Maths Questions By Topic:

Statistical Distributions
Mark Scheme

A-Level Edexcel

0207 060 4494
www.expert-tuition.co.uk
online.expert-tuition.co.uk
enquiries@expert-tuition.co.uk
The Foundry, 77 Fulham Palace Road, W6 8JA

Table Of Contents

Qu	Scheme	Mark	AO
1. (i)	[D = number of bags that are damp] $D \sim \mathrm{B}(35, 0.08)$ NB $0.08 = \frac{2}{25}$	M1	3.3
(ii)	$\mathrm{P}(D = 2) = 0.2430497\ldots$ awrt **<u>0.243</u>**	A1	3.4
	$\mathrm{P}(D > 3) = \left[1 - \mathrm{P}(D \leqslant 3) = 1 - 0.69397...\right] = 0.30602\ldots$ awrt **<u>0.306</u>**	A1	1.1b
		(3)	
		(3 marks)	

	Notes
	M1 for selecting a correct model: sight of or use of B(35, 0.08) [Condone B(0.08, 35)] May be implied by one correct answer or sight of P(D 3) = awrt 0.694 (or allow 0.693) <u>or</u> seeing $\binom{35}{2} 0.08^2 \times (1 - 0.08)^{35-2}$ Saying B(35, 8%) without a correct calculation would score M0
(i)	1st A1 for awrt 0.243
(ii)	2nd A1 for awrt 0.306 (Condone poor use of notation e.g. P(D = 3) = 0.306… i.e. just mark ans)
NB	$\mathrm{P}(D \geqslant 3) = 0.539$ scores 2nd A0 but would of course score M1

Qu	Scheme	Marks		AO
2. (a)	[R = no. of red beads in Aliya's bracelet] $R \sim \mathrm{B}(18, 0.14)$	B1		3.3
		(1)		
(b)(i)	$\mathrm{P}(R = 1) = 0.19403\ldots$ awrt **0.194**	B1		1.1b
(ii)	$\mathrm{P}(R \quad 4) = 1 - \mathrm{P}(R \quad 3) = 1 - [0.76184\ldots]$	M1		3.4
	$= 0.2381588\ldots$ awrt <u>**0.238**</u>	A1		1.1b
		(3)		
(c)	Requires $p = 0.14$ to be constant so need a large number of beads in the sack to ensure that removing 18 beads does not appreciably affect this probability, then it could be suitable.	B1		3.5b
		(1)		
		(5 marks)		

	Notes
(a)	B1 for B(18, 0.14) accept in words e.g. <u>binomial</u> with <u>$n = 18$</u> and <u>$p = 0.14$</u>
(b)(i)	B1 for awrt 0.194
(ii)	M1 for interpreting "at least 4" Need $1 - \mathrm{P}(R \quad 3)$ <u>and</u> $1 - p$ $[0 < p < 1]$ $\mathrm{P}(R = 3) = 0.233..$ OK
	A1 for awrt 0.238
(c)	B1 for mention of <u>large number of beads</u> and need for <u>$p = 0.14$ to be constant</u> for it to be suitable. Do NOT accept e.g. "events are independent"

Question	Scheme	Marks	AOs
3(a)	Let C = the number of successful calls. $C \sim \mathrm{B}\left(9, \frac{1}{6}\right)$	M1	3.3
	$\mathrm{P}(C \geq 3) = 1 - \mathrm{P}(C \leq 2) = 0.1782\ldots$ **awrt 0.178**	A1	1.1b
		(2)	
(b)	Let X = the number of occasions when at least 3 calls are successful. $\mathrm{P}(X = 1) = 5 \times (\text{"}0.1782...\text{"}) \times (\text{"}0.8217...\text{"})^4$	M1	1.1b
	$= 0.4061\ldots$ **awrt 0.406**	A1	1.1b
		(2)	
		(4 marks)	

Notes

3(a)	**M1:**	For selecting the right model
	A1:	awrt 0.178
(b)	**M1:**	For $5 \times (\text{"their}(a)\text{"}) \times (\text{"}1 - \text{their}(a)\text{"})^4$
	A1:	awrt 0.406

Question	Scheme	Marks	AOs
4(a)	(Discrete) uniform (distribution)	B1	1.2
		(1)	
(b)	B(28, 0.2)	B1	3.3
(i)	$\text{P}(X \geq 7) = 1 - \text{P}(X \leq 6)$ [= 1 − 0.6784…]	M1	3.4
	awrt **0.322**	A1	1.1b
(ii)	$\text{P}(4 \leq X < 8) = \text{P}(X \leq 7) - \text{P}(X \leq 3)$ [= 0.818… − 0.160…]	M1	3.1b
	awrt **0.658**	A1	1.1b
		(5)	
			(6 marks)

Notes

(a)	Continuous uniform is B0
(b)	**B1:** for identifying correct model, B(28, 0.2) allow B, bin or binomial may be implied by one correct answer or sight one correct probability i.e. awrt 0.678, awrt 0.818 or awrt 0.160 B(0.2, 28) is B0 unless it is used correctly
(i)	**M1:** Writing or using $1 - \text{P}(X \leq 6)$ or $1 - \text{P}(X < 7)$ **A1:** awrt 0.322 (correct answer only scores M1A1)
(ii)	**M1:** Writing or using $\text{P}(X \leq 7) - \text{P}(X \leq 3)$ or $\text{P}(X < 8) - \text{P}(X < 4)$ or $\text{P}(X = 4) + \text{P}(X = 5) + \text{P}(X = 6) + \text{P}(X = 7)$ Condone P(4) as P(X = 4), etc. **A1:** awrt 0.658 (correct answer only scores M1A1)

Qu	Scheme	Marks	AO
5	Let N = the number of games Naasir wins $N \sim B(15, \quad)$	M1	3.3
(i)	$P(N = 2) = 0.059946\ldots$ **awrt 0.0599**	A1	1.1b
(ii)	$P(N > 5) = 1 - P(N \quad 5) = 0.38162\ldots$ **awrt 0.382**	A1	1.1b
		(3)	
		(3 marks)	
	Notes		
	M1 for selecting a binomial model with correct n and p Award for sight of $B(15, \quad)$ (o.e. e.g. in words) or implied by 1 correct answer 1st A1 for awrt 0.0599 (from a calculator). Allow 0.05995 2nd A1 for awrt 0.382 (from a calculator)		

Qu	Scheme	Marks	AO
6(a)	P(X = 4) = P(X = 2) so P(X = 4) = 0.35 P(X = 1) = P(X = 3) and P(X = 1) + P(X = 3) = 1 – 0.7 So x: 1, 2, 3, 4 P($X = x$): 0.15, 0.35, 0.15, [0.35]	M1 A1 (2)	2.1 1.1b
(b)	Let A = number of spins that land on 4 $A \sim$ B(60, "0.35")	B1ft	3.3
	[P(A > 30) =] 1 – P($A \leqslant$ 30) = 1 – 0.99411… = **awrt 0.00589**	M1 A1 (3)	3.4 1.1b
(c)	$Y - X \leqslant 4 \Rightarrow \frac{12}{X} - X \leqslant 4$ <u>or</u> $12 - X^2 \leqslant 4X$ (since $X > 0$) o.e.	M1	3.1a
	i.e. $0 \leqslant X^2 + 4X - 12 \Rightarrow 0 \leqslant (X+6)(X-2)$ so $X \geqslant 2$	M1	1.1b
	$\text{P}(Y - X \leqslant 4) = \text{P}(X \geqslant 2) = 0.35 + 0.15 + 0.35$ = <u>**0.85**</u>	A1 (3)	3.2a
		(8 marks)	

	Notes
(a)	M1 for using the given information to obtain P(X = 4) Award for statement P(X = 4) = P(X = 2) <u>or</u> writing P(X = 4) = 0.35 A1 for getting fully correct distribution (any form that clearly identifies probs) e.g. can be list P(X = 1) = 0.15, P(X = 3) = …etc or as a probability function $\text{P}(X = x) = \begin{cases} 0.15 & x = 1,3 \\ 0.35 & x = 2,4 \end{cases}$ [Condone missing P(X = 2) as this is given in QP]
(b)	B1 for selecting a suitable model, sight of B(60, their 0.35) o.e. in words f.t. their P(X = 4) from part (a). Can be implied by P($A \leqslant$ 30) = awrt 0.9941 or final answer = awrt 0.00589 M1 for using their model and interpreting "more than half" Need to see 1 – P($A \leqslant$ 30) . Can be implied by awrt 0.00589 Can ignore incorrect LHS such as P($A \geqslant$ 30) A1 for awrt 0.00589
(c)	1st M1 for translating the prob. problem into a <u>correct</u> mathematical inequality Just an inequality in 1 variable. May be inside a probability statement.
ALT	**Table of values:** X: 1, 2, 3, 4; Y: 12, 6, 4, 3 <u>or</u> values of $Y - X$ = 11, 4, 1, – 1
	2nd M1 for solving the inequality leading to a range of values, allow 1 or 2 slips May be a quadratic or cubic but must lead to a set of values of X or $Y - X$
ALT	**Table or values:** They must state clearly which values are required **Both Ms can be implied by a correct answer (or correct ft of their distb'n)** A1 for interpreting the inequality and solving the problem i.e. 0.85 cao

Question	Scheme	Marks	AOs
7	$\mathrm{P}(5 \leq X < 12) = \mathrm{P}(X \leq 11) - \mathrm{P}(X \leq 4)$	M1	1.1b
	$= 0.8939 - 0.0495$ **= awrt <u>0.844</u>**	A1	1.1b
		(2)	
(2 marks)			
Notes:			
M1: For dealing with $\mathrm{P}(5 \leq X < 12)$ they need to use the cumulative prob. Function on the calc. **A1:** awrt 8.44 (from calculator).			

Question	Scheme	Marks	AOs
8	$\mathrm{P}(X \geqslant 16) = 1 - \mathrm{P}(X \leqslant 15)$	M1	1.1b
	$= 1 - 0.949077\ldots \quad = $ awrt $\underline{\mathbf{0.0509}}$	A1	1.1b
		(2)	
			(2 marks)

Continued question 8

Notes:

M1: For dealing with $\mathrm{P}(X \geqslant 16)$ – they need to use cumulative prob. function on calc

A1: awrt 0.0509 (from calculator)

<table>
<tr><th>Question</th><th colspan="2">Scheme</th><th>Marks</th><th>AOs</th></tr>
<tr><td rowspan="2">9(a)(i)</td><td colspan="2">$X \sim \mathrm{B}(15,\ 0.48)$</td><td>M1</td><td>3.3</td></tr>
<tr><td colspan="2">$\mathrm{P}(X=3)=0.019668...$ awrt 0.0197</td><td>A1</td><td>3.4</td></tr>
<tr><td>(ii)</td><td colspan="2">$[\mathrm{P}(X \geqslant 5)=1-\mathrm{P}(X \leqslant 4)]=0.92013...$ awrt 0.920</td><td>A1</td><td>1.1b</td></tr>
<tr><td></td><td colspan="2"></td><td>(3)</td><td></td></tr>
<tr><td rowspan="5">(b)</td><td>Y is the number of hits</td><td>M is the number of misses</td><td></td><td></td></tr>
<tr><td>$Y \sim \mathrm{N}(120, 62.4)$</td><td>$M \sim \mathrm{N}(130, 62.4)$</td><td>B1</td><td>3.3</td></tr>
<tr><td>$\mathrm{P}(X>110) \approx \mathrm{P}(Y>110.5)$
$\left[=\mathrm{P}\left(Z>\frac{110.5-"120"}{\sqrt{"62.4"}}\right)\right]$</td><td>$\mathrm{P}(X>110) \approx \mathrm{P}(M<139.5)$
$\left[=\mathrm{P}\left(Z<\frac{139.5-"130"}{\sqrt{"62.4"}}\right)\right]$</td><td>M1</td><td>3.4</td></tr>
<tr><td colspan="2">= 0.88544…</td><td>A1</td><td>1.1b</td></tr>
<tr><td colspan="2"></td><td>(3)</td><td></td></tr>
<tr><td colspan="5">(6 marks)</td></tr>
</table>

<table>
<tr><th colspan="4">Notes:</th></tr>
<tr><td>(a)</td><td>M1</td><td colspan="2">Writing or using the binomial distribution in (i) or (ii) Allow for sight of B(15, 0.48) or in words: <u>binomial</u> with <u>n = 15</u> and <u>p = 0.48</u> may be implied in (i) or (ii) by one correct answer to 3sf <u>or</u> sight of $\mathrm{P}(X \leqslant 4)=0.07986\ldots$ i.e. awrt 0.0799.
Allow for ${}^{15}C_3 \times 0.48^3 \times 0.52^{12}$ as this is "correct use" Condone B(0.48, 15)</td></tr>
<tr><td>(i)</td><td>A1</td><td colspan="2">awrt 0.0197</td></tr>
<tr><td>(ii)</td><td>A1</td><td colspan="2">awrt 0.920 (Allow 0.92)</td></tr>
<tr><td>(b)</td><td>B1</td><td colspan="2">Setting up a correct Normal model. Allow sight of $\mathrm{N}(120, 62.4)$ or $\mathrm{N}(130, 62.4)$ or $\mathrm{N}\left(120, \frac{312}{5}\right)$ or $\mathrm{N}\left(130, \frac{312}{5}\right)$ or may be awarded if used correctly in standardisation
or in words: <u>Normal</u> with <u>mean = 120/130</u> and
<u>variance = 62.4</u> or sd = $\sqrt{62.4}$ condone $\mathrm{N}(120, \sqrt{62.4})$ or $\mathrm{N}(130, \sqrt{62.4})$ or sd = 62.4
Look out for $\sigma=\frac{\sqrt{1560}}{5}$ or $\frac{2\sqrt{390}}{5}$ or awrt 7.90 (condone 7.9)
This may be implied by sight of 0.897 or 0.8854…</td></tr>
<tr><td rowspan="4"></td><td rowspan="4">M1</td><td colspan="2">Sight of the continuity correction with a normal distribution</td></tr>
<tr><td>110.5 or 111.5 or 109.5</td><td>139.5 or 140.5 or 138.5</td></tr>
<tr><td>NB we will also allow 129.5 or 130.5 or 128.5</td><td>NB we will also allow 120.5 or 119.5 or 121.5</td></tr>
<tr><td colspan="2">Continuity correction may be seen in standardisation
NB No continuity correction(CC) gives awrt 0.897 which is M0 unless CC seen</td></tr>
<tr><td></td><td>A1</td><td colspan="2">awrt 0.8854 or awrt 0.885 dependent on sight of >110.5 or <129.5 or < 139.5 or >120.5
Allow $\leqslant$ or $\geqslant$ instead of $<$ or $>$
NB 0.885548… from B(250, 0.48) scores M0A0</td></tr>
</table>

Qu	Scheme		Marks	AOs
10(a)	$\left[\mathrm{P}\left(L<7.902\right)=0.025\Rightarrow\right]\ \dfrac{7.902-8}{x}=-1.96$ oe		M1	3.4
	$[x=]0.05$ *		A1cso*	1.1b
	SC B1(mark as M0A1) for $\dfrac{7.902-8}{0.05}=-1.96\Rightarrow 0.024998$			
			(2)	
(b)	$\mathrm{P}\left(7.94\leqslant L\leqslant 8.09\right)=0.8490\ldots$ **awrt 0.849**		B1	1.1b
			(1)	
(c)	$[\mathrm{P}\left(L<7.94\right)=]\ 0.115069\ldots$ (awrt 0.115) **or** $[\mathrm{P}\left(L>8.09\right)=]\ 0.03593\ldots$ (awrt 0.036)		B1	1.1b
	$[\mathrm{P}\left(L<7.94\right)=]\ 0.115069\ldots$ (awrt 0.115) **&** $[\mathrm{P}\left(L>8.09\right)=]\ 0.03593\ldots$ (awrt 0.036)		B1	1.1b
	Expected income per 500 rods = $\sum\left(\text{Income}\times\text{probability}\times 500\right)$ $\left(500\times"0.849"\times 0.5\right)+\left(500\times"0.1150..."\times 0.05\right)+\left(500\times"0.03593..."\times 0.4\right)$ **or** Expected profit per rod = $\sum\left(\text{Profit}\times\text{probability}\right)$ $0.30\times"0.849"+-0.15\times"0.1150..."+0.20\times"0.03593..."$ [= 0.2446..]		M1	3.4
	Expected profit per 500 rods $500\times\sum\left(\text{Profit}\times\text{probability}\right)$ **or** $\sum\left(\text{Income}\times\text{probability}\times 500\right)-500\times 0.2$ $=500\times"0.2446..."$ **or** $="222.3"-500\times 0.2$		M1d	3.1b
	= [£]122.3… **awrt [£]122**		A1	1.1b
			(5)	
(d)	Let $X\sim\mathrm{B}(200,0.015)$		M1	3.3
	$\mathrm{P}(X\leqslant 5)=$	$\mathrm{P}\left(X\geqslant 6\right)=$	M1	1.1b
	0.9176…	0.0824	A1	1.1b
	Manufacturer is unlikely to achieve their aim since <u>0.9176 < 0.95</u>	Manufacturer is unlikely to achieve their aim since <u>0.0824 > 0.05</u>	A1ft	2.4
			(4)	

Notes: **(12 marks)**

(a)	M1	Using the normal distribution to set up equation. Allow σ for x and awrt ± 1.96	
	A1*	cso For a correct expression for x followed by 0.05 or 0.05000… No incorrect working seen	
(b)	B1	awrt 0.849	
(c)	B1	awrt 0.115 (Implied by awrt 57.5 for number of rods) **or** awrt 0.036 (Implied by awrt 18 for number of rods)	
	B1	awrt 0.115 (Implied by awrt 57.5 for number of rods) **and** awrt 0.036 (Implied by awrt 18 for number of rods)	
	M1	Correct method to find the total income of 500 rods. Attempt at all 3 with at least two correct and no extras **or** Correct method to find sum of all three profits with at least two of 30, −15 or 20 correct. May work in pence but need to be consistent. Allow awrt 24.5 or 0.245	
	M1d	Dep on previous method for finding profit for 500 rods. May work in pence but need to be consistent. Allow $"0.2446..."\times 500$ or "their income" for 500 rods -500×0.2 (accept 499 or 501)	
	A1	All previous marks must be awarded for awrt 122 awrt 12200p **NB** if uses any integer values for numbers of rods then it is A0 other than for 18 for $L>8.09$	
(d)	M1	Selecting the appropriate model. May be seen or used. Allow B(200,0.985) or Po(3) Condone B(0.015, 200) or B(0.985, 200).	
	M1	Writing or using $\mathrm{P}\left(X\leqslant 5\right)$ Do not accept $\mathrm{P}\left(X<6\right)$ unless found $\mathrm{P}\left(X\leqslant 5\right)$	Writing or using $\mathrm{P}\left(X\geqslant 6\right)$ Do not accept $\mathrm{P}\left(X>5\right)$ unless found $\mathrm{P}\left(X\geqslant 6\right)$
	A1	0.92 (Poisson 0.916…)	0.08 or better
	A1ft	Need at least one of the method marks to be awarded. Correct conclusion with the comparison (may be in words). Ft "their $p=0.9176\ldots$" as long as $p>0.9$ If "their 0.9176…"< 0.95 must … be unlikely… If "their 0.9176…"> 0.95 they must say … be likely... To ft the alternative then $p<0.1$	

Question	Scheme	Marks	AOs
11	eg $p = 0.27$ is unlikely to be constant.	B1	2.4
		(1)	
			(1 mark)

Notes:

11	**B1**	A correct reason referring to • independence (needs context as to what is independent) eg consecutive 14 days unlikely to be independent. • probability [of rain] not being constant. • Allow a comment that conveys the idea that the proportion of days with no rain will be different over the year.

Qu 12	Scheme	Marks	AO
(a)	[Sight or correct use of] $X \sim B(36, 0.08)$	M1	3.3
(i)	$P(X = 4) = 0.167387\ldots$ awrt **<u>0.167</u>**	A1	1.1b
(ii)	$\left[P(X \geqslant 7) = 1 - P(X \leqslant 6) =\right]$ 0.022233… awrt **<u>0.0222</u>**	A1	1.1b
		(3)	
(b)	P(In dance club and dance tango) = 0.4×0.08 = **<u>0.032</u>** <u>or</u> $\underline{\underline{\frac{4}{125}}}$ <u>or</u> **<u>3.2%</u>**	B1	1.1b
		(1)	
(c)	[Let T = those who can dance the Tango. Sight or use of] $T \sim B(50, \text{"0.032"})$	M1	3.3
	$[P(T < 3) = P(T \leqslant 2) =]$ 0.7850815… awrt **<u>0.785</u>**	A1	1.1b
		(2)	
		(6 marks)	
	Notes		
(a)	M1 for sight of B(36, 0.08) Allow in words: <u>binomial</u> with <u>$n = 36$</u> and <u>$p = 0.08$</u> may be implied by one correct answer to 2sf <u>or</u> sight of $P(X \leqslant 6) = 0.97776...$ i.e. awrt 0.98 Allow for $36C4 \times 0.08^4 \times 0.92^{32}$ as this is "correct use"		
(i)	1st A1 for awrt 0.167 NB An answer of just awrt 0.167 scores M1($\Rightarrow$)1st A1		
(ii)	2nd A1 for awrt 0.0222		
(b)	B1 for 0.032 o.e. (Can allow for sight of 0.4×0.08)		
(c)	M1 for sight of B(50, "0.032") ft their answer to (c) provided it is a probability $\neq 0.08$ may be implied by correct answer <u>or</u> sight of $[P(T \leqslant 3)] = 0.924348\ldots$ i.e. awrt 0.924 or $P(T \leqslant 2)$ as part of $1 - P(T \leqslant 2)$ calc. A1 for awrt 0.785		
MR	Allow MR of 50 (e.g. 30) provided clearly attempting $P(T \leqslant 2)$ and score M1A0		

Qu 13	Scheme	Marks	AO
(a)	$\left[\text{Let } \quad F \sim \mathrm{N}\left(166.5, 6.1^2\right)\right]$ $\quad \mathrm{P}(F < k) = 0.01 \Rightarrow \dfrac{k - 166.5}{6.1} = -2.3263$	M1	3.4
	$k = 152.309\ldots$ $\quad$ **152** or awrt **152.3**	A1	1.1b
		(2)	
(b)	[$\mathrm{P}(150 < F < 175) =$] $0.914840\ldots$ $\quad$ awrt **0.915**	B1	1.1b
		(1)	
(c)	$\mathrm{P}(F > 160 \mid 150 < F < 175)$	M1	3.1b
	$= \dfrac{\mathrm{P}(160 < F < 175)}{\mathrm{P}(150 < F < 175)}$ or $\dfrac{\mathrm{P}(160 < F < 175)}{\text{"(b)"}}$	M1	1.1b
	$= \dfrac{0.7749487...}{\text{"}0.91484...\text{"}}$	A1ft	1.1b
	$= 0.84708\ldots$ awrt **0.847**	A1	1.1b
		(4)	
		(7 marks)	

	Notes
(a)	M1 for standardising (allow $\pm$) with k, 166.5 and 6.1 and set equal to a z value $2.3 < \lvert z \rvert < 2.4$
	A1 for 152 or awrt 152.3 **Ans only** 2/2 [Condone poor use of notation e.g. $\mathrm{P}(\frac{k-166.5}{6.1}) = -2.3263$]
	Allow percentages instead of probabilities throughout.
(b)	B1 for awrt 0.915
(c)	1st M1 for interpreting demand as an appropriate conditional probability ($\Rightarrow$ by 2nd M1)
	2nd M1 for correct ratio of expressions (can ft their (b) on denominator) ($\Rightarrow$ by 1st A1ft)
	1st A1ft for a correct ratio of probs (can ft their "0.9148…" to 3sf from (b) if > 0.775)
	2nd A1 for awrt 0.847

Qu 14	Scheme	Marks	AO
(a)	{Let X = time spent, $P(X > 15) =$ } 0.105649… awrt **0.106**	B1 **(1)**	1.1b
(b)(i)	[$P(T < 2) =$] 0.1956… awrt **0.196**	B1 **(1)**	1.1b
(ii)	Require $\frac{P(0<T<2)}{P(T>0)} = \frac{0.119119...}{0.923436...}$; $= 0.1289955…$ awrt **0.129**	M1 A1;A1 **(3)**	3.4 1.1bx2
(iii)	The current model suggests **non-negligible** probability of T values < 0 which is impossible	B1 **(1)**	3.5b
(c)	Require t such that $P(T > t \mid T > 2) = 0.5$ <u>or</u> $P(T < t \mid T > 2) = 0.5$ e.g. $\frac{P(T>t)}{P(T>2)} = 0.5$; so $P(T > t) = 0.5\times[1 – \text{(c)(i)}]$ or $P(T > t) = 0.5\times0.8043..$ [i.e. $P(T > t) = 0.40…$ implies] $\frac{t-5}{3.5} = 0.2533$ <u>or</u> $P(T < t) =$ "0.5978.." $t = 5.886…$ <u>or</u> from calculator 5.867… so awrt **5.9**	M1 M1; A1ft M1 A1 **(5)**	3.1b 1.1b 3.4 1.1b 1.1b
		(11 marks)	

Notes

(a)	B1 for awrt 0.106 (from calculator) [Allow 10.6%]
(b)(i)	B1 for awrt 0.196 (from calculator) [Allow 19.6%]
(ii)	M1 for a correct probability ratio expression (may be implied by 1st A1 scored) 1st A1 for a correct ratio of probabilities (both correct or truncated to 2 dp) 2nd A1 for awrt 0.129
(iii)	B1 for a suitable explanation of why model is not suitable based on negative T values Must say that a **significant** proportion of values < 0 (o.e.) e.g. $P(T > 0)$ should be **closer** to 1 <u>or</u> Difference between $P(T < 2 \mid T > 0)$ and $P(T < 2)$ is **too big** (o.e.)
(c)	1st M1 for a correct conditional probability statement to start the problem <u>or</u> $0.5\times P(T > 2)$ 2nd M1 for correct ratio of probability expressions [Must have $P(T > t)$ or $P(2 < T < t)$] 1st A1ft for a correct equation for $P(T > t)$ (o.e.) ft their answer to part (c)[May be in a diagram] 3rd M1 for attempt to find t (standardising and sight of 0.2533) or prepare to use calc (ft) Arriving at $P(T < \text{median}) = 1 – 0.5\times$"their 0.8043" will score 1st 4 marks 2nd A1 for awrt 5.9 Sight of awrt 5.9 and at least one M mark scores 5/5 [Answer only send to review]

Question	Scheme		Marks	AOs
15(a)	z = (±) 1.28(16)	$[P_{90}=]29.251...$ or $[P_{10}=]15.948...$	B1	3.1b
	2 × 1.2816 × 5.19	'29.251…' – '15.948…'	M1	1.1b
	= awrt **<u>13.3</u>**		A1	1.1b
			(3)	
(b)	Daily mean <u>wind speed</u>/<u>Beaufort</u> conversion since it is <u>qualitative</u> <u>Rain</u>fall since it is not symmetric/lots of days with 0 rainfall		B1 B1	2.4 2.4
			(2)	
				(5 marks)

Notes

(a)	**B1:** Identifying z-value for 10th or 90th percentile (allow awrt (±) 1.28) or for identifying $[P_{90}=]29.251...$ (awrt 29.3) or $[P_{10}=]15.948...$ (awrt 15.9) (This may be implied by a correct answer awrt 13.3) **M1:** for $2 \times z \times 5.19$ where $1 < z < 2$ or for their $P_{90} - P_{10}$ where $25 < P_{90} < 35$ and $10 < P_{10} < 20$ **A1:** awrt 13.3
(b)	**B1:** for one variable identified and a correct supporting reason **B1:** for two variables identified and a correct supporting reason for each Allow any two of the following: • <u>Wind speed/Beaufort</u> since the data is <u>non-numeric</u> (o.e.). They need not mention Beaufort provided there is a description of the data as non-numeric (Do not allow wind direction/wind gust) • <u>Rain</u>fall as not symmetric/is skewed/is not bell shaped/lots of 0s /many days with no rain/mean≠mode or median • <u>Date</u> since each data value appears once/it is uniformly distributed • Daily mean <u>pressure</u> since it is not symmetric/is skewed/not bell shaped • Daily mean <u>wind speed</u> since it is not symmetric/is skewed/not bell shaped Do not allow 'not continuous' or 'discrete' as a supporting reason. Ignore extraneous non-contradicting statements

Question	Scheme	Marks	AOs
16 (a)(i)	$P(X \geq 6) = 1 - P(X \leq 5)$ or $P([X =]6) + P([X =]7) + P([X =]8)$	M1	3.4
	$= 1 - 0.296722...$ awrt **<u>0.703</u>**	A1	1.1b
		(2)	
(a)(ii)	$184 \times P(X = 7)$ $[= 184 \times 0.2811\ldots]$	M1	1.1b
	$= 51.7385...$ awrt **<u>51.7</u>**	A1	1.1b
		(2)	
(b)	Part (a) and part (b)(i) are similar **and** the expected number of 7s (51.7 or 0.281) matches with the number of 7s found in the data set (52 or 0.283) so Magali's model is supported.	B1ft	3.5a
		(1)	
(c)	$\frac{23}{28} = 0.82142...$ awrt **<u>0.821</u>**	B1	1.1b
		(1)	
(d)	Any one of… • Part (d)/'0.821' differs from part (a)/(b)(i)/(0.7…) • there is a **greater/different probability of high cloud cover/more likely to have high cloud cover** if the previous day had high cloud cover • **independence(o.e.)** does not hold	B1	2.4
	…therefore Magali's (binomial) model may not be suitable.	dB1	3.5a
		(2)	
			(8 marks)

Notes

	Allow fractions, decimals or percentages throughout this question.
(a)(i)	**M1:** for writing or using $1 - P(X \leq 5)$ or $P(X = 6) + P(X = 7) + P(X = 8)$ **A1:** awrt 0.703 (correct answer scores 2 out of 2)
(a)(ii)	**M1:** for $184 \times P(X = 7)$ o.e. e.g., $184 \times [P(X \leq 7) - P(X \leq 6)]$ **A1:** awrt 51.7
(b)	**B1ft:** comparing '0.717' with '0.703' <u>and</u> '51.7 or '0.281' with 52 or 0.283 **and** concluding that Magali's model **is supported** (must be comparing prob. with prob. <u>and</u> days with days). Allow not supported or mixed conclusions if consistent with their f.t. answers in (a) and (b)
(d)	**B1:** Any bullet point **dB1:** (dep on previous B1) for Magali's model may not be suitable (o.e.) Condone not accurate for not suitable **SC:** part (d) is similar to part (a)/(b)(i) **and** a compatible conclusion (i.e. Magali's model is supported) to score B1B1.

Question	Scheme	Marks	AOs
17(a)	$\frac{24.63-25}{'\sigma'}=-1.0364$	M1	3.1b
	$[\sigma=]0.357$ (must come from compatible signs)	A1	1.1b
	$P(D>k)=0.4$ or $P(D<k)=0.6$	B1	1.1b
	$\frac{k-25}{'0.357'}=0.2533$	M1	3.4
	$k=$ awrt **25.09**	A1	1.1b
		(5)	
(b)	$[Y \sim B(200, 0.45) \rightarrow]\ W \sim N(90, 49.5)$	B1	3.3
	$P(Y<100) \approx P(W<99.5)\ \left[=P\left(Z<\frac{99.5-90}{\sqrt{49.5}}\right)\right]$	M1	3.4
	$= 0.9115\ldots$ awrt **0.912**	A1	1.1b
		(3)	
			(8 marks)

Notes

(a)	**M1:** for standardising 24.63, 25 and 'σ' (ignore label) and setting = to z where $1<\lvert z\rvert<2$ **A1:** [$\sigma=$] awrt 0.36. Do **not** award this mark if signs are not compatible. **B1:** for either correct probability statement (may be implied by correct answer) this mark may be scored for a correct region shown on a diagram **M1:** for a correct expression with $z=$ awrt 0.253 (may be implied by correct answer) **A1:** awrt 25.09 (Correct answer with no incorrect working scores 5 out of 5)
(b)	**B1:** setting up normal distribution approximation of binomial N(90, 49.5) (may be implied by a correct answer) Look out for e.g. $\sigma=\frac{3\sqrt{22}}{2}$ or $\sigma=$ awrt 7.04 **M1:** attempting a probability using a continuity correction i.e. $P(W<100.5)$, $P(W<99.5)$ or $P(W<98.5)$ condone $\leq$ (The continuity correction may be seen in a standardisation). **A1:** awrt 0.912 [Note: 0.911299… from binomial scores 0 out of 3]

Qu 18	Scheme	Marks	AO
(a)	The probability of a dart hitting the target is constant (from child to child and for each throw by each child) (o.e.)	B1	1.2
	The throws of each of the darts are independent (o.e.)	B1	1.2
		(2)	
(b)	[P($H \geqslant 4$) = 1 – P($H \leqslant 3$) = 1 – 0.9872 = 0.012795.. =] awrt **0.0128**	B1	1.1b
		(1)	
(c)	P(F = 5) = $0.9^4 \times 0.1$, = 0.06561	M1,	3.4
	= awrt **0.0656**	A1	1.1b
		(2)	
(d)	n: 1, 2, …, 10; P($F = n$): 0.01, 0.01 + α, …, 0.01+9α	M1	3.1b
	Sum of probs = 1 $\Rightarrow \frac{10}{2}\left[2\times 0.01+9\alpha\right]=1$	M1A1	3.1a 1.1b
	[i.e. 5(0.02 + 9α) = 1 or 0.1 + 45α = 1] so α = **0.02**	A1	1.1b
		(4)	
(e)	P(F = 5| Thomas' model) = **0.09**	B1ft	3.4
		(1)	
(f)	Peta's model assumes the probability of hitting target is constant (o.e.) **and** Thomas' model assumes this probability increases with each attempt(o.e.)	B1	3.5a
		(1)	
		(11 marks)	

n	1	2	…	10
P($F = n$)	0.01	0.01 + α	…	0.01+9α

Notes

(a) 1st B1 for stating that the probability (or possibility or chance) is constant (or fixed or same)
2nd B1 for stating that throws are independent ["trials" are independent is B0]

(b) B1 for awrt 0.0128 (found on calculator)

(c) M1 for a probability expression of the form $(1-p)^4 \times p$ where $0 < p < 1$
A1 for awrt 0.0656
SC Allow M1A0 for answer only of 0.066

(d) 1st M1 for setting up the distribution of F with at least 3 correct values of n and P($F = n$) in terms of α. (Can be implied by 2nd M1 or 1st A1)
2nd M1 for use of sum of probs = 1 **and** clear summation or use of arithmetic series formula (allow 1 error or missing term). (Can be implied by 1st A1)
1st A1 for a correct equation for α
2nd A1 for α = 0.02 (must be exact and come from correct working)

(e) B1ft for value resulting from 0.01 + 4×"their α" (provided α and the answer are probs)
Beware If their answer is the same as their (c) (or a rounded version of their (c)) score B0

(f) B1 for a suitable comment about the probability of hitting the target
ALT Allow idea that Peta's model suggests the dart may never hit the target but Thomas' says that it will hit at least once (in the first 10 throws).

Qu 19	Scheme	Marks	AO
(a)	$P(L > 16) = 0.69146\ldots$ **awrt 0.691**	B1 (1)	1.1b
(b)	$P(L > 20 \mid L > 16) = \dfrac{P(L > 20)}{P(L > 16)}$	M1	3.1b
	$= \dfrac{0.308537...}{(a)}$ <u>or</u> $\dfrac{1-(a)}{(a)}, = 0.44621\ldots$	A1ft, A1	1.1b 1.1b
	For calc to work require $(0.44621...)^4 = 0.03964\ldots$ **awrt <u>0.0396</u>**	dM1 A1 (5)	2.1 1.1b
(c)	Require: $[P(L > 4)]^2 \times [P(L > 20 \mid L > 16)]^2$	M1	1.1a
	$= (0.99976...)^2 \times ("0.44621...")^2$	A1ft	1.1b
	$= 0.19901\ldots$ **awrt <u>0.199</u> (*)**	A1cso* (3)	1.1b
		(9 marks)	

	Notes
(a)	B1 for evaluating probability using their calculator (awrt 0.691) Accept 0.6915
(b)	1st M1 for a first step of identifying a suitable conditional probability (either form) 1st A1ft for a ratio of probabilities with numerator = awrt 0.309 or 1 – (a) and denom = their (a) 2nd A1 for awrt 0.446 (o.e.) Accept 0.4465 (from $\frac{0.3085}{0.691} = 0.44645...$) NB $\frac{P(16<L<20)}{P(L>16)} = 0.5538\ldots$ scores M1A1A1 when they do $1 - 0.5538 = 0.4462\ldots$ 2nd M1 (dep on 1st M1) for 2nd correct step i.e. (their $0.446\ldots)^4$ <u>or</u> X~B(4, "0.446") and $P(X = 4)$ 3rd A1 for awrt 0.0396
(c)	1st M1 for a correct approach to solving the problem (May be implied by A1ft) 1st A1ft for $P(L > 4)$ = awrt 0.9998 used <u>and</u> ft their 0.44621 in correct expression If use $P(L > 20) = 0.3085..$ as 0.446.. in (b) then M1 for $(0.3085..)^2 \times [P(L > 4)]^2$; A1ft as above
*	2nd A1cso for 0.199 or better with clear evidence of M1 [NB $(0.4662..)^2 = 0.199\ldots$ is M0A0A0] **Must see M1 scored by correct expression in symbols or values (M1A1ft)**

Question	Scheme	Marks	AOs
20(a)	[A = no. of bulbs that grow into plants with blue flowers,] A~B(40, 0.36)	M1	3.3
	$p = \mathrm{P}(A \geq 21) = 0.0240$	A1	1.1b
	C = no. of bags with more than 20 bulbs that grow into blue flowers, C~B(5, p)	M1	3.3
	So $\mathrm{P}(C \leq 1) = 0.9945\ldots$ awrt 0.995	A1	1.1b
		(4)	
(b)	[T ~ number of bulbs that grow into blue flowers]T~ B(n, 0.36)		
	T can be approximated by N(0.36n, 0.2304n)	B1	3.4
	$\mathrm{P}\left(Z < \dfrac{244.5 - 0.36n}{\sqrt{0.2304n}}\right) = 0.9479$	M1	1.1b
	$\dfrac{244.5 - 0.36n}{\sqrt{0.2304n}} = 1.625$ or $\dfrac{244.5 - 0.36x^2}{0.48x} = 1.625$	M1 A1	3.4 1.1b
	$0.36n + 0.78\sqrt{n} - 244.5 = 0$	M1	1.1b
	$n = 625$	A1cso	1.1b
		(6)	
			(10 marks)

Notes:

(a) M1: for selecting an appropriate model for A
A1: for a correct value of the parameter p for C
M1: for selecting an appropriate model for C
A1: for awrt 0.995

(b) B1: for correct normal distribution
M1: for correct use of continuity correction equal to a z value where $|z| > 1$
M1: for standardisation with their μ and σ
A1: for a correct equation
M1: using a correct method to solve their 3-term quadratic
A1: 625 on its own cso

Question	Scheme	Marks	AOs
21(a)	$\mathrm{P}(L_X > 160) = \mathrm{P}\left(Z > \frac{160-150}{25}\right)$		
	$= \mathrm{P}(Z > 0.4)$		
	$= 1 - 0.6554$		
	= awrt 0.345 0.34457…..	B1	1.1b
	Expected number = $12 \times "0.345"$	M1	1.1b
	= 4.13 (allow 4.14)	A1	1.1b
		(3)	
(b)	$\mathrm{P}(L_Y < 180) = 0.841621…..$	B1	3.4
	$\frac{180-160}{\sigma} = 0.8416$	M1	1.1b
	$\sigma =$ awrt 23.8	A1	1.1b
		(3)	
(c)	The standard deviations for two companies are close but the mean for company *Y* is higher	M1	2.4
	therefore choose company *Y*	A1	2.2b
		(2)	
			(8 marks)

Notes:

(a) B1: awrt 0.345
M1: for multiplying their probability by 12
A1: 4.13 (allow 4.14)

(b) B1: for use of the correct model to find the correct value of z awrt 0.842
M1: for standardising = to a Z value $0.5 < Z < 1$
A1: awrt 23.8

(c) M1: for a correct reason following their part(b)
A1: for making an inference that follows their part(b)

Question	Scheme	Marks	AOs
22(a)	[H = no. of hours] P($H > 10.3$) or P($Z > 1$) = [0.15865…]	M1	3.4
	Predict $31 \times 0.15865... =$ **4.9 or 5 days**	A1	1.1b
		(2)	
(b)	(5 or) 4.9 days < (7 or) 6.9 days so model may **not** be suitable	B1	3.5a
		(1)	
		(3 marks)	

Notes:

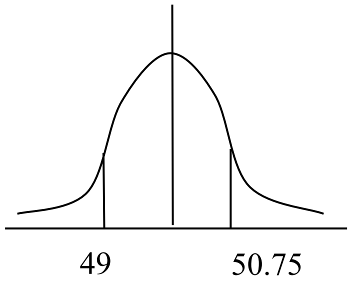
(a)

M1: for a correct probability attempted

A1: for a correct prediction

(b)

B1: for a suitable comparison and a compatible conclusion

Question	Scheme	Marks	AOs
Q23(a)			
	P (L > 50.98) = 0.025	B1cao	3.4
	$\therefore \ \dfrac{50.98-\mu}{0.5} = 1.96$	M1	1.1b
	$\therefore \quad \mu = 50$	A1cao	1.1b
	P(49 < L < 50.75)	M1	3.4
	= 0.9104… awrt **<u>0.910</u>**	A1ft	1.1b
		(5)	
(b)	S = number of strips that cannot be used so S~B(10, 0.090)	M1	3.3
	= P($S \leqslant$ 3) = 0.991166… awrt 0.991	A1	1.1b
		(2)	
			(7 marks)

Question 23 continued
Notes:
(a) **1st M1:** for standardizing with μ and 0.5 and setting equal to a z value ($\lvert z\rvert > 1$) **2nd M1:** for attempting the correct probability for strips that can be used **2nd A1ft:** awrt 0.910 (allow ft of their μ)
(b) **M1:** for identifying a suitable binomial distribution **A1:** awrt 0.991 (from calculator)

Question	Scheme	Marks	AOs
24 (a)	The seeds would be destroyed in the process so they would have none to sell	B1	2.4
		(1)	
(b)	[S = no. of seeds out of 24 that germinate, $S \sim B(24, 0.55)$]		
	T = no. of trays with at least 15 germinating. $T \sim B(10, p)$	M1	3.3
	$p = P(S \geqslant 15) = 0.299126...$	A1	1.1b
	So $P(T \geqslant 5) = 0.1487…$ awrt $\underline{\mathbf{0.149}}$	A1	1.1b
		(3)	
(c)	n is large and p close to 0.5	B1	1.2
		(1)	
(d)	$X \sim N(132, 59.4)$	B1	3.4
	$P(X \geqslant 149.5) = P\left(Z \geqslant \frac{149.5-132}{\sqrt{59.4}}\right)$	M1	1.1b
	$= 0.01158…$ awrt $\underline{\mathbf{0.0116}}$	A1cso	1.1b
		(3)	
(e)	e.g The probability is very small therefore there is evidence that the company's claim is incorrect.	B1	2.2b
		(1)	
			(9 marks)

Notes:

(a)
B1: cao

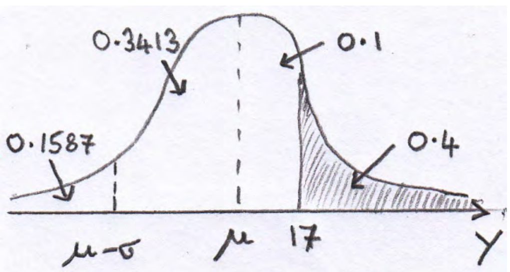
(b)
M1: for selection of an appropriate model for T
1st A1: for a correct value of the parameter p (accept 0.3 or better)
2nd A1: for awrt 0.149

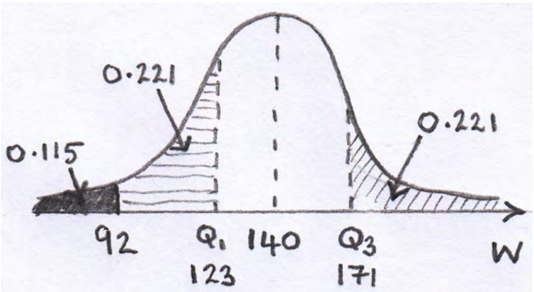
(c)
B1: both correct conditions

(d)
B1: for correct normal distribution
M1: for correct use of continuity correction
A1: cso

(e)
B1: correct statement

Question Number	Scheme	Marks
25. (a)	[P($\mu < Y < 17$) =] 0.5 – 0.4 = **0.1**	B1 (1)
(b)	P($Y > \mu - \sigma$) = P(Z > – 1)	M1
	= 0.841(3)	A1
	P($\mu - \sigma < Y < 17$) = 0.8413 – 0.4	dM1
	= **0.441**(3)	A1 (4)
ALT	P($Y > \mu - \sigma$) = P(Z > – 1)	M1
	P(Y > 17) = 0.4 $\Rightarrow Z = \left[\frac{17-\mu}{\sigma}\right]$ = 0.25(33471...) so need P(– 1 < Z < 0.25)	dM1
	Sight of P(– 1 < Z < 0.253…)	1st A1
	= **0.441**(3)	2nd A1
		[Total 5]
	Notes	
(a)	B1 for 0.1 as clearly their final answer or clear statement "P($\mu < Y < 17$) = 0.1" Ignore poor or incorrect notation if answers are correct	
(b)	1st M1 for an attempt to standardise $\mu - \sigma$ allow for $\pm \frac{(\mu-\sigma)-\mu}{\sigma}$ can be un-simplified 1st A1 for 0.841 or better (calc 0.84134473…) or 1 – 0.8413…= 0.1587 (accept 0.159) Sight of 0.841(3) or 0.1587 or 0.159 (or better) scores M1 A1 May be statement e.g. P($Y > \mu - \sigma$) = 0.841(3) or on clearly labelled diagram. 2nd dM1 (dep on 1st M1) for a correct use of their 0.8413 and the given 0.4 or 0.341(3) + their (a) or 0.6 – their 0.1587 2nd A1 for 0.441 or better (correct answer only 4/4)	
ALT	Standardise $\mu - \sigma$ (and may get z = – 1) scores 1st M1 as in scheme Use inv' normal to get $\frac{17-\mu}{\sigma}$ = 0.25(33471...) and write/ attempt P(– 1 < Z < 0.25..) 2nd M1 Write or attempt P(– 1 < Z < 0.253…) also scores 1st A1 (need 0.253 or better) NB Just standardising and getting 0.2533 etc is no use unless it is part of a correct probability statement that would lead to the final answer.	



Question Number	Scheme	Marks
26.	[$W \sim N(140, 40^2)$]	
(a)	$P(W < 92) = P\left(Z < \frac{92-140}{40}\right) = [P(Z < -1.2)]$	M1
	$= 1 - 0.8849$ = awrt **<u>11.5</u>** (%) or **<u>0.115</u>**	dM1,A1 (3)
(b)	$[P(W > q_3) = P(W > 92) \times P(W > q_3 \mid W > 92) =]$ $(1 - (a)) \times 0.25 = 0.8849 \times 0.25$	M1
	$= 0.221225$ = awrt **<u>0.221</u>**	A1 (2)
(c)	$P(W < q_1 \mid W > 92) = 0.25$ <u>or</u> $P(W > q_1 \mid W > 92) = 0.75$	M1
	$P(92 < W < q_1) = 0.25 \times 0.8849 = \text{"}0.221..\text{"}$ <u>or</u> $P(W > q_1) = 0.75 \times 0.8849 = 0.663675$	M1
	$P(W < q_1) = 0.221225 + 0.115$ = awrt **0.336** <u>or</u> $P(W > q_1) = 0.663675$ = awrt **0.664**	A1
	$\frac{q_1 - 140}{40} = -0.42$ (calculator gives $-0.422513 \sim -0.423404$)	M1
	so $q_1 = 123.2$ = awrt **<u>123</u>** (g)	A1 (5)
(d)	 $\frac{1}{4} \times \frac{1}{4} \times \frac{1}{2} \times 3!$	M1M1
	$= \frac{3}{16}$ or 0.1875	A1 (3)
		[Tot 13]

	Notes
	Condone poor use of notation etc e.g. "P > q_1" for P($W > q_1$) etc
(a)	1st M1 for standardising attempt with 92 or 188, 140 and 40 (o.e.) Accept $\pm$ ignore inequality 2nd dM1 dependent on 1st M1, for attempting $1 - p$ where $0.5 < p < 1$ A1 for awrt 11.5 (%) or 0.115
(b)	M1 for $(1 - \text{their (a)}) \times 0.25$ <u>or</u> $1 - [(1-(a)) \times 0.75 + (a)] = 1 - [0.8849 \times 0.75 + 0.1151]$ A1 for awrt 0.221
(c)	1st M1 for a correct conditional prob. statement with q_1, 92 and 0.25 or 0.75 2nd M1 for either correct probability statement and 0.25 or 0.75 $\times (1 - \text{their (a)})$ 1st A1 for $P(W < q_1)$ = awrt 0.336 or $P(W > q_1)$ = awrt 0.664 NB May be standardised Award M1M1A1 for either probability clearly stated or marked on a correct sketch. 3rd M1 for standardising with q_1, 140 and 40 and setting equal to z where $0.40 < \lvert z \rvert < 0.45$ 2nd A1 for awrt 123 (condone minor slips in working if correct answer obtained)
(d)	1st M1 for $0.25 \times 0.25 \times 0.5$ (o.e.) e.g. $\frac{1}{32}$ may be seen as decimals or fractions 2nd M1 for $\times 3!$ or $\times 6$ or adding all 6 cases. Must be multiplying probabilities. A1 for $\frac{3}{16}$ or any exact equivalent

Question Number	Scheme	Marks
27(a)	Symmetric (or little skew) so <u>normal (or Rika's suggestion) may be suitable</u>	B1ft (1)
(b)	$\frac{c-50}{10} = 0.8416$ [N.B. use of (1 – 0.8416) is B0]	M1, B1
	c = 58.416 = (£) 58.42 awrt **<u>58.4</u>**	A1 (3) **[4]**
	Notes	
(a)	B1ft Suggest normal is or isn't suitable **with** suitable reason based on (e) or mean and med	
(b)	M1 for stand'ing using "c", 50 and 10 and setting equal to $\pm z$ value where $0.84 \le z \le 0.85$ B1 for using $z = \pm 0.8416$ or better (calc gives 0.8416212…) in standard' attempt e.g. $\sqrt{10}$ for 10 A1 for awrt 58.4 (accept 3sf here) (Ans only of awrt 58.4 is M1B0A1 but 58.416 or better is 3/3)	

Question Number	Scheme	Marks
28. (a)	$\left[P(T>20)=\right]\ P\left(Z>\frac{20-18}{5}\right)$	M1
	$P(Z>0.4)=1-0.6554$	M1
	$=$ **<u>0.3446</u>** <u>or</u> awrt **<u>0.345</u>**	A1
		(3)
(b)	Require $P(T>20 \mid T>15)$ <u>or</u> $\frac{P(T>20)}{P(T>15)}$	M1
	$\frac{\text{"(a)"}}{P(Z>\frac{15-18}{5})} = \frac{\text{"(a)"}}{P(Z>-0.6)}$, $= \frac{\text{"0.3446"}}{0.7257}$ <u>or</u> $\frac{\text{"0.345"}}{0.726}$	M1, A1ft
	$= 0.47485\ldots =$ awrt **<u>0.475</u>**	A1
		(4)
(c)	$P(T>d \mid T>15) = 0.5$ <u>or</u> $P(T<d \mid T>15) = 0.5$	M1
	$P(T>d)$ <u>or</u> $P(15<T<d) = 0.5\times$"0.7257" $=[0.36285]$	A1ft
	$P(T<d) =$ "0.63715"	M1
	So $\frac{d-18}{5}=0.35$ (calculator gives 0.35085…)	A1
	$d = 19.754\ldots$ = awrt **<u>19.8</u>**	A1cso
	(Accept 19 mins 45(secs) or 19:45 but 19.45 is A0)	(5)
		[12]

	Notes
(a)	1st M1 for standardising with 20, 18 and 5. Accept $\pm$ 2nd M1 for attempting $1-p$ [where $0.5<p<0.7$]. Beware $1-0.4$ (or their z value) is M0 A1 for awrt 0.345 (Correct ans only 3/3)
(b)	1st M1 for either correct conditional probability statement (allow "in words" or any letter except Z) 1st M1 can be implied by 2nd M1 so a mark of M0M1 should not be given. 2nd M1 for using their (a) on num. and attempting to standardise $P(T>15)$ (no $\pm$)on denom. Num.>Deno. is M0 Allow one digit transcription errors from (a) e.g. 0.3464 or 0.3466 etc for 2nd M1 and 1st A1ft 1st A1ft for their 0.3446 on numerator and denominator of 0.7257 (or better: 0.7257469…) provided Num < Denom. Allow 0.726 on the denominator Sight of $\frac{\text{"0.3446"}}{0.7257 \text{ or } 0.726}$ will score M1M1A1ft 2nd A1 for awrt 0.475
(c)	1st M1 for a correct conditional probability statement that includes the 0.5 1st A1ft for $P(T>d)$ or $P(15<T<d) = 0.5 \times$ their $P(T>15)$ [provided $P(T>15)>0.5$] Follow through (3sf) their $P(T>15) = 0.7257$ or better from part (b). (Allow 0.726) Sight of $0.5\times$their 0.7257 = "0.36285" or better scores 1st M1 and 1st A1ft (Allow 0.363) 2nd M1 (dep on 1st M1) for $P(T<d) = 1 -$ "0.36285" <u>or</u> "0.36285" + 1 – "0.7257" = [0.6371~0.6372] Sight of their 0.63715 or better (calc: 0.637126…) scores first 3 marks (Allow 0.637) 2nd A1 for $\frac{d-18}{5}=0.35$ (or better) (Calc could give 0.350788…) 3rd A1cso for (d =) awrt 19.8 (accept 19.7 not awrt 19.7) **Must** come from correct work.
Beware!	$0.5\times0.7257 = 0.36285$ and using <u>this</u> (instead of 0.35) as z value leads to 19.8 but is A0A0

EXPERT TUITION

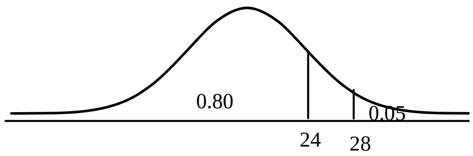
Question Number	Scheme	Marks
29(a)	$[\mathrm{P}(W<3)=\mathrm{P}\left(Z<\dfrac{-0.43}{0.65}\right)]=\mathrm{P}(Z<-\ 0.6615..)$ $= 1 - 0.7454$ (tables) $= 0.2546$ awrt **0.254~0.255**	M1 M1 A1 (3)
(b)	(b) and (c)(i) mean $\neq$ med or skew <u>or</u> mean<u>~</u> median or no skew **and** comment (d) = 0.254 or 0.255 compare data = 0.18 (or 12.7 compared with 9) 0.18 different from 0.25 so normal not good <u>or</u> 0.18 similar to 0.25 so normal is OK	B1 B1 dB1 (3)
(c)(i) **(ii)**	No change in mean (since weight is the same) s.d. will decrease (Extra value is at "centre" so data more concentrated) Both statements correct <u>and</u> correct reasons for <u>each</u>	B1 B1 dB1 (3) **[9 marks]**
	Notes	
(a)	1st M1 for an attempt to standardise with 3, 3.43 and 0.65. Allow <u>+</u> and also use of their sd 2nd M1 for $1-p$ where $0.74<p<0.75$ NB calculator gives 0.7458665… A1 for awrt 0.254 or 0.255	
(b)	1st B1 for a statement about mean/median **and** compatible comment about normal 2nd B1 for statement comparing their (d) with data (sight of 0.18 <u>or</u> 12.7 and 9 required) 3rd dB1 dep on 2nd B1 for conclusion about normal compatible with <u>2nd</u> statement	
(c)(i) **(ii)**	1st B1 for no change in mean {send a correct argument for <u>decrease</u> to review} 2nd B1 for s.d. decreases 3rd dB1 dep on 1st and 2nd Bs for a correct reason for <u>both</u> mean <u>and</u> sd e.g. "new mean the same so within 1 s.d. of old mean"	

Question Number	Scheme	Marks
30.(a)	[$T \sim N(240, 40^2)$…require $P(T > 300)$] $P\left(Z > \frac{300-240}{40}\right)$ $= 1 - P(Z < 1.5)$ or $1 - 0.9332$ = awrt **<u>0.0668</u>** or 6.68%	M1 M1 A1 (3)
(b)	$\left[P(T < n) = 0.20 \Rightarrow\right]$ $\frac{n-240}{40} = -0.8416$ n = awrt **<u>206</u>** minutes	M1 B1 A1 (3)
(c)	$[P(W < \mu - 30 \mid W < \mu) =]$ $\frac{P(W < \mu - 30)}{P(W < \mu)}$ $= \frac{1-0.82}{0.50}$ = **<u>0.36</u>**	M1 A1 A1cao (3) **[9 marks]**
	Notes	
(a)	1st M1 for standardising with 300, 240 and 40. May be implied by use of 1.5 Allow $\pm$ 2nd M1 for 1 – P(Z < “1.5”) i.e. a correct method for finding P(Z > “1.5”) e.g. $1 - p$ where $0.5 < p < 0.99$ A1 for awrt 0.0668 (Answer only 3/3)	
(b)	M1 for an attempt to standardise with 240, 40 and n and set = $\pm z$ ($0.8 < \lvert z\rvert < 0.9$) B1 for $z = \pm 0.8416$ (or better) <u>used</u> as a z value. Do not allow for 1 0.8416 Calc gives 0.8416212…[**May be implied by awrt 206.34**, give B1 as well as A1 if seen] A1 for awrt 206 (can be scored for using a z value of 0.84 or even 0.85) Must follow from correct working but a range of possible z values are OK	
Ans only	If answer is awrt 206 score M1B0A1 (unless of course z = 0.8416 seen) but awrt 206.34 scores 3/3	
(c)	M1 for the correct ratio expression (<u>Not</u> $P([W < 30 - \mu] \cap [W < \mu])$ on numerator) Condone use of Z instead of W <u>only if</u> they later get a correct numerical ratio otherwise M0 However they may write $P\left(Z < \frac{-30}{\sigma}\right)$ etc which is of course fine 1st A1 for a correct numerical ratio	
Use tables	May see use of $z = 0.92$ or better (calc: 0.9153650…) or σ = 32.6~32.8 allow:	
ALT	1st M1 for $\frac{P(Z < -0.92)}{P(Z < 0)}$ and 1st A1 for $\frac{1-0.8212}{0.5}$ or $\frac{0.1788}{0.5}$ 2nd A1 for 0.36 or an exact equivalent e.g. $\frac{9}{25}$ (Answer only M1A1A0) The final answer of 0.36 <u>must</u> come from exact values; 0.36 rounded from 0.3576 etc is A0	

Question	Scheme	Marks
31. (a)(i)	P(A) = P($Z > 1.1$) = 1 – 0.8643 = **0.1357** (accept awrt 0.136)	B1
(ii)	P(B) = P($Z > -1.9$) = **0.9713** (accept awrt 0.971)	B1
(iii)	P(C) = [P($-1.5 < Z < 1.5$)] = 0.9332 – (1 – 0.9332) or (0.9332 – 0.5) × 2 = **0.8664** (accept awrt 0.866)	M1 A1
(iv)	$P(A \cup C) = P(Z > -1.5)$ or $P(Z < 1.5)$ or $= P(A) + P(C) - P(A \cap C) = "0.1357" + "0.8664" - (0.9332 - 0.8643)$ = **0.9332** (accept awrt 0.933)	M1 A1 (6)
(b)	$\left[P(X > w \mid X > 28) = \right] \frac{P(X > w)}{P(X > 28)} = [0.625]$	M1
	$P(X > 28) = P\left(Z > \frac{28-21}{5}\right) = P(Z > 1.4) = [0.0808 \text{ calc: } 0.80756..]$	M1
	P($X > w$) = 0.0808×0.625 (= 0.0505) or (P($X < w$) = 0.9495)	A1
	$\frac{w-21}{5} = 1.64$	M1 B1
	w = awrt **29.2**	A1 (6) (12 marks)
	Notes	
	Mark final answer here so in (ii) 0.9713 followed by 1 – 0.9713 is B0 but for rounding errors e.g. 29.245 followed by 29.3 apply ISW and award for 29.245	
(a)(iii)	M1 for correct expression with probability values . Correct ans implies M1A1	
(iv)	M1 for a correct addition formula with some correct substitution (or correct ft) or $P(Z > -1.5)$ (o.e) or for a fully correct expression with correct probabilities A1 for 0.9332 (accept 0.933) Correct answer only is M1A1	
(b)	M1 for correct expression for conditional probability- must have P($X > w$) as num' May be implied by P($X > w$) = $0.625 \times$ (any probability) M1 for standardising 28 with 21 and 5 Allow $\pm$ (May be implied by 0.0808 [or awrt 0.081] seen in correct position) A1 for P($X > w$) = 0.0808×0.625 or P(X > w) = 0.0505 or P($X < w$) = 0.9495) This A1 depends on both Ms but seeing P($X > w$) = 0.0808×0.625 scores M1M1A1	
1st 3 marks	Allow $P\left(Z > \frac{w-21}{5}\right)$ instead of P($X > w$) for these first 3 marks	
	M1 for standardising w with 21 and 5 (allow $\pm$) and setting equal to a z-value $\lvert z \rvert > 1$ Allow any letter instead of w B1 for 1.64 (or better) used correctly. [Calculator gives: 1.6402851...] A1 allow awrt 29.2	

Question Number	Scheme	Marks
32 (a)	The random variable H ~ height of females	
	$\mathrm{P}(H>170) \;= \mathrm{P}\left(Z>\frac{170-160}{8}\right) \quad [=\mathrm{P}(Z>1.25)]$	M1
	$=1-0.8944$	M1
	$= 0.1056$ (calc 0.1056498…) **awrt 0.106** (accept 10.6%)	A1 **(3)**
(b)	$\mathrm{P}(H>180) = \mathrm{P}\left(Z>\frac{180-160}{8}\right) \quad [=1-0.9938]$	M1
	$= 0.0062$ (calc 0.006209…) awrt 0.0062 or $\frac{31}{5000}$	A1
	$[\mathrm{P}(H>180 \mid H>170)] = \frac{0.0062}{0.1056}$	M1
	$= 0.0587$ (calc 0.0587760…) **awrt 0.0587 or 0.0588**	A1 **(4)**
(c)	$\mathrm{P}(H>h \mid H>170)$ (= 0.5) <u>or</u> $\frac{\mathrm{P}(H>h)}{\mathrm{P}(H>170)}(=0.5)$	M1
	$[\mathrm{P}(H>h)] = 0.5\times"0.1056" = 0.0528$ (calc 0.0528249…) <u>or</u> $[\mathrm{P}(H<h)] = 0.9472$	A1ft
	$\frac{h-160}{8}=1.62$ (calc 1.6180592…)	M1 B1
	h = awrt 173 cm **awrt 173**	A1 **(5)**
		Total 12
	Notes	
(a)	1^{st} M1 for attempt at standardising with 170, 160 and 8. Allow <u>+</u> i.e. for $\pm\frac{170-160}{8}$	
	2^{nd} M1 for attempting 1 – p where $0.8 < p < 1$. Correct answer only 3/3	
(b)	1^{st} M1 for standardising with 180, 160 and 8	
	1^{st} A1 for 0.0062 seen, maybe seen as part of another expression/calculation.	
	2^{nd} M1 using conditional probability with denom = their (a) and num < their denom. <u>Values</u> needed.	
	2^{nd} A1 for awrt 0.0587 <u>or</u> 0.0588. Condone 5.87% or 5.88% or $\frac{31}{528}$ Correct answer only 4/4	
(c)	1^{st} M1 for a correct conditional probability statement. Either line and don't insist on 0.5, ft (a)	
	1^{st} A1ft for $[\mathrm{P}(H>h)] = 0.5\times\text{their}(a)$	
	Award M1A1ft for correct evaluation of $0.5\times\text{their}(a)$ or sight of 0.0528 or better	
	2^{nd} M1 for attempt to standardise (<u>+</u>) with 160 and 8 and set equal to <u>+</u> z value ($1.56 < \lvert z\rvert < 1.68$)	
	B1 for (z =) awrt <u>+</u> 1.62 (seen)	
	2^{nd} A1 for awrt 173 but dependent on <u>both</u> M marks.	

Question Number	Scheme	Marks
33	(i) $P(Y = 10) = 0$	B1
	(ii) $P(Y < 10) = \frac{1}{2}$	B1
		(2)
		[Total 2]

Question Number	Scheme	Marks
34. (a)	 24 and 28 (above the mean)	B1
	For 0.80 and 0.05 (clearly indicated)	B1 **(2)**
(b)	15%	B1 **(1)**
(c)(i)	$\frac{(28-\mu)}{\sigma}=1.64(49)$ or $\frac{(24-\mu)}{\sigma}=0.84(16)$	M1
	0.8416 and 1.6449 seen	B1
	$\mu=28-1.64(49)\sigma$, $\mu=24-0.84(16)\sigma$	A1,A1
(ii)	$24-0.8416\sigma=28-1.6449\sigma$ eliminating μ or σ	M1
	$\sigma=4.9794597...$ **awrt** 4.98	A1
	$\mu=19.809286...$ **awrt** 19.8	A1 **(7)**
(d)	$z=\frac{(12-'19.8...')}{'4.97...'}$	M1
	$\mathrm{P}(Z<-1.57) = 1-\mathrm{P}(Z<1.57)$	dM1
	1 − 0.9418 = 0.0582 **awrt** 0.06	A1 **(3)**
		[Total 13]

	Notes
(a)	1st B1 24 and 28 labelled on the horizontal axis above the mean in the correct order. They must clearly indicate where 24 and 28 are on the horizontal axis.
	2nd B1 for clear, correct labelling of probabilities. Must be associated with correct <u>area</u>.
(b)	B1 for 15% or 0.15 NB 0.15% is B0
(c)	1st M1 for $\frac{\pm(28-\mu)}{\sigma}=z_1$ <u>or</u> $\frac{\pm(24-\mu)}{\sigma}=z_2$ where $\lvert z_1\rvert > 1.5$ and $\lvert z_2\rvert < 1$
	Condone $z_2=0.8$
	B1 for both values 0.8416 <u>and</u> 1.6449 or better seen. Calc: 0.8416212.., 1.644853..
	1st A1 for $\mu=28-1.64(49)\sigma$ or any correct arrangement (allow 1.64 ~1.65 inclusive)
	2nd A1 for $\mu=24-0.84(16)\sigma$ or any correct arrangement (allow 0.84 or better)
	2nd M1 for an attempt to solve simultaneous equations by eliminating μ or σ
	3rd A1 for **awrt** 4.98 (Condone σ = 5 or awrt 5.0 if B0 scored)
	4th A1 for **awrt** 19.8
SC	For use of 0.84 and 1.64 giving σ = 5 and μ = awrt 19.8 score M1B0A1A1M1A1A1
	<u>or</u> 0.84 and 1.65 giving σ = awrt 4.94 and μ = awrt 19.9 score M1B0A1A1M1A1A1
(d)	1st M1 for standardising with 12, their μ and σ provided $\sigma>0$
	If $\sigma<0$ from their equations in (c) allow M1 if they use $\lvert\sigma\rvert$
	2nd dM1 for $1-\mathrm{P}(Z<'1.57')$ dependent on the 1st M1 being scored i.e. leads to prob < 0.5
	A1 for awrt 0.06 from correct working

Question	Scheme	Marks
35. (a)	[Let X be the amount of beans in a tin. P(X < 200) = 0.1]	
	$\frac{200-\mu}{7.8} = -1.2816$ [calc gives 1.28155156…]	M1 B1
	μ = 209.996…. awrt 210	A1
		(3)
(b)	$\text{P}(X > 225) = \text{P}\left(Z > \frac{225-"210"}{7.8}\right)$	M1
	$= \text{P}(Z > 1.92)$ <u>or</u> 1 – P(Z < 1.92) (allow 1.93)	A1
	= 1 – 0.9726 = 0.0274 (or better) [calc gives 0.0272037…] = 0.0274	
	= awrt **<u>2.7%</u>** allow **<u>0.027</u>**	A1
		(3)
(c)	[Let Y be the new amount of beans in a tin]	
	$\frac{210-205}{\sigma} = 2.3263$ <u>or</u> $\frac{200-205}{\sigma} = -2.3263$ [calc gives 2.3263478…]	M1 B1
	$\sigma = \frac{5}{2.3263}$	dM1
	$\sigma = 2.15$ (2.14933…)	A1
		(4)
		(10 marks)
	Notes	
	Condone poor handling of notation if answers are correct but A marks must have correct working.	
(a)	M1 for an attempt to standardise (allow $\pm$) with 200 and 7.8 and set = $\pm$ any z value ($\lvert z\rvert > 1$) B1 for $z = \pm 1.2816$ (or better used as a z)[May be implied by 209.996(102…) or better seen] A1 for awrt 210 (can be scored for using 1.28 but then they get M1B0A1) The 210 must follow from correct working – sign scores A0 If answer is awrt 210 **and** 209.996… or better seen then award M1B1A1 z = 1.28 gives 209.984 and z = 1.282 gives 209.9996 and both score M1B0A1 If answer is awrt 210 or awrt 209.996 then award M1B0A1 (unless of course z = 1.2816 is seen)	
(b)	M1 for attempting to standardise with 225, their mean and 7.8 . Allow $\pm$ 1st A1 for Z > awrt 1.92/3. Allow a diagram but must have 1.92/3 and correct area indicated. Must have the Z so P(X > 225) with or without a diagram is not sufficient. Award for 1 – 0.9726 or 1 – 0.9732 2nd A1 for 2.7 % or better (calculator gives 2.72…) Allow awrt 0.027. Correct ans scores 3/3	
(c)	1st M1 for an attempt to standardise with 200 or 210, 205 and σ and set = $\pm$ any z value ($\lvert z\rvert > 2$) B1 for z = 2.3263 (or better) **and** compatible signs. If B0 in (a) for using a value in [1.28, 1.29] but not using 1.2816: allow awrt 2.33 here 2nd dM1 **Dependent on the first M1** for correctly rearranging to make $\sigma = \ldots$ May be implied e.g. $\frac{5}{\sigma} = 2.32 \rightarrow \sigma = 2.16$ (M1A0) BUT must have $\sigma > 0$ A1 for awrt 2.15 . Must follow from correct working but a range of possible z values will do. NB $2.320 < z \leq 2.331$ will give an answer of awrt 2.15	

Question	Scheme	Marks
36. (a)	$\left[\mathrm{P}\left(M<145\right)=\right]\ \mathrm{P}\left(Z<\frac{145-150}{10}\right)$	M1
	$=\mathrm{P}(Z<-0.5)$ or $\mathrm{P}(Z>0.5)$	A1
	= **awrt <u>0.309</u>**	A1 (3)
(b)	$\left[\mathrm{P}(B>115)=0.15\Rightarrow\right]\ \frac{115-100}{d}=1.0364$ (Calc gives 1.036433...)	M1B1A1
	***<u>d</u>* <u>= 14.5</u>** (Calc gives 14.4727...)	A1 (4)
(c)	[P($X>\mu+15$ | $X>\mu-15$) =] $\frac{\mathrm{P}\left(X>\mu+15\right)}{\mathrm{P}\left(X>\mu-15\right)}$	M1
	$=\frac{0.35}{1-0.35}$	A1
	$=\underline{\frac{7}{13}}$ or **<u>awrt 0.538</u>**	A1 (3)
		[10]
	Notes	
	Condone poor use of notation if a correct line appears later.	
(a)	M1 for standardising with 145, 150 and 10. Allow $\pm$ and use of symmetry so 155 instead of 145 1st A1 for P($Z<-0.5$) or P($Z>0.5$) i.e. a z value of $\pm$ 0.5 and a correct region indicated 2nd A1 for awrt 0.309 Answer only is 3/3	
(b)	M1 for $\pm\frac{115-100}{d}=z$ where $\lvert z\rvert>1$ Condone MR of μ = 150 instead of 100 for M1B1only B1 for a standardised expression = $\pm$ 1.0364 (do not allow for use of 1 – 1.0364) 1st A1 for z = awrt 1.04 and compatible signs i.e. a correct equation with z = awrt 1.04 2nd A1 for awrt 14.5 (allow awrt 14.4 if z = awrt 1.04 is seen)	
Calc	Answer only of awrt 14.473 scores M1B1A1A1 Answer only of awrt 14.48 scores M1B0A1A1	
(c)	M1 for a correct ratio expression need P($X>\mu+15$) on numerator. Allow use of a value for μ May be implied by next line. NB $\frac{0.35\times0.65}{0.65}=\frac{0.2275}{0.65}$ is M0 1st A1 for a correct ratio of probabilities 2nd A1 for awrt 0.538 or $\frac{7}{13}$ (o.e.). Allow 0.5385 provided 2nd A1 is scored.	

Question Number	Scheme	Marks
37.		
(a)	$\frac{127-100}{15}$	M1
	So P(L > 127) = P(Z > 1.8) or $1-\text{P}(Z<1.8)$ o.e.	A1
	= 1 – 0.9641 = **<u>0.0359</u>** (awrt **<u>0.0359</u>**)	A1
		(3)
(b)	$\frac{d-100}{15}=-1.2816$ (Calculator gives $-1.2815515\ldots$)	M1, B1
	d = 80.776 (awrt **<u>80.8</u>**)	A1
		(3)
(c)	Require P(L > 133 | L > 127)	M1
	$=\left[\frac{\text{P}(L>133)}{\text{P}(L>127)}\right]=\frac{\text{P}(Z>2.2)}{\text{P}(L>127)}$	dM1
	$=\left[\frac{1-0.9861}{1-0.9641}\right]=\frac{0.0139}{[0.0359]}$	A1
	= 0.3871... = awrt **<u>0.39</u>**	A1
		(4)
S.C.	An attempt at P(L < 133| L > 127) that leads to awrt 0.61 (M0M1A0A0)	
		10
	Notes	
(a)	M1 for attempting to standardise with 127, 100 and 15 . Allow <u>+</u> 1st A1 for Z > 1.8. Allow a diagram but must have 1.8 and correct area indicated. Must have the Z so P(L > 127) with or without a diagram is insufficient. May be implied by 0.0359 2nd A1 for awrt 0.0359 (calc. gives 0.035930266…). Correct ans only 3/3. M1A0A1 not poss.	
(b)	M1 for an attempt to standardise with 100 and 15 and set = <u>+</u> any z value (|z| > 1) B1 for z = <u>+</u> 1.2816 (or better) seen anywhere [May be implied by 80.776(72…) or better seen] A1 for awrt 80.8 (can be scored for using 1.28 but then they get M1B0A1) The 80.8 must follow from correct working.	
Calc	If answer is awrt 80.8 **and** awrt 80.777 or 80.776… or better seen then award M1B1A1 If answer is awrt 80.8 or 80.77 then award M1B0A1 (unless of course z = 1.2816 is seen)	
(c)	1st M1 for clear indication of correct conditional probability or attempt at correct ratio So clear attempt at $\frac{\text{P}(L>133)}{\text{P}(L>127)}$ is sufficient for the 1st M1 2nd dM1 dependent on 1st M1 for P(L > 133) leading to P(Z > 2.2). 1st A1 for 0.0139 or better seen coming from P(Z > 2.20). Dependent on both Ms 2nd A1 for awrt 0.39. Both Ms required	
ALT	If they assume Alice did not check that the phone was working you may see: [P(L< 127).0] + P(L > 127).<u>P(L > 133| L > 127)</u> Provided the <u>conditional probability</u> is seen as part of this calculation the 1st M1 can be scored and their final answer will be 0.0139(4/4) An answer of 0.0139 without sight of the conditional probability is 0/4.	

Question Number	Scheme	Marks
38. (a)	$z = \pm\frac{80}{150}$ P(240< X < 400) = <ins>**0.40 ~ 0.41**</ins>	M1 A1 (2)
(b)	(e) suggests a reasonable fit for this range BUT (d) since skew it will not be a good fit overall	B2/1/0 (2) **4**
	Notes	
(a)	M1 for an attempt to standardise using the 320 and 150 and either 240 or 400 (implied by 0.53) A1 for answer in range [0.40 , 0.41] (tables gives 0.4038, calculator 0.40619...) Ans only 2/2	
(b)	For B2 we need 2 comments that make reference to each of part (e) and part (d) One comment should suggest it is <ins>not</ins> good since <ins>skew</ins>. The other it <ins>is</ins> since matches <ins>range in (e)</ins> 1st B1 for one relevant comment 2nd B1 for both comments NB Do not use B0B1	

Question	Scheme	Marks
39. **(a)**	$[z=]\pm\left(\frac{150-162}{7.5}\right)$	M1
	$[z=]-1.6$	A1
	$[\mathrm{P}(F>150)=\mathrm{P}(Z>-1.6)=]$ $=0.9452(0071\ldots)$ **awrt <u>0.945</u>**	A1 (3)
(b)	$z = \pm\ 0.2533$ (or better seen)	B1
	$(\pm)\frac{s-162}{7.5}=0.2533(47\ldots)$	M1
	$s = 163.9$ **awrt <u>164</u>**	A1 (3)
(c)	$z = \pm\ 1.2816$ (or better seen)	B1
	$\frac{162-\mu}{9}=-1.2815515...$	M1 A1
	$\mu = 173.533\ldots$ **awrt <u>174</u>**	A1 (4)
		[10]
	Notes	
(a)	M1 for attempting to standardise with 150, 162 and 7.5. Accept $\pm$ Allow use of symmetry and therefore 174 instead of 150 1st A1 for -1.6 seen. Allow 1.6 seen if 174 used or awrt 0.945 is seen. Sight of 0.945(2) is A1. 2nd A1 for awrt 0.945 Do not apply ISW, if 0.9452 is followed by 1 – 0.9452 then award A0 Correct answer only 3/3	
(b)	B1 for (z =) $\pm$ 0.2533 (or better) seen. Giving $z = \pm$ 0.25 or $\pm$ 0.253 scores B0 here but may get M1A1 M1 for standardising with s (o.e.), 162 and 7.5, allow $\pm$, and setting equal to a z value Only allow $0.24 \le z \le 0.26$ Condone e.g. 160 for 162 etc A1 for awrt 164 (Correct answer only scores B0M1A1)	
(c)	B1 for (z =) $\pm$ 1.2816 (or better) seen. Allow awrt $\pm$ 1.28 if B0 scored in (b) for z = awrt$\pm$ 0.25 M1 for attempting to standardise with 162, 9 and μ, and setting equal to a z value where $1.26 < \lvert z\rvert < 1.31$. Allow $\pm$ here so signs don't have to be compatible. 1st A1 for a correct equation <u>with</u> compatible signs and $1.26 < \lvert z\rvert < 1.31$ 2nd A1 for awrt 174 (Correct answer only scores B0M1A1A1). **Dependent on 1st A1**	
	An equation $\frac{162-\mu}{9}=1.2816$ leading to an answer of μ = 174 is A0A0 <u>unless</u> there is clear correct working such as: $\frac{162-x}{9}=1.2816 \Rightarrow x=\ldots \therefore \mu=162+(162-x)=174$ then award A1A1	
NB	A common error is: $\frac{162-\mu}{9}=1.2816$ followed by $\mu=162+9\times1.2816$ = awrt 174 It gets A0A0	

Question Number	Scheme		Marks
40 (a)	P(W < 224) $= \mathrm{P}\left(z < \dfrac{224-232}{5}\right)$		M1
	$= \mathrm{P}(z < -1.6)$		
	$= 1 - 0.9452$		M1
	$= 0.0548$	awrt 0.0548	A1
			(3)
(b)	$0.5 - 0.2 = 0.3$	0.3 or 0.7 seen	M1
	$\dfrac{w-232}{5} = 0.5244$	0.5244 seen	B1; M1
	$w = 234.622$	awrt 235	A1
			(4)
(c)	$0.2\times(1-0.2)$		M1
	$2\times0.8\times(1-0.8) = 0.32$		M1 A1
			(3)
			Total 10

NOTES

(a) M1 for standardising with 232 and 5. (i.e. not 5^2 or $\sqrt{5}$). Accept $\pm\dfrac{w-232}{5}$.

M1 for finding (1- a probability > 0.5)

A1 awrt 0.0548

(b) M1 Can be implied by use of ± 0.5244 or $\pm(0.52$ to $0.53)$

B1 for ± 0.5244 only.

Second M1 standardise with 232 and 5 and equate to z value of (0.52 to 0.53) or (0.84 to 0.85)

1 – z used award second M0.

Require consistent signs i.e. $\dfrac{232-w}{5} = -0.5244$ or negative z value for M1.

A1 dependent upon second M mark for awrt 235 but see note below.

Common errors involving probabilities and not z values:

P(Z<0.2) = 0.5793 used instead of z value gives awrt 235 but award M0B0M0A0

P(Z<0.8) = 0.7881 used instead of z value award M0B0M0A0.

M1B0M0A0 for 0.6179, M1B0M0A0 for 0.7580

(c) M1 for 0.16 seen

M1 for '$2\times p(1-p)$'

A1 0.32 correct answer only

Question Number	Scheme	Marks
41. **(a)**	awrt $\pm$ 1.40	B1
	$\frac{23-\mu}{5}="1.40"$ (o.e)	M1A1ft
	$\underline{\mu=16}$ (or awrt 16.0)	A1
		(4)
(b)	<u>0.4192</u>	B1 (1) **5**

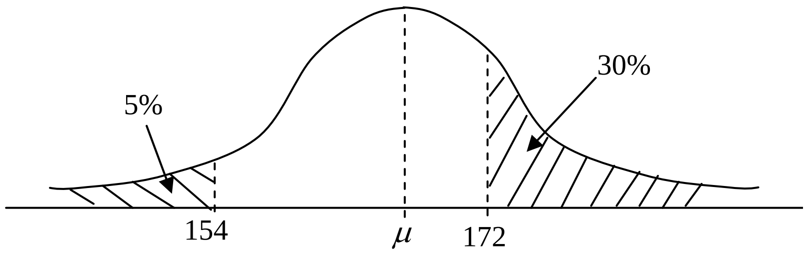
	Notes
(a)	B1 for awrt $\pm$ 1.40 or better seen anywhere. Condone 1.4 instead of 1.40
	M1 for attempting to standardise with 23 and 5 and μ, accept $\pm$
	e.g. $\frac{23-\mu}{25}=1.40$ can score B1M0 (since using 25 not 5 for standardising)
	$\frac{23-\mu}{5}=0.9192$ can score B0M1 (since have correct standardisation)
	Can accept equivalent equations e.g. $23-\mu=5\times"1.40"$
	1st A1ft for standardised expression = to a z value ($\|z\|$ > 1). Signs must be compatible.
	Follow through their z
	e.g. $\frac{23-\mu}{5}$ = their z where $z > 1$ or $\frac{\mu-23}{5}$ = their z where $z < -1$
	2nd A1 for 16 or awrt 16.0 if they are using a more accurate z
	Correct answer only scores 4/4 but if any working is seen apply scheme
(b)	B1 for 0.4192 (but accept 3sf accuracy if 0.9192 – 0.5 is seen)

Question Number	Scheme	Marks
42.		
(a)	$(z=\pm)\dfrac{15-16.12}{1.6}(=-0.70)$	M1
	P(Z < -0.70) = 1 - 0.7580	M1
	= <u>0.2420</u> **(awrt 0.242)**	A1
		(3)
(b)	[P(T < t)=0.30 implies] $z=\dfrac{t-16.12}{1.6}=-0.5244$	M1 A1
	$\dfrac{t-16.12}{1.6}=-0.5244 \Rightarrow t=16.12-1.6\times\text{"}0.5244\text{"}$	M1
	t = awrt <u>15.28</u> (allow awrt 15.28/9)	A1
		(4)
		7

	Notes
	Allow slips e.g. 16.2 for 16.12 for 1st M1 in (a) and (b)
(a)	1st M1 for standardising expression with 15, 16.12 and 1.6 - allow <u>+</u> 2nd M1 for 1 - a probability (> 0.5) from tables or calculator based on their standardised value **Correct answer only scores 3/3**
(b)	**In part (b) they can use any letter or symbol instead of *t*** 1st M1 for standardising with t (o.e.), 16.12 and 1.6, allow <u>+</u>, and setting equal to a z value 1st A1 for an equation with z = <u>+</u> 0.5244 or better e.g. $\dfrac{t-16.12}{1.6}=\pm0.52$ (or 0.525) scores M1 (but A0) 2nd M1 for solving <u>their</u> linear equation as far as $t = a \pm b\times 1.6$. Not dependent on 1st M1 e.g. solving $\dfrac{t-16.12}{1.6}=0.3$ to give $t=16.12+1.6\times0.3$ scores this M1 Allow $\dfrac{t-16.12}{1.6^2}=0.3$ to give $t=16.12+1.6^2\times0.3$ to score M1 too 2nd A1 dependent on both M marks. Allow awrt 15.28 or awrt 15.29 Condone awrt 15.3 if a correct expression for t = ... is seen. **Answers with no working:** 15.28 is M1A1M1A1, 15.29 is M1A0M1A1, 15.3 is M1A0M1A0

Question Number	Scheme	Marks
43.		
(a)	$\mathrm{P}(X > 168) = \mathrm{P}\left(Z > \frac{168-160}{5}\right)$	M1
	$= \mathrm{P}(Z > 1.6)$	A1
	$= 0.0548$ **awrt 0.0548**	A1
		(3)
(b)	$\mathrm{P}(X < w) = \mathrm{P}\left(Z < \frac{w-160}{5}\right)$	
	$\frac{w-160}{5} = -2.3263$	M1 B1
	$w = 148.37$ **awrt 148**	A1
		(3)
(c)	$\frac{160-\mu}{\sigma} = 2.3263$	M1 B1
	$\frac{152-\mu}{\sigma} = -1.2816$	B1
	$160 - \mu = 2.3263\sigma$	
	$152 - \mu = -1.2816\sigma$	
	$8 = 3.6079\sigma$	M1
	$\sigma = 2.21\ldots.$ **awrt 2.22**	A1
	$\mu = 154.84\ldots$ **awrt 155**	A1 (6)
		[12]
	<u>Notes</u>	
(a)	M1 for an attempt to standardize 168 with 160 and 5 i.e. $\pm\left(\frac{168-160}{5}\right)$ or implied by 1.6 1st A1 for P(Z > 1.6) or P(Z < -1.6) ie z = 1.6 and a correct inequality or 1.6 on a shaded diagram **Correct answer to (a) implies all 3 marks**	
(b)	M1 for attempting $\pm\left(\frac{w-160}{5}\right)$ = recognizable z value ($\lvert z\rvert > 1$) B1 for $z = \pm$ 2.3263 or better. Should be z =… or implied so: $1-2.3263 = \frac{w-160}{5}$ is M0B0 A1 for awrt 148. This may be scored for other z values so M1B0A1 is possible **For awrt 148 only with no working seen award M1B0A1**	
(c)	M1 for attempting to standardize 160 or 152 with μ and σ (allow $\pm$) <u>and</u> equate to z value ($\lvert z\rvert$>1) 1st B1 for awrt $\pm$ 2.33 or $\pm$ 2.32 seen 2nd B1 for awrt $\pm$ 1.28 seen 2nd M1 for attempt to solve their two linear equations in μ and σ leading to equation in just one variable 1st A1 for σ = awrt 2.22 . Award when 1st seen 2nd A1 for μ = awrt 155. Correct answer only for part (c) can score all 6 marks. NB σ = 2.21 commonly comes from z = 2.34 and usually scores M1B0B1M1A0A1 **The A marks in (c) require both M marks to have been earned**	

Question Number	Scheme	Marks
44 (a)	$\text{P}(D > 20) = \text{P}\left(Z > \frac{20-30}{8}\right)$	M1
	$= \text{P}(Z > -1.25)$	A1
	$=$ **<u>0.8944</u>** **<u>awrt 0.894</u>**	A1 (3)
(b)	$\text{P}(D < Q_3) = 0.75$ so $\frac{Q_3 - 30}{8} = 0.67$	M1 B1
	$Q_3 =$ **awrt <u>35.4</u>**	A1 (3)
(c)	$35.4 - 30 = 5.4$ so $Q_1 = 30 - 5.4 =$ **awrt <u>24.6</u>**	B1ft (1)
(d)	$Q_3 - Q_1 = 10.8$ so $1.5(Q_3 - Q_1) = 16.2$ so $Q_1 - 16.2 = h$ or $Q_3 + 16.2 = k$	M1
	h=**<u>8.4 to 8.6</u>** and k= **<u>51.4 to 51.6</u>** both	A1 (2)
(e)	$2\text{P}(D > 51.6) = 2\text{P}(Z > 2.7)$	M1
	$= 2[1 - 0.9965]$ = awrt **<u>0.007</u>**	M1 A1 (3)
		Total 12
(a)	M1 for an attempt to standardise 20 or 40 using 30 and 8. 1st A1 for $z = \pm 1.25$ 2nd A1 for awrt 0.894	
(b)	M1 for $\frac{Q_3 - 30}{8}$ = to a z value M0 for 0.7734 on RHS. B1 for (z value) between 0.67~0.675 seen. M1B0A1 for use of $z = 0.68$ in correct expression with awrt 35.4	
(c)	Follow through using their of quartile values.	
(d)	M1 for an attempt to calculate 1.5(IQR) and attempt to add or subtract using one of the formulae given in the question - follow through their quartiles	
(e)	1st M1 for attempting $2\text{P}(D >$ their $k)$ or ($\text{P}(D >$their $k)$+ $\text{P}(D <$ their $h)$) 2nd M1 for standardising their h or k (may have missed the 2) so allow for standardising $\text{P}(D > 51.6)$ or $\text{P}(D < 8.4)$ Require boths Ms to award A mark.	

Question Number	Scheme	Marks
45 (a)		
	bell shaped, must have inflexions	B1
	154,172 on axis	B1
	5% and 30%	B1 (3)
(b)	$\mathrm{P}(X < 154) = 0.05$	
	$\frac{154-\mu}{\sigma} = -1.6449$ or $\frac{\mu-154}{\sigma} = 1.6449$	M1 B1
	$\mu = 154 + 1.6449\sigma$ **given**	A1 cso (3)
(c)	$172 - \mu = 0.5244\sigma$ or $\frac{172-\mu}{\sigma} = 0.5244$ (allow z = 0.52 or better here but must be in an equation)	B1
	Solving gives $\sigma = 8.2976075$ (**awrt 8.30**) and $\mu = 167.64873$ (**awrt 168**)	M1 A1 A1 (4)
(d)	P(Taller than 160cm) = $\mathrm{P}\left(Z > \frac{160-\mu}{\sigma}\right)$	M1
	$= \mathrm{P}(Z < 0.9217994)$	B1
	$= 0.8212$ **awrt 0.82**	A1 (3)
		Total [13]
(a)	2nd B1 for 154 and 172 marked but 154 must be $< \mu$ and $172 > \mu$. But μ need not be marked. Allow for $\frac{154-\mu}{\sigma}$ and $\frac{172-\mu}{\sigma}$ marked on appropriate sides of the peak. 3rd B1 the 5% and 30% should be clearly indicated in the correct regions i.e. LH tail and RH tail.	
(b)	M1 for $\pm\frac{(154-\mu)}{\sigma} = z$ value (z must be recognizable e.g. 1.64, 1.65, 1.96 but NOT 0.5199 etc) B1 for $\pm$ 1.6449 seen in a line before the final answer. A1cso for no incorrect statements (in μ, σ) equating a z value and a probability or incorrect signs e.g. $\frac{154-\mu}{\sigma} = 0.05$ or $\frac{154-\mu}{\sigma} = 1.6449$ or $\mathrm{P}(Z < \frac{\mu-154}{\sigma}) = 1.6449$	
(c)	B1 for a correct 2nd equation (NB $172 - \mu = 0.525\sigma$ is B0, since z is incorrect) M1 for solving their two linear equations leading to $\mu = \ldots$ or $\sigma = \ldots$ 1st A1 for σ = awrt 8.30, 2nd A1 for μ = awrt 168 [NB the 168 can come from false working. These A marks require use of correct equation from (b), and a z value for "0.5244" in (c)] NB use of z = 0.52 will typically get σ =8.31 and μ = 167.67… and score B1M1A0A1 No working and both correct scores 4/4, only one correct scores 0/4 Provided the M1 is scored the A1s can be scored even with B0 (e.g. for z =0.525)	
(d)	M1 for attempt to standardise with 160, their μ and their σ (> 0). Even allow with symbols μ and σ. B1 for z = awrt $\pm$ 0.92 No working and a correct answer can score 3/3 provided σ and μ are correct to 2sf.	

Question Number	Scheme	Marks
46 (a)	Let the random variable X be the lifetime in hours of bulb	
	$P(X < 830) = P(Z < \frac{\pm(830-850)}{50})$ Standardising with 850 and 50	M1
	$= P(Z < -0.4)$	
	$= 1 - P(Z < 0.4)$ Using 1-(probability>0.5)	M1
	$= 1 - 0.6554$	
	$= 0.3446$ or 0.344578 by calculator awrt 0.345	A1
		(3)
(b)	0.3446×500 Their (a) x 500	M1
	$= 172.3$ Accept 172.3 or 172 or 173	A1
		(2)
(c)	Standardise with 860 and σ and equate to z value $\frac{\pm(818-860)}{\sigma} = z$ value	M1
	$\frac{818-860}{\sigma} = -0.84(16)$ or $\frac{860-818}{\sigma} = 0.84(16)$ or $\frac{902-860}{\sigma} = 0.84(16)$ or equiv.	A1
	$\pm 0.8416(2)$	B1
	$\sigma = 49.9$ 50 or awrt 49.9	A1
		(4)
(d)	Company Y as the ***mean*** is greater for Y. both	B1
	They have (approximately) the same ***standard deviation*** or ***sd***	B1
		(2)
		[11]
Notes	8(a) If 1-z used e.g. 1-0.4=0.6 then award second M0 8(c) M1 can be implied by correct line 2 A1 for completely correct statement or equivalent. Award B1 if 0.8416(2) seen Do not award final A1 if any errors in solution e.g. negative sign lost. 8(d) Must use statistical terms as underlined.	

Question Number	Scheme	Marks
47 (a)	$\text{P}(X < 39) = \text{P}\left(Z < \frac{39-30}{5}\right)$	M1
	$= \text{P}(Z < 1.8) = \underline{0.9641}$ (allow awrt 0.964)	A1 (2)
(b)	$\text{P}(X < d) = \text{P}\left(Z < \frac{d-30}{5}\right) = 0.1151$	
	$1 - 0.1151 = 0.8849$	M1
	$\Rightarrow \quad z = -1.2$ (allow $\pm$ 1.2)	B1
	$\therefore \frac{d-30}{5} = -1.2$ $\quad \underline{d = 24}$	M1A1 (4)
(c)	$\text{P}(X > e) = 0.1151$ so $e = \mu + (\mu$ - their $d)$ <u>or</u> $\frac{e-30}{5} = 1.2$ or – their z	M1
	$\underline{e = 36}$	A1 (2)
(d)	$\text{P}(d < X < e) = 1 - 2 \times 0.1151$	M1
	$= 0.7698$ AWRT $\underline{0.770}$	A1 (2)
		[10]
	Answer only scores all marks in each section BUT check (b) and (c) are in correct order	
(a)	M1 for standardising with σ, $z = \pm\frac{39-30}{5}$ is OK	
	A1 for 0.9641 or awrt 0.964 but if they go on to calculate 1 – 0.9641 they get M1A0	
(b)	1st M1 for attempting 1- 0.1151. Must be seen in (b) in connection with finding d	
	B1 for $z = \pm$ 1.2. They must state $z = \pm$ 1.2 or imply it is a z value by its use. This mark is only available in part (b).	
	2nd M1 for $\left(\frac{d-30}{5}\right) =$ their negative z value (or equivalent)	
(c)	M1 for a full method to find e. If they used z = 1.2 in (b) they can get M1 for $z = \pm$ 1.2 here. If they use symmetry about the mean $\mu + (\mu$ - their $d)$ then ft their d for M1. Must explicitly <u>see</u> the method used unless the answer is correct.	
(d)	M1 for a complete method or use of a correct expression e.g. "their 0.8849" - 0.1151 <u>or</u> **If their *d* < their *e*** using their values with P(X < e) - P(X < d). If their $d \geq$ their e then they can only score from an argument like 1 – 2x0.1151. A negative probability or probability > 1 for part (d) scores M0A0	

Question Number	Scheme	Marks
48 (a)	$z=\frac{53-50}{2}$ Attempt to standardise	**M1**
	P(X>53)=1-P(Z<1.5) 1-probability required can be implied	**B1**
	=1-0.9332	
	=0.0668	**A1**
		[3]
(b)	$\mathrm{P}(X\le x_0)=0.01$	**M1**
	$\frac{x_0-50}{2}=-2.3263$	**M1B1**
	$x_0=45.3474$ awrt 45.3 or 45.4	**M1A1**
		[5]
(c)	$\mathrm{P}(\text{2 weigh more than 53kg and 1 less})=3\times 0.0668^2(1-0.0668)$	**B1M1A1ft**
	$=0.012492487..$ awrt 0.012	**A1**
		[4]
		Total 12
	<u>Notes:</u> (a) M1 for using 53,50 and 2, either way around on numerator B1 1- any probability for mark A1 0.0668 cao (b) M1 can be implied or seen in a diagram or equivalent with correct use of 0.01 or 0.99 M1 for attempt to standardise with 50 and 2 numerator either way around B1 for ± 2.3263 M1 Equate expression with 50 and 2 to a z value to form an equation with consistent signs and attempt to solve A1 awrt 45.3 or 45.4 (c) B1 for 3, M1 $p^2(1-p)$ for any value of p A1ft for p is their answer to part (a) without 3 A1 awrt 0.012 or 0.0125	

49. (a)	200 or 200g	**B1** **(1)**
(b)	P(190 < X < 210) = 0.6 or P(X < 210) = 0.8 or P(X > 210)= 0.2 or diagram (o.e.)	**M1**
	Correct use of 0.8 or 0.2	**A1**
	$Z = (\pm)\dfrac{210-200}{\sigma}$	**M1**
	$\dfrac{10}{\sigma} = 0.8416$ 0.8416	**B1**
	$\sigma = 11.882129....$ AWRT 11.9	**A1** **(5)**
(c)	$P(X < 180) = P\left(Z < \dfrac{180-200}{\sigma}\right)$	**M1**
	$= P(Z < -1.6832)$	
	$= 1 - 0.9535$	**M1**
	= 0.0465 or AWRT 0.046	**A1** **(3)** **Total 9 marks**
(a)	"mean = 200g" is B0 but "median = 200" or just "200" alone is B1 **Standardization in (b) and (c).** They must use σ not σ^2 or $\sqrt{\sigma}$.	
(b)	1st M1 for a correct probability statement (as given or eg P(200<X<210)=0.3 o.e.) or shaded diagram - must have values on z-axis and probability areas shown 1st A1 for correct use of 0.8 or p = 0.2. Need a correct probability statement. May be implied by a suitable value for z seen (e.g. z = 0.84) 2nd M1 for attempting to standardise. Values for x and μ used in formula. Don't need z = for this M1 nor a z-value, just mark standardization. B1 for z = 0.8416 (or better) [z = 0.84 usually just loses this mark in (a)] 2nd A1 for AWRT 11.9	
(c)	1st M1 for attempting to Standardise with 200 and their sd(>0) e.g. $(\pm)\dfrac{180-200}{\text{their }\sigma}$ 2nd M1 **NB on epen this is an A mark ignore and treat it as 2nd M1** for 1 – a probability from tables provided compatible with their probability statement. A1 for 0.0465 or AWRT 0.046 (Dependent on both Ms in part (c))	

Question Number	Scheme	Marks
50(a)	Only 2 outcomes **Heads** and **Tails oe**	
	Constant probability of **spinning** a **Head/Tail oe**	
	Coin is **spun** a fixed number of times **oe**	
	Each **spin** of the **coin** is independent **oe**	B1 B1
		(2)
(b)	$T \sim \text{B}(6, 0.5)$	
	$\text{P}(T \le 5) - \text{P}(T \le 4) = 0.9844 - 0.8906$ or $6\left(\frac{1}{2}\right)^5\left(\frac{1}{2}\right)$ **oe**	M1
	$= 0.09375$ or $\frac{3}{32}$ oe awrt 0.0938	A1
		(2)
(c)	$\text{P}(T = 4,5,6) = 1 - \text{P}(T \le 3)$	M1
	$= 1 - 0.6563$	
	$= 0.3437$ or $\frac{11}{32}$ awrt 0.344	A1
		(2)
(d)	$\text{P}(H = 3,4,5,6) = 1 - \text{P}(H \le 2)$	B1M1d
	$= 1 - 0.8306$	
	$= 0.1694$ or $\frac{347}{2048}$ awrt 0.169	A1
		(3)
	Notes	**Total 9**

(a) B1 A correct statement – does not need to be in context
B1 A second correct statement in context include coin or heads or tails(do not allow H and T) or spins/flip oe.

(b) M1 [writing or using B(6, 0.5) **and** writing or using $\text{P}(T \le 5) - \text{P}(T \le 4)$] **or** [$6\left(\frac{1}{2}\right)^6$ **oe**]

(c) M1 for realising they need find $\text{P}(T = 4, 5 \text{ or } 6)$ eg $1 - \text{P}(T \le 3)$ or $\text{P}(T \ge 4)$

(d)

B1	writing/using B(6, 0.25) **and** $\text{P}(H \ge 3)$ **oe**	writing/using B(6, 0.75) **and** $\text{P}(T \le 3)$
M1d	dep on B1 for $1 - \text{P}(H \le 2)$	dep on B1 $(0.25)^6 + 6(0.75)(0.25)^5 + 15(0.75)^2(0.25)^4 + 20(0.75)^3(0.25)^3$
A1	awrt 0.169	awrt 0.169
NB	Only accept correct use of H and T in the probability statement unless their variable is correctly defined	
NB	awrt 0.169 with no incorrect working gains B1M1A1	

51(a)	$P(M < 10) = P\left(Z < \frac{12-14}{\sigma}\right) = 0.1$		
	$\Rightarrow \frac{12-14}{\sigma} =,\ -1.2816$	**M1** standardising ($\pm$) with 12, 14 and σ and setting equal to a z value where $\lvert z \rvert > 1$ **B1** $\pm$1.2816 or better	**M1** **B1**
	$\sigma = 1.5605......$ =awrt 1.56 minutes	**A1** awrt 1.56 Do **not** allow answer written as an exact fraction.	**A1** **(3)**
(b)	T represents number less than 12 minutes. $T \sim B(15, 0.1)$	**B1** Writing or using B(15, 0.1) .	**B1**
	$P(T \leq 1)$	**M1** writing $P(T \leq 1)$ or $P(T < 2)$ any letter may be used.	**M1**
	= 0.549	**A1** awrt 0.549	**A1**
		NB 0.549 gets B1 M1 A1	**(3)**
(c)	[T ~ number of people who take less than 12 mins to complete the test] $T \sim B(n, 0.1)$		
	T can be approximated by N($0.1n$, $0.09n$)	**B1** mean = $0.1n$ and Var = $0.09n$ **oe** may be seen in an attempt at standardisation	**B1**
	$P\left(Z < \frac{8.5 - 0.1n}{\sqrt{0.09n}}\right) = 0.3085$	**M1** using a continuity correction either 8.5 or 7.5 in an attempt at standardised form. Allow 0.09 for sd.	**M1**
	$\frac{8.5-0.1n}{\sqrt{0.09n}} = -0.5$ or $\frac{8.5-0.1x^2}{0.3x} = -0.5$	**B1** a z value of awrt $\pm$ 0.5	**B1**
		M1 standardising using their mean and sd. (If these have not been given then they must be correct here) **and** one of 7.5, 8, 8.5, 9 or 9.5 **and** equal to a z value where $\lvert z \rvert > 0.4$. Allow any form	**M1**
		A1 A correct equation in **any form**. ISW. Do **not** allow if they have $0.3n$ rather than $0.3\sqrt{n}$	**A1**
	$0.1n - 0.15\sqrt{n} - 8.5 = 0$ $\sqrt{n} = 10$	**M1** using either the quadratic formula or completing the square or factorising or any correct method to solve **their 3 term quadratic**. If they write the quadratic formula down then allow one slip. If no formula written down then it must be correct for their equation. May be implied by seeing 10 or 8.5. They must show working if the equation used is not correct. 2nd **A1** awrt 10.0 – do not need to see n or $\sqrt{n}$. Allow n = 10 May be implied by 100	**M1A1**
	n = 100	3rd **A1 cso** 100 If they have a second answer of 72.25 they must reject it to get this final mark.	**A1cso** **(8)**
			(Total 14)

Question Number	Scheme		Marks
52(a)	$0.05n = 3$	M1: using $0.05n$	M1
	$n = 60$	A1: cao NB: for 60 with no incorrect working award M1A1	A1 (2)
(b)	$R \sim \mathrm{B}(20, 0.05)$	B1: using or writing B(20, 0.05) in (i) or (ii)	B1
(i)	$\mathrm{P}(R = 4) = {}^{20}C_4\left(0.05\right)^4\left(0.95\right)^{16}$ **OR** $\mathrm{P}(R = 4) = \mathrm{P}(R \le 4) - \mathrm{P}(R \le 3)$ $= 0.9974 - 0.9841$	M1 writing or using $\mathrm{P}(R \le 4) - \mathrm{P}(R \le 3)$ or using ${}^{20}C_4\left(p\right)^4\left(1-p\right)^{16}$	M1
	$= 0.0133$	A1: awrt 0.0133	A1
(ii)	$\mathrm{P}(R \ge 4) = 1 - \mathrm{P}(R \quad 3)$ $= 1 - 0.9841$	M1: writing or using $1 - \mathrm{P}(R \quad 3)$	M1
	$= 0.0159$	A1: awrt 0.0159	A1 (5)
			Total 7

Question Number	Scheme		Marks
53.	N(0.2n, 0.16n)	B1: Mean = 0.2n and Var = 0.16n oe this may be awarded if they appear in the standardisation as 0.2n and either 0.16n or $\sqrt{0.16n}$	B1
	$\mathrm{P}\left(Z > \dfrac{55.5-0.2n}{\sqrt{0.16n}}\right) = 0.0401$	M1: Using a continuity correction either 55.5 or 54.5	M1
	$\dfrac{55.5-0.2n}{\sqrt{0.16n}} = 1.75$	B1: Using a z = awrt $\pm$ 1.75 M1: Standardising using either 55.5, 54.5 or 55 and equal to a z value. Follow through their mean and variance. If they have not given the mean and Var earlier then they must be correct A1: A correct equation. May be awarded for $\dfrac{55.5-0.2n}{\sqrt{0.16n}} = 1.75$ Condone use of an inequality sign rather than an equals sign	B1M1A1
	$0.2n + 0.7\sqrt{n} - 55.5 = 0$	M1**d**: This is dependent on the previous method mark being awarded. Using either the quadratic formula or completing the square or factorising or any correct method to solve **their 3 term** equation. If they write the formula down then allow a slip. If no formula written down then it must be correct for their equation. May be implied by correct answer or $\sqrt{n} = 15$ or 342.25 **NB** you may award this mark if they use 54.5 for awrt 14.9, -18.4, 221 or 337 55 for awrt -18.4, 14.9,223 or -117 If the answer is not one of these then the method for solving their 3 term equation must be seen.	M1**d**
	$\sqrt{n} = 15$	A1: Allow 15 or -18.5 do not need to see n or $\sqrt{n}$. Condone n = 15 or n = -18.5	A1
	n = 225	A1 : cao 225 do not need to see n or $\sqrt{n}$	A1 (8)
	Alternative method for last 3 marks $(0.2n - 55.5)^2 = (-0.7\sqrt{n})^2$ $0.04n^2 - 22.69n + 3080.25 = 0$ n = 225 or 1369/4 n = 225	M1 solving 3 term quadratic in n as above A1 either 225 or 1369/4 or 342.25 A1must select 225	**Total 8**

Question Number	Scheme	notes	Marks
54		**notes**	
	$X \sim B(30, 0.25)$	B1: using B(30, 0.25)	B1
	$P(X \leq 10) - P(X \leq 4) \quad = 0.8943 - 0.0979$	M1: using $P(X \leq 10) - P(X \leq 4)$ or $P(X \geq 5) - P(X \geq 11)$ oe	M1 A1
	$= 0.7964$	A1: awrt 0.796	
	NB a correct answer gains full marks		**Total 3**

Question Number	Scheme	Marks
55. (a)	X is the random variable the Number of successes, $X \sim B(10, 0.75)$	B1
(i)	P $(X = 6) = (0.75)^6 (0.25)^4\ {}^{10}C_6$ or $P(X \le 6) - P(X \le 5)$	M1
	$= 0.145998$ awrt 0.146	A1
(ii)	Using $X \sim B(10, 0.75)$ $P(X \ge 8) = P(X = 8) + P(X = 9) + P(X = 10)$	M1
	$= (0.75)^8 (0.25)^2\ {}^{10}C_8 + (0.75)^9 (0.25)^1\ {}^{10}C_9 + (0.75)^{10}$	
	$= 0.52559$ awrt 0.526	A1
	Or Using $Y \sim B(10, 0.25)$ and $P(Y \le 2) = 0.5256$	(5)
(b)	$1 - P(0) = 0.8$ or $P(0) = 0.2$	M1
	$(1-p)^{20} = 0.2$	
	$1 - p = 0.9227$	
	$p = 0.0773$	A1
	$\frac{3}{200}(90 - x) = 0.0773$	M1
	$x = 84.84$	
	$x = 85$	A1cao (4)
	Notes	[9]
(a)	B1 writing or using $p = 0.75$ or $p = 0.25$ anywhere in (a)(i) or (a)(ii)	
(i)	M1 writing or using $(p)^6 (1-p)^4\ {}^{10}C_6$ **or** writing for p =0.75, $P(X \le 6) - (X \le 5)$ **or** for $p = 0.25$, $P(X \le 4) - P(X \le 3)$ **or** correct answer.	
(ii)	M1 writing B(10, 0.75) and writing or using $P(X = 8) + P(X = 9) + P(X = 10)$ oe **or** writing B(10, 0.25) and writing or using $P(Y \le 2)$. Using correct Binomial must be shown by $(0.75)^n (0.25)^{10-n}$ or a correct answer.	
(b)	M1 for writing or using $1 - P(0) = 0.8$ or $P(0) = 0.2$ or $(1-p)^{20} = 0.2$. Allow any inequality sign. A1 awrt 0.0773 or awrt 0.923. M1 subst in $\frac{3}{200}(90 - x)$ for p **NB** this may be substituted in earlier for p. Allow for $\frac{3}{200}(90 - x) = k$ where $0 < k < 1$ $k \ne 0.8$ or 0.2 Allow any inequality sign A1 condone $x \ge 85$. Do not allow $x \le 85$.	

Question	Scheme	Marks
56.		
(a)	$T \sim \mathrm{B}(10, 0.4)$	M1A1 (2)
(b)	P(2′ 2′ 2) or P(5 5 2, 5 >5 2, >5 >5 2) $= 0.6^2 \times 0.4$ = $(0.25)^2(0.4) + 2\times(0.25)(0.35)(0.4) + (0.35)^2(0.4)$	M1
	$= 0.144$	A1 (2) **(4)**
	Notes	
(a)	M1 for binomial A1 for n = 10 and p = 0.4 NB If they give 2 options then unless they select the correct one they gain M0A0	
(b)	M1 for identifying the correct possibilities 2′ 2′ 2 **<u>or</u>** 5 5 2 and 5 >5 2 and >5 5 2 and >5 >5 2 **or** a correct probability statement. The possibilities must be in the correct order. Condone 2× (5 >5 2) or 2× (>5 5 2). Implied a correct answer. A1 for 0.144 or exact equivalent e.g. $\frac{18}{125}$	

Question Number	Scheme	Marks
57(a)	Distribution $X \sim B(n, 0.1)$	B1
		(1)
57(b)	$Y \sim B(10, 0.1)$	B1
	$P(Y \geq 4) = 1 - P(Y \leq 3)$	M1
	$= 1 - 0.9872$	
	$= 0.0128$	A1
		(3)
57(c)		
	$0.9^n < 0.05$ or $1 - (0.9)^n > 0.95$	M1
	$n > 28.4$	A1
	$n = 29$	A1
	alternative	
	B(28,0.1): P(0) = 0.0523	M1
	B(29,0.1): P(0) = 0.0471	A1
	$n = 29$	A1cao
		(3)
		Total marks 7
	Notes	
57(a)	B1 for "binomial" or B(…	
57(b)	B1 writing or using B(10,0.1)	
	M1 writing or using $1 - P(Y \leq 3)$	
	A1 awrt 0.0128	
57(c)	M1 $(0.9)^n < 0.05$,oe, or $(0.9)^n = 0.05$,oe, or $(0.9)^n > 0.05$, oe, or seeing 0.0523 or seeing 0.0471	
	1st A1 [P(0)] = 0.0471 or getting awrt 28.4 May be implied by correct answer.	
	2nd A1 cao $n = 29$ should not come from incorrect working.	
	NB An answer of 29 on its own with no working gains M1A1A1	

Question Number	Scheme		Marks
58(a) (i)	$P(X < 5) = 0.8424$	awrt 0.842	B1
(ii)	$P(X \geq 7) = 1 - P(X \leq 6)$		M1
	$= 1 - 0.9857$		
	$= 0.0143$	awrt 0.0143	A1
			(3)
(b)	$P(X = 0) = (1 - p)^{12}$		
	$(1 - p)^{12} = 0.05$		M1
	$(1 - p) = \sqrt[12]{0.05}$		M1
	$p = 0.221$	awrt 0.221	A1
			(3)
	Notes		**Total 6**
(a) (ii)	M1writing or using $1 - P(X \leq 6)$ Do not accept $1 - P(X < 7)$ unless $1 - P(X \leq 6)$ has been used		
(b)	1st M1 $(1 - p)^n = 0.05$ 2nd M1 taking nth root. If they have used logs they need to get to a correct expression for $1 - p$ for their equation.		

Question Number	Scheme	Marks
59(a)	Let X be the random variable the number of customers asking for water.	
(i)	X ~B(10,0.6) | Y ~B(10,0.4)	B1
	$P(X=6)=(0.6)^6(0.4)^4\frac{10!}{6!4!}$ | $P(Y=4)=(0.4)^4(0.6)^6\frac{10!}{6!4!}$	M1
	= 0.2508… | = 0.2508 | awrt 0.251	A1
(ii)	X ~B(10,0.6) | Y ~B(10,0.4)	
	$P(X<9)=1-(P(X=10)+P(X=9))$ $=1-(0.6)^{10}-(0.6)^9(0.4)^1\frac{10!}{9!1!}$ | $P(X<9)=1-P(Y\le 1)$ $=1-0.0464$	M1
	= 0.9536… | = 0.9536… | awrt 0.954	A1
		(5)
(b)	X ~B(50,0.6) Y ~B(50,0.4) $P(X<n)\geq 0.9$	M1
	$P(Y>50-n)\geq 0.9$ or $P(X<34)=0.8439$ awrt 0.844 $P(Y\leq 50-n)\leq 0.1$ $P(X<35)=0.9045$ awrt 0.904/0.905 $50-n\leq 15$ $n\geq 35$	M1
	$n=35$	A1
		(3) **Total 8**
	Notes	
(a) (i)	B1 writing or using B(10,0.6) / B(10,0.4) in either part(i) or (ii) M1 $(0.6)^6(1-0.6)^4\frac{10!}{6!4!}$ Allow ${}^{10}C_6$ oe or writing or using $P(X\le 6)-P(X\le 5)$ if using B(10,0.6) or $P(X\le 4)-P(X\le 3)$ if using B(10,0.4) NB use of Poisson will gain M0A0	
(ii)	M1 writing or using $1-(P(X=10)+P(X=9))$ if using B(10,0.6) or $1-P(Y\le 1)$ if using B(10,0.4) NB use of Poisson will gain M0A0	
(b)	1st M1 for writing or using either B(50,0.6) or B(50,0.4) 2nd M1 $P(Y>50-n)\geq 0.9$ or $P(Y\leq 50-n)\leq 0.1$ or $P(X<34)$ = awrt 0.844 or $P(X<35)$ = awrt 0.904/0.905 or $50-n=15$ or $50-n=16$ or $50-n\leq 15$ or $50-n\leq 16$ – allow different letters A1 cao 35. Do not accept $n\geq 35$ for final A1. SC use of normal. M1 M0 A0 for use of N(30,12) leading to an answer of 35	

Number		
60 (a)	$P(X=0)=0.85^{10}$ or from tables	M1
	$=0.1969$ awrt 0.197	A1 (2)
(b)	$P(X>3)=1-P(X\le 3)$	M1
	$=1-0.6477$ $=0.3523$ awrt 0.352	A1 (2)
(c)	$n\times 0.15=5$	M1
	$n=33$ or 34	A1 (2)
(d)	1 - P(X = 0) > 0.95	M1
	$1-(0.85)^n>0.95.$ $0.85^n<0.05$	A1
	$n>18.4$	
	$n=19$	A1 (3) **9**
	Notes	
(a)	M1 $(p)^{10}$ with $0<p<1$	
(b)	M1writing or using 1 - P($X\le 3$)	
(c)	M1 $np=5$ $0<p<1$	
(d)	M1 writing or using 1 - P(X = 0) > 0.95 or P(X = 0) < 0.05 (also accepted are = or $\geq$ instead of > and = or $\leq$ instead of or <) P($X\le 0$) is equivalent to P(X =0) A1 writing or using 1 - $(0.85)^n>0.95$ or $(0.85)^n<0.05$ (also accepted are $\geq$ instead of > and $\leq$ instead of or <). Any value of n may be used A1 cao NB an answer of 18.4 gets M1 A1 A0 An answer of 19 gets M1 A1 A1 unless it follows from clearly incorrect working.	

Question Number	Scheme	Marks
61. **(a)**	Occurrences of the disease are independent The probability of catching the disease remains constant.	B1 B1 (2)
(b)	$X \sim \text{Bin}(10, 0.03)$ $\text{P}(X = 2) = \frac{10\times 9}{2}(0.03)^2(0.97)^8 = 0.0317$	B1 M1A1 (3)
		[5]
	Notes	
(a)	B1 independent B1 <u>probability</u> remains <u>constant</u>. One of these must have the context of disease. No context only one correct B0B0 If only one mark awarded give the first B1 SC if they are both correct without context award B1B0	
(b)	B1 for writing or using B(10,0.03) M1 for writing or using $(p)^2\ (1-p)^8\ \frac{10!}{2!8!}$ allow ${}^{10}C_2, \binom{10}{2}$ etc Allow P(X≤2) – P(X≤1) A1 awrt 0.0317	

Question Number	Scheme	Marks
62 (a)	Let X be the random variable the number of games Bhim loses. X ~B(9, 0.2)	B1
	$P(X \le 3) - P(X \le 2) = 0.9144 - 0.7382$ or $(0.2)^3(0.8)^6\dfrac{9!}{3!6!}$	M1
	$= 0.1762$ $= 0.1762$ awrt 0.176	A1 (3)
(b)	$P(X \le 4) = 0.9804$ awrt 0.98	M1A1 (2)
		[5]
	Notes	
(a)	B1 – writing or use of B(9, 0.2) **M1** for writing/ using $P(X \le 3) - P(X \le 2)$ or $(p)^3(1-p)^6\dfrac{9!}{3!6!}$ **A1** awrt 0.176	
(b)	**M1** for writing or using $P(X \le 4)$ **A1** awrt 0.98	

Question Number	Scheme	Marks
63 (a)	$X \sim B(20,0.05)$	B1 B1 (2)
(b)	P(X = 0) = 0.95^{20} = 0.3584859… or 0.3585 using tables .	M1 A1 (2)
(c)	$\text{P}(X > 4) = 1 - \text{P}(X \le 4)$	M1
	$= 1 - 0.9974$	
	$= 0.0026$	A1 (2)
		Total [6]
	Notes	
63 (a)	**1st B1** for binomial **2nd B1** for 20 and 0.05 o.e These must be in part (a)	
(b)	**M1** for finding $(p)^{20}$ $0 < p < 1$ this working needs to be seen if answer incorrect to gain the M1 **A1** awrt 0.358 or 0.359.	
(c)	**M1** for writing $1 - \text{P}(X \le 4)$ or 1 – [P(X = 0) + P(X = 1) + P(X = 2) + P(X = 3) + P(X = 4)] or 1 – 0.9974 or 1 – 0.9568 **A1** awrt 0.0026 or 2.6×10^{-3}, do not accept a fraction e.g. 26/10000	

Question Number	Scheme	Marks
64	$[X \sim \mathrm{B}(30, 0.15)]$ $\mathrm{P}(X \leq 6)$, = 0.8474 awrt 0.847	M1, A1 (2) **[2]**
Notes	M1 for a correct probability statement $\mathrm{P}(X \leq 6)$ or $\mathrm{P}(X < 7)$ or P $(X=0)$ + P $(X = 1)$ + P $(X = 2)$+ P $(X=4)$ + P $(X=5)$ + P $(X=6)$. (may be implied by long calculation) Correct answer gets M1 A1. allow 84.74%	

EXPERT TUITION

Question Number	Scheme	Marks
65.	$X \sim B(100, 0.58)$ $Y \sim N(58, 24.36)$	B1 B1 B1
	$[P(X > 50) = P(X \geq 51)]$ using 50.5 or 51.5 or 49.5 or 48.5	M1
	$= P\left(z \geq \pm\left(\frac{50.5 - 58}{\sqrt{24.36}}\right)\right)$ standardising 50.5, 51, 51.5, 48.5, 49, 49.5 and their μ and σ for M1	M1
	$= P(z \geq -1.52\ldots)$	A1
	$= 0.9357$	A1
	alternative	(7)
	$X \sim B(100, 0.42)$ $Y \sim N(42, 24.36)$	B1 B1 B1
	$[P(X < 50) = P(X \leq 49)]$ using 50.5 or 51.5 or 49.5 or 48.5	M1
	$= P\left(z \leq \pm\left(\frac{49.5 - 42}{\sqrt{24.36}}\right)\right)$ standardising 50.5, 51, 51.5, 48.5, 49, 49.5 and their μ and σ for M1	M1 A1
	$= P(z \leq 1.52\ldots)$	
	$= 0.9357$	A1 (Total 7)
	Notes The first 3 marks may be given if the following figures are seen in the standardisation formula :- 58 or 42, 24.36 or $\sqrt{24.36}$ or $\sqrt{24.4}$ or awrt 4.94. Otherwise B1 normal B1 58 or 42 B1 24.36 M1 using 50.5 or 51.5 or 49.5 or 48.5. ignore the direction of the inequality. M1 standardising 50.5, 51, 51.5, 48.5, 49, 49.5 and their μ and σ. They may use $\sqrt{24}$ or $\sqrt{24.36}$ or $\sqrt{24.4}$ or awrt 4.94 for σ or the $\sqrt{}$of their variance. A1 $\pm$ 1.52. may be awarded for $\pm\left(\frac{50.5 - 58}{\sqrt{24.36}}\right)$ or $\pm\left(\frac{49.5 - 42}{\sqrt{24.36}}\right)$ o.e. A1 awrt 0.936	

Question Number	Scheme	Marks
66	$X \sim B(11000, 0.0005)$	M1 A1 (2) Total 2
	<u>Notes</u> M1 for Binomial, A1 fully correct These cannot be awarded unless seen in part a	

Question Number	Scheme	Marks
67(a)	$X \sim B(15, 0.5)$	B1 B1 (2)
(b)	$P(X=8) = P(X \le 8) - P(X \le 7)$ or $\left(\frac{15!}{8!7!}(p)^8(1-p)^7\right)$	M1
	$= 0.6964 - 0.5$	
	$= 0.1964$ awrt 0.196	A1 (2)
(c)	$P(X \ge 4) = 1 - P(X \le 3)$	M1
	$= 1 - 0.0176$	
	$= 0.9824$	A1 (2)
		(Total 6)
	Notes (a) B1 for Binomial B1 for 15 and 0.5 must be in part a This need not be in the form written (b) M1 attempt to find $P(X=8)$ any method. Any value of p A1 awrt 0.196 Answer only full marks (c) M1 for $1 - P(X \le 3)$. A1 awrt 0.982	

68 (a)	Let X be the random variable the number of faulty bolts	M1
	$P(X \leq 2) - P(X \leq 1) = 0.0355 - 0.0076$ or $(0.3)^2(0.7)^{18}\frac{20!}{18!2!}$	A1
	$= 0.0279$ $= 0.0278$	(2)
		M1 A1
(b)	$1 - P(X \leq 3) = 1 - 0.1071$ $= 0.8929$	(2)
	or $1-(0.3)^3(0.7)^{17}\frac{20!}{17!3!}-(0.3)^2(0.7)^{18}\frac{20!}{18!2!}-(0.3)(0.7.)^{19}\frac{20!}{19!1!}-(0.7)^{20}$	M1A1√A1
(c)	$\frac{10!}{4!6!}(0.8929)^6(0.1071)^4 = 0.0140.$	(3)
		(Total 7)
Notes:		
68. (a)	**M1** Either attempting to use P $(X \leq 2)$ – P $(X \leq 1)$ or attempt to use binomial and find p(X = 2). Must have $(p)^2(1-p)^{18}\frac{20!}{18!2!}$, with a value of p **A1** awrt 0.0278 or 0.0279.	
(b)	**M1** Attempting to find $1 - P(X \leq 3)$ **A1** awrt 0.893	
(c)	**M1** for $k\ (p)^6(1-p)^4$. They may use any value for p and k can be any number or ${}^nC_6 p^6(1-p)^{n-6}$ **A1**√ $\frac{10!}{4!6!}(their\ part\ b)^6(1-their\ part\ b)^4$ may write ${}^{10}C_6$or ${}^{10}C_4$ **A1** awrt 0.014	