OCR GCSE GATEWAY PHYSICS A · J249

# PHYSICS



## MARK SCHEME

### P8.3 BEYOND EARTH

| SCORE | PERCENTAGE |
| --- | --- |
| /118 | % |

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| Question | | | Answer/Indicative content | Marks | Guidance |
|---|---|---|---|---|---|
| 1 | | | C | 1 | |
| | | | **Total** | **1** | |
| 2 | | | A | 1 | |
| | | | **Total** | **1** | |
| 3 | a | | Gravitational / centripetal (force) (1) | 1 | **ALLOW** ‘gravity' (1) Ignore ‘weight force’ |
| | b | | Moon (1) | 1 | |
| | c | | Recall weight = mass × gravitational field strength (1)<br><br>Substitute: 185 × 3.75 (1)<br><br>694 to 3 sig.figs (2)<br><br>N (1) | 5 | **ALLOW** 693.75 (1) but no marks for significant figures |
| | d | | ‘g’ is greater on Earth than Mars / weight is bigger as ‘g’ is greater on Earth (1) | 1 | |
| | | | **Total** | **8** | |
| 4 | | | B | 1 | |
| | | | **Total** | **1** | |

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| Question | | | Answer/Indicative content | Marks | Guidance |
|---|---|---|---|---|---|
| 5 | | | * Please refer to point 10 of the marking instructions of this mark scheme for guidance on how to mark this question.<br><br>Level 3 (5–6 marks)<br><br>Interpretation of the diagram and how it provides evidence for an expanding universe and the Big Bang model<br><br>*There is a well-developed line of reasoning which is clear and logically structured. The information presented is relevant and substantiated*.<br><br>Level 2 (3–4 marks)<br><br>Description of red shift AND recognition of what the red shift diagram indicates relating to the Big Bang model<br><br>*There is a line of reasoning presented with some structure. The information presented is relevant and supported by some evidence*.<br><br>Level 1 (1–2 marks)<br><br>Simple description of the Big Bang model OR redshift<br><br>*The information is basic and communicated in an unstructured way. The information is supported by limited evidence and the relationship to the evidence may not be clear*.<br><br>0 marks<br><br>*No response or no response worthy of credit*. | 6 | AO3.2b: Analyse the diagram to conclude how it provides evidence for an expanding universe and the Big Bang model<br><br>• The further away a galaxy is the more red shifted it is indicating an expanding universe<br>• If galaxies are moving away then the universe must be expanding<br>• If whole universe is expanding then it must have started from a certain point – the singular point where the Big Bang occurred<br>• More distant galaxies are more red shifted than stars that are closer<br>• Distant galaxies show the lines moving towards the red end of the spectrum<br>• Dark bands are moving towards the red end of the spectrum<br><br>AO1.1: Description of evidence linking red shift to the Big Bang model<br><br>• Red shift is caused by a change in frequency / wavelength of light<br>• Description of the changes in frequency and wavelength of light from distant galaxies<br>• Red shift shows galaxies moving away. |
| | | | Total | 6 | |

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| Question | | | Answer/Indicative content | Marks | Guidance |
|---|---|---|---|---|---|
| 6 | | | Any two features from:<br><br>Polar orbit travels over both poles (1)<br><br>Travels faster than a geostationary satellite (1)<br><br>Multiple orbits in a day (1)<br><br>Lower orbit than geostationary satellites(1)<br><br>Any one use from:<br><br>Mapping / weather / surveillance (1) | 3 | |
| | | | **Total** | **3** | |
| 7 | | | made of rock [1]<br><br>have caused craters / dust / fires / species extinction /named species [1] | 2 | **ignore** ice / metal / dust<br><br>**ignore** collided with Earth<br><br>**Examiner's Comments**<br><br>Approximately half of the candidates knew that asteroids were made of rock and caused craters when they hit the earth. Other correct effects were fires and species extinction. |
| | | | **Total** | **2** | |

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| Question | | | Answer/Indicative content | Marks | Guidance |
|---|---|---|---|---|---|
| 8 | a | | any 2 from<br><br>(idea that) satellite has a wide coverage [1]<br><br>(idea that) satellite always in same (relative) position [1]<br><br>(idea that) satellite receivers (on the house) don't need to be moved to follow satellite / AW [1] | 2 | Examiner's Comments<br><br>Very few could describe the advantages of satellites in geostationary orbit for TV signals |
| | b | | less time [1] | 1 | **allow** faster [1]<br>**allow** any time less than 24 hours<br><br>Examiner's Comments<br><br>Most stated that low polar satellites were faster or took less time to orbit |
| | c | | Risks any one or two from:<br>Loss of life / need oxygen or food or water or heat / high cost / large energy input needed / failed launch / fall back to Earth / difficult to repair / risk ofcollision [1]<br><br>Benefits and uses - any one or two from:<br>Spying / communication / scientific research / GPS / imaging of Space / [1] | 3 | Maximum two marks from each section<br>**allow** higher level answers<br><br>**ignore** Satellite TV<br>**ignore** weather forecasts<br><br>Examiner's Comments<br><br>Most could state at least one benefit (usually spying or space exploration) or one risk (usually collision) of putting satellites into space. Most commonly fullmarks were not gained due to a repetition of uses already given earlier in the question |
| | | | Total | 6 | |

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| Question | | | Answer/Indicative content | Marks | Guidance |
|---|---|---|---|---|---|
| 9 | | i | gravity (1) | 1 | **allow** centripetal force<br>**allow** gravitational force / gravitational pull<br>**ignore** centrifugal<br>**ignore** gravitational potential energy / GPE<br><br>Examiner's Comments<br><br>Almost all stated gravity correctly. |
| | | ii | Moon / other correctly named moon (of another planet) (1)<br><br>(natural satellite) not put into space by man / not controlled by man / cannot be adjusted by man / not made by man / made of rock / not made of just metal / ora (1) | 2 | **allow** named planet as a satellite of the Sun e.g. Jupiter is a satellite of the Sun<br><br>**allow** moon is (much) larger / artificial satellite is (much) smaller<br><br>**ignore** references to uses of artificial satellites<br><br>Examiner's Comments<br><br>Most candidates gained at least one mark ? usually for identifying the Moon and/or that it was not man-made. A misconception by a minority of candidates was that a stationary satellite is an example of a natural satellite. |
| | | | Total | 3 | |

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| Question | | | Answer/Indicative content | Marks | Guidance |
|---|---|---|---|---|---|
| 10 | | i | **lower speed** (than 8000 m/s) then:<br><br>–centripetal / gravitational force too high (to stay in this orbit) [1]<br>–rocket may fall / move or spiral to Earth [1]<br><br>**higher speed** (than 8000 m/s) then:<br><br>–centripetal / gravitational force too low (to stay in this orbit) [1]<br>–rocket may move away from Earth / spiral out of orbit [1]<br><br>(idea of) higher stable orbits experience lower gravitational force or lower speed / ORA [1] | 3 | **Eg**. rocket may fall as centripetal / gravitational force is too big [2]<br><br>**Eg**. rocket may move away as centripetal / gravitational force is too small [2]<br><br>**allow** any idea that correct speed needed to allow correct angle of re-entry to avoid overheating [1]<br><br>Examiner's Comments<br><br>This was an intentionally challenging question, which required both confidence in the physics and some skill in its communication. Few referred correctly in terms of the forces. The idea that lower speeds would cause the satellite to spiral to Earth was reasonably common. Less common was the idea that at higher speeds the satellites would spiral into space. |

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| Question | | | Answer/Indicative content | Marks | Guidance |
|---|---|---|---|---|---|
| | | ii | (+/?) 4 ($m/s^2$) scores [3]<br><br>**but if answer is incorrect then:**<br><br>$(+/-)\ \frac{(120^2 - 2000^2)}{2 \times 5 \times 10^5}$ [2]<br><br>**Or if no other marks scored then**<br><br>evidence of correct substitution into $v^2 = u^2 + 2as$<br><br>**or** evidence of **rearranged** formula:<br><br>$\frac{v^2 - u^2}{2s}$ [1] | 3 | **allow** 3.99 / 3.9856 ($m/s^2$) [3]<br><br>Examiner's Comments<br><br>The calculation of deceleration was challenging but it discriminated well with about a quarter gaining full marks. |
| | | | **Total** | **6** | |



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| Question | | | Answer/Indicative content | Marks | Guidance |
|---|---|---|---|---|---|
| 11 | a | | P wave (no mark)<br><br>because they are faster [1] | 1 | **Allow** primary / pressure / longitudinal wave<br><br>**Ignore** 'powerful / stronger'<br><br>S wave …etc scores [0]<br><br>Examiner's Comments<br><br>This question was about p and s waves and it was better answered than equivalent questions in the past.<br><br>Most knew that p (or primary) waves were received first due to their higher speed. |
| | b | | can measure lag time / time between waves [1]<br>idea that distance is determined by lag time [1]<br><br>**but**<br>difference in time can be used to calculate the distance from earthquake [2]<br><br>determine wave direction / direction that the wave(s) have come from / AW [1]<br><br>idea of triangulating the results [1]<br><br>compare results from different sites [1] | 2 | **maximum 2 marks**<br>find time taken by waves [1]<br><br>**E.g.** readings taken from different points on Earth [1]<br><br>Examiner's Comments<br><br>This question was about p and s waves and it was better answered than equivalent questions in the past.<br><br>In tracing earthquakes many referred to the idea of using the wave directions to predict the source. Some referred to measuring the times and a few to the idea of triangulating the results. |

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| Question | | | Answer/Indicative content | Marks | Guidance |
|---|---|---|---|---|---|
| | c | | (can't get through because) **outer** core is liquid [1] | 1 | **Ignore** S-waves can't get through liquid<br><br>Eg. S-waves can't get through liquid **inner** core scores [0]<br><br><u>Examiner's Comments</u><br><br>This question was about p and s waves and it was better answered than equivalent questions in the past.<br><br>There were some good answers here that described the waves as being unable to get through the liquid outer core. This idea was better answered than in past papers. |
| | | | Total | 4 | |

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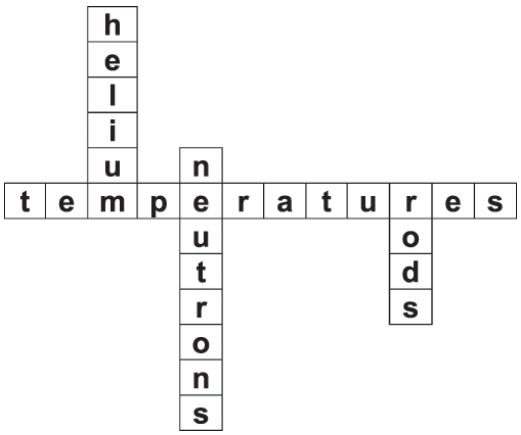
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| Question | Answer/Indicative content | Marks | Guidance |
|---|---|---|---|
| 12 | [Level 3]<br>Answers must give a comparison and an explanation of at least two ideas with reference to gravitational / centripetal force. (See summary chart)<br>Quality of written communication does not impede communication of the science at this level.<br>**(5–6 marks)**<br><br>[Level 2]<br>Answers must give a comparison and a description of at least two ideas.<br>Quality of written communication partly impedes communication of the science at this level.<br>**(3–4 marks)**<br><br>[Level 1]<br>Answers are limited to one simple description OR a description of an appropriate use of a satellite.<br>Quality of written communication impedes communication of the science at this level.<br>**(1–2 marks)**<br><br>[Level 0]<br>Insufficient or irrelevant science. Answer not worthy of credit.<br>**(0 marks)** | 6 | This question is targeted at grades up to A*.<br>allow reverse arguments for geostationary orbits throughout.<br>Indicative scientific points may include at level 3:<br>• higher gravitational force and lower altitude for polar orbit<br>• higher gravitational force and higher speed or acceleration for polar orbit<br>• higher gravitational force and shorter period for polar orbit<br><br>Indicative scientific points may include at level 2:<br>• lower altitudes for polar orbit<br>• higher speeds for polar orbit<br>• shorter period for polar orbit<br>• polar orbit over poles and geostationary orbit over equator<br><br>Indicative scientific points may include at level 1:<br>• short(er) time period for polar orbit<br>• geostationary orbits around equator<br>• Correct use for a relevant satellite (eg polar – military, mapping, navigation, weather, etc. Geostationary –navigation, communication, weather etc.)<br><br>Use the L1, L2, L3 annotations in Scoris; do not use ticks.<br>At level 3 accept higher level answer in terms of acceleration<br><br>Examiner's Comments<br><br>This was a 6 mark question on artificial |

| ideas | geostationary | polar |
|---|---|---|
| orbit description | equator | Go over poles |
| period | longer | shorter |
| speed | lower | higher |
| gravitational force | lower | higher |



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| Question | | | Answer/Indicative content | Marks | Guidance |
|---|---|---|---|---|---|
| | | | | | satellites targeted up to grade A*. There were many level 2 answers (3 or 4 marks) that correctly compared the orbital periods, speeds and heights. Level 3 answers were obviously less common and this discriminated well at A and A*. For this they had to relate the orbits to the relative force of gravity. |
| | | | Total | 6 | |
| 13 | | |  | 2 | answers in crossword take precedent but if crossword blank<br>**allow** answers next to the clues<br><br>0 or 1 correct = 0 marks<br>2 or 3 correct = 1 mark<br>4 correct = 2 marks<br><br>Examiner's Comments<br><br>Most gave two or three correct answers in the crossword [1]. One common error was 'reactant' (instead of neutrons). |
| | | | Total | 2 | |

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| Question | | | Answer/Indicative content | Marks | Guidance |
|---|---|---|---|---|---|
| 14 | a | | idea that tsunamis are caused by earthquakes / AW (1) | 1 | **allow** (pressure) sensors in oceans can detect tsunamis<br>**allow** visual confirmation of tsunami (eg water recedes)<br>**allow** correct description<br>eg plates move and cause tsunami<br>eg earth movement disturbed water and made tsunami<br>eg earthquake happens under water<br>**ignore** merely rising sea levels<br><br>Examiner's Comments<br><br>The idea that earthquakes **cause** tsunamis or that the earthquake happened under the sea, together with the idea of equipment, better positioning of 'sensors' or constant monitoring in the second part, usually secured both marks. |
| | b | | idea of more data gathered / AW<br>or<br>better able to process (more) data now / AW<br>or<br>better (more sensitive) equipment / better technology<br>or<br>idea of better positioning of monitors<br>or<br>constant or more frequent monitoring (1) | 1 | **ignore** idea of data sharing<br><br>**allow** description<br>eg use more sensors or put sensors in areas known to<br>produce earthquakes / AW<br><br>Examiner's Comments<br><br>A significant number thought that historical data could be used to predict the next event. |
| | | | Total | 2 | |

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| Question | | | Answer/Indicative content | Marks | Guidance |
|---|---|---|---|---|---|
| 15 | a | i | (improved) astronomical observation (of planets) (1)<br><br>mathematical explanation or physical model used (1)<br><br>reviewing previous theories or made use of previous observations / AW (1) | 1 | Ignore telescopes<br><br>**Examiner's Comments**<br><br>About 40% or so stated that he used models [1] or astronomical observations [1]. Many merely repeated information in the table. |
| | | ii | (He) used a (better) telescope (1)<br><br>(He) invented / developed a telescope / AW (1)<br><br>(He) observed moons around Jupiter (1)<br><br>(He) observed that not all bodies orbited Earth (1) | 1 | **Examiner's Comments**<br><br>Again less than half of candidates got this right. Those that did usually referred to an improved telescope being used or invented. |
| | | iii | contradicted religious views / AW (1) | 1 | **Examiner's Comments**<br><br>Just over half knew that the influence of the Church was responsible here. |
| | b | | galaxies move away / show red-shift / AW (1)<br><br>Distant galaxies move faster (than closer galaxies) (1)<br><br>BUT distant galaxies move away quicker / AW (2) | 2 | **ignore** background microwave radiation<br>**ignore** planets / merely stars moving away<br>**ignore** universe expanding<br><br>**Examiner's Comments**<br><br>This question about the Big Bang theory uncovered the usual misconceptions about it. Frequent ideas seen were that galaxies / stars / planets / moon were expanding. Many though (50%) knew that galaxies were moving apart [1] and some (only about 10%) went on to say that the outer ones moved faster than the inner ones [1]. |
| | c | | Only current evidence explained (1)<br><br>Further research done / new evidence may be found in future (1)<br><br>Technological advances (1) | 1 | eg new data (will be found) (1)<br><br>**Examiner's Comments**<br><br>This was mostly correct. |
| | | | **Total** | 6 | |

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|---|---|---|---|---|---|
| 16 | | | explosion / start of universe (from a point) / expansion / AW [1] | 1 | **NOT** just 'creation of the Earth'<br>**NOT** just 'creation of life'<br>**BUT** 'an explosion created the Earth and the Universe' / AW scores [1]<br><br>**NOT** colliding rocks / matter<br><br>**Examiner's Comments**<br><br>Many knew that The Big Bang was an explosion which created the Universe [1]. Some thought it just created the Earth or the Earth and moon system [0]. Some thought that it was when rocks collided [0]. |
| | | | **Total** | 1 | |
| 17 | | i | Anka (1)<br><br>Imani (1) | 2 | **either order** |
| | | ii | **any one from:**<br><br>**most** galaxies are moving away from us (1)<br><br>few galaxies are moving towards us (1)<br><br>further galaxies travel faster (1)<br><br>closer galaxies travel slower than further galaxies (1) | 1 | **Allow** Galaxies travel at different speeds / AW (1)<br>Not all galaxies travel at the speed of light (1) |
| | | | **Total** | 3 | |

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|---|---|---|---|---|---|
| 18 | | i | TOP BOX:<br>(Gravitational) collapse / (dust and gas ) pulled together / proto-star (1)<br><br>LEFT BOXES:<br>(planetary) nebula **and then** white dwarf<br>OR (planetary) nebula **and then** black dwarf<br>OR white dwarf **and then** black dwarf (1)<br><br>RIGHT BOXES:<br>supernova **and then** neutron star / black hole (1) | 3 | **NOT Proton** star<br><br>**in correct order and both required for (1) mark**<br><br>**in correct order and both required for (1) mark**<br><br>**If middle box is a neutral answer then award this mark if answer is correct in lowest box.**<br>**Eg.** LHS: middle box – it explodes and sheds its outer layer Bottom box – white dwarf then black dwarf (1) |
| | | ii | (Difference in) **mass** / weight (1) | 1 | **Allow** (differences in) the number of (hydrogen) nuclei (1)<br><br>**Ignore** references to size / large and small stars |
| | | | **Total** | **4** | |

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|---|---|---|---|---|---|
| 19 | a | | (force of) gravity (1)<br><br>attracts the Moon to the Earth (1) | 2 | **allow** idea of centripetal force (1) |
| | b | | **any one from**<br><br>communications (1)<br><br>military use (1)<br>scientific research (1)<br><br>GPS (1)<br><br>imaging the Earth (1) | 1 | **ignore** weather forecast<br><br>**allow** examples e.g. (satellite) TV (1)<br><br>**allow** Satnav (1) |
| | c | i | 1000km takes 105 minutes **and** 2000km takes127–128 minutes (1)<br>not double / use of values to show not double/ 23 difference (1) | 2 | |
| | | ii | **any one from**<br><br>scan whole surface of the Earth / can 'see' much of the surface of the Earth / can 'see' the weather patterns (of the Earth) (1)<br><br>orbit the Earth many times a day / can 'see' changes in weather patterns / can be used to forecast future weather / can see the changes more quickly(1)<br><br>idea of a more detailed image (due to proximity to the Earth) (1) | 1 | **ignore** more accurate<br><br>**allow** clearer image (1) |
| | | | **Total** | 6 | |

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|---|---|---|---|---|---|
| 20 | a | | Any two from:<br><br>If too **fast** -<br><br>• Satellite goes deeper into space (1)<br>• (centripetal / gravitational) force is too small to maintain orbit (at this speed) (1)<br><br>If too **slow** -<br><br>• Satellite goes towards Earth / atmosphere (1)<br>• Hits Earth (1)<br>• (centripetal / gravitational) force is too high to maintain this orbit (at this speed) (1) | 2 | **If no mark awarded** - general unspecified answer of 'just leaves orbit' for (1)<br>Eg. Too fast crashes to Earth scores (1) |
| | b | i | 7.8 – 7.9 (1) | 1 | **Allow** numbers that can be rounded to these values. Eg. 7.78 (1) |
| | | ii | **any two from**<br><br>In a high(er) orbital path<br><br>• less gravitational / centripetal force / ORA (1)<br><br>In a higher (er) orbital path<br><br>• low(er) speed / ORA (1)<br><br>(sensible reference to) inverse square law (1) | 2 | **Ignore** references to the function of the satellite<br><br>**Allow** geostationary for higher orbit<br><br>**Allow** polar for lower orbit<br><br>If no other marks scored then different heights / forces give different speeds [1] |

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| Question | | | Answer/Indicative content | Marks | Guidance |
|---|---|---|---|---|---|
| | | iii | any one from<br>• higher resolution / detailed images<br>• Scans whole surface of Earth (over a period of time) | 1 | Eg. more detailed weather maps / photos (1)<br>Eg. 'can cover more area' (1)<br>Ignore references to merely updates of / changes in weather<br>BUT more frequent weather forecasts scores (1) |
| | | | Total | 6 | |
| 21 | | | D ✓ | 1 (AO1.1) | |
| | | | Total | 1 | |
| 22 | | | C ✓ | 1 (AO2.1) | Examiner's Comments<br>Most candidates demonstrated a good knowledge about the orbits of artificial satellites at different heights (P8.3f and P8.3g). Most other candidates correctly identified that the force of gravity would be less when the satellite is moved to a higher orbit, but also predicted that the speed would increase (distractor D). |
| | | | Total | 1 | |
| 23 | | | C ✓ | 1 (AO1.1) | |
| | | | Total | 1 | |
| 24 | | | B ✓ | 1 (AO 2.1) | Examiner's Comments<br>This question assessed P8.3e and was answered correctly by around 40% of candidates. All three distractors were chosen with equal frequency. |
| | | | Total | 1 | |

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| 25 | | | B ✓ | 1<br>(AO 1.1) | Examiner's Comments<br><br>Candidates were mainly able to apply their knowledge to link correctly the amount of red-shift to the movement of galaxies. |
| | | | Total | 1 | |
| 26 | | | A ✓ | 1<br>(AO 1.1) | |
| | | | Total | 1 | |
| 27 | | | C ✓ | 1<br>(AO 1.1) | Examiner's Comments<br><br>This question assessed candidates' knowledge of how the force of gravity can change the velocity of a planet but its speed stays the same. Most candidates correctly chose option C. |
| | | | Total | 1 | |
| 28 | | i | Neutron(s) ✓ | 1<br>(AO 1.1) | IGNORE gamma<br><br>Examiner's Comments<br><br>About two thirds of the candidates did not know that neutrons were also produced in a fusion reaction. Common misconceptions included water, carbon dioxide and protons. |
| | | ii | Any one from:<br>Gravity ✓<br><br>(very) high temperatures ✓<br><br>high pressure ✓ | 1<br>(AO 1.1) | ALLOW (high) gravitational field strength<br><br>ALLOW hot (temperatures) / lots of heat<br>IGNORE just heat<br><br>Examiner's Comments<br><br>The majority of candidates answered this correctly. |
| | | | Total | 2 | |

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| Question | | | Answer/Indicative content | Marks | Guidance |
|---|---|---|---|---|---|
| 29 | | | B ✓ | 1<br>(AO 2.1) | <u>Examiner's Comments</u><br><br>A number of candidates struggled with this question about satellite orbits. A common error was option C as candidates incorrectly thought that the speed of the satellite in orbit would increase as it is moved further from Earth. |
| | | | Total | 1 | |

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| Question | | | Answer/Indicative content | Marks | Guidance |
|---|---|---|---|---|---|
| 30 | | | Please refer to the marking instructions on page 4 of this mark scheme for guidance on how to mark this question.<br><br>**Level 3 (5–6 marks)**<br>Detailed description of the structure of the Earth<br>**AND**<br>Detailed explanation of the trends in **Table 22.1.**<br><br>*There is a well-developed line of reasoning which is clear and logically structured. The information presented is relevant and substantiated.*<br><br>**Level 2 (3–4 marks)**<br>Description of the structure of the Earth.<br>**AND**<br>Explanation of the trends in **Table 22.1.**<br><br>**OR**<br>Detailed description of the structure of the Earth.<br><br>**OR**<br>Detailed explanation of the trends in **Table 22.1.**<br><br>*There is a line of reasoning presented with some structure. The information presented is relevant and supported by some evidence.*<br><br>**Level 1 (1–2 marks)**<br>**A basic description of the structure of the Earth.**<br>**OR**<br>A basic description of the trends in **Table 22.1.**<br><br>*There is an attempt at a logical structure with a line of reasoning. The information is in the most part relevant.*<br><br>**0 marks**<br>*No response or no response worthy of credit.* | 6 (AO 2×3.1a) (AO 2×3.2a) (AO 2×2.1) | **AO3.1a Analyse information and ideas to interpret some basic trends in data**<br><br>• density increases as depth increases<br>• speed (of P/S waves) increases as density increases<br>• speed (of P/S waves) increases as depth increases<br><br>**AO2.1 Apply knowledge and understanding of scientific ideas to explain trends in the data**<br><br>• Earth contains layers<br>• velocity changes at a boundary<br>• as density changes at a boundary<br>• particles more tightly packed<br>• P is longitudinal, S is transverse<br><br>**AO3.2a Analyse information and ideas to make judgements about the structure of the Earth**<br><br>• core has highest density<br>• core has highest speed for P waves<br>• S waves do not travel through the core<br>• so the outer core is a liquid<br>• pressure highest in core / P = ρgh<br>• pressure and so density increase with depth<br>• large change in density between mantle and outer core<br><br>Examiner's Comments<br><br>This was the Level of Response question, targeted up to Grade 9, and assessed AO2 and AO3. There was a wide range of marks achieved and the question discriminated well. Very few candidates did not achieve any credit.<br><br>The majority of candidates were able to describe some basic trends in the table for density and speed of P and S waves. More detailed responses also included a description of the structure of the Earth for Level 2. |

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| Question | | | Answer/Indicative content | Marks | Guidance |
|---|---|---|---|---|---|
| | | | | | Many excellent responses from the more able candidates at Level 3 included:<br>• trends in the data identified and explained<br>• linking facts about P and S waves to an explanation of why the outer core is liquid.<br><br>Poor quality of communication, including contradictions or the same facts repeated a number of times, prevented some candidates from achieving a higher mark.<br><br>**Exemplar 2**<br>Describe what information the data in **Table 22.1** gives about the structure of the Earth.<br>In your answer you should explain any trends in the data in **Table 22.1**.<br>P waves are longitudinal and travel through both solid and liquids but S waves are transverse and only travel through solids. There is no data for the wave speed of S waves through the top of the outer core and the bottom so the core must be made of liquid, however both waves can travel through the crust and the mantle as there is data for it so these must be made of solid. the density of the layers at the earth decreases down the table so the density of the earth must decrease from the surface of the crust to the centre of the inner core. The speed of both P waves and S waves increase down the table as well, P waves travel faster in denser [6]<br>22 material as the particles are close together so they carry the wave to each other faster, which the data therefore backs up that the density of the earth increases towards the centre.<br><br>This response achieved Level 3, 6 marks. The candidates included a detailed description of the structure of the Earth, including ideas about density and the liquid outer core.<br><br>There is also a detailed explanation of the trends shown in the table. |
| | | | **Total** | **6** | |
| 31 | | | D ✓ | 1 (AO1.1) | <u>Examiner's Comments</u><br><br>This was generally well answered. Candidates who did not gain the correct answer often chose C indicating that the direction of the electric field was not fully understood. |
| | | | **Total** | **1** | |

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| Question | | | Answer/Indicative content | Marks | Guidance |
|---|---|---|---|---|---|
| 32 | a | | spoon A<br>**AND**<br>(More radiation emitted) at higher temperature / hotter objects (emit more radiation) / spoon A is hotter / AW / ORA✓ | 1 (AO1.1) | **ALLOW** spoon A is heated (more)<br><br>Examiner's Comments<br><br>Many candidates correctly ticked Spoon A but did not explain their answer correctly. It was expected that they would state that objects at higher temperatures would emit more radiation. |
| | b | | **Any one from:**<br>Eye can only detect visible light / eye cannot detect IR ✓ | 1 (AO1.1) | **ALLOW** see for detect<br>**ALLOW** spoon is not hot enough for a change in colour AW<br><br>Examiner's Comments<br><br>The common incorrect answer to this question was to refer to the spoons not melting rather than stating that infrared radiation cannot be detected by the eye. |
| | | | Total | 2 | |

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| Question | | | Answer/Indicative content | Marks | Guidance |
|---|---|---|---|---|---|
| 33 | | i | Nuclei join (in fusion) ✓ | 1 (AO 1.1) | **ALLOW** fuse / combine<br><br>Examiner's Comments<br><br>There were many vague answers in terms of hydrogen reacting to produce large amounts of energy. Ideally candidates should understand that fusion is where nuclei join together. |
| | | ii | **Any two from:**<br>High temperature ✓<br><br>High pressure ✓<br><br>Large gravitational forces (due to large mass) ✓ | 2 (AO 2×2.1) | **IGNORE** heat<br><br>Examiner's Comments<br><br>Examiners were keen that correct physics terms were used. Answers such as a lot of heat were not credited. Some candidates did mention very high temperatures. Other acceptable answers included high pressure and large gravitational forces. There needed to be some idea of size, e.g. high, large<br><br>Often only one comment was made when the mark bracket was [2] which indicates two points need to be made. |
| | | iii | The sun will expand / become a red giant / (ultimately) become a white dwarf ✓ | 1 (AO 1.1) | **ALLOW** fusion of helium / heavier elements<br><br>Examiner's Comments<br><br>The question required candidates to state what would happen when the sun ran out of hydrogen. Many candidates state what would happen to the sun eventually. |
| | | | **Total** | **4** | |
| 34 | | | Big Bang ✓<br>Red shift ✓<br>Expanding ✓ | 3 (AO3 × 1.1) | |
| | | | **Total** | **3** | |
| 35 | | | **A** ✓ | 1 (AO1.1) | |
| | | | **Total** | **1** | |

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| Question | | | Answer/Indicative content | Marks | Guidance |
|---|---|---|---|---|---|
| 36 | | | C ✓ | 1 (AO1.1) | |
| | | | Total | 1 | |
| 37 | | | A ✓ | 1 (AO1.1) | |
| | | | Total | 1 | |

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| Question | | | Answer/Indicative content | Marks | Guidance |
|---|---|---|---|---|---|
| 38 | a | | (All galaxies) showed <u>red-shift</u> ✓<br><br>(Hubble measured the) wavelength/frequency of <u>light</u> (from the galaxy) ✓ | 2 (AO2 × 1.1) | **ALLOW** (all galaxies) showed <u>light</u> with a longer wavelength/lower frequency for 2 marks |
| | b | i | Readings of speed taken for two different values of distance ✓<br><br>Working to show that the factor increase in speed is the same as distance ✓ | 2 (AO2 × 3.1a) | **ALLOW** +/- ½ a small square<br><br>**ALLOW** a statement for the second mark e.g. as the distance doubles so does the speed.<br><br><u>Example:</u><br>At 20 Mpc, speed = 1400 km/s<br>At 40 Mpc, speed = 2800 km/s<br><br>40/20 = 2 = 2800/1400<br><br>**ALLOW** 1 mark maximum for it is a (straight) line of best fit through the origin (therefore it is proportional) |
| | | ii | **Any one from:**<br>The more distant galaxies are travelling faster ✓<br><br>The evidence suggests the universe is expanding ✓<br>The universe was smaller in the past ✓ | 1 (AO1.1) | **ALLOW** galaxies are moving away from each other |
| | c | | To ensure results are reproducible / check the work is of high enough quality / claims are not false / for new theories to be accepted / to develop theories / AW ✓ | 1 (AO1.1) | **ALLOW** check validity / for mistakes/anomalies / AW<br>**ALLOW** check that it's not biased / AW |
| | d | i | **FIRST CHECK THE ANSWER ON ANSWER LINE**<br>**If answer = 5 800 000 (m/s) award 2 marks**<br><br>(Reads off speed from graph =) 5800 (km/s) ✓<br><br>Speed = 5800 × 1000 = 5 800 000 (m/s) ✓ | 2<br><br>(AO2.2)<br><br>(AO1.2) | **ALLOW** $5.8 \times 10^6$ (m/s)<br><br>**ALLOW** ecf for their speed from graph x 1000 |

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| Question | | | Answer/Indicative content | Marks | Guidance |
|---|---|---|---|---|---|
| | | ii | FIRST CHECK THE ANSWER ON ANSWER LINE<br>If answer = $4.36 \times 10^{17}$ (s) award 3 marks<br><br>time = distance / speed ✓<br><br>(time =) $2.53 \times 10^{24}$ / 5 800 000 ✓<br><br>(time =) $4.36 \times 10^{17}$ (s) ✓ | 3<br><br>(AO1.2)<br><br>(AO2.1)<br><br>(AO2.1) | ALLOW ecf from (i)<br>ALLOW $4.4 \times 10^{17}$ (s)<br><br>ALLOW equation in any form |
| | | | Total | 11 | |
| 39 | | | A ✓ | 1<br>(AO1.1) | |
| | | | Total | 1 | |

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