# Mark Scheme (Results)

Summer 2018

Pearson Edexcel GCE Further Mathematics
AS Further Statistics S1 Paper 8FM0_23

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## General Marking Guidance

- All candidates must receive the same treatment. Examiners must mark the last candidate in exactly the same way as they mark the first.
- 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.
- 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/indicative content will not be exhaustive.

## EDEXCEL GCE MATHEMATICS

## General Instructions for Marking

1. The total number of marks for the paper is 40.

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) | **1.36 or 1.37** | B1 | 1.1b |
| | | **(1)** | |
| (b) | $H_0$: Po(1.75) is a suitable model<br>$H_1$: Po(1.75) is not a suitable model | B1 | 3.4 |
| | | **(1)** | |
| (c) | Cells are combined for expected **frequencies < 5** so **combine** the last **3 cells** | B1 | 2.4 |
| | subtract 1 since **totals** agree | B1 | 2.4 |
| | | **(2)** | |
| (d) | $\chi^2_4 = 9.488$ | B1 | 1.1b |
| | therefore, the **researcher's belief** is supported<br>or evidence that **Po**(1.75) is a good model for the **number of orchids** in each square metre | B1ft | 3.5a |
| | | **(2)** | |
| (e) | P(exactly 6 orchids) = awrt 0.00353 | B1 | 1.1b |
| | $X$~ B(200, "0.00353") mean $= 200 \times$ "0.00353" = awrt 0.706 | M1 | 3.3 |
| | $Y$~ Po("0.706") 1 – P($Y = 0$) $= 1 - e^{-"0.706"}$ | M1 | 3.4 |
| | = 0.506* | A1* | 2.1 |
| | | **(4)** | |
| | | | **(10 marks)** |

**Notes**

**(a) B1:** accept 1.36 or 1.37

**(b) B1:** For both hypotheses correct. Must have Po(1.75) or Poisson with mean 1.75 and be attached to $H_0$ and $H_1$the right way round.

**(c) B1:** Explaining why there are 5 classes. Must mention **combine** the **3** cells when **frequencies < 5** or to **combine** the 3 cells to make **frequency > 5**

**B1:** Explaining why 1 is subtracted. Must say/show **1 is subtracted and** Totals agree **or** Total frequency must be 150 **or** only need 4 pieces of data to find the other **or** $\lambda$ is known or 1.75 is given.

**NB** B0 for "only 1 constraint" on its own.

**(d) B1:** awrt 9.49

**B1ft:** ft their critical value only. For drawing the correct conclusion – condone missing 1.75.
If hypotheses are the wrong way round or there are no hypotheses in (b) award B0

**(e) B1:** awrt 0.00353. May be implied by awrt 0.706 for mean.

**M1:** Selecting the model B(200,"their P(exactly 6 orchids)") and using $np$ ($0 < p < 1$) to find the mean. May be implied by awrt 0.706

**M1: Using** the model Po(their $np$) **and** using or writing 1 – P($Y = 0$) or 1 – P($Y \leq 0$) or $1 - e^{-"0.706"}$

**A1*:** only award if the previous 3 marks have been awarded. **and 0.506** stated.

| Question | Scheme | Marks | AOs |
|---|---|---|---|
| **2(a)** | $P(H \geq 2) = 0.1558$ awrt **0.156** | **B1** | 1.1b |
| | | **(1)** | |
| **(b)** | $H \sim Po(0.7)$ $G \sim Po(3)$ | | |
| | $Y = H + G \rightarrow Y \sim Po(3.7)$ | M1 | 3.4 |
| | $P(Y \leq 3) = 0.494*$ | A1cso* | 1.1b |
| | | **(2)** | |
| **(c)** | $K \sim B(6, 0.494)$ | M1 | 3.3 |
| | $P(K \geq 5) = 1 - P(K \leq 4)$ | M1 | 1.1b |
| | $= 1 - 0.896...$ | | |
| | $= 0.1039\ldots$ awrt **0.104** | A1 | 1.1b |
| | | **(3)** | |
| **(d)** | $H_0: \lambda = "3.7"$ $H_1: \lambda > "3.7"$ | B1ft | 2.5 |
| | $J \sim Po(7.4)$ | B1ft | 1.1b |

| | Method 1 | Method 2 | | |
|---|---|---|---|---|
| | $P(J \geq 14) = 1 - P(J \leq 13)$<br>$= 1 - 0.9804\ldots$ | $P(J \geq 12) = 0.0735...$<br>$P(J \geq 13) = 0.0391...$ | M1 | 1.1b |
| | $= 0.0195\ldots$ | CR $J \geq 13$ | A1 | 1.1b |
| | $0.0195 < 0.05$ or $14 \geq 13$ or 14 is in the critical region or 14 is significant or Reject $H_0$. There is evidence at the 5% level of significance that the **number** of **heaters** brought in total from the two supermarkets has **increased**. | | A1 | 2.2b |
| | | | **(5)** | |
| | | | | **(11 marks)** |

**Notes**

**(a) B1:** awrt 0.156

**(b) M1:** For combining distributions and use of Po(3.7)

**A1*cso:** $P(Y \leq 3) = 0.494$ we need to see $P(Y \leq 3)$ or $P(Y < 4)$ allow different letters.

**(c) M1:** Setting up a new model B(6, 0.494) may be implied by a correct answer or ${}^6C_n (0.494)^n (0.506)^{6-n}$

**M1:** Using $1 - P(K \leq 4)$

**A1:** awrt 0.104

**(d) B1:** Both hypotheses correct using $\lambda$ or $\mu$. ft"3.7" from their 3.7 in part (b) and allow $2 \times$"their 3.7" Ignore any words

**B1:** Realising that Po($2 \times$"their 3.7") is to be used. This may be stated or used.

**M1:** writing or using $1 - P(J \leq 13)$ or $1 - P(J < 14)$

or if finding a CR for writing $P(J \geq 12) = 0.0735...$ **and** $P(J \geq 13) = 0.0391...$

**A1:** awrt 0.0195 or CR $J \geq 13$ or $J > 12$

**A1:** A fully correct solution and drawing a correct inference in context.

| Question | Scheme | Marks | AOs |
|---|---|---|---|
| **3(a)** | 2.5 | B1 | 1.1b |
| | | **(1)** | |
| **(b)** | A complete strategy to find a value for $a$ and a value for $b$. | dM1 | 3.1b |
| | <table><tr><td>Greg</td><td>Nilaya</td></tr><tr><td>4</td><td>1</td></tr><tr><td>4</td><td>2</td></tr><tr><td>3</td><td>1</td></tr></table> | M1 | 2.1 |
| | $\frac{1}{6}(2a+b)+\frac{1}{3}(a+b)=\frac{1}{6}$ oe<br>$4a+3b=1$ oe | M1 | 1.1b |
| | $3a+2b=0.7$ oe | M1 | 1.1b |
| | $a=0.1 \quad b=0.2$ | A1 | 1.1b |
| | | **(5)** | |
| **(c)** | $2\mathrm{E}(W)-5=2.6$ | M1 | 3.1a |
| | $\mathrm{E}(W)=3.8$ | | |
| | $8a+b+cb+1.2[=3.8]$ **or**<br>$"0.3"+2\times"0.1"+4\times0.3+5\times"0.1"+"0.2"c=["3.8"]$ | M1 | 1.1b |
| | $c=\frac{2.6-8"a"-"b"}{"b"}$ | | |
| | $c=8$ | A1 | 1.1b |
| | $\mathrm{E}(W^2)=30a+c^2b+b+4.8$ **or**<br>$"0.3"+4\times"0.1"+16\times0.3+25\times"0.1"+"8"^2\times0.2$ | M1 | 1.1b |
| | $\mathrm{E}(W^2)=20.8$ | | |
| | $\mathrm{Var}(W)="20.8"-"3.8"^2$ or 6.36 | M1 | 1.1a |
| | Var($X$) = 25.44 | A1ft | 1.2 |
| | | **(6)** | |
| | | | **(12 marks)** |

| Notes |
|---|
| **(a)** **B1:** $\frac{5}{2}$ or 2.5 |
| **(b)** **dM1:** Dependent on 3rd and 4th Method marks being awarded.<br>For a complete strategy to find a value of *a* and a value of *b*.<br>Need 2 independent equations in *a* and *b*, one equation must be prob = 1/6 and the other $3a + 2b = 0.7$ oe **and** an attempt to solve. For an attempt we require a method to eliminate one variable leading to a value for *a* and *b*, or correct values.<br>**M1:** For using the given contextual information to list 3 different combinations for Greg to win.<br>Implied by $4a + 3b = 1$ oe<br>**M1:** For using $\mathrm{P}(g) \times \mathrm{P}(n)$ for each combination identified as a win for Greg $= \frac{1}{6}$<br>It must be a linear equation in *a* and *b* with 2/3 terms on the LHS, at least one of which must be correct and equal to 1/6<br>**M1:** For use of $\sum \mathrm{P}(W = w) = 1$<br>**A1:** For both values correct |
| **(c)** **M1:** For translating the given mathematical context into an expression for E(*W*)<br>May be implied by a correct equation or E(*W*) = 3.8<br>**M1:** For use of $\sum w\mathrm{P}(W = w)[= 3.8]$ If algebraic then at least 2 terms must be correct, if numerical at least 3 terms correct ft their values of *a* and *b*. This must be seen in part (c)<br>**[NB:** $16a + 2b + 2cb + 2.4 - 5 = 2.6$ oe would get M1M1]<br>**A1:** cao<br>**M1:** For use of $\sum w^2\mathrm{P}(W = w)$ . If algebraic then at least 2 terms must be correct, if numerical at least 3 terms correct ft their values of *a* and *b*.<br>**M1:** For use of $\mathrm{Var}(W) = \mathrm{E}(\mathrm{W}^2) - [\mathrm{E}(W)]^2$<br>**A1ft:** $4 \times$"their Var($W$)" ft their Var(W) provided *a*, *b* and Var(*W*) are > 0 and c > 5 |

Alternative for (c). allow a mix of methods

| | | |
|---|---|---|
| **(c)** | $[\mathrm{E}(X) =] -3 \times (a + b) - 1 \times a + 0.9 + 5 \times a + (2c - 5) \times b$ | **M1** |
| | $-3 \times (a + b) - 1 \times a + 0.9 + 5 \times a + (2c - 5) \times b = 2.6$ | **M1** |
| | $c = 8$ | **A1** |
| | Values of $X$ -3, -1, 3, 5, 2*c* -5 | **M1** |
| | $\mathrm{E}(X^2) = 9 \times (a + b) + 1 \times a + 2.7 + 25 \times a + (2c - 5)^2 \times b$<br>= 32.2 | **M1** |
| | $\mathrm{Var}(X) =$"32.2"$- 2.6^2$<br>= 25.44 | **A1ft** |
| **Notes for alternative** | | |
| | **M1:** allow with their *a*, *b* and $X$ values | |
| | **M1:** allow with their *a*, *b* and $X$ values | |
| | **A1:** cao | |
| | **M1:** at least 3 correct | |
| | **M1:** allow with their *c*, *a*, *b* and $X$ values | |
| | **A1ft:** ft their $\mathrm{E}(X^2)$ provided *a* and *b* are > 0 and c > 5 | |
| | | |

<table>
<tr><th>Question</th><th>Scheme</th><th>Marks</th><th>AOs</th></tr>
<tr><td rowspan="5">4</td><td>$H_0$: There is no association between the treatment of the plants and their survival/outcome.<br>$H_1$: There is an association between the treatment of the plants and their survival/outcome</td><td>B1</td><td>3.4</td></tr>
<tr><td><table>
<tr><th></th><th>No action</th><th>Plant sprayed once</th><th>Plant sprayed every day</th></tr>
<tr><td>Plant died within a month</td><td>13.44</td><td>24.64</td><td>17.92</td></tr>
<tr><td>Plant survived for 1 – 6 months</td><td>10.32</td><td>18.92</td><td>13.76</td></tr>
<tr><td>Plant survived beyond 6 months</td><td>6.24</td><td>11.44</td><td>8.32</td></tr>
</table></td><td>M1<br>A1</td><td>1.1b<br>1.1b</td></tr>
<tr><td>$\chi^2 = \sum \frac{(O-E)^2}{E} = \frac{(15-"13.44")^2}{"13.44"} + \frac{(16-"24.64")^2}{"24.64"} + 8.29$</td><td>M1</td><td>1.1b</td></tr>
<tr><td>awrt <u>11.5</u></td><td>A1</td><td>1.1b</td></tr>
<tr><td>Degrees of freedom (3 –1) (3 –1) = 4<br>$\chi^2_{4,0.025} = 11.143$</td><td>M1</td><td>3.1b</td></tr>
<tr><td>Reject $H_0$ There is an association between the treatment of the plants and their survival/outcome</td><td>dA1ft</td><td>2.2b</td></tr>
<tr><td colspan="4">(7 marks)</td></tr>
</table>

**Notes**

**B1**: For correct hypotheses at least one in context. Allow independent and not independent. Do not accept correlation.

**M1:** For attempt at $\frac{(\text{Row Total})(\text{Column Total})}{(\text{Grand Total})}$ to find expected frequencies. ( they may put numbers in table)

**A1:** awrt 13.44 and 24.64 This may be implied by a correct value of $\chi^2$

**M1:** For applying $\sum \frac{(O-E)^2}{E}$ ft their expected values. If no method shown at least 1 of the two missing $\chi^2$ contributions must be correct – you may need to check this (correct ones are 0.181… and 3.0296… allow 2sf) (condone missing 8.29)

**A1:** awrt 11.5

**M1:** For using degrees of freedom to set up $\chi^2$ model critical value, implied by CV 11.143 or better

**dA1ft:** dependent on the 2nd and 3rd M marks. Correct conclusion ft their $\sum \frac{(O-E)^2}{E}$ there is an **association** between the **treatment** of the plants and their **survival**/outcome: - do not allow contradicting statements. Do not award if hypotheses are the wrong way round or there are no hypotheses.

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