solution and phenolphthalein indicator in a test tube; it is pink because the mixture is alkaline.

2. Put this tube and a tube of lipase in a water bath at one temperature, and wait until both reach it.

3. Add a measured volume of lipase, start the stopwatch, and stop it when the pink colour disappears.

4. Repeat at other temperatures, e.g. 20 °C to 60 °C.

Lipase breaks down the fat in the milk to fatty acids and glycerol; the fatty acids lower the pH until the indicator turns colourless. Rate = 1 ÷ time.

The end point is judged by eye. Improvement: compare each tube against a colourless reference, or use a pH probe.

Questions examiners ask about every practical

'Give a control variable' – say how it is controlled: 'the same volume of sucrose solution, 10 cm^3, measured with a measuring cylinder'.

'Why repeat?' – to identify anomalies and calculate a mean, which reduces the effect of random error and of variation between individuals.

'Suggest an improvement' – be specific: a gas syringe instead of counting bubbles; a colorimeter instead of judging colour; sampling every 10 s instead of 30 s; more quadrats.

'Describe the results' – use numbers from the table or graph, and say where the pattern changes: 'the time fell from 150 s at pH 5 to 60 s at pH 7, then rose to 120 s at pH 8'.