OCR
Oxford Cambridge and RSA

# GCE

# Physics B

## H557/03: Practical skills in physics

A Level

# Mark Scheme for June 2022

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This mark scheme is published as an aid to teachers and students, to indicate the requirements of the examination. It shows the basis on which marks were awarded by examiners. It does not indicate the details of the discussions which took place at an examiners' meeting before marking commenced.

All examiners are instructed that alternative correct answers and unexpected approaches in candidates' scripts must be given marks that fairly reflect the relevant knowledge and skills demonstrated.

Mark schemes should be read in conjunction with the published question papers and the report on the examination.

# MARKING INSTRUCTIONS

## PREPARATION FOR MARKING

1. Make sure that you have accessed and completed the relevant training packages for on-screen marking: *RM Assessor Online Training*; *OCR Essential Guide to Marking*.
2. Make sure that you have read and understood the mark scheme and the question paper for this unit. These are available in RM Assessor.
3. Log-in to RM Assessor the **required number** of standardisation responses.

## MARKING

1. Mark strictly to the mark scheme.
2. Marks awarded must relate directly to the marking criteria.
3. The schedule of dates is very important. It is essential that you meet the RM Assessor 50% and 100% (traditional 50% Batch 1 and 100% Batch 2) deadlines. If you experience problems, you must contact your Team Leader (Supervisor) without delay.
4. If you are in any doubt about applying the mark scheme, consult your Team Leader by telephone, email or via the RM Assessor messaging system.
5. **Crossed Out Responses**
   Where a candidate has crossed out a response and provided a clear alternative then the crossed out response is not marked. Where no alternative response has been provided, examiners may give candidates the benefit of the doubt and mark the crossed out response where legible.

**Rubric Error Responses – Optional Questions**
Where candidates have a choice of question across a whole paper or a whole section and have provided more answers than required, then all responses are marked and the highest mark allowable within the rubric is given. Enter a mark for each question answered into RM assessor, which will select the highest mark from those awarded. *(The underlying assumption is that the candidate has penalised themselves by attempting more questions than necessary in the time allowed.)*

**Multiple Choice Question Responses**
When a multiple choice question has only a single, correct response and a candidate provides two responses (even if one of these responses is correct), then no mark should be awarded (as it is not possible to determine which was the first response selected by the candidate).
*When a question requires candidates to select more than one option/multiple options, then local marking arrangements need to ensure consistency of approach.*

**Contradictory Responses**
When a candidate provides contradictory responses, then no mark should be awarded, even if one of the answers is correct.

**Short Answer Questions** (requiring only a list by way of a response, usually worth only **one mark per response**)
Where candidates are required to provide a set number of short answer responses then only the set number of responses should be marked. The response space should be marked from left to right on each line and then line by line until the required number of responses have been considered. The remaining responses should not then be marked. Examiners will have to apply judgement as to whether a 'second response' on a line is a development of the 'first response', rather than a separate, discrete response. *(The underlying assumption is that the candidate is attempting to hedge their bets and therefore getting undue benefit rather than engaging with the question and giving the most relevant/correct responses.)*

**Short Answer Questions** (requiring a more developed response, worth **two or more marks**)
If the candidates are required to provide a description of, say, three items or factors and four items or factors are provided, then mark on similar basis – that is downwards (as it is unlikely in this situation that a candidate will provide more than one response in each section of the response space.)

**Longer Answer Questions** (requiring a developed response)
Where candidates have provided two (or more) responses to a medium or high tariff question which only required a single (developed) response and not crossed out the first response, then only the first response should be marked. Examiners will need to apply professional judgement as to whether the second (or a subsequent) response is a 'new start' or simply a poorly expressed continuation of the first response.

6. Always check the pages (and additional objects if present) at the end of the response in case any answers have been continued there. If the candidate has continued an answer there then add a tick to confirm that the work has been seen.

7. Award No Response (NR) if:
   - there is nothing written in the answer space.

   Award Zero '0' if:
   - anything is written in the answer space and is not worthy of credit (this includes text and symbols).

   Team Leaders must confirm the correct use of the NR button with their markers before live marking commences and should check this when reviewing scripts.

8. The RM Assessor **comments box** is used by your Team Leader to explain the marking of the practice responses. Please refer to these comments when checking your practice responses. **Do not use the comments box for any other reason.**

   If you have any questions or comments for your Team Leader, use the phone, the RM Assessor messaging system, or email.

9. Assistant Examiners will send a brief report on the performance of candidates to their Team Leader (Supervisor) via email by the end of the marking period. The report should contain notes on particular strengths displayed as well as common errors or weaknesses. Constructive criticism of the question paper/mark scheme is also appreciated

10. **Level of response (LoR)**

    Read through the whole answer from start to finish, concentrating on features that make it a stronger or weaker answer using the indicative scientific content as guidance. The indicative scientific content indicates the expected parameters for candidates' answers, but be prepared to recognise and credit unexpected approaches where they show relevance.

    Using a 'best-fit' approach based on the science content of the answer, first decide which set of level descriptors, Level 1 (L1), Level 2 (L2) or Level 3 (L3), **best** describes the overall quality of the answer using the guidelines described in the level descriptors in the mark scheme.

    Once the level is located, award the higher or lower mark.
    **The higher mark** should be awarded where the level descriptor has been evidenced and all aspects of the communication statement (in italics) have been met. **The lower mark** should be awarded where the level descriptor has been evidenced but aspects of the communication statement (in italics) are missing.

In summary:
- the **science** content determines the **level**
- the **communication statement** determines the **mark within a level**.

11. **Annotations**

| Annotation | Meaning |
|---|---|
| **DO NOT ALLOW** | Answers which are not worthy of credit |
| **IGNORE** | Statements which are irrelevant |
| **ALLOW** | Answers that can be accepted |
| ( ) | Words which are not essential to gain credit |
| __ | Underlined words must be present in answer to score a mark |
| **ECF** | Error carried forward |
| **AW** | Alternative wording |
| **ORA** | Or reverse argument |

Annotations available in RM Assessor

| Annotation | Meaning |
|---|---|
| BOD | Benefit of doubt given |
| CON | Contradiction |
|  | Incorrect response |
| ECF | Error carried forward |
| NBOD | Benefit of doubt not given |
| POT | Power of 10 error |
| ^ | Omission mark |
| RE | Rounding error |
| SF | Error in number of significant figures |
|  | Correct response |
|  | Wrong physics or equation |

**Note about significant figures:**

If the data given in a question is to 2 sf, then allow to 2 or more significant figures.
If an answer is given to fewer than 2 sf, then penalise once only in the entire paper.
If the answer on the answer line is given to more than 2sf, award the mark if their answer rounds to 2sf correctly to the answer given in the markscheme.
Any exception to this rule will be mentioned in the Additional Guidance.

Always mark the answer given on the answer line (if there is one).

**Section A**

| Question | | | Answer | Mark | Guidance |
|---|---|---|---|---|---|
| 1 | (a) | | Oscillations (in a polarised wave) are only in one plane<br><br>transverse waves can be polarised (and EM waves are tranverse) | 2 | NOT oscillations are in one direction.<br>NOT travel in one plane.<br>ALLOW the electric / magnetic field is in the same plane.<br><br>ALLOW a correct description of a transverse wave. |
| 1 | (b) | | Rotate filter /polaroid<br>Polarised light will show (gradual) change in the intensity/brightness of light (whilst the filter is rotated)<br><br>Angle between max and min intensity of polarised light will be equal to 90º | 3 | ALLOW description of non-polarised light (no change in intensity)<br>DO NOT ALLOW 2nd marking point if there is a statement that intensity is abruptly changing.<br><br>ALLOW filter parallel to oscillating plane will be max intensity and filter perpendicular to plane will be min intensity,<br><br>IGNORE reference to two polarising filters |
| 1 | (c) | (i) | Use a protractor<br>Measure angle between base of grille and table OR measure angle between direction of bars and a vertical plumbline OR mark lines at varying angles on a piece of paper behind the grille | 2 | ALLOW trigonometric method eg.<br>Measure appropriate distances in order to calculate angle by trig [1], detail of actual calc [1]<br>ALLOW clinometer [1], attached to edge of grille [1]. |
| 1 | (c) | (ii) | Attempt to calculate $V \div \cos^2\theta$ or equivalent using a set of coordinates from a point on a graph.<br>Repeat twice more correctly (with different values of voltage) OR substitute constant of proportionality to check 2 other points.<br>Conclusion drawn from at least 2 calculations. | 3 | Example (60,0.8), (100,0.1), (125, 1.1)<br>$V \div \cos^2\theta$ for each pair; 3.2, 3.3 and 3.3<br>If only 2 valid sets of data used, then max 2 marks (first and third marking points).<br><br>ALLOW ecf for conclusion mark as long as there is an attempt to calculate constant of proportionality. |
| | | | **Total** | **10** | |

| Question | | | Answer | Mark | Guidance |
|---|---|---|---|---|---|
| 2 | (a) | (i) | Temperature (of the gas) ✓ | 1 | |
| 2 | (a) | (ii) | outlier identified (can be implied); area = 79<br><br>Calculate mean correctly (= 87.1 $mm^2$)<br><br>Calculation of spread or uncertainty<br>= ± ½ × range = 3.5 or 4<br>= max – mean = 3.9<br>= mean – min = 3.1<br><br>Calculate percentage uncertainty = (uncertainty value ÷ mean) × 100%<br>AND final answer given to 2sf and uncertainty to 1 sf (eg 87 $mm^2$ ± 4% or 5%) | 4 | If the outlier in included in the calculation of mean the value is 86.5 [1].<br>If more than one outlier is identified (eg 79, 90, 91, 91), mean = 86.1 [1]<br><br>NO ecf for wrongly identified outliers in uncertainty calculation.<br><br>Sig fig mark can be awarded with ecf.<br><br>If mean – min has been used then percent uncert = 3% |
| 2 | (a) | (iii) | Absolute uncertainty between ± 2mm and ± 5 mm.<br>due to parallax / measuring to/through curved surfaces / meniscus. | 2 | |
| 2 | (b) | | 1/absolute pressure = $2.8\times10^{-6}$<br><br>Units $Pa^{-1}$ (must be consistent with POT of answer) | 2 | IGNORE POT for first marking point.<br><br>Accept $m^2\,N^{-1}$<br>ALLOW 0.0028 $kPa^{-1}$ |

| Question | | | Answer | Mark | Guidance |
|---|---|---|---|---|---|
| 2 | (c) | | **Level 3 (5-6 marks)**<br>Several improvements to presentation.<br>Correct calculation of *n* starting from ideal gas equation.<br><br>*There is a well-developed line of reasoning which is clear and logically structured. The information presented is clear, relevant and substantiated.*<br><br>**Level 2 (3-4 marks)**<br>Some improvements explained.<br>Attempt at finding n using the ideal gas equation and the gradient of the line.<br><br>*There is a line of reasoning presented with some structure. The information presented is in the most-part relevant and supported by some evidence.*<br><br>**Level 1 (1-2 marks)**<br>Limited improvements stated OR evidence of use of ideal gas equation<br><br>*There is a line of reasoning presented with some structure. The information presented in the most part relevant and supported by some evidence.*<br><br>**0 marks**<br>*No response or no response worthy of credit.* | 6 | **Indicative scientific points may include:**<br>Presentation:<br>• x-axis scale should go up in a more appropriate scale, not 0.3 to 1 cm.<br>• y-axis scale should be larger to make the plotted points cover over half of the grid.<br>• Plotted points should be drawn more precisely eg. crosses not blobs.<br>• Drawn line of best fit is too steep AW.<br>• Third data point is an anomalous plot.<br>• Add error bars to plotted points<br>• Include units on y-axis<br><br>Analysis:<br>• Stating gas law equation $PV = nRT$<br>• Rearrangement to $\frac{1}{P} = \frac{V}{nRT}$<br>• $Volume = Ah$<br>• Gradient of line is $\frac{A}{nRT}$<br>• Rearranged to give $nRt = A \div gradient$ or $n = A \div RTgradient.$<br>• Calculation of $n = 1.4\times10^{-3}$ moles.<br>• ALLOW ecf of candidate's value of A from (a)(ii)<br><br>Assumptions:<br>• Gas is monatomic<br>• Ideal gas<br>• No interactions between particles<br>• particles have negligible volume<br>• particles make perfectly elastic collisions<br>• Time taken for collisions is negligible. |
| | | | **Total** | **15** | |

| Question | | | Answer | Mark | Guidance |
|---|---|---|---|---|---|
| 3 | (a) | | Negative because *N* is decreasing.<br>*λ* is the probability of a nucleus decaying per unit time OR proportion of nuclei decaying per unit time. | 2 | ALLOW probability of a nucleus decaying per second. |
| 3 | (b) | (i) | Third row: 720, 1080<br>Fourth row: 1080, 432, 648<br>Fifth row: 648, 259, 389 | 2 | No marks allocated for just completing third row.<br><br>ALLOW 259.2 and 388.8 |
| 3 | (b) | (ii) | Any 2 points plotted correctly<br>Third point plotted correctly | 2 | Points are (3, 1080), (4, 648), (5, 389)<br>To within half a small square.<br>Allow ecf from 3 (b) (i)<br>IGNORE lines drawn |
| 3 | (b) | (iii) | Either:<br>Activity is the gradient (of the sections) of the graph.<br>Or:<br>Activity is (assumed to be) constant during each time interval. | 1 | NOT tangent to a curve |
| 3 | (b) | (iv) | ANY two from:<br>Smoother curve produced<br>nearer to continuously changing rate of decay/activity ORA<br>More realistic<br>closer to exponential | 2 | ALLOW twice as many points plotted in the same time.<br><br>NOT ‘better’, NOT more accurate, NOT less uncertain |
| 3 | (c) | (i) | ANY 2 from:<br>10 seconds will give large enough / measurable count (because sample sufficiently active)<br>10 seconds is long enough to smooth the effects of randomness<br>Short time to reduce exposure to radiation<br>Reasonable effect in a few minutes as sample has short enough half-life | 2 | |

| Question | | | Answer | Mark | Guidance |
|---|---|---|---|---|---|
| 3 | (c) | (ii) | Coordinates of two data points at least half the length of the line apart used in a correct method to find gradient.<br><br>Calculation of gradient.<br><br>Decay constant = - gradient value.<br><br>Calculation of half-life = ln2 ÷ $\lambda$ | 4 | You need to see the calculation, or this may be shown on the graph.<br>$\Delta x \geq 75s$ in gradient calculation.<br>NOT $\frac{\Delta x}{\Delta y}$.<br><br>Gradient should be −0.0096.<br>[acceptable range $-0.0097 \geq m \geq -0.0095$]<br>*Any misreading of plots should get penalised here.*<br><br>Half-life should be approx 72s.<br>[acceptable range $71 \geq T_{½} \geq 73$]<br>A raw value of 72 s will get 3 marks, but you need to see evidence of the gradient triangle for the 4th mark. |
| | | | **Total** | **15** | |
| | | | **Total Section A** | **40** | |

## Section B

| Question | | | Answer | Mark | Guidance |
|---|---|---|---|---|---|
| 4 | (a) | (i) | Basic description of experimental technique<br><br>(Greatest) source of uncertainty: Measurement of extension OR alignment of zero extension<br><br>Method to minimise uncertainty<br>any one from the list<br>• Repeat readings taken<br>• Set square (against table) used to ensure ruler perpendicular or plumbline.<br>• Pointer used to help eliminate parallax error/other suitable suggestion to eliminate parallax error.<br><br>Risk – one from<br>• Safety glasses should be worn.<br>• Do not exceed breaking force of band.<br>• Keep body away from drop zone.<br>• Clamp or weigh down retort stand so it doesn't topple AW | 4 | eg. suspend rubber band from clamp stand, add masses and measure length/extension with ruler for different loads.<br><br>IGNORE reference to precision of ruler<br><br>NOT just view at eye level |

| Question | | | Answer | Mark | Guidance |
|---|---|---|---|---|---|
| 4 | (a) | (ii) | **Level 3 (5-6 marks)**<br>Clear description of the behaviour shown in the graph. At least 2 sections of the graph should be clearly explained with understanding of the microstructure using correct terminology.<br><br>*There is a well-developed line of reasoning which is clear and logically structured. The information presented is clear relevant and substantiated.*<br><br>**Level 2 (3-4 marks)**<br>Clear description of the behaviour shown in the graph relating to stiffness / $\Delta F/\Delta x$ of rubber.<br>AND/OR correct description the microstructure of rubber and how it behaves when loaded.<br>Some use of correct terminology.<br><br>*There is a line of reasoning presented with some structure. The information presented is in the most-part relevant and supported by some evidence.*<br><br>**Level 1 (1-2 marks)**<br>Basic description of the behaviour shown in the graph.<br>AND/OR basic description of the microstructure of rubber. Limited or incorrect terminology used.<br><br>*There is a line of reasoning presented with some structure. The information presented in the most part relevant and supported by some evidence.*<br><br>**0 marks**<br>*No response or no response worthy of credit.* | 6 | **Indicative scientific points may include:**<br><br>Data:<br>• extension increases as force increases<br>• non-linear relationship<br>• $\Delta F/\Delta x$ higher at first, then lower, then higher again AW.<br>• gradient of **graph relates to stiffness** of material<br>• starts off fairly stiff / large force for small extension.<br>• then stiffness reduces / larger extension for small force<br>• before stiffness increases again / more force for small extension AW<br><br>Microstructure of rubber.<br>• Rubber is a polymer<br>• Polymers identified as long-chain molecules<br>• Polymers in rubber arranged randomly<br>• (Sulphur) cross-links used to stiffen rubber.<br>• Could be shown on a labelled diagram.<br><br>Linking microstructure to graph:<br>• Polymer chains are initially tangled up.<br>• As force applied untangle the chains and break cross links, this requires high F for small x.<br>• Once untangled chains are simply straightening out hence greater x for F, and can slide over one another.<br>• In final section large F needed for small x, stretch (C-C) bonds within chains.<br>• Could be shown as labels/diagrams relating to graph.<br><br>**Elastic NOT plastic deformation**<br>**Relating to stiffness NOT strength or failure**<br>**IGNORE reference to unloading** |

<table>
<tr><th colspan="3">Question</th><th>Answer</th><th>Mark</th><th>Guidance</th></tr>
<tr><td>4</td><td>(b)</td><td>(i)</td><td>Steepest line from (0.0035, 40) to (0.0005, 0)<br>OR<br>Shallowest line from (0.0045, 40) to (−0.0005, 0)</td><td>1</td><td>ALLOW Steepest line from (0.0035, 40) to (0.0009, 4)<br>ALLOW Shallowest line from (0.0045, 40) to (−0.0001, 4)<br>Tolerance ±half a small square.<br>Line can extend to edges of grid.<br>Line should not be too thick or hairy and should be straight (by eye).</td></tr>
<tr><td>4</td><td>(b)</td><td>(ii)</td><td>$E = (gradient \times l) \div A$ AND $A = \frac{\pi d^2}{4}$<br><br>$E$ = (10100 × 4) ÷ 1.96×10$^{-7}$ = 2.1×10$^{11}$ Pa = 210 GPa<br><br>Calculation of uncertainty<br>EITHER<br>find gradient of line drawn in part (i)<br>find % difference between this value and 10100,<br>use this % to find absolute uncertainty of E value.<br>OR<br>find gradient of line drawn in part (i)<br>Calculation of E value new gradient.<br>Hence find absolute uncertainty in E value.</td><td>3</td><td>ALLOW rounding $A$ to 2sf (2.0×10$^{-7}$ m$^2$) to give $E$ = 200 GPa<br><br><table><tr><td>Max gradient</td><td>13333 Nm$^{-1}$</td><td>13846 Nm$^{-1}$</td></tr><tr><td>% diff</td><td>32.0%</td><td>37.1%</td></tr><tr><td>Max E</td><td>272 GPa</td><td>284 GPa</td></tr><tr><td>uncertainty</td><td>66 or 67 GPa</td><td>77 or 78 GPa</td></tr><tr><td colspan="2">Accept range of uncert</td><td>60 GPa to 80 GPa</td></tr></table><br><table><tr><td>Min gradient</td><td>8000 Nm$^{-1}$</td><td>7826 Nm$^{-1}$</td></tr><tr><td>% diff</td><td>20.8%</td><td>22.5%</td></tr><tr><td>Min E</td><td>163 GPa</td><td>160 GPa</td></tr><tr><td>uncertainty</td><td>43 or 44 GPa</td><td>46 or 47 GPa</td></tr><tr><td colspan="2">Accept range of uncert</td><td>40 GPa to 50 GPa</td></tr></table><br>ALLOW ecf from candidate’s line in part (i) with working shown.<br>ALLOW answers given to more than the appropriate number of sf, as long as they round to the values shown.</td></tr>
<tr><td>4</td><td>(c)</td><td>(i)</td><td>0.01 mm OR 10 μm OR 1×10$^{-5}$ m<br>(from 0.5 mm/50)</td><td>1</td><td></td></tr>
</table>

| Question | | | Answer | Mark | Guidance |
|---|---|---|---|---|---|
| 4 | (c) | (ii) | (take multiple measurements) along the length / in different places / in different planes AND find the mean<br><br>(uncertainty is) ± half range or spread | 2 | <br><br><br><br>ALLOW find the largest difference between the mean and a reading.<br>ALLOW if half the range is smaller than the precision, then the uncertainty is ± precision of the instrument. |
| 4 | (c) | (iii) | Area = $\frac{\pi d^2}{4}$ = 9.6 × $10^{-8}$ $m^2$<br><br>EITHER<br>%uncert in d = (0.02/0.35) = 5.7%, so so %uncert in A = 11.4%<br>absolute uncert = ± 1.1 × $10^{-8}$ $m^2$ (± 1.0 x $10^{-8}$ $m^2$)<br><br>OR<br>EITHER max area = 1.08 × $10^{-7}$ $m^2$ OR min area = 8.55 × $10^{-8}$ $m^2$<br>Uncertainty = (max – mean) OR (mean – min) OR ½(max – min) = ± 1.1 × $10^{-8}$ $m^2$ (± 1.0 x $10^{-8}$ $m^2$) | 3 | <br><br>ALLOW ecf for uncertainty in their value of area.<br><br><br>ALLOW uncertainty values given to more than 1 sf. |
| | | | **Total** | **20** | |
| | | | **Total Section B** | **20** | |

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