

GCSE

Physics B (Twenty First Century)

Unit **J259H/03**: Higher Tier – Breadth in physics

General Certificate of Secondary Education

Mark Scheme for June 2018

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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.

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Annotations available in RM Assessor

Annotation	Meaning
	Correct response
	Incorrect response
	Omission mark
	Benefit of doubt given
	Contradiction
	Rounding error
	Error in number of significant figures
	Error carried forward
	Level 1
	Level 2
	Level 3
	Benefit of doubt not given
	Noted but no credit given
	Ignore

Abbreviations, annotations and conventions used in the detailed Mark Scheme (to include abbreviations and subject-specific conventions).

Annotation	Meaning
/	alternative and acceptable answers for the same marking point
✓	Separates marking points
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

The breakdown of Assessment Objectives for GCSE (9-1) in Physics B:

	Assessment Objective
AO1	Demonstrate knowledge and understanding of scientific ideas and scientific techniques and procedures.
AO1.1	Demonstrate knowledge and understanding of scientific ideas.
AO1.2	Demonstrate knowledge and understanding of scientific techniques and procedures.
AO2	Apply knowledge and understanding of scientific ideas and scientific enquiry, techniques and procedures.
AO2.1	Apply knowledge and understanding of scientific ideas.
AO2.2	Apply knowledge and understanding of scientific enquiry, techniques and procedures.
AO3	Analyse information and ideas to interpret and evaluate, make judgements and draw conclusions and develop and improve experimental procedures.
AO3.1	Analyse information and ideas to interpret and evaluate.
AO3.1a	Analyse information and ideas to interpret.
AO3.1b	Analyse information and ideas to evaluate.
AO3.2	Analyse information and ideas to make judgements and draw conclusions.
AO3.2a	Analyse information and ideas to make judgements.
AO3.2b	Analyse information and ideas to draw conclusions.
AO3.3	Analyse information and ideas to develop and improve experimental procedures.
AO3.3a	Analyse information and ideas to develop experimental procedures.
AO3.3b	Analyse information and ideas to improve experimental procedures.

Question		Answer	Marks	AO element	Guidance
1	(a)	<p>Any two from:</p> <p>planets are not all made of rock / some are made of gas ✓</p> <p>planets do not orbit in perfect circles / in ellipses ✓</p> <p>not all planets have moons (e.g. Venus, Mercury) ✓</p> <p>moons not all rocky/may be icy (e.g. Enceladus) [even though they may all have rocky cores) ✓</p>	2	1.1 x2	<p>ALLOW specific correct examples, e.g. Jupiter not made of rock / made of gas, Venus does not have a moon, Saturn has moon(s) of ice</p> <p>ALLOW a correctly identified statement quoted or identified from the report</p> <p>IF more than two examples given apply list rule</p> <p>IGNORE attempts to qualify a correctly identified statement with an incorrect example</p>
	(b)	<p>dust and gas ✓</p> <p>pulled together by gravity ✓</p>	2	1.1 x2	<p>ALLOW dust / gas / matter / nebula</p> <p>Only give credit for responses that describe the formation of the solar system</p>
	(c)	<p>mass is converted into energy (of radiation) ✓</p>	1	1.1	<p>e.g. quoting $E = mc^2$</p> <p>ALLOW mass is lost in the form of energy</p> <p>ALLOW mass is transferred/turned into energy</p>

Question		Answer	Marks	AO element	Guidance
2	(a)	(transferred by) electric current / electrically / electrical working ✓	1	1.1	ALLOW by a flow of electrons / current / electricity / IGNORE references to National Grid / wires /cables /transformers
	(b) (i)	<p>FIRST CHECK THE ANSWER ON ANSWER LINE If answer = 864 (J) award 3 marks</p> <p>recall and rearrange equation: energy = p.d. × charge ✓</p> <p>substitution $2 \times 1.2 \times 360$ ✓</p> <p>= 864 (J) ✓</p>	3	1.2 2.1 2.1	<p>Equations used to calculate energy must have energy as the subject (accept W for E). ALLOW $E = ItV$ and $Q = It$ / $E = Pt$ and $P = VI$ and $Q = It$ / 360×1.2 seen</p> <p>Correct substitutions gain m.p 1 also</p> <p>DO NOT ALLOW bald '86400' or '1728' or '432'. Credit can only be given for working</p>
	(b) (ii)	<p>FIRST CHECK THE ANSWER ON ANSWER LINE If answer = 3.0 (A) award 4 marks</p> <p>Recall and rearrange: current = charge / time ✓</p> <p>Convert 2 minutes = 120 s ✓</p> <p>= $360 / 120$ ✓</p> <p>= 3.0 (A) ✓</p>	4	1.2 2.1 2.1 2.1	<p>ALLOW 3 marks for 180 (unit conversion omitted)</p> <p>ALLOW '3 (A)'</p>

Question		Answer	Marks	AO element	Guidance
3	(a)	<p>FIRST CHECK THE ANSWER If answer = 720 000 (J) award 2 marks</p> <p>substitution $4.5 \times 1600 \times (120-20) \checkmark$ $= 720\,000 \text{ (J)} \checkmark$</p>	2	2.1 2.1	<p>ALLOW 20 or 120 for ΔT to give 144 000 or 864 000</p> <p>Does not need comparison with 700 000 for the mark</p>
	(b)	(i) <p>FIRST CHECK THE ANSWER ON ANSWER LINE If answer = 480 (s) award 3 marks</p> <p>recall and rearrange: $\text{time} = \text{energy} / \text{power} \checkmark$</p> <p>substitution $720\,000 / 1500 \checkmark$ $= 480 \text{ (s)} \checkmark$</p>	3	1.2 2.1 2.1	<p>ECF (a) or energy = 700 000 (J)</p> <p>ALLOW for 2 marks '48' or '4800' as a transcription error.</p>
		(ii) <p>energy transferred to the metal radiator / in the wires \checkmark</p>	1	1.1	<p>ALLOW 'energy is lost to the surroundings'</p> <p>IGNORE it heats up the room / ignore efficiency arguments</p> <p>DO NOT ALLOW 'loss' on its own</p>

Question		Answer	Marks	AO element	Guidance
4	(a)	<p>FIRST CHECK THE ANSWER ON ANSWER LINE If answer = 89 / 90 / 88.9 (m/s) award 2 marks</p> <p>$320 \times 1000 / 3600 \checkmark$</p> <p>$= 88.9 = 89 \text{ (m/s)} \checkmark$</p>	2	2.2 x2	<p>ALLOW for 1 mark answers that round to 8.89×10^1 ALLOW answers that round to 88.9</p>
	(b) (i)	<p>FIRST CHECK THE ANSWER ON ANSWER LINE If answer = 75 (m) award 3 marks</p> <p>select and rearrange equation: $s = (v^2 - u^2)/2a \checkmark$</p> <p>$= (20^2 - 80^2)/(2 \times -40) \checkmark$</p> <p>$= 75 \text{ (m)} \checkmark$</p> <p>OR</p> <p>Recall and rearrange $s = (\text{average}) \text{ speed} \times (\text{change in } v \div \text{acceleration}) \checkmark$</p> <p>$= 50 \times 1.5 \text{ (s)} \checkmark$</p> <p>75 (m) \checkmark</p>	3	<p>1.2</p> <p>2.1</p> <p>2.1</p>	<p>ALLOW one mark for correct substitution before rearrangement $20^2 - 80^2 = 2 \times -40 \times s$</p> <p>IGNORE incorrect signs, but DO NOT ALLOW $20^2 + 80^2$</p> <p>ALLOW -75 (m)</p> <p>ALLOW if both formulae are seen separately</p> <p>ALLOW evaluation of distance using $1.5 \times$ either 80 or 20</p>
	(b) (ii)	<p>velocity has a direction/is a vector \checkmark</p> <p>direction is changing (as it turns corner) \checkmark</p>	2	1.1 x2	

Question		Answer			Marks	AO element	Guidance	
5	(a)		Increase	Decrease	2	1.1 x2		
		speed	(✓)					
		frequency						✓
		wavelength	✓					
	(b)	<p>FIRST CHECK THE ANSWER ON ANSWER LINE If answer = 500 (Hz) award 3 marks</p> <p>select and rearrange: $f = v / \lambda$ ✓</p> <p>= 600 / 1.2 ✓</p> <p>= 500 (Hz) ✓</p>			3	<p>1.2</p> <p>2.2</p> <p>2.1</p>	Correct substitution also gains m.p. 1	


Question		Answer	Marks	AO element	Guidance
6	(a)	<p>sound is transmitted/vibrations pass through bones in ear ✓</p> <p>this works best/more sensitive over a limited range of frequencies/between 1000 to 3000 Hz ✓</p>	2	1.1 x2	<p>IGNORE ear drum</p> <p>IGNORE pick up / detect</p> <p>ALLOW low frequency produce smaller vibrations (in our ears) ORA</p> <p>ALLOW e.g. low frequencies produce smaller vibrations in the bones (=2 mks)</p> <p>ALLOW higher frequencies are more within our hearing range / lower frequencies are on the edge of our hearing range / we are more/less sensitive to certain frequencies</p> <p>DO NOT ALLOW just 'higher frequencies are easier to hear'</p> <p>DO NOT ALLOW just 'we are sensitive to certain frequencies'</p>
	(b)	(i)	1	3.3a	<p>IGNORE distance between Mia and wall</p> <p>IGNORE the same phone/speaker/app</p>
	(b)	(ii)	2	1.1 x2	<p>ALLOW as vibrations / as longitudinal waves / as compressions and rarefactions</p> <p>ALLOW a description of absorption e.g. the wave loses energy by vibrating the particles in the wall</p>

Question			Answer	Marks	AO element	Guidance
						ALLOW a description of reflection e.g. the wave echoes off the wall/bounces back from the wall
	(c)		wider range covering frequencies higher than 2 kHz / 2000Hz ✓ more closely spaced frequencies ✓ smaller volume steps / more sensitive volume control ✓	3	3.3b x3	Or clear ref to table e.g. 'should have a range which went higher than those used in their experiment' ALLOW any step less than 880 Hz ALLOW volume settings between 0 and 1 ALLOW increase distance (between Mia and phone) so volume setting can be higher IGNORE repeat and average

Question		Answer	Marks	AO element	Guidance
7	(a)	changing magnetic field (around coil) ✓ induces a p.d. / voltage ✓	2	1.1 x2	ALLOW magnetic field is cut (by coil) ALLOW produces p.d./voltage
	(b)	(i) all points plotted correctly at (800, 6.7) (1000, 9.1) (1200,11) ✓ line of best-fit ✓	2	2.2 1.2	To within ± 0.5 small divisions in each direction IGNORE lbf below 200 turns
		(ii) correct value read from candidate's line, to within half a small square ✓	1	2.2	
		(iii) use motor/machine/electrical device/mechanical device/pendulum (to pull magnet at fixed speed) ✓	1	3.3b	ALLOW drop magnet from fixed height
	(c)	current in coil generates a magnetic field ✓ which opposes the change causing it / is a like pole ✓	2	1.1 x2	DO NOT ALLOW references to positive / negative / charges

Question		Answer	Marks	AO element	Guidance
8	(a)	correct numbers for neutron (1 over 0) ✓ correct numbers for electron (0 over -1) ✓	2	1.1 x2	
	(b)	Any two from: half-life of Tc-99m is short (compared to transport time) ✓ so (almost) all Tc-99m would have decayed ✓ gamma is more penetrating (than beta) so it would be more difficult to shield as it is transported to the hospital ✓	2	3.2b x2	ALLOW it only has a half-life of 6 hours ALLOW it would have decayed a lot / its activity would be too low
	(c)	(i) FIRST CHECK THE ANSWER ON ANSWER LINE If answer = 6.25 (%) award 2 marks 4 half lives ✓ = 6.25 (%) ✓	2	2.2 x2	ALLOW $24 \div 6 = 4$ seen ALLOW evidence of four successive halvings ALLOW 93.75(%) (percent of Tc-99m that has decayed)
	(c)	(ii) longer time for thallium (because it has a longer half-life) / ORA ✓ causing greater radiation dose/ risk of cancer / ORA ✓	2	3.1b x2	ALLOW more damage to cells ALLOW for 2 marks exposure is greater if the patient is exposed for more time

Question		Answer	Marks	AO element	Guidance
9	(a)	The material in the tablet is denser than water AND Water is denser than the gas in the bubbles ✓	1	1.1	
	(b)	upwards arrow on tablet labelled reaction ✓ force labelled 18 mN ✓	2	1.1 x2	ALLOW contact force / normal reaction force Independent mark, unit required
	(c) (i)	Any two from: pressure (of water) ✓ pressure increases with depth / there is a pressure difference between the top and bottom of the tablet ✓ so net force is upwards ✓	2	1.1 x2	ALLOW Archimedes principle e.g. water displaced by tablet ALLOW the weight of this water is equal to the upthrust ALLOW more force upwards
	(c) (ii)	Any one from: tablet has larger volume ✓ tablet has greater thickness ✓ tablet has more pressure difference ✓ tablet has larger area ✓	1	1.1	DO NOT ALLOW 'it is bigger' on its own ALLOW ORA DO NOT ALLOW it is heavier/more mass

Question		Answer	Marks	AO element	Guidance
10	(a)		1	1.1	
	(b)	(i)	3	3.1a 1.1 1.1	
		as temperature increases, potential difference increases ✓ (because) as temperature increases, resistance of thermistor/ R_2 decreases ✓ (so) p.d. across thermistor falls (so p.d. across R_1 must increase) ✓			
	(b)	(ii)	2	3.2b x2	IGNORE sensitivity ALLOW smaller gradient/less steep at lower temperatures ORA ALLOW e.g. it goes up 0.1 between 10 and 20 ALLOW for 2 marks at lower temperatures there are smaller changes in p.d. for the same change in temperature
	(c)	(i)	1	1.1	ALLOW equipment / zero / apparatus
	(c)	(ii)	2	2.1 3.3a	ALLOW because of the current
		current heats the thermistor ✓ use lower current / increase R_1 / decrease voltage / add a heat sink (OWTTE) / measure the effect and take it into account ✓			

Question		Answer	Marks	AO element	Guidance	
11	(a)	<p>FIRST CHECK THE ANSWER ON ANSWER LINE If answer = 2.0 (Nm) award 3 marks</p> <p>Recall: $W = mg$ ✓ $= 1.0 \times 10 \times 0.2$ ✓ $= 2.0 \text{ (Nm)} / 200 \text{ Ncm}$ ✓</p>	3	1.2 2.1 2.1	<p>ALLOW Force down = 10N = 1kg x 10</p> <p>Also gains m.p.1 ALLOW for 2 marks $1.0 \times 10 \times 20 = 200$</p> <p>ALLOW '2' (Nm)</p>	
	(b)	(i)	moment due to metre ruler not included ✓	1	3.2a	ALLOW any clear reference to the unbalanced nature of the metre rule e.g the ruler has mass/weight
		(ii)	centre / balance metre ruler on pivot / use ruler made of material with negligible mass /use weights much larger than weight of ruler / use extra weights to balance ruler before checking predictions ✓	1	3.3b	

Question		Answer	Marks	AO element	Guidance
12	(a)	<p>FIRST CHECK THE ANSWER ON ANSWER LINE If answer = 8 (kg m/s) award 2 marks</p> <p>Recall: momentum = mass \times velocity / $5 \text{ kg} \times 1.6 \text{ m/s} \checkmark$</p> <p>= $8 \text{ (kg m/s)} \checkmark$</p>	2	1.2 2.1	
	(b)	(i)	4	1.1 2.1 2.1 2.1	<p>ALLOW for 3 marks 1.6 (m/s) with working shown (the candidate has added 8 and 4 to give the total momentum = 12)</p> <p>ALLOW bald answer 0.53 only (=2 mks) (candidate may have used only the momentum of trolley B)</p> <p>ALLOW if no other mark awarded, 1 mark for 7.5 (= total mass after the collision)</p> <p>OR m.p.3 & 4 can be Momentum of joined trolleys = $7.5 \text{ (kg)} \times 0.5 \text{ (m/s)}$ = $3.75 \text{ (kg m/s)} \checkmark$ Which agrees with the momentum before (so speed $\approx 0.5 \text{ (m/s)} \checkmark$</p>

Question		Answer	Marks	AO element	Guidance
	(b) (ii)	<p>FIRST CHECK THE ANSWER ON ANSWER LINE If answer = 27 (N) award 4 marks</p> <p>select and rearrange to get $F = \Delta p / \Delta t$ ✓</p> <p>for A, $\Delta p = 5 \text{ kg} \times (0.53 \text{ (m/s)} - 1.6 \text{ (m/s)})$ OR $= (-)5.35 \text{ (kg m/s)}$ ✓</p> <p>$F = 5.35 \text{ (kg m/s)} / 0.20 \text{ (s)}$ ✓</p> <p>$= 26.75 \text{ (N)} = 27 \text{ (N)}$ ✓</p>	4		<p>ECF throughout</p> <p>1.1 ALLOW $F = \text{momentum} \div \text{time} / F = m \times \Delta v \div t$</p> <p>2.1 Using $v_{\text{final}} = 0.5 \text{ (m/s)}$ gives $\Delta p = 5.5 \text{ (kg m/s)}$</p> <p>2.1 Also gains m.p.2</p> <p>2.1 and $F = 27.5 \text{ (N)}$</p>

Question		Answer	Marks	AO element	Guidance
13	(a) (i)	Out of the page ✓	1	1.2	
	(ii)	<p>FIRST CHECK THE ANSWER ON ANSWER LINE If answer = 1.2 (N) award 4 marks</p> <p>select force = magnetic flux density x current x length of conductor ✓</p> <p>calculate length correctly, including unit conversion length = $0.025 \times 200 = 5 \text{ (m)}$ ✓</p> <p>$= 0.40 \times 0.60 \times 5$ ✓</p> <p>$= 1.2 \text{ (N)}$ ✓</p>	4		<p>ALLOW 3 marks if 200 turns omitted, 0.0060 N</p> <p>ALLOW 3 marks if using 5000mm, 1200N</p> <p>ALLOW 2 marks if 200 turns omitted and no conversion of 25mm to m, 6N</p> <p>ALLOW 1 mark for a substitution that shows evidence of the formula</p> <p>2.1 Also gains m.p.1 and m.p.2</p> <p>2.1</p>

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