

| Question |     |      | Expected response                                                                                                                                                                                                                                                                                                                                                                                                                                                                   | Max mark | Additional guidance                                                                                                                                                               |
|----------|-----|------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 5.       | (a) |      | <p>When moving away from the students:<br/>Statement that there are fewer wavefronts per second<br/><b>OR</b><br/>The wavefronts are further apart (1)</p> <p>When moving towards the students:<br/>Statement that there are more wavefronts per second<br/><b>OR</b><br/>The wavefronts are closer together (1)</p> <p><b>OR</b></p> <p>diagram showing wavefronts closer together ahead of the buzzer (1)<br/>and further apart behind it. (1)</p> <p>or any similar response</p> | 2        | <p>Look for reference to wavefronts/wavelengths/waves first, otherwise (0) marks.</p> <p>In a diagram, there must be an implication of direction of travel.</p>                   |
|          | (b) | (i)  | $z = \frac{\lambda_{\text{observed}} - \lambda_{\text{rest}}}{\lambda_{\text{rest}}} \quad (1)$ $z = \frac{610 \times 10^{-9} - 580 \times 10^{-9}}{580 \times 10^{-9}} \quad (1)$ $z = 0.052 \quad (1)$                                                                                                                                                                                                                                                                            | 3        | <p>Accept: 0.05, 0.0517, 0.05172</p> $z = \frac{\lambda_{\text{observed}} - \lambda_{\text{rest}}}{\lambda_{\text{rest}}}$ $z = \frac{610 - 580}{580}$ $z = 0.052$                |
|          |     | (ii) | $z = \frac{v}{c} \quad (1)$ $0.052 = \frac{v}{3.00 \times 10^8} \quad (1)$ $v = H_0 d \quad (1)$ $0.052 \times 3.00 \times 10^8 = 2.3 \times 10^{-18} \times d \quad (1)$ $d = 6.8 \times 10^{24} \text{ m} \quad (1)$                                                                                                                                                                                                                                                              | 5        | <p><b>OR</b> consistent with (b)(i)</p> <p>Accept: 7, 6.78, 6.783</p> $z = \frac{v}{c} \quad \text{relationship anywhere (1)}$ $v = H_0 d \quad \text{relationship anywhere (1)}$ |
|          | (c) | (i)  | $F = G \frac{m_1 m_2}{r^2} \quad (1)$ $F = 6.67 \times 10^{-11} \times \frac{2.19 \times 10^{30} \times 1.80 \times 10^{30}}{(3.44 \times 10^{12})^2} \quad (1)$ $F = 2.22 \times 10^{25} \text{ N} \quad (1)$                                                                                                                                                                                                                                                                      | 3        | Accept: 2.2, 2.222, 2.2219                                                                                                                                                        |
|          |     | (ii) | (Force is) four (times greater).                                                                                                                                                                                                                                                                                                                                                                                                                                                    | 1        |                                                                                                                                                                                   |