GCE

Physics B

H557/01: Fundamentals of physics

A Level

Mark Scheme for June 2023

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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
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.

   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

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

Section B

Question			Answer	Mark	Guidance
31	(a)		A polarised wave only oscillates in one plane (1) (at right angles to direction of energy transfer).	1	**Allow** wave oscillates in one direction as long as it does not imply longitudinal wave
31	(b)		(Observe the reflected light through a polarising filter and) rotate the filter. (1). Intensity/amplitude of transmitted light will change (during rotation if the light has been partially polarised) (1)	2	**Allow** brightness will change
			Total	3	

32	**(a)**	**(i)**	1280 x 720 x 24 = 2.21 x 10^7 bits (1)	**1**	
32		**(ii)**	Average file size = 0.74 x 8 x 10^9/(30 x 60 x 40) = 82.2 kbits (1)	**1**	Need own answer and evidence of working **Allow** evaluation to 82kbits if working is clear **Allow** reverse argument
32	**(b)**		(Larger file size means) greater rate of transmission/greater memory required AW (1) One of: • This could cause the video to freeze/jump • Greater resolution not needed for teaching • Fewer lessons can be stored • Some homes may not have fast enough broadband / large enough data package • Some students may use phones of lower than necessary specification (1)	**2**	**Allow** both of these points for two marks **Allow** more bandwidth required **Not** storage
			Total	**4**	

Question			Answer	Mark	Guidance
33	(a)		$v = (2 \times 5000 \times 1.6 \times 10^{-19}/9.1 \times 10^{-31})^{1/2}$ (1) $= 4.2 \times 10^{7}$ m s^{-1} (1)	2	Bald correct answer gains both marks. First mark can be gained by correctly calculating energy of electron as 8.0×10^{-16}J.
33	(b)		(1.7 = total energy/ rest energy = 1 + E_k/rest energy) $E_k = 0.7 \times 8.2 \times 10^{-14}$ (1) accelerating p.d. = $0.7 \times 8.2 \times 10^{-14}/ 1.6 \times 10^{-19}$ $= 3.6 \times 10^{5}$ V (1)	2	Bald correct answer gains both marks. First mark can be gained by showing evidence of $E_k = 5.7(4) \times 10^{-14}$ J
33	(c)		One of: • overcome (possible) repulsion of (charges) • (they have) very short wavelengths (1)	1	**Allow** "to approach close to the nucleus"
			Total	5	

Question			Answer	Mark	Guidance
34	(a)		R = 4.0/2.5 (1) = 1.6 Ω	1	Must show working **Allow** values that correctly evaluate to 1.6 with rounding
34	(b)		conductivity = 1.8×10^7 x (0.93/1.6) (1) = 1.0×10^7 (1) (S m^{-1})	2	**Allow** first mark for using A/l = 1/ conductivity x 0.93 Bald correct answer gains both marks
34	(c)		temperature of filament increases / greater oscillation (amplitude) of ions (1) more collisions between (conduction) electrons and ions / increased energy transfer between electrons and ions (1)	2	**DO NOT ALLOW** heat increases **DO NOT ALLOW** atoms or nuclei as alternative to ions **DO NOT ALLOW** decrease of mean drift velocity. **DO NOT ALLOW** makes it harder for electrons to flow **DO NOT ALLOW** changing resistance changes conductivity
			Total	5	

35	**(a)**		r = $(3.2 \times 10^{-19} \times 1.3 \times 10^{-17} \times 8.98 \times 10^{9})/4 \times 10^{-13}$ (1) $= 9.3 \times 10^{-14}$ m (1)	**2**	Bald correct answer gains both marks. If 9.0×10^{9} used, accept final answer of 9.4×10^{-14}m
35	**(b)**		Closest to the nucleus at this point (1) Force on alpha particle proportional to $1/r^2$ AW (1)	**2**	**Allow** r is smallest (not r is small) **Allow** (acceleration is greatest) because the force is greatest Second mark needs idea of inverse square force.
			Total	**4**	

Section C

Question			Answer	Mark	Guidance
36	**(a)**		V = - 6.67 x 10^{-11} x 7.3 x 10^{22}/ 1.7 x 10^{6} = - 2.86 x 10^{6} J kg^{-1} (1)	**1**	Need own value or working. Must include negative sign. Allow use of 6.7 x 10^{-11} to give -2.88 x 10^{6}
36	**(b)**	**(i)**	v = (2 x 6.67 x 10^{-11} x 7.3 x 10^{22}/ 1.7 x 10^{6})$^{1/2}$ (1) 2400 m s^{-1} (1);	**2**	Need own value or working. **ALLOW** use of answer to part **(a)**
		(ii)	Any two points from: (projectile) does not need to go to infinity / potential equals zero Change in GPE is smaller / less (than Moon to infinity) (projectile only) needs to reach point where GPE of Earth is more negative than GPE of Moon Projectile does not need to climb out of Moon's potential well before 'falling into' Earth's well Gravitational attraction between projectile and Earth accelerates projectile towards Earth	**2**	 **ALLOW** Earth distorts potential lines around the Moon Give credit for sketch graph of potential versus distance

Question			Answer	Mark	Guidance
36	(c)*		**Level 3 (5–6 marks)** *There is a well-developed line of reasoning which is clear and logically structured. The information presented is relevant and substantiated.* Correct and clear calculation of angular frequency Clear explanation of both methods to reduce stress Discussion includes a mostly correct attempt at comparison of methods **Level 2 (3–4 marks)** *There is a line of reasoning presented with some structure. The information presented is in the most-part relevant and supported by some evidence.* Correct calculation of angular frequency and clear discussion of at least one method of stress reduction OR correct calculation of angular frequency and two methods partially explained OR clear explanation of both methods with angular frequency calculation that includes small mistakes / superficial comparison **Level 1 (1–2 marks)** *The information is basic and communicated in an unstructured way. The information is supported by limited evidence and the relationship to the evidence may not be clear.* Correct calculation OR one method of stress reduction clearly explained OR two methods of stress reduction superficially explained. **0 marks** No response or no response worthy of credit	6	**Indicative scientific points may include:** Angular frequency • $v = 2\pi r/T$ • $T = 2\pi x20/1900 = 0.06$ s • $f = 15$ Hz Stress reduction discussion (1) • longer arm • reduces F as $F=mv^2/r$ • reduces f • as $f = v/2\pi r$ and v is constant • longer arm more likely to bend • longer arm more massive – adding to tension in the arm (2) • larger cross section • (reduces stress) as F/A decreases • but more massive – adding to tension in the arm • other logical reasons acceptable (3) • lower density material • less massive arm • may bend more easily
			Total	**11**	

Question			Answer	Mark	Guidance
37	(a)	(i)	p.d. across resistor = 3.5 V (1) resistance of LDR = (2.5/3.5) x 10 x 10^3 = 7.1 kΩ (1)	2	**Allow** 3.4 to 3.6V May use potential divider equation. Allow 6.94 to 7.35 kΩ
		(ii)	Gradient of tangent at 200 lux (1) Answer 0.01 V lux^{-1} to 1 s.f. (1)	2	**Allow** evidence of values taken from graph Answer must be clearly evaluated from gradient **Do not allow** 2.5 / 200 (incorrect use of 2.5V)
		(iii)	Statement of test (constant ratio property) (1) At least three data pairs stated (giving two ratios) Eg. 400 lux, 4 sheets; 200 lux, 16 sheets; 100 lux, 32 sheets (1) Conclusion: eg. it takes 12 sheets to half from 400 – 200 and 16 sheets to half from 200 – 100 so the data does not show exponential fall (1)	3	First mark can be implicit from working. ('half-life' arguments acceptable) Can gain all marks by using natural log relationship.
37	(b)	(i)	Any three from: • source-detector distance constant • use absorbers of different, measured / known thickness • take readings of count (from transmitted beam) for equal time intervals • Background count recorded (and subtracted from count rate) • Repeat for each thickness (and calculate a mean value)	3	**ALLOW** position of detector / source constant

Question			Answer	Mark	Guidance
			• Plot a graph of ln (count) v thickness and calculate gradient		
		(ii)	ln(0.15) = -μ x 3.2 (1) μ = 0.59 (cm^{-1}) (1)	**2**	
			Total	**12**	

38	(a)		**Level 3 (5–6 marks)** *There is a well-developed line of reasoning which is clear and logically structured. The information presented is relevant and substantiated.* Detailed description of procedure AND Recognising **two** sources of uncertainty and giving a description of how to estimate them AND a description of how to estimate uncertainty in E – for example by using 'best' and 'worst fit' line **Level 2 (3–4 marks)** *There is a line of reasoning presented with some structure. The information presented is in the most-part relevant and supported by some evidence* Clear description of procedure AND recognising / estimating uncertainties in measurement / describing uncertainty analysis OR Superficial description of procedure AND detailed consideration of sources of uncertainty / estimating uncertainties in measurement / describing uncertainty analysis **Level 1 (1–2 marks)** *The information is basic and communicated in an unstructured way. The information is supported by limited evidence and the relationship to the evidence may not be clear* A superficial description of experimental procedure OR showing an understanding of sources of uncertainty and their	**6**	**Indicative scientific points may include:** Method: • Measure diameter of wire • Define/measure original length (e.g. placing a fiducial marker) • With wire under a small amount of tension • Add weights in uniform manner, recording new length or extension for each weight • Plot a graph of force vs extension (or vice versa) • Take gradient • *E* = gradient x length/c.s.a. (or csa/(gradient x length) if axis are reversed) • Safety considerations (goggles, floor protector etc) Sources of uncertainty : • diameter • extension • original length • force Uncertainty estimation • measuring diameter in a number of places to establish range of values

			estimation even if incomplete OR showing an understanding of estimation uncertainty for the final results. **0 marks** No response or no response worthy of credit		• Measuring mass of each slotted mass and taking a mean • Take into account resolution of ruler Explain how uncertainty in Young's Modulus can be estimated: • Uncertainty in final value by best fit and 'worst fit' lines (passing through uncertainty bars) • Calculating percentage uncertainties and summing to determine final absolute uncertainty. Level 3 response must have detailed procedure AND both other aspects considered, at least one of which must be well developed.
38	**(b)**	**(i)**	yield strain = $3.5 \times 10^{8} / 2.8 \times 10^{11} = 1.25 \times 10^{-3}$ (1) extension = $1.4 \times 1.25 \times 10^{-3} = 1.75 \times 10^{-3}$ (m) (1)	**2**	
		(ii)	Energy = ½ x $3.5 \times 10^{8} \times 0.52 \times 10^{-6} \times 1.75 \times 10^{-3}$ (1) = 0.16 (J) (1)	**2**	Other methods may be used. One mark for correctly calculating k as 1.04×10^{5} N m^{-1} Correct bald answer scores both marks.
		(iii)	Yield strain will not change (1) energy stored will double (1)	**2**	
		(iv)	They can store/absorb more energy (before breaking / yielding) (1) so will not break/yield if sudden acceleration required AW (1)	**2**	**Accept** will increase extension before yielding for first mark

					Other sensible reason for need for energy storage in wire acceptable for second mark. Second mark independent of first.
			Total	**14**	

<table>
<tr><th colspan="3">Question</th><th>Answer</th><th>Mark</th><th>Guidance</th></tr>
<tr><td>39</td><td>(a)</td><td>(i)</td><td>9.77 x 10^{14} s (1)
= 31 million years (31.5x 10^{6} years) (1)</td><td>2</td><td></td></tr>
<tr><td>39</td><td>(b)</td><td>(i)</td><td><table><tr><td>total number of up quarks</td><td>4</td><td>3</td></tr><tr><td>total number of down quarks</td><td>2</td><td>3</td></tr></table></td><td>1</td><td>All must be correct for mark</td></tr>
<tr><td></td><td></td><td>(ii)</td><td>Zero on LHS = -1 (positron) + 1 (neutrino) on RHS</td><td>1</td><td>It must be clear that the lepton number is 0 before the reaction and particles must be in the correct order or clearly identified
Allow 0 = -1+1 OR 0 = +1 neutrino - 1 positron
Allow 0 +0 = 0 -1 +1
Not 0 = +1 – 1</td></tr>
<tr><td>39</td><td>(c)</td><td>(i)</td><td>Energy released per nucleon = 7.2 MeV (1)
Energy released per reaction =
4 x 7.2 x 1.6 x 10^{-13} = 4.6 x 10^{-12} J</td><td>2</td><td>Must have own value for two marks.
Answer of 1.15 x 10^{-12} gains one mark.</td></tr>
<tr><td></td><td></td><td>(ii)</td><td>3.9 x 10^{26}/4.6 x 10^{-12} (1)
= 8.5 x 10^{37} (1)</td><td>2</td><td>ALLOW 7.8 x 10^{37} if ‘show that’ value used,</td></tr>
<tr><td></td><td></td><td>(iii)</td><td>M = 3.9 x 10^{26}/(3 x 10^{8})^{2} (1)
= 4.3 x 10^{9} (kg s^{-1}) (1)</td><td>2</td><td>ALLOW repeat calculation e.g. 8.5 x 10^{37} ×4.6 ×10^{-12} ÷ (3 × 10^{8})^{2} OR 7.8 × 10^{37} × 5 × 10^{-12} ÷ (3 × 10^{8})^{2}</td></tr>
<tr><td></td><td></td><td>(iv)</td><td>any two from
Calculation of mass loss per year = 1.4 x 10^{17} kg /
Calculation of % mass loss per year = 7 x 10^{-12} % /</td><td>3</td><td>ECF on calculation from c(iii)</td></tr>
</table>

Question			Answer	Mark	Guidance
			total mass lost in 4.5 billion years is 6.1×10^{26} (kg) (1) % loss in 4.5 billion years 0.031(%) (1) Contraction model gives shorter duration of Sun than the age of the Earth/ only a very small % of mass transferred to energy. (1)		Bald answer of 0.031% gains first two marks. Accept 0.032 Explanation has to agree with calculation. If no attempt at calculation but a statement 'contraction model gives shorter duration than age of Earth AW' give one mark.
			Total	**13**	

Question			Answer	Mark	Guidance
40	**(a)**		Curve of same shape as P.E. curve but 'upside-down' i.e. zero at A and -A, maximum at 0.	**1**	
40	**(b)**		$x = 0.050 \cos(2\pi \times 0.8 \times 0.25)$ (1) = 0.0155 m (1) Working though to final answer of 0.24($m\ s^{-1}$) (1)	**3**	Bald correct answer gains 3 marks. If degree mode on calculator is used, one mark for x = 0.04999 or 0.05 – can lead to two marks max for final answers around 0.005 $m\ s^{-1}$
40	**(c)**	**(i)**	$f = 1/2\pi \times (520/1.7 \times 10^{-27})^{1/2}$ (1) $= 8.8 \times 10^{13}$ Hz (1)	**2**	1 mark for calculating $T = 1.14 \times 10^{-14}$ s
		(ii)	Any three from • Photons have specific energy values • Photons emitted when energy levels change between specific values	**3**	Not specific frequencies Not just E=hf

Question			Answer	Mark	Guidance
			• Energy of oscillator / molecule can only have specific values • amplitudes can only take specific values • as $E = ½ kA^2$		
			Total	**9**	

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