

**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).

<b>Annotation</b>	<b>Meaning</b>
/	alternative and acceptable answers for the same marking point
✓	Separates marking points
<b>DO NOT ALLOW</b>	Answers which are not worthy of credit
<b>IGNORE</b>	Statements which are irrelevant
<b>ALLOW</b>	Answers that can be accepted
( )	Words which are not essential to gain credit
—	Underlined words must be present in answer to score a mark
<b>ECF</b>	Error carried forward
<b>AW</b>	Alternative wording
<b>ORA</b>	Or reverse argument

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

	<b>Assessment Objective</b>
<b>AO1</b>	<b>Demonstrate knowledge and understanding of scientific ideas and scientific techniques and procedures.</b>
AO1.1	Demonstrate knowledge and understanding of scientific ideas.
AO1.2	Demonstrate knowledge and understanding of scientific techniques and procedures.
<b>AO2</b>	<b>Apply knowledge and understanding of scientific ideas and scientific enquiry, techniques and procedures.</b>
AO2.1	Apply knowledge and understanding of scientific ideas.
AO2.2	Apply knowledge and understanding of scientific enquiry, techniques and procedures.
<b>AO3</b>	<b>Analyse information and ideas to interpret and evaluate, make judgements and draw conclusions and develop and improve experimental procedures.</b>
<b>AO3.1</b>	Analyse information and ideas to interpret and evaluate.
AO3.1a	Analyse information and ideas to interpret.
AO3.1b	Analyse information and ideas to evaluate.
<b>AO3.2</b>	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.
<b>AO3.3</b>	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><b>Any two from:</b></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><b>ALLOW</b> 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><b>ALLOW</b> a correctly identified statement quoted or identified from the report</p> <p>IF more than two examples given apply list rule</p> <p><b>IGNORE</b> 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><b>ALLOW</b> 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 <math>E = mc^2</math></p> <p><b>ALLOW</b> mass is lost in the form of energy</p> <p><b>ALLOW</b> 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	<b>ALLOW</b> by a flow of electrons / current / electricity / <b>IGNORE</b> references to National Grid / wires /cables /transformers
	(b) (i)	<p><b>FIRST CHECK THE ANSWER ON ANSWER LINE</b>  <b>If answer = 864 (J) award 3 marks</b></p> <p>recall <b>and</b> rearrange equation: energy = p.d. × charge ✓</p> <p>substitution <math>2 \times 1.2 \times 360</math> ✓</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).  <b>ALLOW</b> <math>E = ItV</math> <b>and</b> <math>Q = It</math> / <math>E = Pt</math> <b>and</b> <math>P = VI</math> and <math>Q = It</math> / <math>360 \times 1.2</math> seen</p> <p>Correct substitutions gain m.p 1 also</p> <p><b>DO NOT ALLOW</b> bald '86400' or '1728' or '432'.  Credit can only be given for working</p>
	(b) (ii)	<p><b>FIRST CHECK THE ANSWER ON ANSWER LINE</b>  <b>If answer = 3.0 (A) award 4 marks</b></p> <p>Recall <b>and</b> rearrange: current = charge / time ✓</p> <p>Convert 2 minutes = 120 s ✓</p> <p>= <math>360 / 120</math> ✓</p> <p>= 3.0 (A) ✓</p>	4	1.2  2.1  2.1  2.1	<p><b>ALLOW</b> 3 marks for 180 (unit conversion omitted)</p> <p><b>ALLOW</b> '3 (A)'</p>

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



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

Question		Answer			Marks	AO element	Guidance	
5	(a)		Increase	Decrease	2	1.1 x2		
			(✓)					
		speed						✓
		wavelength	✓					
	(b)	<p><b>FIRST CHECK THE ANSWER ON ANSWER LINE</b>                      If answer = 500 (Hz) award 3 marks</p> <p>select <b>and</b> rearrange: <math>f = v / \lambda</math> ✓</p> <p>= 600 / 1.2 ✓</p> <p>= 500 (Hz) ✓</p>			3	1.2 2.2 2.1	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><b>IGNORE</b> ear drum</p> <p><b>IGNORE</b> pick up / detect</p> <p><b>ALLOW</b> low frequency produce smaller vibrations (in our ears) ORA</p> <p><b>ALLOW</b> e.g. low frequencies produce smaller vibrations in the bones (=2 mks)</p> <p><b>ALLOW</b> 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><b>DO NOT ALLOW</b> just 'higher frequencies are easier to hear'</p> <p><b>DO NOT ALLOW</b> just 'we are sensitive to certain frequencies'</p>	
	(b)	(i)	<p><b>Any one from:</b></p> <p>distance between phone/James and Mia ✓</p> <p>background noise ✓</p> <p>time to listen to each sound ✓</p> <p>same frequency/ies</p>	1	3.3a	<p><b>IGNORE</b> distance between Mia and wall</p> <p><b>IGNORE</b> the same phone/speaker/app</p>
	(b)	(ii)	<p>waves are transmitted / pass through the wall ✓</p> <p>but some waves are absorbed / reflected by the wall ✓</p>	2	1.1 x2	<p><b>ALLOW</b> as vibrations / as longitudinal waves / as compressions and rarefactions</p> <p><b>ALLOW</b> a description of absorption e.g. the wave loses energy by vibrating the particles in the wall</p>

Question			Answer	Marks	AO element	Guidance
						<b>ALLOW</b> 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'  <b>ALLOW</b> any step less than 880 Hz  <b>ALLOW</b> volume settings between 0 and 1 <b>ALLOW</b> increase distance (between Mia and phone) so volume setting can be higher <b>IGNORE</b> 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	<b>ALLOW</b> magnetic field is cut (by coil) <b>ALLOW</b> 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 $\pm 0.5$ small divisions in each direction <b>IGNORE</b> 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	<b>ALLOW</b> 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	<b>DO NOT ALLOW</b> 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)	<b>Any two from:</b> 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	<b>ALLOW</b> it only has a half-life of 6 hours <b>ALLOW</b> it would have decayed a lot / its activity would be too low
	(c)	(i) <b>FIRST CHECK THE ANSWER ON ANSWER LINE</b> <b>If answer = 6.25 (%) award 2 marks</b> 4 half lives ✓ = 6.25 (%) ✓	2	2.2 x2	<b>ALLOW</b> $24 \div 6 = 4$ seen <b>ALLOW</b> evidence of four successive halvings <b>ALLOW</b> 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	<b>ALLOW</b> more damage to cells <b>ALLOW</b> 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 <b>AND</b> 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	<b>ALLOW</b> contact force / normal reaction force  Independent mark, unit required
	(c) (i)	<b>Any two from:</b>  pressure (of water) ✓  pressure increases with depth / there is a pressure difference between the top and bottom of the tablet ✓  so <b>net</b> force is upwards ✓	2	1.1 x2	<b>ALLOW</b> Archimedes principle e.g. water displaced by tablet <b>ALLOW</b> the weight of this water is equal to the upthrust  <b>ALLOW more</b> force upwards
	(c) (ii)	<b>Any one from:</b> tablet has larger volume ✓ tablet has greater thickness ✓ tablet has more pressure difference ✓ tablet has larger area ✓	1	1.1	<b>DO NOT ALLOW</b> 'it is bigger' on its own <b>ALLOW</b> ORA  <b>DO NOT ALLOW</b> it is heavier/more mass

Question		Answer	Marks	AO element	Guidance
10	(a)		1	1.1	
	(b)	(i) 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) ✓	3	3.1a  1.1  1.1	
	(b)	(ii) at lower temperatures there are smaller changes in p.d. ORA ✓  justified with evidence from graph ✓	2	3.2b x2	<b>IGNORE</b> sensitivity  <b>ALLOW</b> smaller gradient/less steep at lower temperatures ORA <b>ALLOW</b> e.g. it goes up 0.1 between 10 and 20 <b>ALLOW</b> for 2 marks at lower temperatures there are smaller changes in p.d. for the same change in temperature
	(c)	(i) systematic ✓	1	1.1	<b>ALLOW</b> equipment / zero / apparatus
	(c)	(ii) 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 ✓	2	2.1  3.3a	<b>ALLOW</b> because of the current



Question		Answer	Marks	AO element	Guidance	
11	(a)	<p><b>FIRST CHECK THE ANSWER ON ANSWER LINE</b>  <b>If answer = 2.0 (Nm) award 3 marks</b></p> <p>Recall: <math>W = mg</math> ✓  <math>= 1.0 \times 10 \times 0.2</math> ✓  <math>= 2.0 \text{ (Nm)} / 200 \text{ Ncm}</math> ✓</p>	3	1.2 2.1 2.1	<p><b>ALLOW</b> Force down = 10N = 1kg x 10</p> <p>Also gains m.p.1  <b>ALLOW</b> for 2 marks <math>1.0 \times 10 \times 20 = 200</math></p> <p><b>ALLOW</b> '2' (Nm)</p>	
	(b)	(i)	moment due to metre ruler not included ✓	1	3.2a	<b>ALLOW</b> 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><b>FIRST CHECK THE ANSWER ON ANSWER LINE</b>  <b>If answer = 8 (kg m/s) award 2 marks</b></p> <p>Recall: momentum = mass x velocity / <math>5 \text{ kg} \times 1.6 \text{ m/s} \checkmark</math></p> <p><math>= 8 \text{ (kg m/s)} \checkmark</math></p>	2	1.2 2.1	
	(b)	(i)	4	1.1 2.1 2.1 2.1	<p><b>ALLOW</b> 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><b>ALLOW</b> bald answer 0.53 only (=2 mks) (candidate may have used only the momentum of trolley B)</p> <p><b>ALLOW</b> if no other mark awarded, 1 mark for 7.5 (= total mass after the collision)</p> <p><b>OR</b> m.p.3 &amp; 4 can be  Momentum of joined trolleys = <math>7.5 \text{ (kg)} \times 0.5 \text{ (m/s)}</math>  <math>= 3.75 \text{ (kg m/s)} \checkmark</math>  Which agrees with the momentum before (so speed <math>\approx 0.5 \text{ (m/s)} \checkmark</math></p>

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

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

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