

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.

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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

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.

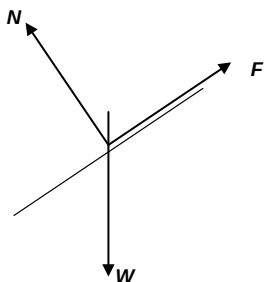
You should ensure also that you are familiar with the administrative procedures related to the marking process. These are set out in the OCR booklet **Instructions for Examiners**. If you are examining for the first time, please read carefully **Appendix 5 Introduction to Script Marking: Notes for New 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 $\times$ specific latent heat ✓ Conversion 20 g = 0.020 kg ✓ 334 000 $\times$ 0.020 = 6680 (J) ✓	3	1.2 1.2 2.1	ALLOW 6.68 $\times 10^3$ / 6700 / 6.7 $\times 10^3$ 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 $\times$ 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 $\times$ 2	ALLOW AVP e.g. use solid CO ₂ that sublimates 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.

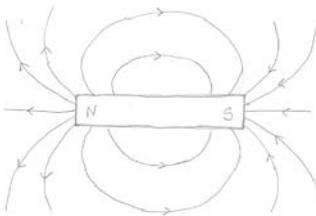
Question			Answer	Marks	AO element	Guidance
3	(a)		contamination effect ✓ (because the isotope/source/it) is inside/on the body ✓	2	1.1 × 2	
	(b)		it emits <u>ionising</u> radiation (which mutates DNA / cells) ✓	1	1.1 × 1	DO NOT ALLOW 'causes cancer / radiation sickness' on its own
	(c)		Any two from: (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 ✓ 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) ✓	2	2.1 3.1a	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 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 ✓ yes if it was calibrated / yes if you plotted it on a graph and used the graph ✓	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 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 $\text{mass} = \text{weight} \div g$ ✓ $= 5.1 \div 10 = 0.51 \text{ (kg)}$ ✓	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 Recall and rearrange current = p.d. $\div$ resistance ✓ 3.0 $\div$ 2800 or 9.0 $\div$ 8400 ✓ = 0.0011 or 1.1×10^{-3} (A) ✓ 2 significant figures ✓	4	1.2 2.1 $\times$ 2 1.2	ALLOW (9.0/2800 =) 0.0032148257 or (3.0/8400 =) 0.00035714(= two marks) ALLOW any calculated value in mark point 3 to 2 s.f. (independent mark = one mark)
	(b)	(i)	brightness stays the same ✓ p.d. across each bulb is the same / 3.0 V ✓	2	1.1 2.1	
		(ii)	Any one from: (Circuit A because more cells so) torch will run for longer before new batteries needed ✓ (Circuit B because parallel circuit so) if one lamp breaks the others will not go out ✓ (Circuit B because only one cell so) more compact design possible / not as heavy ✓	1	3.2a	IGNORE lamps will be brighter ALLOW some lamps can be on while others are off 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 $0.10 \text{ (nm)} = 1.0 \times 10^{-10} \text{ (m)}$ ✓ $3.0 \times 10^8 \div 1.0 \times 10^{-10} = 3.0 \times 10^{18} \text{ (Hz)}$ ✓	3	1.2 1.2 2.1	Maximum of one mark if incorrect conversion ALLOW $3 \times 10^8 \div 0.1$ as evidence of a rearranged formula ALLOW $3 \times 10^{18} / 3\,000\,000\,000\,000\,000\,000$

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 $\times$ time or time = distance $\div$ 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 $t_{\text{cloud}}/t_{\text{light}} = v_{\text{light}}/v_{\text{cloud}}$ ✓ recognise that speed of visible light = speed of X-rays ✓ $t_{\text{cloud}} = (3 \times 10^8 \div 500\,000) \times 8.3$ ✓ = 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 $F = mg$ ✓ $1.6 \times 10 \times 5.0 = 80 \text{ (J)}$ ✓	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 $v = \sqrt{2E/m}$ ✓ $v = \sqrt{2 \times 80 / 1.6}$ ✓ $= 10 \text{ (m/s)}$ ✓	3	1.2 2.1 × 2	ALLOW ECF from (b)(i) ALLOW rearranged $v^2 - u^2 = 2as$ to give $v = \sqrt{2as}$ 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 $\times$ time ✓ (For 1 kg of twistrans) $250 \times 60 = 15\,000$ (J/kg) ✓ $15\,000 \times 3.5 \times 10^{-5} = 0.525$ (J) ✓	3	1.2 2.1 $\times$ 2	Alternative route to mark point 2 and mark point 3: 250 (W/Kg) $\times 3.5 \times 10^{-5}$ (Kg) = 8.75×10^{-3} (W) or 0.00875 (W) ✓ $8.75 \times 10^{-3} \times 60$ (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 $\div$ efficiency ✓ (in one second) $10 \div 0.011 = 909.09$ ✓ = 910 (W) ✓	3	1.2 2.1 $\times$ 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/m³) 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