

All AQA GCSE required practicals, one page each

Biology, Chemistry and Physics, including Combined Science: Trilogy. Each page gives the aim, variables, method, risks and safety, typical results and conclusion, and the most common exam mistake.

28 practicals

21 in Combined Science

7 Separate science only

Biology (8461)

1. Use a light microscope to observe plant and animal cells
2. Separate Biology: investigate antibiotics or antiseptics
Separate only
3. Investigate osmosis in plant tissue
4. Use qualitative tests to identify food groups
5. Investigate the effect of pH on amylase
6. Investigate light intensity and photosynthesis rate
7. Investigate how a factor affects human reaction time
8. Investigate how light or gravity affects the growth of seedlings
Separate only
9. Investigate population size and species distribution in a habitat
10. Separate Biology: investigate temperature and fresh-milk decay
Separate only

Chemistry (8462)

1. Prepare a pure, dry soluble salt
2. Titrate a strong acid and strong alkali **Separate only**
3. Identify products of aqueous electrolysis
4. Investigate how different variables affect the temperature change when solutions react
5. Investigate how concentration affects reaction rate
6. Separate and identify coloured substances by paper chromatography
7. Separate Chemistry: identify ions in unknown single ionic compounds **Separate only**
8. Analyse and purify water samples

Physics (8463)

1. Determine the specific heat capacity of a material
2. Investigate thermal insulation
Separate only
3. Investigate factors affecting resistance
4. Investigate I-V characteristics
5. Determine densities of solids and liquids
6. Investigate force and extension of a spring
7. Investigate force, mass and acceleration
8. Measure frequency, wavelength and wave speed
9. Investigate reflection and refraction of light **Separate only**
10. Investigate infrared absorption and emission by surfaces

Revision resource, not a laboratory instruction sheet. Carry out practical work only with trained supervision and your school's current risk assessment.

Online version with links to the notes: www.examva.com/gcse-required-practicals

Illustrated AQA GCSE science notes at www.examva.com. The first topic in every subject is free.

Numbered as in the AQA Biology (8461), Chemistry (8462) and Physics (8463) specifications; Trilogy numbers from Combined Science: Trilogy (8464). Examva is independent and not affiliated with or endorsed by AQA.

Use a light microscope to observe plant and animal cells

Aim. Prepare, observe, draw and label plant and animal cells using a light microscope, including a magnification scale.

Variables

Independent: type of prepared cell specimen or magnification being compared

Dependent: structures resolved and measurements made in the microscope image

Control:

- specimen thickness and preparation method
- stain identity and amount
- lighting and focus procedure
- calibrated scale or the same image-measurement method

Risks and safety

- Wear eye protection when using stains and avoid skin contact; follow the school's reagent guidance.
- Handle glass slides and coverslips by their edges and report chips or breakages.
- Carry the microscope with two hands and keep it away from the bench edge.

Method

1. Place a thin specimen on a clean slide; add a suitable stain if instructed, then lower a coverslip at an angle to reduce trapped air bubbles.
2. Put the slide on the stage and begin with the lowest-power objective lens.
3. Use the coarse focus to find the specimen, then sharpen it with fine focus; use fine focus only at high power.
4. Centre the specimen before changing to a higher-power objective and adjust the light if needed.
5. Draw several representative cells using clear single lines, add labels and include a scale or calculated magnification.
6. Repeat with the other specimen type and compare visible structures.

Typical results and conclusion

Label only structures supported by the image. Calculate total magnification from the eyepiece and objective, or use an image scale to estimate real size, stating units and sensible precision.

Calculation: Total magnification = eyepiece magnification × objective magnification. Use a scale bar to estimate real size.

Common exam mistake

Drawing artistic shading or labelling structures that the image does not actually resolve.

Revise it in context: www.examva.com/biology/cell-biology (Cell Biology notes)

Separate Biology: investigate antibiotics or antiseptics

Aim. Use aseptic technique to compare how antibiotics or antiseptics affect bacterial growth on agar by measuring clear zones of inhibition.

Variables

Independent: identity or concentration of the antibiotic or antiseptic on each disc

Dependent: mean diameter or calculated area of the clear zone around the disc

Control:

- bacterial strain and starting culture
- agar depth and plate size
- disc size and treatment volume
- incubation temperature and time
- solvent-only control disc

Risks and safety

- Use only the school-approved microorganism and follow trained supervision for flame sterilisation.
- Incubate at no more than 25 °C, tape without fully sealing to avoid anaerobic conditions, store plates upside down and never reopen them.
- Wear eye protection, disinfect spills as instructed and dispose of cultures through the school's sterilisation procedure.

Method

1. Disinfect the bench, wash hands and label the base of a sterile agar plate before inoculation.
2. Sterilise the inoculating loop in a flame as instructed, let it cool, then use it to spread the bacterial culture evenly across the agar.
3. Open the lid only slightly and briefly; place sterile treatment discs on the agar with sterile forceps.
4. Include a control disc carrying only the solvent, then replace the lid promptly.
5. Tape the lid in a few places without sealing all the way around, invert the plate and incubate at no more than 25 °C.
6. Keep the incubated plate closed; measure two perpendicular clear-zone diameters and calculate a mean, or calculate area with πr^2 .
7. Repeat each treatment on separate plates and compare mean clear-zone sizes.

Typical results and conclusion

A larger clear zone suggests stronger inhibition under the tested conditions. Compare repeats and the solvent control; zone size does not by itself show that a treatment is safe or effective in a patient.

Calculation: Compare mean zone diameter, or calculate zone area with $\text{area} = \pi r^2$ when the question asks for it.

Common exam mistake

Treating a large clear zone as proof that a treatment is safe or effective inside a person.

Revise it in context: www.examva.com/biology/cell-biology (Cell Biology notes)

Investigate osmosis in plant tissue

Aim. Measure how a range of salt or sugar concentrations changes the mass of equal plant-tissue pieces.

Variables

Independent: concentration of the salt or sugar solution

Dependent: percentage change in mass of the plant tissue

Control:

- plant species and source tissue
- initial cylinder length and diameter
- solution volume
- immersion time and temperature
- blotting method before each weighing

Risks and safety

- Use a tile and cut away from fingers when using a cork borer or scalpel; follow teacher supervision.
- Wear eye protection if the chosen solutions require it and wipe up spills promptly.

Method

1. Prepare labelled tubes containing equal volumes of a range of salt or sugar concentrations, including distilled water.
2. Cut plant-tissue cylinders to equal length and diameter, remove any skin, blot them consistently and record each initial mass.
3. Place one cylinder in each solution for the same time at the same temperature.
4. Remove each cylinder, blot it in the same way and record its final mass.
5. Calculate percentage change in mass for every concentration.
6. Repeat each concentration, calculate a mean and plot mean percentage change against concentration.

Typical results and conclusion

Positive percentage change means net water entry; negative change means net water loss. The graph's zero-change concentration estimates where there was no net movement of water.

Calculation: Percentage change in mass = $(\text{final mass} - \text{initial mass}) \div \text{initial mass} \times 100$.

Common exam mistake

Comparing raw mass changes between unequal pieces instead of percentage change, or forgetting to blot before weighing.

Revise it in context: www.examva.com/biology/cell-biology (Cell Biology notes)

Use qualitative tests to identify food groups

Aim. Use visible results from standard reagents to test prepared food samples for reducing sugars, starch, protein and lipids.

Variables

Independent: food sample being compared while one food-group test is kept fixed

Dependent: the observed colour or layer produced by that fixed test

Control:

- sample preparation and volume
- identity and volume of the reagent or reagents for the chosen test
- heating time and water-bath temperature for Benedict's test
- clean apparatus for each sample

Risks and safety

- Wear eye protection and follow the reagent hazard guidance supplied by the school.
- Ethanol is highly flammable; keep it stoppered and well away from naked flames, hot equipment and other ignition sources.
- Biuret reagent contains corrosive sodium hydroxide and poisonous copper sulfate; avoid contact and rinse skin spills immediately.
- Heat Benedict's test indirectly in a water bath; use a holder for hot tubes and point them away from people.

Method

1. Prepare a food solution and divide it into separate, labelled samples.
2. Add iodine solution to one sample; a blue-black result indicates starch.
3. Add Benedict's solution to another sample and warm it in a water bath; a change away from blue towards green, yellow, orange or brick-red indicates reducing sugar.
4. Add Biuret reagent to a fresh sample; a lilac or purple result indicates protein.
5. Shake a fresh sample with ethanol, then add distilled water; a cloudy white emulsion indicates lipid.
6. Compare each observation with a negative control and repeat uncertain results.

Typical results and conclusion

A qualitative test identifies presence rather than an exact concentration. Record the starting and final appearance and compare with a positive control. A negative Benedict's result does not rule out a non-reducing sugar such as sucrose.

Calculation: This is qualitative evidence: record the starting appearance and the final positive or negative result rather than inventing a concentration.

Common exam mistake

Mixing up the reagent-result pairs or heating every test as though it were Benedict's test.

Revise it in context: www.examva.com/biology/organisation (Organisation notes)

Investigate the effect of pH on amylase

Aim. Measure how pH affects the time taken for amylase to digest starch while keeping temperature constant.

Variables

Independent: pH of the reaction mixture

Dependent: time until starch is no longer detected, or rate calculated from that time

Control:

- temperature
- amylase concentration and volume
- starch concentration and volume
- 30-second sampling interval
- total reaction volume

Risks and safety

- Wear eye protection and avoid skin contact with iodine solution.
- Use a thermostatically controlled water bath at a safe temperature.
- Use clean transfer equipment and wipe up spills promptly.

Method

1. Place separate drops of iodine solution into the wells of a spotting tile.
2. Bring measured starch, amylase and buffer solutions to the chosen water-bath temperature.
3. Mix the starch and amylase with a buffer of known pH, start timing at once, and keep the mixture in the water bath throughout sampling.
4. Every 30 seconds, transfer a drop of the reaction mixture to a fresh iodine drop.
5. Record the first time at which the iodine remains orange-brown, showing that starch is no longer detected.
6. Repeat at other pH values and repeat each condition before comparing mean times or calculated rates.

Typical results and conclusion

A shorter disappearance time indicates a faster reaction. Plot rate ($1/\text{time}$, s^{-1}) against pH to identify the optimum under the tested conditions; $1000/\text{time}$ may be plotted if the axis is labelled 'rate / 10^{-3} s^{-1} '.

Calculation: Rate is proportional to $1 \div \text{time}$. If you use a scaled reciprocal such as $1000 \div \text{time}$, define it consistently.

Common exam mistake

Mixing the starch, amylase and buffer before each has reached the water-bath temperature, calling the shortest time the lowest rate, or changing the sampling interval between pH values.

Revise it in context: www.examva.com/biology/organisation (Organisation notes)

Investigate light intensity and photosynthesis rate

Aim. Measure how changing light intensity affects the photosynthesis rate of an aquatic organism such as pondweed.

Variables

Independent: distance from the lamp or calculated light intensity

Dependent: mean oxygen-bubble count or oxygen volume released per unit time

Control:

- temperature, using a heat shield or water bath
- carbon dioxide concentration and solution volume
- pondweed species, length and orientation
- measurement and equilibration times
- lamp and background-light conditions

Risks and safety

- Keep water away from electrical connections and dry hands before adjusting the lamp or leads.
- A lamp can become hot; use a heat shield, avoid touching the bulb and allow it to cool before moving it.
- Wear eye protection if instructed and avoid splashing the solution.

Method

1. Place a freshly cut piece of pondweed in sodium hydrogencarbonate solution with its cut end pointing upwards.
2. Position a lamp at a measured distance from the pondweed and allow the apparatus to equilibrate.
3. For a fixed time, count oxygen bubbles or collect and measure the volume of oxygen released.
4. Repeat the measurement at the same distance and calculate a mean rate in bubbles/min or cm^3/min .
5. Move the lamp to several measured distances, allowing equilibration and repeating the timed measurement each time.
6. Keep temperature, carbon dioxide supply, pondweed species and length, solution volume and measurement time constant.
7. Plot mean photosynthesis rate against distance or, at Higher Tier, calculated relative light intensity $1/d^2$.

Typical results and conclusion

Calculate a mean rate for each distance and identify anomalies. Gas volume is more valid than bubble count because bubble sizes vary. Higher Tier: use $1/d^2$ to represent relative intensity.

Calculation: Calculate oxygen produced per unit time. Higher Tier may use relative light intensity = $1 \div \text{distance}^2$.

Common exam mistake

Assuming bubble count is perfectly proportional to oxygen volume, or letting the lamp change the temperature too.

Revise it in context: www.examva.com/biology/bioenergetics (Bioenergetics notes)

Investigate how a factor affects human reaction time

Aim. Use a ruler-drop test to investigate how the hand used affects one participant's reaction time.

Variables

Independent: hand used to catch the ruler

Dependent: catch distance in centimetres, used as an indicator of reaction time

Control:

- same ruler and release position
- same participant posture and catching technique
- same person releasing the ruler
- same number of repeats and rest interval
- no countdown or intentional warning before release

Risks and safety

- Keep the floor and movement area clear and perform the test while seated.
- Obtain the participant's agreement, stop if they report discomfort and do not collect names or medical information.
- Use a light plastic or wooden ruler with smooth, undamaged edges.

Method

1. Seat the participant with one forearm supported and their thumb and finger open beside the ruler's zero mark.
2. Hold the ruler vertically so zero is level with the top of the participant's thumb, without giving a countdown.
3. Release the ruler; the participant catches it as quickly as possible. Record the catch distance in centimetres.
4. Repeat at least five times with the same hand, allowing short rests, then calculate a mean.
5. Repeat the same procedure with the other hand and compare the mean catch distances.
6. Repeat with more participants if making a group-level claim; present anonymised results and identify anomalies.

Typical results and conclusion

Calculate a mean catch distance for each hand after checking anomalies. A shorter mean indicates a faster reaction. Conclusions apply to the tested participants and conditions, not automatically to everyone.

Calculation: Calculate a mean for each condition after identifying anomalies. A shorter ruler-drop distance indicates a faster response; if a conversion table is given, convert each distance to a reaction time in seconds.

Common exam mistake

Giving a countdown, changing the release position or generalising from one participant to everybody.

Revise it in context: www.examva.com/biology/homeostasis-and-response (Homeostasis and Response notes)

Investigate how light or gravity affects the growth of seedlings

Aim. Investigate how one-sided light affects the direction of growth in newly germinated seedlings.

Variables

Independent: direction from which light reaches the seedlings

Dependent: change in shoot angle and shoot length over the fixed growth period

Control:

- plant species and seedling age
- water volume and growing medium
- temperature and exposure time
- light intensity and distance from the lamp
- initial shoot size as closely as practical

Risks and safety

- Wash hands after handling seeds, seedlings and growing medium; do not eat laboratory plant material.
- Use a cool LED light and keep water away from electrical equipment.
- Handle scissors or craft tools only under teacher supervision when preparing boxes.

Method

1. Choose similar newly germinated seedlings and measure each shoot's initial length and angle.
2. Make a careful, labelled biological drawing of each starting seedling at a consistent scale.
3. Place one group in a light-proof box with a side opening so light arrives from one direction.
4. Place a control group in otherwise identical conditions with light arriving evenly from above.
5. Keep water, temperature, species, seedling age, growing medium, time and light intensity as similar as possible.
6. After a fixed period, measure the shoot length and angle of growth for every seedling.
7. Make a second careful, labelled biological drawing at the same scale to show the growth response.
8. Calculate group means and compare both growth amount and bending direction.

Typical results and conclusion

Compare mean angle changes, variation and sample sizes. Bending towards one-sided light supports positive phototropism; length data help separate directional bending from general growth differences.

Calculation: Compare mean change in shoot angle and mean growth. Photographs taken from the same position can make angle measurements more reliable.

Common exam mistake

Changing light direction and light intensity together, then pretending only direction caused the result.

Revise it in context: www.examva.com/biology/homeostasis-and-response (Homeostasis and Response notes)

Investigate population size and species distribution in a habitat

Aim. Use quadrats to estimate a common species population and a transect to investigate how an environmental factor affects distribution.

Variables

Independent: position along the transect or the measured environmental factor associated with position

Dependent: abundance, frequency or percentage cover of the target species

Control:

- quadrat dimensions and boundary-count rule
- distance between transect samples
- species-identification method
- time of day and weather where practical
- instrument and measurement technique
- total sampling effort at each location

Risks and safety

- Complete the school's fieldwork risk assessment; wear suitable footwear and clothing and avoid steep, unstable, roadside or deep-water sites.
- Do not touch unknown plants, fungi, animals, waste or sharp objects; cover cuts and wash hands after fieldwork.
- Keep the group together, follow site boundaries and weather guidance, and carry equipment so tapes and quadrats do not become trip hazards.
- Minimise disturbance: replace moved objects, avoid trampling outside the sample and release any organism promptly if observation is permitted.

Method

1. Define the habitat boundary, identify the target species reliably and measure or obtain the total area.
2. Generate random coordinate pairs, locate each position with tape measures and place a quadrat of known area.
3. Count the target species using the same rule for organisms touching the boundary; repeat at many random positions.
4. Calculate mean abundance or density and scale it to the habitat area to estimate population size.
5. For distribution, lay a tape across an environmental gradient and place quadrats at regular distances to form a belt transect.
6. At each distance, record target-species abundance and measure the relevant abiotic factor with suitable equipment.
7. Repeat with parallel transects where practical, calculate means and plot abundance and the factor against distance.
8. Look for a pattern, quote data and discuss other variables before suggesting a causal explanation.

Typical results and conclusion

Calculate means and an estimated population with units. Plot suitable graphs and describe correlation, but use biological reasoning and control of other factors before claiming cause.

Calculation: Estimated population = mean count per quadrat × number of quadrat-sized areas in the habitat.

Common exam mistake

Placing quadrats where the species is easiest to see, then calling the sample random.

Revise it in context: www.examva.com/biology/ecology (Ecology notes)

Separate Biology: investigate temperature and fresh-milk decay

Aim. Investigate how temperature affects the rate of decay of fresh milk by timing a fixed pH change.

Variables

Independent: temperature of the milk and lipase mixture in the water bath

Dependent: time to a fixed pH endpoint and calculated relative rate, $1 / \text{time}$

Control:

- milk volume and starting batch
- lipase volume and concentration
- sodium carbonate volume and concentration
- indicator identity and volume
- starting pH and chosen endpoint
- equilibration time and mixing method

Risks and safety

- Wear eye protection. Lipase, sodium carbonate and indicator can irritate skin or eyes; use prepared solutions, avoid aerosols and rinse splashes as instructed.
- Use thermostatically controlled water baths, heatproof mats and test-tube racks; take care with hot water and glassware.
- Use fresh pasteurised milk; check school allergy information, avoid skin contact, never taste materials, clean spills and follow the disposal procedure.
- Carry out the practical under trained school supervision and follow the reagent-specific risk assessment.

Method

1. Label tubes for several temperatures; add equal volumes of fresh milk and sodium carbonate for the same alkaline start, then the same amount of Cresol red, to each.
2. Prepare equal portions of the same lipase solution, which models decay by breaking milk fat into fatty acids that lower pH.
3. Place each milk mixture and lipase portion in its water bath until both reach the target temperature; verify with a thermometer.
4. Add the lipase to the milk, mix in the same way and start the timer immediately.
5. Stop timing at one defined indicator-colour or pH endpoint and record the time in seconds.
6. Repeat at each temperature, calculate a mean endpoint time and calculate relative rate = $1 / \text{mean time}$.
7. Plot mean relative rate against temperature and describe the pattern within the measured range.

Typical results and conclusion

For each temperature, calculate a mean time and its reciprocal in s^{-1} . A larger relative rate means faster pH change; identify anomalies and do not extrapolate beyond the data.

Calculation: Relative rate = $1 \div \text{mean time to the fixed pH endpoint}$, in s^{-1} . Calculate the mean time for each temperature before comparing rates.

Common exam mistake

Adding the lipase before the milk tube and the lipase tube have both reached the water-bath temperature, or comparing different colour or pH endpoints.

Revise it in context: www.examva.com/biology/ecology (Ecology notes)

Prepare a pure, dry soluble salt

Aim. Prepare pure, dry copper sulfate crystals from dilute sulfuric acid and insoluble copper oxide.

Variables

Independent: No investigative variable; the prescribed acid and insoluble base determine the salt made.

Dependent: Formation and quality of the pure, dry copper sulfate crystal sample.

Control:

- volume and concentration of sulfuric acid
- warming and evaporation conditions
- addition of copper oxide until a visible excess remains
- clean apparatus and drying method

Risks and safety

- Wear eye protection; dilute sulfuric acid and copper sulfate solution can irritate or harm eyes and skin.
- Avoid inhaling copper oxide powder and clean spills using the school's chemical-safety procedure.
- Use a water bath or gentle controlled heating, handle hot glassware carefully and do not heat the solution to dryness.

Method

1. Wear eye protection and warm a measured volume of dilute sulfuric acid gently in a water bath.
2. Add small portions of copper oxide while stirring until fresh solid no longer reacts and some remains in excess.
3. Filter the mixture to remove the excess copper oxide, collecting the blue copper sulfate solution as filtrate.
4. Heat the filtrate gently in an evaporating basin until some water has evaporated and the solution is concentrated.
5. Stop heating before the solution dries out and leave it to cool so crystals form.
6. Separate the crystals from the remaining solution and dry them between clean filter papers.

Typical results and conclusion

Excess copper oxide shows that all acid has reacted; filtration removes that solid excess. Controlled evaporation concentrates the filtrate, and slow cooling forms crystals. Record crystal appearance and dry mass only after removing surface solution.

Calculation: Separate Chemistry only: percentage yield = (actual mass ÷ theoretical mass) × 100. Working out the theoretical mass from the balanced equation is Higher Tier. Combined Science does not need a calculation here.

Common exam mistake

Stopping before the base is in excess, so unreacted acid is left in the filtrate; or heating the filtrate to dryness instead of stopping once it is concentrated and leaving it to crystallise, which gives a powder rather than crystals and can drive off the water of crystallisation.

Revise it in context: www.examva.com/chemistry/chemical-changes (Chemical Changes notes)

Titrate a strong acid and strong alkali

Aim. Determine accurately the volumes of a strong acid and strong alkali that react completely.

Variables

Independent: Volume of solution delivered from the burette.

Dependent: Indicator end point and the corresponding titre.

Control:

- fixed pipetted volume
- concentrations and identities of the acid and alkali
- indicator identity and number of drops
- apparatus rinsing and eye-level reading technique

Risks and safety

- Wear eye protection and rinse acid or alkali splashes from skin immediately with plenty of water.
- Clamp the burette securely and fill it below eye level, using a funnel that is removed before readings.
- Handle glass pipettes and burettes carefully; use a pipette filler, never mouth pipetting.

Method

1. Rinse the pipette with the solution it will measure, then transfer a fixed volume into a conical flask.
2. Add a few drops of one suitable indicator, such as phenolphthalein or methyl orange, and place the flask on a white tile.
3. Rinse and fill the burette with the other solution, remove the funnel and record the initial reading at eye level.
4. Run solution into the flask while swirling; use a rough titration to locate the end point.
5. Repeat, adding solution dropwise near the sharp colour change, then record the final burette reading.
6. Calculate titre = final reading – initial reading, recording burette readings to the precision of the scale.
7. Repeat until concordant titres are obtained and calculate their mean, excluding the rough result and justified anomalies.

Typical results and conclusion

Find a mean from concordant titres. Higher Tier: convert volume from cm^3 to dm^3 by dividing by 1000, use reacting ratios to find an unknown concentration in mol/dm^3 , and multiply by M_r when g/dm^3 is required.

Calculation: Higher Tier: concentration (mol/dm^3) = moles $\div$ volume in dm^3 ; use the mean titre (concordant results within 0.10 cm^3) and the mole ratio from the equation.

Common exam mistake

Averaging the rough titre with the accurate ones, or reading the burette from the top of the meniscus.

Revise it in context: www.examva.com/chemistry/chemical-changes (Chemical Changes notes)

Identify products of aqueous electrolysis

Aim. Investigate the products formed at inert electrodes when different aqueous ionic solutions are electrolysed.

Variables

Independent: Identity of the dissolved ionic compound.

Dependent: Substance formed and identified at each electrode.

Control:

- solution concentration and volume
- electrode material, area, depth and separation
- supply voltage and electrolysis time
- gas-collection and identification method

Risks and safety

- Wear eye protection and use the low-voltage direct-current supply with dry hands.
- Use small quantities in good ventilation; chlorine is toxic, so do not inhale gases and stop after enough is collected for the test.
- Follow school hazard guidance for each electrolyte, including harmful copper compounds, and wash hands after the practical.

Method

1. Add a measured volume and concentration of one aqueous electrolyte to a labelled container.
2. Insert clean inert electrodes at a fixed depth and separation, then connect them to a low-voltage direct-current supply.
3. Switch on for a fixed time and record bubbles, colour changes or solid deposits separately at each electrode.
4. Collect any gas in small inverted test tubes without swapping the cathode and anode samples.
5. Test hydrogen with a lighted splint, oxygen with a glowing splint and chlorine with damp litmus paper, using only small samples.
6. Switch off, clean the electrodes and repeat with the other solutions under the same conditions.

Typical results and conclusion

Match each observation and gas test to a product, then compare it with the aqueous rules. A deposit may be weighed only after the electrode is rinsed and dried; identify cathode and anode evidence separately.

Calculation: Higher Tier: write half equations at each electrode, for example $2\text{Cl}^- \rightarrow \text{Cl}_2 + 2\text{e}^-$ at the anode and $2\text{H}^+ + 2\text{e}^- \rightarrow \text{H}_2$ at the cathode.

Common exam mistake

Forgetting that hydrogen forms at the cathode when the metal is more reactive than hydrogen, and that oxygen forms at the anode unless a halide ion is present.

Revise it in context: www.examva.com/chemistry/chemical-changes (Chemical Changes notes)

Investigate how different variables affect the temperature change when solutions react

Aim. Measure how hydrochloric acid concentration affects the maximum temperature rise when it reacts with sodium hydroxide solution.

Variables

Independent: concentration of dilute hydrochloric acid

Dependent: maximum temperature rise of the neutralisation mixture

Control:

- 25.0 cm³ volume of each reactant
- concentration of sodium hydroxide solution
- same measured starting temperature for both reactants
- same insulated cup, lid, probe, stirring and reading intervals

Risks and safety

- Wear eye protection and use only teacher-approved dilute hydrochloric acid and sodium hydroxide concentrations and quantities.
- Avoid skin contact; rinse splashes or spills promptly with plenty of water and follow the teacher's local instructions.
- Keep the polystyrene cup supported in a beaker and carry the separate reactant beaker carefully before mixing.

Method

1. Using its own clean, dry, labelled measuring cylinder, measure 25.0 cm³ of teacher-approved dilute hydrochloric acid into an insulated polystyrene cup supported in a beaker.
2. Using a separate clean, dry, labelled measuring cylinder, measure 25.0 cm³ of fixed-concentration sodium hydroxide into a labelled beaker and fit a lid to the cup.
3. Measure each reactant with a clean probe. Rinse it with distilled water and dry it between solutions; once both readings are steady at the same starting temperature, record them.
4. Pour the sodium hydroxide into the acid, replace the lid, stir with the temperature probe and record at fixed intervals until the maximum passes.
5. Calculate maximum temperature rise, rinse and dry the apparatus, then repeat with a fresh teacher-approved acid concentration.
6. Repeat every concentration, calculate mean temperature rises and plot mean rise against hydrochloric acid concentration.

Typical results and conclusion

Compare mean maximum temperature rises without assuming a linear trend. A rise shows exothermic transfer; exchange with the cup and air means the measured maximum may be lower than the ideal value.

Calculation: Temperature rise = maximum temperature – starting temperature. Compare the mean rise for each acid concentration.

Common exam mistake

Reading the temperature too early or too late, and not using a lid and polystyrene cup to reduce heat loss.

Revise it in context: www.examva.com/chemistry/energy-changes (Energy Changes notes)

Investigate how concentration affects reaction rate

Aim. Test concentration using both a gas-volume method and a separate colour-or-turbidity method.

Variables

Independent: concentration of one reactant

Dependent: gas volume over time or time to a fixed turbidity endpoint

Control:

- temperature
- reactant volumes
- solid mass and surface area for gas method
- same apparatus and endpoint rule

Risks and safety

- Wear eye protection and use only teacher-approved dilute acid and reactant quantities.
- Sodium thiosulfate with acid releases sulfur dioxide; use a well-ventilated laboratory, small quantities and the teacher's local risk controls.
- Keep the gas syringe pointed away from people, check that it moves freely and do not use sealed apparatus without an expansion path.
- Do not lean directly over the reaction vessel; clear spills using the teacher's instructions.

Method

1. Develop the hypothesis that increasing reactant concentration increases rate because particles collide more often, producing more successful collisions each second.
2. Before every trial, use fresh reactants and clean, rinsed and dried apparatus; for turbidity, confirm the cross is visible before mixing.
3. Gas method: measure 25.0 cm³ of teacher-approved dilute hydrochloric acid at a stated concentration, such as 0.50, 1.00 or 1.50 mol/dm³, into a conical flask.
4. Add 0.20 g of same-size marble chips (calcium carbonate), immediately fit the bung to a freely moving 100 cm³ gas syringe, and start timing at first contact using the same start-and-seal routine each time.
5. Record the carbon dioxide volume at regular intervals until the reading plateaus; repeat for each acid concentration.
6. Turbidity: make a sodium thiosulfate concentration series by replacing some solution with water, keeping total volume and viewing depth fixed. Add the same dilute hydrochloric acid volume each time and start timing.
7. Stop timing when the cross is no longer visible through the same depth of mixture, viewed from the same position.
8. Repeat each concentration and calculate means. For gas curves at all tiers, draw a tangent at time zero and compare its steepness.
9. Higher Tier: calculate the initial tangent gradient in cm³/s.
10. For turbidity, calculate relative rate = 1/mean time.
11. Plot the Higher Tier gas method's numerical initial rate or the turbidity method's relative rate against concentration, then test the hypothesis.

Typical results and conclusion

Gas at all tiers: draw a tangent at time zero on CO₂ curves and compare steepness. Higher Tier: calculate tangent gradient = $\Delta \text{volume} \div \Delta \text{time}$ in cm³/s. Turbidity: relative rate = 1/mean time in s⁻¹, not an absolute rate. Equal plateaus need equal limiting CaCO₃ and excess acid.

Calculation: Gas method: mean rate = volume of gas produced $\div$ time, in cm³/s. Disappearing cross: relative rate = 1 $\div$ mean time to the endpoint, in s⁻¹ (a comparison, not an absolute rate).

Common exam mistake

Changing the temperature or volume by accident when only concentration should change, and starting the timer late.

Revise it in context: www.examva.com/chemistry/rate-of-change (Rate and Extent of Chemical Change notes)

Separate and identify coloured substances by paper chromatography

Aim. Separate coloured mixtures by paper chromatography and calculate R_f values from the finished chromatogram.

Variables

Independent: sample or solvent being compared

Dependent: spot pattern, distance moved and calculated R_f

Control:

- paper type and dimensions
- origin and solvent depth
- spot volume and drying
- development time and temperature

Risks and safety

- Wear eye protection and follow the school hazard guidance for the selected solvent and samples.
- Keep volatile or flammable solvents covered and away from flames, hot equipment and ignition sources.
- Avoid skin contact and use the solvent only in the teacher-approved quantity and ventilation.

Method

1. Draw a pencil origin line above the solvent. Use a separate clean capillary for each sample; apply a small, concentrated spot and let each application dry before re-spotting.
2. Stand the paper in a covered container with the solvent below the origin; keep it upright and avoid touching the sides.
3. Allow the solvent to rise, remove the paper before it reaches the top and mark the solvent front immediately in pencil.
4. Dry the paper, mark spot centres, measure distances from the origin and calculate R_f values.
5. Repeat with standards or another solvent if the identification needs stronger evidence.

Typical results and conclusion

Compare the number and positions of spots. Calculate R_f for each spot using the same origin and solvent front; compare only with reference data collected using the same solvent and conditions.

Calculation: $R_f = \text{distance moved by the spot} \div \text{distance moved by the solvent front}$. R_f has no units and is always less than 1.

Common exam mistake

Drawing the baseline in ink (it dissolves and runs) or letting the solvent level start above the baseline.

Revise it in context: www.examva.com/chemistry/chemical-analysis (Chemical Analysis notes)

Separate Chemistry: identify ions in unknown single ionic compounds

Aim. Use flame, hydroxide and anion tests to identify the ions in teacher-provided unknown single ionic compounds.

Variables

Independent: identity of the teacher-provided unknown

Dependent: flame colour, gas result or precipitate colour and behaviour

Control:

- sample amount and concentration
- reagent identity, concentration and volume
- clean apparatus and separate sample portions
- flame conditions where used

Risks and safety

- Wear splash-proof eye protection and follow the school's risk assessment throughout.
- Use only small, teacher-approved quantities; acids, alkalis and several test reagents can irritate or damage skin and eyes.
- Keep hair and loose clothing secured around a lit Bunsen burner; extinguish it when flame testing is complete.
- Treat barium and silver reagents and unknowns as hazardous laboratory chemicals; avoid contact and dispose of them in labelled school waste, not the sink.
- Do not deliberately inhale gases; use the specified test at the tube mouth or by transferring gas as directed.

Method

1. Plan a test sequence from the possible ions and label a fresh portion of unknown for each branch.
2. Carry out a flame test on a clean wire loop where appropriate and record the colour.
3. Add sodium hydroxide solution dropwise, then in excess where needed; record precipitate colour and solubility.
4. Test fresh portions for carbonate, halide or sulfate using the correct acid and reagent sequence.
5. Compare observations with known controls and report evidence before the final identity.

Typical results and conclusion

Use a decision table to connect each exact positive result with the supported ion. An absent or ambiguous result should trigger a repeat with fresh apparatus, not a forced conclusion.

Calculation: No calculation. Flame: Li^+ crimson, Na^+ yellow, K^+ lilac, Ca^{2+} orange-red, Cu^{2+} green. Sodium hydroxide: Cu^{2+} blue, Fe^{2+} green, Fe^{3+} brown; Al^{3+} , Ca^{2+} and Mg^{2+} white (only Al^{3+} dissolves in excess). Carbonate: add dilute acid, the gas turns limewater milky. Halide: nitric acid, then silver nitrate (Cl^- white, Br^- cream, I^- yellow). Sulfate: hydrochloric acid, then barium chloride (white).

Common exam mistake

Testing for a halide before adding dilute nitric acid, so carbonate ions give a false precipitate with silver nitrate.

Revise it in context: www.examva.com/chemistry/chemical-analysis (Chemical Analysis notes)

Analyse and purify water samples

Aim. Measure water-sample properties, purify water by simple distillation and collect the distillate using teacher-approved samples.

Variables

Independent: water sample or treatment stage

Dependent: pH, dissolved-solid residue or distillate properties

Control:

- starting sample volume
- filter-paper grade, funnel and filtration procedure when filtration is needed
- apparatus and heating conditions
- measurement method
- collection time or distillate volume

Risks and safety

- Wear eye protection and use only teacher-approved water samples; never taste laboratory water.
- Use a heatproof mat, clamp glassware securely and check it for damage before heating.
- Do not seal the apparatus; point openings away from people and allow hot glassware to cool before handling.
- Use an electric heater or teacher-approved heat source and follow the school's risk assessment.

Method

1. Split each water sample into separate labelled aliquots before adding indicator, evaporating or distilling; never reuse a treated aliquot for another comparison.
2. Observe and record the sample, then measure pH with indicator or a calibrated probe. Rinse the probe with distilled water and blot it dry between samples.
3. If the sample contains suspended material, filter it before measuring the aliquot for dissolved solids. Use the same filter-paper grade, funnel and filtration procedure for every comparable sample.
4. Dry an empty evaporating basin, allow it to cool and record its mass.
5. Measure a known volume of water into the basin and heat gently to evaporate the water without spitting.
6. Cool and reweigh the basin and residue; if directed, repeat the heat-cool-weigh cycle to constant mass. Subtract the empty-basin mass to find the dissolved-solid residue mass.
7. Set up simple distillation with anti-bumping granules before heating.
8. Heat gently, cool vapour in the condenser and collect the distillate; stop heating before the distillation flask boils dry.
9. Compare starting water and distillate using the planned measurements.

Typical results and conclusion

Compare pH and residue mass for equal sample volumes, allowing for measurement uncertainty. Non-volatile dissolved solids remain in the flask during distillation, but volatile contaminants can evaporate and co-distil. A school result alone does not certify water as safe to drink.

Calculation: Mass of dissolved solids = mass of the evaporating basin after evaporation – mass of the empty basin; compare samples using the same starting volume.

Common exam mistake

Calling distilled water 'pure' without a test: pure water boils at 100 °C at standard pressure and leaves no residue when evaporated.

Revise it in context: www.examva.com/chemistry/using-resources (Using Resources notes)

Determine the specific heat capacity of a material

Aim. Link a measured electrical energy input to the temperature rise of a known mass and calculate the material's specific heat capacity.

Variables

Independent: electrical energy supplied to the heater, usually varied by changing heating time

Dependent: temperature change of the block

Control:

- mass and material of the block
- heater power
- insulation
- starting conditions

Risks and safety

- Use a heatproof mat and allow the heater and block to cool before moving them.
- Switch the power off before adjusting the apparatus.
- Keep electrical connections dry and secure.
- Use only the teacher-approved low-voltage laboratory supply and follow the school's risk assessment.

Method

1. Measure the block's mass, then place a suitable low-voltage laboratory heater and thermometer in their correct holes under teacher supervision.
2. Insulate the block, place it on a heatproof mat and record its initial temperature.
3. Measure the electrical energy supplied to the heater with a joulemeter or from current, potential difference and heating time.
4. Record temperature at regular intervals while the heater operates.
5. Find $\Delta\theta$ and calculate $c = E / (m \times \Delta\theta)$.
6. Repeat readings and compare the result with an accepted value only after considering heat loss.

Typical results and conclusion

Plot electrical energy supplied against temperature change and use the straight-line region. Ideally, gradient = $m \times c$, so $c = \text{gradient} / m$. Heat loss usually makes the estimate too large.

Calculation: $E = m c \Delta\theta$, so $c = E \div (m \Delta\theta)$. Read the energy E in joules from a joulemeter, or calculate it as $E = Pt$ with power $P = V \times I$.

Common exam mistake

Forgetting insulation and lag time: the thermometer keeps rising after the heater is off, so the measured $\Delta\theta$ is too small and c comes out too high.

Revise it in context: www.examva.com/physics/energy (Energy notes)

Investigate thermal insulation

Aim. Compare how material type or thickness affects the cooling of a container of hot water.

Variables

Independent: insulating material or its thickness

Dependent: temperature decrease over a fixed time

Control:

- thickness when comparing materials; material when comparing thicknesses
- water volume
- starting temperature
- container and lid
- room conditions
- timing intervals

Risks and safety

- Use hot rather than boiling water and pour it carefully.
- Keep containers stable and use eye protection where required.
- Handle thermometers through the lid without forcing them.

Method

1. Place equal volumes of hot water at the same starting temperature into identical lidded containers.
2. Wrap each container with the same thickness of a different material, or vary only the thickness of one material.
3. Measure the temperature at equal time intervals for the same total time.
4. Compare the temperature falls; the smallest fall indicates the most effective insulation under those conditions.
5. Repeat each condition and calculate a mean.

Typical results and conclusion

Plot temperature against time or compare the mean fall over the chosen interval. A smaller cooling rate indicates a lower rate of unwanted energy transfer.

Calculation: Temperature fall = starting temperature – temperature after the fixed time; compare falls across materials or thicknesses.

Common exam mistake

Using different starting temperatures or volumes of water for different insulators, which breaks the comparison.

Revise it in context: www.examva.com/physics/energy (Energy notes)

Investigate factors affecting resistance

Aim. Investigate wire length at constant temperature and compare resistor combinations in series and parallel.

Variables

Independent: length of test wire, or resistor arrangement in the combinations investigation

Dependent: resistance calculated from the measured potential difference and current

Control:

- wire material and cross-sectional area
- wire temperature
- supply setting
- meters and connection points

Risks and safety

- Use only the teacher-approved low-voltage laboratory supply.
- Keep current small and switch off between readings because the wire can become hot.
- Switch off the supply before changing connections and keep leads tidy.

Method

1. Build a low-voltage circuit with the test wire and ammeter in series, and a voltmeter in parallel across the measured wire length.
2. Include a variable resistor to keep the current small and protect the wire from appreciable heating.
3. Change the wire length across a suitable range, measure V and I for each length, and calculate $R = V/I$.
4. Switch off between readings where needed so the wire remains at approximately constant temperature.
5. Repeat readings, calculate means and plot resistance against wire length.
6. Build series and parallel resistor combinations, measure total V and I , and calculate each total resistance for comparison.

Typical results and conclusion

A straight resistance–length graph through the origin supports direct proportionality for a uniform wire at constant temperature. Compare series and parallel totals using circuit rules, and identify anomalies.

Calculation: Resistance $R = V \div I$ for each length or arrangement. In series the total is the sum of the resistances; in parallel it is less than the smallest single resistance (calculating the parallel total is not required).

Common exam mistake

Leaving the current on so the wire heats up and its resistance drifts, and reading the length from the wrong end of the ruler.

Revise it in context: www.examva.com/physics/electricity (Electricity notes)

Investigate I–V characteristics

Aim. Measure and compare the current–potential-difference characteristics of a resistor, filament lamp and diode.

Variables

Independent: potential difference across the test component

Dependent: current through the test component

Control:

- component being tested for each data set
- resistor temperature where constant temperature is required
- meter ranges and circuit arrangement

Risks and safety

- Use only the teacher-approved low-voltage laboratory supply.
- Limit current to protect the components and avoid touching a hot filament lamp.
- Switch off before reversing connections.

Method

1. Build a low-voltage circuit with the test component, ammeter and variable resistor in series, and a voltmeter across the component.
2. Adjust the variable resistor to obtain a sensible range of positive V and I readings at regular intervals.
3. For the resistor, keep current low or switch off between readings so its temperature remains approximately constant.
4. Switch off, reverse the supply connections so the meters give negative readings, and repeat; use a suitable meter range for the diode.
5. Repeat for the filament lamp and diode, then plot I vertically against V horizontally for each component.
6. Compare shapes and calculate $R = V/I$ at selected points where appropriate.

Typical results and conclusion

Expect a straight line through the origin for the constant-temperature resistor, a curved filament-lamp graph, and appreciable diode current in one direction only. Investigate anomalies rather than smoothing them away.

Calculation: $R = V \div I$ at each point; for a resistor at constant temperature the value is constant, for a filament lamp it rises as the lamp heats.

Common exam mistake

Not reversing the supply to get negative values, so the characteristic graph is only half drawn and the diode's one-way behaviour is missed.

Revise it in context: www.examva.com/physics/electricity (Electricity notes)

Determine densities of solids and liquids

Aim. Measure mass and volume with appropriate apparatus to determine the density of regular solids, irregular solids and liquids.

Variables

Independent: material or sample being measured

Dependent: calculated density

Control:

- temperature
- volume-reading method
- sample dryness for solid measurements

Risks and safety

- Lower irregular objects gently so they do not crack the measuring cylinder or splash water.
- Keep water away from the balance and wipe spills promptly.
- Handle glassware and dense or sharp-edged samples carefully under teacher instructions.

Method

1. Zero a balance and measure each solid's mass. For a liquid, weigh the empty measuring cylinder, add the liquid and reweigh it; subtract, or tare the empty cylinder before filling.
2. For a regular solid, measure every needed dimension with suitable equipment—Vernier callipers, a micrometer or a ruler—then calculate volume.
3. For an irregular solid, record the initial water volume, submerge it fully and find volume from the rise or displaced water.
4. For a liquid, read a measured volume at eye level from the appropriate meniscus.
5. Calculate density = mass $\div$ volume using a consistent unit pair, then repeat measurements where practical.

Typical results and conclusion

Calculate density for each repeat and compare a mean. Check units before comparing with reference values; explain whether uncertainty comes mainly from dimensions, the meniscus or trapped air.

Calculation: Density $\rho = m \div V$. For a cuboid $V = l \times w \times h$ (use the matching formula for other regular shapes); for irregular solids use the volume of water displaced; for liquids use a measuring cylinder.

Common exam mistake

Reading the displacement can or cylinder before the water settles, and mixing cm^3 with m^3 ($1 \text{ m}^3 = 1,000,000 \text{ cm}^3$).

Revise it in context: www.examva.com/physics/particle-model (Particle Model of Matter notes)

Investigate force and extension of a spring

Aim. Measure how a spring's extension changes with applied force and determine its spring constant in the linear region.

Variables

Independent: force applied to the spring

Dependent: extension of the spring

Control:

- same spring and ruler position
- starting reference point
- gravitational field strength
- reading method

Risks and safety

- Secure the stand with a heavy base and keep feet clear of falling masses.
- Wear eye protection and do not overstretch the spring.
- Add or remove masses only when the spring is steady.

Method

1. Clamp the spring securely beside a vertical ruler and record its unloaded length at eye level.
2. Add a known mass, allow oscillations to stop, record the new length and calculate extension.
3. Calculate applied force from $F = mg$ using the total hanging mass.
4. Increase force in equal steps without exceeding the teacher-set safe limit, recording force and extension each time.
5. Repeat readings and unload the spring to check whether it returns to its original length.
6. Plot force vertically against extension horizontally and find the gradient of the straight-line region.

Typical results and conclusion

A straight line through the origin supports $F \propto e$. For force plotted against extension, gradient = spring constant k . Curvature marks departure from proportionality; failure to return indicates inelastic deformation.

Calculation: Force = mass $\times$ 9.8 N/kg for each added mass; $F = k e$, so the spring constant k is the gradient of force against extension.

Common exam mistake

Measuring total length instead of extension, and loading past the limit of proportionality then treating the whole line as straight.

Revise it in context: www.examva.com/physics/forces-motion (Forces and Motion notes)

Investigate force, mass and acceleration

Aim. Test how acceleration changes with force at constant mass and with mass at constant force.

Variables

Independent: driving force in the first investigation; total accelerated mass in the second

Dependent: acceleration of the trolley system

Control:

- total mass while varying force
- driving force while varying mass
- runway slope and surface
- release point and measuring equipment

Risks and safety

- Use a stop block so the trolley cannot leave the runway.
- Keep feet clear of the hanging masses and use only a teacher-approved load.
- Keep fingers, hair and loose clothing away from the moving trolley and pulley.

Method

1. Set a trolley on a level runway connected over a pulley to a hanging mass, with light gates or a motion sensor measuring acceleration.
2. To vary force at constant total mass, transfer slotted masses from the trolley to the hanger and record acceleration for each driving force.
3. Repeat each force setting, calculate a mean acceleration and keep the trolley-plus-hanger system's total mass constant.
4. To vary mass at constant force, keep the hanging mass fixed and add masses to the trolley.
5. Measure repeated accelerations for each total mass while keeping the runway, release point and driving force unchanged.
6. Plot acceleration against force, then acceleration against reciprocal mass for the second investigation.

Typical results and conclusion

At constant mass, acceleration should rise linearly with resultant force. At constant force, acceleration falls as mass rises; plotting a against $1/m$ should be linear. Friction can create a non-zero intercept.

Calculation: Measure acceleration directly, $a = \Delta v \div t$ from light-gate or motion-sensor data, then compare it with $a = F \div m$; transfer masses between trolley and hanger to keep total mass constant.

Common exam mistake

Adding masses to the hanger from the desk, which changes the total mass being accelerated as well as the force.

Revise it in context: www.examva.com/physics/forces-motion (Forces and Motion notes)

Measure frequency, wavelength and wave speed

Aim. Measure frequency, wavelength and wave speed for water ripples and transverse waves on a stretched string.

Variables

Independent: source frequency or the water/string wave system being measured

Dependent: measured wavelength and calculated wave speed

Control:

- water depth
- source amplitude
- measurement region
- apparatus alignment
- string material and linear density
- hanging mass and string tension
- vibrating string length

Risks and safety

- Use only the teacher-approved low-voltage supply and switch it off before adjusting the vibrator.
- Keep water away from electrical connections and wipe spills immediately.
- Keep the tank stable and follow the school's instructions for the solid-wave apparatus.
- Secure the pulley and clamps, wear eye protection, do not overstretch the string and keep feet clear of hanging masses.

Method

1. Set a ripple tank on a stable bench with shallow water and a low-voltage vibration source; view wave fronts against a scale.
2. Watch one point. Start timing as a crest passes (count it as zero); stop as the Nth crest after it passes. N complete waves took time t, so frequency $f = N \div t$.
3. Measure the distance across several wavelengths and divide by the number of wavelengths.
4. Calculate $v = f\lambda$ and repeat at fixed water depth and source setting.
5. For a solid, attach a stretched string to a low-voltage vibration generator; pass it over a secured pulley to a known hanging mass that sets the tension.
6. Set a low amplitude and adjust the signal-generator frequency until the string shows a clear stationary wave; record the frequency.
7. Measure the vibrating length L across n half-wavelength loops, calculate $\lambda = 2L/n$, then calculate $v = f\lambda$.
8. Repeat at other resonant frequencies while keeping the same string, vibrating length, hanging mass and source amplitude; compare a mean speed.

Typical results and conclusion

For ripples, use several cycles and wavefront gaps. For the string, use $\lambda = 2L/n$ from several loops. Calculate $v = f\lambda$, repeat and compare mean speeds with uncertainty.

Calculation: Wave speed $v = f\lambda$. Wavelength from the ripple tank is the spacing of several waves $\div$ the number of gaps; frequency from the signal generator or by counting waves per second.

Common exam mistake

Measuring one wavelength (a large percentage uncertainty) instead of across ten and dividing, and confusing the number of wave crests with the number of gaps between them.

Revise it in context: www.examva.com/physics/waves (Waves notes)

Investigate reflection and refraction of light

Aim. Separately compare reflected brightness, sharpness and scatter from surfaces, then reconstruct refraction through transparent blocks.

Variables

Independent: surface finish, or incident angle/transparent material for the block test

Dependent: reflected brightness, sharpness and scatter, or reconstructed ray angles

Control:

- light colour
- ray width
- source setting and distance
- sensor distance and angle
- component position and outline
- angle-measurement method

Risks and safety

- Never look directly into the ray box or aim it at anyone's eyes.
- Switch off and allow a hot lamp housing to cool before moving it.
- Handle glass blocks carefully and report chips or breakage to the teacher.

Method

1. Surface test: set a ray box at a fixed distance and incident angle from the first surface; keep light colour, beam width and source setting unchanged.
2. Measure reflected brightness with a light sensor at a fixed distance and angle; record reflected-patch sharpness or width and the spread of scattered light.
3. Repeat for smooth, matt and rough surfaces, resetting the same geometry and taking repeat readings.
4. Block test: place a transparent rectangular block on plain paper, draw its outline and send one narrow ray into it at a chosen angle.
5. Mark two points on the incident ray and two on the emergent ray, then switch off the ray box and remove the block.
6. Join the marks with a ruler and reconstruct the ray through the block; draw normals and measure incidence and refraction angles from them.
7. Repeat for several incident angles and with at least one different transparent substance, changing only the intended angle or material.

Typical results and conclusion

Compare mean reflected brightness, patch sharpness or width and scatter only at matched geometry. For each block, reconstruct the internal ray and compare angles measured from the normals.

Calculation: No calculation. Measure angles from the normal: angle of incidence equals angle of reflection. Smooth surfaces give a sharp reflection; rough surfaces scatter the light. Light entering glass from air at an angle bends towards the normal.

Common exam mistake

Measuring angles from the surface instead of the normal, and using a wide ray so the traced line has no precise edge.

Revise it in context: www.examva.com/physics/waves (Waves notes)

Investigate infrared absorption and emission by surfaces

Aim. Compare how surface nature affects infrared absorption or emission under controlled conditions.

Variables

Independent: surface colour with finish fixed, or surface finish with colour fixed

Dependent: infrared detector reading or temperature change over a fixed time

Control:

- distance and angle
- surface area
- starting temperature
- exposure time
- room conditions

Risks and safety

- Use hot rather than boiling water and keep the cube on a stable heatproof mat.
- Do not touch a hot lamp, cube or surface; allow equipment to cool before moving it.
- Keep liquids away from electrical equipment and follow the school's risk assessment.

Method

1. For emission, fill a Leslie cube with hot water as directed and measure infrared intensity from each surface at the same distance.
2. For absorption, place identical sensors or containers with different surfaces at equal distances from an infrared source.
3. Record starting readings, expose each surface for the same time and record temperature or detector change.
4. Repeat readings while keeping geometry, starting temperature and exposure time constant.
5. Compare colours while finish is fixed, then finishes while colour is fixed; repeat each matched condition.

Typical results and conclusion

Compare mean readings within matched sets. Black surfaces and matt surfaces usually absorb and emit more infrared than light or shiny surfaces; keep each conclusion tied to the apparatus used.

Calculation: Emission: compare detector readings for matt black, shiny black, white and silver surfaces at the same distance and temperature. Absorption: temperature rise = final – starting temperature after the same exposure time.

Common exam mistake

Placing the detector at different distances from each surface, or letting the Leslie cube cool between readings.

Revise it in context: www.examva.com/physics/waves (Waves notes)