

**Chi Squared Tests (Contingency Tables) (From OCR 4734)**

**Q1, (Jan 2008, Q6)**

(i)	$37 \times 58 / 120$ $17.883..$ , $17.88$ AG	M1 A1 <b>2</b>	Or equivalent												
(ii)	$H_0$ : Gender and shade are independent $(H_1$ :--are not independent $3.02^2(14.02^{-1} + 14.98^{-1}) +$ $6.12^2(17.88^{-1} + 19.12^{-1})$ $+ 3.1^2(26.1^{-1} + 27.9^{-1})$ $= 6.03$ EITHER: CV 5.991 $6.03 > 5.991$ , reject $H_0$ and accept that gender and shade are not independent OR: $P(\chi^2 > 6.03) = 0.049$ $< 0.05$ , reject $H_0$ and accept that gender and shade are not independent	B1  M1 A1  A1 B1 M1 A1√ <b>7</b> B1 M1 A1√	At least two correct All correct      Ft $\chi^2$ . Can be assertive.   Ft $\chi^2$												
(iii)	<table style="margin-left: 20px;"> <tr> <td></td> <td><math>G_1</math></td> <td><math>G_2</math></td> <td><math>G_3</math></td> </tr> <tr> <td>O</td> <td>29</td> <td>37</td> <td>54</td> </tr> <tr> <td>E</td> <td>40</td> <td>40</td> <td>40</td> </tr> </table> $121/40 + 9/40 + 196/40$ $= 8.15$ Using $df = 2$ 2.5% tables, 1.7% calculator		$G_1$	$G_2$	$G_3$	O	29	37	54	E	40	40	40	M1 A1 M1 A1 M1 A1 <b>6 (15)</b>	For combining
	$G_1$	$G_2$	$G_3$												
O	29	37	54												
E	40	40	40												

**Q2, (Jan 2010, Q7)**

(i)	$H_0$ : Vegetable preference is independent of gender $H_1$ : All alternatives  <table style="margin-left: 20px;"> <tr> <td>E-Values</td> <td>26</td> <td>16.25</td> <td>22.75</td> </tr> <tr> <td></td> <td>22</td> <td>13.75</td> <td>19.25</td> </tr> </table> $\chi^2 = 5^2(26^{-1} + 22^{-1}) + 7.25^2(16.25^{-1} + 13.75^{-1})$ $+ 2.25^2(22.75^{-1} + 19.25^{-1})$ $= 9.641$  $9.64 > 5.991$ Reject $H_0$ , (there is sufficient evidence at the 5% that) vegetable preference and gender are not independent	E-Values	26	16.25	22.75		22	13.75	19.25	B1  M1 A1 M1 A1 A1 A1  M1 A1  <b>8</b>	For both hypotheses  At least one correct All correct Correct form of any one All correct ART 9.64  OR: $P(\geq 9.641) = 0.00806 < 0.05$
E-Values	26	16.25	22.75								
	22	13.75	19.25								
(ii)	- $(H_0$ : Vegetables have equal preference $H_1$ : All alternatives) Combining rows: 48    30    42 E-Values:            40    40    40  $\chi^2 = (8^2 + 10^2 + 2^2) / 40$ $= 4.2$  $4.2 < 4.605$ Do not reject $H_0$ , there is insufficient evidence at the 10% significance level of a difference in the proportion of preferred vegetables	M1 A1  M1 A1  M1 A1  <b>6</b> <b>[14]</b>	OR: $P(\geq 4.2) = 0.122 > 0.10$  AEF in context								

**Q3, (Jun 2010, Q3)**

<p><b>(i)</b> <math>H_0</math>: There is no association between the area in which a shopper lives and the day they shop  <math>(H_1</math>: All alternatives)                  E-Values 27.3 14.7                  37.7 20.3  <math>\chi^2 = (4.3-0.5)^2(27.3^{-1}+37.7^{-1}+14.7^{-1}+20.3^{-1})</math>  <math>= 2.606</math>                  Compare with 2.706 Do not reject <math>H_0</math>.                  There is insufficient evidence of an association.                   SR: If <math>H_0</math> association, lose 1<sup>st</sup> B1 and last M1A1</p>	<p>B1  M1 A1  M1 ft A1 A1  M1 A1 <b>8</b></p>	<p>SR difference in proportions                  B1 define and evaluate <math>p_1</math> and <math>p_2</math> with <math>H_0</math>                  B1 for <math>p=0.42</math>                  M1A1 for <math>z = \pm 1.827</math> or <math>1.835</math> (no pe)                  M1A0 Max 5/8                   At least one E value correct (M1)                  All correct(A1)                  At least one <math>\chi^2</math>, no or wrong cc, (M1FtE)                  All correct (A1); 2.606 or 2.61 (A1)                  Or use calculator (<math>p = 0.106</math>) SR: B1 if no explicit comparison, as Q2                  SR: If <math>H_0</math> association, lose 1<sup>st</sup> B1 and last M1A1</p>
<p><b>(ii)</b> Conclusion the same since critical value &gt; 2.706                  (and test statistic unchanged)</p>	<p>B1 <b>1</b></p>	<p>OR from <math>z=\pm 2.17</math>, SR</p>
<b>[ 9 ]</b>		

**Q4, (Jan 2011, Q7)**

<p><b>(i)</b> In a <math>2 \times 2</math> contingency table</p>	<p>B1 <b>1</b></p>	<p>Or equivalent Accept <math>df=1</math></p>
<p><b>(ii)</b> <math>H_0</math>: Vaccine type and outcome are independent  <math>H_1</math>: They are not independent                  E-values: 10.81 12.19                  318.19 358.81  <math>\chi^2 = 7.69^2(10.81^{-1}+12.19^{-1}+318.19^{-1}+358.81^{-1})</math>  <math>= 10.67</math>                  CV = 6.635  <b>10.67 &gt; CV</b>                  Reject <math>H_0</math>, there is sufficient evidence at the 1% significance level that the outcome of the test depends on the vaccine used                   The results is significant at a level less than <math>\frac{1}{2}</math> %, so the evidence is very strong</p>	<p>B1M*dep  M1 A1 M1 M1 A1 B1 M1  A1√ dep*M  A1 √ <b>10</b> <b>[11]</b></p>	<p>Accept omission of <math>H_1</math>  1 correct E value                  Accept 1 dp                  1 correct <math>\chi^2</math> value ft E values                  Using Yates' correctly                  Accept 10.7   <math>\sqrt{10.67}</math>                   Sensible comment. <math>\sqrt{10.67}</math></p>

**Q5, (Jun 2012, Q2)**

Assumes population of time differences is normal

$$H_0: \mu_F = \mu_S, H_1: \mu_F \neq \mu_S$$

Differences 6 -3 7 3

Sample mean = 3.25

$$\text{Sample variance} = 4.5^2 = 20.25$$

$$TS = 3.25 / (\sqrt{4.5} / \sqrt{2})$$

$$= 1.44(4)$$

Not  $\geq 2.353$  do not reject  $H_0$

There is insufficient evidence of a difference in the mean times of the two populations

B1

Need population.

If 2 sample test used.  
Popns N, equal var B1

B1

Allow  $\mu_d=0$  etc.

Hypotheses B1

M1

Means 44.25, 41 B1

A1

One tail

(vars 21.583, 14)

A1

B1 B0 M1 A1 A1 M1 A1 M1 (CV=1.638) A0

(Var=(3x21.583+3x14)/6

M0 =17.792 A0)

TS=(44.25 -

41) /  $\sqrt{17.792 \cdot (1/4 + 1/4)}$  M1

M1

A1

1.09 A0

M1

Comparison with correct t and correct first conclusion ft.

1.09 < 1.943 do not reject NH. M1

A1 ft

Ft TS Not over-assertive.

Conclusion A1 ✓

Max 6/9

**[9]**

**Q6, (Jun 2013, Q6)**

<b>(i)</b>	<p>17.5 4.2 6.3 32.5 7.8 11.7 oe</p>	<p>M1 A1 A1 <b>[3]</b></p>	<p>eg <math>50 \times 28 \div 80</math> At least 2 correct. All correct.</p>
<b>(ii)</b>	<p>The E value of <math>4.2 &lt; 5</math> Combine Biology and Chemistry (both sciences).</p>	<p>B1 B1 <b>[2]</b></p>	<p>Need not mention 4.2 May need to look at (iii) to see which subjects combined.</p>
<b>(iii)</b>	<p>Ho: Subject and sex are independent H<sub>1</sub>: They are not independent 21.7 6.3 40.3 11.7 <math>\chi^2 = (4.7 - 0.5)^2(21.7^{-1} + 6.3^{-1} + 40.3^{-1} + 11.7^{-1})</math> = 5.558... (v = 1) (α) 2½ % CV = 5.024 5.558 &gt; CV or in CR and reject H<sub>0</sub> (β) <math>P(\chi^2_1 \geq 5.558) = 0.0184</math> &lt; 0.025 and reject H<sub>0</sub>  There is significant evidence that subject and sex are not independent</p>	<p>B1 B1 M1M1 A1 B1 M1 B1 M1 A1 <b>[8]</b></p>	<p>oe. NOT 'variables', 'they' etc or 17.5 10.5 32.5 19.5 if C/A combined. No Yates (inc v &gt; 1) or incorrect Yates (eg no modulus) M1M0. allow 6.96 or 6.79 Chem./Art combined B1B1M1M1A0B1M1A0. (TS = 3.75) fit TS &amp; CV. Correct first conclusion. If C/A prob. accept H<sub>0</sub>.  cwo. NOT over-assertive. Thus no or incorrect Yates can score max 6/8 B1B1M1M0A1B1M1A0.</p>

**Q7, (Jun 2016, Q2)**

<p><math>H_0</math>:there is no assoc. between party and opinion, <math>H_1</math>:there is assoc. between p/o.                  Expected frequencies                  45, 18, 27, 20, 8, 12, 35, 14, 21  <math>\frac{(58-45)^2}{45} + \dots + \frac{(33-21)^2}{21}</math>                  30.48                  TS &gt; 13.28, reject <math>H_0</math>                  There is evidence that there is an association between party and opinion.</p>	<p>B1                  M1                  A1                  M1                  A1                  M1                  A1                  [7]</p>	<p>For both.Allow indpt. etc.                    At least one correct term; at least 7 terms.                  Allow awrt 30.5                  CWO</p>	<p>If classes combined, all 6.</p>
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**Q8, (Jun 2017, Q3)**

<p><math>H_0</math>: there is no assoc between hair/eyes colours. <math>H_1</math>: there is assoc .....</p>	<p>B1</p>		
<p>Es 30.16, 27.84, 21.84, 20.16</p>	<p>B1</p>		
<p><math>( 36 - 30.16  - 0.5)^2/30.16 + \dots</math></p>	<p>M1</p>	<p>allow this mark if no Yates' correction.(5.61)</p>	<p>0.945+1.306+1.024+1.414</p>
<p>4.69</p>	<p>A1</p>		
<p>CV = 3.841</p>	<p>B1</p>		
<p>4.69 &gt; 3.841, reject <math>H_0</math>.</p>	<p>M1</p>	<p>ft TS and CV</p>	
<p>There is evidence of an assoc. between hair/eye colours.</p>	<p>A1                  [7]</p>	<p>cwo. Contextualised.</p>	