

Question	Scheme	Marks	AOs
1(a)	Degrees of freedom $(2 - 1)(2 - 1) \rightarrow \chi^2_{(1,0.05)} = 3.841$	M1	3.1b
	$[0.245 < 3.841, \text{therefore do not reject } H_0]$ There is not enough evidence to suggest an association between age and time spent on social media.	A1	2.2b
		(2)	
(b)	Some of the expected frequencies may fall below 5	B1	3.5b
		(1)	
(c)	$\sum \frac{(O - E)^2}{E} = 0.47 + 0.40 + \dots + \frac{(7 - \frac{92 \times 26}{200})^2}{\frac{92 \times 26}{200}} + \frac{(19 - \frac{108 \times 26}{200})^2}{\frac{108 \times 26}{200}}$	M1	2.1
	awrt <u>9.57</u>	A1	1.1b
	$\nu = (5 - 1)(2 - 1) \rightarrow \chi^2_{(4,0.05)} = 9.488$	B1	3.1b
	$[9.57 > 9.488, \text{therefore reject } H_0]$ There is an association between age and time spent on social media.	A1	2.2b
		(4)	
(d)	Part (c) uses more information, so should be more reliable.	B1	3.2b
		(1)	
(8 marks)			
Notes			
(a)	M1 Finding the critical value for the test A1 Correct conclusion in context		
(b)	B1 Understanding that to carry out the test, expected frequencies should be > 5		
(c)	M1 Calculating the test statistic A1 awrt 9.57 B1 Obtaining correct degrees of freedom and critical value for the test A1 Correct contextual conclusion		
(d)	B1 Correct choice of conclusion and supporting reason		

Question	Scheme	Marks	AOs
2(a)	$[E(Y) =] 2^2 \times \frac{1}{50} + 3^2 \times a + 6^2 \times \frac{1}{25} + 11^2 \times b = 50.3$	M1	3.1a
	$\frac{1}{50} + a + \frac{1}{25} + b = 1$		
	$\begin{cases} 9a + 121b = 48.78 \\ a + b = 0.94 \end{cases} \rightarrow 112b = 40.32$	M1	1.1b
	$\underline{a = 0.58} \text{ and } \underline{b = 0.36}$	A1	1.1b
		(3)	
(b)	$P(9 - Y > 0) [= P(9 - X^2 > 0) = P(X < 3)]$	M1	1.1b
	$= P(X = 2)$	$\frac{1}{50}$	A1
		(2)	
(c)(i)	$[E(T) = 120 \times (\frac{1}{50} + \frac{1}{25}) =]$	7.2	B1
		(1)	
(ii)	$[Var(T) = 120 \times (\frac{1}{50} + \frac{1}{25}) \times (1 - (\frac{1}{50} + \frac{1}{25})) =]$	awrt 6.77	B1
		(1)	
(d)	$T \sim B(120, \frac{3}{50}) \rightarrow Po(7.2)$	M1	3.3
	$P(T > 10) = 1 - P(T \leq 10) [= 1 - 0.88667...]$	M1	1.1b
		awrt 0.113	A1
		(3)	
(10 marks)			
Notes			
(a)	1 st M1 Realising that both equations are required 2 nd M1 Solving simultaneously to eliminate one variable A1 Both $a = 0.58$ and $b = 0.36$		
(b)	M1 For identifying $P([-3 <]X < 3)$ or $P(Y < 9)$		
(d)	1 st M1 Selecting Poisson approximation to binomial 2 nd M1 Using Poisson model A1 awrt 0.113 NB: Using exact binomial $P(T > 10) = 0.10661...$		

Question	Scheme	Marks	AOs
3(a)	$r = 80 \times P(X = 2)$ $s = 80 - (6.56 + 17.11 + \dots)$ or $s = 80 \times (1 - P(X \leq 4))$	M1	3.4
	$r = \text{awrt } \underline{21.57}$ and $s = \text{awrt } \underline{6.99}$	A1	1.1b
		(2)	
(b)	H_0 : B(30, 0.08) is a suitable model H_1 : B(30, 0.08) is not a suitable model	B1	2.5
	$\chi^2 = \sum \frac{(O - E)^2}{E} = \frac{(14 - 6.56)^2}{6.56} + \dots + \frac{(5 - 6.99)^2}{6.99}$	M1	2.1
	$= \text{awrt } \underline{11.5}$	A1	1.1b
	Degrees of freedom = 6 - 1 = 5	B1	1.1b
	$11.5 > \chi^2_{5,(0.05)} = 11.070$ so reject H_0	M1	1.1b
	B(30, 0.08) is not a suitable model for the number of empty hotel rooms.	A1	3.5a
		(6)	
(c)	Using the data to estimate p $\frac{0 \times 14 + 1 \times 18 + 2 \times 22 + 3 \times 11 + 4 \times 10 + 5 \times 5}{80} = 2$	M1	3.3
	B(30, $\frac{2}{30}$)	A1	1.1b
		(2)	
(10 marks)			
Notes			
(a)	M1 Either correct calculation A1 both $r = \text{awrt } \underline{21.57}$ and $s = \text{awrt } \underline{6.99}$		
(b)	B1 Both hypotheses 1 st M1 Attempting to find the test statistic using $\chi^2 = \sum \frac{(O - E)^2}{E}$ 1 st A1 awrt 11.5 B1 for df = 5 2 nd M1 comparing test statistic with critical value 2 nd A1 correct conclusion in context		
(c)	M1 Suggesting using the data to improve the model A1 Correct model (also allow Po(2))		

Question	Scheme	Marks	AOs
4(a)	$[X \sim \text{Po}(2.4) \quad Y \sim \text{Po}(1.6)]$ $P(X = 2) = \frac{e^{-2.4} \times 2.4^2}{2} = 0.261\dots$ $P(Y = 2) = \frac{e^{-1.6} \times 1.6^2}{2} = 0.258\dots$	M1	1.1b
	Therefore the photocopier is more likely to break down exactly twice.	A1	1.1b
		(2)	
(b)	$P(X \leq 1) \times P(Y \leq 1)$	M1	1.1b
	$[= 0.3084\dots \times 0.5249\dots]$ awrt 0.162	A1	1.1b
		(2)	
(c)	$\frac{P(X = 4) \times P(Y = 0) + P(X = 3) \times P(Y = 1)}{P(X + Y = 4)}$	M1	3.1b
	$= \frac{\frac{e^{-2.4} 2.4^4}{4!} \times e^{-1.6} + \frac{e^{-2.4} 2.4^3}{3!} \times \frac{e^{-1.6} 1.6}{1}}{\frac{e^{-4} 4^4}{4!}}$	M1 M1	1.1b 1.1b
	$= \frac{297}{625}$ awrt 0.475	A1	1.1b
		(4)	
(d)	$H_0: \quad \lambda = 4 \quad \mu = 8$ $H_1: \quad \lambda < 4 \quad \mu < 8$	B1	2.5
	$T \sim \text{Po}(8) \quad P(T \leq 3) [= \text{awrt } 0.0424]$	M1	3.3
	$[0.0424 < 0.05]$ Reject H_0	M1	1.1b
	There is evidence that the rate of breakdowns has decreased following the repairs.	A1	1.1b
		(4)	
(12 marks)			
Notes			
(a)	M1 Using each Poisson model to attempt each probability A1 Both correct awrt 3sf and correct conclusion		
(b)	M1 Multiplication of two correct cumulative probabilities A1 awrt 0.162		
(c)	1 st M1 Correct ratio expression 2 nd M1 Use of $P(X = 4) \times P(Y = 0) + P(X = 3) \times P(Y = 1)$ $[0.125\dots \times 0.201\dots + 0.209\dots \times 0.323\dots]$ 3 rd M1 Ratio of probabilities with denominator $\frac{e^{-4} 4^4}{4!}$ [0.195...] A1 awrt 0.475		
(d)	B1 Both hypotheses with λ or μ 1 st M1 Using $\text{Po}(8)$ to calculate $P(T \leq 3)$ 2 nd M1 Correct non-contextual conclusion A1 Conclusion in context and no errors		