AQA

A-LEVEL
Statistics

SS06
Mark scheme

6360
June 2016

Version 1.0: Final Mark Scheme

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.

Final A and/or E marks for Hypothesis tests is/are only awarded if all workings correct

Q1	Solution	Marks	Total	Comments
(a)	H_O $\mu_{24+} = \mu_{12-24} = \mu_{2-12} = \mu_{less2}$ H_1 at least 2 (of the means) differ 5% 1 tail	B1		Disallow if labels eg A,B,C,D used without identification Allow 'population mean' for H_O H_O $\mu_i = \mu_j$ for all i,j H_1 $\mu_i \neq \mu_j$ for some i,j
	$T_{24+} = 345.3$ $T_{12-24} = 328.7$ $T_{2-12} = 303.2$ $T_{less2} = 241.7$ $n_{24+} = 5$ $n_{12-24} = 5$ $n_{2-12} = 5$ $n_{-less2} = 4$ T= 1218.9 $\sum\sum x_{ij}^2 = 78811.89$ N= 19			
	Total SS $78811.89 - \frac{1218.9^2}{19} = \underline{616.3}$	M1		Total SS effort
	Times SS $\frac{345.3^2}{5} + \frac{328.7^2}{5} + \frac{303.2^2}{5} + \frac{241.7^2}{4} - \frac{1218.9^2}{19} = \underline{250.3}$	M1		Times SS effort
		M1 dep		error ss dep SS above and (all SS) positive
		B1		error df PI
		M1 dep		method for either ms ft PI
		A1 dep		F test stat awrt 3.4
		B1		cv cao Alt Allow p =0.0448 compared with 0.005 for A1 B1
	$F = \frac{83.4}{24.4} = \mathbf{3.42}$ $F_{15}^{3} = \mathbf{3.287}$ $3.287 < 3.42$ Reject H_o			
	There is significant evidence of a difference in mean coursework marks (for at least two of the handing in times).	A1 dep		Correct conclusion in context
	Students handing in coursework more than 24 hours before the deadline gain higher marks, on average, than those handing in coursework less than 2 hours before the deadline	E1dep		Explanation, in full, of conclusion
			10	
(b)	Coursework **marks** are **normally distributed** with a **common variance.**	B1 E1	**2**	Normal and common variance In context mentioning marks normally distributed or marks have common variance
		Total	**12**	

	ss	df	ms
Between times	250.3	3	83.4
Error	**366.0**	**15**	24.4
Total	616.3	18	

Q2	Solution	Marks	Total	Comments
(a)	H_o pop mean diff or $\mu_d = 0$ H_1 pop mean diff or $\mu_d > 0$ [QC – DD] 1 tail 5%	B1		Hypotheses consistent with *d*
	d = QC - DD | | **A** | **B** | **C** | **D** | **E** | **F** | | *d* | +5 | 0 | +4 | +3 | -1 | -1 | | | **G** | **H** | **I** | **J** | **K** | **L** | | *d* | +4 | +2 | +8 | +4 | +9 | +2 |	M1 A1		Differences (ignore signs) At least 8 correct differences PI
	$\bar{d}$ = 3.25 s = 3.166 n = 12	m1dep		Attempt to evaluate $\bar{d}$ and s sc 0 excluded gives $\bar{d}$ = 3.545 M1A1m1 max
	$t = \frac{3.25-0}{3.166/\sqrt{12}} = 3.56$	B1 m1		Use of $\frac{s}{\sqrt{n}}$, n =12 ft in ts oe PI Method for *t*
	df = 11 cv = **1.796** 1.796 < 3.56	A1 B1		(±) 3.56 (3.50 – 3.60) for correct cv Allow p value = 0.00225(for m1 B1 m1A1) compared with 0.05(B1)
	Reject H_o Significant evidence to suggest that: the belief is correct OR the time taken, after placing on ward, before a box of *Chok Delights* is opened is, on average, less than that for a box of *Quality Chox*	A1 dep E1dep	**10**	correct conclusion correct conclusion in context
(b)	H_0 $\eta_{\text{difference}} = 0$ H_1 $\eta_{\text{difference}} \neq 0$ 2 tail 1%	B1		Hypotheses oe ref population median difference
	Signs [QC – DD] + + – – + + + + + + + + 10^+ / 2^- signs – test values	M1 A1		Signs PI Test stat correct
	Binomial (12, 0.5) model P (≥ 10^+) = P(≤ 2^-) = **0.0193** > **0.005** for 2 tail test	M1 m1		Correct Bin prob Comparison with **0.005** Alt cr found {0.1,11,12} Must see P(≤ 1) = **0.0032** compared with **0.005**
	Accept H_o . There is insufficient evidence, at the 1% level, to suggest that there is a difference in the average time since opening a box for a chocolate to be taken for the 2 brands.	E1dep	**6**	Correct conclusion in context
		Total	**16**	

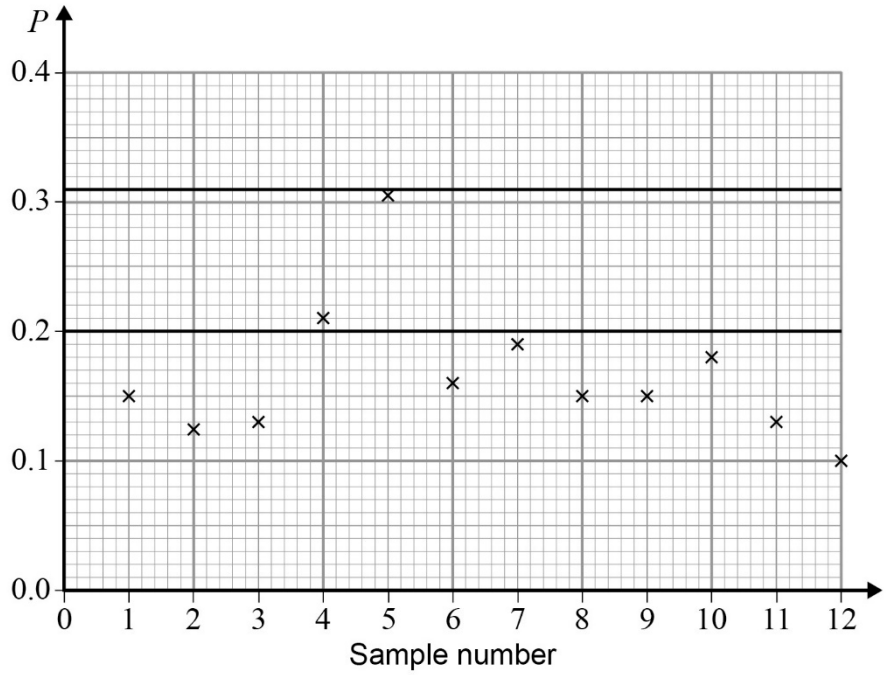
Q3	Solution	Marks	Total	Comments
(a)(i)	Age group	E1		
(ii)	The diet (assigned : D1, D2, D3, D4)	E1		
(iii)	A blocking factor is used to reduce experimental error (reduce effect of nuisance factors) by enabling treatments to be applied to the same subjects under the same conditions.	E1 E1	4	Reduction of experimental error Same conditions. E1 **Allow:** difference in diets is more likely to be detected if one exists. E1
(b)(i)				
(ii)	Randomised Block	B1 B1	6	Block mentioned Randomised
(iii)	Two-factor ANOVA	B1 B1		ANOVA Two factor
		Total	**10**	

		Diet			
		D1	**D2**	**D3**	**D4**
Age group	**20-29**				
	30-39				
	40-49				
	50-59				

M1 Age groups and D1-D4 appear in table

A1 Fully labelled correct table

Q4	Solution	Marks	Total	Comments
(a)	$67 + 55 + \ldots. + 59 = 780$ $780 / 12 = 65 \quad n = 65$	M1 A1		Totalling numbers in each scoop PI
	$p = \frac{10 + \ldots..+ 6}{780} = \frac{130}{780} = \frac{1}{6}$	B1	**3**	Showing $p = \frac{1}{6}$ ag (disallow 0.167)
(b)(i)	$\frac{1}{6} + 1.96 \times \sqrt{\frac{\frac{1}{6} \times \frac{5}{6}}{65}} = 0.257$ UWL	B1 M1ft		**1.96 and 3.09** seen $\sqrt{65}$ used or their n from (a) if small slip
	$\frac{1}{6} + 3.09 \times \sqrt{\frac{\frac{1}{6} \times \frac{5}{6}}{65}} = 0.309$ UAL	m1ft A1 A1	**5**	Formula for upper control limit correct (condone both limits) awrt 0.26 awrt 0.31
(ii)	UWL and UAL plotted correctly	B1		0.26 0.31
	Attempt to evaluate proportions for each sample 10/67 = 0.149 etc	M1(PI)		0. 149, 0.127, 0.133, 0.211, 0.303, 0.161, 0.190, 0.149, 0.15, 0.181, 0.132, 0.102
	Proportions seen correct (at least 6, to 2 dp)	A1(PI)		Allow small slip/rounding errors
	Points plotted correctly	A1	**4**	Allow small slip of 1 square
(iii)	Sample 5 proportion is close to UAL/between UWL and UAL but process then back under control with all subsequent proportions well below UWL	E1	**1**	Mention of sample 5 proportion close to UWL but afterwards process back under control
(c)	(i) 20/69 = 0.290 (ii) 19/60 = 0.317	M1		Effort to evaluate proportions for each new sample (at least one seen)
(i)	0.290 lies between UWL and UAL. Take another sample immediately.	E1 dep E1 dep		Between UWL/UAL Take another sample Dep proportion effort and (b)(i)A1A1
(ii)	0.317 lies above UAL. Stop production immediately.	E1 dep E1 dep	**5**	Beyond UAL Stop production Dep proportion effort and (b)(i)A1A1
		Total	**18**	


P
0.4
0.3
0.2
0.1
0.0
0 1 2 3 4 5 6 7 8 9 10 11 12
Sample number

Q5	Solution	Marks	Total	Comments
(a)	$\frac{0.6}{\sqrt{4}}$ $z = \frac{9.8-\mu}{0.6/\sqrt{4}}$ 9.2: **.023**; 9.4: .091; 9.6: **.252**; 9.8: 0.5; 10.0: **.748**; 10.2: .909; 10.4: **.977**	M1 m1 A1 A1	**4**	Effort to find *z* score 2 probabilities correct All correct Allow small arithmetic slip/rounding error
(b)	$\frac{k-10}{0.6/\sqrt{n}} \leq -1.6449$ Amur's requirement $\frac{k-9.4}{0.6/\sqrt{n}} \geq 2.3263$ Owners' requirement $(k-10)\times\frac{\sqrt{n}}{0.6} = -1.6449$ I $(k-9.4)\times\frac{\sqrt{n}}{0.6} = 2.3263$ II $-0.6\times\frac{\sqrt{n}}{0.6} = -3.9712$ I – II n = 16 (15.77) $(k-9.4)\times\frac{4}{0.6} = 2.3263$ $k = 9.75$ kg	B1 M1 M1 M1 A1 A1	**6**	2.3263 and 1.6449 appear (allow ±). Use of *k* and *n* (oe) in z score anywhere Correct **equality or inequality expression** (condone incorrect inequality sign) Rearrangement and effort to solve simultaneous equation *n* = 16 *k* = 9.75 (9.7489445)
		Total	**10**	

<table>
<tr><th>Q6</th><th>Solution</th><th>Marks</th><th>Total</th><th>Comments</th></tr>
<tr><td>(a)</td><td>Latin Square</td><td>B1</td><td>1</td><td></td></tr>
<tr><td>(b)(i)</td><td>H_O $\mu_A = \mu_B = \mu_C = \mu_D = \mu_E$
H_1 at least 2 of the means differ 1% 1 tail

<table>
<tr><td></td><td>ss</td><td>df</td><td>ms</td></tr>
<tr><td>Between radio st</td><td>177.84</td><td>4</td><td>44.46</td></tr>
<tr><td>Between days</td><td>123.44</td><td>4</td><td>30.86</td></tr>
<tr><td>Between weeks</td><td>11.84</td><td>4</td><td>2.96</td></tr>
<tr><td>Error</td><td>120.72</td><td>12</td><td>10.06</td></tr>
<tr><td>Total</td><td>433.84</td><td>24</td><td></td></tr>
</table>

$F = \frac{44.46}{10.06} = 4.42$ $F_{12}^{4} = 5.412$

4.42< 5.412 Accept H_o

No significant evidence of a difference in mean hourly production (for the five radio stations.)</td><td>B1

M1

M1

m1

A1

E1dep</td><td>6</td><td>Allow ‘population mean’ for H_O
H_O $\mu_i = \mu_j$ for all i,j
H_1 $\mu_i \neq \mu_j$ for some i,j

ss Error PI
(allow small slip – not if negative)

df Between Radio St and Error – BOTH PI

ms Error and Between Radio St and divided PI dep previous M1,M1

F ts awfw 4.3-4.6

Correct conclusion in context with correct cv used</td></tr>
<tr><td>(ii)</td><td>There is no interaction between radio station and day of the week or week involved.

One type of radio station is not better/worse for output on a particular day of the week or during a particular week.</td><td>B1(PI)

E1</td><td>2</td><td>No interaction mentioned with some context used

Full explanation</td></tr>
<tr><td></td><td></td><td>Total</td><td>9</td><td></td></tr>
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