Question Number	Scheme	Marks
1(a)	X = Defects per 150 cm so $X \sim \text{Po}(7.5)$	
	$\frac{e^{-7.5} \times 7.5^5}{5!}$ or $0.2414 - 0.1321$	M1
	$0.10937\ldots$ awrt 0.109	A1
		(2)
(b)	Y = Defects per 100 cm so $Y \sim \text{Po}(5)$	
	$[\text{P}(Y < 4) =] \text{P}(Y \leqslant 3) = 0.2650$	M1
	R = number of 100 cm planks with fewer than 4 defects so $R \sim \text{B}(6, "0.265")$	M1
	$\text{P}(R = 2) = {}^6C_2 \times "0.265"^2 (1 - "0.265")^4$	M1
	$= 0.3074$ awrt 0.307	A1
		(4)
(c)	T = Defects per 600 cm so $T \sim \text{Po}(30)$	
	$V \sim \text{N}(30, 30)$	M1
	$\text{P}(T < 28) \approx \text{P}\left(Z < \frac{27.5 - "30"}{\sqrt{"30"}} [= -0.46]\right)$	M1 M1
	$\left[\text{P}\left(Z < -0.46\right)\right] = 0.3228$ (calc 0.32403…) awrt 0.323 – awrt 0.324	A1
		(4)
	Notes	**Total 10**

(a)	**M1**	For use of $\frac{e^{-\lambda} \times \lambda^5}{5!}$ (for any λ) **or** use of $\text{P}(X \leqslant 5) - \text{P}(X \leqslant 4)$
	A1	awrt 0.109
(b)	**M1**	For writing or using $\text{P}(Y \leqslant 3)$ (allow any letter) May be implied by 0.265(0)
	M1	For writing or using $\text{B}(6, "0.265")$ ft their 0.265
	M1	For use of ${}^6C_2 \times p^2 (1 - p)^4$ where p is a probability. This calculation implies the previous M1 mark
	A1	awrt 0.307
(c)	**M1**	For writing or using N(30, 30) (May be implied by standardisation)
	M1	For standardising using 26.5/27/27.5/28/28.5, their mean and their standard deviation
	M1	For a correct continuity correction (27.5)
	A1	Allow answers in the range awrt 0.323 – awrt 0.324

Question Number	Scheme	Marks
2(a)	$F(8)-F(2)$ or $k\times8^3-k\times2^3$	M1
	$k\times8^3-k\times2^3=\frac{7}{24}$	M1
	$504k=\frac{7}{24}\left[\Rightarrow k=\frac{1}{1728}\right]$*	A1*
		(3)
(b)	$F(b)=1$ So $\frac{b^3}{1728}=1$	M1
	$b=12$	A1
	$f(x)=\left[\frac{d}{dx}F(x)=\right]\frac{1}{576}x^2$	M1
	$f(x)=\begin{cases}\frac{1}{576}x^2 & 0\leqslant x\leqslant 12\\ 0 & \text{otherwise}\end{cases}$	A1
		(4)
(c)	[Median =] $\frac{1}{1728}x^3=\frac{1}{2}$	M1
	x = awrt 9.52	A1
		(2)
(d)	[Mode =]12	B1ft
		(1)
(e)	Negative skew as Median < Mode	B1ft
		(1)

	Notes	Total 11
(a)	**M1**	For writing or using F(8) – F(2)
	M1	For use $F(8)-F(2)=\frac{7}{24}$
	A1*	cso Simplifying to a single term on each side leading to the given answer. Answer is given so there can be no incorrect working seen. $504k=\frac{7}{24}$ leading to $k=\frac{1}{1728}$ **on its own** scores M1M1A0
(b)	**M1**	For use of F(b) = 1
	A1	cao
	M1	For an attempt at $\frac{d}{dx}F(x)$ $x^3\to x^2$
	A1	Fully correct pdf including limits. Allow < instead of $\leqslant$ If b = 12 has been found, allow use of b as an upper limit on line 1
(c)	**M1**	For setting the cdf = 0.5
	A1	awrt 9.52 Condone $\sqrt[3]{864}$ oe e.g. $2(\sqrt[3]{108})$
(d)	**B1ft**	12 cao Allow ft on their value of b / their upper limit **provided $b > 8$**
(e)	**B1ft**	For a correct (ft) reason **and** description of skewness which must be consistent with **their median** and **their mode** (Allow reference to sketch if shown). Ignore reference to mean if they write e.g. "mean < median < mode" Do not allow comparison of median/mode with mean on its own unless the mean, E(X) = 9, seen.

Question Number	Scheme	Marks
3(a)	A **list** of all patients	B1
		(1)
(b)	Individual patients	B1
		(1)
(c)	Advantage: e.g. Less time consuming to obtain data and analysis it/less expensive	B1
	Disadvantage: e.g. May not be representative of the entire population	B1
		(2)
(d)(i)	$B(3000, 0.003) \Rightarrow Po(9)$	M1
	$\left[P(X < 4) = P(X \leqslant 3\right] = 0.0212$	A1
(ii)	$\left[P(7 < X \leqslant 10)\right] = P(X \leqslant 10) - P(X \leqslant 7)$ $=0.7060 - 0.3239$	M1
	$= 0.3821$ awrt 0.382	A1
		(4)
(e)	[*n* is large and] *p* is small	B1
		(1)
	Notes	**Total 9**

(a)	**B1**	Idea of a list e.g. database/register of all patients. All can be implied but do not allow a partial list e.g. A list of 100 patients. Do not allow a list of patient's opinions
(b)	**B1**	Allow patient. Do not allow a patient's opinion
(c)	**B1**	A correct advantage of taking a sample. If not labelled, assume the response refers to a sample (rather than a census)
	B1	A correct disadvantage of taking a sample. If not labelled, assume the response refers to a sample (rather than a census). Condone e.g. 'may not be accurate'
(d)(i)	**M1**	For writing or using Po(9)
	A1	awrt 0.0212 (this implies M1A1) Note: exact binomial gives 0.02109… and scores M0A0
(ii)	**M1**	For writing or using $P(X \leqslant 10) - P(X \leqslant 7)$ or $P(X = 8) + P(X = 9) + P(X = 10)$
	A1	awrt 0.382 (this implies M1A1 and this also implies the M1 mark from part (i)) Note: exact binomial gives 0.38262… and scores M1 (for adding correct probabilities) A0
(e)	**B1**	A correct explanation. Allow mean $\approx$ variance if $np = 9$ and $npq = 8.97(3)$ are found

Question Number	Scheme	Marks
4(a)	There are **2 outcomes**, faulty (component) or not faulty (component) There is a **fixed number** of components (sent to the company for testing) Faults occur **independently** The **probability** of a faulty (component) is **constant**	B1B1
		(2)
(b)	$\left[H_0 : p = 0.2 \quad H_1 : p \neq 0.2\right]$	
	$\left[P(X \leqslant 1) =\right] 0.0105$ or $\left[P(X \leqslant 2) =\right] 0.0442$	M1
	$\left[P(X \geqslant 11) = 1 - P(X \leqslant 10) =\right] 0.0256$ or $\left[P(X \geqslant 12) = 1 - P(X \leqslant 11) =\right] 0.0095$	M1
	$X \leqslant 1 \cup X \geqslant 11$	A1
		(3)
(c)	$\left[0.0105 + 0.0256 =\right] 0.0361$	B1ft
		(1)
(d)	4 is not in the CR [1 < 4 < 11/Do not reject H_0/Not significant]	M1
	Insufficient evidence to reject the company's **claim**	A1ft
		(2)
(e)	$H_0 : p = 0.2 \quad H_1 : p < 0.2$	B1
	$P(X \leqslant 2) =$ awrt 0.0982 or CR $\leqslant 2$	M1
	Reject H_0/Significant/2 is in CR	M1
	Sufficient evidence to suggest that the **probability** of a **faulty** electrical component has **decreased**	A1
		(4)

	Notes	**Total 12**
(a)	**B1**	One correct reason in context **or** two correct reasons not in context For context we require faults/faulty/components mentioned at least once
	B1	Two correct reasons with context mentioned **at least once** (ignore extraneous non-contradictory comments)
(b)	**M1**	For awrt 0.0105 or awrt 0.0442
	M1	For awrt 0.0256 or awrt 0.0095 (allow awrt 0.974 or awrt 0.991)
	A1	A1 for both tails of the CR oe e.g. $X < 2$ and $X > 10$ Allow use of any letter
(c)	**B1ft**	Ft their CR provided that the answer < 0.05
(d)	**M1**	Ft their CR. For a correct ft comparison of 4 with their CR from part (b) Do not allow non-contextual contradictory statements.
	A1ft	For a correct contextual statement ft their CR. Must have the words highlighted in bold Allow e.g. evidence to support **percentage** of **faulty** components is **20**%
(e)	**B1**	Both hypotheses correct must be correctly linked to H_0 and H_1 Must be in terms of p or π
	M1	For p –value of $\left[P(X \leqslant 2) =\right]$awrt 0.0982 (If multiple p –values seen, then 0.0982 must be selected) or for CR $\leqslant 2$
	M1	For a correct non contextual statement consistent with their p-value and 10% / their CR and 2 Do not allow non-contextual contradictory statements. May be implied by a correct contextual statement on its own
	A1	(Dep on 2nd M1) For a correct contextual statement. Must have the words highlighted in bold o.e.

Question Number	Scheme	Marks
5(a)	(4, 4, 4) (4, 4, 6) (4, 4 8)	B1
	(4, 4, 4) (4, 4, 6) (4, 6, 4) (6, 4, 4) (4, 4, 8) (4, 8, 4) (8, 4, 4)	B1
		(2)
(b)	(4, 4, 4) $\left(\frac{1}{2}\right)^3\left[=\frac{1}{8}\right]$	M1M1
	(4, 4, 6) $3\times\left(\frac{1}{2}\right)^2\times\left(\frac{3}{10}\right)\left[=\frac{9}{40}\right]$ (4, 4, 8) $3\times\left(\frac{1}{2}\right)^2\times\left(\frac{2}{10}\right)\left[=\frac{3}{20}\right]$	
	$P(M=4)=\frac{1}{8}+\frac{9}{40}+\frac{3}{20}=\frac{1}{2}$	M1A1
		(4)
(c)	$P(M=8)=\left(\frac{2}{10}\right)^3+3\times\left(\frac{2}{10}\right)^2\times\frac{1}{2}+3\times\left(\frac{2}{10}\right)^2\times\frac{3}{10}\left[=\frac{13}{125}\right]$	M1 M1
	$P(M=6)=\left(\frac{3}{10}\right)^3+3\times\left(\frac{3}{10}\right)^2\times\frac{1}{2}+3\times\left(\frac{3}{10}\right)^2\times\frac{2}{10}+6\times\frac{1}{2}\times\frac{3}{10}\times\frac{2}{10}\left[=\frac{99}{250}\right]$	A1
	m | 4 | 6 | 8 $P(M=m)$ | $\frac{1}{2}$ [= 0.5] | $\frac{99}{250}$ [= 0.396] | $\frac{13}{125}$ [= 0.104]	A1
		(4)
(d)	$1-"\frac{99}{250}"="\frac{151}{250}"\Rightarrow \quad \left("\frac{151}{250}"\right)^n<0.05$	M1
	$n>5.94$ or $n>\frac{\log(0.05)}{\log\left("\frac{151}{250}"\right)}$ or $n>\log_{\left("\frac{151}{250}"\right)}(0.05)$ or $\left("\frac{151}{250}"\right)^5$ **and** $\left("\frac{151}{250}"\right)^6$	dM1
	$n=6$	A1
		(3)

	Notes	Total 13
(a)	**B1**	For the 3 distinct possibilities
	B1	For all 7 possibilities with no errors or additions. Allow (4, 4, 4) (4, 4, 6)×3 (4, 4, 8)×3
(b)	**M1**	For a correct calculation for $P(M=4)$ (may be embedded in an overall calculation)
	M1	For 2 correct calculations for $P(M=4)$ (may be embedded in an overall calculation)
	M1	For adding all 3 correct calculations together
	A1	oe Must come from correct working. Answer only is 0 out of 4.
(c)	**M1**	For a correct calculation for either $P(M=8)$ **or** $P(M=6)$ (implied by 1st A1)
	M1	For a correct calculation for both $P(M=8)$ **and** $P(M=6)$ allow $1-"\frac{1}{2}"-\frac{99}{250}$ or $1-"\frac{1}{2}"-\frac{13}{125}$
	A1	For either $\frac{13}{125}$ or $\frac{99}{250}$
	A1	Fully correct sampling distribution. Need not be in a table.
	SC:	If M0M0 scored but $P(M=4)+P(M=6)+P(M=8)=1$, score M0M1A0A0 Except in the case where $P(M=4)=0.5$, $P(M=6)=0.3$, $P(M=8)=0.2$ which scores 0.
(d)	**M1**	For $1-$ '$P(M=6)$' <0.05 (allow = or any inequality sign)
	dM1	(dep on previous M1) For $n>5.9(4)$ (allow = or any inequality sign) **or** a correct method using logs to find the value of n **or** correct trial and improv. method

	A1	cao Must come from correct probability $P(M=6)=\frac{99}{250}$ Do not allow $n \geqslant 6$

Question Number	Scheme	Marks
6(a)	$\frac{a+b}{2}=\frac{5a}{2}$	M1
	$b=4a$	A1
	$\left[P(X>b-2a)\Rightarrow\right]P(X>2a)=\frac{4a-2a}{4a-a}$ or $P\left(X>\frac{b}{2}\right)=\frac{b-\frac{b}{2}}{b-\frac{b}{4}}$	M1
	$\frac{2}{3}$	A1
		(4)
(b)(i)	$\left[E(Y^2)=Var(Y)+E(Y)^2=\right]\frac{(c-3)^2}{12}+\left(\frac{3+c}{2}\right)^2=549$	M1
	$c^2+3c-1638=0$ oe	M1
	$c=39$	A1
		(3)
(ii)	$\left[P\left(4Y-14<\frac{17-Y}{2}\right)\Rightarrow\right]P(Y<5)$	M1
	$\frac{5-3}{"39"-3}$	M1
	$\frac{1}{18}$	A1
		(3)

	Notes	**Total 10**
(a)	**M1**	For use of $\frac{a+b}{2}$ to set up an equation in terms of a and b
	A1	oe e.g. $a=\frac{b}{4}$
	M1	For a correct expression for $P(X>b-2a)$ their a or their b provided this leads to a probability Allow use of integration $\int_{2a}^{4a}\frac{1}{4a-a}\,dx$ or $\int_{\frac{b}{2}}^{b}\frac{1}{b-\frac{1}{4}}\,dx$
	A1	oe
(b)	**M1**	For use of $Var(Y)+E(Y)^2=549$ Allow use of correct integration with limits substituted for this mark $\int_3^c\frac{1}{c-3}y^2\,dy=549\Rightarrow\frac{1}{c-3}\left(\frac{c^3-3^3}{3}\right)=549$
	M1	For a correct 3TQ oe or a correct cubic $c^3-1647c+4914=0$ oe
	A1	cao if other root(s) shown then they must be rejected. Do not allow awrt 39
(ii)	**M1**	For $P(Y<5)$ allow $Y<5$ for this mark
	M1	For use of $\frac{5-3}{"c"-3}$

	A1	Or exact equivalent e.g. $0.0\dot{5}$

Question Number	Scheme	Marks
7(a)	$[140p = 42 \Rightarrow] p = 0.3$	B1
	$\sigma^2 = 140 \times "0.3" \times (1 - "0.3")$	M1
	29.4	A1
		(3)
(b)(i)	${}^nC_2\left(\frac{1}{3}\right)^2\left(1-\frac{1}{3}\right)^{n-2}$	B1
(ii)	${}^nC_2\left(\frac{1}{3}\right)^2\left(1-\frac{1}{3}\right)^{n-2} = {}^nC_3\left(\frac{1}{3}\right)^3\left(1-\frac{1}{3}\right)^{n-3}$ or $"\frac{n(n-1)}{2\times1}\left(\frac{1}{3}\right)^2\left(1-\frac{1}{3}\right)^{n-2}" = \frac{n(n-1)(n-2)}{3\times2\times1}\left(\frac{1}{3}\right)^3\left(1-\frac{1}{3}\right)^{n-3}$ oe	M1
	$\frac{1}{2}\times\frac{2}{3} = \frac{1}{6}\times\frac{1}{3}\times(n-2)$ oe (may be implied by $6 = n - 2$)	M1
	$n = 8$	A1
		(4)
(c)	$\frac{e^{-\lambda}\lambda^r}{r!} = \frac{(r+2)e^{-\lambda}\lambda^{r+2}}{(r+2)!}$	M1
	$\frac{(r+2)!}{r!(r+2)} = \frac{\lambda^{r+2}}{\lambda^r}$	M1
	$\lambda = \sqrt{r+1}$	A1
		(3)

	Notes	**Total 10**
(a)	**B1**	oe cao
	M1	For use of $np(1-p) = \sigma^2$ ft their p
	A1	oe
(b)(i)	**B1**	For a correct expression. isw after a correct expression is seen
(ii)	**M1**	For setting up a correct equation ft (b)(i) Allow use of any clear notation for nC2 and nC3 Condone use of $p = 0.3$
	M1	For reducing to a correct linear equation in n Condone use of $p = 0.3$
	A1	cao
(c)	**M1**	For setting up a correct equation
	M1	For attempting to rearrange to have an equation with one side in terms of r and the other side in terms of λ $r + 1 = \lambda^2$ implies M1M1
	A1	oe e.g. $\lambda = \sqrt{\frac{(r+2)!}{r!(r+2)}}$ do not allow ±