# Mark Scheme (Final)

## October 2019

Pearson Edexcel International A Level
in Statistics S2 (WST02/01)

**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

October 2019
Publications Code WST02_01_1910_MS

**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.

## PEARSON 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)
   - d… or dep – dependent
   - indep – independent
   - dp decimal places
   - sf significant figures
   - * The answer is printed on the paper or ag- answer given
   - $\sqsubset$ or d… The second mark is dependent on gaining the first mark

4. All A marks are 'correct answer only' (cao.), unless shown, for example, as A1 ft to indicate that previous wrong working is to be followed through. After a misread however, the subsequent A marks affected are treated as A ft, but manifestly absurd answers should never be awarded A marks.

5. 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.

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

**Special notes for marking Statistics exams (for AAs only)**

- If a method leads to "probabilities" which are greater than 1 or less than 0 then M0 should be awarded unless the mark scheme specifies otherwise.
- Any correct method should gain credit. If you cannot see how to apply the mark scheme but believe the method to be correct then please send to review.
- For method marks, we generally allow or condone a slip or transcription error if these are seen in an expression. We do not, however, condone or allow these errors in accuracy marks.
- If a candidate gives multiple solutions we mark the last complete solution. If in doubt send to review.

# October 2019
# WST02 STATISTICS 2
# Mark Scheme

| Question | Scheme | Marks |
|---|---|---|
| **1(a)** | $X \sim B(4, p)$ or $Y \sim B(4, 1-p)$ | B1 |
| | $P(X > 2) = P(X = 3) + P(X = 4) = 4p^3(1-p) + p^4$ oe | M1 |
| | $= p^3(4(1-p) + p)$ | |
| | $= p^3(4-3p)$ * | A1cso |
| | | (3) |
| **(b)** | $\sqrt{4p(1-p)} = 0.96$ | M1 |
| | $4p(1-p) = 0.9216 \rightarrow 4p^2 - 4p + 0.9216 = 0$ | M1 |
| | $p = \frac{16}{25}$ or 0.64 | A1 |
| | $P(X > 2) = 0.54525952$ awrt **0.545** | A1 |
| | | (4) |
| **(c)** | $P(X = 3 \mid X > 2) = \frac{4'p'^3(1-'p')}{'(b)'} = \frac{4 \times 0.64^3(0.36)}{0.545...}, = \frac{9}{13}$ awrt **0.692** | M1, A1 |
| | | (2) |
| | | **Total [9]** |

| | Notes |
|---|---|
| **(a)** | B1 writing or using B(4, $p$) or B(4, $1-p$).<br>For using, a correct term for $P(X = a)$ where $1 \leqslant a \leqslant 3$ is needed.<br>M1 correct expression for $P(X > 2)$ in terms of $p$. Allow $^4C_0$ etc oe<br>A1 cso correct working leading to given answer (must see at least one line of intermediate working eg $p^4 + 4p^3 - 4p^4$). NB Do not allow same line but with $^4C_0$ etc calculated as an intermediate line. If they use $P(X > 2) = 1 - P(X = 0) - P(X = 1) - P(X = 2)$ then we need to see a completely correct solution as per the alternatives given below. |
| **(b)** | 1st M1 for a correct **equation** for standard deviation or variance. Allow with " their $p$" eg $\frac{p}{4}$ from part(a)<br>2nd M1 rearranging their equation correctly to form a 3TQ with attempt to solve. If equation or answer is incorrect then the method to solve it must be shown. Allow one sign error<br>1st A1 $p = \frac{16}{25}$ or 0.64 seen<br>2nd A1 awrt 0.545 needs to have rejected any other solutions. Must be seen as answer to part(b)<br>**NB** $4p(1-p) = 0.96$ leading to 0.6 is M0M1A0A0 |
| **(c)** | M1 ft their value of $p$ ($0 < p < 1$). For a ratio in the form $\frac{4'\text{their } p'^3(1-'\text{their } p')}{q}$ where $0 < q < 1$ Need to see working if incorrect answer. Can be awarded even if leads to answer > 1.<br>Allow in terms of $p$ eg $\frac{4p^3(1-p)}{p^3(4-3p)}$ or $\frac{4(1-p)}{(4-3p)}$ Allow with "their $p$" substituted.<br>A1 awrt 0.692 allow awrt 0.693 |

For A1 cso: Use as guidance to check for cso and required equivalent working eg may use $1-2p+p^2$ instead of $(1-p)^2$

$X$ ~B(4,$p$)

Need to see the ticked lines and at least one of the * lines (oe) as the intermediate working

$$\begin{aligned}
\mathrm{P}(X>2) &= 1-\mathrm{P}(X=0)-\mathrm{P}(X=1)-\mathrm{P}(X=2)\\
&= 1-(1-p)^4-4p(1-p)^3-6p^2(1-p)^2 \ \checkmark\\
&= 1-\left(1-4p+6p^2-4p^3+p^4\right)-4p(1-3p+3p^2-p^3)-6p^2(1-2p+p^2) \quad *\\
&= 1-1+4p-6p^2+4p^3-p^4-4p+12p^2-12p^3+4p^4-6p^2+12p^3-6p^4 \quad *\\
&= 4p^3-3p^4 \ \checkmark\\
&= p^3(4-3p) \checkmark
\end{aligned}$$

Need to see the ticked lines and at least two of the * lines (oe) as the intermediate working

$$\begin{aligned}
\mathrm{P}(X>2) &= 1-\mathrm{P}(X=0)-\mathrm{P}(X=1)-\mathrm{P}(X=2)\\
&= 1-(1-p)^4-4p(1-p)^3-6p^2(1-p)^2 \checkmark\\
&= 1-(1-p)^2[(1-p)^2+4p(1-p)+6p^2] \quad *\\
&= 1-(1-2p+p^2)[1-2p+p^2+4p-4p^2+6p^2] \quad *\\
&= 1-(1-2p+p^2)[1+2p+3p^2] \quad *\\
&= 1-(1+2p+3p^2-2p-4p^2-6p^3+p^2+2p^3+3p^4) \checkmark\\
&= 4p^3-3p^4 \ \checkmark\\
&= p^3(4-3p) \checkmark
\end{aligned}$$

$Y$~ B(4,1 – $p$)

need to see the ticked lines and 1 line of intermediate working before answer as per original

$$\begin{aligned}
\mathrm{P}(X>2) &= \mathrm{P}(Y=0)+\mathrm{P}(Y=1)\\
&= (p)^4+4(1-p)(p)^3\\
&= p^3(p+4(1-p))\\
&= 4p^3-3p^4\\
&= p^3(4-3p)
\end{aligned}$$

| Question | Scheme | Marks |
|---|---|---|
| **2(a)** | $\frac{x-(-3)}{12-(-3)}=0.75$ | M1 |
| | $x=8.25$ **$\underline{8.25}$** oe | A1 |
| | | (2) |
| **(b)** | $P(5\leq X<14)=P(5\leq X<12)=\frac{12-(5)}{12-(-3)}=\frac{7}{15}$ | M1 A1 |
| | | (2) |
| **(c)** | $E(X)=4.5\rightarrow E(Y)=7.5$ | B1 |
| | $Var(X)=\frac{(12-(-3))^2}{12}$ [$=\frac{75}{4}$ or 18.75] or $Var(Y)=\frac{(12-(-3))^2}{48}$ [$=\frac{75}{16}$ or 4.6875] | B1 |
| | $\frac{a+b}{2}=$'7.5' and $\frac{(b-a)^2}{12}=$'4.6875' or $(b-a)^2=\frac{225}{4}$ | M1 |
| | $(b-(15-b))^2=56.25$ oe | dM1 |
| | **$\underline{a=3.75}$** **$\underline{b=11.25}$** | A1 |
| | | (5) |
| | | **Total [9]** |

| | Notes |
|---|---|
| **(a)** | M1 for correct expression or correct area on sketch. If using integration they need to get to this equivalent expression. Implied by correct answer<br>A1 $\frac{33}{4}$ or 8.25 oe |
| **(b)** | M1 for a correct probability statement or correct ratio,<br>e.g. $1-P(-3<X<5)$ or $1-P(X\leqslant 5)$ or $P(5\leq X<12)$. Allow $\leqslant$ instead of $<$ and vice versa. Implied by a correct answer.<br>**NB** Do not allow $P(5\leq X<a)$ where $a$ is >12 oe unless correct answer is given<br>A1 $\frac{7}{15}$ or awrt 0.467 |
| **(c)** | 1st B1 [E($Y$)] = 7.5 May be implied by a correct equation for $a$ and $b$ eg $\frac{a+b}{2}-3=4.5$ oe<br>2nd B1 correct expression for Var($X$) or Var($Y$). May be implied by a correct equation.<br>1st M1 Setting up simultaneous equations<br>$\frac{a+b}{2}=$"their E($Y$)" or their E($X$) + 3 and $\frac{(b-a)^2}{12}=\frac{1}{4}$"their Var($X$)" oe<br>2nd dM1 dependent on first M1 being awarded. Solving simultaneously leading to an equation in just $a$ or just $b$. Full method must be shown and correct if equations are incorrect.<br>A1 both $a=\frac{15}{4}$ or 3.75 and $b=\frac{45}{4}$ or 11.25 oe<br>**SC.** If the first 2 B marks are awarded and then 0.25 Var($Y$) is used leading to $a$ = -7.5 and $b$ = 22.5 award B1 – mark as M0M0 A1 on epen.<br>**Alternative:**<br>1st B1 7.5<br>2ndB1 Range of $X$ = 15<br>1st M1 Var($X$) = 4Var ($Y$) Range of $X$ = 2 Range of $Y$<br>2nd M1 7.5 ± 7.5/2 |

| Question | Scheme | Marks |
|---|---|---|
| Question | Scheme | Marks |
| **3(a)** | [Let $X$ = number of hacking attempts per hour]<br>$P(X \geq 1) = 1 - P(X = 0) =$<br>$1 - e^{-0.3} = 0.2591\ldots$ awrt **0.259*** | M1<br>A1cso<br>(2) |
| **(b)** | $Y \sim Po(7.2)$<br>$P(Y = 6) = \dfrac{e^{-7.2} \times 7.2^6}{6!} = 0.144458...$ awrt **0.144** | B1<br>M1 A1<br>(3) |
| **(c)** | $H_0 : \lambda = 0.3$ or $\mu = 50.4$<br>$H_1 : \lambda < 0.3$ or $\mu < 50.4$<br>$W \sim Po(50.4)$ can be approximated by N(50.4, 50.4)<br>$P(W \leq 38) \approx P\left(Z < \dfrac{38.5 - 50.4}{\sqrt{50.4}}\right)$<br>$\approx P(Z < -1.676...) = 0.0468$ (calc) $\approx P(Z < -1.68) = 0.0465$ (tables)<br>Reject $H_0$/significant<br>There is evidence of a decrease in the rate of hacking attempts **or** Saira's belief is supported. | B1<br><br>B1<br>M1 M1<br>A1<br>dM1<br>A1cso<br>(7)<br>**Total [12]** |
| | **Notes** | |
| **(a)** | M1 writing or using $1 - P(X = 0)$<br>A1cso correct expression $1 - e^{-0.3}$ (allow $1 - \dfrac{e^{-0.3}0.3^0}{0!}$) and awrt 0.259 | |
| **(b)** | B1 writing or using Po(7.2)<br>M1 correct expression<br>A1 awrt 0.144 (allow 0.1445) | |
| **(c)** | 1st B1 both hypotheses correct must be $\lambda$ or $\mu$<br>2nd B1 writing or using N(50.4, 50.4)<br>1st M1 for $\pm\left(\dfrac{37.5 / 38 / 38.5 - \textit{their mean}}{\textit{their sd}}\right)$ If they do not have not given a mean and variance they must be correct in here. (allow 1 ± standardisation) If no mean or var given they must be correct here.<br>2nd M1 use of continuity correction 38±0.5<br>1st A1 for answer in the range 0.0465 - 0.04685 Allow awrt 0.9532 > 0.95 or 0.9535 > 0.95<br>3rd dM1 Dependent on the 1st M1.<br>For a correct statement i.e. significant/reject $H_0$ May be a contextual one.<br>Follow through their probability and their $H_1$<br>Do not allow non-contextual conflicting statements<br>NB Do not award if no hypotheses given but can award if letter missing or incorrect letter used.<br>2nd A1cso all previous marks must be awarded and correct contextual statement. Words in bold or their equivalent must be seen.<br>Allow equivalent words for decrease eg lessened, for rate eg number, for belief eg claim, for supported eg true, right, correct, for Saira's eg her | |

| Question | Scheme | Marks |
|---|---|---|
| | Ignore any incorrect comparison eg 0.0465 < 0.025 if all previous marks have been awarded. | |

| Question | Scheme | Marks |
|---|---|---|
| **4(a)** | $\mathrm{E}(X^2) = \int_1^3 \frac{1}{15}(3x^4 - x^5)\,\mathrm{d}x + \int_3^5 \frac{3}{10}(x^3 - 3x^2)\,\mathrm{d}x$ | M1 |
| | $= \left[\frac{1}{15}\left(\frac{3x^5}{5} - \frac{x^6}{6}\right)\right]_1^3 + \left[\frac{3}{10}\left(\frac{x^4}{4} - x^3\right)\right]_3^5$ | M1 A1 |
| | $= \frac{2923}{225} = 12.99....$ awrt **<u>13.0</u>** | A1 (4) |
| **(b)** | $\int_1^x \frac{1}{15}(3t^2 - t^3)\,\mathrm{d}t$ or $\int \frac{1}{15}(3x^2 - x^3)\,\mathrm{d}x$ with $+c$ and $\mathrm{F}(1) = 0$ | M1 |
| | $\int_1^3 \frac{1}{15}(3t^2 - t^3)\,\mathrm{d}t + \int_3^x \frac{3}{10}(t-3)\,\mathrm{d}t$ or $\int \frac{3}{10}(x-3)\,\mathrm{d}x$ with $+d$ and $\mathrm{F}(5) = 1$ | M1 |
| | $[\mathrm{F}(x) =] \begin{cases} 0 & x < 1 \\ \frac{1}{15}x^3 - \frac{1}{60}x^4 - \frac{1}{20} & 1 \le x < 3 \\ \frac{3}{20}x^2 - \frac{9}{10}x + \frac{7}{4} \text{ or } \frac{3}{20}(x-3)^2 + 0.4 & 3 \le x \le 5 \\ 1 & x > 5 \end{cases}$ | B1 A1 A1 (5) |
| **(c)** | $\mathrm{P}(2 < X < 4) = \mathrm{F}(4) - \mathrm{F}(2)$ or $\int_2^3 \frac{1}{15}(3x^2 - x^3)\,\mathrm{d}x + \int_3^4 \frac{3}{10}(x-3)\,\mathrm{d}x$ | M1 |
| | $\frac{3}{20}(4^2) - \frac{9}{10}(4) + \frac{7}{4} - \left(\frac{1}{15}(2^3) - \frac{1}{60}(2^4) - \frac{1}{20}\right) = \underline{\frac{1}{3}}$ | A1 (2) |
| **(d)** | $1 - \mathrm{F}(k) = 0.2$ or $\int_k^5 \frac{3}{10}(x-3)\,\mathrm{d}x = 0.2$ | M1 |
| | $\frac{3}{20}k^2 - \frac{9}{10}k + \frac{7}{4} = 0.8$ or $\frac{3}{20}(k-3)^2 = 0.4 \rightarrow k = 4.63299...$ awrt **<u>4.63</u>** | dM1 A1 (3) |

| | Notes | Total [14] |
|---|---|---|
| **(a)** | 1st M1 for sum of two integrals $\int x^2 \mathrm{f}(x)\mathrm{d}x$ (ignore limits)<br>2nd M1 for attempting to integrate one part of $\int x^2 \mathrm{f}(x)\mathrm{d}x$ (one term correct) Implied by 11.4 or awrt 1.59<br>1st A1 correct integration with limits – both integrals but do not need to add the two integrals.<br>A1: accept exact fraction or awrt 13.0 | |
| **(b)** | 1st M1 Attempting to integrate1st line of pdf (1 term correct)with correct limits **<u>or</u>** $+c$ and F(1)=0 or F(3)= 0. 4<br>2nd M1 for attempting to integrate (1 term correct) 2nd line of pdf with correct limits + $\int_3^x \frac{3}{10}(t-3)\,\mathrm{d}t$ **<u>or</u>** + F(3) **<u>or</u>** correct ft expression for their F(3) **<u>or</u>** + $d$ and F(5) = 1<br>B1 1st and 4th line correct. Allow one to have range of otherwise<br>1st A1 correct 2nd line with limits. Allow ⩽ for < and ⩾ for > and vice versa<br>2nd A1 correct 3rd line with limits. Allow ⩽ for < and ⩾ for > and vice versa | |
| **(c)** | M1 writing or using F(4) – F(2) or addition of correct integrals. Implied by 11/20 – 13/60oe. Allow for ft expression if cdf incorrect.<br>A1 0.333 or better. | |
| **(d)** | 1st M1 writing or using 1 – F($k$) = 0.2 (or F($k$) = 0.8) or correct integral. Allow either line of their cdf for F($k$)<br>2nd dM1 dep on previous method mark being awarded. Setting up 3TQ using 2nd line of cdf = 0.8 | |

| Question | Scheme | Marks |
|---|---|---|
| | A1 Allow $k = 3+\frac{2\sqrt{6}}{3}$ or awrt 4.63 only (must reject other root if found) | |

| Question | Scheme | Marks |
|---|---|---|
| **5(a)** | $(1,1,2) \rightarrow \frac{2}{5}\times\frac{2}{5}\times\frac{1}{5}$ | B1 |
| | $(1,1,5) \rightarrow \frac{2}{5}\times\frac{2}{5}\times\frac{4}{5}$ | B1 |
| | $(1,2,2)(2,1,2) \rightarrow 2\times\frac{2}{5}\times\frac{3}{5}\times\frac{1}{5}$ | M1 |
| | $(1,2,5)(2,1,5) \rightarrow 2\times\frac{2}{5}\times\frac{3}{5}\times\frac{4}{5}$ | M1 |
| | $(2,2,2) \rightarrow \frac{3}{5}\times\frac{3}{5}\times\frac{1}{5}$ | |
| | $(2,2,5) \rightarrow \frac{3}{5}\times\frac{3}{5}\times\frac{4}{5}$ | |
| | $[t]$: 4 \| 5 \| 6 \| 7 \| 8 \| 9<br>$[\mathrm{P}(T=t)]$: $\frac{4}{125}$ (0.032) \| $\frac{12}{125}$ (0.096) \| $\frac{9}{125}$ (0.072) \| $\frac{16}{125}$ (0.128) \| $\frac{48}{125}$ (0.384) \| $\frac{36}{125}$ (0.288) | B1<br>A1<br>A1 |
| | | (7) |
| **(b)** | $m = 1 \quad m = 2$ | B1 |
| | $\mathrm{P}(M=1) = '\frac{4}{125}' + '\frac{16}{125}'$ | |
| | $\mathrm{P}(M=2) = '\frac{12}{125}' + '\frac{9}{125}' + '\frac{48}{125}' + '\frac{36}{125}'$ or $1-\left('\frac{4}{125}' + '\frac{16}{125}'\right)$ | M1 dM1 |
| | $[M]$: 1 \| 2<br>$[\mathrm{P}(M=m)]$: $\frac{4}{25}$ or (0.16) \| $\frac{21}{25}$ or (0.84) | A1 |
| | | (4) |

| | Notes | Total [11] |
|---|---|---|
| **(a)** | NB allow incorrect prob for first 2 B marks and M marks if clear what the probs represent<br>B1 for the 6 samples (1,1,2) (1,1,5) (2,2,2) (2,2,5) (1,2,2) (1,2,5) Allow more than one arrangement for each sample. May be implied by correct answers or product of probabilities ignoring any integer multiplier. Do not award if there are incorrect extras eg (5,5,1) unless they have a probability of zero or are ignored<br>B1 for having just the 8 samples. Must recognise that only one combination of (1,1,2) **and** (1,1,5) **and** (2,2,2) **and** (2,2,5) are possible and two combinations of (1,2,2) **and** (1,2,5) are possible. May be implied by correct answers or product of probabilities with correct multipliers. Do not award if there are incorrect extras eg (5,5,1) unless they have a probability of zero or ignored<br>1st M1 for correct product of probabilities for (1,1,2) or (1,1,5) or (2,2,2) or (2,2,5)<br>2nd M1 for correct product of probabilities for (1,2,2) or (1,2,5) Must have x2 oe<br>B1 all totals correct. (Allow duplicates) Incorrect totals must have probability of 0<br>A1 dep on 1st M1 only. At least 3 correct probabilities with associated totals.<br>A1 all probabilities correct with associated totals. Totals must only appear once. Extra totals must have probability of 0 | |
| **(b)** | B1 both values of $m$. Any extras must have probability of 0<br>1st M1 Follow through part(a). Correct method for P($M$ = 1) **or** P($M$ = 2) Prob in (a) <1<br>2nd dM1 dependent on previous M being awarded. ft part(a).For correct method for P($M$ = 1) **and** P($M$ = 2) Allow 1 – their P($M$ = 1) or 1 – their P($M$ = 2)] Prob in (a) <1<br>A1 fully correct Useful alternative fractions 20/125 and 105/125 | |

| Question | Scheme | Marks |
|---|---|---|
| **6(a)** | 0.95 | B1<br>(1) |
| **(b)** | $X \sim$ B(10, '0.95')<br>$P(X \geq 9) = P(X = 9) + P(X = 10) = 10(0.95)^9(0.05) + 0.95^{10}$<br>0.91386... awrt **0.914** | B1<br>M1<br>A1<br>(3) |
| **(c)** | $Y$ = Number of bolts that cannot be used<br>$Y \sim$ B(120, 0.05) can be approximated by Po(6)<br>P(more than 117 bolts can be used) = $P(Y \leq 2)$<br>$P(Y \leq 2) = 0.06196...$ awrt **0.062** | M1A1<br>dM1<br>A1<br>(4)<br>**Total [8]** |
| | **Notes** | |
| **(b)** | B1 writing or using B(10, '0.95') Allow for a probability of the form ${}^nC_r(0.95)^n(0.05)^{10-n}$ where $1 \leq n \leq 9$ must be seen or a correct answer given<br>M1 for writing or using $P(X = 9) + P(X = 10)$. For using we must see a calculation for each probability using B(10, '0.95') (Condone missing/incorrect ${}^nC_r$ ), ie allow $(0.95)^9(0.05) + 0.95^{10}$ May be implied by a correct answer.<br>**or**<br>for writing or using $1 - P(X = 0) - P(X = 1) - P(X = 2) - P(X = 3) - P(X = 4) - P(X = 5) - P(X = 6) - P(X = 7) - P(X = 8)$. For writing allow … but need a minimum of 3 terms. For using we must see a calculation for each probability using B(10, '0.95') (Condone missing/incorrect ${}^nC_r$ ). May be implied by a correct answer.<br>Do **not** allow for **writing** $P(X \geq 9)$ or $P(X > 8)$ or $1 - P(X \leq 8)$ or $1 - P(X < 9)$.<br>A1 awrt 0.914<br><br>**NB SC** Using Po(9.5) gets B1M0A0<br><br>Alternative<br>B1 writing or using B(10, 0.05)<br>M1 using $P(Y \leq 1)$ [$= P(Y = 1) + P(Y = 0) = 10(0.05)(0.95)^9 + 0.95^{10}$] oe but must use B(10, 0.05)<br>A1 0.9139 from tables<br><br>**NB** Using Po(0.5) gets B1M0A0 | |
| **(c)** | 1st M1 using a Poisson distribution.<br>1st A1 Po(6) is written or used.<br>2nd dM1 dep on first M1 being awarded writing or using $P(Y \leq 2)$ oe eg $P(Y < 3)$<br>2nd A1 awrt 0.062 (0.0620 from tables) Do not ISW<br><br>Note exact binomial gives 0.0575…<br>Note normal approximation gives awrt 0.0713 (calc) or 0.0708 (tables) with cc and awrt 0.0469 (calc) or 0.0465 (tables) without cc | |

| Question | Scheme | Marks |
|---|---|---|
| | **SC** Normal approximation may achieve 2 out of 4<br>B1 for the mean 114 1st A1 on epen<br>B1 for either probability 0.0713 or 0.0708 2nd A1 on epen | |

| Question | Scheme | Marks |
|---|---|---|
| **7(a)** | $f(x) = \frac{1}{3125}(100x^3 - 20x^4)$ or $\frac{4}{125}x^3 - \frac{4}{625}x^4$ | M1 |
| | $f'(x) = \frac{1}{3125}(300x^2 - 80x^3) = 0$ or $\frac{12}{125}x^2 - \frac{16}{625}x^3$ | M1A1 |
| | $x = 3.75$ | A1 |
| | | (4) |
| **(b)** | F(3.95) = 0.7166… F(4.05) = 0.7576… | M1A1 |
| | F(3.95) < 0.75 < F(4.05), therefore the **upper quartile** (oe) is **4.0** to 1 decimal place. | A1 |
| | | (3) |
| **(c)** | $H_0 : p = 0.25$ $H_1 : p < 0.25$ | B1 |
| | $Y \sim B(25, 0.25)$ **and** $P(Y \leq 3) =$ 0.0962 \| or $P(Y \leq 2) =$ awrt 0.0321 CR $Y \leq 2$ | M1 A1 |
| | Do not reject $H_0$ / not significant | dM1 |
| | There is <u>not</u> enough evidence to suggest that the model <u>overestimates</u> the <u>proportion</u> of <u>queuing</u> more than 4 minutes/<u>Olivia's belief</u> is <u>not supported</u>. | A1cso |
| | **SC** If $H_1$ written using > 0.25 and they then go on to use $P(Y \geq 3) = 0.9679$ allow B0M1A0dM0A0. If they go on to use $P(Y \leq 3)$ or $P(Y \geq 4)$ mark as original scheme | |

| | Notes | Total [12] |
|---|---|---|
| **(a)** | 1st M1 for attempting to finding f(x) (at least one $x^n \rightarrow x^{n-1}$ ). May be implied. Condone missing 1/3125<br>2nd M1 for attempting to find $f'(x)$ and equating it to 0 Condone missing 1/3125<br>1st A1 correct differentiation ie $\frac{1}{3125}(300x^2 - 80x^3)$ Condone missing 1/3125<br>2nd A1 3.75oe only | |
| **(b)** | M1 for attempting F(3.95) and F(4.05) or a suitable tighter interval (need to check they give values either side of 0.75)<br>1st A1 for both awrt 0.72 and awrt 0.76<br>**NB** check answers and accuracy if other numbers used.<br>2nd A1 for comparison with "their 0.75" and correct conclusion. Must have bold in conclusion $Q_3 = 4.0$ is enough.<br>**NB** other methods possible – will need to check | M1 for setting up $\frac{1}{3125}(25x^4 - 4x^5) = 0.75$<br>1st A1 for $x = 4.03118$ (4.03 or better)<br>2nd A1 for conclusion. Must have bold in conclusion and a value for $x$ of 4.03 or better |
| **(c)** | B1 both hypotheses correct $p$ or $\pi$<br>1st M1 for writing or using $P(Y \leq 3)$ or $P(Y \geq 4)$ and writing or using $B(25, p)$ may be implied Only award for $P(Y \leq 2) =$ awrt 0.0321 if CR has been given.<br>1st A1 for awrt 0.0962 or correct CR: $Y \leq 2$ or 0.9038 > 0.95<br>2nd dM1 Dependent on the 1st M1.<br>For a correct statement i.e. not significant/do not reject $H_0$<br>Follow through their probability and their $H_1$ | |

| Question | Scheme | Marks |
|---|---|---|
| | Do not allow non-contextual conflicting statements<br>2nd A1cso fully correct solution and correct contextual statement<br>Allow equivalent words to proportion eg fraction but do not allow number<br>Allow equivalent words for supported eg true. Allow her for Olivia | |

(b) Other methods seen. Answers are for using 3.95 and 4.05. Allow 2 sf

$F(x) - 0.75 = 0$

awrt -0.033 and awrt +0.0076

$(F(x) - 0.75) * 3125 * 4 = 0$

awrt +95.3 and awrt -416/416.5

$(F(x) - 0.75) * 3125 = 0$

awrt -104.12 and awrt +23.8

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