OXFORD AQA

INTERNATIONAL QUALIFICATIONS

INTERNATIONAL A-LEVEL

MATHEMATICS

MA04

(9660/MA04) Unit S2 Statistics

Mark scheme

January 2025

Version: 1.0 Final

251XMA04/MS

Mark schemes are prepared by the Lead Assessment Writer and considered, together with the relevant questions, by a panel of subject teachers. This mark scheme includes any amendments made at the standardisation events which all associates participate in and is the scheme which was used by them in this examination. The standardisation process ensures that the mark scheme covers the students' responses to questions and that every associate understands and applies it in the same correct way. As preparation for standardisation each associate analyses a number of students' scripts. Alternative answers not already covered by the mark scheme are discussed and legislated for. If, after the standardisation process, associates encounter unusual answers which have not been raised they are required to refer these to the Lead Examiner.

It must be stressed that a mark scheme is a working document, in many cases further developed and expanded on the basis of students' reactions to a particular paper. Assumptions about future mark schemes on the basis of one year's document should be avoided; whilst the guiding principles of assessment remain constant, details will change, depending on the content of a particular examination paper.

Further copies of this mark scheme are available from www.oxfordaqa.com

Key to mark scheme abbreviations

M	Mark is for method
m	Mark is dependent on one or more M marks and is for method
A	Mark is dependent on M or m marks and is for accuracy
B	Mark is independent of M or m marks and is for method and accuracy
E	Mark is for explanation
√ **or ft**	Follow through from previous incorrect result
CAO	Correct answer only
CSO	Correct solution only
AWFW	Anything which falls within
AWRT	Anything which rounds to
ACF	Any correct form
AG	Answer given
SC	Special case
oe	Or equivalent
A2, 1	2 or 1 (or 0) accuracy marks
–*x* EE	Deduct *x* marks for each error
NMS	No method shown
PI	Possibly implied
SCA	Substantially correct approach
sf	Significant figure(s)
dp	Decimal place(s)
ISW	Ignore subsequent working

Q	Answer	Marks	Comments
1(a)	The **set of values** for the test statistic which lead to **rejection** of the **null hypothesis**	B1	**oe**
		1	

Q	Answer	Marks	Comments
1(b)(i)	$\mathrm{P}(X \leq 5) = 0.0480 (< 5\%)$ $\mathrm{P}(X \leq 6) = 0.1034 (> 5\%)$	M1	Any one correct or correct CR
	$\mathrm{CR}\ (X \leq 5)$	A1	Need both probabilities **oe**
	$\mathrm{P}(X \geq 15) = 0.0607 (> 5\%)$ $\mathrm{P}(X \geq 16) = 0.0308 (< 5\%)$	M1	Any one correct or correct CR
	$\mathrm{CR}\ (X \geq 16)$	A1	Need both probabilities **oe**
		4	

Q	Answer	Marks	Comments
1(b)(ii)	As 17 is in the CR we reject H_0	B1ft	**oe** (must define a CR in (b)(i))
		1	

Q	Answer	Marks	Comments
1(c)(i)	n must be large **and** p must be small	B1	**oe**
		1	

Q	Answer	Marks	Comments
1(c)(ii)	$[np=]\ 80\times 0.05=4$	**B1**	**oe**
		1	

Q	Answer	Marks	Comments
1(d)(i)	$\mathrm{P}(W=0)=0.0183(<5\%)$ $\mathrm{P}(W\leq 1)=0.0916(>5\%)$ CR $\{0\}$	**M1** **A1**	Any one correct Allow $\mathrm{P}(Y\leq 0)$ Need both probabilities **oe**
		2	

Q	Answer	Marks	Comments
1(d)(ii)	As 1 is not in the CR we do not reject H_0	**B1ft**	**Oe** (must define a CR in (d)(i))
		1	

	Question 1 Total	**11**	

Q	Answer	Marks	Comments
2(a)	$\int_2^4 ct^3\,\mathrm{d}t+\int_4^6 \frac{1}{10}\,\mathrm{d}t=1$	**M1**	Correct integral set equal to 1 with at least 1 correct integration **oe**
	$\left[\frac{ct^4}{4}\right]_2^4+\left[\frac{t}{10}\right]_4^6=1$	**M1**	Arriving at a linear equation for c
	$\left[64c-4c\right]+\left[\frac{6}{10}-\frac{4}{10}\right]=1$		
	$60c+\frac{1}{5}=1$		
	$c=\frac{1}{75}$	**A1**	**AG** Requires immediate line after integration
		3	

Q	Answer	Marks	Comments
2(b)(i)	$\left[\int t\times \mathrm{f}\left(t\right)\mathrm{d}t\right]=\int_2^4 ct^4\,\mathrm{d}t+\int_4^6 \frac{1}{10}t\,\mathrm{d}t$	**M1**	**PI** Identifies correct integral **oe**
	$=\frac{1}{75}\left[\frac{t^5}{5}\right]_2^4+\left[\frac{t^2}{20}\right]_4^6$	**M1**	**PI** Correct integration with an attempt to substitute limits Allow with 'c'
	$\frac{992}{375}+1=\frac{1367}{375}$	**A1**	**oe**
		3	

Q	Answer	Marks	Comments
2(b)(ii)	$4-5\mathrm{E}(T)$ $=4-5\times\dfrac{1367}{375}$ $=-\dfrac{1067}{75}$	**M1** **A1ft**	**PI** **oe**
		2	

Q	Answer	Marks	Comments
2(c)(i)	$\left[\mathrm{E}\left(T^2\right)=\int t^2\times \mathrm{f}\left(t\right)\mathrm{d}t\right]=\int_2^4 ct^5\mathrm{d}t+\int_4^6\dfrac{t^2}{10}\mathrm{d}t$	**M1**	Identifies correct integral
	$=\dfrac{1}{75}\left[\dfrac{t^6}{6}\right]_2^4+\left[\dfrac{t^3}{30}\right]_4^6$	**M1**	Correct integration
	$=\dfrac{1}{75}\left[\dfrac{4^6}{6}-\dfrac{2^6}{6}\right]+\left[\dfrac{6^3}{30}-\dfrac{4^3}{30}\right]$		
	$\mathrm{E}\left(T^2\right)=\dfrac{1052}{75}$	**A1**	**PI**
	$\mathrm{Var}\left(T\right)=\mathrm{E}\left(T^2\right)-\mathrm{E}\left(T\right)^2$		
	$=\dfrac{1052}{75}-\left(\dfrac{1367}{375}\right)^2$	**M1**	**ft** Their $\mathrm{E}\left(T^2\right)$
	$=0.738211\ldots$ $=0.738$ [3 sf]	**A1**	Must see both fractions used correctly or the value to 4 or more significant figures **AG**
		5	

Q	Answer	Marks	Comments
2(c)(ii)	$25\,\text{Var}(T)$ $=25\times 0.738...$ $=18.5$ [3 sf]	**M1** **A1**	Allow use of 0.738 **AWRT** 18.5
		2	

	Question 2 Total	**15**	

Q	Answer	Marks	Comments
3	$H_0 : \mu = 205$ $H_1 : \mu > 205$	**B1**	Condone mu or other letters except $\bar{x}$
	$\overline{X} \sim N\left(205, \frac{30^2}{10}\right)$	**B1**	**PI** by correct standardisation formulae
	$z = \frac{220.5 - 205}{\frac{30}{\sqrt{10}}}$	**M1**	**PI** by correct z
	$z = 1.633(843458)...$	**A1**	**AWRT** 1.63 or exact value $\frac{31\sqrt{10}}{60}$ **or** $P\left(z > \frac{31\sqrt{10}}{60}\right) = 0.9489$ allow
	$z_{critical} = 1.6449$	**B1**	allow – 1.6449 **or** 0.94845 from tables or comparison of $P(\overline{T} > 220.5) = 0.0511$ to 0.05155 with 5% Allow 'accept H_0'
	Do not reject H_0 as $z < z_{critical}$ **or** 1.63…< 1.64…	**A1ft**	Comment about H_0 and 0.0511 to 0.05155 > 0.05 Allow $\lvert z \rvert < 1.6449$ Correct conclusion based upon ft their z (signs need to be compatible)
	Insufficient evidence to support the claim that Nok's lap times have increased at the 5% level of significance	**E1**	Correct statement must be in context and must follow from fully correct solution

	Question 3 total	**7**	

Q	Answer	Marks	Comments
4(a)	$\frac{e^{-\lambda}\times\lambda^8}{8!}=\frac{125}{2688}\times\frac{e^{-\lambda}\times\lambda^5}{5!}$	**M1**	**PI** by simplified equation
	$\lambda^3=\frac{125}{8}$	**M1**	Forms a simplified equation for λ **or** λ^3
	$\lambda=2.5$	**A1**	**CAO**
		3	

Q	Answer	Marks	Comments
4(b)(i)	$P(X<5)=P(X\leq 4)$	**M1**	**PI**
	$= 0.0293$ [3 sf]	**A1**	**CAO**
		2	

Q	Answer	Marks	Comments
4(b)(ii)	$\lambda=5$	**B1**	**PI** by 0.9980 or 0.8666
	$P(7<X<13)=P(X\leq 12)-P(X\leq 7)$ $= 0.9980 – 0.8666$	**M1**	**PI** Allow sight of one correct probability for the method mark
	$= 0.131$	**A1**	**CAO**
		3	

Q	Answer	Marks	Comments
4(c)	$\lambda_e = \frac{1}{3}$ (number of advertisements per minute)	B1	**PI (or** $\lambda_e = \frac{5}{3}$**)** (number of advertisements per 5 minutes)
	$P(X > 5) = 1 - \left(1 - e^{-\frac{1}{3}\times 5}\right)$	M1	**PI** $P(X > 1) = 1 - \left(1 - e^{-\frac{5}{3}}\right)$
	$= 0.189$	A1	**CAO**
		3	

	Question 4 total	**11**	

Q	Answer	Marks	Comments
5(a)	$\mathrm{P}(z < a) = 0.1 \Rightarrow a = -1.2816$ and/or $\mathrm{P}(z > b) = 0.2 \Rightarrow b = 0.8416$	**B1**	Allow $a = \pm 1.2816$
	$-1.2816 = \dfrac{1.9-\mu}{\sigma}$ or $0.8416 = \dfrac{3.8-\mu}{\sigma}$	**M1**	Signs must be compatible
	$-1.2816 = \dfrac{1.9-\mu}{\sigma}$ and $0.8416 = \dfrac{3.8-\mu}{\sigma}$	**A1**	
	Attempt to solve simultaneously eg $\dfrac{3.8-\mu}{0.8416} = \dfrac{\mu-1.9}{1.2816}$	**M1**	Reduction to one unknown
	$\mu = 3.05$ [3 sf]	**A1**	**CAO**
	$\sigma = 0.895$ [3 sf]	**A1**	**CAO**
		6	

Q	Answer	Marks	Comments
5(b)	$\mathrm{P}(z > k) > 0.74 \Rightarrow k = 0.6433$	**B1**	**PI** By correct standardisation formula
	$\dfrac{0.82-0.80}{\frac{0.25}{\sqrt{n}}} > 0.6433$	**M1**	
	$\sqrt{n} > \dfrac{0.6433 \times 0.25}{0.02}$	**m1**	Rearranged to find n or $\sqrt{n}$
	$\sqrt{n} > 8.04125 \Rightarrow n > 64.66... \Rightarrow n = 65$	**A1**	**CAO**
		4	

	Question 5 total	**10**	

Q	Answer	Marks	Comments
6(a)(i)	(through symmetry) $k = 13$	B1	
		1	

Q	Answer	Marks	Comments
6(a)(ii)	$5\times\left(\frac{0.125+h}{2}\right)=0.5$		
	$h = 0.075$	B1	
	$m=\frac{0.125-0.075}{8-3}=0.01$	M1	
	$\left[\mathrm{f}(8)=\right]\ 0.01\times 8+c_1=0.125$	M1	
	$c_1 = 0.045$		
	$\left[\mathrm{f}(8)=\right]\ -0.01\times 8+c_2=0.125$	M1	**oe** Use of $\mathrm{f}(8)$ to find a correct equation when $8 < x \leq 13$ or $-m$
	$c_2 = 0.205$		
	$\mathrm{f}(x)=\begin{cases}0.01x+0.045 & 3\leq x\leq 8\\ -0.01x+0.205 & 8<x\leq 13\\ 0 & \text{otherwise}\end{cases}$	A1	**ACF**
		5	

Q	Answer	Marks	Comments
6(b)(i)	$a = 1$	B1	CAO
		1	

Q	Answer	Marks	Comments
6(b)(ii)	$\mathrm{G}(t) = \frac{1}{5}t - 4$	M1	PI oe
	$\frac{\mathrm{d}}{\mathrm{d}t}\mathrm{G}(t) = \frac{1}{5}$	M1	Differentiation of their $\mathrm{G}(t)$
	$\mathrm{g}(t) = \begin{cases} \frac{1}{5} & 20 \leq t \leq 25 \\ 0 & \text{otherwise} \end{cases}$	A1	
		3	

	Question 6 total	10	

Q	Answer	Marks	Comments
7(a)(i)	$\left[\dfrac{\sum x}{n}\right] = \dfrac{7187}{800}$ [g]	B1	**oe** 8.98375 Condone **AWRT** 8.984
		1	

Q	Answer	Marks	Comments
7(a)(ii)	$\dfrac{1}{7}\left(645.6661 - \dfrac{71.87^2}{8}\right)$	M1	**PI**
	$= \dfrac{319}{560000}$ $\left[\text{g}^2\right]$	A1	**oe** Allow **AWRT** 0.00057
		2	

Q	Answer	Marks	Comments
7(b)	$H_0 : \mu = 9$ $H_1 : \mu < 9$	**B1**	Both hypotheses
	$\overline{X} \sim N\left(9, \frac{319/560000}{8}\right)$	**M1**	$\overline{X} \sim N\left(\mu, \frac{s^2}{8}\right)$ **PI**
	$t = \frac{8.98375 - 9}{\frac{\sqrt{\frac{319}{560000}}}{\sqrt{8}}} =$	**M1**	Calculates with their s^2
	$= -1.925737248$	**A1**	**AWRT** –1.93
	$t_7(0.05) = -1.895$	**B1**	Allow $\pm$ provided signs are consistent
	Reject H_0 as $-1.92(57\ldots) < -1.895$	**A1ft**	Implied by correct conclusion in context. Follow through their t and t_7
	Sufficient evidence to suggest that the mass of the packets is less than advertised at the 5% level of significance	**E1**	Must not be definitive
		7	

	Question 7 total	**10**	

Q	Answer	Marks	Comments
8(a)	$1-\mathrm{e}^{-\lambda m}=0.5$ $\mathrm{e}^{-\lambda m}=0.5$	**M1**	**PI**
	$-\lambda m=-\ln 2 \Rightarrow m=\dfrac{\ln 2}{\lambda}$	**A1**	
	$\ln 2<1 \Rightarrow \dfrac{\ln 2}{\lambda}<\dfrac{1}{\lambda} \Rightarrow m<\mathrm{E}(X)$	**A1**	Allow 0.693… < 1 **AG** must be convincingly show
		3	

Q	Answer	Marks	Comments
8(b)	$0.75=1-\mathrm{e}^{-\lambda u} \Rightarrow u=\dfrac{\ln 4}{\lambda}$ or $0.25=1-\mathrm{e}^{-\lambda s} \Rightarrow s=\dfrac{\ln\left(\frac{4}{3}\right)}{\lambda}$	**B1**	**oe** A correct expression for u or a correct expression for s
	$u-s=\dfrac{\ln 4}{\lambda}-\dfrac{\ln\left(\frac{4}{3}\right)}{\lambda}$	**M1**	
	$u-s=\dfrac{\ln 3}{\lambda}$	**A1**	
		3	

	Question 8 Total	**6**	