January 2018

Question	Scheme	Marks
5. (a)	$[X \sim \text{Po}(10)]$ $[\text{P}(X > 12) = 1 - \text{P}(X \le 12) = 1 - 0.7916] = 0.2084$ **awrt <u>0.208</u>**	B1 (1)
(b)	$[\text{P}(X > k) \ge 2 \times \text{'}0.2084\text{'}]$ $\text{P}(X \le k) < 1 - \text{'}0.4168\ldots\text{'}\ [=0.583\ldots]$ $k =$ **<u>10</u>**	M1 A1cao (2)
(c)	$W \sim \text{Po}(5)$ $[\text{P}(W=4)]^2 \left[= \left(\frac{e^{-5}5^4}{4!}\right)^2 = (0.4405 - 0.2650)^2 = \right] = 0.030788...$ **awrt <u>0.0308</u>**	B1 M1 A1 (3)
(d)	$\text{P}((X_1 \ge 10 \cap X_2 \ge 10) \mid (Y=21)) = \dfrac{\frac{e^{-10}10^{10}}{10!} \times \frac{e^{-10}10^{11}}{11!} + \frac{e^{-10}10^{11}}{11!} \times \frac{e^{-10}10^{10}}{10!}}{\frac{e^{-20}20^{21}}{21!}}$ $= 0.336376\ldots$ Use of tables: $\dfrac{2 \times (0.5830 - 0.4579)(0.6968 - 0.5830)}{\frac{e^{-20}20^{21}}{21!}} = 0.336537...$ **awrt <u>0.336/7</u>**	M1 M1 M1 A1 (4)
(e)	$L \sim \text{Po}(40) \approx \text{N}(40, 40)$ $\text{P}(L > 27) = \text{P}\left(Z > \frac{27.5 - 40}{\sqrt{40}}\right)$ $\text{P}(Z > -1.98) = 0.9761$ **<u>awrt 0.976</u>**	B1 B1 M1 M1 A1 (5) **Total 15**

June 2018

5(a)	$[X \sim \text{Po}(6)]$	
(i)	$\text{P}(X=7) = \text{P}(X \leqslant 7) - \text{P}(X \leqslant 6)$ $= 0.7440 - 0.6063$ $= 0.13767697\ldots$ awrt **<u>0.138</u>**	M1 A1
(ii)	$\text{P}(X > 7) = 1 - \text{P}(X \leqslant 7)$ $= 1 - 0.744 \quad = 0.2560202\ldots$ awrt **<u>0.256</u>**	M1 A1 (4)

October 2018

1.(a)	$X \sim \text{Po}(6)$ $\text{P}(X = 1)$ [$=6\text{e}^{-6} = 0.0174 - 0.0025$]$= 0.01487\ldots$ awrt **0.0149**	M1 A1 (2)

October 2018

Question	Scheme	Marks
7.(a)	$X \sim \text{Po}(1)$ and $\text{P}(X \geq n) < 0.05$ or $\text{P}(X < n) > 0.95$ $n = 4$	M1 A1 (2)
(b)	$Y \sim \text{Po}(0.5m)$ $\text{P}(Y = 0) < 0.05$ or $\text{e}^{-\frac{1}{2}m} < 0.05$ $0.5m = 3$ $m = 6$	M1 A1 (2)
(c)	$W \sim \text{Po}(0.5)$ $[\text{P}(W \geq 1)]^3 = (1 - \text{P}(W = 0))^3 = (1 - 0.6065)^3 = 0.06093\ldots$ awrt **0.0609**	M1M1A1 (3)
(d)	$S \sim \text{Po}(4)$ $\text{P}(S = 4) = 0.1953\ldots$ awrt **0.195**	M1 A1 (2)
(e)	$A \sim \text{Po}(1)$ $B \sim \text{Po}(2)$ P(sightings in last 2 months> sightings in first 2 months | 4 sightings in 4 months) = $\dfrac{\text{P}(A=1)\times\text{P}(A=3)+\text{P}(A=0)\times(A=4)}{\text{P}(B=4)} = \dfrac{\text{e}^{-1}\times\frac{\text{e}^{-1}}{3!}+\text{e}^{-1}\times\frac{\text{e}^{-1}}{4!}}{\frac{\text{e}^{-2}\times 2^4}{4!}} = \dfrac{5}{16}$	 M1 M1 A1 (3)
		Total 12

Question Number	Scheme	Marks
2. (a)	$[X \sim \text{Po}(2)]$	
	$\text{P}(X < 5) = \text{P}(X \leq 4)$	M1
	$= 0.947346....$ awrt $\underline{\mathbf{0.947}}$	A1
		(2)
(b)	$Y \sim \text{Po}(6)$	B1
	$\text{e}^{-6}\dfrac{6^n}{(n)!} = \text{e}^{-6}\dfrac{6^{n+1}}{(n+1)!} \rightarrow (n+1) = 6$ **or** $\text{P}(Y = 4) = 0.13385...$, $\text{P}(Y = 5) = 0.16062...$, $\text{P}(Y = 6) = 0.16062...$	M1
	$\underline{\boldsymbol{n = 5}}$	A1
		(3)
(c)	$[D \sim \text{Po}(9)]$	
	$\text{P}(c \leq D \leq 12) = \text{P}(D \leq 12) - \text{P}(D \leq c-1)$ or $\text{P}(X \leq d) = 0.8758 - 0.8546$	M1
	$0.8546 = 0.8758 - \text{P}(D \leq c-1)$ $\qquad = 0.0212$	
	$\text{P}(D \leq c-1) = 0.0212$ $\qquad \text{P}(X \leq 3) = 0.0212$	dM1
	$c - 1 = 3$	
	$\underline{\boldsymbol{c = 4}}$ $\qquad \underline{\boldsymbol{c = 4}}$	A1
		(3)
(d)	$\text{P}(X = 2) = 0.27067...$	B1
	$W \sim \text{B}(6, \text{awrt } 0.27067...)$	B1ft
	$\text{P}(W = 4) = {}^6\text{C}_4(\text{"}0.27067...\text{"})^4(1 - \text{"}0.27067...\text{"})^2$	M1
	$= 0.0428...$ awrt $\underline{\mathbf{0.043}}$	A1
		(4)
		[12 marks]

June 2019

Question Number	Scheme	Marks
1(a)	eg $4750\times\frac{80}{40000}$ o.e. $[=9.5]*$	B1*
		(1)
(b)	Two appropriate assumptions. e.g. **<u>Hazelnuts</u>** occur singly **or** **<u>hazelnuts</u>** occur randomly (independently) **or** **<u>hazelnuts</u>** are well mixed in **or** **<u>mean</u>** number of **<u>hazelnuts</u>** (per kg) is **<u>constant</u>** **or** **<u>hazelnuts</u>** occur at a constant **<u>rate</u>**	B1 B1
		(2)
(c)(i)	Let X = number of hazelnuts. $X \sim \text{Po}(9.5)$	
	$\text{P}(X=12)=\dfrac{\text{e}^{-9.5}\times(9.5)^{12}}{12!}$	M1
	$=0.08444\ldots$ awrt 0.0844	A1
(ii)	$\text{P}(X \leqslant 7)$	M1
	$=0.26866\ldots$ awrt 0.269	A1
		(4)
(d)	Let R = number of bars with fewer than 8 hazelnuts. $R \sim \text{B}(3, 0.2687)$	B1
	$\text{P}(R=1)=\text{"}0.2687\text{"}\times(1-\text{"}0.2687\text{"})^2\times 3$	M1
	$=0.4312\ldots$ awrt 0.431	A1
		(3)

October 2019

Question	**Scheme**	**Marks**
Question	**Scheme**	**Marks**
3(a)	[Let X = number of hacking attempts per hour]	
	$\text{P}(X \geq 1)=1-\text{P}(X=0)=$	M1
	$1-\text{e}^{-0.3}=0.2591\ldots$ awrt **<u>0.259</u>***	A1cso
		(2)
(b)	$Y \sim \text{Po}(7.2)$	B1
	$\text{P}(Y=6)=\dfrac{\text{e}^{-7.2}\times 7.2^6}{6!}=0.144458...$ awrt **<u>0.144</u>**	M1 A1
		(3)

January 2020

Question Number	Scheme		Marks
1 (a)	$\mathrm{P}(H=6)=\dfrac{e^{-4}4^{6}}{6!}$ or $\mathrm{P}(H \le 6)-\mathrm{P}(H \le 5)=0.8893-0.7851$		M1
	$=0.10419\ldots$ $=0.1042$	awrt **<u>0.104</u>**	A1
			(2)
(b)	$J \sim \mathrm{Po}(8)$		B1
	$\mathrm{P}(J \le 7)-\mathrm{P}(J \le 2)=0.4530-0.0138$		M1
	$=0.4392$	awrt **<u>0.439</u>**	A1
			(3)

(d)(i)	The p(robability)/0.97 is not small oe		B1
			(1)
(ii)	$L \sim \mathrm{Po}(3)$		B1
	$\mathrm{P}(L \le 4)=0.8153$	awrt **<u>0.815</u>**	M1A1
			(3)

June 2020

Question Number	Scheme		Marks
4(a)	Common Spotted-orchids occur singly/randomly/independently		B1
			(1)
(b)(i)	$S \sim \mathrm{Po}(4.5)$		
	$\mathrm{P}(S=6)=\dfrac{e^{-4.5}4.5^{6}}{6!}$ or $\mathrm{P}(S \le 6)-\mathrm{P}(S \le 5)$		M1
	$=0.1281\ldots$	awrt 0.128	A1
(ii)	$\mathrm{P}(4<S<10)=\mathrm{P}(S \le 9)-\mathrm{P}(S \le 4)$ or $0.9829-0.5321$		M1
	$=0.4508$	awrt 0.451	A1
			(4)

January 2021

Question Number	**Scheme**		**Marks**
3(a)	$\mathrm{P}(X \ne 4)=1-\mathrm{P}(X=4)$ oe $\left(=1-\dfrac{e^{-7}7^{4}}{4!}\right.$ or $\left.1-(0.1730-0.0818)\right)$		M1
	$=0.90877\ldots$	awrt 0.909	A1
			(2)
(b)	$\mathrm{P}(Y=1)=(1-\text{"}0.90877\ldots\text{"})(\text{"}0.90877\ldots\text{"})^{4}\times {}^{5}C_{1}$		M1M1
	$=0.311\ldots$		A1
			(3)

Question Number	Scheme	Marks
2. **(a)**	[X = number of faults in 4 m^2 so $X \sim \text{Po}(3)$]	
	$\text{P}(X=5)=\text{P}(X\leqslant 5)-\text{P}(X\leqslant 4)[=0.9161-0.8153]$ <u>or</u> $\dfrac{e^{-3}3^5}{5!}$ (allow λ instead of 3)	M1
	$=0.1008$ <u>or</u> 0.100818… awrt <u>**0.101**</u>	A1
		(2)
(b)	[Y = number of faults in 6 m^2 so] $Y \sim \text{Po}(4.5)$ <u>and</u> $\left[\text{P}(Y>5)\right]=1-\text{P}(Y\leqslant 5)$ $[=1-0.7029]$	M1
	$=0.2971$ <u>or</u> (calc) 0.29706956… awrt <u>**0.297**</u>	A1
		(2)
(c)	<u>**0.101**</u> (or ft their answer to (a))	B1ft
	Faults occur independently/ randomly	B1
		(2)
(d)	[F = number of faults in a small rug] $F \sim \text{Po}(0.9)$	B1
	$e^{-\text{"}0.9\text{"}}n\times 80+\left(1-e^{-\text{"}0.9\text{"}}\right)n\times 60\geqslant 4000$ <u>or</u> $(\text{awrt } 0.407)n\times 80+(\text{awrt } 0.593)n\times 60\geqslant 4000$	M1
	$n \geqslant \dfrac{4000}{20e^{-\text{"}0.9\text{"}}+60}=58.71\ldots$	M1
	$n=$ <u>**59**</u>	A1
		(4)

October 2021

Question Number	Scheme		Marks
4(a)	$\mathrm{P}(X=8)=\dfrac{e^{-6}6^8}{8!}$ or $0.8472-0.7440$		M1
	$=0.10325\ldots$	awrt 0.103	A1
			(2)
(b)	[$X \sim \mathrm{Po}(6)$ …] $\mathrm{P}(X \geqslant n) < 0.05$ [or $\mathrm{P}(X \leqslant n-1) > 0.95$]		M1
	$n = 11$		A1cao
			(2)
(c)	$K \sim \mathrm{Po}(0.6m)$ **and** $\mathrm{P}(K=0) < 0.05$ / $e^{-0.6m} < 0.05$ / $-0.6m < \ln 0.05$ oe	<u>or</u> $\lambda = 3$	M1
	$m = 5$		A1cao
			(2)
(d)	$Y \sim \mathrm{Po}(3)$		B1
	$\mathrm{P}(Y \geqslant 1) = 1 - \mathrm{P}(Y=0)$		M1
	$= 0.9502$		A1
			(3)
(e)	[$W \sim \mathrm{Po}(18)$] $\mathrm{P}(W=15)=\dfrac{e^{-18}18^{15}}{15!}$ [$=0.078575\ldots$]	$Y \sim \mathrm{B}(15, \frac{5}{30})$	M1
	$\dfrac{\mathrm{P}\left(Y=1\left[\left\|Y\sim\mathrm{Po}(3)\right]\right]\right)\times\mathrm{P}\left(T=14\left[\left\|T\sim\mathrm{Po}(15)\right]\right]\right)}{\text{"}0.078575...\text{"}}$	$\mathrm{P}(Y=1)$	dM1
	$=\dfrac{\left(e^{-3}\times 3\right)[=0.149...]\times\left(\dfrac{e^{-15}15^{14}}{14!}\right)[=0.102...]}{\text{"}0.078575...\text{"}}$	$=15(\frac{1}{6})(\frac{5}{6})^{14}$	dM1
	$=0.1947\ldots$	awrt 0.195	A1
			(4)

January 2022

Question Number	Scheme	Marks
1 (a)	X = faults in a week $\Rightarrow X \sim \mathrm{Po}(6)$	
	$[\mathrm{P}(X \geqslant x) = 0.1528 \Rightarrow \mathrm{P}(X \leqslant x-1)] = 0.8472$	M1
	Using tables $\mathrm{P}(X \leqslant 8) = 0.8472 \Rightarrow x - 1 = 8$	M1
	$x = 9$	A1
		(3)

June 2022

Question	Scheme	Marks
1. (a)	4	B1
		(1)
(b)	$\mathrm{P}(X=2)=3\times0.2\times0.8^2\left[=\dfrac{48}{125}=0.384\right]$ **or** $\mathrm{P}(X=3)=0.8^3\left[=\dfrac{64}{125}=0.512\right]$	M1
	$[X=]$ 3 is the mode	A1
		(2)
(c)	$\mathrm{P}(W_1=2)=\dfrac{e^{-4}4^2}{2}$ $[=0.1465]$ **and** $\mathrm{P}(X_1=2)=3\times0.2\times0.8^2\left[=\dfrac{48}{125}=0.384\right]$	M1
	$\mathrm{P}(W_1 \text{ and } X_1=2)=\dfrac{e^{-4}4^2}{2}\times(3\times0.2\times0.8^2)$ $[=0.1465\times0.384]$	M1
	$=0.05626564\ldots$ awrt **<u>0.0563</u>**	A1
		(3)
(d)	$X_1=0$ and $W_1>0$, $X_1=1$ and $W_1>1$, $X_1=2$ and $W_1>2$, $X_1=3$ and $W_1>3$	M1
	$0.008\times(1-0.0183)+0.096\times(1-0.0916)+0.384\times(1-0.2381)+0.512\times(1-0.4335)$	M1M1
	$=0.677677\ldots$ awrt **<u>0.678</u>**	A1
		(4)
		[10 marks]

June 2022

Question	Scheme	Marks
5. (a)	$X\sim\mathrm{Po}(7.5)$	B1
(i)	$\mathrm{P}(X=10)$ $[=0.8622-0.7764=\dfrac{e^{-7.5}(7.5)^{10}}{10!}]=0.0858\ldots$ awrt **<u>0.0858</u>**	B1
(ii)	$\mathrm{P}(6\leqslant X\leqslant 11)=\mathrm{P}(X\leqslant 11)-\mathrm{P}(X\leqslant 5)$ $[=0.9208-0.2414]$	M1
	$=0.6794$ awrt **<u>0.679</u>**	A1
		(4)
(b)	Y = number of samples that contain 0 particles	
	$Y\sim\mathrm{B}(12,p)$ or $\mathrm{B}(12,e^{-0.15m})$ or $\mathrm{B}(12,e^{-\lambda})$	M1
	$[\mathrm{P}(Y\geqslant 2)=]\ 1-\mathrm{P}(Y\leqslant 1)=0.1184$	M1
	$\mathrm{P}(Y\leqslant 1)=0.8816\rightarrow$ from tables $[p=]\ 0.05$	A1
	S = number of particles per m millilitres	
	$S\sim\mathrm{Po}(0.15m)$	M1
	$\mathrm{P}(S=0)=0.05$ or $e^{-0.15m}=$ "0.05"	M1
	$-0.15m=\ln(0.05)\rightarrow m=19.9715\ldots$ awrt **<u>20.0</u>**	A1
		(6)
		[10 marks]

October 2022

Question Number	**Scheme**		**Marks**
1(a)(i)	$\left[\mathrm{P}\left(F<3 \mid F\sim \mathrm{Po}(1.5)\right)=\right]0.8088$	awrt 0.809	B1
			(1)
(ii)	$\left[\mathrm{P}\left(F \ldots 6\right)=\right]1-\mathrm{P}\left(F \;,,\; 5\right)$ or $1-0.9955$		M1
	$=0.0045$	awrt 0.0045	A1
			(2)
(b)	$R\sim \mathrm{Po}(10)\ \therefore\left[\mathrm{P}\left(R ,, 12\right)\right]=0.7916$	awrt 0.792	M1
	$X\sim \mathrm{B}(15, \text{"}0.7916\text{"})$		M1
	$\left[\mathrm{P}\left(X=10\right)=\right]{}^{15}C_{10}\left(\text{"}0.7916\text{"}\right)^{10}\left(1-\text{"}0.7916\text{"}\right)^{5}$		M1
	$=0.11405\ldots$	awrt 0.114	A1
			(4)
(c)	$H\sim \mathrm{Po}(0.4)$		M1
	$\left[\mathrm{P}\left(H=0\right)=\right]\mathrm{e}^{-0.4}$ $[=0.6703\ldots]$ **or** $\left[\mathrm{P}\left(H>0\right)=\right]1-\mathrm{e}^{-0.4}$ $[=0.32967\ldots]$		M1
	Profit $=2.4\times\text{"}0.6703...\text{"}-3\times\text{"}0.32967...\text{"}$		dM1
	$=0.6197$	awrt 0.62	A1
			(4)

January 2023

Question Number	Scheme		Marks
1 (a)	Po(isson) with $(\lambda=)4$		B1
			(1)
(b)	Pairs of **shoes** (are **sold**) singly/randomly/independently/at a **constant** (average) **rate**		B1
			(1)
(c) (i)	X = number of sales per hour $\Rightarrow X\sim \mathrm{Po}(4)$		
	$\mathrm{P}(X>4)=1-\mathrm{P}(X\leqslant 4)$		M1
	$=0.3712$	awrt 0.371	A1
(ii)	$(\text{'}0.371...\text{'})^{3}$		M1
	$=0.051147\ldots$	0.05115 or awrt 0.0511	A1
			(4)

January 2023

Number			
5 (a)	$X\sim \mathrm{Po}(5)$		
	$\mathrm{P}(X\leqslant 5)=0.6160$	awrt 0.616	M1 A1
			(2)

June 2023

Question Number	Scheme	Marks
7. (a)	$R \sim \text{Po}(8)$	B1
	$\text{P}(4 \leqslant R \leqslant 8) = \text{P}(R \leqslant 8) - \text{P}(R \leqslant 3) = 0.5925 - 0.0424$	M1
	$= 0.5501 \quad =$ awrt $\underline{\mathbf{0.550}}$	A1
		(3)
(b)	$H \sim \text{Po}(4)$	B1
	$\text{P}(H \leqslant 2) = 0.2381$	B1
	$Y \sim \text{B}(5, \text{“}0.2381\text{”})$	M1
	$\text{P}(Y = 2) = {}^5\text{C}_2(\text{"}0.2381\text{"})^2(1 - \text{"}0.2381\text{"})^3$	M1
	$= 0.25073\ldots \qquad =$ awrt $\underline{\mathbf{0.251}}$	A1
		(5)
(c)	W = number sold in first fifteen minutes X = number sold in last forty five minutes | F = number of muffins sold in first 15 minutes	
	$\text{P}(W > X \mid R = 4) = \dfrac{\text{P}(W=4)\text{P}(X=0) + \text{P}(W=3)\text{P}(X=1)}{\text{P}(R=4)}$ | $F \sim \text{B}(4, 0.25)$	M1
	| $\text{P}(F > 2) = \text{P}(F = 3) + \text{P}(F = 4)$	M1
	$= \dfrac{\frac{e^{-2}2^4}{4!}\frac{e^{-6}6^0}{0!} + \frac{e^{-2}2^3}{3!}\frac{e^{-6}6^1}{1!}}{\frac{e^{-8}8^4}{4!}}$ | $= {}^4\text{C}_3(0.25)^3(0.75) + 0.25^4$	M1
	$= \dfrac{13}{256}$ (awrt 0.0508 or awrt 0.0509)	A1
		(4)
		[Total 12]

October 2023

Question Number	Scheme	Marks
5 (a)	**Complaints** received are independent or occurring at a constant rate or singly	B1
		(1)
(b)(i)	$\left[\text{P}\left(X < 3 \middle\vert X \sim \text{Po}(6)\right) = \right] 0.0620$ awrt 0.062	B1
(ii)	$\left[\text{P}(X \geqslant 6) = \right] 1 - \text{P}(X \leqslant 5)$ or $1 - 0.4457 = 0.5543$ awrt 0.554	M1A1
		(3)
(c)	$\text{H}_0 : \lambda = 6 \qquad \text{H}_1 : \lambda > 6$	B1
	$\text{P}(X \geqslant 12) = 1 - \text{P}(X \leqslant 11) = [1 - 0.9799]$ or $\text{P}(X \geqslant 11) = 1 - \text{P}(X \leqslant 10) = [1 - 0.9574]$	M1
	$= 0.0201$ or CR $\geqslant 11$	A1
	Reject H_0/In the CR/Significant	M1
	There is sufficient evidence to suggest that the mean **number** of **complaints** received is **greater** than 6 per week	A1ft
		(5)

Question Number	Scheme	Marks
1 (a)	[Mean =] 2.95	B1
	[Variance =] $\frac{2091}{180} - ("2.95")^2$	M1
	$= 2.914\ldots$ $(s^2 = 2.930\ldots)$ awrt 2.91 (2.93)	A1
		(3)
(b)	The mean is close to the variance	B1
		(1)
(c)	$W \sim \text{Po}(3)$	
(i)	$\left[\text{P}(W \geqslant 3) =\right] 1 - \text{P}(W \leqslant 2) = 0.5768$ awrt 0.577	M1 A1
(ii)	$\left[\text{P}(4 < W < 8) =\right] \text{P}(W \leqslant 7) - \text{P}(W \leqslant 4)$ or $\text{P}(W=5) + \text{P}(W=6) + \text{P}(W=7)$	M1
	$= 0.1728\ldots$ awrt 0.173	A1
		(4)