| Question Number | Answer | Acceptable answers | Mark |
|---|---|---|---|
| **1(a)** | A | | **(1)** |

| Question Number | Answer | Acceptable answers | Mark |
|---|---|---|---|
| **1(b)** | C | | **(1)** |

| Question Number | Answer | Acceptable answers | Mark |
|---|---|---|---|
| **1(c)** | reference to the connection between water and life | water is needed for life<br>see if we could live there<br>could sustain life<br>water gives possibility of life<br><br>a definite statement that water shows life scores ZERO<br>e.g. prove that there is life there shows signs of life | **(1)** |

| Question Number | Answer | Acceptable answers | Mark |
|---|---|---|---|
| **1(d)** | substitution (1)e.g. $\frac{150\ 000\ 000}{500}$<br><br>evaluation (1)<br>3 (00 000)<br><br>evaluation consistent with unit (1)<br>300 000 (km/s) | $\frac{150\ 000\ 000\ 000}{500}$<br><br>**Ignore** powers of ten<br>e.g. bald 30 000 = 2<br>bald 0.3 = 2<br><br>give full marks for correct answer, no working<br><br>{300 000 000 m/s (with some working) = 3 marks<br>bald 300 000 000 m/s =2} | **(3)** |

| Question Number | Answer | Acceptable answers | Mark |
|---|---|---|---|
| **1(e)(i)** | An explanation linking any two from<br>• (telescope {above / out of}) {atmosphere/air} (1)<br>• dust/clouds/obstructions etc (in atmosphere) (1)<br>• no <u>light</u> pollution in space (1) | | **(2)** |

| Question Number | Answer | Acceptable answers | Mark |
|---|---|---|---|
| **1(e)(ii)** | An explanation linking the following<br>• pulled together by gravity (1)<br>• (converting) {potential / kinetic} energy to {thermal/heat} (1) | collisions create friction (not bald friction)<br>friction produces {thermal/heat}<br>(very) high pressure produced | **(2)** |

| Question Number | Answer | Acceptable answers | Mark |
|---|---|---|---|
| **2(a)(i)** | A description including **three** of the following points<br><br>• {gravitational (potential) energy / GPE} of gas and dust (1)<br><br>• (GPE) changes to kinetic energy (1)<br><br>• (ke) changes to thermal/heat/light (1)<br><br>• (hot enough to release) nuclear energy (1) | Accept description of the process<br><br>{gas and dust / it / nebula} pulled together by gravity<br><br>(particles) move faster<br><br>core becomes hot<br><br>(hot enough for) nuclear fusion/reaction<br><br>accept description shown as chain gpe → ke → thermal → nuclear | **(3)** |

| Question Number | Answer | Acceptable answers | Mark |
|---|---|---|---|
| **2(a)(ii)** | A description including the following points<br><br>• reference to stars of different sizes (1)<br><br>• {Sun/small/medium} becoming {white / black} dwarf (1)<br><br>• more massive becoming a neutron star / black hole (1) | Sun and more massive/bigger star<br><br>red giant / planetary nebula<br><br>(red) supergiant / supernova | **(3)** |

| Question Number | | Indicative content | Mark |
|---|---|---|---|
| **QWC** | ***2(b)** | A discussion linking some of the following points<br><br>red shift<br><br>• linked to movement<br>• both theories have expanding Universe<br>• redshift support both<br><br>CMB<br><br>• linked to ageing Universe<br>• Big Bang ageing , SS not<br>• CMB supports Big Bang only<br>• because only Big Bang has single origin | **(6)** |
| **Level** | **0** | no rewardable material | |
| **1** | **-2** | • a **limited discussion** stating both pieces of evidence **or** limited detail about either red shift or CMB e.g. change in wavelength /red shift shows galaxies / stars moving away<br>• the answer communicates ideas using simple language and uses limited scientific terminology<br>• spelling, punctuation and grammar are used with limited accuracy | |
| **2** | **-4** | • a **simple discussion** including both pieces of evidence **and** simple detail about **either** red shift **or** CMB e.g. a change in wavelength shows galaxies / stars moving away<br>• the answer communicates ideas showing some evidence of clarity and organisation and uses scientific terminology appropriately<br>• spelling, punctuation and grammar are used with some accuracy | |
| **3** | **5 - 6** | • a **detailed discussion** describing both pieces of evidence and drawing a conclusion e.g. a change in wavelength shows galaxies / stars moving away **and** CMB shows Universe has been changing with time **and** redshift supports both theories, CMB supports only Big Bang because Steady State has constant Universe<br>• the answer communicates ideas clearly and coherently uses a range of scientific terminology accurately<br>• spelling, punctuation and grammar are used with few errors | |

| Question Number | Answer | Acceptable answers | Mark |
|---|---|---|---|
| **3(a)(i)** | C | | **(1)** |

| Question Number | Answer | Acceptable answers | Mark |
|---|---|---|---|
| **3(a)(ii)** | telescope | (astronomical/refracting/light) telescope<br>**IGNORE** any other type of telescope | **(1)** |

| Question Number | Answer | Acceptable answers | Mark |
|---|---|---|---|
| **3(b)(i)** | 4 (June) | 4-6; 6-4 (UK/US dates)<br>20 (June); 20-6; 6-20 | **(1)** |

| Question Number | Answer | Acceptable answers | Mark |
|---|---|---|---|
| **3(b)(ii)** | 16 (days) | | **(1)** |

| Question Number | Answer | Acceptable answers | Mark |
|---|---|---|---|
| **3(b)(iii)** | 1 741 000 (km) (2)<br>**OR**<br>1 070 000 + 671 000 (km) (2)<br>**OR**<br>399 000 + {2 x 671 000} (km) (2) | Power of 10 error max 1 mark<br><br>Use of 1 070 000 and 671 000 (km)/<br>Use of 399 000 and 2 x 671 000 (km)/<br>12 June marked correctly on the orbit for Ganymede/<br>answer of 399,000 with no working<br><br>gets 1 mark | **(2)** |

| Question Number | | Indicative Content | Mark |
|---|---|---|---|
| **QWC** | ***) (iv)** | A description including some of the following points<br><br>reasons for the distance changing<br>appreciation of a difference in time/speed/size of orbit<br><br>smallest separation on 4/20th June<br>smallest separation 399 000 km<br>largest separation 1 741 000 km<br>largest separation on 12/28 June<br>moon separation increases after 4th June.<br><br>distance between moons increases and then decreases as they orbit<br>distance increased after 4 June which was smallest separation<br>of 399 000 km<br>Distance increases from a minimum on4th June to a maximum on 12th June, back to a minimum on 20th June and maximum on 28th June<br>distance change is not linear | **(6)** |
| **Level** | **0** | No rewardable content | |
| **1** | **1 - 2** | • a limited description giving 1 relevant piece of information taken from the diagram e.g. Europa orbits in a shorter time **OR** The moons have different sized orbits **OR** Europa orbits in 8 days<br>• the answer communicates ideas using simple language and uses limited scientific terminology<br>• spelling, punctuation and grammar are used with limited accuracy | |
| **2** | **3 - 4** | • a simple description giving either the size or the date of smallest or largest separation **OR** giving increase and/or decrease of separation e.g. The moons are closest on the 4th June **OR** Moon separation increases after 4th June **OR** the distance between the moons increases then it decreases<br>• the answer communicates ideas showing some evidence of clarity and organisation and uses scientific terminology appropriately<br>• spelling, punctuation and grammar are used with some accuracy | |
| **3** | **5 - 6** | • a detailed description indicating an increase and decrease in separation plus a date or distance **OR** describes 3 orbits e.g. The distance between the moons increases till 12 June then it decreases **OR** the distance between the moons increases, then decreases, then increases again<br>• the answer communicates ideas clearly and coherently uses a range of scientific terminology accurately<br>• spelling, punctuation and grammar are used with few errors | |

| Question Number | Answer | Acceptable answers | Mark |
|---|---|---|---|
| **4(a)(i)** | Any one of<br>• radio<br>• visible<br>• microwave | • infrared / IR<br>• ultraviolet / UV | **(1)** |

| Question Number | Answer | Acceptable answers | Mark |
|---|---|---|---|
| **4(a)(ii)** | Any one of<br>• X-ray<br>• gamma ray<br>• far infrared | • infrared / IR<br>• ultraviolet / UV | **(1)** |

| Question Number | Answer | Acceptable answers | Mark |
|---|---|---|---|
| **4(b)(i)** | N = 39 (A.U.) (1)<br>P = 77 (A.U.) (1) | range 38 – 39 inclusive<br>range 76-78 inclusive | **(2)** |

| Question Number | Answer | Acceptable answers | Mark |
|---|---|---|---|
| **4(b)(ii)** | An explanation linking<br>• actual value for Neptune is {different from / lower than} predicted value (1)<br>with **one** of these<br>• (so) the rule does not work (for Neptune) (1)<br>• the rule gives too high a value (1)<br>• (so) Neptune might have been {captured / entered} from outside the original Solar System (1) | actual value for Neptune put on to chart by cross or dot etc. (no need for label) (1)<br>(Neptune) is an anomaly<br>ignore references to age of Neptune | **(2)** |

| Question Number | | Indicative Content | Mark |
|---|---|---|---|
| **QWC** | ***4(c)** | A discussion including some of the following points<br><br>• Methods<br>o space probes<br>o soil experiments by landers<br>o SETI<br>o telescopes<br>o robotic machines<br><br>• Problems<br>• expense / international collaboration needed<br>• large distances involved<br>o if problem difficult to correct<br>o time to react to problem is long<br>o time to respond to any communication would be long<br>o complex technology<br>▪ for human visit<br>▪ for robot investigation<br>▪ fuel<br>• recognition of alternative life-forms<br>• pattern recognition<br>o for SETI<br>o communication if intelligent life-form<br>• possibility of cross-contamination | **(6)** |
| **Level** | **0** | No rewardable content | |
| **1** | **1 – 2** | • a limited discussion including EITHER two named problems, OR two named methods, OR a named problem + a named method e.g. It would be expensive and the distances are large OR Space probes and SETI can be used OR can listen for communications, life beyond Earth may not be water based.<br>• the answer communicates ideas using simple language and uses limited scientific terminology.<br>• spelling, punctuation and grammar are used with limited accuracy. | |
| **2** | **3 – 4** | • a simple discussion including EITHER a problem with its associated method + some other named problem OR a detailed problem + one other named problem e.g. It is expensive to send a space probe to Mars; the distance to Mars very large OR It is difficult to search through the data from space because there is a huge amount of it. Also, any message would be hard to decode.<br>• the answer communicates ideas showing some evidence of clarity and organisation and uses scientific terminology appropriately.<br>• spelling, punctuation and grammar are used with some accuracy. | |

| | | |
|---|---|---|
| **3** | **5 – 6** | • a detailed discussion including EITHER two problems with their associated method(s) + some other named problem OR two detailed problems + one other named problem OR a problem with its associated method + a detailed problem + one other named problem e.g. We can analyse radiowaves from space, but they take so long to arrive that the aliens that sent them could have already died out. It is very expensive to develop the technology needed to go to other planets. Also, we might not recognise alien life-forms there. OR It is difficult to search through the data from space because there is a huge amount of it. Radiowaves in space take a long time to arrive because the distances are so vast. It all costs a lot of money. OR It is very expensive to develop the technology needed to go to other planets. It is difficult to search through the data from space because there is a huge amount of it. Also, we might not recognise alien life-forms there.<br>• the answer communicates ideas clearly and coherently uses a range of scientific terminology accurately.<br>• spelling, punctuation and grammar are used with few errors. |