Mark Scheme (Results)

Summer 2018

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 IAL 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
   - $\lfloor$ 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 2018
WST02
Mark Scheme

Question Number	Scheme	Marks
1(a)(i)	$P(M=1)=0.315124\ldots$ awrt **0.315**	B1
(ii)	$P(M \geqslant 3)=1-P(M \leqslant 2)$	M1
	$=1-0.9885$ awrt **0.0115**	A1
		(3)
(b)	$n\times 0.05=3$ (o.e.)	M1
	$n=60$	A1
		(2)
(c)	$\left[P(F \geqslant 1)>0.99 \Rightarrow\right] 1-P(F=0)>0.99$	M1
	$1-0.95^n>0.99$ or $0.95^n<0.01$ (o.e.)	M1
	$n \log 0.95 < \log 0.01$ or $n > \dfrac{\log 0.01}{\log 0.95}$ [= 89.78…]	M1
	$\therefore n=90$	A1cso
		(4)
	Notes	**Total 9**
(a)(ii)	M1 for $1-P(M \leqslant 2)$. Condone writing $1-P(M<2)$ if the correct answer follows. Just seeing $1-P(X<3)$ is not enough unless it leads to the correct answer.	
	A1 for awrt 0.0115 (Correct answer only 2/2)	
(b)	M1 for writing or using $n\times 0.05$ Can ignore mention of Poisson if correct equation is seen.	
	A1 for 60 only (Correct answer only 2/2)	
(c)	1st M1 for using or writing $1-P(F=0)$ in a correct inequality or equation **with** 0.99	
	2nd M1 for either of the correct inequalities, allow $\geqslant$ or $\leqslant$ or $=$ (oe) [May be implied by 3rd M]	
	Use of "=" instead of inequality can score 1st two M marks only.	
	3rd M1 for solving $0.95^n<0.01$ (o.e.) (must have an inequality) Must have a correct inequality here so n log0.95 = log0.01 is M0A0 even if it leads to 90	
	For trial and improvement approach must see both 89 & 90 used. Trial and improvement needs $P(0\|n=89)=0.0104..>0.01$ and $P(0\|n=90)=0.00988..<0.01$ and then 1st and 2nd M1 implied	
	A1 cso – no sign errors or mistakes	
SC	**Wrong inequality** $1-P(F=0)<0.99$ leading to $n <$ awrt 89.8 can score M0M0M1A0	
NB	**Normal** use of normal distribution will score 0/4	

Question Number	Scheme	Marks
2(a)	$H_0 : \lambda = 4$ $H_1 : \lambda > 4$	B1
	$X \sim \text{Po}(8)$ and $P(X \geqslant 14) = 1 - P(X \leqslant 13)$	M1
	$= 1 - 0.9658 = 0.0341807..$ awrt 0.0342	A1
	There is evidence to reject H_0	dM1
	There is evidence to support Emma's belief (o.e.)	A1
		(5)
(b)	[F = no. of faults in a piece of cloth of length l]	
	$e^{-\frac{4l}{50}} = 0.90$	M1A1
	$e^{-\frac{4\times1.25}{50}} = 0.9048...$, $e^{-\frac{4\times1.35}{50}} = 0.8976...$ or $(\pm)\frac{4l}{50} = \ln 0.9$	M1
	These values are either side of 0.90 $\therefore$ $l = 1.3$ to 2 sf or $l = 1.317\ldots$ $\therefore$ 1.3	A1cso
		(4)
(c)	Expected number with no faults $= 5000\times0.9 = 4500$	
	Expected number with some faults $= 5000\times0.1 = 500$	M1
	So expected profit $= 4500\times2.5 - 500\times0.5$	M1
	$= £11000$	A1
		(3)
	Notes	**Total 12**
(a)	B1 for both hypotheses – allow μ or λ and 4 or 8	
	1st M1 for using or writing $1 - P(X \leqslant 13)$ with $X \sim \text{Po}(8)$	
	1st A1 for awrt 0.0342 [Stating CR is $X \geqslant 14$ scores the M1A1]	
	2nd dM1 dep on 1st M1 for a correct conclusion for a 1-tail test with no incorrect conclusions	
	2nd A1 A correct contextual conclusion mentioning Emma's belief	
	or faults are distributed at a rate of more than 4 per 50 metres	
	Dep' on all previous marks but condone 0.34 for 0.342 on 1st A mark so B1M1A0M1A1 is poss.	
(b)	1st M1 for using $\frac{4l}{50}$ (o.e.) with Poisson. Can be scored anywhere in part (b). Use of Bin is 0/4	
	1st A1 for $e^{-\frac{4l}{50}} = 0.90$ or $\left(e^{-0.08}\right)^l = 0.90$ or $(0.923...)^l = 0.90$ or any other correct equ'n in l	
	BUT $(0.92)^l = 0.90$ is M0A0 since can come from B(l, 0.08)	
	2nd M1 for subst in suitable values either side of 1.3 or using ln to solve	
NB	[$-\frac{50}{4}\ln(0.9)$ or $\frac{50}{4}\times0.10536...$ (allow awrt 0.105) or l = awrt 1.32 scores M1A1M1]	
	2nd A1 for cso with conclusion and no incorrect working seen	
	If using "sandwich" approach we need "$\therefore$ (l =) 1.3 to 2 sf"	
	If using "solve" approach we must see l = awrt 1.32 and "$\therefore$ = 1.3"	
(c)	1st M1 for using either 4500 or 500 or expected profit per sale $2.5\times0.9 - 0.5\times0.1 = 2.2$	
	2nd M1 for $4500\times2.5 - 500\times0.5$ or 5000×2.2 or $5000\times2.5 - 500\times3$	
	A1 for 11000 (correct answer only 3/3)	
ALT	**Po(0.08×1.3 = 0.104…)** They use 0.9012… for 0.9 and 0.09877…for 0.1	
	1st M1 as above but 4506 for 4500, 494 for 500 or 2.204…for 2.2	
	2nd M1 as above using these values and final A1 for £ 11018 but accept £11000 (3sf)	

Question Number	Scheme	Marks
3.(a)	$(102-100)\,p=\frac{1}{3}$ <u>or</u> $\frac{102-100}{k-100}=\frac{1}{3}$ <u>or</u> $\frac{k-102}{k-100}=\frac{2}{3}$ <u>or</u> $(k-100)\,p=1$ (o.e.)	M1
	$p=\frac{1}{6}$ so $(k-100)\frac{1}{6}=1$	dM1
	$k-100=6$ therefore $k=106$ *	A1cso
		(3)
(b)(i)	$\frac{5}{6}$ (or exact equivalent)	B1
(ii)	0	B1
		(2)
(c)	103	B1
		(1)
(d)	$\frac{r-100}{6}=0.15$	M1
	= **<u>100.9</u>**	A1
		(2)
(e)	$3\mathrm{P}(X\leqslant x-1.5)=\mathrm{P}(X\geqslant x+1.5)$ so $\frac{3}{6}(x-1.5-100)=\frac{1}{6}(106-x-1.5)$	M1
	$[3(x-1.5-100)=(106-x-1.5)]$ implies $4x-304.5=104.5$ (o.e.)	dM1
	$x=$ **<u>102.25</u>** (o.e.)	A1
		(3)

	Notes	Total 11
(a)	1st M1 for one of the 4 given equations (o.e.) 2nd M1 for at least one intermediate step of working (condone 1 slip or sign error) A1 cso no incorrect working seen leading to $k = 106$	
ALT	1st M1 $\frac{1}{3}$ represents 2 ml so $\frac{2}{3}$ is 4 ml <u>or</u> total width is 6 ml 2nd dM1 So $k = 102 +$ "4" <u>or</u> $100 +$ "6" A1cso So $k = 106$	These 2 M marks may be seen on a clearly labelled diagram.
(c)	B1 for 103 (if working is seen it must **not** come from a discrete distribution or else B0	
(d)	M1 for $\frac{r-100}{6}=0.15$ oe (any correct equation or expression)	
(e)	1st M1 for a correct equation for x e.g. $3p(x-1.5-100)=p(106-x-1.5)$ allow without $p=\frac{1}{6}$ 2nd dM1 for attempt to simplify, must have a linear equation with x appearing only once (condone 1 slip or sign error but no "lost" terms)	
ALT	1st M1 for $\mathrm{P}(X\leqslant x-1.5)=\frac{1}{8}$ or $\mathrm{P}(X\geqslant x+1.5)=\frac{3}{8}$ 2nd M1 for $1.5+\frac{6}{8}=2.25$ (o.e.)	
	A1 for $x = 102.25$ or any exact equivalent e.g. $\frac{409}{4}$ (Correct answer only 3/3)	

Question Number	Scheme	Marks
4. (a)	Every possible sample (of size 12 cartons) has an equal chance of being selected. **Or** sample selected without bias from the dairy/factory (o.e.) **Or** sample where all cartons have the same chance/prob of being chosen (o.e.)	B1 (1)
(b)	[The volumes of] all the cartons of milk **Or** the cartons of milk from the dairy/factory (o.e.)	B1 (1)
(c)	N(0,1)	B1 (1)
(d)	The probability distribution of X **or** the distribution of all possible values of X **Or** all the values of the statistic and their probabilities (o.e.)	B1 (1)
(e)	Only (II) is not a statistic as it contains (unknown) parameters μ and/or σ **Or** it contains unknown parameters (o.e.)	B1 B1d (2)
	Notes	**Total 6**
(e)	1st B1 for choosing II only 2nd dB1 dependent on choosing II only, for correct reason about parameters	

Question Number	Scheme	Marks
5(a)	$[X \sim \text{Po}(6)]$	
(i)	$\text{P}(X = 7) = \text{P}(X \leqslant 7) - \text{P}(X \leqslant 6)$	M1
	$= 0.7440 - 0.6063$	
	$= 0.13767697\ldots$ awrt **<u>0.138</u>**	A1
(ii)	$\text{P}(X > 7) = 1 - \text{P}(X \leqslant 7)$	M1
	$= 1 - 0.744 \quad = 0.2560202\ldots$ awrt **<u>0.256</u>**	A1
		(4)
(b)	[Let Y be the number of cars that pull into the service station]	
	$Y \sim \text{N}(\lambda, \lambda)$	M1
	$\lambda = 0.6n$	B1
	$\text{P}(Y > 40) = 0.2266$	
	$\dfrac{40.5 - \lambda}{\sqrt{\lambda}} = 0.75$	M1M1 B1 A1
	$\lambda + 0.75\sqrt{\lambda} - 40.5 = 0$	
	$\sqrt{\lambda} = 6$	M1A1
	$n = 60$	A1
		(9)
	Notes	**Total 13**
(a) (i)	M1 for writing or using $\text{P}(X \leqslant 7) - \text{P}(X \leqslant 6)$ or $\dfrac{\text{e}^{-\lambda}\lambda^7}{7!}$ (correct answer only 2/2)	
(ii)	M1 for writing or using $1 - \text{P}(X \leqslant 7)$ (correct answer only 2/2)	
(b)	1st M1 for stating Normal with mean = variance (can be any letter or number)	
	1st B1 for using $\lambda = 0.6n$ somewhere (can be awarded at any stage)	
	2nd M1 for use of a continuity correction on 40 i.e. 40 ± 0.5	
	3rd M1 for standardising with 40, 39.5 or 40.5 and their μ and $\sqrt{\mu}$ and set equal to a z value where $0.74 < \lvert z \rvert < 0.76$ (μ can be any letter, including n, or $3n$ or $0.6n$ etc)	
	2nd B1 for $z = \pm 0.75$ or better	
	1st A1 for a fully correct equation in any form (allow their letter for λ)	
	4th M1 for attempt to solve their 3 term quadratic (must be seen or implied by $\sqrt{\lambda} = 6$ o.e.) e.g. correct substitution in the formula for their coefficients	
	2nd A1 for $\sqrt{\lambda} = 6$ or $\lambda = 36$ (allow their letter including n) oe e.g. $\sqrt{n} = 2\sqrt{15}$	
	3rd A1 for $n = 60$	
NB	Using n (or any letter) instead of λ could score all marks except 1st B1 and 3rd A1	

Question Number	Scheme	Marks
6(a)	$\mathrm{E}(X)=\int_0^1 \frac{1}{4}x\,\mathrm{d}x+\int_1^2 \frac{x^4}{5}\,\mathrm{d}x$	M1
	$=\left[\frac{x^2}{8}\right]_0^1+\left[\frac{x^5}{25}\right]_1^2$; $\left[=\frac{1}{8}+\frac{32}{25}-\frac{1}{25}\right]=$ $\underline{\frac{273}{200}}$ or $\underline{1.365}$ (oe) or awrt **$\underline{1.37}$**	dM1; A1cso
		(3)
(b)	$\mathrm{E}(X^2)=\int_0^1\left(\frac{1}{4}x^2\right)\mathrm{d}x+\int_1^2\left(\frac{1}{5}x^5\right)\mathrm{d}x$	M1
	$\mathrm{Var}(X)=\left[\frac{x^3}{12}\right]_0^1+\left[\frac{x^6}{30}\right]_1^2-[1.365]^2$; $\left[=\frac{1}{12}+\frac{64}{30}-\frac{1}{30}-[1.365]^2\right]=0.32010..$ **$\underline{0.320}$**	dM1; A1cso
		(3)
(c)	$\int\left(\frac{t^3}{5}\right)\mathrm{dt}=\left[\frac{t^4}{20}\right]+D$ and use of F(2) = 1 or F(1) = "$\frac{1}{4}$" $\underline{\text{or}}$ "$\frac{1}{4}$"$+\int_1^x\left(\frac{t^3}{5}\right)\mathrm{d}t$	M1
	$\mathrm{F}(x)=\begin{cases}0 & x<0\\ \frac{1}{4}x & 0\leqslant x<1\\ \frac{x^4}{20}+\frac{1}{5} & 1\leqslant x\leqslant 2\\ 1 & x>2\end{cases}$ Correct 2nd row with range	B1
	Correct 3rd row with range	A1
	Correct 1st and 4th rows with ranges	B1
		(4)
(d)	$\frac{x^4}{20}+\frac{1}{5}=0.5$	M1
	$x=\left[\sqrt[4]{6}\right]$ = 1.565… awrt **$\underline{1.57}$**	A1
		(2)
(e)	Mean < median $\underline{\text{or}}$ mode = 2 and mean or median < mode [or sketch]	M1
	∴ negative skew	A1ft (2)
	Notes	**Total 14**
(a)	1st M1 for using $\int xf(x)dx$ and adding the 2 parts together, ignore limits	The A1 cso in (a) and (b) require evidence of Ms scored.
	2nd dM1 for all integration correct ignore limits	
(b)	1st M1 for using $\int x^2f(x)dx$ and adding the 2 parts together, ignore limits	
	2nd dM1 for using $\mathrm{E}(X^2)-[\mathrm{E}(X)]^2$ Some correct integration must be seen $\underline{\text{and}}$ $-[\mathrm{E}(X)]^2$	
	A1 cso for awrt 0.320 but accept **0.32 following a correct numerical expression** e.g. $\frac{131}{60}-(\frac{273}{200})^2$	
(c)	M1 for integrating and using + D and F(2) =1 or F(1) = $\frac{1}{4}$ $\underline{\text{or}}$ adding ¼ or $\int_0^1\frac{1}{4}\,\mathrm{d}x$ to $\int_1^x\left(\frac{t^3}{5}\right)\mathrm{d}t$	
	1st B1 for correct equation with range for $0\leqslant x<1$ (allow < or $\leqslant$ either end)	
(d)	M1 if "F(1)" < 0.5 then their 3rd row F(x)=0.5 if "F(1)" >0.5 then their 2nd row F(x) = 0.5	
	A1 awrt 1.57	
	For skew follow through their values for mean and median only.	
(e)	M1 for correct comparison of mean/median (for their values in [0, 2]) /mode = 2	
	A1ft for consistent conclusion about skewness [Allow accurate sketch, but must have –ve skew]	

Question Number	Scheme	Marks
7(a)	$X \sim B(25, 0.40)$	M1
	$P(X \leqslant 3) = 0.0024$ (calc: 0.002366768….) accept $P(X < 4)$	A1
	$P(X \geqslant 17) = 0.0043$ (calc: 0.004326388…) accept $P(X > 16)$	A1
	CR: $X \leqslant 3$, $X \geqslant 17$ (o.e.)	A1, A1
		(5)
(b)	0.0067	B1ft
		(1)
(c)	H_0: $p = 0.4$ H_1 : $p < 0.4$	B1
	[$R \sim B(50, 0.4)$]	
	$P(R \leqslant 8) = 0.0002305...$ awrt 0.0002	M1
	Reject H_0	A1
	Evidence that: the changes have been successful **or** there are fewer red sweets (oe)	A1cso
		(4)
	Notes	**Total 10**
(a)	M1 for writing or using B(25, 0.4) [Can be implied by any of the correct answers]	
	1st A1 for $P(X \leqslant 3) = 0.0024$ (Just giving 0.0024 only scores if CR $X \leqslant 3$ is given)	
	2nd A1 for $P(X \geqslant 17) = 0.0043$ (Just giving 0.0043 only scores if CR $X \geqslant 17$ is given)	
	3rd A1 for CR : $X \leqslant 3$ or $X < 4$	
	4th A1 for CR : $X \geqslant 17$ or $X > 16$ Apply ISW for e.g. $3 \geqslant X \geqslant 17$ or $X \leqslant 3$ **and** $X \geqslant 17$ etc	
	If the only answer is $3 \geqslant X \geqslant 17$ award 3rd A1 4th A0	
3rd ,4th As	We mark the region(s) labelled CR. If no CR labels accept $X \leqslant 3$, $X \geqslant 17$ (condone $X \leqslant 3 \cap X \geqslant 17$ or $X \leqslant 3$ and $X \geqslant 17$ etc)	
	Do **not** accept probability statements as critical regions.	
(b)	B1ft for 0.0067 or ft sum of their 2 probabilities (1st A and 2nd A in (a))	
(c)	B1 for both hypotheses in terms of p or π	
	M1 for $P(R \leqslant 8)$ = awrt 0.0002 or stating CR: $R \leqslant 11$	
	Condone writing $P(X = 8)$ = awrt 0.0002 but award 2nd A0 cso	
	1st A1 for a correct non-contextual conclusion	
	2nd A1cso for a correct contextual conclusion dependent on all other marks	
SC	**Use B(25, 0.4)** Can score 1st B1 Also if they get $P(R \leqslant 8) = 0.27353…$= awrt 0.274 award B1	

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