Mark Scheme (Results)

Summer 2016

Pearson Edexcel GCSE in Astronomy (5AS01/01)
Unit 1: Understanding the Universe
Edexcel and BTEC Qualifications

Edexcel and BTEC qualifications are awarded by Pearson, the UK’s largest
awarding body. We provide a wide range of qualifications including academic,
vocational, occupational and specific programmes for employers. For further
information visit our qualifications websites at www.edexcel.com or
www.btec.co.uk. Alternatively, you can get in touch with us using the details on
our contact us page at www.edexcel.com/contactus.

Pearson: helping people progress, everywhere

Pearson aspires to be the world’s leading learning company. Our aim is to help
everyone progress in their lives through education. We believe in every kind of
learning, for all kinds of people, wherever they are in the world. We’ve been
involved in education for over 150 years, and by working across 70 countries, in
100 languages, we have built an international reputation for our commitment to
high standards and raising achievement through innovation in education. Find
out more about how we can help you and your students at:
www.pearson.com/uk

Summer 2016
Publications Code 5AS01_01_1606_MS
All the material in this publication is copyright
© Pearson Education Ltd 2016
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.
<table>
<thead>
<tr>
<th>Question number</th>
<th>Answer</th>
<th>Notes</th>
<th>Marks</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 (a)</td>
<td>B Orion</td>
<td></td>
<td>1</td>
</tr>
<tr>
<td>1 (b)</td>
<td>D Sirius</td>
<td></td>
<td>1</td>
</tr>
<tr>
<td>1 (c)</td>
<td>D Nebula</td>
<td></td>
<td>1</td>
</tr>
<tr>
<td>Question number</td>
<td>Answer</td>
<td>Notes</td>
<td>Marks</td>
</tr>
<tr>
<td>-----------------</td>
<td>-----------------------------</td>
<td>-------</td>
<td>-------</td>
</tr>
<tr>
<td>2 (a)</td>
<td>A William Herschel</td>
<td></td>
<td>1</td>
</tr>
<tr>
<td>(b)</td>
<td>D Variable star</td>
<td></td>
<td>1</td>
</tr>
<tr>
<td>(c)</td>
<td>B Goldilocks Zone</td>
<td></td>
<td>1</td>
</tr>
<tr>
<td>(d)</td>
<td>B 21st March</td>
<td></td>
<td>1</td>
</tr>
<tr>
<td>(e)</td>
<td>C Exoplanets</td>
<td></td>
<td>1</td>
</tr>
<tr>
<td>Question number</td>
<td>Answer</td>
<td>Notes</td>
<td>Marks</td>
</tr>
<tr>
<td>-----------------</td>
<td>------------------------------------------------------------------------</td>
<td>----------------------------------------------------------------------</td>
<td>-------</td>
</tr>
<tr>
<td>3 (a)</td>
<td>Heliocentric / helio-centred</td>
<td>Reject: Sun-centred or Copernican</td>
<td>1</td>
</tr>
<tr>
<td>(b)</td>
<td>It made predictions of the positions of the planets easier/quicker to calculate. OR: Explained retrograde motion of planets</td>
<td>Accept: Better predictions Reject: It had the Sun at the centre / didn’t have the Earth at the centre</td>
<td>1</td>
</tr>
<tr>
<td>(c)</td>
<td>Any 2 from: Moons orbiting Jupiter Phases of planet Venus Earth-like / relief features on Moon Milky Way resolved into individual stars</td>
<td>Insufficient: Sunspots Invention of telescope</td>
<td>2</td>
</tr>
<tr>
<td>Question number</td>
<td>Answer</td>
<td>Notes</td>
<td>Marks</td>
</tr>
<tr>
<td>-----------------</td>
<td>------------------------------------------------------</td>
<td>----------------------------</td>
<td>-------</td>
</tr>
<tr>
<td>4</td>
<td><strong>(a)</strong> Moving / curtains / streamers of (coloured) light</td>
<td>Insufficient: Patches of light</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td><strong>(b)</strong> Point of light moving quickly / steadily across sky</td>
<td>Insufficient: Point of light / dot</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td><strong>(c)</strong> (Bright) Streak of light / bright meteor Meteor brighter than -3</td>
<td>Insufficient: meteor</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td><strong>(d)</strong> Just visible / very faint object</td>
<td>Insufficient: Point of light or star</td>
<td>1</td>
</tr>
<tr>
<td>Question number</td>
<td>Answer</td>
<td>Notes</td>
<td>Marks</td>
</tr>
<tr>
<td>-----------------</td>
<td>---------------</td>
<td>-------</td>
<td>-------</td>
</tr>
<tr>
<td>5 (a)</td>
<td>C Mercury</td>
<td></td>
<td>1</td>
</tr>
<tr>
<td>5 (b)</td>
<td>B Neptune</td>
<td></td>
<td>1</td>
</tr>
<tr>
<td>5 (c)</td>
<td>D Venus</td>
<td></td>
<td>1</td>
</tr>
<tr>
<td>5 (d)</td>
<td>D Venus</td>
<td></td>
<td>1</td>
</tr>
<tr>
<td>Question number</td>
<td>Answer</td>
<td>Notes</td>
<td>Marks</td>
</tr>
<tr>
<td>----------------</td>
<td>--------</td>
<td>-------</td>
<td>-------</td>
</tr>
<tr>
<td>6 (a) (i)</td>
<td>B Rille</td>
<td></td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>(ii)</td>
<td>C Terra</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>(iii)</td>
<td>A Mare</td>
<td>1</td>
</tr>
<tr>
<td>(b)</td>
<td>Any two from: Far side of Moon has more craters Far side of Moon has fewer maria Far side has more highland/terrae Far side appears lighter</td>
<td>Reject: darker, colder invisible</td>
<td>1 (both required)</td>
</tr>
<tr>
<td>Question number</td>
<td>Answer</td>
<td>Notes</td>
<td>Marks</td>
</tr>
<tr>
<td>-----------------</td>
<td>--------</td>
<td>-------</td>
<td>-------</td>
</tr>
<tr>
<td>7 (a) (i)</td>
<td>3000 – 5000</td>
<td>Reject: Answer outside this range. Ignore units</td>
<td>1</td>
</tr>
<tr>
<td>(ii) Arrow(s) are horizontal or slightly inclined towards equator</td>
<td></td>
<td>Accept: to left or right</td>
<td>1</td>
</tr>
<tr>
<td>Both arrows are same length and reflections of each other in equator</td>
<td></td>
<td></td>
<td>1</td>
</tr>
<tr>
<td>(b) Use of projection or filtering light entering telescope</td>
<td></td>
<td>Insufficient: ‘Solar telescope’</td>
<td>1</td>
</tr>
<tr>
<td>Clear labelled diagram showing correct practical set-up</td>
<td></td>
<td></td>
<td>1</td>
</tr>
</tbody>
</table>

**QWC:** *write legibly, with accurate use of spelling, grammar and punctuation in order to make the meaning clear*

Student answer clearly legible with correct SP&G and correct use of any one of the following terms:
- Projection
- Pinhole
- Image
- Telescope
- H-alpha
- Absorption

<p>| | | | |
| | | | |
| | | | 1 |</p>
<table>
<thead>
<tr>
<th>Question number</th>
<th>Answer</th>
<th>Notes</th>
<th>Marks</th>
</tr>
</thead>
<tbody>
<tr>
<td>8 (a)</td>
<td>Either mathematical calculation / prediction of position and</td>
<td></td>
<td>1</td>
</tr>
<tr>
<td></td>
<td><em>Any one of</em></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Irregularities in orbit of Uranus</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Gravitational pull of another planet</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Identified from telescope search</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Named astronomer, e.g. Adams/Le Verrier/Galle/d’Arrest</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>In 1846</td>
<td></td>
<td></td>
</tr>
<tr>
<td>(b)</td>
<td><em>Any two from:</em></td>
<td></td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>Some moons orbiting amongst Neptune’s rings</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>One very large moon (Triton)</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Triton has retrograde / highly inclined / almost circular orbit</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Triton large enough to have atmosphere</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Triton likely to be captured from KBOs/TNOs</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Capture of Triton destroyed previous satellites</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Nereid has highly elliptical orbit</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Question number</td>
<td>Answer</td>
<td>Notes</td>
<td>Marks</td>
</tr>
<tr>
<td>-----------------</td>
<td>--------</td>
<td>-------</td>
<td>-------</td>
</tr>
<tr>
<td>9   (a) (i)</td>
<td>C  Mercury</td>
<td></td>
<td>1</td>
</tr>
<tr>
<td>(ii)</td>
<td>B  Conjunction</td>
<td></td>
<td>1</td>
</tr>
<tr>
<td>(b)</td>
<td>Sequence S V E or E V S</td>
<td></td>
<td>1</td>
</tr>
</tbody>
</table>
| (c)            | *Any two from* Disc of Venus appears very small in sky  
                 Sun is very bright  
                 Telescope needed to observe it in detail  
                 Transits not accurately predicted |       | 2     |
| (d)            | Venus (or Earth) has a tilted *orbit/orbital plane*  
                 compared to each other / ecliptic or  
                 orbits only cross/align in two places | *Reject:* Venus/Earth is tilted  
                 *Accept:* Inclined to ecliptic =2 | 1     |
<table>
<thead>
<tr>
<th>Question number</th>
<th>Answer</th>
<th>Notes</th>
<th>Marks</th>
</tr>
</thead>
</table>
| 10 (a)          | Any two from:  
Large objective lenses are difficult to make  
Large lenses are hard to support  
Reflectors can be made of multiple mirrors  
Telescopes with large lenses are difficult to keep stable and steer/point accurately  
Lenses introduce false colour/chromatic aberration  
Reflector design has higher resolution | Insufficient:  
Cheaper  
More powerful  
Easier to build | 2 |
| (b)             | The mark scheme for this question is tiered depending on the complexity/detail level with which candidates discuss the advantages/disadvantages of each telescope. | | |

<table>
<thead>
<tr>
<th>Hale</th>
<th>Hubble</th>
</tr>
</thead>
<tbody>
<tr>
<td>Simple statement</td>
<td>Bigger mirror</td>
</tr>
</tbody>
</table>
| Explanation     | Gives improved light grasp or resolution | Gives brighter/sharper/higher contrast/lower distortion images.  
*Insufficient: ‘better’ or ‘clearer’ images* |
| Detail or quantitative comparison | Light grasp four times better or resolution twice as good | *Any one from:*  
Can observe in near UV/IR  
Unaffected by weather/Earth’s rotation  
Harder to repair |
<table>
<thead>
<tr>
<th>Question number</th>
<th>Answer</th>
<th>Notes</th>
<th>Marks</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>11</strong> (a)</td>
<td>To avoid risking human life in early missions / safer / easier cheaper / no return</td>
<td></td>
<td><strong>1</strong></td>
</tr>
<tr>
<td>(b) (i)</td>
<td>Lower gravity on Moon</td>
<td><em>Reject: No gravity</em></td>
<td><strong>1</strong></td>
</tr>
<tr>
<td>(ii)</td>
<td>No atmosphere / air resistance for parachutes</td>
<td></td>
<td><strong>1</strong></td>
</tr>
<tr>
<td>(c) (i)</td>
<td>Apollo (any number)</td>
<td><em>Reject: Eagle</em></td>
<td><strong>1</strong></td>
</tr>
<tr>
<td>(ii)</td>
<td><em>Any two from:</em> Seismic measurements, Charged particle measurements, Solar Wind measurements, Atmospheric pressure measurements, Heat flows in/out of lunar surface, LASER reflection measurements of distance to Earth, Composition of lunar atmosphere, Micrometeorite detection and measurement, Surface gravity measurements, Surface magnetic field measurements, Rock samples</td>
<td><em>Reject: Any other answers</em></td>
<td><strong>2</strong></td>
</tr>
<tr>
<td>(d)</td>
<td>Sunlight is not <em>scattered</em>... ... as the Moon has no atmosphere</td>
<td></td>
<td><strong>1</strong></td>
</tr>
<tr>
<td>Question number</td>
<td>Answer</td>
<td>Notes</td>
<td>Marks</td>
</tr>
<tr>
<td>-----------------</td>
<td>--------</td>
<td>-------</td>
<td>-------</td>
</tr>
<tr>
<td>12 (a) (i)</td>
<td>09:00 / 9 o’clock / 9a.m.</td>
<td></td>
<td>1</td>
</tr>
<tr>
<td>(ii)</td>
<td>09:00 − −2m = 09:02 (08:58)</td>
<td></td>
<td>2</td>
</tr>
<tr>
<td>(iii)</td>
<td>09:10 − 09:02 = 8 mins, 8m / 4 i.e. evidence of 4 mins representing 1° of longitude (= 2°W)</td>
<td>Reject: 09:08 or 09.12</td>
<td>1 (1)</td>
</tr>
<tr>
<td>(b)</td>
<td>Curve drawn with similar U-shape</td>
<td>Accept: curve shifted left or right</td>
<td>1 1</td>
</tr>
<tr>
<td></td>
<td>Curve drawn higher than June curve</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Question number</td>
<td>Answer</td>
<td>Notes</td>
<td>Marks</td>
</tr>
<tr>
<td>-----------------</td>
<td>--------</td>
<td>-------</td>
<td>-------</td>
</tr>
<tr>
<td><strong>13</strong> (a) (i)</td>
<td><em>Diagram/explanation shows:</em> Oort Cloud centred around the Sun. Highly elliptical orbit (open / closed) with Sun at focus</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>(ii)</td>
<td><em>P</em> marked as point on orbit closest to Sun.</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>(iii)</td>
<td>Gravitational pull of major planet / nearby star</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>(b)</td>
<td>100</td>
<td>2</td>
<td></td>
</tr>
<tr>
<td></td>
<td>10 (or evidence of squaring)</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>(c)</td>
<td>27( years) Evidence of $9^3 (=729)$</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>Question number</td>
<td>Answer</td>
<td>Notes</td>
<td>Marks</td>
</tr>
<tr>
<td>-----------------</td>
<td>--------</td>
<td>-------</td>
<td>-------</td>
</tr>
<tr>
<td>14 (a)</td>
<td>Objects in the sky which never set / are always above the observer’s horizon.</td>
<td>Reject: Always visible orbit Polaris</td>
<td>1</td>
</tr>
<tr>
<td>(b)</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Viewed from London (Latitude: 52°N)</th>
<th>Viewed from Brazil (Latitude: 16°S)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Pole Star</strong></td>
<td>C</td>
</tr>
<tr>
<td><strong>Sun</strong> at midday on June 21&lt;sup&gt;st&lt;/sup&gt;</td>
<td>R</td>
</tr>
<tr>
<td><strong>Sirius</strong> (Declination: -16°)</td>
<td>R</td>
</tr>
<tr>
<td><strong>Orion’s Belt</strong> (Declination: 0°)</td>
<td>R</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>(c)</th>
<th>6 correct</th>
<th>4 or 5 correct</th>
<th>2 or 3 correct</th>
<th>0 or 1 correct</th>
<th>3</th>
<th>2</th>
<th>1</th>
<th>0</th>
<th>2</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Any two from:</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Most southerly point(s)/latitude</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>where Sun is directly overhead at noon on Winter/Southern Summer solstice 21&lt;sup&gt;st&lt;/sup&gt; December</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Question number</td>
<td>Answer</td>
<td>Notes</td>
<td>Marks</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>-----------------</td>
<td>------------------------------------------------------</td>
<td>---------------------------</td>
<td>-------</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>15 (a) (i)</td>
<td>New Photosphere</td>
<td>Insufficient: Disc</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Reject: Corona</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>(ii)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(b) (i)</td>
<td>Ellipse / Elliptical</td>
<td></td>
<td>1</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(ii)</td>
<td>Establishes that shadow cone of Moon doesn’t reach</td>
<td>angle of Moon’s disc is</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Earth’s surface OR: angle of Sun’s disc</td>
<td>less than angle of Sun’s</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Labelled diagram to illustrate this.</td>
<td>disc</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Question number</td>
<td>Answer</td>
<td>Notes</td>
<td>Marks</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>-----------------</td>
<td>------------------------------------------------------------------------</td>
<td>-------</td>
<td>-------</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>16 (a) (i)</td>
<td>Planetary / Eskimo and Supernova Remnant / Crab (both required either order)</td>
<td></td>
<td>1</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>(ii) Supernova Remnant / Crab</td>
<td></td>
<td>1</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>(iii) Star Formation / Eagle and Absorption/Horsehead (both required either order)</td>
<td></td>
<td>1</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(b) (i)</td>
<td>Tuning fork shaped diagram with galaxies Stem and tines of fork labelled with correct type of galaxy Progression of shape indicated along branches of diagram.</td>
<td></td>
<td>1</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>(ii) M labelled half-way along Spiral or Barred Spiral fork (SBb)</td>
<td></td>
<td>1</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>(iii) E7 labelled on stem of fork, close to tines</td>
<td></td>
<td>1</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Question number</td>
<td>Answer</td>
<td>Notes</td>
<td>Marks</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>-----------------</td>
<td>--------</td>
<td>-------</td>
<td>-------</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>17 (a)</td>
<td>Two stars/objects Linked by force of gravity / in orbit around each other</td>
<td>Insufficient ‘close’</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(b) (i)</td>
<td>Escape velocity greater than speed of light Extremely strong gravity pulls back even light/EM waves</td>
<td></td>
<td>2</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
| (ii)            | *Any one of three alternative answers:*  
**Binary systems**  
Star orbiting black hole  
Shows gravitational pull of black hole  
**Emissions from nearby mass**  
Material falling into black hole / accretion disc  
Emits strong X-ray signals  
**Gravitational Lensing**  
Gravity of black hole bends space/light from another star  
Causes a double image of the star for viewers on Earth | | 2 |
| (c)             | X-rays do not penetrate the Earth’s atmosphere | | 1 |
| (d)             | 25 000 / 2.511 (=23 842) / 2.51211 (=25 131)  
11 (or clear evidence of an initial error carried forward, e.g. calculating 2.5^{10}) | | 2 |

[Magnitude difference = 4.5 - - 6.5 = 11  
11 magnitudes = 2.5 x 100 x 100 = 25 000]
<table>
<thead>
<tr>
<th>Question number</th>
<th>Answer</th>
<th>Notes</th>
<th>Marks</th>
</tr>
</thead>
<tbody>
<tr>
<td>18 (a)</td>
<td>Star dims as planet transits / passes in front</td>
<td></td>
<td>1</td>
</tr>
<tr>
<td>(b)</td>
<td>150 000 km</td>
<td></td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>Time of 1h read from graph</td>
<td></td>
<td></td>
</tr>
<tr>
<td>(c)</td>
<td>Very accurate measurement of star’s position / astrometry</td>
<td>Reject: Transit method</td>
<td></td>
</tr>
<tr>
<td></td>
<td>To detect tiny ‘wiggles’ as it is orbited by planet</td>
<td></td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>Radial velocity / Doppler measurement</td>
<td></td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>To detect tiny ‘wiggles’ as it is orbited by planet</td>
<td></td>
<td>1</td>
</tr>
<tr>
<td></td>
<td></td>
<td>[1st – 2nd contact time from graph = 1 hour</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>1 hour x 150 000 km/h – 150 000 km]</td>
<td></td>
</tr>
<tr>
<td>Question number</td>
<td>Answer</td>
<td>Notes</td>
<td>Marks</td>
</tr>
<tr>
<td>----------------</td>
<td>--------</td>
<td>-------</td>
<td>-------</td>
</tr>
<tr>
<td>19 (a)</td>
<td>Universe was originally very small&lt;br&gt;Expanded outwards after Big Bang</td>
<td></td>
<td>1</td>
</tr>
<tr>
<td>(b)</td>
<td>CMB = ‘left over’ radiation from the Big Bang&lt;br&gt;Wavelength of CMB agreed with estimates of rate of cooling of Universe (or similar argument based on temperature)</td>
<td>Accept: ‘echo of Big Bang’</td>
<td>1</td>
</tr>
<tr>
<td>(c)</td>
<td>Quasars are (only) observed at very large distances/high red-shifts&lt;br&gt;Indicating early universe was different to present day (i.e. not Steady State)</td>
<td></td>
<td>1</td>
</tr>
</tbody>
</table>

**QWC:** ‘organise relevant information clearly and coherently, using specialist vocabulary when appropriate’

Student answer contains a clearly expressed argument with the correct use of **ANY TWO** of the following terms:
- Red shift
- Universe
- Steady State
- Luminosity
- Galaxy
- AGN
- Spectrum/a or Spectral line(s)
<table>
<thead>
<tr>
<th>Question number</th>
<th>Answer</th>
<th>Notes</th>
<th>Marks</th>
</tr>
</thead>
<tbody>
<tr>
<td>20  (a)</td>
<td><strong>Group of nearby galaxies linked to Milky Way by gravity</strong></td>
<td></td>
<td>1</td>
</tr>
</tbody>
</table>
| (b) (i)         | 3.5                                                                    | Correct substitution of values and evaluation of \( \log(1 \ 000 \ 000) = 6 \) OR:  
|                 | \(-11.5\)                                                              | \( \log(1000) + \text{ecf} = -31.5 \)                                 | 3     |
| (ii)            | \(-1.5\)                                                               | Any evidence of squaring or \( \log(100 \ 000) \)                      | 2     |
| (iii)           | **Bright object in night sky / easily visible to naked eye / large angle in sky** | [10 x closer = 100 x brighter = 5 mags]                              | 1     |

