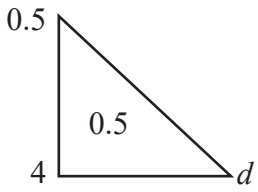
Question Number	Scheme	Marks
1 (a) (i)	$X \sim B(14, 0.2)$	
	$[P(X = 2) =] {}^{14}C_2 \times 0.2^2 \times 0.8^{12}$	M1
	$= 0.2501$ awrt 0.2501	A1
(ii)	$X \sim B(25, 0.2)$	
	$P(X > 3) = 1 - P(X \leqslant 3) = 1 - 0.2340$ or $1 - (0.0038 + 0.0236 + 0.0708 + 0.1358)$	M1
	$= 0.7660$ awrt 0.766	A1
		(4)
(b)(i)	$[np = 6 \Rightarrow] n = \frac{6}{0.2}$	M1
	$= 30$	A1
		(2)
(ii)	$Y \sim B(n, 0.2)$ we require $P(Y \geqslant 1) > 0.95$	
	$1 - P(Y = 0) > 0.95 \Rightarrow P(Y = 0) < 0.05$	M1
	$[{}^{n}C_0 \times 0.2^0] \times 0.8^n < 0.05$	M1
	$0.8^{14} = 0.04398...[< 0.05]$ | $n > \frac{\ln 0.05}{\ln 0.8} \Rightarrow n > 13.425$	dM1
	$n = 14$	A1
		(4)

	Notes		Total 10
(a) (i)	**M1**	For writing or using ${}^{14}C_2 \times 0.2^2 \times 0.8^{12}$ (Allow 91 for ${}^{14}C_2$)	
	A1	awrt 0.2501 **NB** 0.2501 with no working scores M1A1	
(ii)	**M1**	For writing or using $1 - P(X \leqslant 3)$	
	A1	awrt 0.766 **NB** awrt 0.766 with no working scores M1A1	
(b)(i)	**M1**	For use of $np = 6$ e.g $0.2n = 6$ (Allow $\geqslant$)	
	A1	Cao	
(ii)	**M1**	For writing or using $P(Y \ldots 1) = 1 - P(Y = 0)$ (Allow $P(Y \ldots 1) = 1 - P(Y \leqslant 0)$)	
	M1	For $0.8^n < 0.05$ oe (Allow = or $\leqslant$)	
	dM1	Dependant on previous M1 For substitution of n (allow $0.8^{13} = 0.05497\ldots$) or rearranging to $n > \ldots$ (Allow = or $\geqslant$) If using logs allow any base e.g. $n > \log_{0.8} 0.05$	
	A1	Cao	

Question Number	Scheme		Marks
2 (a)	[Mode =] 4		B1
			(1)
(b)	$\left[a\int_0^4 x^3\mathrm{d}x=\frac{1}{2}\Rightarrow\right]a\left[\frac{x^4}{4}\right]_0^4=\frac{1}{2}$		M1
	$64a=\frac{1}{2}\Rightarrow a=\frac{1}{128}$ *		A1*
			(2)
(c)	 $\frac{1}{2}\times\frac{1}{2}\times(d-4)=\frac{1}{2}$ or $\frac{1}{2}\times\frac{1}{2}\times(d-4)+\int_0^4 ax^3\mathrm{d}x=1$		M1
	$d=6$		A1
			(2)
(d)	$b=\frac{-\frac{1}{2}}{'6'-4}\left[=-\frac{1}{4}\right]$	$4b+c=0.5$ oe	M1
	$0='-\frac{1}{4}'\times'6'+c$ or $\frac{1}{2}='-\frac{1}{4}'\times4+c$	$10b+2c=0.5$ oe or $'6'b+c=0$ oe	M1
	$b=-\frac{1}{4}$ and $c=\frac{3}{2}$		A1
			(3)
	Notes		**Total 8**

(a)	**B1**	Cao
(b)	**M1**	For integrating the 1st line of the pdf and setting = 0.5 Ignore limits
	A1*	Answer is given so a correct solution must be seen with no errors. There must be at least one line of correct working from the M mark to the final answer.
		Mark parts c and d together
(c)	**M1**	For setting the area of the triangle = 0.5
	A1	Cao
(d)	**M1**	A correct method for finding b ft their d value or $4b+c=0.5$ oe (this may be seen any part of this question) Allow $4b+c=64a$
	M1	A correct method for finding c ft their b and d value or $10b+2c=0.5$ oe or $'d'\times b+c=0$ oe (these may be seen any part of this question) Allow $db+c=0$
	A1	For both b and c correct **NB** b = - 0.25 oe and c = 1.5 oe will score 3/3

Question Number	Scheme	Marks
3 (a)(i)	$3 + [0] + 29 = 32$*	B1*
(ii)	$3 + 15 + 29 = 47$*	B1*
		(2)
(b)	$f(t) = \begin{cases} \frac{1}{15} & 32 \text{ ,, } t \text{ ,, } 47 \\ 0 & \text{otherwise} \end{cases}$	M1 A1
		(2)
(c) (i)	$[E(T) =]$ 39.5 oe	B1
(ii)	$[\text{Var}(T) =]\frac{(47-32)^2}{12}$	M1
	$\frac{75}{4} = 18.75$	A1
		(3)
(d)	$(40-32)\times\frac{1}{15}$	M1
	$=\frac{8}{15}$	A1
		(2)

	Notes	Total 9
(a)(i)	**B1***	For $3 + [0] + 29$
(ii)	**B1***	For $3 + 15 + 29$ Allow $32 + 15$
(b)	**M1**	For $f(t) = \frac{1}{15}$ $32 \text{ ,, } t \text{ ,, } 47$ Allow use of $<$ instead of one/both $\leq$ signs. Allow the use of any letter for f(t) and t (Condone inconsistent use of letters) but we must have f(t) and an inequality
	A1	Fully correct pdf $f(t) = \begin{cases} \frac{1}{15} & 32 \text{ ,, } t \text{ ,, } 42 \\ 0 & \text{otherwise} \end{cases}$ Must be f(t) and t. Condone f(T) and T Allow use of $<$ instead of one/both $\leq$ signs Allow equivalent for the 0 otherwise.
(c)(i)	**B1**	For 39.5 oe
(ii)	**M1**	For use of $\text{Var}(T) = \frac{(\beta-\alpha)^2}{12}$
	A1	For 18.75 oe
(d)	**M1**	For use of $(40-\alpha)\times\frac{1}{\beta-\alpha}$
	A1	For $\frac{8}{15}$ oe Allow awrt 0.533

Question Number	Scheme	Marks
4 (a)	$0.2\times£10+0.3\times£12+0.5\times£15$	M1
	$=[£]13.10$	A1
		(2)
(b)	10 10 10 10 10 12 (×3) 10 10 15 (×3) 10 12 15 (×6) 12 12 12 12 12 15 (×3) 10 12 12 (×3) 15 15 15 12 15 15 (×3) 10 15 15 (×3)	B1 B1
		(2)
(c)	$P(10)=0.2$ $P(12)=0.3$ $P(15)=0.5$	B1
	Median can be 10, 12 or 15	B1
	$P(M=10)=0.2^3+0.2^2\times0.3\times3+0.2^2\times0.5\times3$ **or** $1-0.8^3-3\times0.8^2\times0.2$	M1
	$P(M=12)=0.3^3+0.3^2\times0.5\times3+0.3^2\times0.2\times3+0.2\times0.3\times0.5\times6$	M1
	$P(M=15)=0.5^3+0.5^2\times0.3\times3+0.5^2\times0.2\times3$ **or** $1-0.5^3-3\times0.5^2\times0.5$	M1
	M | 10 | 12 | 15 $P(M=m)$ | $\frac{13}{125}=0.104$ | $\frac{99}{250}=0.396$ | $\frac{1}{2}=0.5$	A1
		(6)

	Notes	Total 10
(a)	**M1**	For $0.2\times10+0.3\times12+0.5\times15$ May be implied by a correct answer
	A1	Cao Allow 13.1
(b)	**B1**	B1 for at least 5 possible combinations. Ignore repeats. May be seen in part c
	B1	For all 10 possible combinations. Ignore repeats. May be seen in part c
(c)	**B1**	Correct probabilities – may be seen in an equation or implied by a correct probability
	B1	All 3 medians and no extras
	M1	A correct method for one of the probabilities (May be implied by a correct probability)
	M1	A correct method for two of the probabilities (May be implied by 2 correct probabilities)
	M1	A correct method for all three probabilities (May be implied by 3 correct probabilities) or 3 probabilities that add to 1
	A1	Cao Need not be in a table but probabilities must be attached to the correct median

Question Number	Scheme	Marks
5 (a)	**Complaints** received are independent or occurring at a constant rate or singly	B1
		(1)
(b)(i)	$\left[\mathrm{P}\left(X<3\middle\vert X\sim \mathrm{Po}(6)\right)=\right]0.0620$ awrt 0.062	B1
(ii)	$\left[\mathrm{P}\left(X\ldots 6\right)=\right]1-\mathrm{P}\left(X\,„\,5\right)$ or 1 – 0.4457 = 0.5543 awrt 0.554	M1A1
		(3)
(c)	$\mathrm{H}_0:\lambda=6 \quad \mathrm{H}_1:\lambda>6$	B1
	$\mathrm{P}(X\ldots 12)=1-\mathrm{P}(X\,„\,11)=[1-0.9799]$ or $\mathrm{P}(X\ldots 11)=1-\mathrm{P}(X\,„\,10)=[1-0.9574]$	M1
	$=0.0201$ or CR …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)
(d)	$\mathrm{H}_0:\lambda=6 \quad \mathrm{H}_1:\lambda<6$	B1
	6 week period is Po(36) $\Rightarrow$ N(36, 36)	B1
	$\mathrm{P}\left(Y\,„\,26\right)\approx \mathrm{P}\left(Y<26.5\right)=P\left(Z<\dfrac{26.5-36}{6}\right)$ or $\dfrac{x+0.5-36}{\sqrt{36}}<-1.6449$	M1 M1
	$\left[P\left(Z<-1.583...\right)\right]=0.0571$ (Calculator 0.05667…) or $x<25.63...$ awrt 0.057 awrt 25.6	A1
	Do not reject H_0/Not in the CR/Not significant	M1
	There is insufficient evidence to suggest that the mean **number** of **complaints** received after the changes made is **less** than 6 per week	A1ft
		(7)

	Notes	**Total 16**
(a)	**B1**	A correct assumption. Must be in context so need 'complaints' and then independent/random or constant rate or singly
(b)(i)	**B1**	awrt 0.062
(ii)	**M1**	For writing or using $1-\mathrm{P}(X\,„\,5)$ May be implied by awrt 0.554
	A1	awrt 0.554
(c)	**B1**	Both hypotheses correct. Must be attached to H_0 and H_1 in terms of λ or μ
	M1	For writing or using $1-\mathrm{P}(X\,„\,11)$ or $1-\mathrm{P}(X\,„\,10)$
	A1	For 0.0201 or CR …11
	M1	A correct statement – no context needed but do not allow contradicting non contextual comments
	A1ft	Correct conclusion in context with the words highlighted in bold
(d)	**B1**	Both hypotheses correct. Must be attached to H_0 and H_1 in terms of λ or μ Allow use of 36 rather than 6
	B1	For writing or using N(36, 36)
	M1	For standardising using 25.5/26/26.5, their mean and their standard deviation or standardising using x–0.5/x/x + 0.5, their mean and their standard deviation and setting equal to –1.6449
	M1	For a correct continuity correction written or used e.g. 26.5 or x + 0.5
	A1	awrt 0.057 (NB Poisson used gives 0.0512685… and scores M0M0A0) or CR < awrt 25.6 (Allow $\leqslant$)
	M1	A correct statement – no context needed but do not allow contradicting non contextual comments
	A1ft	Correct conclusion in context with the words in bold (Allow The mean **number** of **complaints** has **stayed the same/not changed** oe)

Question Number	Scheme	Marks
6(a)	$\left[\mathrm{P}\left(Y<\frac{1}{4}k \mid Y<k\right)=\right]\frac{\mathrm{F}\left(\frac{1}{4}k\right)}{\mathrm{F}(k)}=\frac{\frac{1}{21}\left(\frac{k}{4}\right)^2}{\frac{1}{21}k^2}=\frac{1}{16}$ oe	M1 A1
		(2)
(b)	$\frac{1}{21}k^2=-\frac{1}{15}k^2+\frac{4}{5}k-\frac{7}{5}$ $\quad \frac{\mathrm{d}}{\mathrm{d}y}\left(\frac{1}{21}y^2\right)=\frac{2}{21}y$ or $\frac{\mathrm{d}}{\mathrm{d}y}\left(\frac{2}{15}\left(6y-\frac{y^2}{2}\right)-\frac{7}{5}\right)=\frac{2}{15}(6-y)$	M1
	$\Rightarrow 4k^2-28k+49=0$ oe $\quad \frac{\mathrm{d}}{\mathrm{d}y}\left(\frac{1}{21}y^2\right)=\frac{2}{21}y$ & $\frac{\mathrm{d}}{\mathrm{d}y}\left(\frac{2}{15}\left(6y-\frac{y^2}{2}\right)-\frac{7}{5}\right)=\frac{2}{15}(6-y)$	A1
	$\Rightarrow (2k-7)^2=0$ $\quad \frac{2}{21}k=\frac{2}{15}(6-k)$	M1
	$k=\frac{7}{2}$ oe	A1
		(4)
(c)	$\mathrm{f}(y)=\begin{cases}\frac{2}{21}y & 0 \text{ „ } y \text{ „ } '3.5' \\ \frac{2}{15}(6-y) & '3.5'<y \text{ „ } 6 \\ [0] & [\text{otherwise}]\end{cases}$	M1 M1
	$\mathrm{E}(Y)=\frac{2}{21}\int_0^{'3.5'}y^2\mathrm{d}y+\frac{2}{15}\int_{'3.5'}^{6}\left(6y-y^2\right)\mathrm{d}y \quad \Rightarrow \quad \frac{2}{21}\left[\frac{y^3}{3}\right]_0^{'3.5'}+\frac{2}{15}\left[3y^2-\frac{y^3}{3}\right]_{'3.5'}^{6}$	M1 M1
	$\frac{2}{21}\left(\frac{343}{24}\right)+\frac{2}{15}\left(\frac{325}{24}\right)=\frac{19}{6}=3.166...$ awrt 3.17	dM1 dA1
		(6)
		Total 12

(a)	**M1**	For a correct probability statement or a correct ratio of probabilities
	A1	For $=\frac{1}{16}$ oe or 0.0625
(b)	**M1**	For setting the two lines of the cdf = to each other or $\frac{2}{21}y$ or $\frac{2}{15}(6-y)$ (Implied by a correct 3TQ)
	A1	For a correct 3TQ or $\frac{2}{21}y$ and $\frac{2}{15}(6-y)$
	M1	For solving their 3TQ. If the 3TQ is not correct, then a correct method must be shown or setting their 2 lines of the pdf = to each other
	A1	$k = 3.5$ oe **NB** $k = 3.5$ with no incorrect working scores 4/4
(c)	**M1**	Attempting to differentiate 1 of the functions. May be seen in part (b) or in an attempt to find E(Y)
	M1	Attempting to differentiate both with one correct. May be seen in part (b) or in an attempt to find E(Y)
	M1	For writing or using $\mathrm{E}(Y)=\int_0^{3.5}y\ \mathrm{f}(y)\ \mathrm{d}y+\int_{3.5}^{6}y\ \mathrm{f}(y)\ \mathrm{d}y$ Ignore limits
	M1	For attempting to integrate
	dM1	Dependent on previous M1. For substitution of limits, must be 0 or 6 and ft their 3.5. May be implied by $\frac{49}{36}$ oe or $\frac{65}{36}$ oe or $\frac{19}{6}$ oe. If the integral is not correct, then we must see evidence of substitution.
	dA1	Dependent on previous M1. For $\frac{19}{6}$ or awrt 3.17

Question Number	Scheme	Marks
7(a)	$\frac{97.5-\mu}{\sigma}=1.25$ $\quad$ $\frac{85.5-\mu}{\sigma}=-0.75$	M1 M1 M1 M1 M1
	$2\sigma=12$	M1
	$\sigma=6*$ $\quad[\mu=90]$	dA1*
		(7)
(b)	$np=90$ and $np(1-p)=36$	M1
	$1-p=0.4$	M1
	$p=0.6$ and $n=150$	A1
		(3)
	Notes	**Total 10**

NB Condone use of np for μ and $\sqrt{np(1-p)}$ for σ

(a)	**M1**	For standardising using 96.5/97/97.5 and = z value, where $1<z<1.5$
	M1	For standardising using 85.5/86/86.5 and = z value, where $-1<z<-0.5$
	M1	For use of a correct continuity correction in either equation
	M1	For a correct z value used in either equation
	M1	An attempt at both equations with one fully correct
	M1	For solving simultaneously eliminating μ or σ As this is a show that question then working must be seen.
	dA1	Dependent on all previous M marks being awarded $\sigma=6*$
(b)	**M1**	For $np=\mu$ and $np(1-p)=\sigma^2$ Follow through their μ (Condone $npq=\sigma^2$)
	M1	For solving simultaneously. May be implied by a correct value for p and n
	A1	Both $p=0.6$ and $n=150$