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

Q1, (Jan 2008, Q6)

(i)	$37\times58/120$ 17.883.. , 17.88 AG	M1 A1 **2**	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√ **7** B1 M1 A1√	At least two correct All correct Ft X^2 . Can be assertive. Ft X^2
(iii)	G_1 G_2 G_3 O 29 37 54 E 40 40 40 121/40 + 9/40+196/40 = 8.15 Using df = 2 2.5% tables, 1.7% calculator	M1 A1 M1 A1 M1 A1 **6 (15)**	For combining

Q2, (Jan 2010, Q7)

(i)	H_0:Vegetable preference is independent of gender H_1: All alternatives	B1	For both hypotheses
	E-Values 26 16.25 22.75 22 13.75 19.25 $\chi^2 = 5^2(26^{-1}+22^{-1}) + 7.25^2(16.25^{-1}+13.75^{-1}) + 2.25^2(22.75^{-1}+19.25^{-1})$ =9.641	M1 A1 M1 A1 A1	At least one correct All correct Correct form of any one All correct ART 9.64
	9.64 > 5.991 Reject H_0 , (there is sufficient evidence at the 5% that) vegetable preference and gender are not independent	M1 A1 **8**	OR: P(≥ 9.641)=0.00806 <0.05
(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 **6** **[14]**	OR:P(≥ 4.2) = 0.122 > 0.10 AEF in context

Q3, (Jun 2010, Q3)

(i)	H_0: There is no association between the area in which a shopper lives and the day they shop (H_1: All alternatives) E-Values 27.3 14. 7 37.7 20.3 $\chi^2 = (4.3\text{-}0.5)^2(27.3^{-1}+37.7^{-1}+14.7^{-1}+20.3^{-1})$ $= 2.606$ Compare with 2.706 Do not reject H_0. There is insufficient evidence of an association. SR: If H_0 association, lose 1st B1 and last M1A1	B1 M1 A1 M1 ft A1 A1 M1 A1 **8**	SR difference in proportions B1 define and evaluate p_1 and p_2 with H_0 B1 for p=0.42 M1A1 for z = ±1.827 or 1.835(no pe) M1A0 Max 5/8 At least one E value correct (M1) All correct(A1) At least one χ^2, no or wrong cc, (M1FtE) All correct (A1); 2.606 or 2.61 (A1) Or use calculator (p = 0.106) SR: B1 if no explicit comparison, as Q2 SR: If H_0 association, lose 1st B1 and last M1A1
(ii)	Conclusion the same since critical value > 2.706 (and test statistic unchanged)	B1 **1** **[9]**	OR from z=±2.17, SR

Q4, (Jan 2011, Q7)

(i)	In a 2×2 contingency table	B1 **1**	Or equivalent Accept df=1
(ii)	H_0: Vaccine type and outcome are independent H_1: They are not independent E-values: 10.81 12.19 318.19 358.81 $\chi^2 = 7.69^2(10.81^{-1}+12.19^{-1}+318.19^{-1}+358.81^{-1})$ $=10.67$ CV = 6.635 **10.67** > CV Reject H_0, 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 ½ %, so the evidence is very strong	B1M*dep M1 A1 M1 M1 A1 B1 M1 A1√ dep*M A1 √ **10** **[11]**	Accept omission of H_1 1 correct E value Accept 1 dp 1 correct χ^2 value ft E values Using Yates' correctly Accept 10.7 √ 10.67 Sensible comment.√ 10.67

Q5, (Jun 2012, Q2)

(i)

H_0: no association between sex and artist preferred
H_1: some association between sex and artist preferred

EXPECTED	Monet	Renoir	Degas	Cézanne
Male	12.13	28	13.07	16.8
Female	13.87	32	14.93	19.2

CONTRIB'N	Monet	Renoir	Degas	Cézanne
Male	1.4081	0.3214	1.8626	0.2881
Female	1.2321	0.2813	1.6298	0.2521

$X^2 = 7.28$
Refer to χ_3^2

Critical value at 10% level = 6.251

Result is significant

There is evidence to **suggest** that there is some association between sex and artist preferred

NB if H_0 H_1 reversed, or 'correlation' mentioned, do not award first B1 or final E1

[12]

B1	For both hypotheses in context
M1 A2	For expected values (to 2 dp where appropriate) (allow A1 for at least one row or column correct)
M1 A2	For valid attempt at $(O–E)^2/E$ For all correct (to 2 dp) and presented in a table or clear list. (Allow A1 for at least one row or column correct)
B1 B1	Allow 7.27 for 3 deg of f
B1	CAO for cv No FT from here if wrong or omitted, unless *p*-value used instead
B1	FT their X^2
E1	For correct (FT their X^2), non-assertive conclusion, in context.

NB:These three marks cannot be implied by a correct final value of X^2

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B1 for *p*-value = 0.0636

(ii)		Monet: **More females and fewer males than expected** prefer Monet, as indicated by l**arge contribution(s)** (of 1.4081 and 1.2321).	E1* E1dep*	FT their table of contributions	NB MAX 3/6 for answers not referring to contributions (explicitly or implicitly).
		Renoir: Preferences are much **as expected**, as indicated by **small contributions.**	E1		
		Degas: **Fewer females and more males than expected** prefer Degas, as indicated by **large contribution(s)** (of 1.8626 and 1.6298).	E1* depE1*		
		Cézanne: Preferences are much **as expected**, as indicated by **small contributions**.	E1		SC1 Renoir and Cézanne have correct comments for both but without referring to contributions
			[6]		

Q6, (Jun 2013, Q6)

(i)		17.5 4.2 6.3 32.5 7.8 11.7 oe	M1 A1 A1 **[3]**	eg $50 \times 28 \div 80$ At least 2 correct. All correct.
(ii)		The E value of $4.2 < 5$ Combine Biology and Chemistry (both sciences).	B1 B1 **[2]**	Need not mention 4.2 May need to look at (iii) to see which subjects combined.
(iii)		Ho: Subject and sex are independent H_1: They are not independent 21.7 6.3 40.3 11.7 $\chi^2 = (4.7 - 0.5)^2(21.7^{-1} + 6.3^{-1} + 40.3^{-1} + 11.7^{-1})$ $= 5.558\ldots$ ($\nu = 1$) (α) 2½ % CV = 5.024 5.558 > CV or in CR and reject H_0	B1 B1 M1M1 A1 B1 M1	oe. NOT 'variables', 'they' etc or 17.5 10.5 32.5 19.5 if C/A combined. No Yates(inc $\upsilon > 1$) or incorrect Yates (eg no modulus) M1M0. allow 6.96 or 6.79 Chem./Art combined B1B1M1M1A0B1M1A0. (TS = 3.75) ft TS & CV. Correct first conclusion. If C/A prob. accept H_0.
		(β) $P(\chi^2_1 \geq 5.558) = 0.0184$ < 0.025 and reject H_0	B1 M1	
		There is significant evidence that subject and sex are not independent	A1 **[8]**	cwo. NOT over-assertive. Thus no or incorrect Yates can score max 6/8 B1B1M1M0A1B1M1A0.

Q7, (Jun 2016, Q2)

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

Q8, (Jun 2017, Q3)

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