Oxford Cambridge and RSA

H

GCSE (9–1)

Physics A (Gateway Science)

J249/04: Paper 4 (Higher Tier)

General Certificate of Secondary Education

Mark Scheme for Autumn 2021

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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.

1. 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

2. 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

3. **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**.

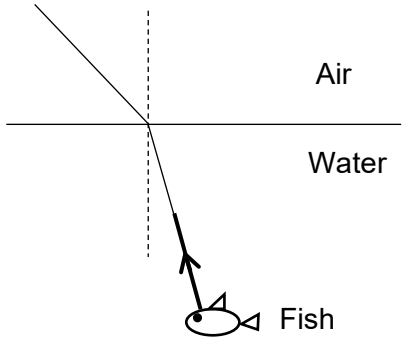
Please ask for help or guidance whenever you need it. Your first point of contact is your Team Leader.

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

	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.

For answers to Section A if an answer box is blank ALLOW correct indication of answer e.g. circled or underlined.

Question			Answer	Marks	AO element	Guidance
1			C ✓	1	2.1	
2			C ✓	1	2.1	
3			B ✓	1	1.1	
4			C ✓	1	2.1	
5			A ✓	1	1.1	
6			D ✓	1	1.1	
7			C ✓	1	1.1	
8			C ✓	1	1.1	
9			A ✓	1	1.2	
10			B ✓	1	1.1	
11			C ✓	1	2.2	
12			B ✓	1	1.1	
13			D ✓	1	2.1	
14			C ✓	1	1.2	
15			D ✓	1	1.1	

Question			Answer	Marks	AO element	Guidance
16	(a)	(i)	Any **one** from: It is refracted ✓ It changes direction/bends (away from the normal) ✓ The speed <u>increases</u> ✓ The wavelength <u>increases</u> ✓	1	1.1	**DO NOT ALLOW** bends towards the normal **IGNORE** speed/wavelength changes **DO NOT ALLOW** the speed/wavelength decreases
		(ii)	Ray continues in a straight line **AND** normal line drawn (90° by eye relative to interface) where incident ray meets the interface ✓ Ray enters the air **AND** is to the left of the normal line ✓ angle of refraction > angle of incidence **AND** angle of incidence < 90° ✓  	3	3 × 1.2	**DO NOT ALLOW** if the ray emerges vertically or to the right-hand side of the normal **IGNORE** any reflected rays **IGNORE** direction of any arrows **ALLOW** marking points 2 and 3 to be awarded if the ray does not come from the fish
	(b)		At least two of the rays are reflected in different directions ✓	1	1 × 1.2	**IGNORE** any normal lines
	(c)		The fish <u>absorbs</u> the green (light) / <u>does not reflect</u> the green (light) / the fish reflects red (light) <u>only</u> ✓ There is no red (light) (to reflect) / the (green) light contains no red (light) / no light is reflected ✓	2	2 × 2.1	

Question			Answer	Marks	AO element	Guidance
17	(a)	(i)	2 or 3 correctly plotted points to within ½ small square ✓ 4 points correctly plotted to within ½ small square ✓ Smooth curved line of best fit through most points ✓	3	3 × 2.2	**DO NOT ALLOW** a straight line of best fit **ALLOW ECF** from incorrectly plotted points
		(ii)	Candidate's line of best fit extended to 2.00 **AND** their value of p.d. is correct for their graph ✓ Value of p.d. = 2.55 – 2.70 ✓	2	2 × 3.2b	**IGNORE** line of best fit past 2.00
		(iii)	Any **one** from: Repeat readings and calculate the mean/discard anomalies✓ Carry out investigation in the dark / reduce ambient light ✓ Use a greater range / more values of light intensity ✓ Use higher light intensities ✓ Use a light meter to check light intensity ✓	1	3.3b	
	(b)	(i)	Any **two** from: To reduce energy bills / sell electricity (back to national grid) ✓ People are more aware of environmental issues / they are better for the environment ✓ To reduce reliance on/use of fossil fuels / fossil fuels are running out ✓ To reduce CO_2 / greenhouse emissions / global warming ✓ They are cheaper (than 20 years ago) ✓ The government has encouraged people to install them / grants available to fit them ✓ More efficient / better/newer panels/technologies are now available ✓	2	2 × 3.2a	**IGNORE** people are more environmentally friendly/green. **ALLOW** they use a renewable energy resource **IGNORE** they weren't available twenty years ago.

Question			Answer	Marks	AO element	Guidance
17		(ii)	Maximum **two** from: (24 ÷ 1.6 =) 15 panels ✓ (15 × 26 =) 390 MJ / maximum energy he could generate > energy required / maximum energy is 26 MJ greater ✓ **OR** (364 ÷ 26 =) 14 panels ✓ (14 × 1.6 =)22.4 m^2 / area of panels required < area of roof / area of panels is 1.6 m^2 greater ✓ And any **one** from: When it is night/cloudy/dark/sun not at highest point energy output would/could be too low ✓ Would need (batteries) to store energy / to obtain energy at night / may need back-up power/generator ✓ Amount of energy generated can change with weather/seasons so may be less ✓	**3**	**3 × 3.1b**	**ALLOW** 390 MJ / maximum energy is 26 MJ greater for 2 marks **ALLOW** 22.4 m^2 / area of panels is 1.6 m^2 greater for 2 marks

Question			Answer	Marks	AO element	Guidance
18	(a)		Nuclear Thermal ✓	1	2.1	**BOTH** required **DO NOT ALLOW** more than one energy store on each answer line
	(b)	(i)	Any **one** from: The nucleus is unstable / to make the nucleus more stable ✓ So the energy of the nucleus reduces / to get rid of energy from the nucleus ✓	1	1.1	**IGNORE** because it is radioactive (already in the stem)
		(ii)	234 ✓ 92 ✓	2	2 × 1.1	
	(c)		**FIRST CHECK THE ANSWER ON ANSWER LINE** **If answer = 85-90 (years) award 2 marks** Evidence on graph (or elsewhere) of half of activity indicated ✓ Half-life = 85-90 (years) ✓	2	2 × 2.2	
	(d)	(i)	(when neutron is absorbed, nucleus splits and) releases more / several / (>1) <u>neutrons</u> ✓ Each (additional) neutron can be absorbed by another (plutonium) nucleus ✓	2	2 × 1.1	**IGNORE** nucleus releases another neutron. **ALLOW** a suitable diagram for two marks. **IGNORE** atom/plutonium for nucleus **IGNORE** hits nucleus
		(ii)	Two <u>nuclei</u> combine (at very high temperature) ✓	1	1.1	

Question			Answer	Marks	AO element	Guidance
19	(a)		**FIRST CHECK THE ANSWER ON ANSWER LINE** **If answer = 260 (s) award 4 marks** (time =) distance ÷ speed ✓ distance = ($2.28 \times 10^{11} - 1.50 \times 10^{11}$ =) 7.8×10^{10} (m) ✓ (time =) $7.8 \times 10^{10} \div 300\,000\,000$ ✓ (time =) 260 (s) ✓	4	**1.2** **3 × 2.1**	**ALLOW** 0.8 x 10^{11} (m)
	(b)		(Mars is further from the Sun) so receives less energy/heat from the Sun/sunlight ✓ Temperature on Mars is lower ✓	2	**2 × 3.2b**	**ALLOW** other sensible explanation. e.g. Mars has a thin atmosphere / does not have an atmosphere so there is little/no greenhouse effect (AW) **ALLOW** it is difficult to know without knowing about the atmosphere on Mars

Question			Answer	Marks	AO element	Guidance
20	(a)		**FIRST CHECK THE ANSWER ON ANSWER LINE** **If answer = 0.7 OR 70% award 3 marks** (Efficiency =) useful energy output ÷ energy input ✓ (Efficiency =) 8400 ÷ 12000 or 70 ✓ (Efficiency =) 0.7 ✓	3	**1 × 1.2** **2 × 2.1**	**ALLOW** equation in any form **ALLOW** 70 (without % sign) for 2 marks **ALLOW** 0.7% for 2 marks
	(b)		**FIRST CHECK THE ANSWER ON ANSWER LINE** **If answer = 40 (W) award 3 marks** (Power =) energy transferred ÷ time ✓ (Power =) 12000 ÷ 300 ✓ (Power =) 40 (W) ✓	3	**1 × 1.2** **2 × 2.1**	**ALLOW** 2400 (W) for 2 marks (no unit conversion) **ALLOW** equation in any form

Question			Answer	Marks	AO element	Guidance
20	(c)*		Please refer to the marking instructions on page 4 of this mark scheme for guidance on how to mark this question. **Level 3 (5–6 marks)** Detailed explanation of how equipment is used to take appropriate measurements **AND** Detailed explanation of how the quantities are calculated. *There is a well-developed line of reasoning which is clear and logically structured. The information presented is relevant and substantiated.* **Level 2 (3–4 marks)** Detailed explanation of how equipment is used to take appropriate measurements **OR** Detailed explanation of how the quantities are calculated **OR** Explanation of how equipment is used to take appropriate measurements **AND** explanation of how the quantities are calculated. *There is a line of reasoning presented with some structure. The information presented is relevant and supported by some evidence.* **Level 1 (1–2 marks)** Simple explanation of how equipment is used to take appropriate measurements **OR** Simple explanation of how the quantities are calculated. **OR** correct equation stated.	6	**2 × 1.2** **4 × 3.3a**	**AO3 – Analyses information to develop a method to calculate energy input and energy output** • p.d./voltage measured with voltmeter • Current measured with ammeter • Mass of water measured with top-pan balance (allow weighing scales) or volume of water measured using measuring cylinder and density of water used • Temperature change measured using thermometer / temperature probe attached to data-logger • Heater used for a fixed time / AW measured with stopwatch • Keep temperature changes low / fully immerse immersion heater in water / do not touch hot immersion heater / insulate the beaker • Stopwatch used to measure time **AO1 – Demonstrates knowledge of scientific ideas to work out energy input and energy output** • Energy input = power (of heater) × time • Power (of heater) = current × p.d. • Energy input = I × V × t • Energy increase in water = mass × SHC × temperature rise • Mass of water = density × volume

Question			Answer	Marks	AO element	Guidance
			There is an attempt at a logical structure with a line of reasoning. The information is in the most part relevant. **0 marks** *No response or no response worthy of credit.*			

Question			Answer	Marks	AO element	Guidance
21	(a)	(i)	**FIRST CHECK THE ANSWER ON ANSWER LINE** **If answer = 1.6 (J) award 3 marks** (Energy transferred in stretching =) ½ × 40 × 0.2^2 ✓ (Energy transferred in stretching =) 0.8 (J) ✓ (Total energy transferred in stretching =) 2 × 0.8 = 1.6 (J) ✓	3	**1 × 1.2** **2 × 2.1**	
	(b)		**Any two from:** Not all of the elastic (potential) energy is converted into kinetic energy ✓ Some energy is converted to gravitational potential energy (store) ✓ Total energy (in a system) must be constant / mention of conservation of energy ✓	2	**2 × 2.1**	**ALLOW** Some energy converted to thermal energy store/surroundings for **1** mark. **ALLOW** Kinetic energy = elastic (potential) energy – gravitational potential energy for 2 marks
	(c)		**FIRST CHECK THE ANSWER ON ANSWER LINE** **If answer = 4.8 (m) award 4 marks** (Height =) potential energy ÷ (mass × gravitational field strength) **OR** EPE = GPE✓ g = 10 N/kg ✓ (Height =) 2.4 / (0.05 × 10) ✓ (Height =) 4.8 (m) ✓	4	**2 × 1.2** **2 × 2.1**	**ALLOW** Use of 9.8 N/kg and 9.81 N/kg for g Use of 9.8 or 9.81 gives 4.9 (m) (to 2SF) **ALLOW** POT (power of ten) error for incorrect conversion of mass for 3 marks
	(d)		Ensure springs extended by the same length each time / use the same springs / same spring constant ✓	1	**3.3a**	**ALLOW** constant diameter of the ball **IGNORE** Use the same equipment.

Question			Answer	Marks	AO element	Guidance
22	(a)		**FIRST CHECK THE ANSWER ON ANSWER LINE** **If answer = 12.0 (s) award 3 marks** (time =) change in velocity ÷ acceleration ✓ (time =) (18 – 0) ÷ 1.5 ✓ (time =) 12.0 (s) ✓	**3**	 **1 × 1.2** **2 × 2.1**	**ALLOW** 12 (s)
	(b)		Any **one** from: Thinking distance unchanged (by ice) ✓ Stopping distance = thinking distance + braking distance ✓ **AND** any **two** from: Friction/force between tyres and road reduced ✓ Initial kinetic energy of van is the same ✓ Since distance = work done ÷ force (or energy ÷ force) ✓ Braking distance becomes greater / stopping distance is greater ✓	**3**	**1.1** **2 × 2.1**	
	(c)		Any **two** from: Acceleration will increase ✓ Force = mass × acceleration ✓ So greater force (acting on occupants) ✓ And this could lead to injury (of occupants of the van) ✓	**2**	**2 × 2.1**	**ALLOW** Higher ideas about momentum **ALLOW** Rate of change of momentum is greater ✓ **ALLOW** Force = rate of change of momentum ✓

Question			Answer	Marks	AO element	Guidance
23	(a)		Our eyes can only detect / we can only see a small part of the EM spectrum/visible light ✓ So new inventions/technology/machines were needed (to detect beyond visible light) ✓	2	2 × 1.2	**ALLOW** we cannot see UV/IR **ALLOW** machines/inventions/technology were not available to detect it
	(b)		**FIRST CHECK THE ANSWER ON ANSWER LINE** **If answer = 1.7×10^{15} (Hz) award 5 marks** $0.18\mu m = 1.8 \times 10^{-7}$ m ✓ (Frequency =) wave speed ÷ wavelength ✓ (Frequency =) $3.0 \times 10^{8} \div 1.8 \times 10^{-7}$ ✓ (Frequency =) $1.666666... \times 10^{15}$ ✓ (Frequency =) 1.7×10^{15} (Hz) (2sf) ✓	5	3 × 1.2 2 × 2.1	**ALLOW** 3 marks for 1.6666×10^{n} (POT and SF error) **ALLOW** 4 marks for 1.7×10^{n} (POT error) **ALLOW** 1 mark for their value of frequency rounded correctly to 2SF
	(c)	(i)	(Transmission) at 0.31μm = 9-11 % **AND** (Transmission) at 0.37μm = 41 % ✓ Absorption at 0.31μm = 89-91 % **AND** Absorption at 0.37μm = 59 % ✓ (much) more UV is absorbed at 0.31μm compared to 0.37μm / ORA ✓	3	3 × 3.1a	**ALLOW** the difference in transmission is between 30-32% **ALLOW** the difference in absorption is between 30-32% **ALLOW ECF** 100 minus their value from graph for absorption values **ALLOW** more UV is absorbed at shorter wavelengths / ORA
		(ii)	Any **TWO** from: Ozone layer absorbs/prevents <u>most/lots/some</u> UV / ORA ✓ Ozone layer absorbs the most dangerous UV ✓ (wavelengths)	2	2 × 2.1	**DO NOT ALLOW** Ozone absorbs <u>all</u> UV. **ALLOW** UV is harmful (to humans)

Question			Answer	Marks	AO element	Guidance
			(Too much) UV causes (skin) cancer/damages (skin) cells ✓			

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