PCFGSTUDY

Cambridge OCR GCSE Combined Science A — Physics

Topic CS7

Practical skills

Specification J250 · Cambridge OCR

Free edition

Revision notes for one topic, free to download.

These are the summary notes only. The full edition of this booklet also carries the worked examples, the required practicals and the formula sheets, with every topic in one place.

Colour Codes

Definitions

Diagrams

Notes and warnings

Sub-topic headings

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Cambridge OCR GCSE (9–1) Combined Science A (Gateway Science) J250 · Specification reference CS7 · Assessed on every paper: Papers 1–6 (Foundation) and Papers 7–12 (Higher). Practical work is 15% of the marks.

Define Hypothesis

- a testable idea, based on a scientific theory, about how one variable affects another; a **prediction** says what you expect and why, before the experiment.

Define Control variable

- a quantity kept the same so that it cannot affect the result; a **control experiment** is a run with the independent variable absent.

Define Resolution

- the smallest change an instrument can detect.

Define Repeatable

- the same person, method and equipment give the same results again; **reproducible** — a different person, or different equipment, does.

Define Anomalous result (outlier)

- a result lying well outside the pattern of the others.

Define Uncertainty

- the interval within which the true value is expected to lie.

Define Practical Activity Group (PAG)

- one of the **sixteen** groupings into which Cambridge OCR has split the Department for Education's required apparatus and techniques: **five biology (B1–B5), five chemistry (C1–C5) and six physics (P1–P6)**.

Define Independent variable

- the one thing you deliberately change. **Dependent variable** — the thing you measure.

Define Range

- lowest to highest value of the independent variable. **Interval** — the gap between consecutive values.

Define Accuracy

- how close a measurement is to the true value. **Precision** — how close repeat measurements are to one another.

Define Random error

- unpredictable scatter above and below the true value.

Define Systematic error

- an error shifting every reading the same way by the same amount; a **zero error** is one.

Define Valid

- an investigation that measures what it set out to measure and answers the question asked.

CS7.1 The sixteen Practical Activity Groups

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Cambridge OCR sets **no numbered list of named required practicals**. It splits Appendix 4 of the DfE's *Combined science GCSE subject content, July 2015* into **sixteen PAGs**, each defined by the **apparatus and techniques** it must cover. Any activity using those techniques counts towards that PAG, so different schools legitimately do different experiments, and centres may devise their own provided the same apparatus and techniques are covered at GCSE level. Some appear in **more than one** PAG, so a centre must check that its chosen sixteen activities cover the whole list.

Biology — PAG B1 to B5

PAG and group	What it involves	OCR's example activity	Where it appears
B1 Microscopy	Apparatus, techniques and magnification, including microscopes, to observe specimens and produce **labelled scientific drawings**; accurate measurement	Investigate different magnification techniques to draw scientific diagrams from a number of biological specimens	B1.1, B2.1, B2.2, B4.1, B6.3
B2 Sampling techniques	**Sampling techniques** used in the field to investigate the **distribution and abundance** of organisms, including **biotic and abiotic factors**; accurate measurement	Investigate the differences in habitats using ecological sampling techniques	B1.3, B4.1, B6.1
B3 Rates of enzyme-controlled reactions	Safe use of **heating devices** (Bunsen burner, water bath, electric heater); **observation and measurement of biological changes and processes**; **rates of reaction** by gas production, water uptake or indicator colour change	Investigate the factors that can affect the rate of enzyme activity	B1.2, B1.3, B4.1
B4 Photosynthesis	Observation and measurement of biological changes and processes; **safe and ethical use of living organisms** to measure physiological functions and responses; rates of reaction; heating devices	Investigate the factors that can affect the rate of photosynthesis in *Cabomba*	B1.1, B1.3, B1.4, B2.1, B2.2, B6.1
B5 Microbiological techniques	Observation and measurement of biological changes and processes; microscopy and labelled drawings; heating devices, including working **aseptically** around a Bunsen burner	Investigate the effectiveness of antimicrobial agents on the growth of a bacterial lawn	B1.1, B2.1, B2.2, B3.1, B3.3, B4.1

Chemistry — PAG C1 to C5

PAG and group	What it involves	OCR's example activity	Where it appears
C1 Electrolysis	Apparatus and techniques to draw, set up and use **electrochemical cells** for the separation and production of elements and compounds	Electrolysis of aqueous sodium chloride, or of aqueous copper sulfate solution, testing for the gases produced	C3.4, C6.1
C2 Separation techniques	Safe use of equipment to **purify and separate** mixtures — evaporation, filtration, crystallisation, **chromatography** and distillation	Use of chromatography to identify the mixture of dyes in an unknown ink	C2.1
C3 Distillation	Purification and separation as above, with **heating devices**, and accurate measurement of mass, time, temperature and volume of liquids and gases	Distillation of a mixture — for example orange juice, cherry cola, hydrocarbons or inks	C2.1, and applied to crude oil in C6.1
C4 Production of salts	Purification and separation; accurate measurement; **conducting and monitoring chemical reactions**, including **pH**; safe handling and careful mixing of gases, liquids and solids; heating	Production of a pure, dry sample of a salt	C2.1, C3.3, C4.1, C5.1
C5 Measuring rates of reaction	Accurate measurement of mass, time, temperature and volume; **making and recording observations** during reactions, including temperature change and **rates** measured by gas production and colour change	Investigate the effect of surface area or concentration on the rate of an acid/carbonate reaction	C3.2, C4.1, C5.1

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Physics — PAG P1 to P6

PAG and group	What it involves	OCR's example activity	Where it appears
P1 Materials	Accurate measurement of length, area, mass, time, volume and temperature, and using them to determine the **densities** of solid and liquid objects	Determine the densities of a variety of objects, both solid and liquid	P1.1, P1.2
P2 Forces	Apparatus to measure and observe the **effects of forces**, including the **extension of springs**; accurate measurement as above	Investigate the effect of forces on springs	P2.2, P2.3
P3 Motion	Apparatus and techniques for **measuring motion**, including determination of **speed and rate of change of speed** (acceleration and deceleration)	Investigate the acceleration of a trolley down a ramp	P2.1, P2.2, P6.1
P4 Waves	Observations of **waves in fluids and solids** to identify the suitability of apparatus to measure **speed, frequency and wavelength**; observations of the **interaction of electromagnetic waves with matter**	Use a ripple tank to measure the speed, frequency and wavelength of a wave	P4.1, P4.2
P5 Energy	Safe use of apparatus in a range of contexts to measure **energy changes and transfers** and associated values such as **work done**	Determine the specific heat capacity of a material	P1.2, P2.2, P5.1, P5.2
P6 Circuits	Apparatus to measure **current, potential difference and resistance** and explore circuit elements; **circuit diagrams** to construct and check **series and parallel** circuits	Investigate the *I*–*V* characteristics of circuit elements	P3.2, P6.2

- Note the overlaps OCR flags. **Accurate measurement** runs through almost every group; **heating devices** appear in B3, B4, B5, C3 and C4; **rates of reaction** in B3, B4 and C5; **microscopy** in B1 and B5. One well-chosen activity can therefore serve more than one PAG, and one line of requirements can be split across two or more activities.

CS7.2 Planning: hypotheses, variables and fair testing

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1. **Start from a scientific idea.** Build a **hypothesis** on theory, then predict **with a reason**: *"doubling the concentration will double the rate, because there are more particles in the same volume so collisions are more frequent."*
2. **Name the three kinds of variable** and say **how** each control variable is controlled — "in a water bath at 30 °C", not "keep the temperature the same". If more than one variable changes, the result is not **valid**.
3. **Choose a sensible range and interval** — at least five or six evenly spaced values across the whole range the apparatus allows. Two values never show a pattern.
4. **Choose apparatus by resolution and range.** A cylinder reading to 1 cm^3 is useless for 0.5 cm^3; a 10 N newtonmeter cannot measure 25 N; a stopclock reading to 0.01 s cannot beat a reaction time of 0.2 s.
5. **Plan repeats** — at least three at each value, so a mean can be found and anomalies spotted — after a **preliminary trial** to check range, interval and timings.
6. **Include a control** where one is meaningful: boiled enzyme, distilled water, a bare can beside the lagged one.
7. **Write the method as numbered steps with quantities.** "Add acid" earns nothing; "add 50 cm^3 of 1.0 mol/dm^3 hydrochloric acid" earns the mark.
8. **Risk-assess properly**: name the **hazard**, the **risk** and the **control measure** — *hot water scalds → use a lid and a heatproof mat*. Marks are for the control measure, never for "be careful".

NOTE

A common exam task is to improve or correct a given method. Look for: no repeats; no control; only two or three values of the independent variable; an uncontrolled variable; an instrument of the wrong resolution; a step that cannot be timed or measured reliably. Say what is wrong **and** what to do instead.

CS7.3 Apparatus and techniques

Across the sixteen activities you must have had the opportunity to use **every** apparatus and technique listed in the CS7 tables above. The one that runs through nearly all of them is **accurate measurement** — of length, area, mass, time, temperature, volume of liquids and gases, and pH.

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Quantity	Instrument	Typical resolution	Technique points
Length	Metre rule, 30 cm rule	1 mm	Read at eye level to avoid **parallax**; measure from a mark, not the worn end
Volume	Measuring cylinder, gas syringe, eureka can	1 cm^3	Read the **bottom of the meniscus**, at eye level
Mass	Digital balance	0.01–0.1 g	**Zero (tare)** it first and check for a zero error
Time	Stopclock; **light gates and data logger**	0.01 s (human reaction 0.2 s)	Time **many events** and divide; light gates remove reaction time altogether
Temperature	Thermometer, temperature probe	1 °C, 0.1 °C	Bulb fully immersed, not touching the container; stir before reading
pH	Universal indicator, pH probe	1 pH unit, 0.1	A probe gives continuous data; indicator colour is a judgement
Current, p.d., force	Ammeter **in series**, voltmeter **in parallel**, newtonmeter	0.01 A, 0.01 V, 0.1 N	Check for zero errors; switch off between readings so components do not heat

- **Scientific diagrams** of apparatus are drawn in **section**, as simple labelled 2D outlines; circuits use straight lines, right-angled corners and the correct symbols. Biological **drawings** use clear continuous unshaded pencil lines, horizontal label lines with no arrowheads, and a title with a magnification or scale bar.
- **Data loggers, light gates and probes** improve **resolution**, remove human reaction time and record several quantities at once.

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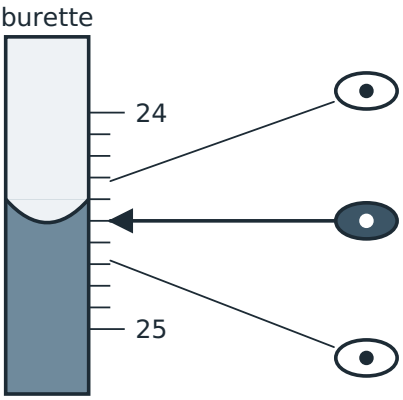
Reading a scale at eye level, choosing apparatus by resolution, and spotting a zero error.

Reading a burette at eye level



eye above the liquid level — the reading is wrong (a parallax error)

eye level with the bottom of the meniscus — the correct reading, 24.50 cm³

eye below the liquid level — the reading is wrong (a parallax error)

Clamp the burette vertically, fill it below eye level, run the liquid through the tip to remove the air bubble, and read the bottom of the meniscus against the scale every time.

Choosing apparatus by resolution — the smallest change it can detect

burette — divisions of 0.1 cm³ (resolution 0.1 cm³)
pipette — one fixed volume, 25.0 cm³
measuring cylinder — 1 cm³ at best, for rough volumes
balance — 0.01 g, or 0.001 g
thermometer — 1 °C, or 0.1 °C for a probe
uncertainty = half the smallest division, so a burette reading is ±0.05 cm³ (titre ±0.10)

an empty balance pan

A zero error is a systematic error

The pan is empty, yet the balance reads 0.02 g, so every mass measured with it is 0.02 g too large. Repeating does not remove this, because the mean is shifted too. Zero (tare) the balance before use.

CS7.4 Recording, processing and presenting data

- Draw the **results table before you start**: independent variable in the **first column**, then each repeat, then the mean and any processed quantity in its own labelled column.
- Put the **quantity and unit in the heading only** — *time / s*, never beside each number — and give every value in a column to the **same number of decimal places**, fixed by the instrument's resolution.
- **Calculate means, excluding anomalies**, and say that you have excluded one and why. Never quietly erase a result.
- Give answers to a **sensible number of significant figures** — no more than the least precise measurement used — and **convert units before calculating**: minutes → seconds, cm → m, mA → A, cm³ → m³, g → kg. Use **standard form** for very large or small numbers, and **order-of-magnitude estimates** to check that an answer is sensible.

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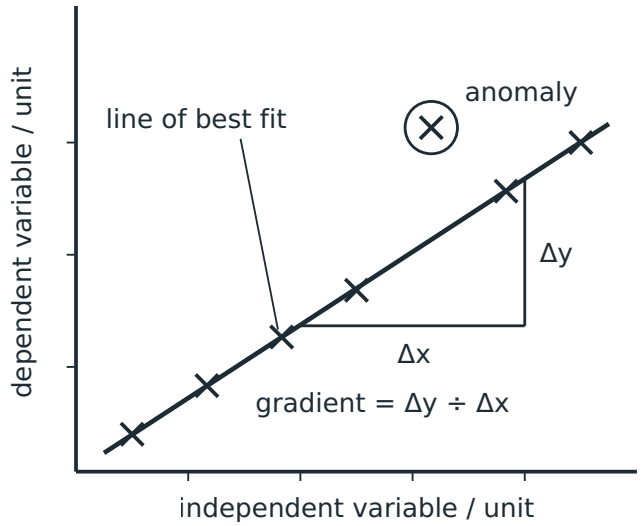
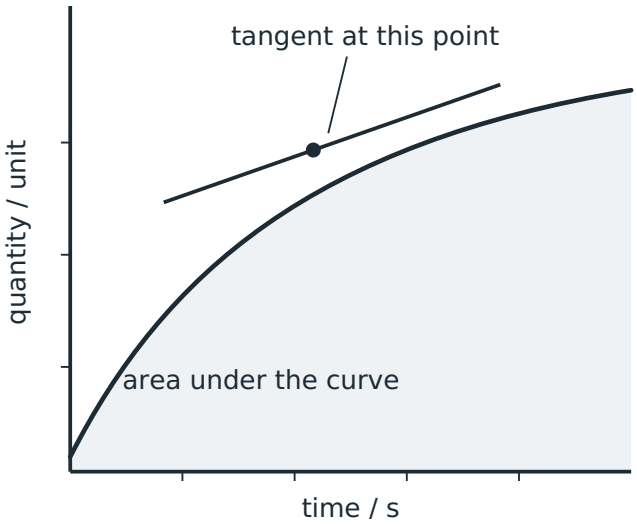
CS7.5 Graphs, gradients and areas

- **Independent variable on the *x*-axis, dependent variable on the *y*-axis**, both labelled with **quantity / unit**, on a **scale using at least half the grid** in each direction and rising in steps of 1, 2, 5 or 10 — never 3 or 7.
- Plot small neat **crosses**, then draw a **line of best fit**: a ruled straight line or a **smooth curve**, with roughly equal numbers of points either side. Never join the dots, and never force the line through the origin unless the data support it. **Circle anomalies and ignore them** when drawing the line.
- **A straight line through the origin means directly proportional.** A straight line not through the origin fits **y = mx + c**, where *c* is the intercept.
- **Gradient** = change in *y* ÷ change in *x*, from a **large** triangle drawn on the line, not from two data points. Its meaning comes from the axes: distance–time gives **speed**, velocity–time gives **acceleration**, force–extension gives the **spring constant**, volume–time gives the **rate of reaction**.
- For a **curve**, draw a long **tangent** at the point of interest and take its gradient — the rate at that instant (M4e). The **area** under a graph matters too (M4f): the area under a **velocity–time** graph is the **distance travelled**, found by counting squares or splitting the shape into triangles and rectangles.
- **Bar charts** are for categoric data, **histograms** for continuous data in classes, and a **scatter diagram** to look for a **correlation**. Correlation does not prove cause.

Drawing a line of best fit and a gradient triangle, and taking a tangent and an area from a curve.



Independent variable on the x-axis, dependent on the y-axis. Plot small crosses and draw a single line of best fit. Circle an anomaly and ignore it. Take the gradient from a big triangle.



For a curve, the gradient of a tangent gives the rate at that instant. The area between the curve and the x-axis has a meaning too — on a velocity–time graph it is the distance travelled.

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CS7.6 Analysing and evaluating

- **Describe the pattern first**, quoting figures with units and the range over which it holds: *"the rate rises from 2 cm³/min at 10 °C to a maximum of 9 cm³/min at 40 °C, then falls to zero by 60 °C."*
- **Then explain it** using the science of the topic — collision frequency, enzyme denaturing, dissipation, resistance. Describing is not explaining.
- **Conclude by answering the original question**, saying whether the hypothesis is **supported** and how far. Results at three temperatures do not license a claim about all temperatures, and you should not extrapolate far beyond the data.
- **Evaluate the method, not your care.** Comment on the **quality of the data**, the **suitability of the apparatus** and the **range and interval**. Then name a **specific** weakness, say **what effect it had and in which direction**, and give a realistic improvement: *"gas escaped before the bung was fitted, so every volume was too low — a systematic error; use a pre-stoppered flask."* Avoid "human error" and "be more accurate".
- **Judge the whole investigation.** Was it **valid**? Would an independent group repeating it strengthen the conclusion? Cambridge OCR also expects you to recognise the value of **peer review**, to communicate findings to different audiences, and to weigh the personal, social, economic and environmental implications of scientific applications.

CS7.7 Accuracy, precision, repeatability, reproducibility and error

Term	What it means	How to improve it
Accuracy	Close to the true value	Remove systematic errors; calibrate; use a more suitable instrument
Precision	Repeats close to one another	Use instruments of finer resolution; control variables more tightly
Repeatability	The same experimenter, method and equipment give the same results	Keep the method identical; repeat at least three times
Reproducibility	A different experimenter, or different equipment or method, gets the same results	Publish a clear method; compare with another group's results
Random error	Unpredictable scatter either side of the true value	**Repeat and take a mean**; use data loggers
Systematic error	Every reading shifted by the same amount in the same direction	**Check for zero errors**; calibrate; correct the technique

- **Identify anomalies** in the table by eye, or as a point far from the line of best fit; investigate the cause and repeat that reading if you can.

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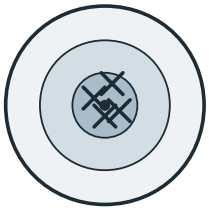
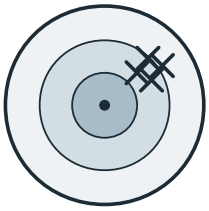
Accuracy and precision are different things, and only one of them is improved by repeating.



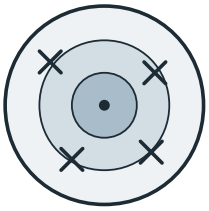
Precise and accurate

The results agree with each other and with the true value.



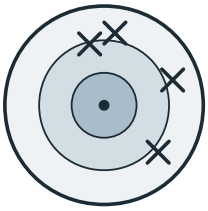
Precise, not accurate

The results agree with each other but are all shifted the same way — a systematic error.



Accurate, not precise

The results scatter, but their mean is close to the true value — random error.



Neither

The results scatter and their mean is a long way from the true value.

Each cross is one repeat measurement; the centre of the target is the true value. Repeating and taking a mean reduces random error. Only correcting the method or the instrument removes a systematic error.

WATCH OUT

Accurate and precise are not the same thing. A stopclock started late every time gives readings that agree beautifully with one another — **precise but not accurate**, because a **systematic error** has shifted them all one way. Repeating and taking a mean will **not** fix that; only finding and removing the cause will.

Equally, **more repeats do not make a measurement more accurate** if the ruler is bent or the balance does not read zero. Repeats reduce the effect of **random** error only.

CS7.8 The maths skills Cambridge OCR lists

The assessment includes **at least 20% mathematical skills** at the appropriate tier for combined science. The skills flagged **CS** in J250's appendix 5f are:

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Code	Skill
M1a–d	Expressions in **decimal form** and in **standard form**; **ratios, fractions and percentages**; **estimates** of the results of simple calculations
M2a–c	An appropriate number of **significant figures**; **arithmetic means**; frequency tables and diagrams, **bar charts and histograms**
M2f–h	The terms **mean, mode and median**; a **scatter diagram** to identify a **correlation**; **order of magnitude** calculations
M3a–d	The symbols **=, <, ≪, ≫, >, ∝, ~**; **changing the subject** of an equation; **substituting** values using appropriate units; solving simple algebraic equations
M4a–f	Translating between **graphical and numeric** form; **y = mx + c**; **plotting** two variables; **slope and intercept**; the **tangent to a curve** as a measure of rate of change; the physical significance of the **area between a curve and the x-axis**, measured by counting squares
M5a–c	**Angular measures in degrees**; visualising and representing **2D and 3D forms**; **areas** of triangles and rectangles and **volumes** of cubes
• • •	Each sub-topic in J250 also lists the maths outcomes most likely to appear in its own questions, coded **BM1.1i**, **CM3.2ii**, **PM4.1i** and so on. Skills in **bold** in appendix 5f are Higher Tier only. **Foundation Tier** maths questions are no less demanding than Key Stage 3 mathematics; **Higher Tier** questions are no less demanding than Foundation Tier GCSE Mathematics. **Units.** Learn the SI base units and the prefixes **tera, giga, mega, kilo, centi, milli, micro and nano**, and interconvert them: most lost calculation marks come from a missing unit or an unconverted prefix.

NOTE

Equations in practical questions. Cambridge OCR provides an **equation sheet as an insert** with the Combined Science **physics** papers, carrying **both** the "recall and apply" and "select and apply" groups from appendix 5g, and a separate **chemistry data sheet** carrying the Periodic Table with the chemistry papers. The marks in a practical calculation are therefore for **selecting** the right equation, **rearranging** it, **converting** units and quoting a sensible number of significant figures — never for remembering the letters.

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