

Covering teacher guide

Half-life and radioactive-decay graphs

Start here / subject briefing

Before this lesson: Consolidation after pupils have met radioactive decay, count rate and half-life graphs. HOD/teacher assigns one tier route before handing over. Shared pages 1-6 and 9; Foundation page 7 OR Higher page 8.

Half-life is the elapsed time for a sample's expected undecayed nuclei, activity or corrected source count rate to halve. It is a statistical trend; one nucleus has no predictable decay deadline. A measured detector rate includes background. Subtract background from each reading before halving; add it back only if a measured target is requested.

Words and symbols you will need

Term	Plain-English meaning
Half-life	Time for one halving of the sample quantity, measured between two corresponding times.
Activity, Bq	Number of nuclear decays per second in the source.
Count rate	Detector events per unit time. It is not automatically the activity in Bq.
Measured / corrected	Measured includes background. Corrected subtracts the supplied background, using the same rate unit.
Higher: decrease ratio	Decrease = initial - remaining. Decrease : initial differs from remaining : initial.

Help pupils choose a method

1. Check the graph label: already corrected, or measured including background? Correct each measured value once.
2. For a graph half-life, choose a corrected level and half that level; subtract the corresponding times.
3. For several halvings count intervals, then multiply by known half-life or divide a known total time. Higher: name the requested ratio numerator before simplifying.

Use the supplied model - pupil page 2

Use pupil page 2: 9 h contains three 3 h intervals, so 640 Bq halves three times to 80 Bq. The separate detector example subtracts 12 from 90 to give 78 counts/min. These examples deliberately use different quantities and units.

$9 / 3 = 3$ half-lives: $640 \rightarrow 320 \rightarrow 160 \rightarrow 80$ Bq. In the separate detector test, corrected count rate = $90 - 12 = 78$ counts/min. Activity uses Bq; detector count rate uses counts per unit time. Do not automatically equate them.

If pupils are still stuck

Read the matching Say/Ask/Expect coaching and direct the named fresh retry in its replacement time. If still insecure, help label measured/corrected values and the time interval, then record the exact difficulty. For Higher ratio errors, use the page 8 model, ask whether $100 : 400$ describes remaining or decrease (remaining), then let pupils retry their own ratio working.

Turn to teacher page 2 for the timed run sheet. Keep this guide separate from the pupil booklet.

Run the lesson from this page

Half-life and radioactive-decay graphs

Print one complete 9-page pupil booklet per pupil, stapled in order; double-sided printing is fine. Keep the 11-page teacher guide separate.

Confirm the HOD/teacher-assigned tier and tick it on pupil page 1. Everyone uses pages 1-6 and 9. Foundation completes page 7; Higher completes page 8 instead. Never assign both tier pages.

Read teacher page 1, then use the timed run sheet on page 2. Pupils need pens, a ruler and calculator. All figures and data are supplied; no login, devices or radioactive materials are required.

Min	Pupil page / Q	Read aloud / check	Next action and answer key
0-5	1 / 1-3	Assign and tick one tier route. Everyone starts from memory; check at 5 minutes.	If insecure, use Try again A in the first 2 reading minutes. Answers: teacher page 3. Coaching: page 8.
5-15	2 / reading	Read the quantity table and both models. Name measured versus corrected rates.	Check A if used, then continue reading.
15-20	3 / 4	Choose a letter and show correction, halving and the measured target. Pause.	If insecure, Try again B replaces questions 5-6. Answers: teacher page 3. Coaching: page 9.
20-30	3-4 / 5-12	Complete the definitions, separate test and corrected graph questions.	If B was used, leave 5-6 blank. Figure 1 is already corrected. Answers: teacher page 4.
30-33	5 / 13	Complete question 13 independently, then pause.	If insecure, Try again C replaces questions 14-15. Answers: teacher page 4. Coaching: page 10.
33-45	5-8 / 14-22	Use the Sample B graph for 14-18. At 41 minutes Foundation uses page 7; Higher uses page 8 instead.	If C was used, leave 14-15 blank. Do not assign both tier pages. Higher: distinguish remaining from decrease. Answers: teacher pages 5, 6.
45-55	9 / 23	Correct assigned practice and explain one correction.	Share only assigned practice answers. Keep the exit hidden. For Higher, check numerator/order in both ratios. Answers: teacher page 6.
55-60	9 / 24	Cover earlier pages. Everyone completes shared question 24 independently.	Collect every booklet; check afterwards. D is next lesson only. Record Higher ratio practice separately. Answers: teacher page 7. Coaching: page 11.

Estimated 60 minutes. Practice: 10 minutes, a 3-minute check, 8 minutes shared background work and 4 minutes on ONE tier page. A uses reading time; B replaces 5-6; C replaces 14-15; D is next lesson only. Timings are not classroom-trialled.

Entry and hinge - pupil pages 1 and 3

Match the pupil number. Accept equivalent correct wording. Keep this guide separate from pupils.

1. (pupil p1) $96 / 2 = 48$ counts/s.

2. (pupil p1) $62 - 12 = 50$ counts/s.

3. (pupil p1) No. Individual decay times are random; half-life describes the statistical trend for a sample, not a deadline for one nucleus.

4. (pupil p3) C. Initial source contribution = $110 - 10 = 100$ counts/s; half is 50 counts/s; add unchanged background: $50 + 10 = 60$ counts/s.

Try again A - pupil page 1

Only if your teacher asks. Use the first 2 reading minutes, then continue on page 2.

(a) 42 counts/s. (b) $77 - 7 = 70$ counts/s. (c) No: an individual nucleus decays randomly, while half-life describes a sample trend.

Try again B - pupil page 3

Only if your teacher asks. Complete this instead of questions 5-6, then continue with questions 7-12.

Initial corrected rate = $150 - 10 = 140$ counts/s. After one half-life it is 70 counts/s. Measured target = $70 + 10 = 80$ counts/s.

First practice and mid-check - pupil pages 3-5

Match the pupil number. Accept equivalent correct wording. Keep this guide separate from pupils.

5. (pupil p3) The time taken for the number of undecayed nuclei of the isotope in a sample to halve. Accept time for its activity or background-corrected source count rate to fall to half its initial value. A nucleus does not split in half.

6. (pupil p3) Radioactive decay is random; the exact decay time of an individual nucleus cannot be predicted. A predictable large-sample trend is not an individual timetable.

7. (pupil p4) $8.0 / 4.0 = 2$ half-lives: $640 \rightarrow 320 \rightarrow 160$ counts/s. This is a separate test from Sample A in Figure 1.

8. (pupil p4) 160 counts/s. Accept approximately 155-165 counts/s from the supplied graph.

9. (pupil p4) The times are 0 and 4.0 min; half-life = $4.0 - 0 = 4.0$ min. Half-life is an elapsed time, not a count rate.

10. (pupil p4) Times are 8.0 and 12 min; half-life = $12 - 8.0 = 4.0$ min. Do not report the final clock reading, 12 min, as the interval.

11. (pupil p4) $80 \rightarrow 40 \rightarrow 20$ is two half-lives. Time = $2 \times 4.0 = 8.0$ min. Equivalently the graph times are 8 and 16 min, separated by 8 min.

12. (pupil p4) $120 \rightarrow 60 \rightarrow 30 \rightarrow 15$ is three half-lives. Half-life = $18 / 3 = 6.0$ min.

13. (pupil p5) Corrected rates: 100, 50 and 25 counts/s. They halve from 0 to 3 min and again from 3 to 6 min. Half-life = 3 min; it is not 6 min or a count rate.

Try again C - pupil page 5

Only if your teacher asks. Complete this instead of questions 14-15, then continue with questions 16-18.

Corrected rates: 80, 40 and 20 counts/s. Each halving takes 4 min, so half-life = 4 min.

Background correction - pupil pages 5-6

Match the pupil number. Accept equivalent correct wording. Keep this guide separate from pupils.

14. (pupil p5) 100 counts/s. Accept approximately 96-104 counts/s.

15. (pupil p5) Corrected rate = measured - background = $100 - 20 = 80$ counts/s. Allow follow-through from the graph reading.

16. (pupil p6) At 4.0 h: $60 - 20 = 40$ counts/s. At 6.0 h: $40 - 20 = 20$ counts/s. Allow sensible graph-reading tolerance and consistent follow-through.

17. (pupil p6) Corrected rate halves from 80 to 40 counts/s between 2.0 h and 4.0 h. Half-life = $4.0 - 2.0 = 2.0$ h = 120 min.

18. (pupil p6) Initial source contribution = $180 - 20 = 160$ counts/s. Half is 80 counts/s. The background stays at 20 counts/s, so the measured target is $80 + 20 = 100$ counts/s. Halving the full measured rate incorrectly halves the background too.

One assigned tier route, then review

Match the pupil number. Accept equivalent correct wording. Keep this guide separate from pupils.

19. (pupil p7) Two half-lives: $320 \rightarrow 160 \rightarrow 80$ counts/s.

20. (pupil p7) $320 \rightarrow 160 \rightarrow 80 \rightarrow 40 \rightarrow 20$ requires four half-lives. Earliest time = $4 \times 3.0 = 12$ min. At 9 min the expected rate is still 40 counts/s.

21. (pupil p8) $320 \rightarrow 160 \rightarrow 80 \rightarrow 40$ counts/s. Remaining : initial = $40 : 320 = 1 : 8$.

22. (pupil p8) Decrease = $320 - 40 = 280$ counts/s. Decrease : initial = $280 : 320 = 7 : 8$. Alternatively initial 8 units, remaining 1 unit, decrease 7 units. $1 : 8$ describes what remains, not the decrease.

23. (pupil p9) Accept a corrected answer with a valid reason, not a copied final value. All-correct route: only the sample contribution halves; subtract background, halve that corrected value, then add the unchanged background to recover a measured target. Higher pupils should also explain any remaining/decrease ratio error.

Shared exit and follow-up - pupil page 9

Match the pupil number. Accept equivalent correct wording. Keep this guide separate from pupils.

24. (pupil p9) (a) $170 - 10 = 160$ counts/s; $50 - 10 = 40$ counts/s. (b) $160 \rightarrow 80 \rightarrow 40$ is two half-lives in 4.0 min, so half-life = $4.0 / 2 = 2.0$ min. (c) No. Individual decay is random; half-life describes a statistical sample trend.

Try again D - next lesson - pupil page 9

Leave this today. Your usual teacher may ask you to do it next lesson.

Corrected rates: 192 and 48 counts/s. $192 \rightarrow 96 \rightarrow 48$ is two half-lives in 12 min, so half-life = 6 min. It cannot predict an individual decay time because decay is random.

Collect and follow up

Collect all named booklets with the assigned tier ticked. One tier page should be blank. Record shared half-life, correction and randomness evidence from question 24; use Higher questions 21-22 separately for ratio evidence. Tell the usual teacher the precise error and who needs Try again D.

Source provenance - for the usual teacher

Pupil question	Original worksheet part / page
5	WS-07 Q1(a) / source p1
6	WS-07 Q1(b) / source p1
7	WS-07 Q2(a) / source p1
8	WS-07 Q2(c) / source p2
9	WS-07 Q2(e) / source p2
10	WS-07 Q2(f) / source p2
11	WS-07 Q2(g) / source p2
12	WS-07 Q2(h) / source p3
14	WS-07 Q3(a) / source p3
15	WS-07 Q3(b) / source p3
16	WS-07 Q3(c) / source p4
17	WS-07 Q3(d) / source p4
18	WS-07 Q3(e) / source p4
19	WS-07 Q5(a) / source p6
20	WS-07 Q5(b) / source p6
21	WS-07 Q6(a) / source p7
22	WS-07 Q6(b) / source p7

Selected practice is reformatted from the maintained PhysicsUK worksheet. Required context is included; unassigned parts are omitted.

Source worksheet | Maintained solutions | Revision notes

Shared reading/models use note sections 1-3. Higher page 8 uses section 5 and its 400-to-100 worked example, here expressed as a corrected detector rate. Note section 4, source Q4/Q7 and unassigned parts are omitted. Foundation Q5(a,b) and Higher Q6(a,b) are replacements, not cumulative tasks.

Check 1: Entry

Question 1, Question 2, Question 3

Look for: Question 1: 48 counts/s; question 2: 50 counts/s; question 3 rejects an exact individual deadline because decay is random.

If secure: Continue to reading and models on pupil page 2.

If: Does not halve 96, or adds background to 62 instead of subtracting it.

Likely issue: The relevant source contribution or arithmetic step is insecure.

Say: Background adds detector events unrelated to this sample. Subtract it to isolate the sample contribution; a half-life then halves that corrected contribution.

Ask: For questions 1-2, what are 96 divided by 2 and 62 minus 12?

Expect: 48 counts/s and 50 counts/s. Keep detector rate units.

Next: Use the quantity table and methods on page 2. Direct Try again A on page 1 in the first 2 reading minutes.

Pupil page 2, corrected rate and halving; Try again A on page 1.

If: Agrees that every individual nucleus must decay after exactly one half-life.

Likely issue: A sample trend is being treated as an individual timetable.

Say: We cannot predict the exact decay time of one nucleus. Half-life describes the expected halving of a large population, not a deadline for each member.

Ask: In question 3, can knowing the sample half-life identify which nucleus decays next?

Expect: No. Individual decays are random, even though the large sample follows a statistical trend.

Next: Use page 2, the opening paragraph. Direct Try again A during reading time and check the reason as well as the numbers.

Pupil page 2, random individual decay; Try again A on page 1.

If the retry remains insecure, use the support guidance on teacher page 1 and record the precise difficulty for the usual teacher.

Check 2: Hinge

Question 4

Look for: C, with $110 - 10 = 100$, then 50, then $50 + 10 = 60$ counts/s. A letter alone is insufficient.

If secure: Start questions 5-12 and require quantities and units in working.

If: A halves the entire measured 110 counts/s to get 55.

Likely issue: The unchanged background has incorrectly been halved.

Say: Only the sample contribution halves. The constant background stays at 10 counts/s, so remove it before halving and add it back for a measured target.

Ask: In question 4, which part of 110 comes from the sample, and what remains of that part after one half-life?

Expect: 100 counts/s comes from the sample and halves to 50; adding background gives 60 counts/s.

Next: Use the three-step method on page 2. Complete Try again B on page 3 instead of questions 5-6.

Pupil page 2, Measured or corrected?; Try again B on page 3.

If: B reports the corrected 50 counts/s as the measured target.

Likely issue: The pupil has not restored background to the detector reading.

Say: Fifty is the corrected sample contribution. A detector still counts the unchanged background as well, so the measured target is larger.

Ask: In question 4, what does the detector record in addition to the sample's 50 counts/s?

Expect: The background 10 counts/s, making measured rate 60 counts/s.

Next: Use page 2, the last step of the measured-target method. Complete Try again B instead of questions 5-6.

Pupil page 2, Measured or corrected?; Try again B on page 3.

If: D stops at 100, or C is chosen without all three steps.

Likely issue: The halving step is missing or the correct letter may be a guess.

Say: Name each step: initial sample contribution, halved sample contribution, final detector reading. A corrected starting value alone is not the final measured result.

Ask: Show all three numbers for question 4 and explain what each describes.

Expect: 100 counts/s initially from the sample, 50 after halving, and 60 including background.

Next: Ask for the three named quantities. If insecure, use the page 2 method and Try again B instead of questions 5-6.

Pupil page 2, three-step measured-target method; Try again B on page 3.

If the retry remains insecure, use the support guidance on teacher page 1 and record the precise difficulty for the usual teacher.

Check 3: Mid Practice

Question 13

Look for: Question 13: corrected rates 100, 50, 25 counts/s; two successive halving intervals each last 3 min.

If secure: Continue questions 14-18, then one assigned tier page at about 41 minutes.

If: Uses raw rates 110, 60 and 35 directly for halving, or subtracts background only once.

Likely issue: Each measured reading needs its own correction.

Say: Every measured reading includes the same supplied background. Subtract it separately from every reading before comparing the sample.

Ask: For question 13, what are $110 - 10$, $60 - 10$ and $35 - 10$?

Expect: 100, 50 and 25 counts/s. Those corrected values show the halving pattern.

Next: Use page 2, corrected-rate definition. Complete Try again C on page 5 instead of questions 14-15, then continue 16-18.

Pupil page 2, Measured or corrected?; Try again C on page 5.

If: Gives 6 min, a final graph time, or a count-rate value as half-life.

Likely issue: Half-life is an elapsed halving interval, not the end time or height.

Say: One half-life is the interval for a single halving. A fourfold fall contains two halvings. Subtract the paired times or divide the total interval by two.

Ask: In question 13, between which times does corrected rate go from 100 to 50, then 50 to 25?

Expect: 0-3 min and 3-6 min. Each lasts 3 min; half-life is 3 min.

Next: Use page 2, Count halvings, then use elapsed time. Complete Try again C instead of questions 14-15.

Pupil page 2, elapsed-time method; Try again C on page 5.

If the retry remains insecure, use the support guidance on teacher page 1 and record the precise difficulty for the usual teacher.

Check 4: Exit

Question 24

Look for: Question 24: corrected rates 160 and 40 counts/s; two half-lives in 4.0 min gives 2.0 min; individual decay remains unpredictable. For Higher ratio evidence, also inspect questions 21-22; the exit checks shared objectives.

If secure: Record independently secure shared skills and the exact remaining difficulty. Report assigned tier practice separately.

If: Incorrect corrected rates, only one halving, or 4 min given as half-life.

Likely issue: Background correction or counting halving intervals needs follow-up.

Say: Correct both readings first. Then count the halving steps between them before sharing the total elapsed time equally between those steps.

Ask: In question 24, what are the corrected values and how many halvings connect them?

Expect: 160 and 40 counts/s; $160 \rightarrow 80 \rightarrow 40$ is two halvings, so $4.0 / 2 = 2.0$ min.

Next: Next lesson, revisit page 2, then direct Try again D independently on page 9.

Pupil page 2, correction and elapsed-time methods; Try again D on page 9, next lesson.

If: Claims the calculated half-life predicts one nucleus's exact decay time.

Likely issue: Random individual decay and a sample trend are still confused.

Say: A statistical population trend does not tell us when a particular nucleus will decay. The corrected sample rate can halve while individual events remain unpredictable.

Ask: Does the 2.0 min half-life in question 24 identify the next nucleus to decay? Explain.

Expect: No. Decay of an individual nucleus is random; 2.0 min describes the sample trend.

Next: Next lesson, use the opening explanation on page 2 before Try again D. Keep this outside today's 60 minutes.

Pupil page 2, random individual decay; Try again D on page 9, next lesson.

If the retry remains insecure, use the support guidance on teacher page 1 and record the precise difficulty for the usual teacher.

Specification and review

AQA 8463: 4.4.2.3 | AQA 8464: 6.4.2.3. Both courses: shared half-life/graph work, random individual decay and supplied-background correction. Foundation uses pupil page 7; Higher uses page 8 instead for remaining/decrease ratios. One tier page only. No hazard comparison, background-origin recall or practical completion is assigned.

PhysicsUK original cover lesson. Reviewed 2026-10-31. Timings estimated.