

# INTERNATIONAL A-LEVEL MATHEMATICS

## MA04

(9660/MA04) Unit S2 Statistics

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Mark scheme

January 2026

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Version: 1.0 Final

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### Key to mark scheme abbreviations

|                |                                                                    |
|----------------|--------------------------------------------------------------------|
| <b>M</b>       | Mark is for method                                                 |
| <b>m</b>       | Mark is dependent on one or more M marks and is for method         |
| <b>A</b>       | Mark is dependent on M or m marks and is for accuracy              |
| <b>B</b>       | Mark is independent of M or m marks and is for method and accuracy |
| <b>E</b>       | Mark is for explanation                                            |
| <b>✓ or ft</b> | Follow through from previous incorrect result                      |
| <b>CAO</b>     | Correct answer only                                                |
| <b>CSO</b>     | Correct solution only                                              |
| <b>AWFW</b>    | Anything which falls within                                        |
| <b>AWRT</b>    | Anything which rounds to                                           |
| <b>ACF</b>     | Any correct form                                                   |
| <b>AG</b>      | Answer given                                                       |
| <b>SC</b>      | Special case                                                       |
| <b>oe</b>      | Or equivalent                                                      |
| <b>A2, 1</b>   | 2 or 1 (or 0) accuracy marks                                       |
| <b>–x EE</b>   | Deduct x marks for each error                                      |
| <b>NMS</b>     | No method shown                                                    |
| <b>PI</b>      | Possibly implied                                                   |
| <b>SCA</b>     | Substantially correct approach                                     |
| <b>sf</b>      | Significant figure(s)                                              |
| <b>dp</b>      | Decimal place(s)                                                   |
| <b>ISW</b>     | Ignore subsequent working                                          |

| Q    | Answer                                                       | Marks                      | Comments                                                                                                                                      |
|------|--------------------------------------------------------------|----------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------|
| 1(a) | $P(T < 4) = 1 - e^{-\frac{1}{8} \times 4}$<br><br>$= 0.3935$ | <b>M1</b><br><br><b>A1</b> | <b>PI</b> Attempts to find correct probability using the cdf of the exponential distribution or through integration<br><br><b>AWRT</b> 0.3935 |
|      |                                                              | <b>2</b>                   |                                                                                                                                               |

| Q    | Answer                                                                                                                       | Marks                      | Comments                                                                                                                                                                    |
|------|------------------------------------------------------------------------------------------------------------------------------|----------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 1(b) | $P(3 < T < 10) = \left(1 - e^{-\frac{1}{8} \times 10}\right) - \left(1 - e^{-\frac{1}{8} \times 3}\right)$<br><br>$= 0.4008$ | <b>M1</b><br><br><b>A1</b> | <b>oe</b> sight of $\left(1 - e^{-\frac{1}{8} \times 10}\right)$ or $\left(1 - e^{-\frac{1}{8} \times 3}\right)$<br><b>PI</b> by 0.7134... or 0.3127....<br><br><b>AWRT</b> |
|      |                                                                                                                              | <b>2</b>                   |                                                                                                                                                                             |

| Q    | Answer                                                                               | Marks                      | Comments                                                                         |
|------|--------------------------------------------------------------------------------------|----------------------------|----------------------------------------------------------------------------------|
| 1(c) | $e^{-\frac{1}{8}t} = 0.2$<br><br>$-\frac{1}{8}t = \ln 0.2$<br><br>$t = 12.9$ [hours] | <b>M1</b><br><br><b>A1</b> | Sets up a correct equation and attempts to solve for $t$<br><br><b>AWRT</b> 12.9 |
|      |                                                                                      | <b>2</b>                   |                                                                                  |

| Q    | Answer | Marks     | Comments |
|------|--------|-----------|----------|
| 1(d) | 64     | <b>B1</b> |          |
|      |        | <b>1</b>  |          |

| Q    | Answer                                                                                | Marks                      | Comments   |
|------|---------------------------------------------------------------------------------------|----------------------------|------------|
| 1(e) | $P(T > 12   T > 9) = P(T > 3)$<br>$P(T > 3) = e^{-\frac{1}{8} \times 3}$<br>$= 0.687$ | <b>M1</b><br><br><b>A1</b> | <b>CAO</b> |
|      |                                                                                       | <b>2</b>                   |            |
|      | <b>Question 1 total</b>                                                               | <b>9</b>                   |            |

| Q           | Answer                                                       | Marks     | Comments                                    |
|-------------|--------------------------------------------------------------|-----------|---------------------------------------------|
| <b>2(a)</b> | $\int_2^a \frac{3}{1072} \sqrt{5x+6} dx = 1$                 | <b>M1</b> | Attempt to integrate and set equal to 1     |
|             | $\frac{1}{2680} \left[ (5x+6)^{\frac{3}{2}} \right]_2^a = 1$ | <b>A1</b> | Correct integration and limits seen or used |
|             | $(5a+6)^{\frac{3}{2}} - 64 = 2680$                           | <b>m1</b> | Attempt to use limits to find $a$           |
|             | $5a+6 = 196$                                                 |           |                                             |
|             | $a = 38$                                                     | <b>A1</b> | <b>CAO</b>                                  |
|             |                                                              | <b>4</b>  |                                             |

| Q           | Answer | Marks     | Comments |
|-------------|--------|-----------|----------|
| <b>2(b)</b> | 0      | <b>B1</b> |          |
|             |        | <b>1</b>  |          |

|  |                         |          |  |
|--|-------------------------|----------|--|
|  | <b>Question 2 total</b> | <b>5</b> |  |
|--|-------------------------|----------|--|

| Q    | Answer                     | Marks    | Comments  |
|------|----------------------------|----------|-----------|
| 3(a) | $0.85^{30}$<br>$= 0.00763$ | M1<br>A1 | oe<br>CAO |
|      |                            | 2        |           |

| Q    | Answer                                                                                                                                                                                                                                         | Marks                                | Comments                                                                                                                                                                                                                                                                                                                                                                                                                     |
|------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 3(b) | $H_0 : p = 0.15$<br>$H_1 : p < 0.15$<br>$X \sim B(30, 0.15)$<br>$P(X \leq 1) = 0.0480$<br>$0.0480 < 0.05$<br>Reject $H_0$<br>Evidence to suggest that the new computer system has decreased the proportion of missed appointments each workday | B1<br>M1<br>A1<br>A1ft<br>B1ft<br>E1 | Both hypotheses $H_0 : p = 0.85$<br>$H_1 : p > 0.85$<br>PI by a binomial probability calculation $Y \sim B(30, 0.85)$<br>$P(Y \geq 29) = 0.0480$ or CR is $X \leq 1$<br>Compares their probability with 0.05 or states 1 is in the CR<br>Correct conclusion on $H_0$ based on a comparison of their test statistic with 0.05<br>Must be in context, must not be definite and all the previous 5 marks must have been awarded |
|      |                                                                                                                                                                                                                                                | 6                                    |                                                                                                                                                                                                                                                                                                                                                                                                                              |

| Q    | Answer                                                                                    | Marks | Comments |
|------|-------------------------------------------------------------------------------------------|-------|----------|
| 3(c) | Concluding that the proportion of missed appointments has decreased even though it hasn't | B1    |          |
|      |                                                                                           | 1     |          |

|  |                  |   |  |
|--|------------------|---|--|
|  | Question 3 total | 9 |  |
|--|------------------|---|--|

| Q    | Answer                                                                                                                                          | Marks     | Comments                             |
|------|-------------------------------------------------------------------------------------------------------------------------------------------------|-----------|--------------------------------------|
| 4(a) | Any <b>two</b> from;<br>That each car arrives independently of another car<br>That cars arrive at a constant average rate<br>Cars arrive singly | <b>B2</b> | <b>B1</b> for one correct assumption |
|      |                                                                                                                                                 | <b>2</b>  |                                      |

| Q       | Answer                                                                          | Marks                                       | Comments                                                                                                                                  |
|---------|---------------------------------------------------------------------------------|---------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------|
| 4(b)(i) | $\sum fx = 140$ or $\sum fx^2 = 528$<br><br>$\bar{x} = 2.8$<br><br>$s^2 = 2.78$ | <b>M1</b><br><br><b>A1</b><br><br><b>A1</b> | Sight of either summary statistic<br><b>PI</b> by at one correct value<br><br><b>oe</b><br><br><b>AWRT</b> 2.78<br>Allow $\frac{136}{49}$ |
|         |                                                                                 | <b>3</b>                                    |                                                                                                                                           |

| Q        | Answer                                                                                             | Marks     | Comments                                                                |
|----------|----------------------------------------------------------------------------------------------------|-----------|-------------------------------------------------------------------------|
| 4(b)(ii) | As $\bar{x} \approx s^2$ we can conclude that a Poisson distribution might be a good model for $X$ | <b>B1</b> | <b>ft</b> their $\bar{x}$ and $s^2$ with correct comment on suitability |
|          |                                                                                                    | <b>1</b>  |                                                                         |

| Q       | Answer              | Marks     | Comments |
|---------|---------------------|-----------|----------|
| 4(c)(i) | $[2.9 + 3.6] = 6.5$ | <b>B1</b> |          |
|         |                     | <b>1</b>  |          |

| Q        | Answer                                   | Marks     | Comments                                                                          |
|----------|------------------------------------------|-----------|-----------------------------------------------------------------------------------|
| 4(c)(ii) | $P(T \leq 13) = 0.9929$                  | <b>M1</b> | <b>oe</b> such as $P(T < 14) = 0.9929$                                            |
|          | $P(T \leq b) = 0.9929 - 0.7692$          | <b>M1</b> | <b>oe</b> $P(T \leq b) = P(T \leq 13) - 0.7692$<br><b>ft</b> their $P(T \leq 13)$ |
|          | $P(T \leq 4) = 0.2237 \Rightarrow b = 4$ | <b>A1</b> | <b>CAO</b> from fully correct working                                             |
|          |                                          | <b>3</b>  |                                                                                   |

|  |                         |           |  |
|--|-------------------------|-----------|--|
|  | <b>Question 4 total</b> | <b>10</b> |  |
|--|-------------------------|-----------|--|

| Q    | Answer                                   | Marks | Comments                               |
|------|------------------------------------------|-------|----------------------------------------|
| 5(a) | $1 - \int_0^{0.5} \frac{1}{2} x^2 \, dx$ | M1    | oe<br>1 – their attempt at integration |
|      | $= 1 - \frac{1}{6} \times 0.5^3$         | A1    | AWRT 0.979                             |
|      | $= \frac{47}{48}$                        |       |                                        |
|      |                                          | 2     |                                        |

| Q    | Answer                                                                                        | Marks | Comments                                                                           |
|------|-----------------------------------------------------------------------------------------------|-------|------------------------------------------------------------------------------------|
| 5(b) | $[E(X) =] \int_0^1 \frac{1}{2} x^3 \, dx + \int_1^4 \frac{x}{54} (35 - 8x) \, dx$             | M1    | Correct integrals and limits PI                                                    |
|      | $= \left[ \frac{x^4}{8} \right]_0^1 + \left[ \frac{35x^2}{108} - \frac{4x^3}{81} \right]_1^4$ | A1    | Correct integration with correct limits seen or used<br>PI by correct final answer |
|      | $= \left( \frac{1}{8} - 0 \right) + \left( \frac{164}{81} - \frac{89}{324} \right)$           |       |                                                                                    |
|      | $= \frac{15}{8}$                                                                              | A1    | oe                                                                                 |
|      |                                                                                               | 3     |                                                                                    |

| Q    | Answer                                                                                                                                                                                                                                                                                                                                                                                                               | Marks                                                               | Comments                                                                                                                                                                                                                                           |
|------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 5(c) | $\left[ E(X)^2 = \int_0^1 \frac{1}{2}x^4 dx + \int_1^4 \frac{x^2}{54}(35-8x) dx \right]$ $= \left[ \frac{x^5}{10} \right]_0^1 + \left[ \frac{35x^3}{162} - \frac{x^4}{27} \right]_1^4$ $= \left( \frac{1}{10} - 0 \right) + \left( \frac{352}{81} - \frac{29}{162} \right)$ $= \frac{64}{15}$ $\left[ \text{Var}(X) = E(X)^2 - (E(X))^2 = \right] \frac{64}{15} - \left( \frac{15}{8} \right)^2$ $= \frac{721}{960}$ | <p><b>M1</b></p> <p><b>A1</b></p> <p><b>M1</b></p> <p><b>A1</b></p> | <p>Correct integrals and limits</p> <p>Correct value for <math>E(X)^2</math></p> <p>ft their <math>E(X)^2</math> and their <math>E(X)</math> in the correct formula for <math>\text{Var}(X)</math></p> <p><b>AG</b> Must be convincingly shown</p> |
|      |                                                                                                                                                                                                                                                                                                                                                                                                                      | <b>4</b>                                                            |                                                                                                                                                                                                                                                    |

| Q    | Answer                                                                                    | Marks                             | Comments                                                   |
|------|-------------------------------------------------------------------------------------------|-----------------------------------|------------------------------------------------------------|
| 5(d) | $\left[ 3^2 \times \text{Var}(X) = \right] 9 \times \frac{721}{960}$ $= \frac{2163}{320}$ | <p><b>M1</b></p> <p><b>A1</b></p> | <p><b>PI</b> by correct final answer</p> <p><b>CAO</b></p> |
|      |                                                                                           | <b>2</b>                          |                                                            |

|  |                         |           |  |
|--|-------------------------|-----------|--|
|  | <b>Question 5 total</b> | <b>11</b> |  |
|--|-------------------------|-----------|--|

| Q    | Answer  | Marks | Comments |
|------|---------|-------|----------|
| 6(a) | $c = 6$ | B1    |          |
|      |         | 1     |          |

| Q    | Answer                                                                                                                                                                                                                        | Marks                  | Comments                                                                                                                                                                                                                                                                                                                                                                                                         |
|------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 6(b) | $\frac{d}{dt}\left(1 - \frac{t}{32}(t-6)^2\right) = \frac{-3t^2}{32} + \frac{3}{4}t - \frac{9}{8}$ $f(t) = \begin{cases} \frac{-3t^2}{32} + \frac{3}{4}t - \frac{9}{8} & 2 \leq t \leq 6 \\ 0 & \text{otherwise} \end{cases}$ | <p>M1 A1</p> <p>A1</p> | <p>M1: Attempts to differentiate wrt to <math>t</math></p> <p>A1: Correct expression for <math>f(t)</math> in terms of <math>t</math> for <math>2 \leq t \leq 6</math></p> <p>PI by <math>\frac{-3}{32}(t-2)(t-6)</math> oe</p> <p>Fully correct pdf<br/>condone <math>c</math> for 6</p> <p>Allow <math>t &lt; 2</math>, <math>t &gt; 6</math> in place of 'otherwise', which may be written over two lines</p> |
|      |                                                                                                                                                                                                                               | 3                      |                                                                                                                                                                                                                                                                                                                                                                                                                  |

|  |                  |   |  |
|--|------------------|---|--|
|  | Question 6 total | 4 |  |
|--|------------------|---|--|

| Q    | Answer                                                                                                                                                                                                                                                                                                                                                                                                                     | Marks                                                                                                                             | Comments                                                                                                                                                                                                                                                                                                                                                                                              |
|------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 7(a) | $H_0 : \mu = 2000$<br>$H_1 : \mu \neq 2000$<br><br>$\bar{X} \sim N\left(2000, \frac{18^2}{40}\right)$<br><br>$z = \frac{1995 - 2000}{\sqrt{\frac{18^2}{40}}}$<br><br>$z = -1.75682\dots$<br><br>$z_{critical} = -1.9600\dots$<br><br>Fail to reject $H_0$ as $-1.96 < -1.76$<br>or $ z  <  z_{critical} $<br><br>Insufficient evidence to suggest the LED lightbulb meantime has changed [at the 5% level of significance] | <b>B1</b><br><br><br><b>M1</b><br><br><br><b>M1</b><br><br><br><b>A1</b><br><br><b>B1</b><br><br><b>A1ft</b><br><br><br><b>E1</b> | Both hypotheses<br><br><b>PI</b><br><br><br><b>PI</b><br><br><br><b>AWRT</b> $-1.76$<br><b>AWRT</b> $-1.96$ or<br>$P(\bar{X} > 1995) = \text{AWFW}$ [0.0392, 0.0395]<br><b>oe</b> Dependent on both <b>M1</b> marks and a correct comparison of their values using a $z$ -test, e.g. $z_{critical} < z$ , or $0.039511 > 0.025$<br><br>Correct statement must be in context and must not be definite. |
|      |                                                                                                                                                                                                                                                                                                                                                                                                                            | <b>7</b>                                                                                                                          |                                                                                                                                                                                                                                                                                                                                                                                                       |

| Q    | Answer                                                                                                                                                                                                                                      | Marks                          | Comments                                                                                            |
|------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------|-----------------------------------------------------------------------------------------------------|
| 7(b) | An increase in the standard deviation causes a <b>decrease</b> in the magnitude of the $z$ -value of the test statistic.<br><br>This will have <b>no</b> effect to the conclusion of the hypothesis as $ z  <  z_{critical} $ remains true. | <b>E1</b><br><br><br><b>E1</b> | <b>oe</b><br><br><br><b>oe</b> $z_{critical} < z$<br>Must have been awarded previous <b>E1</b> mark |
|      |                                                                                                                                                                                                                                             | <b>2</b>                       |                                                                                                     |

| Q    | Answer                                                                                                                          | Marks | Comments                               |
|------|---------------------------------------------------------------------------------------------------------------------------------|-------|----------------------------------------|
| 7(c) | Central limit theorem [applies as the sample size is large enough, the sample mean will be approximately] normally distributed] | E1    | Refers to central limit theorem        |
|      | The sample size is 40 which is sufficient [to apply the central limit theorem]                                                  | E1    | Refers to sample size being sufficient |
|      |                                                                                                                                 | 2     |                                        |
|      | Question 7 total                                                                                                                | 11    |                                        |

| Q    | Answer                                          | Marks | Comments |
|------|-------------------------------------------------|-------|----------|
| 8(a) | $H_0 : \lambda = 15$<br>$H_1 : \lambda \neq 15$ | B1    |          |
|      |                                                 | 1     |          |

| Q    | Answer                                                                                                                                                                                            | Marks                            | Comments                                                                                                                                                                                                                                                                                            |
|------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 8(b) | $P(X \leq 8) = 0.0374 (< 0.05)$<br>$P(X \leq 9) = 0.0699 (> 0.05)$<br><br>$CR \{X \leq 8\}$<br><br>$P(X \geq 22) = 0.0531 (> 0.05)$<br>$P(X \geq 23) = 0.0327 (< 0.05)$<br><br>$CR \{X \geq 23\}$ | M1<br><br>A1<br><br>M1<br><br>A1 | Either correct probability statement<br><br>Both probabilities and a correct CR for the lower tail<br><br>Either correct probability statement or at least one of<br>$P(X \leq 21) = 0.9469 (< 0.95)$<br>$P(X \leq 22) = 0.9673 (> 0.95)$<br>Both probabilities and a correct CR for the upper tail |
|      |                                                                                                                                                                                                   | 4                                |                                                                                                                                                                                                                                                                                                     |

| Q    | Answer                                                                                                                                                                                              | Marks            | Comments                                                                                                                                  |
|------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------|-------------------------------------------------------------------------------------------------------------------------------------------|
| 8(c) | As 22 is not in the Critical Region.<br><br>... there is insufficient evidence to support that the [population] mean number of bacteria in the water has changed (at the 10% level of significance) | E1ft<br><br>E1ft | Comparison of 22 to their CR<br><br>Comment in context which cannot be definite<br>ft their CR<br>Must have been awarded previous E1 mark |
|      |                                                                                                                                                                                                     | 2                |                                                                                                                                           |

| Q    | Answer                                                                                                                   | Marks | Comments           |
|------|--------------------------------------------------------------------------------------------------------------------------|-------|--------------------|
| 8(d) | Rejecting that there has been a change in the [population] mean number of bacteria in water when there has been a change | E1    | Must be in context |
|      |                                                                                                                          | 1     |                    |

|  |                  |   |  |
|--|------------------|---|--|
|  | Question 8 total | 8 |  |
|--|------------------|---|--|

| Q    | Answer                                                                                                                                                           | Marks                                                               | Comments                                                                                                                                                                                 |
|------|------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 9(a) | $\left[ P(\bar{X}_1 > 182) = 0.9 \Rightarrow \right] z = -1.2816$ $-1.2816 > \frac{182 - 185}{\frac{20}{\sqrt{n}}}$ $\sqrt{n} > 8.544...$ $n > 72.9...$ $n = 73$ | <p><b>B1</b></p> <p><b>M1</b></p> <p><b>m1</b></p> <p><b>A1</b></p> | <p><b>Allow</b> <math>\pm 1.28</math><br/> <b>PI</b> by answer correct to 3 sf before rounding</p> <p>For standardising</p> <p>Attempt to solve for <math>n</math></p> <p><b>CAO</b></p> |
|      |                                                                                                                                                                  | <b>4</b>                                                            |                                                                                                                                                                                          |

| Q    | Answer                                                      | Marks | Comments                                                                                                      |
|------|-------------------------------------------------------------|-------|---------------------------------------------------------------------------------------------------------------|
| 9(b) | Mean of $X_T = 555 + \mu$                                   | B1    | PI if embedded correctly in calculations                                                                      |
|      | Variance of $X_T = 625 + \sigma^2$                          | B1    | PI if embedded correctly in calculations                                                                      |
|      | $1.6449 = \frac{750 - (555 + \mu)}{\sqrt{625 + \sigma^2}}$  | M1 A1 | M1: Attempt to standardise with <b>AWRT</b><br>$z = 1.64$<br>A1: Fully correct expression                     |
|      | $-2.0537 = \frac{650 - (555 + \mu)}{\sqrt{625 + \sigma^2}}$ | M1 A1 | M1: Attempt to standardise with <b>AWRT</b><br>$z = -2.05$<br>A1: Fully correct expression                    |
|      | $3.6986\sqrt{625 + \sigma^2} = 100$                         | m1    | Correctly eliminates one unknown<br>$\frac{1.6449}{-2.0537} = \frac{195 - \mu}{95 - \mu}$                     |
|      | $\sigma = 10.3$ [3 sf]                                      | A1    | <b>AWRT</b> 10.3<br>(use of 3 sf for 1.64 and $-2.05$ gives 10.5 (3sf) gets <b>A0</b> then <b>A1</b> for 151) |
|      | $\mu = 151$ [3 sf]                                          | A1    | <b>AWRT</b> 151                                                                                               |
|      |                                                             | 9     |                                                                                                               |

|  |                         |           |  |
|--|-------------------------|-----------|--|
|  | <b>Question 9 total</b> | <b>13</b> |  |
|--|-------------------------|-----------|--|