A-LEVEL Statistics

SS06

Mark scheme

6380

June 2018

Version/Stage: 1.0 Final

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 Assessment Writer.

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 aqa.org.uk

Key to mark scheme abbreviations

M	mark is for method
m or dM	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 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
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
c	candidate
sf	significant figure(s)
dp	decimal place(s)

No Method Shown

Where the question specifically requires a particular method to be used, we must usually see evidence of use of this method for any marks to be awarded.

Where the answer can be reasonably obtained without showing working and it is very unlikely that the correct answer can be obtained by using an incorrect method, we must award **full marks**. However, the obvious penalty to candidates showing no working is that incorrect answers, however close, earn **no marks**.

Where a question asks the candidate to state or write down a result, no method need be shown for full marks.

Where the permitted calculator has functions which reasonably allow the solution of the question directly, the correct answer without working earns **full marks**, unless it is given to less than the degree of accuracy accepted in the mark scheme, when it gains **no marks**.

Otherwise we require evidence of a correct method for any marks to be awarded.

Q1	Solution	Mark	Total	Comment
(a)				
(i)	$P(\overline{X} > 25.3) = P(z > \frac{25.3-24.75}{0.75/\sqrt{8}})$ =0.019	M1 m1 dep		Use of $\frac{\sigma}{\sqrt{8}}$ PI Standardising used PI dep M1
(ii)	$P(\overline{X} > 25.3) = P(z > \frac{25.3-25.50}{0.75/\sqrt{8}})$ =0.775	A1 A1	4	0.019 awrt awfw 0.77 – 0.78
(b)				
(i)	For $\overline{X}$ = 24.75 $P(\overline{X} < 25.25) = P(z < \frac{25.25-24.75}{0.75/\sqrt{10}})$ =0.982	M1		Use of $\frac{\sigma}{\sqrt{10}}$ PI
	For $\overline{X}$ = 25.75 $P(\overline{X} < 25.25)$ = 1 – 0.982 by symmetry 0.018 > 0.01 so does not satisfy requirement 0.982 > 0.95 so satisfies requirement	A1 E1dep		For 0.98 -0.983 or 0.017-0.018 obtained Clear explanations of requirement satisfied/not satisfied for **both**.
(ii)	Increase sample size	B1	4	
(c)	A Type II error is to <u>accept</u> a <u>batch</u> of bags (of cement) when, in fact, the batch is not of acceptable quality (for the builder's merchant/Aled.)	B1 E1	2	Correct idea for Type II error P(accept H_0 | H_0 false) In context of sampling scheme
	Total		**10**	

Q2	Solution	Mark	Total	Comment
	H_O $\mu_{Shetland} = \mu_{Argyll} = \mu_{NCentral}$ H_1 at least 2 of the means differ 5% 1 tail $T_{Shetland}$ = 64.23 T_{Argyll} =74.08 $T_{N\ Central}$ = 64.85 $n_{Shetland}$ = 6 n_{Argyll} = 5 $n_{N\ Central}$ = 7 T= 203.16 $\sum\sum x_{ij}^2$ = 2404.94 N= 18	B1		
	Total SS 2404.94 - $\frac{203.16^2}{18}$ = <u>111.94</u>	M1PI		Total SS effort
	Areas SS $\frac{64.23^2}{6}+\frac{74.08^2}{5}+\frac{64.85^2}{7}$ - $\frac{203.16^2}{18}$ = <u>92.94</u>	M1PI		Areas SS effort
	ANOVA table (ss / df / ms): Between areas: 92.94 / 2 / 46.47 Error: 19.00 / 15 / 1.27 Total: 111.94 / 17	M1PI		dep error ss positive
		B1PI		error df = 15
		m1PI		method for ms ft dep B1 M1 previously
	F = $\frac{46.47}{1.27}$ = 36.7	m1PI		F test stat (awfw 30-40)
	F_{15}^{2} = 3.682 36.7 >3.682	B1		cv cao or p = 0.00000167 <0.05
	Reject H_o	A1 dep		Correct conclusion dep ts/cv correct
	There is significant evidence of a difference in <u>mean mercury</u> concentration for <u>at least two of the areas</u> of Scotland. Shetland / Argyll / N Central mean: 10.705 / 14.816 / 9.264	E1PI		Correct conclusion in context – 'at least two' included dep ts and cv correct and not too definite PI if fully explained as below
	Otters in the <u>Argyll</u> area of Scotland have significantly <u>higher</u> (bioaccumulations of) mercury, <u>on average</u>, than those otters in the <u>N Central</u> area or N Central lower than Argyll.	E1	11	Explanation in full of conclusion with some numerical justification attempt or <u>reference to means</u> (not referring to totals)
	Total		**11**	

Q3	Solution	Mark	Total	Comment
(a) (i)	H_o pop mean diff μ_d = 0 H_1 pop mean diff μ_d > 0 [Before – After] 1 tail 5%	B1		Hypotheses consistent with *d*
	d = Before - After **A** 0.8 | **B** - 0.3 | **C** 0.6 | **D** 1.9 | **E** 0.3 | **F** 2.6 **G** 0.9 | **H** -0.9 | **I** -0.7 | **J** 1.6	M1 A1		Differences (ignore signs) At least 8 correct differences
	$\bar{d}$ = 0.68 *s* = 1.135 *n* = 10	m1		Attempt to evaluate $\bar{d}$ and s Condone 1.0768 here
	$t = \frac{0.68-0}{1.135/\sqrt{10}}$ = 1.89	m1 A1		Wholly correct method for *t* (condone small slip in $\bar{d}$, s) (±) 1.89 (1.85 – 1.95) or *p* =0.0453
	df = 9 cv = 1.833 1.833 < 1.89 or 0.0453<0.05	B1		for correct cv or *p* compared with 0.05
	Reject H_o	A1dep		correct conclusion dep ts/cv correct
	Significant evidence to suggest that after the introduction of the bonus/ (scheme) there was a reduction in the mean absenteeism level.	E1dep	9	correct conclusion in context Not too definite
(ii)	Differences in absenteeism levels are normally distributed	B1	1	Normally distributed with some context.
(b)	H_0 η = 5.2 H_1 η > 5.2 1 tail 5%	B1		Hypotheses
	Signs (score -5.2) - + + + + + + - + + + . - - + + 11^+ / 4^- signs – test values	M1 A1		Signs Test stat correct PI
	Binomial (15, 0.5) model P ($\geq 11^+$) = P($\leq 4^-$) = 0.0592 > 0.05	A1 m1		Correct Bin prob AWRT 0.059 0.059 comparison with 0.05 seen Condone comparison with 0.06 for m1 only
	Accept H_o . There is insufficient evidence, at the 5% level, to suggest that that the bonus /(scheme) results in a higher median/average satisfaction (score) (or to suggest that Rupal's claim is true).	E1dep	6	Correct conclusion in context dep 0.059/0.05 comparison seen and not too definite
	Total		**16**	

4	Solution	Mark	Total	Comment
(a)				
(i)	$\begin{array}{\|c\|c\|c\|}\hline \mathbf{E_1} & \mathbf{E_2} & \mathbf{E_3} \\ \hline S_2 & S_1 & S_4 \\ S_5 & S_3 & S_6 \\ S_9 & S_8 & S_7 \\ \hline \end{array}$	M1 m1 A1		Table with labels for environments (allow mark in part (b)) 9 saplings allocated to environments 'Random' allocation intention
(ii)	<u>Completely randomised</u> design	B1		
(iii)	1 factor ANOVA	B1	5	
(b)				
(i)	$\begin{array}{\|c\|c\|c\|c\|}\hline & \mathbf{E_1} & \mathbf{E_2} & \mathbf{E_3} \\ \hline \mathbf{V_1} & S_1 & S_2 & S_3 \\ \mathbf{V_2} & S_4 & S_5 & S_6 \\ \mathbf{V_3} & S_7 & S_8 & S_9 \\ \hline \end{array}$	M1 A1		Table fully labelled with each variety/environment/sapling number Correct allocation of one of each variety to each environment
(ii)	Randomised Block	B1		
(iii)	2 factor ANOVA	B1	4	
(c)	<u>Each variety</u> of pine sapling has its growth measured <u>in each environment</u> for the design in(b)(ii)	E1		Any 2 relevant points made: Allocation of one of each variety to each environment in randomised block Enables a comparison of 3 environments as varieties removed as a nuisance factor E1
	whereas in the design in part (a)(ii) it could be that all of one variety may end up having growth measured in the same environment – there is not an 'even allocation of varieties to environments	E1	2	Contrast with potential 'unfair' allocation in fully randomised
	Total		**11**	

Q5	Solution	Mark	Total	Comment
(a)(i)	Warning lines 95% $500 \pm 1.96 \times \frac{2.1}{\sqrt{6}} = (498.3, 501.7)$ Action lines 99.8% $500 \pm 3.09 \times \frac{2.1}{\sqrt{6}} = (497.4 \text{ or } 497.3, 502.6)$ or $(497.4, 502.7)$	M1PI M1PI A1	3	For z = 1.96 and 3.09 Correct formula attempted (must include $\frac{2.1}{\sqrt{6}}$) Both Warning and Action lines correct 1dp– allow 1 small arith slip
(ii)	$d \times 2.1$ 4.361 $\times 2.1$ = 9.16 5.619 $\times 2.1$ = 11.80	M1 A1	2	Correct *d* values Both correct awrt 9.2, 11.8
(iii)	**Sample 1** $\overline{X} = 497.5$ Range = 10.7 Mean lies between (lower) warning and action lines. Range lies between (upper) warning and action lines Take another sample (immediately) **Sample 2** $\overline{X} = 500.03$ Range = 4.8 Mean lies between (upper) warning (and lower warning) lines. Range is below (upper) warning line. No action required	M1 A1 E1dep E1dep	4	Attempt to find $\overline{X}$ and range At least one $\overline{X}$ and one range correct Correct explanation dep correct $\overline{X}$ and range Correct explanation dep correct $\overline{X}$ and range sc2 Both means correct B1 Both comments on mean correct B1

(b) **(i)**	*z* score corresponding to 92.5% z =1.440 (condone 1.405 – 1.476) $\frac{(500+w)-500}{2.1}=\frac{w}{2.1}=1.440$ $w=2.1\times1.440=3.02$	M1 A1	2	Attempt to find *z* score (1.44 or 1.036) PI *w* correct awfw 2.9 – 3.1 (condone 502.9 -503.1 or 497.1 -496.9 seen)
(ii)	$0.15+1.96\times\sqrt{\frac{0.15\times0.85}{40}}$ = 0.261 UWL $0.15+3.09\times\sqrt{\frac{0.15\times0.85}{40}}$ = 0.324 UAL	M1 m1 A1 A1	4	Use of 0.15 and 1.96 and 3.09 Formula correct UWL AWFW 0.26 -0.27 UAL AWFW 0.32 -0.33
(iii)	**Sample 3** $p=\frac{11}{40}=0.275$ **(**0.27-0.28) *p* lies between UWL and UAL . Take another sample (immediately) **Sample 4** $p=\frac{18}{40}=0.45$ *p* lies above UAL . Stop process	B1 E1dep E1dep	3	Two proportions found Explanations dep proportions correct to 2dp and UWL, UAL correct (condone small arithmetic error)
	Total		**18**	

<table>
<tr><th>Q6</th><th>Solution</th><th>Marks</th><th>Total</th><th>Comments</th></tr>
<tr><td>(a)</td><td>
<table>
<tr><th>Addit</th><th>V</th><th>W</th><th>X</th><th>Y</th></tr>
<tr><td></td><td>21
20
16
15</td><td>26
27
15
20</td><td>25
26
16
17</td><td>20
23
13
20</td></tr>
<tr><td>Total</td><td>72</td><td>88</td><td>84</td><td>76</td></tr>
</table>
ss between additives =
$(\frac{72^2}{4}+\frac{88^2}{4}+\frac{84^2}{4}+\frac{76^2}{4})-\frac{320^2}{16}=6440-6400$
= 40
<table>
<tr><th></th><th>ss</th><th>df</th><th>ms</th></tr>
<tr><td>Between drivers</td><td>216</td><td>3</td><td>72</td></tr>
<tr><td>Between makes</td><td>24</td><td>3</td><td>8</td></tr>
<tr><td>Between additives</td><td>40</td><td>3</td><td>13.3</td></tr>
<tr><td>Error</td><td>16</td><td>6</td><td>2.67</td></tr>
<tr><td>Total</td><td>296</td><td>15</td><td></td></tr>
</table>
</td><td>M1

m1

m1

m1

B1</td><td>5</td><td>Separating data according to additive PI

Totals of data in each additive category

Attempt at ss for between additives

Subtraction to find error ss (disallow if negative)

df correct for error</td></tr>
<tr><td>(b)</td><td>H_O $\mu_V=\mu_W=\mu_X=\mu_Y$
H_1 at least 2 of the means differ 1% 1 tail

F = $\frac{13.33}{2.67}=5$

$F^{\ 3}_{\ 6}$ = 9.78

9.78 > 5 Accept H_o

No significant evidence of a difference in <u>mean (emission) reduction</u> for the four varieties of <u>additives.</u></td><td>B1

A1

B1

E1dep</td><td>4</td><td>Hypotheses

F test statistic correct (5 or 4.99)

cv correct cao
OR
p =0.0452 0.0452 > 0.01

Accept H_o explained in context.
Dep ts/cv correct
Not too definite</td></tr>
<tr><td></td><td>Total</td><td></td><td>9</td><td></td></tr>
</table>