H

GCSE (9–1)

Physics B (Twenty First Century Science)

J259/03: Breadth in physics (Higher Tier)

General Certificate of Secondary Education

Mark Scheme for June 2019

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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.

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

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.

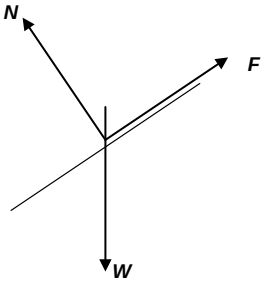
You should ensure also that you are familiar with the administrative procedures related to the marking process. These are set out in the OCR booklet **Instructions for Examiners**. If you are examining for the first time, please read carefully **Appendix 5 Introduction to Script Marking: Notes for New Examiners**.

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

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)		**FIRST CHECK THE ANSWER ON ANSWER LINE** **If answer = 6680 (J) award 3 marks** Select equation: energy to cause a change of state = mass × specific latent heat ✓ Conversion 20 g = 0.020 kg ✓ 334 000 × 0.020 = 6680 (J) ✓	**3** **1.2** **1.2** **2.1**		**ALLOW** 6.68 x 10^3 / 6700 / 6.7 x10^3 If the conversion is missing or incorrect, max 2 marks available.
	(b)		**Any two from:** (time to melt depends on) rate of (thermal) energy transfer ✓ energy is transferred to the ice cube ✓ (which depends on) thickness of material / conductivity of material / foil is a good conductor / carpet is an insulator / carpet is thick / foil or paper are thin / AW ✓	**2**	**2.1 × 2**	**ALLOW** the ice is heated/heating **Not just** heat is transferred to the ice **ALLOW** some materials are better insulators or conductors than others **ALLOW** thermal energy is transferred in the least time by aluminium because it is the best conductor (2 marks)
	(c)	(i)	put ice in container and wrap the container in material / AW ✓ measure temperature / use a thermometer / put (all equipment) in freezer ✓	**2**	**3.3b × 2**	**ALLOW** AVP e.g. use solid CO_2 that sublimes rather than melts / wrap the ice-cube in cling film/ use waterproof paper / laminate / cover in a thin layer of plastic
		(ii)	use smaller ice cubes / put the ice cubes on a warm surface / put each ice cube under a lamp ✓	**1**	**3.3b**	**ALLOW** put in a warmer environment / break up the ice

Question			Answer	Marks	AO element	Guidance
2	(a)	(i)	arrow perpendicular to surface, upwards and left labelled N ✓	1	2.1	 Perpendicular and parallel by eye. **ALLOW** in **(a)(ii)** one mark for missing or incorrect labels for both parts of the question **ALLOW** arrows anywhere on diagram
		(ii)	arrow parallel to surface **AND** upwards and right labelled F ✓	1	2.1	
	(b)	(i)	if A exerts a force on B then B exerts a force on A ✓ forces are <u>equal</u> and <u>opposite</u> ✓	2	1.1 × 2	**ALLOW** (an interaction) pair of forces (that are the same type) that act on different objects e.g. book pushes on table, table pushes on book **NOT** if only one object **ALLOW** second mark for 'every action has an equal and opposite reaction'
		(ii)	(equal and opposite force) acts on the Earth ✓	1	2.1	**ALLOW** the Earth is attracted to Jamal / there is a force pulling the Earth upwards.

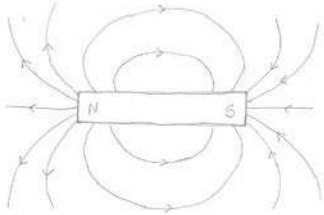
Question			Answer	Marks	AO element	Guidance
3	(a)		contamination effect ✓ (because the isotope/source/it) is inside/on the body ✓	2	1.1 × 2	
	(b)		it emits ionising radiation (which mutates DNA / cells) ✓	1	1.1 × 1	**DO NOT ALLOW** 'causes cancer / radiation sickness' on its own
	(c)		**Any two from:** (If radium is chosen) emits alpha so it is (most) ionising ✓ absorbed by bones so stays in body/not excreted ✓ least penetrating so radiation emitted is absorbed by tissue ✓ long half-life so stays in body/stays radioactive for a long time ✓ (If technetium is chosen) short half-life so lots of radiation in a short time / so high dose/exposure ✓ (If plutonium is chosen) absorbed by bones so stays in body/not excreted ✓ long half life so stays in body ✓	2	3.2a × 2	**ALLOW** converse **ALLOW** alpha to identify radium and vice versa etc. **ALLOW** least penetrating so stays in body

Question			Answer	Marks	AO element	Guidance
4	(a)	(i)	it is not a straight line / it is a curved line (over the whole range) / extension and force are not directly proportional ✓	2	2.1	**ALLOW** the line on the graph is non-linear / extension goes up more and more each time / same increase in force causes more extension / same increase in extension needs less force **IGNORE** the graph is a straight line up to 8N
			data from graph used to justify, e.g. doubling force from 6 N to 12 N increases extension from 24 cm to 60 cm (factor of 2.5 increase) ✓		3.1a	**ALLOW** it is not a constant gradient of 0.25 N/cm
		(ii)	**Any one from:** no, because plastic deformation means it won't return to its original length ✓	1	2.1	**ALLOW** force meter would need a non-linear scale **ALLOW** no because readings would not be proportional **Not just** it won't return to its original length
			yes if it was calibrated / yes if you plotted it on a graph and used the graph ✓			**ALLOW** yes, but lines on force meter would not be equally spaced
	(b)	(i)	spring does not return to original length/zero ✓ **OR** extension when the force is removed/is 12.5cm ✓	1	1.1	**ALLOW** spring does not return to original extension/shape
		(ii)	load the spring to a different mass/weight and unload ✓ until it does not return to its original length ✓ **OR** use graph to determine point at which straight line becomes a curve ✓ use a smaller range of loads around this point ✓	2	3.3a	**ALLOW** one marking point each for any of the below statements that relate to an alternative approach using more than one spring: test several springs load each spring to a different weight and unload measure length of spring before and after loading Dependent mark**,** only award this mark if the mark for using the graph has been awarded

Question			Answer	Marks	AO element	Guidance
	(c)		**FIRST CHECK THE ANSWER ON ANSWER LINE** **If answer = 0.51(kg) award 2 marks** Rearrange equation mass = weight ÷ g ✓ = 5.1 ÷ 10 = 0.51 (kg) ✓	**2**	**1.2** **2.1**	

Question			Answer	Marks	AO element	Guidance
5	(a)		228 ✓ 88 ✓	2	1.2 × 2	
	(b)		alpha (decay / particle / radiation) ✓ two neutrons and two protons / helium nucleus (lost from nucleus) ✓	2	1.1 × 2	 **ALLOW** 2n and 2p **ALLOW** mass number decreases by 4 **AND** two protons/two neutrons (lost) **ALLOW** He nucleus in nuclide notation
	(c)		arrow from [140,88] to [139,89] ✓	1	1.2	

Question			Answer	Marks	AO element	Guidance
6	(a)		**FIRST CHECK THE ANSWER ON ANSWER LINE** **If answer = 0.0011 (A) or 1.1 × 10^{-3} (A) award 4 marks**	4		
			Recall and rearrange current = p.d. ÷ resistance ✓		1.2	
			3.0 ÷ 2800 **or** 9.0 ÷ 8400 ✓ = 0.0011 or 1.1 × 10^{-3} (A) ✓		2.1 × 2	**ALLOW** (9.0/2800 =) 0.0032148257 **or** (3.0/8400 =) 0.00035714(= two marks)
			2 significant figures ✓		1.2	**ALLOW** any calculated value in mark point 3 to 2 s.f. (independent mark = one mark)
	(b)	(i)	brightness stays the same ✓	2	1.1	
			p.d. across each bulb is the same / 3.0 V ✓		2.1	
		(ii)	**Any one from:** (Circuit A because more cells so) torch will run for longer before new batteries needed ✓	1	3.2a	**IGNORE** lamps will be brighter
			(Circuit B because parallel circuit so) if one lamp breaks the others will not go out ✓			**ALLOW** some lamps can be on while others are off
			(Circuit B because only one cell so) more compact design possible / not as heavy ✓			**IGNORE** 'fewer batteries are needed'

Question			Answer	Marks	AO element	Guidance
7	(a)	(i)	correct shape of field lines ✓ arrows point away from north / towards south ✓	2	1.1 × 2	Minimum of one field line on each side of magnet. No overlapping of field lines. No converging of field lines into a single field line. Condone minor touching of field lines e.g. at the poles. 
		(ii)	at the poles **AND** field lines closest together/densest ✓	1	1.1	**IGNORE** at the North pole / at the South pole **DO NOT ALLOW** field lines converge to one point
	(b)		permanent magnet ✓ because it stays magnetised when moved away from the bar magnet / it keeps its magnetism / it loses its magnetism slowly ✓	2	1.1 × 2	 **DO NOT ALLOW** it is always magnetic

Question			Answer	Marks	AO element	Guidance
8	(a)		**Any two from:** X-rays shorter wavelength / visible light longer wavelength ✓ X-rays higher frequency / visible light lower frequency ✓ X-rays higher energy (photons) / visible light lower energy (photons) ✓ X-rays ionising / visible light non-ionising ✓ X-rays not detectable by human eye / visible light detectable by human eye **OR** X-rays can penetrate the body / visible light cannot penetrate the body ✓	**2**	**1.1 × 2**	Mark point 1, 2 and 3 must be comparative **DO NOT ALLOW** X-rays are more ionising than visible light
	(b)	**(i)**	**FIRST CHECK THE ANSWER ON ANSWER LINE** **If answer = 3.0 × 10^{18} (Hz) award 3 marks** recall and rearrange the wave equation to give frequency = speed ÷ wavelength ✓ conversion 0.10 (nm) = 1.0 × 10^{-10} (m) ✓ 3.0 × 10^{8} ÷ 1.0 × 10^{-10} = 3.0 × 10^{18} (Hz) ✓	**3** **1.2** **1.2** **2.1**	Maximum of one mark if incorrect conversion **ALLOW** 3 x 10^{8} ÷ 0.1 as evidence of a rearranged formula **ALLOW** 3 x 10^{18} / 3 000 000 000 000 000 000

Question			Answer	Marks	AO element	Guidance
		(ii)	**FIRST CHECK THE ANSWER ON ANSWER LINE** **If answer = 4980 (minutes) award 4 marks** recall and rearrange the speed equation to give e.g. distance = speed × time or time = distance ÷ speed ✓ recognise that speed of visible light = speed of X-rays ✓ distance travelled = $3 \times 10^8 \times (8.3 \times 60)$ **or** 1.494×10^{11} **or** $3 \times 10^8 \times 498$ ✓ time taken = $3 \times 10^8 \times 8.3 \div 500\,000 = 4980$ (minutes) **or** $1.494 \times 10^{11} \div (500\,000 \times 60) = 4980$ (minutes) ✓	4	1.2 1.1 2.1 x2	**ALLOW** max three marks if conversion from seconds to minutes omitted = 298800 seconds **ALLOW** max three marks if incorrect speed of light but all else is correct **ALTERNATIVE APPROACH:** t is proportional to 1/speed OR $t_{cloud}/t_{light} = v_{light}/v_{cloud}$ ✓ recognise that speed of visible light = speed of X-rays ✓ $t_{cloud} = (3 \times 10^8 \div 500\,000) \times 8.3$ ✓ = 4980 (minutes) ✓

Question			Answer	Marks	AO element	Guidance
9	(a)		change resistance of variable resistor ✓ record current and voltage readings (from ammeter and voltmeter) ✓ power = potential difference × current ✓	3	3.3a × 2 1.2	 **ALLOW** take the readings from the ammeter and the voltmeter **IGNORE** multiply the readings from the meters to get the power
	(b)		5 × 8 = 40 **OR** 6 × 9 = 54 ✓ 25/40 = 0.625 **AND** 32/54 = 0.593 ✓ **OR** 40/25 = 1.6 **AND** 54/32 = 1.6875 ✓ **OR** Y is 1.35 times bigger than X **AND** Y is 1.28 times more power than X ✓ Conclusion: Cell X is more effective (because it provides more power per unit area **or** less area is needed per watt) ✓	3	1.2 2.2 3.2a	Check space next to Fig. 9.1 **ALLOW** 0.592 or 0.59 **Dependent mark,** only award this mark if the conclusion is based on calculations
	(c)		**Any two from:** (installation/maintenance) cost / savings / pay-back time ✓ low pollution / no CO_2 / renewable / eco-friendly / sustainable / environmental impact ✓ (take up large) amount of space / size / surface area / appearance ✓ availability of light ✓	2	1.1 × 2	**IGNORE** efficiency

Question			Answer	Marks	AO element	Guidance
10	(a)		chemical to gravitational ✓ gravitational to kinetic in falling ✓ kinetic to thermal ✓	3	1.1 × 3	 **ALLOW** kinetic to heat energy If no other mark award one mark for a correct sequence of energy transfer e.g. chemical to thermal **IGNORE** sound / elastic
	(b)	(i)	**FIRST CHECK THE ANSWER ON ANSWER LINE** **If answer = 80 (J) award 2 marks** recall W = Fd and F = mg ✓ 1.6 × 10 × 5.0 = 80 (J) ✓	2	 1.2 2.1	 **ALLOW** GPE = mgh
		(ii)	**FIRST CHECK THE ANSWER ON ANSWER LINE** **If answer = 10 (m/s) award 3 marks** recall and rearrange the KE equation to give v = √(2E/m) ✓ v = √(2×80/1.6) ✓ = 10 (m/s) ✓	3	 1.2 2.1 × 2	**ALLOW ECF** from **(b)(i)** **ALLOW** rearranged $v^2 - u^2 = 2as$ to give v = √2as **ALLOW** g or a = 9.8 (gives 9.9 (m/s) = 3mks)

Question			Answer	Marks	AO element	Guidance
11	(a)		cooler / lower temperature ✓	1	1.1	
	(b)		**Any two from:** planet is closer to star / AW ✓ surface/it absorbs more (star) light / surface/it is darker / AW ✓ more greenhouse gases / greater greenhouse effect / more of named greenhouse gas ✓	2	2.1 × 2	**ALLOW ECF** converse arguments if higher or same temperature is given in **(a)** **ALLOW** atmosphere absorbs more radiation/traps more heat
	(c)		(James) **Any two from:** (although the probability is small) it would be a very important /significant / breakthrough discovery AW ✓ bigger telescopes are more likely to provide evidence for/against life ✓ money spent on telescopes is small fraction of total spending ✓ **OR** (Mia) **Any two from:** very small possibility of life ✓ bigger telescopes are very expensive ✓ specific example of other spending priority e.g. healthcare / education etc. ✓	2	3.1b × 2	**ALLOW** a bigger telescope will gather more information / be able to see more / we will be able to see if there is life **IGNORE** same conditions as Earth so there is a possibility of life **ALLOW** other technological advancements (from the money spent on development) **ALLOW** remote possibility of discovering life e.g. it is unlikely that we will find out **IGNORE** 'there are more important things'

Question			Answer	Marks	AO element	Guidance
12	(a)	(i)	**FIRST CHECK THE ANSWER ON ANSWER LINE** **If answer = 0.525 (J) award 3 marks** Recall P = E/t and rearrange to give energy transferred = power × time ✓ (For 1 kg of twistrons) 250 × 60 = 15 000 (J/kg) ✓ 15 000 × 3.5×10^{-5} = 0.525 (J) ✓	3	**1.2** **2.1 × 2**	Alternative route to mark point 2 and mark point 3: 250 (W/Kg) × 3.5×10^{-5} (Kg) = 8.75×10^{-3} (W) or 0.00875 (W) ✓ 8.75×10^{-3} × 60 (gains mp1 also) = 0.525 (J) ✓✓ **ALLOW** 0.005775 (= two marks – the candidate has given 1.1% of 0.525)
		(ii)	**FIRST CHECK THE ANSWER ON ANSWER LINE** **If answer = 910 (W) award 3 marks** recall and rearrange: total energy transferred = useful energy transferred ÷ efficiency ✓ (in one second) 10 ÷ 0.011 = 909.09 ✓ = 910 (W) ✓	3	**1.2** **2.1 × 2**	**ALLOW** two marks for 9.1 (did not convert percentage, rounded to 2 s.f.) **ALLOW** one mark for 9.0909…, 9.09, etc. (did not convert percentage, did not round to 2 s.f.) **ALLOW** any calculated value in mark point 2 to 2 s.f. (independent mark = one mark)
	(b)	(i)	reduce burning of fossil fuels / emission of greenhouse gases / no contribution to global warming ✓ **OR** small-scale energy generation in developing countries ✓ **OR** other reasonable suggestion e.g. incentive to exercise **or** reduce need for power stations **or** use to charge phone ✓	1	**1.1**	**IGNORE** vague comments e.g. 'environmental impact', renewable, sustainable, non-polluting, cheaper

Question			Answer	Marks	AO element	Guidance
		(ii)	idea of communication to a non-specialist audience ✓	1	3.1b	**ALLOW** for marketing to the public / so the public/people can understand it more/know what it means **IGNORE** more likely to buy it/invest in it **IGNORE** to make it easy to remember / so people know about it

Question			Answer	Marks	AO element	Guidance
13	(a)		pressure is due to the weight of water above ✓ which increases with depth ✓	2	1.1 × 2	**ALLOW** due to the effect of gravity on the mass of water above ✓ **ALLOW** $P = h \rho g$ ✓✓
	(b)	(i)	100 (kPa) ✓	1	2.2	**IGNORE** units **ALLOW** 100 000 (Pa) **DO NOT ALLOW** students estimating x-axis intercept
		(ii)	pressure at surface ✓ due to weight of air in the atmosphere / due to air pressure ✓	2	2.1 1.1	**ALLOW** pressure at/above sea level / at 0 m
	(c)	(i)	**FIRST CHECK THE ANSWER ON ANSWER LINE** **If answer = 10.25 (kPa/m) award 2 marks** 410 ÷40 **or** 310 ÷ 30 ✓ = 10.25 **or** 10.33 (kPa/m) ✓	2	2.2 × 2	**ALLOW** 10 250 (Pa/m) for 2 marks **ALLOW** 10.20 to 10.33 for 2 marks **ALLOW** 10.0 to 10.19 or 10.34 to 10.5 for 1 mark
		(ii)	**FIRST CHECK THE ANSWER ON ANSWER LINE** **If answer = 1025 (kg/m^3) award 2 marks** 10.25 × 1000 = 10 250 (Pa) ✓ 10 250 / 10 = 1025 (kg/m^3) ✓	2	2.1 × 2	**ALLOW ECF** from **(c)(i)** **ALLOW** 1 mark ECF if an attempt has been made to convert kPa to Pa and the answer is correctly divided by 10 for MP3

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