Mark Scheme (Results)

Summer 2017

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

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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. If a candidate makes more than one attempt at any question:
    - If all but one attempt is crossed out, mark the attempt which is NOT crossed out.
    - If either all attempts are crossed out or none are crossed out, mark all the attempts and score the highest single attempt.

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

June 2017
WST02 STATISTICS 2
Mark Scheme

Question	Scheme	Marks
1.(a)	$X \sim \text{Po}(\frac{1}{4})$	B1
	$\text{P}(X = 0) = \text{e}^{-\frac{1}{4}} = 0.778800\ldots$ awrt **0.779**	B1
		(2)
(b)	$[(\text{P}(X \geqslant 1))^3] = (1 - \text{'0.7788'})^3 = 0.010823\ldots$ awrt **0.0108**	M1 A1
		(2)
(c)	$Y \sim \text{B}(7, 0.7788\ldots)$	B1ft
	$\text{P}(Y = 5) = 7\text{C}5\ (0.7788)^5(1 - 0.7788)^2 = 0.294386\ldots$ awrt **0.294**	M1 A1
		(3)
(d)	H_0: $\mu = 8$ or $\lambda = 0.25$ $\quad$ H_1: $\mu < 8$ or $\lambda < 0.25$	B1
		(1)
(e)	$W \sim \text{Po}(8)$	B1
	$\text{P}(W \leqslant 3) = 0.0424\ (< 0.05)$	M1
	$\text{P}(W \leqslant 4) = 0.0996\ (> 0.05)$	
	Largest possible value of f is 3	A1
		(3)
		Total 11

	Notes
(a)	1st B1 for writing or using $\text{Po}(\frac{1}{4})$. May be implied by a correct answer or by awrt 0.78
(b)	M1 for $(1-0.779)^3$ or $(1 - \text{'their (a)'})^3$
(c)	B1ft for writing or using B(7, 'their a'). May be implied by M1 scored.
	M1 for a correct binomial expression for $\text{P}(Y = 5)$ (ft their value of p). Allow $\binom{7}{2}$ etc or 21
	May be implied by the correct answer but if $p \neq 0.779$ or better we must see expression
ALT	They may use $W \sim \text{B}(7, \text{" } 1 - \text{their (a)"})$ for B1ft then $\text{P}(W = 2)$ for the M1
(d)	B1 for both hypotheses correct. Must use λ or μ for either 8 or 0.25 [Use of $\leqslant$ is B0]
	If (d) is blank but correct hypotheses are seen in (e) can award retrospectively BUT if hypotheses are given in (d) and (e) award this mark for answer in (d).
(e)	B1 for writing Po(8) can be awarded if seen in (d) (may be implied e.g. by scoring M1)
	M1 for using Po(8) to find a lower-tail critical region
	Need to see one of the given probability statements or implied by Po(8) and $f = 3$ seen.
	A1 for $[f] = 3$ but allow $f \leqslant 3$ Correct answer only scores 3/3

Question	Scheme	Marks
2. (a)(i)	X~B(6, 0.25)	B1
(ii)	Prizes are randomly placed in packets. Each packet has a 25% chance of containing a prize Each packet contains a prize independently of others	B1 (2)
(b)	$P(X = 1) = \binom{6}{1}(0.25)(1 - 0.25)^5$ [= 0.355957…] or 0.5339 – 0.1780 [=0.3559]	M1
	P(only 1 box contains exactly 1 prize) = $2P(X = 1)(1 - P(X = 1))$ = answer in the range **0.458~0.459** (inc)	M1 A1 (3)
(c)	$P(X \geqslant 2) = 1 - P(X \leqslant 1) = 1 - 0.5339 = 0.4661$ awrt **0.466**	M1 A1 (2)
(d)	$Y \sim B(80\ ,\ '0.4661') \rightarrow N$(awrt 37.3, awrt 19.9) [Calc : 37.285…., 19.9078…]	B1ft
	$P(Y \leqslant 30) \approx P\left(Z < \frac{30.5 - '37.3'}{\sqrt{'19.9'}}\right)$	M1 dM1A1ft
	$P(Z < -1.52) = 1 - 0.9357 = 0.0643$ (calc: 0.064165….) awrt **0.064**	A1 (5) **Total 12**

	Notes
(a)(i)	B1 for a completely specified distribution. Condone B(6,25%) must be in (a)(i)
(ii)	B1 for a contextualised reason involving randomness, independence or constant probability Must mention "prize" and "packet" and for constant prob "0.25" in correct statement.
(b)	1st M1 for a correct expression for $P(X = 1)$ may use $P(X \leqslant 1) - P(X = 0)$ from tables with $X \sim B(6, 0.25)$ (May be implied by sight of awrt 0.356 or answer in range) 2nd M1 for writing or using $2P(X = 1)(1 - P(X = 1))$ NB M0M1A0 is possible Allow just $2P(X = 1)(1 - P(X = 1))$ or a numerical expression with any $p = P(X = 1)$ except $p = 0.25$ provided $0 < p < 1$
(c)	M1 for writing or using $1 - P(X \leqslant 1)$ A1 for awrt 0.466 (calc: 0.46606445….)
(d)	1st B1ft for mean = np and variance = $np(1 - p)$ where p = 'their (c)' ft their $0.466 \neq 0.25$ Any ft values must be correct to at least 3sf 1st M1 $\pm\left(\frac{29.5 \text{ or } 30 \text{ or } 30.5 - \text{their mean}}{\text{their sd}}\right)$ 2nd M1 dependent on 1st M1 for using a continuity correction 30 ± 0.5 1st A1ft for (±) correct standardized expression (ft their μ and σ) or z = awrt ± 1.52 2nd A1 awrt 0.064 [Use of $p = 0.25$ giving N(20, 15) can score B0M1M1A1A0 i.e. max 3/5]
NB	Use of binomial (leads to 0.063398… or 0.063477…) but scores 0 marks.

Question	Scheme	Marks
3. (a)	Using area of triangle: $\mathrm{P}(X>4)=\dfrac{(6-4)\times \mathrm{f}(4)}{2}$ $=\dfrac{1}{2}$ [so median of X is 4] Solve: $\dfrac{(6-4)\left(\frac{3}{2}-\frac{1}{4}x\right)}{2}=\dfrac{1}{2}x$ $=4$ [so median of X is 4] Using integration: $\mathrm{P}(X>4)$ $=\int_4^6(\frac{3}{2}-\frac{1}{4}x)\,\mathrm{d}x=\left[\frac{3}{2}x-\frac{1}{8}x^2\right]_4^6$ M1 $=\dfrac{1}{2}$ [so median of X is 4]	A1cso (2)
(b)	Area of triangle from $1<x<4$ $=0.5$ $\dfrac{(4-1)\times(4a+b)}{2}=0.5\rightarrow 12a+3b=1$ $\mathrm{f}(1)=0\ \rightarrow a+b=0$ Solving simultaneously: $12a-3a=1$ $a=\dfrac{1}{9}\quad b=-\dfrac{1}{9}$ $\int_1^4(ax+b)\,\mathrm{d}x=0.5$ $\left(\frac{16a}{2}+4b\right)-\left(\frac{a}{2}+b\right)=0.5\rightarrow 15a+6b=1$ M1 $\mathrm{f}(1)=0\ \rightarrow a+b=0$ M1 Solving simultaneously: $15a-6a=1$ dM1 $a=\dfrac{1}{9}\quad b=-\dfrac{1}{9}$ A1 A1	(5)
(c)	$\int_1^x(\frac{1}{9}t-\frac{1}{9})\,\mathrm{d}t$ or $\int(\frac{1}{9}x-\frac{1}{9})\,\mathrm{d}x$ with + c and F(1) = 0 or F(4) = 0.5 M1 $0.5+\int_4^x(\frac{3}{2}-\frac{1}{4}t)\,\mathrm{d}t$ or $\int(\frac{3}{2}-\frac{1}{4}x)\,\mathrm{d}x$ with + c and F(6) = 1 or F(4) = 0.5 M1 $\mathrm{F}(x)=\begin{cases}0 & x<1\\ \frac{1}{18}x^2-\frac{1}{9}x+\frac{1}{18} & 1\leqslant x<4\\ \frac{3}{2}x-\frac{1}{8}x^2-\frac{7}{2} & 4\leqslant x\leqslant 6\\ 1 & x>6\end{cases}$ B1 A1 A1	(5)
		Total 12

	Notes
(a)	M1 for a correct expr' area above 4 using triangle or correct integral & attempt to integrate A1cso for ½ or $x = 4$ with no errors. **NB f(4)=1.5 – 1 = 0.5 or 1.5 – 0.25x = 0.5 is M0A0** Allow use of **correct** F(x) = 0.5 provided F(4) = 0.5 **not** used to establish F(x)
(b)	1st M1 for a correct equation in a and b for an area (need not be simplified) 2nd M1 for a correct equation in a and b using f(1) = 0 3rd dM1 dep on at least 1 M1; for solving two linear equations in a and b by eliminating one variable (allow one slip). If one equation is incorrect we must see explicit method to solve. 1st A1 for a and 2nd A1 for b (allow exact equivalents)
(c)	1st M1 for attempt to integrate $ax + b$ with correct limits **or** + c and F(1) = 0 or F(4) = 0.5 2nd M1 for attempt to integrate $\frac{3}{2}-\frac{1}{4}x$ with correct limits & + 0.5 **or** +c and F(6) = 1 or F(4) = 0.5 For the 2nd M1 allow $\int_1^4$(their $ax+b$) dx or F(4) based on their cdf for [1, 4) instead of + 0.5 B1 for 1st and 4th line correct 1st A1 correct 2nd line with limits NB $\frac{1}{18}(x-1)^2$ 2nd A1 correct 3rd line with limits NB $1-\frac{1}{8}(x-6)^2$ Allow < or ⩽ anywhere for the last 3 marks

Question	Scheme	Marks
4. (a)(i)	mean = $np = 3.5$	B1
(ii)	standard deviation = $\sqrt{700 \times \frac{1}{200}(1-\frac{1}{200})} = 1.86614...$ awrt **1.866**	M1 A1 (3)
(b)(i)	H_0: $p = \frac{1}{200}$ H_1: $p > \frac{1}{200}$	B1
(ii)	$X \sim B(500, \frac{1}{200}) \rightarrow Po(2.5)$	B1
	$P(X \geqslant 5) = 1 - P(X \leqslant 4) = 1 - 0.8912 = 0.1088$	M1 A1
	[0.1088 > 0.05] therefore do not reject H_0, not significant, 5 does not lie in CR	M1
	The doctor's claim is not supported. **or** Past records are not out of date/reliable **or** Number/ Proportion / Probability of people/ with allergy is not higher.	A1 cso (6)
(c)	$Y \sim B(n, 0.30)$	
	$P(Y = 0) = (0.70)^n < 0.005$	M1
	$n > 14.85$	A1cao
	$n = 15$	
	$P(Y \geqslant w) < 0.005$	M1
	$P(Y \leqslant 8) = 0.9848$ or $P(Y \geqslant 9) = 0.0152$ [>0.005]	
	$P(Y \leqslant 9) = 0.9963$ or $P(Y \geqslant 10) = 0.0037$[<0.005]	A1
	$w = 10$	(4)
		Total 13

	Notes
(a)(ii)	M1 for a correct expression for standard deviation including root NB Assuming Poisson will get $\sqrt{3.5}$ =1.87082… but scores M0A0 [Ans only 2/2]
(b)(i)	B1 H_0 and H_1 correct with p or π (may be seen in (ii)) [Use of λ or $\mu = 2.5$ for (i) is B0]
(ii)	B1 for writing or using Po(2.5) 1st M1 for $1 - P(X \leqslant 4)$ and use with bin or Poisson or for CR $P(X \geqslant 6) = 0.042$ [<0.05] 1st A1 for awrt 0.109 or for CR $X \geqslant 6$ 2nd M1 for a non-contradictory statement which follows from their probability/CR 2nd A1cso correct contextual statement and fully correct solution with all other marks scored in (b) (ii)
NB	Use of Binomial leading to 0.1083 in (b) can score B1B0M1A0M1A0 Use of Normal [may get 0.103 (Po) or 0.102 (bin)] in (b) can score B1B0M0A0M1A0
(c)	1st M1 for a correct expression for $P(Y = 0)$ and comparison with 0.005 [allow inequality or equation]. Use of tables alone is M0 1st A1 for $n = 15$ cao [Answer only is M0A0 unless we see the 0.7^n compared to 0.005] 2nd M1 for using B("15", 0.30) to try and find an upper tail, need sight of one of given probs
ft	If 1st M1 scored can ft their n but need sight of probability expression and probability one of which must be a correct ft and must be just above or just below 0.005 (o.e.) 2nd A1 for $w = 10$ [but $w \geqslant 10$ is A0] Allow $Y \geqslant 10$ or $Y > 9$ [Correct answer only scores M0A0M1A1]

Question	Scheme	Marks
5. (a)	P(customer waits > 4 minutes) = 1 – F(4) = 1 – [0.3(4) – 0.004(4^3)] = $\frac{7}{125}$ or **0.056**	M1 A1 (2)
(b)	P(customer waits > 4 minutes | customer waits > 2 minutes) = $\frac{\mathrm{P}(T>4)}{\mathrm{P}(T>2)} = \frac{"0.056"}{1-\mathrm{F}(2)}, = \frac{"0.056"}{1-[0.3(2)-0.004(2^3)]} = \frac{"0.056"}{0.432} =$ $\frac{7}{54}$ or awrt **0.130**	M1,A1ft A1 (3)
(c)	F(2.7) = 0.73(1268…) or F(2.7) – 0.75 = – 0.02… F(2.8) = 0.752(192…) or F(2.8) – 0.75 = (+) 0.002… F(2.7) < 0.75 < F(2.8) therefore 2.7 < upper quartile < 2.8	M1 A1cso (2)
(d)	$\mathrm{f}(t) = 0.3 - 0.012t^2$ $\mathrm{E}(T) = \int_0^5 t(0.3-0.012t^2)\,\mathrm{d}t = \left[\frac{0.3t^2}{2} - \frac{0.012t^4}{4}\right]_0^5$,= $\frac{0.3\times5^2}{2} - \frac{0.012\times5^4}{4}$ = $\frac{15}{8}$ or 1.875	M1 M1, A1 A1 (4)
		Total 11

	Notes
(a)	M1 for writing or using 1 – F(4) [Just writing F(4) = 0.944 alone is M0]
(b)	M1 for a correct ratio expression $\frac{\mathrm{P}(T>4)}{\mathrm{P}(T>2)}$ or $\frac{"(a)"}{\mathrm{P}(T>2)}$ or better. Ignore e.g. P($T>2|T>4$) Allow other letters for T. If only numerical values are used, must have num < denom. 1st A1ft for a correct ratio expression with 'their (a)' on numerator and correct numerical expression or 0.43 or better on denominator.
(c)	M1 for attempting to find F(2.7) **and** F(2.8) A1cso for both F(2.7) = awrt 0.73 < 0.75 < F(2.8) = awrt 0.752 and correct conclusion. May use F(x) – 0.75 and look for a change of sign. There must be sight of 0.75
ALT	Using calculator: M1 for $0.3t - 0.004t^3 = 0.75$ leading to t = awrt 2.79 (2.78937…) A1 for correct conclusion (must reject other roots i.e. 6.9218… and -9.7112 if found) Conclusion must clearly state that Q_3 is between 2.7 and 2.8. Penalise false statements.
(d)	1st M1 for differentiating F(t) to find f(t) [Just 2 terms with at least 1 correct] 2nd M1 for attempting to integrate $t\times$their f(t) ignore limits[at least one $t^n \to t^{n+1}$] 1st A1 for correct integration of correct f(t) & use of limits (must see some correct use of 5) This mark may be implied by a correct answer. 2nd A1 $\frac{15}{8}$ or 1.875 (condone 1.88) [Correct answer only of $\frac{15}{8}$ or 1.875 scores 4/4]
Special Case	Use of $\mathrm{E}(T) = 5 - \int_0^5 \mathrm{F}(t)\mathrm{d}t$ can score 4 out of 4 if fully correct.

Question	Scheme	Marks
6. (a)	(3, 3, 3) (3, 3, 4) × 3 [(3, 4, 3), (4, 3, 3)] (3, 4, 4) × 3 [(4, 3, 4), (4, 4, 3)] (4, 4, 4)	B1B1 (2)
(b)	$P(M = 3) = (0.5)^3 = 0.125$	B1
	$P(M = 5) = 1 - (0.8)^3$ <u>or</u> $P(M = 5) = 3(0.2)(0.8)^2 + 3(0.2)^2(0.8) + (0.2)^3$ <u>or</u> $P(M = 4) = 3(0.5)^2(0.3) + 3(0.5)(0.3)^2 + (0.3)^3$	M1
	$P(M = 4) = 1 - [(P(M = 3) + P(M = 5)]$ <u>or</u> $P(M = 5) = 1 - [(P(M = 3) + P(M = 4)]$	M1
	m | 3 | 4 | 5 $P(M = m)$ | 0.125 $\left(\frac{1}{8}\right)$ | 0.387 $\left(\frac{387}{1000}\right)$ | 0.488 $\left(\frac{61}{125}\right)$	A1 (4)
(c)	Mode of $\underline{\underline{S_1 = 3}}$ and Mode of $\underline{\underline{M = 5}}$	B1 (1)
		Total 7

	Notes
(a)	1st B1 for at least 4 correct samples listed e.g. (3, 3, 3) and (3, 3, 4) ×3 2nd B1 for all 8 correct samples listed (with no extra or incorrect ones given)
(b)	B1 for $P(M = 3) = 0.125$oe Condone e.g. $X = 3$ and 12.5% 1st M1 for a correct expression <u>or</u> a correct probability for $P(M = 5)$ or $P(M = 4)$ 2nd M1 for a correct expression for third probability of 3, 4 or 5 **or** if B1 or 1st M1 are scored then award this mark for using the sum of the probs = 1 A1 for both $P(M = 4) = 0.387$oe and $P(M = 5) = 0.488$oe
(c)	B1 for both correct modes with clear S and M labels

Question	Scheme	Marks
7.(a)	$E(3-2X)= 3-2E(X)\ [= 3-2\left(\frac{(a+b)}{2}\right)]$ $= \underline{\mathbf{3-a-b}}$	M1 A1 (2)
(b)	$P(X > \frac{1}{3}b+\frac{2}{3}a) =$ $\frac{b-(\frac{1}{3}b+\frac{2}{3}a)}{b-a}, = \frac{2}{3}$ or $1-\frac{(\frac{1}{3}b+\frac{2}{3}a)-a}{b-a}, = \frac{2}{3}$	M1, A1 (2)
(c)	$E([3]X^2) = \int_a^b \frac{1}{(b-a)}[3]x^2\ dx$ $= \left[\frac{1}{(b-(-b))}x^3\right]_{-b}^{b} = \left(\frac{b^3-(-b^3)}{2b}\right)$ $= b^2$ $[\mathrm{Var}(X) = E(X^2)-[E(X)]^2]$ $\frac{(b-a)^2}{12} = E(X^2)-0^2$ or $E(X^2)-\frac{(a+b)^2}{4}$ $E(3X^2) = 3\left(\frac{(b-(-b))^2}{12}\right)$ $= b^2$	M1 dM1 A1 (3)
(d)	Range $= b-a = 18$ or $b--b = 18$ or $b = 9$ Var $(X) = \left[\frac{18^2}{12}\ \text{or}\ \frac{9^2}{3}-0^2\right] = \underline{\mathbf{27}}$	M1 A1 (2) **Total 9**

	Notes
(a)	M1 for using $3-2E(X)$ where $E(X)$ is a linear function of a and b A1 for $3-a-b$ or $3-(a+b)$
(b)	M1 for a correct fraction expression for $P(X > \frac{1}{3}b+\frac{2}{3}a)$ in terms of a and b (need brackets!) A1 for $\frac{2}{3}$
(c)	1st M1 for a correct integral for $E(3X^2)$ or $E(X^2)$ (ignore limits) 2nd dM1 dependent on 1st M1 for correct integration and correct use of $a = -b$ including in limits. Must be $E(3X^2)$
ALT	1st M1 for a correct expression for $E(3X^2)$ or $E(X^2)$ in terms of a and b from substituting into Var(X) and using $E(X) = 0$ or $\frac{(a+b)}{2}$ 2nd dM1 dependent on 1st M1 for $3\,E(X^2)$ and correct use of $a = -b$
(d)	M1 for writing or using $(b-a) = 18$ or $b--b = 18$ or $b = 9$ A1 for 27 [Correct answer only is 2/2]