

GCSE (9–1)

Physics B (Twenty First Century Science)

J259/03: Breadth in physics (Higher Tier)

General Certificate of Secondary Education

Mark Scheme for November 2020

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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

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)		(D) bubble wrap reduces conduction / has low thermal conductivity ✓ thicker insulation / more layers reduces heat loss (so slower than C) ✓ OR (E) bubble wrap reduces conduction / has low thermal conductivity ✓ metal foil reduces heat loss by radiation ✓	2	3.2a	ALLOW one mark for C and bubble wrap reduces conduction / has low thermal conductivity ALLOW bubble wrap doesn't conduct instead of low conductivity. IGNORE convection ALLOW foil reflects thermal radiation.
	(b)	(i)	experiment gives the same results / same data ✓ if performed by another person / with similar equipment / in a different lab ✓	2	1.1	
		(ii)	Any one from: size / shape / thickness / material of tin ✓ volume / mass of water ✓ temperature of surroundings ✓	1	2.1	ALLOW amount of water

Question			Answer	Marks	AO element	Guidance
2	(a)	(i)	(use of biofuels has) increased ✓	1	3.1a	Increase could be shown by use of data.
		(ii)	Any one from: use of biofuels has been encouraged/government incentives, ✓ more cost effective ✓ to reduce carbon (dioxide) emissions, ✓ to make use of by-products/waste materials. ✓	1	3.1a	IGNORE renewable ALLOW cheap/not expensive. ALLOW to reduce/prevent climate change
	(b)	(i)	Any one from: trend shows (large) increase in wind ✓ trend shows nuclear staying the same/ (slight) increase ✓ AND any one from: (supports statement because) if trends continue we will use more wind than nuclear ✓ (does not support statement because) we do not know if the trends will continue in the future ✓	2	3.1b	ALLOW nuclear not (significantly) changed ALLOW evaluation based on both trends e.g. the evidence / it support this statement because wind is increasing and nuclear is not [2]
		(ii)	data includes nuclear which is not renewable ✓	1	3.2b	DO NOT ALLOW biofuel is not renewable.
		(iii)	any value from 9(%) to 10(%) ✓	1	2.2	

Question			Answer	Marks	AO element	Guidance
3	(a)		electrons (in atoms) ✓ lose energy ✓	2	1.1	ALLOW electrons change energy levels (2 marks) DO NOT ALLOW beta decay or emission of particles
	(b)	(i)	(ultraviolet radiation is) ionising ✓ damages / mutates DNA or cells OR causes cancer/tumours ✓	2	1.1	ALLOW kills cells
		(ii)	(ultraviolet radiation) cannot penetrate the steel casing ✓	1	3.2 b	ALLOW radiation absorbed by steel casing ALLOW steel casing reflects (ultraviolet radiation inside the container).
	(c)		Any two from: (alpha radiation) not penetrating enough (to disinfect all of the water) ✓ alpha-emitting isotope could contaminate water supply ✓ activity of alpha source will fall with time ✓ risk of handling alpha <u>source</u> ✓	2	1.1	ALLOW alpha radiation cannot penetrate water DO NOT ALLOW alpha particles remain in the water IGNORE alpha cannot penetrate the steel case ALLOW alpha source may have a short half-life

Question			Answer	Marks	AO element	Guidance
4	(a)		FIRST CHECK THE ANSWER ON ANSWER LINE If answer = 3.17×10^{29} award 3 marks recall momentum = mass $\times$ velocity ✓ $2.73 \times 10^{24} \times 116\,000$ ✓ 3.17×10^{29} (kg m/s) ✓	3	1.2 2 $\times$ 2.1	ALLOW 3.2×10^{29} ALLOW up to 2 marks for the correct calculation using data for the wrong planet Planet 2: $6.26 \times 10^{25} \times 89\,000 = 5.57 \times 10^{30}$ (kg m/s) or 5.6×10^{30} Planet 3: $3.87 \times 10^{25} \times 59\,000 = 2.28 \times 10^{30}$ (kg m/s) or 2.3×10^{30}
	(b)	(i)	velocity depends on/has direction ✓ (due to force of gravity) direction changes ✓	2	1.1	ALLOW velocity is a vector quantity ALLOW force of gravity is always towards the centre of the orbit.
		(ii)	force of gravity is weaker at larger radius ORA ✓ so slower speed needed to maintain a stable orbit/constant radius ORA ✓	2	1.1	ALLOW centripetal force/force/gravity gets weaker with distance ALLOW so (a faster planet) would not stay in orbit / so not strong enough to change direction (of a faster planet)

Question			Answer	Marks	AO element	Guidance
5	(a)	(i)	our eyes (only) detect a (narrow) range of frequencies ✓ this range does not include radio waves ✓	2	1.1	ALLOW wavelength for frequency ALLOW the frequency is out of range ALLOW the frequency is too low ALLOW the frequency is below the visible range = 2 marks ALLOW radio waves are not in the range of frequencies our eyes can detect = 2 marks
		(ii)	FIRST CHECK THE ANSWER ON ANSWER LINE If answer = 0.67 award 4 marks 446 MHz = 446×10^6 Hz ✓ = $3.0 \times 10^8 \div 446 \times 10^6$ ✓ = 0.67264.... (m) ✓ = 0.67 (m) (2sf) ✓	4	1.2 2.1 × 2 1.2	ALLOW substitution and calculation using their conversion ALLOW their calculated value seen and converted to 2 s.f.
	(b)		<u>oscillations</u> (in the electrical circuits) ✓	1	1.1	

Question			Answer	Marks	AO element	Guidance
6	(a)		FIRST CHECK THE ANSWER ON ANSWER LINE If answer = 5.0 (m/s²) award 3 marks recall acceleration = change in velocity ÷ time ✓ 25 × 0.5 = 12.5 ✓ (25 × 0.5 OR 12.5) ÷ 2.5 ✓ = 5.0 (m/s ²) ✓	4	1.2 × 2 2.1 × 2	ALLOW final answer to be either negative or positive. ALLOW 5 ALLOW max 3 if incorrect calculation of change in speed
	(b)		FIRST CHECK THE ANSWER ON ANSWER LINE If 5000 ≤ answer ≤ 18000 award 4 marks recall momentum = mass × velocity AND rearrange force = change in momentum ÷ time ✓ estimate of mass ✓ (16 × estimate of mass) ÷ 2.2 ✓ 5000 to 18000 (N) (inclusive) ✓	4	1.2 × 2 2.1 × 2	Values given based on mass for car being between 700kg to 2500kg. ALLOW recall Force = mass × acceleration AND a = ΔV ÷ t ALLOW (±) 7.27 (m/s ²) seen

Question			Answer	Marks	AO element	Guidance
7	(a)		(measure mass using) balance AND (measure volume using) measuring cylinder ✓ AND any two from: accuracy of balance specified, e.g. 1 g or 0.1 g ✓ method to compensate for mass of container ✓ read volume at eye level to avoid parallax error ✓ read volume from bottom of meniscus ✓	3	1.2	
	(b)		FIRST CHECK THE ANSWER ON ANSWER LINE If answer = 7.18×10^{-4} award 2 marks $0.12 \times 0.13 \times 0.046 / 0.0007176 / 7.176 \times 10^{-4}$ ✓ 7.18×10^{-4} ✓	2	2.1 1.2	
	(c)		put sample of yoghurt in a syringe ✓ read volume from <u>scale</u> on syringe ✓ OR fill container to top and ensure top is level ✓ refill container with water and then measure volume of <u>water</u> with <u>measuring cylinder</u> ✓	2	3.3a	ALLOW other sensible suggestions reasonable idea to accurately contain a sample in a measurable volume or a known volume ✓ specifies method for measuring this volume ✓ IGNORE pour it in a container

Question			Answer	Marks	AO element	Guidance
8	(a)	(i)	(measure length of tray with) ruler / tape measure ✓ (measure time using) timer / stop clock / stopwatch ✓ AND any one from: measure time to travel several lengths of tray ✓ video the waves and replay in slow motion ✓	3	1.2	ALLOW e.g. paper marked in centimetres IGNORE measure the time / measure the distance
		(ii)	Any one from: method to drop tray identically, e.g. rest end of tray on book, then remove book ✓ alternative method to generate waves, e.g. use vibrating dipper/bar as in a ripple tank ✓	1	3.3b	ALLOW drop tray from same height or tip the tray to the same angle / stated angle IGNORE vague methods e.g. use a machine to drop the tray ALLOW e.g. use a ripple tank/apparatus with a set frequency or use a vibrating motor
	(b)	(i)	point plotted to within half a small square ✓	1	2.2	
		(ii)	as depth increases speed increases ✓ description of non-linear relationship / idea that the variables are not proportional ✓	2	3.1a	
		(iii)	Line drawn up from x-axis and along to y-axis ✓ any value between 0.1 and 0.2 ✓	2	2.2	Rationale for these values is that the candidate should recognise it is a curve and extrapolate using a curve, not a straight line.

Question			Answer	Marks	AO element	Guidance
9	(a)		(some energy is transferred by) radiation / electromagnetic waves / gamma rays ✓ (some energy is transferred to/from a store of) kinetic energy of the particles ✓	2	1.1	DO NOT ALLOW thermal energy (given in (b)(ii)) ALLOW the KE of the neutron
	(b)	(i)	Any two from: More neutrons so more fission ✓ More uranium for the neutrons to hit ✓ The neutron(s) released in one fission go on to cause more fissions ✓	2	1.1	ALLOW neutrons released in one fission go on to cause further reactions / split more nuclei = 2 marks
	(b)	(ii)	(coolant A) because difference in density is larger than difference in specific heat capacity ✓ calculation to support argument (e.g. s.h.c. of B is 8.7 times greater than A, but density of A is 12.8 times greater than B) ✓	2	3.2b	ALLOW A has lower shc but it is a lot more dense Alternative approach: A removes more energy per m ³ per °C e.g. 150 x 11000 = 1.65 MJ/m ³ °C but 1300 x 860 = 1.118 MJ/m ³ °C

Question			Answer	Marks	AO element	Guidance
10	(a)		Any one from: (vibration in P-waves is) parallel / same direction, ✓ (vibration in S-waves is) perpendicular / right angles ✓ AND to direction of travel / propagation / energy transfer / AW ✓	2	1.1	independent mark
	(b)	(i)	S-waves do not travel through liquids / <u>only</u> travel through solids ✓ liquid in Earth's core has blocked / reflected S-waves ✓	2	2.1	IGNORE references to P-waves
		(ii)	waves reflect from boundaries ✓ waves pass through mantle by reflection / refraction / diffraction ✓	2	2.1	ALLOW wave passing through mantle and reflecting from crust or core on diagram = 2 marks

Question			Answer	Marks	AO element	Guidance
11	(a)		resultant force must be zero ✓	1	1.1	ALLOW net force is zero IGNORE balanced / all forces are equal
	(b)	(i)	downwards arrow drawn ✓ labelled weight / force of gravity / contact force ✓	2	2.1	ALLOW gravity
		(ii)	They (both) accelerate upwards ✓ OR Elastic rope contracts/shortens/tension becomes zero, pulling the metal ring up ✓	1	2.1	

Question			Answer	Marks	AO element	Guidance
12	(a)		wavelength / colour (of emitted light) depends on temperature ✓ the stars have different temperatures ✓	2	1.1	ALLOW C has shortest wavelength / B has longest wavelength ALLOW C is the hottest / B is the coolest / blue is hotter than red ORA ALLOW hottest star / C has shortest wavelength / is bluer OR coolest star / B has longest wavelength / is redder =2 marks IGNORE different colours have different wavelengths - stem
	(b)	(i)	FIRST CHECK THE ANSWER ON ANSWER LINE If answer = 625 award 3 marks recall / rearrange time = distance ÷ speed ✓ ($6 \times 10^{18} \div 3.0 \times 10^8 =$) 2×10^{10} (s) ✓ ($2 \times 10^{10} \div 3.2 \times 10^7 =$) 625 (years) ✓	3	1.2 2 × 2.1	ALLOW 1 mark for 2×10^n , $n \neq 10$ ALLOW 2 marks for 6.25×10^n , $n \neq 2$
		(ii)	(all electromagnetic radiation) travels at the same speed (in space) ✓	1	2.1	ALLOW travels at the speed of light

Question			Answer	Marks	AO element	Guidance
13	(a)		FIRST CHECK THE ANSWER ON ANSWER LINE If answer = 224 award 4 marks 5.0 cm = 0.050 m ✓ Select equation: $E = \frac{1}{2} kx^2$ ✓ Substitute (and rearrange); $k = 2 \times 0.28 / 0.05^2$ ✓ 224 (N/m) ✓	4	1.2 1.2 2.1 × 2	ALLOW 3 marks if unit conversion omitted (0.0224)
	(b)		FIRST CHECK THE ANSWER ON ANSWER LINE If answer = 4 award 3 marks recall $\frac{1}{2} mv^2$ and rearrange to give: $v = \sqrt{(2E/m)}$ ✓ substitute: $v = \sqrt{(2 \times 0.32 / 0.040)}$ ✓ 4.0 (m/s) ✓	3	1.2 2.1 × 2	ALLOW 2 marks for 16
	(c)	(i)	work done = force × distance moved ✓	1	1.2	ALLOW $W = Fs$
		(ii)	FIRST CHECK THE ANSWER ON ANSWER LINE If answer = 0.0625 award 4 marks calculate GPE gain: $0.040 \times 10 \times 0.50 / 0.20$ (J) ✓ calculate thermal energy transfer: $(0.25 - 0.20 =) 0.05$ J ✓ substitute into work done equation: $0.05 = F \times 0.80$ ✓ calculate F: 0.0625 (N) ✓	4	2.1	

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