GCE

Physics B

H557/01: Fundamentals of physics

A Level

Mark Scheme for June 2024

OCR (Oxford Cambridge and RSA) is a leading UK awarding body, providing a wide range of qualifications to meet the needs of candidates of all ages and abilities. OCR qualifications include AS/A Levels, Diplomas, GCSEs, Cambridge Nationals, Cambridge Technicals, Functional Skills, Key Skills, Entry Level qualifications, NVQs and vocational qualifications in areas such as IT, business, languages, teaching/training, administration and secretarial skills.

It is also responsible for developing new specifications to meet national requirements and the needs of students and teachers. OCR is a not-for-profit organisation; any surplus made is invested back into the establishment to help towards the development of qualifications and support, which keep pace with the changing needs of today's society.

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
RM ASSESSOR

1. Make sure that you have accessed and completed the relevant training packages for on-screen marking: *RM Assessor 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 posted on the RM Cambridge Assessment Support Portal http://www.rm.com/support/ca

3. Log-in to RM Assessor and mark the **required number** of practice responses ("scripts") and the **number of required** standardisation responses.

   YOU MUST MARK 10 PRACTICE AND 10 STANDARDISATION RESPONSES BEFORE YOU CAN BE APPROVED TO MARK LIVE SCRIPTS.

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 40% 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 or the RM Assessor messaging system, or by email.

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 a 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 e-mail.

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. For answers marked by levels of response:
    a. **To determine the level** – start at the highest level and work down until you reach the level that matches the answer
    b. **To determine the mark within the level**, consider the following

Descriptor	Award mark
On the borderline of this level and the one below	At bottom of level
Just enough achievement on balance for this level	Above bottom and either below middle or at middle of level (depending on number of marks available)
Meets the criteria but with some slight inconsistency	Above middle and either below top of level or at middle of level (depending on number of marks available)
Consistently meets the criteria for this level	At top of 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
DO NOT ALLOW	Answers which are not worthy of credit

12. **Subject Specific Marking Instructions**

INTRODUCTION

Your first task as an Examiner is to become thoroughly familiar with the material on which the examination depends. This material includes:

- the specification, especially the assessment objectives
- the question paper
- the mark scheme.

You should ensure that you have copies of these materials.

You should ensure also that you are familiar with the administrative procedures related to the marking process.

Please ask for help or guidance whenever you need it. Your first point of contact is your Team Leader.

Significant figure penalties

Significant figure penalties will be shown on the markscheme. There is a maximum of one significant figure penalty on each paper. Not all papers will include such penalties – this depends on the particular questions given in the paper. The question that attracts a significant figure penalty (if one does so) will be decided by the examiners at the standardisation meeting. You must not penalize such errors unless clearly stated in the markscheme.

Annotation on scripts

Each markworthy point should be registered with a tick – the total number of ticks on the paper should equal the number of marks awarded for non-LOR questions. Mark errors in physics with a cross and omissions with a carat. Centres and candidates who request scripts back find such annotations extremely useful.
LOR questions do NOT have ticks on the papers. These questions should only be annotated with L1, L2, L3.

Question			Answer	Marks	Guidance
1			D	1	
2			B	1	
3			D	1	
4			B	1	
5			D	1	
6			A	1	
7			C	1	
8			B	1	
9			C	1	
10			A	1	
11			B	1	
12			C	1	
13			B	1	
14			D	1	
15			B	1	
16			A	1	
17			A	1	
18			B	1	
19			B	1	
20			D	1	
21			C	1	
22			C	1	
23			C	1	
24			D	1	
25			A	1	
26			A	1	
27			A	1	
28			B	1	
29			B	1	
30			C	1	
			Total	30	

Question			Answer	Mark	Guidance
31	(a)		The changing current (in the primary coil) produces a (continually) changing magnetic field/flux (1) Any **two** from • Magnetic field / flux links the secondary coil through the iron core • The (changing) magnetic field / flux in the secondary coil induces an emf (in the secondary coil) • The induced emf then causes an alternating current in the secondary coil (2)	**3**	Must have the concept of alternating / changing flux/field **Not** moving magnetic field **Not** p.d. or voltage **Accept** causes
31	(b)		(I_S = 50/800 = 0.063 A) (I_P = 0.0625 x 50/20 = 0.16A) 0.16 (A) (1) 0.063 (A) (1)	**2**	**Allow** any number of SF
			Total	**5**	

Question				Answer	Mark	Guidance
32	(a)			Table values: 1mV, 0mV, 1mV **AND** binary 001, 000, 001 (1) Three plotted points at (4,1) (5,0) and (6,1) mV (1)	**2**	**Not** just 1,0,1 for binary values **No** ecf from table values Ignore attempts at drawing reconstructed signal
32	(b)			The sampling rate is lower than twice the maximum frequency in the signal (1) Not enough (quantisation) levels / (quantisation) levels too far apart / resolution of levels insufficient AW (1)	**2**	**Accept** need at least 2 samples per cycle
				Total	**4**	

Question			Answer	Mark	Guidance
33	(a)		a = 8.9(2) (m s^{-2}) (1)	**1**	Bald correct answer gains mark
33	(b)		Equation of line is $t^2 = 2s/a$ (1) a =2 /gradient of graph (1)	**2**	**Allow** g for acceleration a **Allow** gradient of graph = $2/a$ from $s=ut+1/2\ at^2$ **Allow** gradient of graph is t^2/s **Allow** description of process for full credit Must have in the form a =

Question			Answer	Mark	Guidance
			Total	**3**	

Question			Answer	Mark	Guidance
34	**(a)**		The frequency of signal 1 is half that of signal 2 **OR** the frequency of signal 1 is (about) 10 Hz and the frequency of signal 2 is (about) 20 Hz. (1) The peak amplitude / potential difference for signal 1 is three times that for signal 2 **OR** The peak amplitude / pd for signal 1 is 0.6 V and the peak pd for signal 2 is 0.2 V (1)	**2**	**ORA** **ORA**
34	**(b)**		Amplitude of two squares **AND** same period (1) Peak at approx 1.5 squares out of phase (1)	**2**	Must be the shape of sine graph by eye and show at least ¾ of the trace **Allow** leading or lagging
			Total	**4**	

Question			Answer	Mark	Guidance
35	(a)		For one molecule E = -ln(1.64 x 10^{-23}) x 1.38 x 10^{-23} x 1000 (1) = 7.24 x 10^{-19} (J) (1) For one mole E = (7.24 x 10^{-19} x 6.02 x 10^{23}) = 4.36 x 10^{5} (J) (1)	3	**Allow** E = -ln(1.64 x 10^{-23}) x 8.314 x 1000 for one mark leading to full credit for correct evaluation of E
35	(b)		One point from: • molecules making many collisions per second • high (enough) molecule density (1) One point from: • some molecules gain enough energy (above the average) in random collisions and keep gaining energy up to the bond breaking level • some molecules within Maxwell-Boltzman / energy distribution will gain enough energy to break bonds • value of kT allows reasonable rate (1)	2	
			Total	5	

Question			Answer	Mark	Guidance
36	(a)	(i)	k = 29 / (15.2 x 10^{-4}) (1) = 1.9 x 10^{4} N m^{-1} (1)	2	**Allow** any pair of values of F and e within ± ½ small square **Accept** evaluations that round to 1.9 x 10^{4} **Allow** 1.9 for 1 mark MAX Raw answer of 1.9 x 10^{4} scores both marks
36	(a)	(ii)	$T = 2\pi\sqrt{((10/9.81)/(1.9 \times 10^{4}))}$ (1) = 4.6 x 10^{-2} s (1)	2	**Allow** ecf from (i)
36	(a)	(iii)	For the wire (which shows SHM) the restoring force is proportional to the negative of the displacement (1) The extension (from the equilibrium) is not proportional to tension for the rubber strip (whereas it is for the wire) (1)	2	**Allow** Restoring force = - constant × displacement. Need direction of force being opposite to displacement / towards the equilibrium point **Do not allow** linear **Accept** rubber does not obey Hooke's Law (but wire does) **Accept** stiffness of rubber is not constant

<table>
<tr>
<td>36</td>
<td>(b)*</td>
<td>Level 3 (5-6 marks)
Clear comparison involving all three strands
• Structure of metal alloys
• Structure of polymers
• Explanation of shape of graphs

There is a well-developed line of reasoning which is clear and logically structured. The information presented is relevant and substantiated.

Level 2 (3–4 marks)
Shows clear understanding of at least two of
• Structure of metal alloys
• Structure of polymers
• Explanation of shape of graphs
or covers all three in a superficial manner.

There is a line of reasoning presented with some structure. The information presented is in the most-part relevant and supported by some evidence.

Level 1 (1–2 marks)
Shows some understanding of one strand or covers two strands in a superficial manner.
• Structure of metal alloys
• Structure of polymers
• Explanation of shape of graphs

There is an attempt at a logical structure with a line of reasoning. The information is in the most part relevant</td>
<td>6</td>
<td>Indicative scientific points from three strands may include the following. Annotated diagrams should be given appropriate credit:
Structure of metal alloys
• Metal alloys contain impurity atoms/ions that disrupt the planes of metal atoms / ions
• Strong bonds between atoms / ions make the wire stiff but elastic
• Layers of atoms / ions prevented from sliding over each other by the impurity atoms / ions
• Making the alloy brittle
Structure of polymers
• Made up of long chains of repeated monomers
• Chains curled up and entangled when polymer not under tension
• Deformation of rubber is elastic because it is expected to return to its original length when the load is removed
Shape of Graphs
Metal alloy:
• Increases in distances between atomic planes are proportional to the force applied
• Eventually the force becomes large enough to pull the planes of atoms/ions apart completely

Rubber:
• Chains / bonds straighten and untangle when the rubber strip first stretched so small force needed to cause given extension
• Chains are then stretched and more force needed to cause the same extension</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Total</td>
<td>12</td>
<td></td>
</tr>
</table>

Question			Answer	Mark	Guidance
37	(a)		$L_2/L_1 = \lambda_2/\lambda_1 = v_2 / v_1$ **AND** $v_2 / v_1 = \sqrt{(\mu_1 / \mu_2)}$ (1) $= \sqrt{(d_1^2 / d_2^2)} = d_1 / d_2 = 1/1.4 = 0.714$ (1) $L_2 = 0.714 \times L_1 = 0.13$ (m) (1)	3	Alternative methods acceptable (e.g. numerical methods) Bald correct answers gain all marks.
37	(b)	(i)	$v = 0.17 \times 4 \times 440$ (1) $= 299$ (m s^{-1}) (1) This assumes that C is insignificant/zero AW (1)	3	Credit explanation that $L \sim \lambda/4$ **Not** 300 as the question is "show that…" Bare 299 gains the first two marks
37	(b)	(ii)	Clear use of gradient using more than half the range of values giving gradient of around 0.012 s m^{-1} (1) Leading to speed value of 300 to 360(1)	2	Bare answer scores zero as question states "use the graph" so evidence of gradient method required
37	(b)	(iii)	Equation of line identified as: $L = \frac{\lambda}{4} - C$ or $\frac{\lambda}{4} = L + C$ (1) Rearrangement to: $\frac{1}{f} = \frac{4L}{v} + \frac{4C}{v}$ (1) Comparison with: $y = mx$ (+c) (1)	3	Allow explanation from gradient is 1/f / L linked to v=f λ Comparison with $y = mx$ can be in words, end correction not required

	Question		Answer	Mark	Guidance
37	(b)	(iv)	Any two points, clearly stated **and** linked to advantage/disadvantage • Signal generator will give a signal of constant amplitude – giving more time to change and measure the length of the tube at resonance • Power/volume of note from speaker is greater than from tuning fork so easier to detect resonance point. • Tuning fork is of known frequency so uncertainty in frequency is reduced • More frequencies available from the signal generator giving more data to produce a straight line graph AW (2)	**2**	AW throughout. **Not** just signal generator provides more accurate / known frequency **Accept** any reasonable statement linked to advantage / disadvantage e,g “tuning fork will not give accurate frequency if it has been damaged” Response does not need to include the term ‘advantage/disadvantage’ as long as reasoning is clear’ Two points without clear reasoning / links to advantage/disadvantage gains one mark max
			Total	**13**	

Question			Answer	Mark	Guidance
38	(a)	(i)	New pressure = 567 kPa (1) (*m* = ((567-170) ×10^3×15×10^{-4})/9.81) =60.7(kg) (1)	2	Complete substitution or correct own value must have own evaluation for the 2nd mark as the question is “show that”
38	(a)	(ii)	3.0/291 = new length/303 (1) New length = 0.031(2) m (1)	2	Bald correct answer gains both marks Do not accept answers in cm unless unit is clearly given
38	(b)	(i)	% uncertainty in *V* = 1/61 x 100% = 1.6 %(1) % uncertainty in *T* = 1/30 x 100% = 3.3 % (1)	2	**Accept** 2 **Accept** 3
38	(b)	(ii)	Gradient = 0.2 (0.21) (1) Equation of line: y = 0.2x + 55 (1) Absolute zero = -55/0.2 = -275 (°C) (1)	3	**Allow** values in range 0.2-0.22. Must be clear that 0.2 is the gradient (can be from drawing triangles on graph etc) **Allow** use of any gradient value **Allow** use of own value for gradient to give value in range -250 to -290 °C **Accept** use of alternative methods – e.g. simultaneous equations - for full credit
			Total	9	

Question		Answer	Mark	Guidance
39	(a)	**Unstable nucleus** – one that does not have enough binding energy to hold the nucleus together (1) **Random process** – the probability of a nucleus decaying in a given time is the same for all nuclei in a sample (1)	**2**	**Allow** other coherent arguments that describe, for example, decaying to other nuclei or descriptions of emission process or proton-neutron imbalance related to line of stability / description of nuclear forces **Allow** coherent arguments that describe the unpredictability of individual decay (at a given instant)
39	(b)	Any **four** from • Alpha particles are very ionising **OR** alpha particles can damage living tissue • alpha particles (from the thorium) won't penetrate skin / alpha particles from Thorium lack energy to penetrate the skin OWTTE • Idea that alpha particles from the thorium are (very) unlikely to reach living tissue (of the welder as the rod is not handled often) • Radon can be breathed in (and so alpha particles are more likely to enter tissue and do harm) / radon may decay inside lungs/body • Wearing gloves / apron will protect against Thorium contamination • Wearing gloves / apron will not protect against Radon exposure • Wearing mask will not protect from Radon-emitted alpha unless airtight • Relative half-lives is not a relevant factor as Thorium activity limits Radon activity • Radon has a short half-life so it might decay before entering the body	**4**	**Must** cover both Thorium and Radon emission to gain maximum marks otherwise maximum 3 marks

	Question		Answer	Mark	Guidance
39	**(c)**	**(i)**	Idea that (current is proportional to emission of alpha particles and) rate of emission of alpha particles is proportional to the number of radioactive nuclei /atoms present.	**1**	**Allow** $A \propto N$ **Allow** use of $dN/dT = -\lambda N$ if terms are explained but no credit for formula alone as on formula sheet

	Question		Answer	Mark	Guidance
39	**(c)***	**(ii)**	Level 3 (5-6 marks) Clear explanation of both strands • Calculating half life from graph • Explanation of why graph value is more accurate *There is a well-developed line of reasoning which is clear and logically structured. The information presented is relevant and substantiated.* Level 2 (3–4 marks) Clear explanation of one strand and a superficial coverage of the other: • Calculating half life from graph • Explanation of why graph value is more accurate *There is a line of reasoning presented with some structure. The information presented is in the most-part relevant and supported by some evidence.* Level 1 (1–2 marks) Shows some understanding of one strand or covers both strands in a superficial manner: • Calculating half life from graph • Explanation of why graph value is more accurate *There is an attempt at a logical structure with a line of reasoning. The information is in the most part relevant*	**6**	Indicative scientific points from the two strands may include: **Calculating half life from graph** • Missing ln values calculated (-29.67, -29.93) • Points plotted correctly • Reasonable straight line of best fit drawn • Gradient = - λ • $T_{1/2}$ = ln2/λ or - ln2/gradient • Value from graph in range 46-56 s **Explanation of why graph value is more accurate** • value of half-life from table depends on which points are chosen • Example from results – e.g. 0 – 60 s current falls by half, but then by 60s to 120 s from 0.42 pA to 0.18 pA or 0.04 pA from 120 s to 140 s • 60s just one of a number of these possible values • One reading does not remove random fluctuation • One reading does not “average out” errors in readings • Line uses more than one pair of points OWTTE • Decay is random so average value / gradient value is more accurate • Line of best fit requires some judgement • Anomalies are easy to identify / discount
			Total	**13**	

Question			Answer	Mark	Guidance
40	(a)	(i)	½ m_e v^2 = 1000 x 1.6 x 10^{-19} (1) v = √((1.6 x 10^{-16} x 2)/(9.1 x 10^{-31}) = 1.87 x 10^7 (m s^{-1}) (1)	**2**	**Not** just 1.9 x 10^7 as show that question
40	(a)	(ii)	The electron will be deflected towards the bottom of the page AW (1) In a circular path (1) Radius = *mv/Be* (1) = (9.1 x 10^{-31} x 1.9 x 10^7)/(0.02 x 1.6 x 10^{-19}) = 5.4 x 10^{-3} m (1)	**4**	**Allow** shown on diagram. **Do not allow** downwards unless made clear this is down the page and not into the page. Must be stated, not from diagram Using 1.87 x 10^7 m s^{-1} gives 5.3 x 10^{-3} m **No ECF** on *v* from a(i) as value is given A correct value of the radius on its own scores 2 marks **Allow** calculation of acceleration / force with centripetal direction for last two marks
40	(b)		*Bev* = *Ee* or *E* = *Bv* (1) *V* = *Bvd* = 0.020 x 1.9 x 10^7 x 0.04 = 15000 (V) (1)	**2**	**No ECF** on *v* from a(i) as value is given Answer on its own scores both marks 1.87 × 10^7 gives 14960
40	(c)		*v* = *E/B* = (120/0.04)/0.02 (1) = 1.5 x 10^5 m s^{-1} (1) ½ mv^2 = 1000 *Q* Giving *Q/m* = v^2/2000 (1) = 1.125 x 10^7 (C kg^{-1}) (1)	**4**	
			Total	**12**	

Need to get in touch?

If you ever have any questions about OCR qualifications or services (including administration, logistics and teaching) please feel free to get in touch with our customer support centre.

Call us on

01223 553998

Alternatively, you can email us on

support@ocr.org.uk

For more information visit

ocr.org.uk/qualifications/resource-finder

ocr.org.uk

Twitter/ocrexams

/ocrexams

/company/ocr

/ocrexams

CAMBRIDGE
UNIVERSITY PRESS & ASSESSMENT

OCR is part of Cambridge University Press & Assessment, a department of the University of Cambridge.

OCR operates academic and vocational qualifications regulated by Ofqual, Qualifications Wales and CCEA as listed in their qualifications registers including A Levels, GCSEs, Cambridge Technicals and Cambridge Nationals.

OCR provides resources to help you deliver our qualifications. These resources do not represent any particular teaching method we expect you to use. We update our resources regularly and aim to make sure content is accurate but please check the OCR website so that you have the most up-to-date version. OCR cannot be held responsible for any errors or omissions in these resources.

Though we make every effort to check our resources, there may be contradictions between published support and the specification, so it is important that you always use information in the latest specification. We indicate any specification changes within the document itself, change the version number and provide a summary of the changes. If you do notice a discrepancy between the specification and a resource, please contact us.

Whether you already offer OCR qualifications, are new to OCR or are thinking about switching, you can request more information using our Expression of Interest form.

Please get in touch if you want to discuss the accessibility of resources we offer to support you in delivering our qualifications.