Teacher Support Materials
2008

Maths GCE

Paper Reference SSO3

Question 1

A manufacturer of an electrical appliance wants to adjust one of the components used in the appliance. The effect that the adjustment would have on the resistance of the component is investigated.

The manufacturer selects, at random, 8 components. Each component has its resistance, in ohms, measured before and after the adjustment.

The results of the investigation are shown in the table.

Component	**A**	**B**	**C**	**D**	**E**	**F**	**G**	**H**
Before	38	42	44	35	44	36	44	42
After	41	49	42	40	43	40	46	50

(a) Carry out a Wilcoxon signed-rank test, at the 5% significance level, to investigate whether or not the average resistance of the component is changed by the adjustment. Interpret your conclusion in context.

(9 marks)

(b) (i) Give **one** reason why a Wilcoxon signed-rank test might be preferred to a sign test in carrying out an investigation similar to the one carried out in part (a).

(1 mark)

(ii) Describe **one** situation in which it would **not** be possible to carry out a Wilcoxon signed-rank test but it would be possible to carry out a sign test.

(2 marks)

Student Response

Question number

Lea
bla

1a. H_0 - Population Median = 0
H_1 - Population Median ≠ 0
2 tailed test at 5%   (before - after)

	rank	
	+	-
-3		4
-7		7
2	2.5	
-5		6
1	1	
-4		5
-2		2.5
-8		8
	3.5	32.5

$\text{total}^- = 32.5$
$\text{total}^+ = 3.5$

test Statistic = 3.5.
Critical value = 4.

test Statistic < 4
H_0 is rejected significant evidence that the population median does not = 0 and that there is a difference between ~~the two~~ before and after resistant.

bi) more depth.

ii) If the data was not numerical, it would not be possible to use a wilcoxon Signed rank test.

Commentary

Many candidates made a very good effort at this question and the majority showed the differences between pairs of values and the rank values used. Several incorrectly ranked -8 with rank 1. Candidates should understand the difference with the smallest absolute value is assigned rank 1.

Hypotheses were usually correctly stated and conclusions were generally fairly well done and in context. The solution shown for part (a) gained full marks and is clearly laid out.

In part (b) (i) most candidates had a good idea of the required comment but many did not express themselves clearly enough to gain the mark.

In part (b) (ii) there were some excellent solutions with clear examples given but many candidates gained only 1 mark as they were not specific enough in their explanation. This candidate did not clearly express the reason or give an example.

Mark scheme

<table>
<tr><td>1(a)</td><td>H_o pop median/mean diff $\eta_d = 0$
H_1 pop median/mean diff $\eta_d \neq 0$
1 tail 5% (d is after – before)</td><td>B1</td><td></td><td></td></tr>
<tr><td></td><td><table><tr><td>diff</td><td>3</td><td>7</td><td>-2</td><td>5</td><td>-1</td></tr><tr><td>rank</td><td>4</td><td>7</td><td>-2½</td><td>6</td><td>-1</td></tr></table></td><td>M1</td><td></td><td>For differences (before–after) or (after - before) - ignore signs</td></tr>
<tr><td></td><td><table><tr><td>diff</td><td>4</td><td>2</td><td>8</td></tr><tr><td>rank</td><td>5</td><td>2½</td><td>8</td></tr></table></td><td>M1
m1</td><td></td><td>For ranks
For ties</td></tr>
<tr><td></td><td>$T_+ = 3 + 7 + \ldots + 8 = 32½$
$T_- = 2½ + 1 = 3½$</td><td>m1
A1</td><td></td><td>For total attempted
For one correct total</td></tr>
<tr><td></td><td>Test stat T = 3½ $n = 8$ 1 tail 5%
n = 8 cv = 4
T < 4</td><td>B1
M1</td><td></td><td>For cv
Comparison cv/ts</td></tr>
<tr><td></td><td>Significant evidence at 5% level to reject H_o and conclude that the average resistance differs after the adjustment (higher)</td><td>E1</td><td>9</td><td>In context</td></tr>
<tr><td>(b)(i)</td><td>Wilcoxon signed rank test takes into account the magnitude of the differences not simply whether they are + or –</td><td>E1</td><td>1</td><td></td></tr>
<tr><td>(ii)</td><td>When the data is not symmetrically distributed so Wilcoxon signed-rank cannot be carried out.

Data given only as signs/preferences so only sign test possible – no numerical differences can be evaluated</td><td>B1
E1</td><td>2</td><td>Correct reasoning and explained well</td></tr>
</table>

Question 2

. A road safety organisation obtained the annual number of road deaths, x per 100 000 of the population, and the number of motor vehicles, y per 1000 of the population, for countries in the EU.

The table gives the results for a random sample of 10 countries in the EU.

Country	**A**	**B**	**C**	**D**	**E**	**F**	**G**	**H**	**I**	**J**
x	5.9	6.1	6.3	8.0	8.4	10.2	10.5	12.8	14.8	19.3
y	559	528	518	650	487	607	754	597	496	480

(a) Calculate the value of Spearman's rank correlation coefficient between x and y.

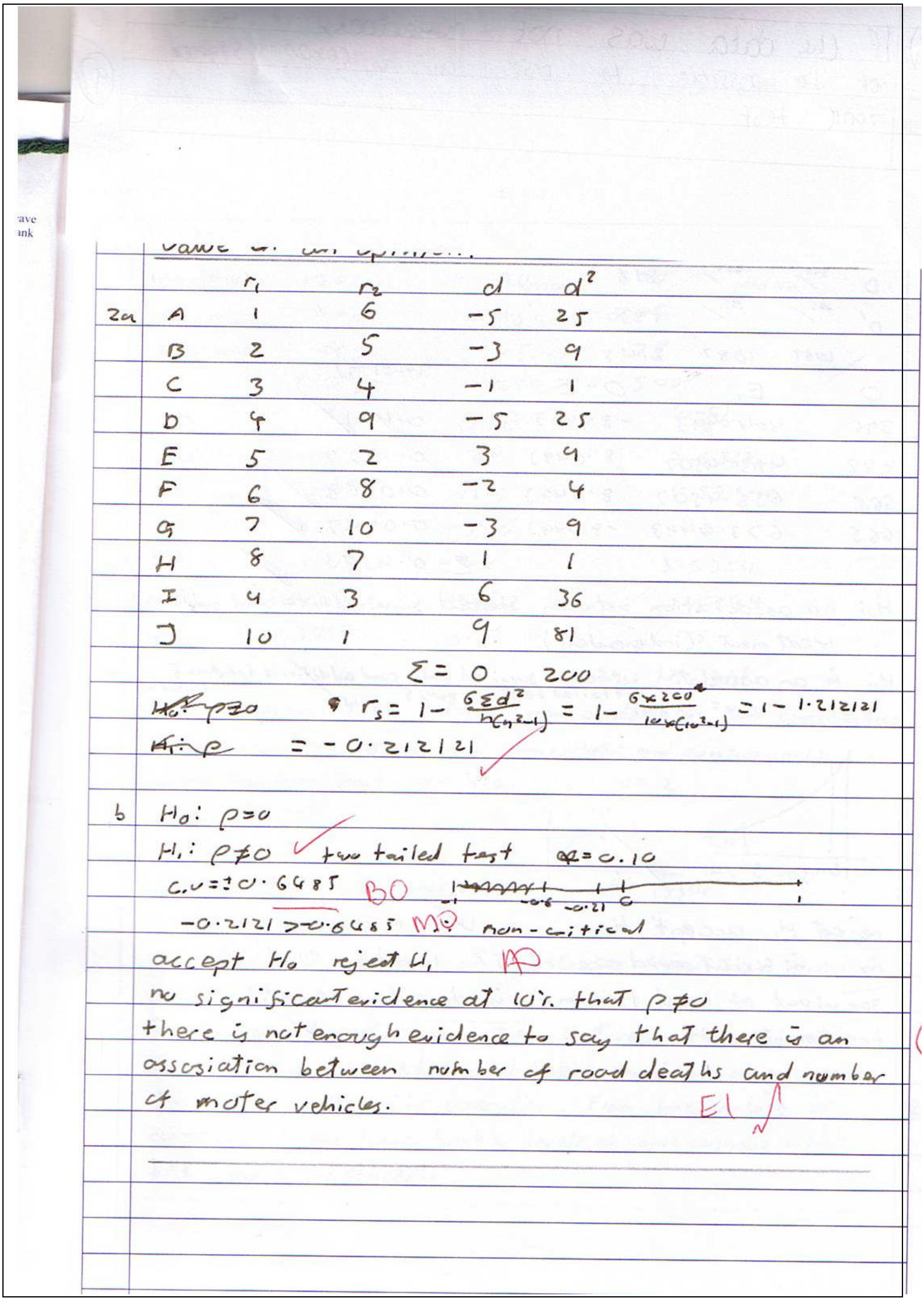
.

(6 marks)

(b) Carry out a hypothesis test, at the 10% level of significance, to determine whether the value you calculated in part (a) indicates an association between the annual number of road deaths per 100,000 of the population and the number of motor vehicles per 1,000 of the population for countries in the EU.

(5 marks)

Student Response



	r_1	r_2	d	d^2
2a A	1	6	−5	25
B	2	5	−3	9
C	3	4	−1	1
D	4	9	−5	25
E	5	2	3	9
F	6	8	−2	4
G	7	10	−3	9
H	8	7	1	1
I	4	3	6	36
J	10	1	9	81
		Σ =	0	200

~~$H_0: \rho \neq 0$~~ $r_s = 1 - \frac{6\Sigma d^2}{n(n^2-1)} = 1 - \frac{6 \times 200}{10 \times (10^2-1)} = 1 - 1.212121$

~~$H_1: \rho$~~ $= -0.212121$ ✓

b $H_0: \rho = 0$

$H_1: \rho \neq 0$ ✓ two tailed test $\alpha = 0.10$

c.v $= \pm 0.6485$ BO

$-0.2121 > -0.6485$ MO non-critical

accept H_0 reject H_1 AO

no significant evidence at 10% that $\rho \neq 0$

there is not enough evidence to say that there is an asscsiation between number of road deaths and number of moter vehicles.

E1 ✓

Commentary

Part (a) was answered correctly by many candidates but a significant number found the product moment correlation coefficient in error. Some candidates successfully obtained the coefficient from a calculator but many detailed the use of the formula. Ranks were generally quoted thus gaining method marks even if the final answer was incorrect. The candidate shown gave all ranks and method and gained full marks.
In part (b), the critical value was usually quoted correctly but often candidates compared a negative correlation coefficient with the positive critical value. This candidate obtained an incorrect critical value although a comparison between a negative ts with a negative cv was made.
Conclusions were often wrong indicating a lack of understanding of the critical region. The conclusion in context stated often did not make sense, for example “road deaths are not associated with cars”. This candidate displays excellent wording for the conclusion in context.

Mark scheme

<table>
<tr>
<td>2.(a)</td>
<td>
<table>
<tr><td>Country</td><td>A</td><td>B</td><td>C</td><td>D</td><td>E</td></tr>
<tr><td><i>x</i> rank</td><td>1</td><td>2</td><td>3</td><td>4</td><td>5</td></tr>
<tr><td><i>y</i> rank</td><td>6</td><td>5</td><td>4</td><td>9</td><td>2</td></tr>
<tr><td>Country</td><td>F</td><td>G</td><td>H</td><td>I</td><td>J</td></tr>
<tr><td><i>x</i> rank</td><td>6</td><td>7</td><td>8</td><td>9</td><td>10</td></tr>
<tr><td><i>y</i> rank</td><td>8</td><td>10</td><td>7</td><td>3</td><td>1</td></tr>
</table>
</td>
<td>M1
M1
A1</td>
<td></td>
<td>attempt at ranks
(can be reversed)
for 16 correct</td>
</tr>
<tr>
<td></td>
<td>r_s = -0.212(3 sf from calc)</td>
<td>B3</td>
<td>6</td>
<td>alternative
d = 5, 3, 1, 5, 3, 2, 3, 1, 6, 9
$\sum d^2 = 200$ B1
$r_s = 1 - \frac{6 \times 200}{10 \times 99} = 1 - 1.212$
= - 0.212 M1, A1</td>
</tr>
<tr>
<td>(b)</td>
<td>H_o Rank orders of annual road deaths and number of motor vehicles are independent.
H_1 Rank orders of annual road deaths and number of motor vehicles are not independent – there is an association
2 tail 10%</td>
<td>B1</td>
<td></td>
<td>or alternatives
H_o No association
H_1 Association</td>
</tr>
<tr>
<td></td>
<td>cv = ±0.5636 n = 10 2 tail 10%</td>
<td>B1</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>test stat r_s = - 0.212
r_s > - 0.5636</td>
<td>M1</td>
<td></td>
<td>for cv</td>
</tr>
<tr>
<td></td>
<td>Accept H_o No significant evidence at 10% level to suggest an association between rank orders of annual road deaths and number of motor vehicles for countries in the EU</td>
<td>A1
E1</td>
<td>5</td>
<td>for comparison ts/cv
r_s = 0.212 / cv = 0.5636
r_s = -0.212 / cv =- 0.5636</td>
</tr>
</table>

Question 3

. (a) A long term trial was carried out into the effectiveness of giving accident victims with serious head traumas a steroid drug in addition to other treatments.
In the trial, 1061 victims were randomly assigned to be given the steroid drug and the remainder were given a drug with no active ingredient (a placebo).
The victims either died as a result of their injuries or survived.

The results of the trial are summarised in Table 1.

Table 1	**Additional treatment given**		
Outcome	**Steroid Drug**	**Placebo**	**Total**
Died	396	422	**818**
Survived	665	665	**1330**

Carry out a test, using the 5% level of significance, to investigate whether the survival of accident victims with serious head traumas is independent of the additional treatment given.

(10 marks)

(b) A trial was carried out into the effectiveness of a new anaesthetic drug. A sample of 500 patients undergoing a minor operation volunteered for the trial. Of these patients, 250 were randomly assigned to be given the standard anaesthetic drug and the remaining 250 were given the new anaesthetic drug.

The level of consciousness of each patient, 30 minutes after the operation was completed, was recorded as unconscious, semi-conscious or fully conscious. The **percentages** of patients in these levels of consciousness, for those given the standard anaesthetic drug and for those given the new anaesthetic drug are shown in Table 2.

Table 2	**Anaesthetic drug used**	
Level of Consciousness	**Standard (percentage)**	**New (percentage)**
Unconscious	52	36
Semi-conscious	36	46
Fully conscious	12	18

(i) Using the 1% level of significance, carry out a χ^2 test for association between the drug used and the level of consciousness 30 minutes after the operation was completed.

(10 marks)

(ii) Interpret your conclusion in part (a)(i) in the context of the question.

(2 marks)

SS03

Student Response

3a) H_0 = Survival of victims with head trauma is independent of additional treatment

H_1 = Survival of victims with head traumas is not independent of additional treatment

Two tailed test at 5% significance. ✓

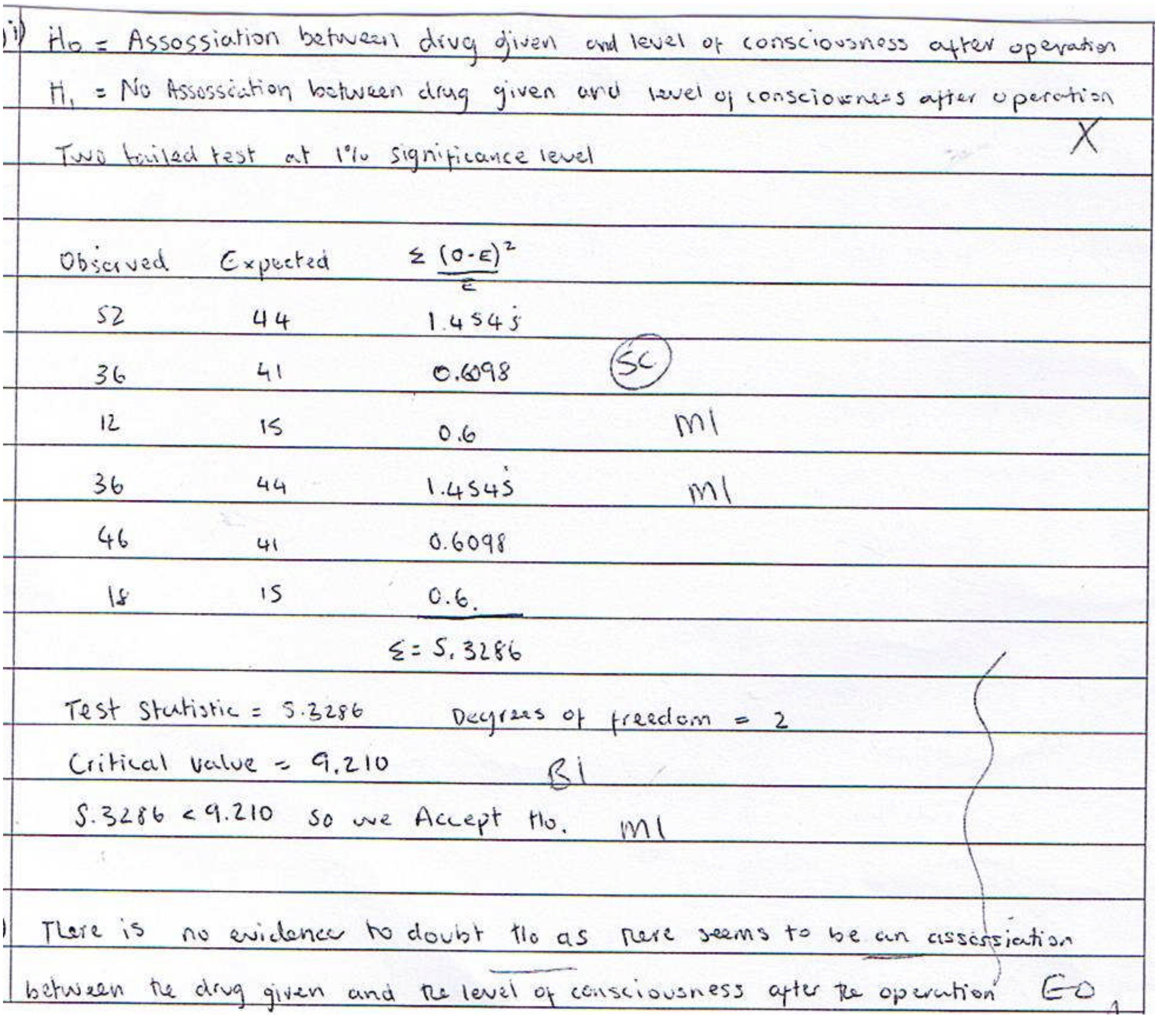
	Steriod	Placebo	Total
Died	396	422	818
Survived	665	665	1330
Total	1061	1087	2148

observed	Expected	$\frac{(\lvert O-E\rvert-0.5)^2}{E}$
396	404.05	0.141 ✓
665	656.95	0.087 ✓
422	413.95	0.137
665	637.05 ✓✓	1.183
		1.548. A0

Test Statistic = 1.548   Degrees of freedom = 1

Critical value = 3.841 B1 M1 A0

1.548 < 3.841 ∴ We accept H_0 as there is significant evidence to suggest that the survival of victims with head trauma is independent of the additional treatment. E1 M1



i) Ho = Assossiation between drug given and level of consciousness after operation

H₁ = No Assossciation between drug given and level of consciowness after operation

Two tailed test at 1% significance level

X

Observed	Expected	$\Sigma \frac{(O-E)^2}{E}$
52	44	1.4545
36	41	0.6098
12	15	0.6
36	44	1.4545
46	41	0.6098
18	15	0.6

SC M1 M1

$\Sigma = 5.3286$

Test Statistic = 5.3286 Degrees of freedom = 2

Critical value = 9.210 B1

5.3286 < 9.210 so we Accept Ho. M1

There is no evidence to doubt Ho as there seems to be an assossiation between the drug given and the level of consciousness after the operation E0

Commentary

Many candidates stated the hypotheses correctly but often the null and alternative hypotheses were reversed in either part (a) or part (b) or both. Some nonsense statements were common, for example
“Head trauma independent of treatment”
“Survival independent of death”
The candidate shown has incorrect, reversed hypotheses in part (b)
Expected frequencies in part (a) were usually correctly evaluated and a sensible attempt at a test statistic with use of Yates’ correction was generally seen. Very few applied Yates’ correction correctly with the majority finding $(O – E – 0.5)^2$. The solution shown has, in error, used $(O – E – 0.5)^2$ for some elements of the test statistic and has obtained an incorrect answer. The conclusion shown for part (a) is clear, correct and in context.
In part (b) (i) there were a few excellent solutions but many candidates simply carried out a χ^2 test for association using the percentages given and made no effort to evaluate the actual frequencies. This is shown in the solution given where expected values of 44, 41 and 15 are seen.
In part (b) (ii) few candidates referred to observed and expected frequencies to identify a source of association. The conclusion seen in the example solution has incorrectly identified acceptance of the null hypothesis as meaning that there is an association but has not made any attempt to identify any source of that association.

Mark scheme

<table>
<tr><td>3(a)</td><td>H_o No association between survival and drug treatment used.
H_1 Association exists between survival and drug treatment used.</td><td>B1</td><td></td><td></td></tr>
<tr><td></td><td>1 tail 5%</td><td></td><td></td><td></td></tr>
<tr><td></td><td><table><tr><th></th><th>Steroid</th><th>Placebo</th></tr><tr><td>Died</td><td>404.05</td><td>413.95</td></tr><tr><td>Survived</td><td>656.95</td><td>673.05</td></tr></table></td><td>M1
m1</td><td></td><td>E method
All correct</td></tr>
<tr><td></td><td>ts = $\sum\frac{(|O-E|-0.5)^2}{E}$ = $\frac{7.55^2}{404.05}+\frac{7.55^2}{413.95}+\frac{7.55^2}{656.95}+\frac{7.55^2}{673.05}$</td><td>M1
m1</td><td></td><td>ts correct denominators
Yates’ correction</td></tr>
<tr><td></td><td>= 0.456</td><td>A1</td><td></td><td>Range 0.4 – 0.5</td></tr>
<tr><td></td><td>cv df = 1 5% cv = 3.841
ts $<$ 3.841</td><td>B1
M1</td><td></td><td></td></tr>
<tr><td></td><td>Accept H_o</td><td>A1</td><td></td><td></td></tr>
<tr><td></td><td>No sig evidence to suggest an association between survival and whether or nor additional drug treatment is used.</td><td>E1</td><td>10</td><td></td></tr>
<tr><td>(b)(i)</td><td>H_O No association between the drug used and the level of consciousness
H_1 An association exists between the drug used and the level of consciousness
1 tail 1%</td><td>B1</td><td></td><td></td></tr>
<tr><td></td><td><table><tr><th>Drug
Level</th><th>Standard</th><th>New</th></tr><tr><td>Unconscious</td><td>130</td><td>90</td></tr><tr><td>Semi-conscious</td><td>90</td><td>115</td></tr><tr><td>Fully conscious</td><td>30</td><td>45</td></tr></table></td><td>M1
A1</td><td></td><td>For attempt to find raw frequencies
4 or more correct</td></tr>
</table>

<table>
<tr><td></td><td>Expected frequencies<table><tr><th>Drug
Level</th><th>Standard</th><th>New</th></tr><tr><td>Unconscious</td><td>110</td><td>110</td></tr><tr><td>Semi-conscious</td><td>102.5</td><td>102.5</td></tr><tr><td>Fully conscious</td><td>37.5</td><td>37.5</td></tr></table></td><td>M1
m1</td><td></td><td>For one E correct
For all E correct
ft if original % used</td></tr>
<tr><td></td><td>ts = $\sum \frac{(O-E)^2}{E}$
$= \frac{(130-110)^2}{110} + \frac{(90-110)^2}{110} + ..$
= 13.3</td><td>M1ft
A1</td><td>10</td><td>ts sum with correct denominators
For ts in range 13.0 – 13.6</td></tr>
<tr><td></td><td>df = 2 1% cv = 9.21
ts > 9.21
Reject H_o</td><td>B1
M1
A1</td><td></td><td>For cv
For comparison ts/cv</td></tr>
<tr><td>(ii)</td><td>Sig evidence to suggest an association exists between drug used and level of consciousness – patients given the new drug are far less likely to be unconscious 30 minutes after their operation was completed (and vice versa).</td><td>E1
E1</td><td>2</td><td>Sensible correct interpretation in context.
Sources of association identified correctly</td></tr>
</table>

Question 4

The nicotine content, in milligrams, is measured for a random sample of 16 king-size cigarettes each from a different brand. The brands are either categorised as ‘Very Low Tar’, ‘Low Tar’ or no claim is made about tar content.

The results are given in the table.

Very Low Tar	**Low Tar**	**No Claim Made**
0.40	0.69	0.86
0.67	0.96	1.06
0.76	1.03	1.12
0.82	1.04	1.26
1.01	1.08	2.03
1.02		

Carry out a distribution- free test, using the 5% significance level, to investigate whether there is any difference in the average nicotine content for cigarette brands categorized as ‘Very Low Tar’ , ‘Low Tar’ or those for which no claim is made about tar content.

Interpret your conclusion in context. *(13 marks)*

Student Response

B1, 0

4 Ho no difference in average nicotine content 5% S.L.

H₁ is " " " " " two tail

Very Low Tar n=6	Low Tar n=5	No Claim Made n=5
1	3	6
2	7	12
4	10	14
5	11	15
8	13	16
9		

✓✓

$T^V = 29$ $T^L = 44$ $T^N = 63$ ✓✓

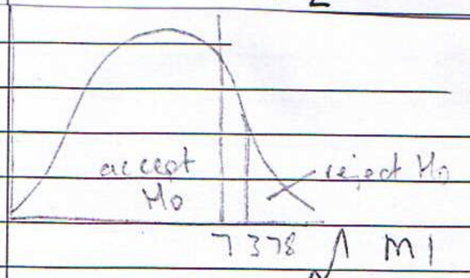
$$H = \frac{12}{N(N+1)} \sum \frac{T^2}{n} - 3(N+1)$$ ✓

$$= \frac{12}{16 \times 17} \times \frac{29^2}{6} + \frac{44^2}{5} + \frac{63^2}{5} - 3 \times 17$$

$= 7.287$ (3sf) ✓

Degrees of freedom = 3−1 CV = 7.378 B0

= 2 →



✓ M1

Conclusion

$7.287 < 7.378$ ∴ Ho is accepted A0

Evidence to suggest there is no difference in average nicotine content.

E1, B0

✓ RR

Commentary

Candidates frequently incorrectly stated the hypotheses and, if referring to population medians, failed to mention that the alternative hypothesis should be that **at least two** of the average nicotine levels from the three cigarette brands differ. The solution shown illustrates this.
The Kruskal Wallis test was carried out successfully by many candidates as seen in the solution considered here but some candidates did not seem to have the confidence to start the test. Most candidates showed their rank values but many made errors in ranking.
Critical values were frequently obtained from *n =16* rather than *n* = 3.
The solution shown has an incorrect cv but one from the correct tables with the correct degrees of freedom so gains a method mark for comparison with the test statistic.
The conclusion was explained well in context and most candidates gained one mark. In this case the candidate has followed through an incorrect conclusion with a correct interpretation.

Mark scheme

<table>
<tr><td>4</td><td>H_0 Samples are taken from identical populations
H_1 Samples are not taken from identical populations – population average nicotine levels differ
5% 1 tail</td><td>B1
B1</td><td></td><td>or
H_0 $\eta_{VLow} = \eta_{Low} = \eta_{Noclaim}$
H_1 at least two of $\eta_{VLow} = \eta_{Low} = \eta_{Noclaim}$ do differ</td></tr>
<tr><td></td><td>Ranks
<table>
<tr><th>Very Low Tar</th><th>Low Tar</th><th>No Claim Made</th></tr>
<tr><td>1</td><td>3</td><td>6</td></tr>
<tr><td>2</td><td>7</td><td>12</td></tr>
<tr><td>4</td><td>10</td><td>14</td></tr>
<tr><td>5</td><td>11</td><td>15</td></tr>
<tr><td>8</td><td>13</td><td>16</td></tr>
<tr><td>9</td><td></td><td></td></tr>
</table></td><td>M1
m1</td><td></td><td>Ranks
At least 10 correct</td></tr>
<tr><td></td><td>$T_{V\,Low} = 29$ $T_{Low} = 44$ $T_{No\ claim} = 63$
$n_{V\,Low} = 6$ $n_{Low} = 5$ $n_{No\ claim} = 5$</td><td>m1
A1</td><td></td><td>Totals -any one correct</td></tr>
<tr><td></td><td>$$\sum_{i=1}^{m}\frac{T_i^2}{n_i} = \frac{29^2}{6}+\frac{44^2}{5}+\frac{63^2}{5} = 1321.17$$</td><td>m1</td><td></td><td>test stat H = $$\frac{12}{N(N+1)}\sum_{i=1}^{m}\frac{T_i^2}{n_i} - 3\,(N+1)$$ 7.0 -7.5</td></tr>
<tr><td></td><td>$$H = \frac{12}{16\times 17}\times 1321.17 - (3\times 17) = 7.29$$</td><td>A1</td><td></td><td></td></tr>
<tr><td></td><td>Critical value from χ_2^2 = 5.991 5%
H > 5.991</td><td>B1
M1</td><td></td><td></td></tr>
<tr><td></td><td>Sig evidence to reject H_0 and conclude that samples are not from identical populations.</td><td>A1</td><td></td><td>Difference in context</td></tr>
<tr><td></td><td>Significant evidence at the 5% level to suggest that the population average nicotine level differs for the three categories of king-size cigarettes.</td><td>E1</td><td></td><td>Mention of ‘at least two’ or a sig difference between nicotine levels of king-sizecigarettes for which no</td></tr>
</table>

	It appears that those king-size cigarettes that have no claim made about tar levels have a significantly higher average nicotine level than those claimed to have ‘Very Low Tar’.	E1	**13**	claim made and those claimed to have ‘Very Low Tar’.

Question 5a

The LDL cholesterol level was measured for each of 16 males living in the USA in 2006. Of these, 8 had been randomly selected from males aged under 30 years and 8 had been randomly selected from males aged over 50 years.

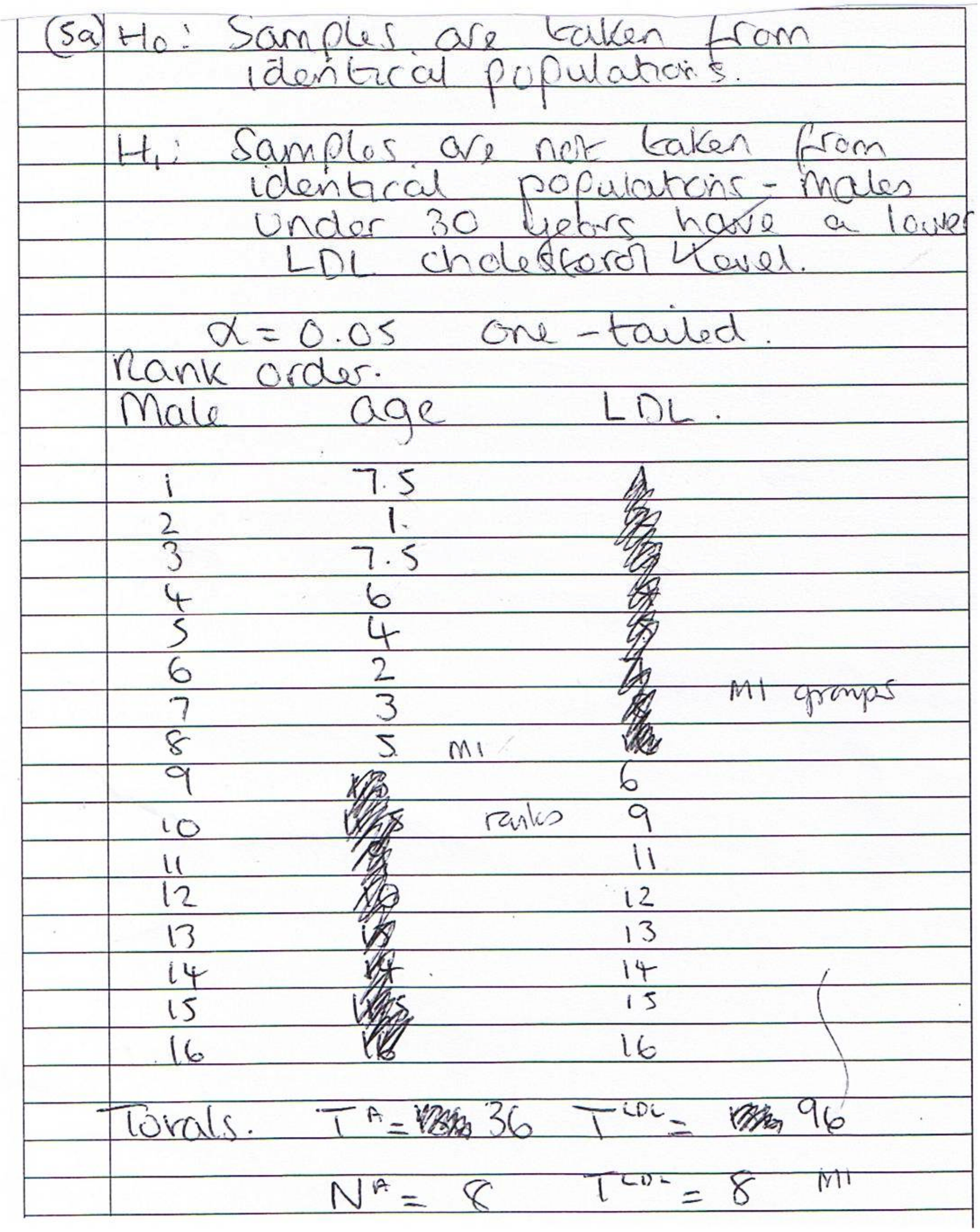
The age and the LDL cholesterol level, in mg/dl, for each male are given in the table.

Male	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**
Age	29	18	29	28	23	19	21	27	56	54	51	52	71	65	54	76
LDL	121	137	140	159	177	189	191	201	181	196	225	228	234	249	259	339

(a) Carry out a Mann-Whitney *U* test, at the 5% level of significance, to investigate whether, in the USA, males aged under 30 years have, on average, a lower LDL cholesterol level than those aged over 50 years.

(10 marks)

Student Response



(5a) H_0: Samples are taken from identical populations.

H_1: Samples are not taken from identical populations - males under 30 years have a lower LDL cholesterol level.

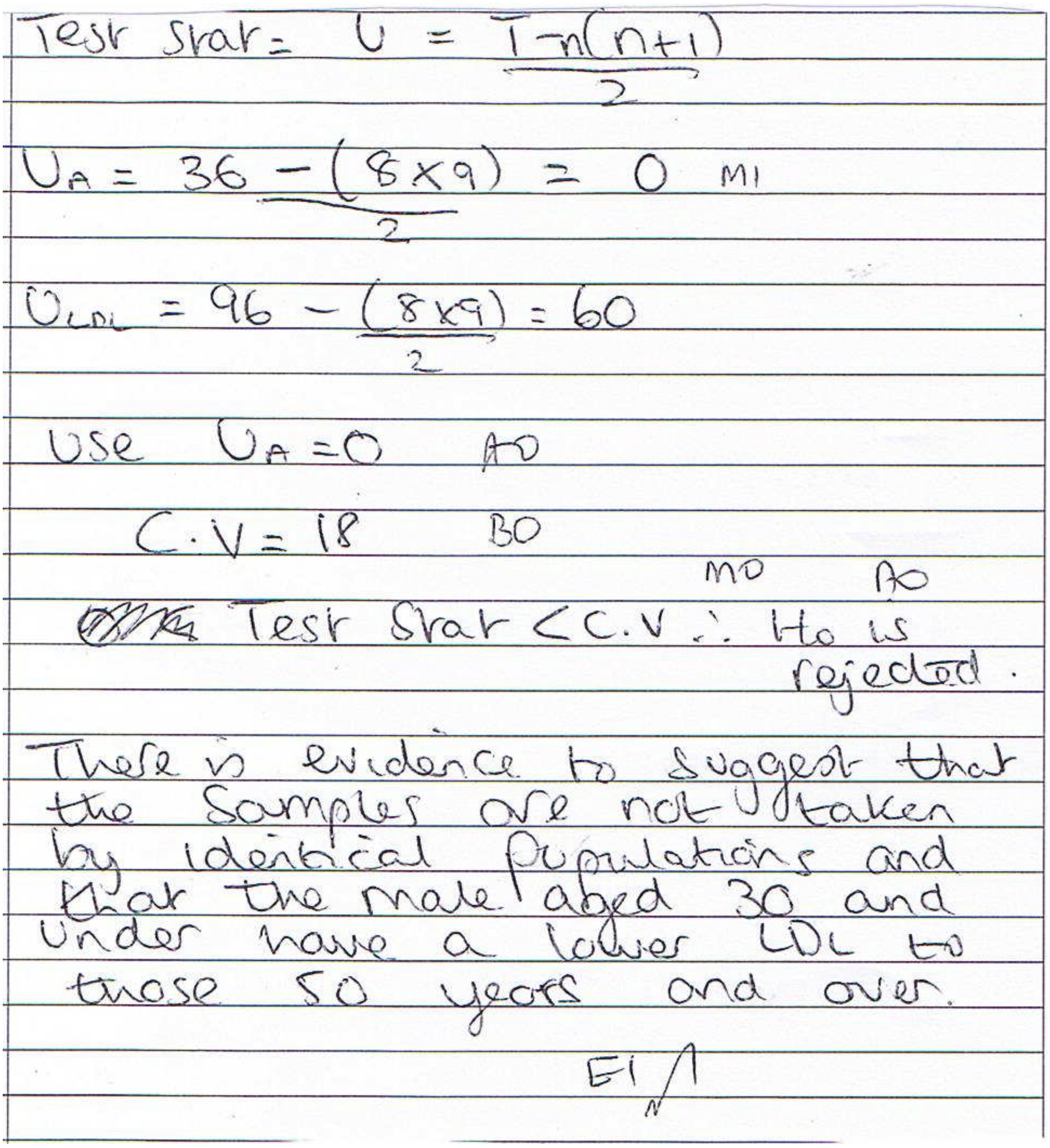
$\alpha = 0.05$ one-tailed.

Rank order.

Male	age	LDL	
1	7.5		
2	1.		
3	7.5		
4	6		
5	4		
6	2		
7	3		M1 groups
8	5		M1
9		6	
10		9	ranks
11		11	
12		12	
13		13	
14		14	
15		15	
16		16	

Totals. $T^A = 36$ $T^{LDL} = 96$

$N^A = 8$ $T^{LDL} = 8$ M1



Test Stat = $U = T - \frac{n(n+1)}{2}$

$U_A = 36 - \frac{(8\times9)}{2} = 0$ M1

$U_{LDL} = 96 - \frac{(8\times9)}{2} = 60$

Use $U_A = 0$ A0

C.V = 18 B0

M0 A0

Test Stat < C.V ∴ Ho is rejected.

There is evidence to suggest that the Samples are not taken by identical populations and that the male aged 30 and under have a lower LDL to those 50 years and over.

E1

Commentary

In part (a), few students had the confidence to separate the two age groups and carry out the required The Mann-Whitney test on the LDL levels.
Some candidates made an attempt to sort the data into two groups and some made an effort to rank the data as one group but frequently the ages were ranked as well or were ranked as one group with the LDL levels. This is seen in the solution here.
Hypotheses were well worded in most cases as in the given solution but very few totally correct answers were seen.

Mark scheme

<table>
<tr><td>5(a)</td><td>H_o Samples are taken from identical populations
H_1 Samples are not taken from identical populations (males aged under 30 years have lower average LDL)</td><td>B1</td><td></td><td>Hypotheses referrring to population averages also acceptable</td></tr>
<tr><td></td><td>1 tail 5%</td><td></td><td></td><td></td></tr>
<tr><td></td><td><table><tr><th>Under 30 ranks</th><th>Over 50 ranks</th></tr><tr><td>1</td><td>6</td></tr><tr><td>2</td><td>9</td></tr><tr><td>3</td><td>11</td></tr><tr><td>4</td><td>12</td></tr><tr><td>5</td><td>13</td></tr><tr><td>7</td><td>14</td></tr><tr><td>8</td><td>15</td></tr><tr><td>10</td><td>16</td></tr></table></td><td>M1
M1</td><td></td><td>Successful separation of age groups
Attempt at M-Whitney - ranks as one group</td></tr>
<tr><td></td><td>$T_G = 1 + 2 + \ldots + 10 = 40$
$T_R = 6 + 9 + \ldots + 16 = 96$</td><td>M1</td><td></td><td>for total attempt</td></tr>
<tr><td></td><td>$U_G = 40 - \frac{8\times9}{2} = 4$
$U_R = 96 - \frac{8\times9}{2} = 60$</td><td>M1</td><td></td><td>for U formula correct</td></tr>
<tr><td></td><td>Test stat U = 4</td><td>A1</td><td></td><td></td></tr>
<tr><td></td><td>cv = 16 $n = 8$ $m = 8$ 1 tail 5%</td><td>B1</td><td></td><td>correct/relevant cv used</td></tr>
<tr><td></td><td>$U = 4 < 16$</td><td>M1</td><td>10</td><td></td></tr>
<tr><td></td><td>Reject H_o</td><td>A1</td><td></td><td></td></tr>
<tr><td></td><td>Significant evidence at the 5% level to suggest that the average LDL level is lower for males aged under 30 years.</td><td>E1</td><td></td><td>In context</td></tr>
</table>

SS03

Question 5b

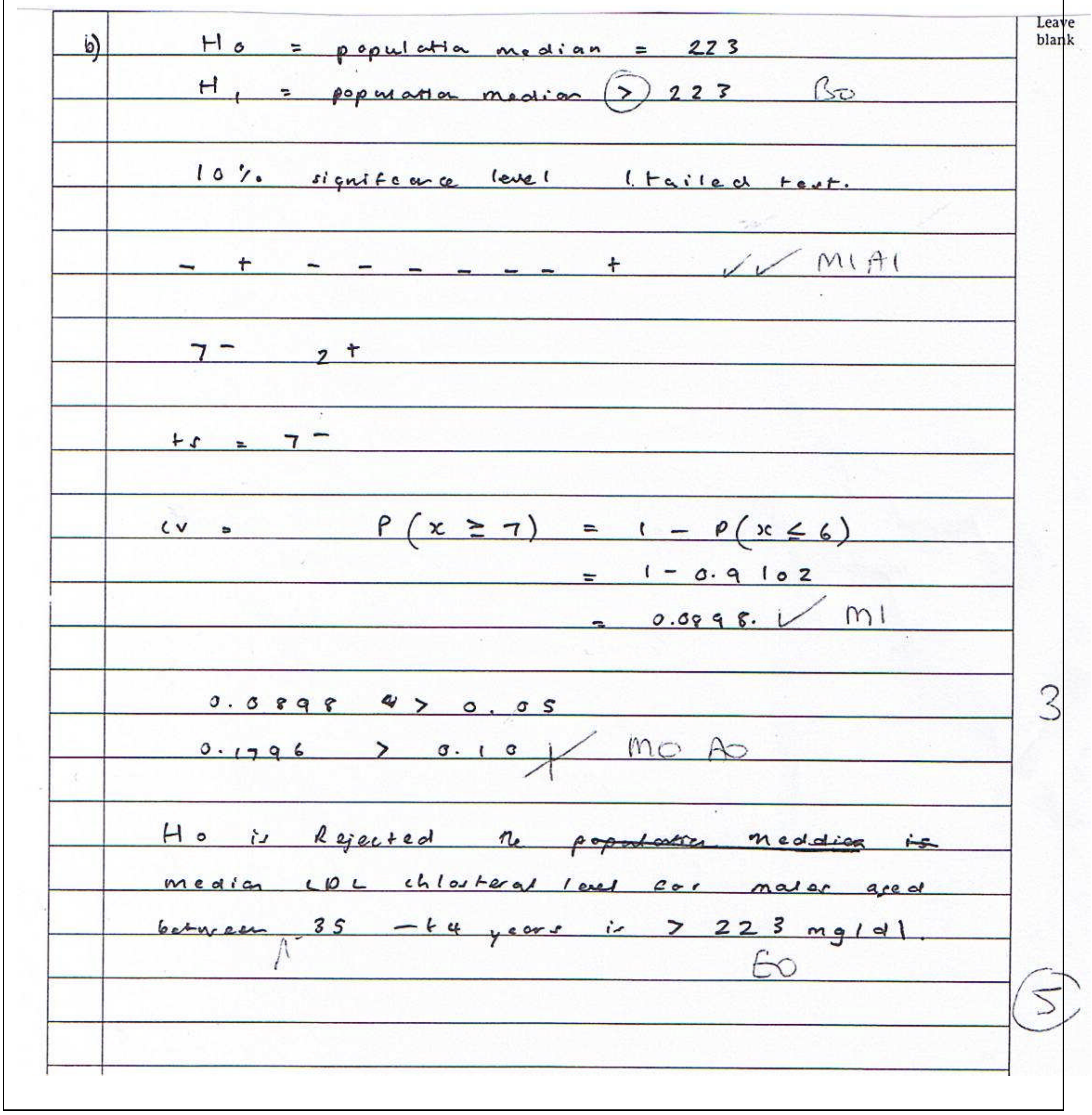
The median LDL cholesterol level, for males aged between 35 years and 64 years living in the USA, is known to be 223 mg/dl.
A random sample of 9 males, aged between 35 years and 64 years, living in China, each had their LDL level, in mg/dl, measured with the following results:

158 225 164 178 182 184 191 195 231

Carry out a sign test, at the 10% level of significance, to investigate the claim that the median LDL cholesterol level for males aged between 35 years and 64 years is greater for those living in the USA than for those living in China.
Interpret your conclusion in context.

(7 marks)

Student Response



b) H_0 = population median = 223

H_1 = population median ⓶ 223 B0

10% significance level 1 tailed test.

− + − − − − − − + ✓✓ M1A1

7 − 2 +

ts = 7 −

cv = $P(x \geq 7) = 1 - P(x \leq 6)$

$= 1 - 0.9102$

$= 0.0898.$ ✓ M1

$0.0898 > 0.05$

$0.1796 > 0.10$ ✗ M0 A0

H_0 is Rejected the ~~population~~ meddian ~~is~~
median LDL chlosteral level for males aged
between 35 − 64 years is > 223 mg/dl.
B0

Leave blank

3

⑤

Commentary

Some excellent solutions were seen in part (b) and the majority of candidates quoted the binomial probability of 0.0898 and showed a comparison with 0.10. The solution shown gives the correct value of 0.898 from the binomial tables but compares to a 2 tail significance level of 5%.
Candidates lost marks if probabilities from the binomial tables were not stated or a critical region was identified without the relevant probability being quoted.
The hypotheses were frequently stated incorrectly with $H_1\ \eta_{>}$ 223 commonly seen as in the solution given here.
Conclusions were often incorrectly stated or poorly worded

Mark scheme

5(b)	$H_0\ \eta\ = 223$ $H_1\ \eta\ < 223$ 1 tail 10%	B1		
	Signs - + - - - - - - - +	M1		signs
	2^+ / 7^- signs – test values	A1		test stat correct and identified
	Binomial (9, 0.5) model	M1		Binomial model used and probability attempted
	P ($\geq$ 7 -) = P($\leq$2 +) = 0.0898 < 0.10 for one tail test	M1		Comparison of Binomial probability with 0.10
	Reject H_o .	A1		
	There is sufficient evidence, at the 10% level, to suggest that the median LDL level is greater for males aged 35 to 64 years living in the USA than that for those living in China.	E1	**7**	Interpretation in context