GCE 2004
June Series

ASSESSMENT and QUALIFICATIONS ALLIANCE

Mark Scheme

Mathematics and Statistics B
MBS7

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Key to Mark Scheme

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	accuracy
E	mark is for	explanation
√ or ft or F		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
sf		significant figure(s)
dp		decimal place(s)
A2,1		2 or 1 (or 0) accuracy marks
–*x* ee		deduct *x* marks for each error
pi		possibly implied
sca		substantially correct approach

Abbreviations used in Marking

MC – *x*	deducted *x* marks for mis-copy
MR – *x*	deducted *x* marks for mis-read
isw	ignored subsequent working
bod	given benefit of doubt
wr	work replaced by candidate
fb	formulae book

Application of Mark Scheme

No method shown:	
Correct answer without working	**mark as in scheme**
Incorrect answer without working	**zero marks unless specified otherwise**
More than one method / choice of solution:	
2 or more complete attempts, neither/none crossed out	**mark both/all fully and award the mean mark rounded down**
1 complete and 1 partial attempt, neither crossed out	**award credit for the complete solution only**
Crossed out work	**do not mark unless it has not been replaced**
Alternative solution **using a correct or partially correct method**	**award method and accuracy marks as appropriate**

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Question Number and Part	Solution	Marks	Total	Comments
1 (a)	$\sum x = 21 \qquad \sum x^2 = 44.2314$			
	$s = 0.12083 \qquad s^2 = 0.0146$ $(n-1)s^2 = 0.1314 \qquad \sigma^2 = 0.01314$	B1		awrt 0.121 cao 0.0146 awrt 0.131 awrt 0.0131
	H_0: $\sigma^2 = 0.01$ H_1: $\sigma^2 \neq 0.01$	B1		Both Must be population parameters
	SL $\alpha = 0.05$ DF $\nu = 10 - 1 = 9$	B1		cao
	CV $\chi^2 = (2.7)$ and 19.023 **or** CV $F = 2.114$	B1		Accept 19.0 but not 19 awrt 2.11
	$\chi^2 = \frac{(n-1)s^2}{\sigma^2}$ **or** $F = \frac{s^2}{\sigma^2}$ =	M1		Use of; accept use of s and/or σ or σ^4
	$\frac{9 \times 0.0146}{0.01} = 13.14$ **or** $\frac{0.0146}{0.01} = 1.46$	A1		awfw 13.1 to 13.2 cao 1.46
	Thus, at 5% level of significance, no evidence that value is not plausible	A1√	7	**ag**; or equivalent ft on χ^2 **or** F and CV **sc** CI: B1 B0 B1 B1 M0 A0 A0 (max 3/7)
(b)	$\bar{x} = 2.1$	B1		cao
	CI: $\bar{x} \pm z\frac{\sigma}{\sqrt{n}}$	M1		Accept $\bar{x} \pm t\frac{s}{\sqrt{n}}$ or mixture
	$z = 2.5758$	B1		awfw 2.57 to 2.58
	CI: $2.1 \pm 2.5758 \times \frac{0.1}{\sqrt{10}}$	A1√		ft on $\bar{x}$ and z but no mixture Accept $\pm 3.25 \times \frac{s}{\sqrt{10}}$; no ft on t
	Thus (2.02, 2.18)	A1	5	Dependent on use of correct z **sc** Test: B1 M0 B1 A0 A0 (max = 2/5)
	Total		**12**	

MBS7 (cont)

Question Number and Part	Solution	Marks	Total	Comments
2(a)	SD(T) = 8	B1	1	cao
(b)	P($5 < T < 15$) =			
	P($T < 15$) – P($T < 5$)	M1		Use of; or use of $\int \lambda e^{-\lambda t}\, dt$
	$= \left(1 - e^{-\frac{15}{8}}\right) - \left(1 - e^{-\frac{5}{8}}\right)$	A1		Or $\left[-e^{-\lambda t}\right]_5^{15}$ ≥ 1 correct term
	$= e^{-\frac{5}{8}} - e^{-\frac{15}{8}}$			
	= 0.53526 – 0.15335 = 0.382	A1	3	awrt
(c)	P(none from 5.45 to 6.00) = P($T > 15$)	M1		Attempt at either probability
	$= e^{-\frac{15}{8}} = 0.153$	A1√		ft on part (b) (0.153355)
	P(none from 6.00 to 6.15) = P($S > 15$)			
	$= e^{-1} = 0.368$	A1		cao/awrt (0.367879)
	P(none from 5.45 to 6.15) = 'product'	m1		Use of
	$= e^{-\frac{23}{8}} = 0.056$ to 0.057	A1	5	awfw
	Or (using Poisson) =	(M1)		
	$P(0\|\lambda = \frac{15}{8} = 1.875)$ × $P(0\|\lambda = \frac{15}{15} = 1)$	(A1) (A1)		
	$= e^{-1.875} \times e^{-1}$	(m1)		Product
	$= e^{-2.875} = 0.056$ to 0.057	(A1)		awfw
	Total		**9**	

MBS7 (cont)

Question Number and Part	Solution	Marks	Total	Comments
3(a)(i)	H_0: $p = 0.015$ (1.5%) H_1: $p > 0.015$ (1.5%)	B1 B1	2	Accept $\lambda = 1.5$ } cannot be Accept $\lambda > 1.5$ } scored later
(ii)	$\lambda = 1.5$	B1		Stated or implied in (ii)
	$P(X \geq 4) = 1 - P(X \leq 3)$	M1		Attempt at
	$=1-e^{-1.5}\left(1+1.5+\frac{1.5^2}{2}+\frac{1.5^3}{6}\right)$	M1		Attempt at $P(X \leq 3)$ for Po(1.5)
	$=1 - 0.22313 \times 4.1875 = 0.065$ to 0.066	A1		awfw
	< 0.10 (10%)	M1		Comparison with 10%
	Thus, at 10% level of significance, reason to accept wholesaler's suspicion.	A1√	6	ft probability with 10%
(b)	Normal approximation with:			
	$\mu = 30$ and $\sigma^2 = 29.55$ or 30 or $\hat{p} = 0.018$	B1		Both; cao, awfw 29.5 to 30 cao
	CV $z = 1.2816$	B1		awrt 1.28
	$z = \frac{(36 \text{ or } 35.5) - 30}{\sqrt{29.55 \text{ or } 30}}$ or $\frac{0.018 - 0.015}{\sqrt{\frac{0.015 \times 0.985}{2000}}}$	M1		Normal standardisation
	1.00 to 1.15	A1		awfw; (p-value = 0.125 to 0.160)
	$P(X \geq 36 \mid B(2000, 0.015)) = 0.155669$ $P(X \geq 36 \mid Po(30)) = 0.157383$ Comparison with 0.10 (10%)	(M1) (A2) (m1)		
	Thus, at 10% level of significance, no reason to accept wholesaler's suspicion	A1√	5	ft on z and CV or ft on probability with 10%
	Total		**13**	

MBS7 (cont)

Question Number and Part	Solution	Marks	Total	Comments
4(a)	**Linear** relationship **Negative** relationship	E1 E1	2	Or equivalent Or equivalent
(b)	$\hat{\beta} = \frac{-46.5}{6938} = -0.0067$ to -0.006705	B1		awfw
	$\hat{\alpha} = 6.55 + 0.006702 \times 44 = 6.84$ to 6.85	B1	2	awfw
(c)(i)	$s^2 = \frac{1}{12-2}\left(0.3268 - \frac{(-46.5)^2}{6938}\right)$	M1		Attempt at
	$= 0.00151$ to 0.00152	A1	2	awfw
(ii)	H_0: $\beta = -0.005$ H_1: $\beta < -0.005$	B1		Both
	SL $\alpha = 0.01$ DF $\nu = 12 - 2 = 10$	B1		cao
	CV $t = -2.764$	B1		awrt ±2.76
	$t = \frac{\hat{\beta} - \beta_0}{\sqrt{\frac{s^2}{S_{xx}}}} = \frac{-0.0067 - (-0.005)}{\sqrt{\frac{0.0015146}{6938}}}$	M1		Use of; allow $\beta_0 = 0$ but not $\sqrt{n}$
		A1√		ft on $\hat{\beta}$ and s^2
	$= -3.66$ to -3.63	A1		awfw; ignore sign
	Thus, at 1% level of significance, evidence that $\beta < -0.005$	A1√	7	ft on t and CV providing consistent signs
(iii)	For every 1°C **rise** in temperature	B1		Or equivalent
	the pH **decreases**, on average, by **more than 0.005**	B1√	2	Or equivalent ft on part (c)(ii)
	Total		**15**	

MBS7 (cont)

Question Number and Part	Solution	Marks	Total	Comments
5(a)(i)	$P(X < x) = P\left(Z < \frac{x-200}{\sqrt{100}}\right)$ $= P(Z < (0.1x - 20))$	B1	1	Accept 10 rather than $\sqrt{100}$ **ag**
(ii)	**Interval** **Probability** $x < 180$ 0.02275 $180 < x \leq 190$ 0.13591 $190 < x \leq 200$ given (0.34134) $200 < x \leq 210$ 0.34134 $210 < x \leq 220$ 0.13591 $x \geq 220$ 0.02275	B2, 1	2	awfw 0.0227 to 0.0228 awrt 0.136 awrt 0.341 awrt 0.136 awfw 0.0227 to 0.0228 5 or 4 ⇒ B2 3 or 2 ⇒ B1 Cannot be scored in (b)
(b)	H_0: $X \sim N(200, 100)$ H_1: not H_0	B1		or equivalent Not required
	SL $\alpha = 0.05$ DF $\nu = 6 - 1 = 5$	B1		cao
	CV $\chi^2 = 11.070$	B1		awrt 11.1
	O E 19 13.65 74 81.55 193 204.80 218 204.80 85 81.55 11 13.65 600 600.00	M1		Use of probabilities in part (a)(ii)
		M1		Probabilities × 600
	$\chi^2 = \sum \frac{(O-E)^2}{E}$	M1		Use of
	= 4.90 to 5.10	A1		awfw
	Thus, at 5% level of significance, no reason to reject hypothesis that $X \sim N(200, 100)$	A1√	8	Or equivalent ft on χ^2 and upper CV **sc** If (a)(ii) not attempted or not used, then (b): B1 B1 B1 M0 M1 M1 A0 A1√ (max 6/8)
	Total		**11**	
	TOTAL		**60**	