Mark Scheme (Results)

November 2021

General Marking Guidance

- All candidates must receive the same treatment. Examiners must mark the first candidate in exactly the same way as they mark the last.

- Mark schemes should be applied positively. Candidates must be rewarded for what they have shown they can do rather than penalised for omissions.

- Examiners should mark according to the mark scheme not according to their perception of where the grade boundaries may lie.

- There is no ceiling on achievement. All marks on the mark scheme should be used appropriately.

- All the marks on the mark scheme are designed to be awarded. Examiners should always award full marks if deserved, i.e. if the answer matches the mark scheme. Examiners should also be prepared to award zero marks if the candidate's response is not worthy of credit according to the mark scheme.

- Where some judgement is required, mark schemes will provide the principles by which marks will be awarded and exemplification may be limited.

- When examiners are in doubt regarding the application of the mark scheme to a candidate's response, the team leader must be consulted.

- Crossed out work should be marked UNLESS the candidate has replaced it with an alternative response.

Mark schemes have been developed so that the rubrics of each mark scheme reflects the characteristics of the skills within the AO being targeted and the requirements of the command word. So for example the command word 'Explain' requires an identification of a point and then reasoning/justification of the point.

Explain questions can be asked across all AOs. The distinction comes whether the identification is via a judgment made to reach a conclusion, or, making a point through application of knowledge to reason/justify the point made through application of understanding. It is the combination and linkage of the marking points that is needed to gain full marks.

When marking questions with a 'describe' or 'explain' command word, the detailed marking guidance below should be consulted to ensure consistency of marking.

Assessment Objective		Command Word	
Strand	Element	Describe	Explain
AO1*		An answer that combines the marking points to provide a logical description	An explanation that links identification of a point with reasoning/justification(s) as required
AO2		An answer that combines the marking points to provide a logical description, showing application of knowledge and understanding	An explanation that links identification of a point (by applying knowledge) with reasoning/justification (application of understanding)
AO3	1a and 1b	An answer that combines points of interpretation/evaluation to provide a logical description	
AO3	2a and 2b		An explanation that combines identification via a judgment to reach a conclusion via justification/reasoning
AO3	3a	An answer that combines the marking points to provide a logical description of the plan/method/experiment	
AO3	3b		An explanation that combines identifying an improvement of the experimental procedure with a linked justification/reasoning

*there will be situations where an AO1 question will include elements of recall of knowledge directly from the specification (up to a maximum of 15%). These will be identified by an asterisk in the mark scheme.

Question number	Answer	Mark
1(a)	C Mercury A is incorrect Jupiter is the fifth planet from the Sun B is incorrect Mars is the fourth planet from the Sun D is incorrect Venus is the second planet from the Sun	(1) AO1

Question number	Answer	Additional guidance	Mark
1(b)	D a natural satellite A is incorrect, the Moon is not an asteroid B is incorrect, the Moon is not a comet C is incorrect, the Moon is not a nebula		(1) AO1

Question number	Answer	Additional guidance	Mark
1(c)	Any two of the following 1. mass (1) 2. radius (1) 3. density (1)	allow made of different substance/ material if no other mark awarded, allow 1 mark for (Moon is) smaller or Earth is bigger	(2) AO2

Question number	Answer	Additional guidance	Mark
1(d)	substitution (1) (W=) 6.0 x 1.6 evaluation (1) 9.6 unit (independent mark)(1) newton	 award full marks for correct answer without working. accept N, n and/or Newton 9.6 N/n gains full marks	**(3)** **AO2**(2) **AO1**(1)

Total marks for question 1 = 7

Question number	Answer	Additional guidance	Mark
2a(i)	C | ultraviolet	infrared	radio | A is incorrect infrared should be in K, radio should be in L and ultraviolet in J, B is incorrect radio should be in L and ultraviolet should be in K D is incorrect radio should be in L and infrared in K		**(1)** **AO1**

Question number	Answer	Additional guidance	Mark
2a (ii)	C speed amplitude, frequency and wavelength are not the same for all EM waves		**(1)** **AO1**

Question number	Answer	Additional guidance	Mark
2(b) (i)	One from: seeing (broken) bones (1) radiotherapy (1) detecting cracks in metals (1) airport security (1) observing the internal structure of objects(1)	seeing inside the body	**(1)** **AO1**

Question number	Answer	Additional guidance	Mark
2(b) (ii)	One from: can cause cancer (1) can cause burns(1) {damage/kills/harms} cells/tissue (1) mutates DNA/cells (1)	 harms organ(s) / foetus allow (highly) ionising	**(1)** **AO1**

Question number	Answer	Additional guidance	Mark
2(c)	infrared (1) thermal (1)	must be in first sentence space must be in second sentence space award 2 marks for answers in this **order**	**(2)** **AO2**

Total marks for question 2 = 6 marks

Question number	Answer	Additional guidance	Mark
3a	A two B is not correct as a uranium nucleus does not split to give 3 daughter nuclei C is not correct as a uranium nucleus does not split to give 4 daughter nuclei D is not correct as a uranium nucleus does not split to give 5 daughter nuclei		**(1)** **AO1**

Question number	Answer	Additional guidance	Mark
3bi	A description including: EITHER neutrons are absorbed by uranium nuclei/atoms (1) more neutrons are produced/emitted (which are absorbed by uranium nuclei) (1) OR diagram (no labels needed) two nuclei/atoms splitting (1) four or more nuclei/atoms splitting (1) shutterstock.com • 1177431790	ignore any reference to bonds accept hit /collide with accept a controlled chain reaction diagram for 2 marks	**(2)** **AO1**

Question number	Answer	Additional guidance	Mark
3bii	An explanation linking: (because the moderator/it) slows down/increases the chance of absorption of(1) neutrons (1)		(2) AO1

Question number	Answer	Additional guidance	Mark
3biii	substitution(1) $2(.0 \times 10^{(17)}) \times 4(.0 \times 10^{(-11)})$ evaluation (1) $8(.0) \times 10^6$ (J)	accept 8000000(J) accept 8MJ 8 to any other power of ten scores 1 mark award full marks for correct answer without working.	(2) AO2

Question number	Answer	Additional guidance	Mark
3c	A description including **one** from hydrogen nuclei/atoms join (1) helium is produced (1) **one** from lost (total) mass (1) mass is converted to energy (1)	nuclei/atoms join larger/heavier nucleus produced energy is released	(2) AO1

Total marks for question 3 = 9

Question number	Answer	Additional guidance	Mark
4 (a)(i)	substitution (1) (ΔGPE =) 64 x 10 x 24 evaluation (1) 15 000 (J)	 accept 15 360(J) or 15 400(J) award full marks for correct answer without working.	(2) AO2

Question number	Answer	Additional guidance	Mark
4 (a)(ii)	substitution (1) (KE=) ½ x 64 x 6$^{(2)}$ calculation of 6^2 (1) evaluation (1) 1200 (J)	 accept 1152(J) award full marks for correct answer without working. 192 (J) scores 2 marks	(3) AO2

Question number	Answer	Additional guidance	Mark
4(a)(iii)	an explanation linking any **two** from: the kinetic energy (store)/it decreases (to zero) (1) (the energy) has dissipated (1) to the surroundings (1) thermal energy (store) increases (1)	 transferred to ground/brake(s) pads make the brakes hot	(2) AO2

Question number	Answer	Additional guidance	Mark
4 (b)(i)	5000(J)	24 000 – 19 000	**(1) AO2**

Question number	Answer	Additional guidance	Mark
4 (b)(ii)	substitution (1) (efficiency =)$\underline{19000}$ (x100%) 24000 evaluation(1) 0.79 or 79%	allow 0.8 do not award 79 without percentage award full marks for correct answer without working.	**(2) AO2**

Total marks for Question 4 = 10

Question number	Answer	Additional guidance	Mark

Question number	Answer	Additional guidance	Mark
5(a)(i)	D travelling more slowly A is incorrect, more passengers would increase the stopping distance B is incorrect, worn tyres would increase the stopping distance C is incorrect, if the car needed new brakes this would increase the stopping distance		(1) AO1

Question number	Answer	Additional guidance	Mark
5 (a)(ii)	identification of horizontal line as reaction time (1) evaluation (1) 0.6 (s)	award full marks for correct answer without working 0.7 scores 1 mark	(2) AO3

Question number	Answer	Additional guidance	Mark
5b	A description including two from let the car roll down the slope from the same point on the slope (1) measure distance it travels (along horizontal surface) (1) change the surface/ use different surfaces (1)	see how far it travels allow time it takes to stop	(2) AO1

Question number	Answer	Additional guidance	Mark
5(c)(i)	0.52		(1) AO3

Question number	Answer	Additional guidance	Mark
5 (c)(ii)	addition and division (1) $$\frac{0.35+\ 0.32+\ 0.38\ +\ 0.33}{4}$$ evaluation (1) 0.35 (m)	$$\frac{0.35+\ 0.32+\ 0.52\ +\ 0.38\ +\ 0.33}{5}$$ accept 0.345 (m) award full marks for correct answer without working. accept 0.38 for 2 marks (five results included in average	(2) AO2

Question number	Answer	Additional guidance	Mark
5c(iii)	Any **one** from make the slope steeper(1) add more books/blocks (1) push/pull the trolley (1)	accept 'higher slope/high slope accept means of reducing friction e.g. use lubricant	(1) AO1

Question number	Answer	Additional guidance	Mark
5(d)	substitution (1) $$(a=)\ \frac{12-2(.0)}{4(.0)}$$ evaluation (1) 2.5 (m/s^2)	award full marks for correct answer without working.	(2) AO2

Total marks for question5 = 11

Question number	Answer	Additional guidance	Mark
6 (a)	B force A is incorrect, mass is a scalar quantity C is incorrect, energy is a scalar quantity D is incorrect, distance is a scalar quantity		(1) AO1

Question number	Answer	Additional guidance	Mark
6 (b)(i)	A plan including four of the following measurement of appropriate distance (1) measurement of appropriate time (1) use of speed = distance (1) Time detail (1) e.g. repeat and average, use ruler/stop clock, mark a line near the top and bottom of liquid		(4) AO3

Question number	Answer	Additional guidance	Mark
6(b)(ii)	An explanation linking **two** from: add more lines (at equal distances)(1) measure the time of fall for each distance (1) compare the times (1)	 use longer test tube / use different heights of liquid / use different sections of the liquid e.g. { equal times =constant speed} / { shorter time = acceleration}	(2) AO3

Question number	Answer	Additional guidance	Mark
6 (c)	substitution (1) $(v^2 - 0 =)$ 2x 10 x 1.5 evaluation (1) 5.5(m/s)	accept numbers that round to 5.5 e.g. 5.477 30(m/s) gains 1 mark for correct substitution but no square root taken award full marks for correct answer without working.	**(2)** **AO2**

Total marks for question 6 = 9

Question number	Answer	Mark
7(a)	A black B is incorrect as no blue light shines on the object C is incorrect as no green light shines on the object D is incorrect as no red light is reflected from the object	**(1)** **AO3**

Question number	Answer	Additional guidance	Mark
7 (b)(i)	C specular reflection A is incorrect as the reflection is not diffuse B is incorrect as it is not refraction D is incorrect as it is not refraction		**(1)** **AO1**

Question number	Answer	Additional guidance	Mark
7 (b)(ii)	An explanation linking: (the surface/metal ball) is smooth/shiny (1) (for each ray of light) the angle of incidence is equal to the angle of reflection (1)	like a mirror the reflection is even / there is no scattering full marks can be awarded for labelled diagrams	**(2)** **AO2**

Question number	Answer	Additional guidance	Mark
7 c(i)	similarity (both) change direction /bend/refract (rays of light) (1) OR (rays of light/they) pass/go (straight) through the (optical) centre / focus(1) difference one converges the other diverges (1)	accept ray through centre described as 'bottom ray' accept 'top ray' accept refracts/bends in different ways do not allow 'change in direction of top ray' this is a similarity	**(2) AO3**

Question number	Answer	Additional guidance	Mark
7c(ii)	(the power of) P is less than (the power of) Q	ORA allow Q is greater /bigger	**(1) AO2**

Question number	Indicative content	Mark
7d*	Answers will be credited according to candidate's deployment of knowledge and understanding of the material in relation to the qualities and skills outlined in the generic mark scheme. The indicative content below is not prescriptive and candidates are not required to include all the material which is indicated as relevant. Additional content included in the response must be scientific and relevant. **Refraction** • Angle of incidence marked • Angle of refraction marked • Angles are measured from the normal • Angle of refraction is bigger than the angle of incidence • Rays of light travel in straight lines • Refraction occurs at a boundary between two materials of different (optical) density • The angle of incidence is less than the angle of refraction when light passes into a less dense medium (glass into air) • Refraction is a change in direction of a light ray. • Refracted rays bend away from the normal when light passes into a less dense medium (glass into air) • The ray in the more dense medium (glass) travels more slowly ORA **Total Internal Reflection** • Possible critical angle marked • Light stays inside the glass • Only occurs when the incident light is in the more dense medium • Only occurs when the incident angle is equal to greater than the critical angle • Critical angle for glass is about 42° • Angle of incidence is equal to the angle of reflection	(6) AO1

Level	Mark	Descriptor
	0	No rewardable material.
Level 1	1–2	Demonstrates elements of physics understanding, some of which is inaccurate. Understanding of scientific, enquiry, techniques and procedures lacks detail. (AO1) Presents a description which is not logically ordered and with significant gaps. (AO1)
Level 2	3–4	Demonstrates physics understanding, which is mostly relevant but may include some inaccuracies. Understanding of scientific ideas, enquiry, techniques and procedures is not fully detailed and/or developed. (AO1) Presents a description of the procedure that has a structure which is mostly clear, coherent and logical with minor steps missing. (AO1)
Level 3	5–6	Demonstrates accurate and relevant physics understanding throughout. Understanding of the scientific ideas, enquiry, techniques and procedures is detailed and fully developed. (AO1) Presents a description that has a well-developed structure which is clear, coherent and logical. (AO1)

Level	Mark	Additional Guidance	General additional guidance – the decision within levels e.g. - At each level, as well as content, the scientific coherency of what is stated will help place the answer at the top, or the bottom, of that level.
	0	No rewardable material.	
Level 1	1–2	<u>Additional guidance</u> isolated fact(s) about refraction or total internal reflection(TIR)	<u>Possible candidate responses</u> naming of any rays of light or any angles in text or on diagrams light changes direction/bends TIR ray stays inside the glass / does not go into air refracted ray goes through glass and air
Level 2	3–4	<u>Additional guidance</u> simple description of refraction and TIR or facts about one and more detail of the other	<u>Possible candidate responses</u> Angle or ray identified For refraction light changes direction from glass into air or TIR angles are equal inside the glass
Level 3	5–6	<u>Additional guidance</u> detailed description of refraction and TIR	<u>Possible candidate responses</u> For refraction light changes direction from glass into air AND TIR angles are equal inside the glass

Total marks for question 7 = 13

Question number	Answer	Additional guidance	Mark
8(a)	uses data taken from x axis (1) 28(cm) (1)	award full marks for correct answer without working	(2) AO3

Question number	Answer	Additional guidance	Mark
8 b(i)	a description to include count the number of waves(1) (arriving/passing a point) in a specific time(1) use frequency = number of waves / time (1)	ignore in one second count the number of waves in one second scores 2 marks (MP1 and MP3) find the time between one wave and the next scores 2 marks (MP1 and MP2)	(3) AO1

Question number	Answer	Additional guidance	Mark
8 b(ii)	substitution (1) 1.5 = 0.7 x λ rearrangement and evaluation 2.1(4) m	$\dfrac{1.5}{0.7}$ allow $\dfrac{0.7}{1.5}$ for 1 mark award full marks for correct answer without working. λ = v/f scores 1 mark	(2) AO2

Question number	Answer	Additional guidance	Mark
8 b(iii)	A description to include: mention of oscillations/vibrations (1) EITHER transverse – (oscillations) perpendicular to direction of wave (travel) (1) OR longitudinal – (oscillations) in same direction as wave (travel) (1)	up and down OR side to side (movements) OR back and forth transverse movement up and down but longitudinal is side to side (1 mark only)	(2) AO1

Question number	Answer	Additional guidance	Mark
8 (c)	substitution (x) = 330 x 4.0 evaluation 1300 (m)	accept 1320 (m) award full marks for correct answer without working.	**(2)** **AO2**

Total marks for Question 8 = 11

Question number	Answer	Mark
9(a)	B ionising and emitted by unstable nuclei A is incorrect stable nuclei do not give radioactive emissions C is incorrect not all radioactive emissions are neutral D is incorrect not all radioactive emissions are neutral	(1) AO1

Question number	Answer	Additional guidance	Mark
9(b)	same number of protons (1) different number of neutrons (1)	same atomic number different mass number	(2) AO2

Question number	Answer	Additional guidance	Mark
9(c)(i)	An explanation to include; there is no aluminium to absorb β particles (1) (therefore) more β particles reach the G-M tube (1)	aluminium absorbs/stops/blocks beta particles accept reverse arguments accept radiation for beta particles	(2) AO2

Question number	Answer	Additional guidance	Mark
9 c (ii)	(idea of) background radiation	a named source of background radiation	(1) AO3

Question number	Answer	Additional guidance	Mark
9c (iii)	becquerel	accept Bq accept close spelling	(1) AO1

Question number	Indicative content	Mark
9d*	Answers will be credited according to candidate's deployment of knowledge and understanding of the material in relation to the qualities and skills outlined in the generic mark scheme. The indicative content below is not prescriptive and candidates are not required to include all the material which is indicated as relevant. Additional content included in the response must be scientific and relevant. **Dangers of exposing people to radioactive sources/radiation.** • it is ionising • may cause cancer • may destroy /kill cells • can mutate DNA • can burn the skin **Protection of hospital staff using radioactive sources/radiation.** • use tongs to carry radioactive sources • use lead containers to store sources • stay at a distance from radioactive sources • use sources for as short a time as possible • wear (lead lined) protective clothing (PPE) • give treatments from behind a shield /wall • wear a radiation badge (dosimeter)	(6) AO1

Level	Mark	Descriptor
	0	No rewardable material.
Level 1	1–2	Demonstrates elements of physics understanding, some of which is inaccurate. Understanding of scientific, enquiry, techniques and procedures lacks detail. (AO1) Presents a description which is not logically ordered and with significant gaps. (AO1)
Level 2	3–4	Demonstrates physics understanding, which is mostly relevant but may include some inaccuracies. Understanding of scientific ideas, enquiry, techniques and procedures is not fully detailed and/or developed. (AO1) Presents a description of the procedure that has a structure which is mostly clear, coherent and logical with minor steps missing. (AO1)
Level 3	5–6	Demonstrates accurate and relevant physics understanding throughout. Understanding of the scientific ideas, enquiry, techniques and procedures is detailed and fully developed. (AO1)

		Presents a description that has a well-developed structure which is clear, coherent and logical. (AO1)

Level	Mark	Additional Guidance	General additional guidance – the decision within levels e.g. - At each level, as well as content, the scientific coherency of what is stated will help place the answer at the top, or the bottom, of that level.
	0	No rewardable material.	
Level 1	1–2	Additional guidance At least one isolated fact about the dangers of radiation and/or protection from radiation	Possible candidate responses it's ionising causes cancer burns you kills cells mutates DNA wear a radiation badge use tongs work from behind a shield use protective clothing
Level 2	3–4	Additional guidance simple explanation of the dangers of radiation and a fact about protection or reverse OR detailed explanation of the dangers of radiation or protection from radiation	Possible candidate responses radiation is ionising and can kill cells so wear a radiation badge **or** use tongs and stay at a distance from radiation source as it can cause cancer **or** use tongs to stay at a distance from radiation sources and wear a radiation badge
Level 3	5–6	Additional guidance detailed explanation of the dangers of radiation and protection from radiation	Possible candidate responses radiation is ionising and can kill cells **and** use tongs and stay at a distance from the radiation source

Question number	Answer	Mark
10 (a)	**The only correct answer is** **D** the discovery of cosmic microwave background (CMB) radiation **A** is not correct because it does not indicate the Universe had a beginning **B** is not correct, it is evidence against the geocentric model of the Universe **C** is not correct, it is evidence for other solar systems	**(1)** **AO1**

Question number	Answer	Additional guidance	Mark
10(b)	A description to include: wavelength (of the light) (1) appears to increase (1) [increase must be linked with wavelength]	 Red shift/Doppler effect (Red shift) shows galaxy moving away accept answers in terms of frequency	**(2)** **AO1**

Question number	Answer	Additional guidance	Mark
10 (c)	**similarity** (both have) expanding <u>Universe</u> (1) **difference** one from: Steady State, Universe has no beginning (1) Steady State theory requires the continual formation of new matter, the Big Bang theory does not (1)	 different interpretation of CMBR	**(2)** **AO1**

Question number	Answer	Additional guidance	Mark

Question number	Answer		Mark
10 (d)(i)	1050 ± 20 (km/s)		**(1)** **AO3** **marked** **with dii**

Question number	Answer	Additional guidance	Mark
10 (d)(ii)	attempt at $\frac{\Delta y}{\Delta x}$ (1) evaluation (1) 70 ± 5 unit (1) km/s/Mpc	could be seen on graph award 2 marks for correct answer without working independent mark km/s Mpc s^{-1} or per second	**(3)** **AO3**

Question number	Answer	Additional guidance	Mark
10 (d)(iii)	an explanation linking: points are scattered widely about the line (on graph) (1) giving wide range of possible gradients (1)	there are many possible best fit lines	**(2)** **AO3**

(Total for Question 10 = 11 marks)