# Mark Scheme (Results)

## Summer 2025

Pearson Edexcel GCE
In A Level Further Mathematics (9FM0)
Paper 3B Further Statistics 1

**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 2025
Question Paper Log Number P76380A
Publications Code 9FM0_3B_2506_MS
All the material in this publication is copyright
© Pearson Education Ltd 2025

**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.

**EDEXCEL GCE MATHEMATICS**
**General Instructions for Marking**

1. The total number of marks for the paper is 75.

2. The Edexcel Mathematics mark schemes use the following types of marks:

- **M** marks: method marks are awarded for 'knowing a method and attempting to apply it', unless otherwise indicated.
- **A** marks: Accuracy marks can only be awarded if the relevant method (M) marks have been earned.
- **B** marks are unconditional accuracy marks (independent of M marks)
- Marks should not be subdivided.

3. Abbreviations

These are some of the traditional marking abbreviations that will appear in the mark schemes.

- bod – benefit of doubt
- ft – follow through
- the symbol $\surd$ will be used for correct ft
- cao – correct answer only
- cso - correct solution only. There must be no errors in this part of the question to obtain this mark
- isw – ignore subsequent working
- awrt – answers which round to
- SC: special case
- oe – or equivalent (and appropriate)
- dep – dependent
- indep – independent
- dp decimal places
- sf significant figures
- $*$ The answer is printed on the paper
- ⌐ The second mark is dependent on gaining the first mark

4. For misreading which does not alter the character of a question or materially simplify it, deduct two from any A or B marks gained, in that part of the question affected.

5. Where a candidate has made multiple responses and indicates which response they wish to submit, examiners should mark this response.
   If there are several attempts at a question which have not been crossed out, examiners should mark the final answer which is the answer that is the most complete.

6. Ignore wrong working or incorrect statements following a correct answer.

7. Mark schemes will firstly show the solution judged to be the most common response expected from candidates. Where appropriate, alternatives answers are provided in the notes. If examiners are not sure if an answer is acceptable, they will check the mark scheme to see if an alternative answer is given for the method used.

| Question | Scheme | Marks | AOs |
|---|---|---|---|
| **1(a)(i)** | $X \sim \text{NB}(4, 0.15)$ | M1 | 3.3 |
| | $\binom{19}{3}(0.15)^4(1-0.15)^{16} = 0.03642$ **awrt 0.0364** | A1 | 1.1b |
| | | **(2)** | |
| **(a)(ii)** | $X \sim \text{B}(18, 0.15)$ | M1 | 3.3 |
| | $\binom{18}{4}(0.15)^4(1-0.15)^{14} = 0.15920\ldots$ **awrt 0.159** | A1 | 1.1b |
| | | **(2)** | |
| **(b)** | Uses $\frac{4}{p}$ as an expression for the mean | B1 | 3.4 |
| | $\frac{4}{p} \geq 32$ | M1 | 1.1b |
| | $p = \frac{1}{8}$ or 0.125 or 12.5% | A1 | 1.1b |
| | | **(3)** | |
| | | | **(7 marks)** |

**Notes:**

| | | |
|---|---|---|
| **(a)(i)** | **M1:** | selecting NB(4, 0.15) or use of a correct method, may be implied by a correct answer |
| | **A1:** | awrt 0.0364 |
| **(a)(ii)** | **M1:** | selecting B(18, 0.15) or use of a correct method, may be implied by a correct answer |
| | **A1:** | awrt 0.159 |
| **(b)** | **B1:** | [E($X$)] = $\frac{4}{p}$ |
| | **M1:** | for an equation or inequality with **their** expression for mean and 32<br>allow mean = 32 or mean > 32<br>mean $\leq$ 32 or mean $<$ 32 is M0 |
| | **A1:** | 0.125 or exact equivalent<br>Must not come from clearly incorrect working<br>**NB**: $p \leqslant \frac{1}{8}$ is B1M1A0<br>M0 implies A0 (method mark cannot be implied here) |

| Question | Scheme | Marks | AOs |
|---|---|---|---|
| 2(a) | $\mathrm{E}(X) = -1\times\frac{1}{2}+\frac{1}{4}\times a+\frac{1}{4}\times b$<br>$\left[\mathrm{E}(X)=\right]\ \frac{1}{4}a+\frac{1}{4}b-\frac{1}{2}$ | M1<br>A1 | 1.1b<br>1.1b |
| | | **(2)** | |
| (b) | $\mathrm{Var}(Y)=b^2\mathrm{Var}(X)$ | M1 | 1.1b |
| | $b^2=\frac{1}{4}\quad\rightarrow\quad b=\frac{1}{2}$ | A1 | 1.1b |
| | $\mathrm{E}(Y)=a+b\mathrm{E}(X)$ <br> $a-b$ \| $a+ab$ \| $a+b^2$ <br> 0.5 \| 0.25 \| 0.25 | B1 | 2.1 |
| | $a+b\left(\frac{1}{4}a+\frac{1}{4}b-\frac{1}{2}\right)=\frac{5}{16}$ <br> $\frac{1}{2}(a-b)+\frac{1}{4}(a+ab)+\frac{1}{4}(a+b^2)=\frac{5}{16}$ | M1 | 1.1b |
| | $a=\frac{4}{9}$ | A1 | 1.1b |
| | $\mathrm{E}(X)=\frac{1}{4}\left('\frac{4}{9}'\right)+\frac{1}{4}'\left(\frac{1}{2}'\right)-\frac{1}{2}$ | M1 | 3.1a |
| | $\mathrm{E}(X)=-\frac{19}{72}$ | A1 | 1.1b |
| | | **(7)** | |
| | | | **(9 marks)** |

**Notes:**

| | | |
|---|---|---|
| **(a)** | **M1:** | Attempt at E($X$), at least two terms correct |
| | **A1:** | Full correct expression for E($X$), may be unsimplified |
| **(b)** | **M1:** | Writing or using $\mathrm{Var}(Y)=b^2\mathrm{Var}(X)$ |
| | **A1:** | For finding $b=\frac{1}{2}$ |
| | **B1:** | Writing using $\mathrm{E}(Y)=a+b\mathrm{E}(X)$, or writing a correct probability distribution for $Y$ |
| | **M1:** | Correct expression for E($Y$) in terms of $a$ and $b$ (or their value of $b$)<br>**and** equating their expression to $\frac{5}{16}$ |
| | **A1:** | $a=\frac{4}{9}$ or exact equivalent |
| | **M1:** | Substituting their values of $a$ and $b$ into their expression for E($X$) where $a,\ b\neq\frac{5}{16}$ |
| | **A1:** | $\mathrm{E}(X)=-\frac{19}{72}$ or exact equivalent |

| Question | Scheme | Marks | AOs |
|---|---|---|---|
| **3(a)** | $\left[E_1=\frac{180\times 120}{400}\quad E_2=\frac{180\times 160}{400}\quad E_3=\frac{220\times 120}{400}\quad E_4=\frac{220\times 160}{400}\right]$ | | |
| | Two of: $E_1=54\quad E_2=72\quad E_3=66\quad E_4=88$ | B1 | 2.2a |
| | All four of: $E_1=54\quad E_2=72\quad E_3=66\quad E_4=88$ | B1 | 1.1b |
| | | **(2)** | |
| **(b)** | $H_0$: Whether a film passes the (Gender Equality) Test is not associated with the period in which the film is first released<br>$H_1$: Whether a film passes the (Gender Equality) Test or not is associated with the period in which the film is first released | B1 | 2.5 |
| | | **(1)** | |
| **(c)** | Correct method for finding at **least two terms** of $\chi^2$:<br>$\frac{(O_i-E_i)^2}{E_i}$: 1.5, 0.06, 2.24, 1.23, 0.05, 1.83<br>$\frac{O_i^2}{E_i}$: 37.5, 68.06, 78.24, 85.23, 92.05, 45.83 | M1 | 1.1b |
| | $\chi^2$ = **awrt 6.9** | A1 | 1.1b |
| | $\nu = (3-1)(2-1) = \mathbf{2}$ | B1 | 1.1b |
| | $\chi^2_2(5\%) = 5.991$ | B1ft | 1.1b |
| | '6.9' > '5.991'<br>Sufficient evidence to reject $H_0$ | M1 | 3.4 |
| | Sufficient evidence to support journalist's belief<br>or<br>Sufficient evidence that whether a film passes the gender equality test is associated with the period in which the film is first released | A1ft | 2.2b |
| | | **(6)** | |
| **(d)(i)** | The observed frequencies for each period are more than 100<br>or<br>All the $O_i$ and $E_i$ are lower as percentages<br>or<br>The difference between all the $O$i and $E$i is lower | M1 | 3.5a |
| | Therefore, the test statistic would decrease (5.7…) | A1 | 2.2a |
| **(d(ii)** | The journalist should not follow her editor's suggestion (**with** an appropriate reason).<br>e.g.<br>• As it may/will change the result of the test<br>• As they should use the real data rather than percentages | B1 | 2.4 |
| | | **(3)** | |
| | | | **(12 marks)** |

| **Notes:** | | |
|---|---|---|
| **(a)** | **B1:** | Two of $E_1$, $E_2$, $E_3$, $E_4$ correct |
| | **B1:** | All four of $E_1$, $E_2$, $E_3$, $E_4$ correct |
| **(b)** | **B1:** | Correct hypotheses mentioning test, and period/date<br>**and** association/independence mentioned in at least one hypothesis<br>Use of correlation/correlated is B0<br>**NB:** Relationship/related is condoned if association/independence mentioned at all |
| **(c)** | **M1:** | Correct method (terms may be unsimplified in an expression, and hence may need to be checked) shown for finding **two $\chi^2$ terms**, accept either method<br>May be implied by a test statistic of awrt 6.9 |
| | **A1:** | awrt 6.9 |
| | **B1:** | 2 degrees of freedom (can be implied by cv of 5.991) |
| | **B1ft:** | Correct critical value (ft their df)<br>Must be consistent with their df. |
| | **M1:** | For a correct non-contextual conclusion based on their CV and their test statistic<br>May be implied by a correct contextual conclusion if no contradictions |
| | **A1ft:** | For a correct contextual conclusion referring to the journalist's belief **or** mentioning (gender equality) test and period/date (ft their cv)<br>Dependent on 1st A1<br>Do not allow contradictory statements<br>B0 for correlation/correlated<br>Condone 'related/relationship' in part (c)<br>**NB:** We ignore their hypotheses when marking (c) |
| **(d) (i)** | **M1:** | Mentioning that observed totals for each period are more than 100<br>or<br>Mentioning that all the $O_i$ and $E_i$ have reduced<br>Or<br>Mentioning that all the differences between the $O_i$ and $E_i$ have reduced<br>(must state or imply that this is true for all)<br>or<br>Calculating the new test statistic correctly (awrt 5.7) |
| | **A1:** | The test statistic would decrease (dependent on the previous M1) |
| **(d) (ii)** | **B1:** | See scheme.<br>B0 for vague reasoning such as 'should not use percentages as it would be inaccurate'<br>**NB:** Reasoning for (d)(ii) may be seen in (d)(i)<br>Do not award final B1 if contradictions between their reasoning in (i) and (ii) |

| Question | Scheme | M | AOs |
|---|---|---|---|
| 4(a) | $G_X(1)=1 \quad \Rightarrow \quad \frac{1}{1-\frac{2}{5}}-k=1$ | M1 | 2.1 |
| | $k=\frac{2}{3}$ | A1 | 1.1b |
| | | **(2)** | |
| (b) | $G'_X(t)=-\frac{-\frac{2}{5}}{\left(1-\frac{2t}{5}\right)^2}$ | M1 | 2.1 |
| | $\left[G'_X(t)=\right]\frac{2}{5}\left(1-\frac{2t}{5}\right)^{-2}$ may see $\left[G'_X(t)=\right]\frac{10}{(5-2t)^2}$ | A1 | 1.1b |
| | $G'_X(1)=\frac{2}{5\left(1-\frac{2}{5}\right)^2} \quad \Rightarrow \quad \left[E(X)=\right]\frac{10}{9}$ | A1 | 1.1b |
| | | **(3)** | |
| (c) | $G''_X(t)=(-2)\times\frac{2\times\left(-\frac{2}{5}\right)}{5\left(1-\frac{2t}{5}\right)^3}=\frac{8}{25\left(1-\frac{2t}{5}\right)^3}$ Use of binomial expansion or standard power series (at least two terms **or** $t^2$ term correct) | M1 | 3.1a |
| | Use of Maclaurin series for $t^2$ (use of $P(X=2)=\frac{G''_X(0)}{2!}$) $\frac{(-1)(-2)\left(-\frac{2t}{5}\right)^2}{2!}$ | M1 | 1.1b |
| | $\frac{1}{2}\times\frac{8}{25}=\frac{4}{25}$ $\frac{4}{25}$ | A1 | 1.1b |
| | | **(3)** | |
| (d) | Use of $\frac{1}{t}G_X(t)$ or $G_X(t^4)$ shown | M1 | 3.1a |
| | $G_Y(t)=\frac{1}{t}\left(\frac{1}{1-\frac{2t^4}{5}}-'\frac{2}{3}'\right)$ | A1ft | 1.1b |
| | | **(2)** | |
| | | | **(10 marks)** |

**Notes:**

| | | | |
|---|---|---|---|
| **(a)** | **M1:** | For writing or using $G_X(1)=1$ | |
| | **A1:** | For finding $k=\frac{2}{3}$ (must be exact) | |
| **(b)** | **M1:** | Attempt to differentiate $G_X(t)$ to obtain $A\left(1-\frac{2t}{5}\right)^{-2}$ (o.e.) for some constant $A$ | |
| | **A1:** | Correct differential (may be unsimplified) | |
| | **A1:** | For finding $\left[E(X)=\right]\frac{10}{9}$ (must be exact, and must come from a correct differential) | |
| **(c)** | **M1:** | For $G''_X(t)$ in the form $A\left(1-\frac{2t}{5}\right)^{-3}$ **or** a correct expression (not value) for $G''_X(0)$ | Two terms correct from: $\frac{1}{3}+(-1)\left(-\frac{2}{5}t\right)+\frac{(-1)(-2)}{2}\left(-\frac{2}{5}t\right)^2$ |
| | **M1:** | For correct method to find $G''_X(t)$ and use of $P(X=2)=\frac{G''_X(0)}{2!}$ (ft their $G'_X(t)$ in (b) provided $G'_X(t)$ not constant) | Correct unsimplified expression for $t^2$ seen (may be part of expansion) |
| | **A1:** | For $\frac{4}{25}$ o.e. | For $\frac{4}{25}$ o.e |
| **(d)** | **M1:** | Sight or use of $\frac{1}{t}G_X(t)$ or $G_X(t^4)$ stated or effected in expression | |
| | **A1ft:** | Correct expression, ft their $k$ (accept $k$ itself). ISW following a correct expression. | |

| Q | Scheme | M | AOs |
|---|---|---|---|
| **5(a)** | One correct assumption in context from below | B1 | 3.5b |
| | Two correct assumptions from below, with goals or matches mentioned at least once<br>• Goals are scored at a constant rate<br>• Goals are scored independently/randomly **or** matches are independent<br>• Goals are scored not scored simultaneously **or** Goals are scored singly | B1 | 3.5b |
| | | **(2)** | |
| **(b)** | $A_{0.5} \sim \text{Po}(0.9)$ and $A_1 \sim \text{Po}(1.8)$ | B1 | 3.3 |
| | $\text{P}(A_{0.5}=2 \mid A_1=3)=\dfrac{\text{P}(A_{0.5}=2)\times\text{P}(A_{0.5}=1)}{\text{P}(A_1=3)}$ | M1 | 3.4 |
| | $\text{P}(A_{0.5}=2 \mid A_1=3)=\dfrac{\frac{0.9^2\text{e}^{-0.9}}{2!}\times\frac{0.9\text{e}^{-0.9}}{1!}}{\frac{1.8^3\text{e}^{-1.8}}{3!}}$ or $\dfrac{0.164\ldots\times0.365\ldots}{0.160\ldots}$ | M1 | 1.1b |
| | $\text{P}(A_{0.5}=2 \mid A_1=3)=\dfrac{3}{8}$ $\quad\quad$ $\dfrac{3}{8}$ or exact equivalent | A1 | 1.1b |
| | | **(4)** | |
| **(c)(i)** | $X \sim \text{B}(4,\ 0.55)$ | B1 | 3.3 |
| **(c)(ii)** | $\text{E}(X)=\text{'4'}\times\text{'0.55'}\ [=2.2]$ **or** $\text{Var}(X)=\text{'4'}\times\text{'0.55'}\times(1-\text{'0.55'})\ [=0.99]$ | M1 | 2.1 |
| | $\overline{X} \simeq \text{N}\left(2.2,\ \dfrac{0.99}{40}\right)$ | M1 | 3.3 |
| | $\text{P}(\overline{X}>2)$ **awrt 0.898** | A1 | 3.4 |
| | | **(4)** | |
| | | | **(10 marks)** |

**Notes:**

| | | |
|---|---|---|
| **(a)** | **B1:** | One contextual correct assumption relating to independence/constant rate/singly<br>Must mention goals or match, or equivalent context. |
| | **B1:** | Two correct contextual assumptions with goals/matches mentioned at least once.<br>Assumptions relating to probability or number of goals are B0, but do not penalise if two correct assumptions also given. |
| **(b)** | **B1:** | Stating or using both correct Poisson distributions [0.164… or 0.365… implies Po(0.9), 0.160… implies Po(1.8). Both are required for this mark]<br>**or** writing or using B(3, 0.5) |
| | **M1:** | Correct use of conditional probability formula. Implied by $\dfrac{0.164\ldots\times0.365\ldots}{0.160\ldots}$<br>Or writing or using **any** binomial distribution **and** P($X$ = 2) |
| | **M1:** | Correct expression with probabilities **or** writing or using B(3, 0.5) **and** P($X$ = 2) |
| | **A1:** | Correct exact answer. Do not award if there is clear evidence of rounding. |
| **(c)(i)** | **B1** | Stating correct binomial distribution |
| **(c)(ii)** | **M1:** | Correct method to find the mean **or** variance of $X$ (a mean of 2.2 from Poisson is M1)<br>ft their $n$ and $p$ |
| | **M1:** | Correct approximate normal distribution [condone using $X$ not $\overline{X}$]. Allow variance awrt 0.0248 |
| | **A1:** | awrt 0.898<br>**NB:** awrt 0.898 implies the M1M1A1 |

| Question | Scheme | Marks | AOs |
|---|---|---|---|
| **6(a)(i)** | $B \sim \text{Geo}\left(\frac{1}{3}\right)$ | M1 | 3.3 |
| | $\text{P}(B=3)=\left(\frac{2}{3}\right)^2\times\left(\frac{1}{3}\right)=\frac{4}{27}$ awrt 0.148 | A1 | 1.1b |
| | | **(2)** | |
| **(a)(ii)** | $F \sim \text{Geo}\left(\frac{1}{2}\right)$ **and** use of $\text{P}(F\leq n)=1-(1-p)^n$ | M1 | 2.1 |
| | $\text{P}(2\leq F\leq 8)=\text{P}(F\leq 8)-\text{P}(F\leq 1)$ | M1 | 1.1b |
| | $\text{P}(2\leq F\leq 8)=1-\left(\frac{1}{2}\right)^8-\left(1-\frac{1}{2}\right)=\frac{1}{2}-\frac{1}{256}=\frac{127}{256}$ awrt 0.496 | A1 | 1.1b |
| | | **(3)** | |
| **(a)(iii)** | $\text{P}[(F=3)\cup(B=3)]=\text{P}(F=3)+\text{P}(B=3)-\text{P}(F=3)\times\text{P}(B=3)$<br>or<br>$\text{P}[(F=3)\cup(B=3)]=1-\text{P}(F\neq 3)\times\text{P}(B\neq 3)$<br>or<br>$\text{P}[(F=3)\cup(B=3)]=\text{P}(B=3)+\text{P}(F=3)\times\text{P}(B\neq 3)$ | M1 | 2.1 |
| | $'\frac{4}{27}'+\left[\left(\frac{1}{2}\right)^2\times\left(\frac{1}{2}\right)\right]-'\frac{4}{27}'\times\left[\left(\frac{1}{2}\right)^2\times\left(\frac{1}{2}\right)\right]$<br>or<br>$1-\left[1-'\frac{4}{27}'\right]\times\left[1-\left(\frac{1}{2}\right)^2\times\left(\frac{1}{2}\right)\right]$ | M1 | 1.1b |
| | $'\frac{4}{27}'+\frac{1}{8}-'\frac{4}{27}'\times\frac{1}{8}=\frac{55}{216}$ or $1-\left[1-'\frac{4}{27}'\right]\times\frac{7}{8}=\frac{55}{216}$ awrt 0.255 | A1 | 1.1b |
| | | **(3)** | |
| **(b)** | Require $\text{E}(4F)$ and $\text{E}\left(\frac{B^2}{2}\right)$ | M1 | 3.1a |
| | $\text{E}(X)=\text{E}(4F)=4\text{E}(\text{F})=4\times 2=8$ $\text{E}(X)=8$ | B1 | 2.1 |
| | $\text{E}(Y)=\text{E}\left(\frac{B^2}{2}\right)=\frac{1}{2}\text{E}(B^2)=\frac{1}{2}\left(\text{Var}(B)+[\text{E}(B)]^2\right)$ | M1 | 1.1b |
| | $\text{E}\left(\frac{B^2}{2}\right)=\frac{1}{2}\left(\frac{1-\frac{1}{3}}{\left(\frac{1}{3}\right)^2}+(3)^2\right)=\frac{1}{2}(6+9)$ $\text{E}(Y)=7.5$ | A1 | 1.1b |
| | Shivani should choose $X$ as it has a higher expected score | A1ft | 3.2a |
| | | **(5)** | |
| | | | **(13 marks)** |

**Notes:**

| | | |
|---|---|---|
| **(a)(i)** | **M1:** | For sight or use of the correct geometric model |
| | **A1:** | $\frac{4}{27}$ or awrt 0.148<br>(correct answer implies full marks) |
| **(a)(ii)** | **M1:** | For selecting the correct geometric model **and** use of cumulative probability formula<br>Implied by $\frac{1}{256}$ |
| | **M1:** | Sight or use of $\mathrm{P}(F \leq 8) - \mathrm{P}(F \leq 1)$ |
| | **A1:** | $\frac{127}{256}$ or awrt 0.496<br>(correct answer implies full marks) |
| **(a)(iii)** | **M1:** | Sight or use of<br>$\mathrm{P}[(F=3) \cup (B=3)] = \mathrm{P}(F=3) + \mathrm{P}(B=3) - \mathrm{P}(F=3) \times \mathrm{P}(B=3)$<br>or<br>$\mathrm{P}[(F=3) \cup (B=3)] = 1 - \mathrm{P}(F \neq 3) \times \mathrm{P}(B \neq 3)$<br>or<br>$\mathrm{P}[(F=3) \cup (B=3)] = \mathrm{P}(B=3) - \mathrm{P}(F=3) \times \mathrm{P}(B \neq 3)$ |
| | **M1:** | $'\frac{4}{27}' + \left[\left(\frac{1}{2}\right)^2 \times \left(\frac{1}{2}\right)\right] - '\frac{4}{27}' \times \left[\left(\frac{1}{2}\right)^2 \times \left(\frac{1}{2}\right)\right]$<br>or<br>$1 - \left[1 - '\frac{4}{27}'\right] \times \left[1 - \left(\frac{1}{2}\right)^2 \times \left(\frac{1}{2}\right)\right]$<br>ft their $\mathrm{P}(B=3)$ from (a)(i) |
| | **A1:** | $\frac{55}{216}$ or awrt 0.255 (correct answer implies full marks) |
| **(b)** | **M1:** | For attempting to calculate or consider expected values/means of $X$ and $Y$<br>Implied by sight of 8 and 4.5 |
| | **B1:** | for $\mathrm{E}(X) = 8$ |
| | **M1:** | Using $\mathrm{E}(B^2) = \mathrm{Var}(B) + [\mathrm{E}(B)]^2$<br>or<br>$\mathrm{E}(B^2) = \mathrm{G}_B'(1) + \mathrm{G}_B''(1)$ with a correct PGF given for $B$<br>$\mathrm{E}(B^2) = 15$ is M1 |
| | **A1:** | for $\mathrm{E}(Y) = 7.5$ or equivalent |
| | **A1ft:** | for interpreting the outcome of their calculations in terms of the problem.<br>Must clearly choose $X$ or $Y$ and refer to its expectation/average being higher<br>Allow reference to expectation as a comparison e.g. 8 > 7.5<br>ft their E($X$) and E($Y$) provided at least one of E($X$) or E($Y$) correct<br>dependent on 1st M1 being awarded<br>e.g. candidates can score M1B1M0A0A1 or M1B0M1A1A1 or M1B1M1A0A1<br>**NB:** Accept expectations given as totals. E.g. 8$n$ and 7.5$n$, but not 7.5$n^2$ etc |

| Q | Scheme | Marks | AOs |
|---|---|---|---|
| 7(a)(i) | $H_0: \lambda = 7 \quad H_1: \lambda < 7$ | B1 | 2.5 |
| (a)(ii) | $X \sim Po(7)$ [$P(X \leq 2) = 0.0296\ldots$, $P(X \leq 3) = 0.0817\ldots$, $P(X \leq 4) = 0.172\ldots$ ] | M1 | 3.4 |
| | Critical region: $X \leq 3$ | A1ft | 1.1b |
| (a)(iii) | **awrt 0.0818** | B1ft | 1.2 |
| | | **(4)** | |
| (b) | $Y \sim Po(5)$ | M1 | 3.3 |
| | $P(Y \geq '4' \mid \lambda = 5)$ | M1 | 3.4 |
| | $P(Y \geq 4 \mid \lambda = 5) = 0.735$ **awrt 0.735** | A1 | 1.1b |
| | | **(3)** | |
| (c) | Geometric | B1 | 3.3 |
| | | **(1)** | |
| (d) | $T \sim \text{Geo}\left(e^{-\lambda}\right)$ | M1 | 2.1 |
| | $P(T \leq n) = 1 - (1 - e^{-\lambda})^n$ | A1cso* | 1.1b |
| | | **(2)** | |
| (e) | $\left(1 - e^{-2.75}\right)^n < 0.2$ | B1 | 3.4 |
| | $n \log\left(1 - e^{-2.75}\right) < \log 0.2$ | M1 | 2.1 |
| | $n > \dfrac{\log 0.2}{\log\left(1 - e^{-2.75}\right)} \approx$ **awrt 24.4** | A1 | 1.1b |
| | $n = 25$ | A1 | 1.1b |
| | | **(4)** | |
| | | | **(14 marks)** |

**Notes:**

| | | |
|---|---|---|
| **(a)(i)** | **B1:** | Both hypotheses correct in terms of $\lambda$ (do not accept $\mu$ or $\bar{x}$). May be seen in (a)(ii)/(iii) |
| **(a)(ii)** | **M1:** | Sight or use of $X \sim Po(7)$ [may be implied by a correct probability to 2 s.f. in (a)] |
| | **A1ft:** | Correct CR clearly stated (A0 if given only as a probability)<br>[ft their hypotheses from (a)(i), 2-tailed CR is $X \leqslant 2$, $X \geqslant 13$] |
| **(a)(iii)** | **B1ft:** | awrt 0.0818, ft the probability associated with their CR |
| **(b)** | **M1:** | Sight or use of $Y \sim Po(5)$, condone lambda = 5 as a probability statement<br>[implied by a correct probability e.g. 0.124…, 0.265…, 0.0404…, 0.0734…] |
| | **M1:** | Attempt to find $P(Y \geq 4)$ with $Y \sim Po(5)$ (ft from their CR) |
| | **A1:** | awrt 0.735 (correct answer implies full marks) |
| **(c)** | **B1:** | Stating Geometric or Geo (parameter not required, ignore parameter if given) |
| **(d)** | **M1:** | Sight of $T \sim \text{Geo}\left(e^{-\lambda}\right)$ **or** P(zero glitches) = $e^{-\lambda}$ [condone $P(T = 0) = e^{-\lambda}$] |
| | **A1cso*:** | $P(T \leq n)$ o.e. **or** stating that Power = 1 – P(Type II error)<br>leading to $1 - (1 - e^{-\lambda})^n$ [working must be fully correct with no errors] |
| **(e)** | **B1:** | $\left(1 - e^{-2.75}\right)^n < 0.2$ (condone use of = or $\leqslant$ instead of <) |
| | **M1:** | Correct process to reach a linear equation involving logs. May be implied by awrt 24.4 or awrt 3.38 |
| | **A1:** | Solves equation to obtain awrt 24.4 |
| | **A1:** | ($n =$) 25 ($n \geqslant 25$ is A0)<br>Award full marks for 25 if not from clearly incorrect working |

Pearson Education Limited. Registered company number 872828 with its registered office at 80 Strand, London, WC2R 0RL, United Kingdom