Qu 5	Scheme	Marks	AO
(a)	$\left[\text{Let } F \sim \text{N}\left(166.5, 6.1^2\right)\right]$ $\text{P}(F < k) = 0.01 \Rightarrow \dfrac{k-166.5}{6.1} = -2.3263$	M1	3.4
	$k = 152.309\ldots$ **152** or awrt **152.3**	A1	1.1b
		(2)	
(b)	[P($150 < F < 175$) =] 0.914840… awrt **0.915**	B1	1.1b
		(1)	
(c)	P($F > 160 \mid 150 < F < 175$)	M1	3.1b
	$= \dfrac{\text{P}(160 < F < 175)}{\text{P}(150 < F < 175)}$ or $\dfrac{\text{P}(160 < F < 175)}{\text{"(b)"}}$	M1	1.1b
	$= \dfrac{0.7749487...}{\text{"0.91484..."}}$	A1ft	1.1b
	= 0.84708… awrt **0.847**	A1	1.1b
		(4)	
(d)	$\text{H}_0 : \mu = 166.5$ $\text{H}_1 : \mu < 166.5$	B1	2.5
	[Let X = height of female from 2nd country] $\bar{X} \sim \text{N}\left(166.5, \left(\dfrac{7.4}{\sqrt{50}}\right)^2\right)$	M1	3.3
	$\text{P}\left(\bar{X} < 164.6\right) = 0.03472...$	A1	3.4
	[0.0347… < 0.05 so significant or reject H_0] There is evidence to support Mia's belief	dA1	2.2b
		(4)	
		(11 marks)	

	Notes
(a)	M1 for standardising (allow ±) 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. $\text{P}(\frac{k-166.5}{6.1}) = -2.3263$]
	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
(d)	B1 for both correct hypotheses in terms of μ
	1st M1 for selecting the correct model (needn't use $\bar{X}$ $\Rightarrow$ by standardisation or 1st A1)
	1st A1 for correct use of the correct model i.e. awrt 0.035 (allow 0.04 if $\text{P}\left(\text{"}\bar{X}\text{"} < 164.6\right)$ seen)
	Condone $\text{P}(\text{"}\bar{X}\text{"} > 164.6) = 0.9652$ or awrt 0.97 only if comparison with 0.95 is made
ALT	**Use of *z* value:** Need to see $Z = -1.8(15\ldots)$ **and** cv of ± 1.6449 (allow 1.64 or better) for 1st A1
ALT	**Use of CR or CV for $\bar{X}$:** Need to see "$\bar{X}$"< 164.7786… or CV = … (awrt 164.8) for 1st A1
	Condone truncation i.e 164.7 or better
	2nd dA1 (**dep on M1A1** only) for a correct inference in context.
	Must mention Mia's belief **or** mean height of females/women
	Do NOT award if contradictory statements about hypotheses made e.g. "not sig"
SC	**M0 for** $\bar{X}$ ~N(**164.6**, …) If they achieve p = awrt 0.035 (o.e. with z-value or CV of 166.3) **and** a correct conclusion in context is given score M0A0A1 [and SC for awrt 0.97 > 0.95 case]

Qu 5	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
	$= \dfrac{0.308537...}{(a)}$ or $\dfrac{1-(a)}{(a)}, = 0.44621\ldots$	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
(d)	$H_0 : \mu = 18 \quad H_1 : \mu > 18$	B1	2.5
	$\bar{L} \sim N\left(18, \left(\dfrac{4}{\sqrt{20}}\right)^2\right)$	M1	3.3
	$P(\bar{L} > 19.2) = P(Z > 1.3416\ldots) = 0.089856\ldots$	A1	3.4
	(0.0899 > 5%) <u>or</u> (19.2 < 19.5) <u>or</u> 1.34 < 1.6449 so not significant	A1	1.1b
	Insufficient evidence to support Alice's claim (or belief)	A1 (5)	3.5a
		(14 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… 2nd M1 (dep on 1st M1) for 2nd correct step i.e. (their 0.446…)^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)**
(d)	B1 for both hypotheses in terms of μ. M1 for selecting a suitable model. Sight of <u>normal</u>, <u>mean</u> 18, <u>sd</u> $\frac{4}{\sqrt{20}}$ (o.e.) or <u>variance</u> = 0.8 1st A1 for using the model correctly. Allow awrt 0.0899 <u>or</u> 0.09 from correct prob. statement **ALT** **CR** $(\bar{L}) > 19.471\ldots$ (accept awrt 19.5) <u>or</u> **CV** of 1.6449 (or better: calc 1.6448536..) 2nd A1 for correct non-contextual conclusion. Wrong comparison or contradictions A0 Error giving 2nd A0 implies 3rd A0 but just a correct contextual conclusion can score A1A1 3rd A1 dep on M1 and 1st A1 for a correct contextual conclusion mentioning <u>Alice's claim</u> /<u>belief</u> <u>or</u> there is insufficient evidence that the mean <u>lifetime</u> is more than 18 hours

Question	Scheme	Marks	AOs
2(a)	IQR = 26.6 – 19.4 [= 7.2]	B1	2.1
	19.4 – 1.5 × '7.2' [= 8.6] or 26.6 + 1.5 × '7.2' [= 37.4]	M1	1.1b
	Plotting one upper whisker to 32.5 **and** one lower whisker to 8.6 or 9.1	A1	1.1b
	Plotting 7.6 and 8.1 as the only two outliers	A1	1.1b
		(4)	
(b)	October (since it is the month with the coldest temperatures between May and October in Beijing)	B1	2.4
		(1)	
(c)	$[\sigma =]\sqrt{\frac{4952.906}{184}}$ or e.g. $[\sigma =]\sqrt{\frac{S_{xx}}{n}} = 5.188...$ [=5.19*]	B1cso*	1.1b
		(1)	
(d)	$z = (\pm)\ 1.28(16)$ $[P_{90} =]29.251...$ or $[P_{10} =]15.948...$	B1	3.1b
	2 × 1.2816 × 5.19 '29.251…' – '15.948…'	M1	1.1b
	= awrt **13.3**	A1	1.1b
		(3)	
(e)	Daily mean wind speed/Beaufort conversion since it is qualitative Rainfall since it is not symmetric/lots of days with 0 rainfall	B1 B1	2.4 2.4
		(2)	
			(11 marks)

Notes

(a)

B1: for a correct calculation for the IQR (implied by 10.8 **or** 8.6 **or** 37.4 seen)
M1: for a complete method for either lower outlier limit or upper outlier limit (allow ft on their IQR) (may be implied by the 1st A1 or a lower whisker at 8.6)
A1: both whiskers plotted correctly (allow ½ square tolerance)
A1: only two outliers plotted, 7.6 and 8.1 (must be disconnected from whisker)
NOTE: A fully correct box plot with no incorrect working scores 4/4

(c)

B1cso*: Correct expression with square root **or** correct formula and 5.188 or better
Allow a complete correct method finding $\sum x^2 = \text{awrt } 98720$ and $\sigma = \sqrt{\frac{98715.9...}{184} - \left(\frac{4153.6}{184}\right)^2}$

(d)

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

(e)

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:

- Wind speed/Beaufort since the data is non-numeric (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)
- Rainfall as not symmetric/is skewed/is not bell shaped/lots of 0s /many days with no rain/mean≠mode or median
- Date since each data value appears once/it is uniformly distributed
- Daily mean pressure since it is not symmetric/is skewed/not bell shaped
- Daily mean wind speed 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
5(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)	
(c)	$H_0 : \mu = 25 \quad H_1 : \mu < 25$	B1	2.5
	$[\bar{D} \sim] N\left(25, \frac{0.16^2}{20}\right)$	M1	3.3
	$P(\bar{D} < 24.94)[= P(Z < -1.677...)] = 0.046766...$	A1	3.4
	$p = 0.047 < 0.05$ or $z = -1.677\ldots < -1.6449$ or $24.94 < 24.94115\ldots$ or reject H_0 /in the critical region/significant	M1	1.1b
	There is sufficient evidence to support Hannah's belief.	A1	2.2b
		(5)	
			(13 marks)

Notes

(a)

M1: for standardising 24.63, 25 and 'σ' (ignore label) and setting = to z where $1 < |z| < 2$
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]

(c)

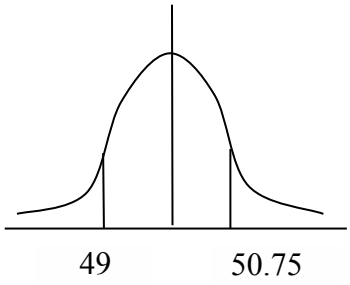
B1: for both hypotheses in terms of μ
M1: selecting suitable model must see N(ormal), mean 25, sd = $\frac{0.16}{\sqrt{20}}$ (o.e.) or var = $\frac{4}{3125}$ (o.e.)
Condone N(25, $\frac{0.16}{\sqrt{20}}$) if $\frac{0.16}{\sqrt{20}}$ then used as s.d.
A1: p value = awrt 0.047 or **test statistic** awrt –1.68 or **CV** awrt 24.941
(any of these values imply the M1 provided they do not come from Normal mean = 24.94)
M1: a correct comparison (including compatible signs) **or** correct non-contextual conclusion (f.t. their p value, test statistic or critical value in the comparison)
M1 may be implied by a correct contextual statement
NB Any contradictory non contextual statements/comparisons score M0A0 e.g. '$p < 0.05$, not significant'
A1: correct conclusion in context mentioning Hannah's belief
or the mean amount/liquid in each bottle is now less than 25ml (**dep on M1A1M1**)

Qu 5	Scheme	Marks	AO
(a)	{Let X = time spent, P($X > 15$) = } 0.105649… awrt **0.106**	B1 **(1)**	1.1b
(b)	$H_0 : \mu = 10$ $H_1 : \mu > 10$	B1	2.5
	$\bar{X} \sim N\left(10, \left(\frac{4}{\sqrt{20}}\right)^2\right)$; $P(\bar{X} > 11.5) = 0.046766…$ [Condone 0.9532…]	M1;A1	3.3;3.4
	[This is significant (< 5%) so] there is evidence to support the complaint	A1 **(4)**	2.2b
(c)(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
(d)	Require t such that P($T > t \mid T > 2$) = 0.5 or P($T < t \mid T > 2$) = 0.5	M1	3.1b
	e.g. $\frac{P(T > t)}{P(T > 2)} = 0.5$; so P($T > t$) = 0.5×[1 – (c)(i)] or P($T > t$) = 0.5×0.8043..	M1; A1ft	1.1b 3.4
	[i.e. P($T > t$) = 0.40… implies] $\frac{t-5}{3.5} = 0.2533$ or P($T < t$) = "0.5978.."	M1	1.1b
	t = 5.886… or from calculator 5.867… so awrt **5.9**	A1 **(5)**	1.1b
		(15 marks)	

	Notes
(a)	B1 for awrt 0.106 (from calculator) [Allow 10.6%]
(b)	B1 for both hypotheses correct in terms of μ. M1 for selection of a correct model (sight or use of correct normal- may not have label $\bar{X}$) 1st A1 for use of this model to get probability allow 0.046~0.047 [Condone awrt 0.953]
ALT	**OR** test statistic z = 1.677… (awrt 1.68) and cv of 1.64 (or better) **or** CR $\bar{X}$ > 11.47.. 2nd A1 (dep on 1st A1 or at least $P(\bar{X} > 11.5) < 0.05$ (o.e.))
SC	for a correct conclusion in context -must mention **complaint**/claim or **time**/mins is > 10 **(M0 for $\bar{X}$ ~N(11.5, …)** for correct probability **and** conclusion (score M0A0A1 on epen)
(c)(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 or Difference between P($T < 2 \mid T > 0$) and P($T < 2$) is **too big** (o.e.)
(d)	1st M1 for a correct conditional probability statement to start the problem or 0.5×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 < median) = 1 – 0.5×"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]

Paper 3: Statistics and Mechanics Mark Scheme

Question	Scheme	Marks	AOs
1(a)	**Area** = $8\times1.5=12$ cm^2 **Frequency** = 8 so 1 cm^2 = $\frac{2}{3}$ **hour (o.e.)**	M1	3.1a
	Frequency of 12 corresponds to area of 18 so height = $18\div2.5$ = **7.2 (cm)**	A1	1.1b
	Width = 5×0.5 = **2.5 (cm)**	B1cao	1.1b
		(3)	
(b)	$[\bar{y}=]\ \frac{205.5}{31}=$ awrt 6.63	B1cao	1.1b
	$[\sigma_y=]\ \sqrt{\frac{1785.25}{31}-\bar{y}^2}$ = $\sqrt{13.644641}$ = **awrt 3.69** allow $[s=]\ \sqrt{\frac{1785.25-31\bar{y}^2}{30}}$ = **awrt 3.75**	M1 A1	1.1a 1.1b
		(3)	
(c)	Mean of Heathrow is higher than Hurn and standard deviation smaller suggesting Heathrow is more reliable	M1	2.4
	Hurn is South of Heathrow so does <u>not</u> support his belief	A1	2.2b
		(2)	
(d)	$\bar{x}+\sigma\approx10.3$ so number of days is e.g. $\frac{(11-"10.3")}{3}\times8\ (+5)$	M1	1.1b
	= 6.86 so **7 days**	A1	1.1b
		(2)	
(e)	[H = no. of hours] P(H > 10.3) or P(Z > 1) = [0.15865…]	M1	3.4
	Predict $31\times0.15865...$ = **<u>4.9 or 5 days</u>**	A1	1.1b
		(2)	
(f)	(5 or) 4.9 days < (7 or) 6.9 days so model may **not** be suitable	B1	3.5a
		(1)	
			(13 marks)

Question	Scheme	Marks	AOs
Q3(a)			
	P ($L > 50.98$) = 0.025	B1cao	3.4
	$\therefore \frac{50.98-\mu}{0.5} = 1.96$	M1	1.1b
	$\therefore \quad \mu = 50$	A1cao	1.1b
	P($49 < L < 50.75$)	M1	3.4
	= 0.9104… awrt **0.910**	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)	
(c)	$H_0 : \mu = 50.1$ $H_1 : \mu > 50.1$	B1	2.5
	$\bar{X} \sim N\left(50.1, \frac{0.6^2}{15}\right)$ and $\bar{X} > 50.4$	M1	3.3
	$P(\bar{X} > 50.4) = 0.0264$	A1	3.4
	$p = 0.0264 > 0.01$ or $z = 1.936\ldots < 2.3263$ and not significant	A1	1.1b
	There is insufficient evidence that the **mean length** of strips is **greater than 50.1**	A1	2.2b
		(5)	
			(12 marks)

Question	Scheme	Marks	AOs
5 (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 $P(T \geqslant 5) = 0.1487\ldots$ awrt **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
	$= 0.01158\ldots$ awrt **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
6	$X \sim \mathrm{N}\left(\frac{1}{6}n, \frac{5}{36}n\right)$	M1A1
	$\mathrm{P}(X < 50) = \mathrm{P}\left(Z < \frac{49.5 - \frac{1}{6}n}{\sqrt{\frac{5}{36}n}}\right)$	M1 dM1
	$\frac{49.5 - \frac{1}{6}n}{\sqrt{\frac{5}{36}n}} = -2.4$	M1 A1
	$49.5 - \frac{1}{6}n = -2.4\frac{\sqrt{5n}}{6}$	
	$n - 2.4\sqrt{5}\sqrt{n} - 297 = 0$	M1 A1
	$\sqrt{n} = \frac{2.4\sqrt{5} \pm \sqrt{(2.4\sqrt{5})^2 + 4 \times 297}}{2}$ $= 9\sqrt{5}$ or awrt 20.1	M1
	$n = 405$ only	A1cao
	Notes	**Total 10**
	M1 Using Normal with mean $\frac{1}{6}n$ A1 Using Normal with mean and Var correct M1 $\pm\left(\frac{(48.5 \text{ or } 49 \text{ or } 49.5 \text{ or } 50 \text{ or } 50.5) - \textit{their mean}}{\textit{their sd}}\right)$ M1 dep on previous M1 being awarded for using a continuity correction 49 ± 0.5 or 50 ± 0.5 M1 setting $\frac{(48.5 \text{ or } 49 \text{ or } 49.5 \text{ or } 50 \text{ or } 50.5) - \textit{their mean}}{\textit{their sd}} = z \textit{ value } \lvert z \rvert > 2$ A1 A correct equation with compatible signs with z value awrt 2.4 M1 rearranging to get a 3TQ in $\sqrt{n}$ or n A1 for a correct 3TQ equation in $\sqrt{n}$ or n e.g. $n - 2.4\sqrt{5}\sqrt{n} - 297 = 0$ M1 Solving (allow one slip in an expression) their 3TQ leading to $\sqrt{n} =$ or $n =$ e.g. $\sqrt{n} = \frac{2.4\sqrt{5} \pm \sqrt{(2.4\sqrt{5})^2 + 4 \times 297}}{2}$ or $9\sqrt{5}$ or awrt 20.1 A1 cao with all previous marks scored.	

Question	Scheme	Marks
2. (a)(i)	X~B(6, 0.25)	B1
(ii)	Prizes are randomly placed in packets. Each packet has a 25% chance of containing a prize Each packet contains a prize independently of others	B1 (2)
(b)	$P(X = 1) = \binom{6}{1}(0.25)(1 - 0.25)^5$ [= 0.355957…] or 0.5339 – 0.1780 [=0.3559]	M1
	P(only 1 box contains exactly 1 prize) = $2P(X = 1)(1 - P(X = 1))$ = answer in the range **0.458~0.459** (inc)	M1 A1 (3)
(c)	$P(X \geqslant 2) = 1 - P(X \leqslant 1) = 1 - 0.5339 = 0.4661$ awrt **0.466**	M1 A1 (2)
(d)	$Y \sim B(80\ ,\ '0.4661') \rightarrow N(\text{awrt } 37.3, \text{awrt } 19.9)$ [Calc : 37.285…., 19.9078…]	B1ft
	$P(Y \leqslant 30) \approx P\left(Z < \frac{30.5 - '37.3'}{\sqrt{'19.9'}}\right)$	M1 dM1A1ft
	$P(Z < -1.52) = 1 - 0.9357 = 0.0643$ (calc: 0.064165….) awrt **0.064**	A1 (5) **Total 12**

	Notes
(a)(i)	B1 for a completely specified distribution. Condone B(6,25%) must be in (a)(i)
(ii)	B1 for a contextualised reason involving randomness, independence or constant probability Must mention "prize" and "packet" and for constant prob "0.25" in correct statement.
(b)	1st M1 for a correct expression for $P(X = 1)$ may use $P(X \leqslant 1) - P(X = 0)$ from tables with $X \sim B(6, 0.25)$ (May be implied by sight of awrt 0.356 or answer in range) 2nd M1 for writing or using $2P(X = 1)(1 - P(X = 1))$ NB M0M1A0 is possible Allow just $2P(X = 1)(1 - P(X = 1))$ or a numerical expression with any $p = P(X = 1)$ except $p = 0.25$ provided $0 < p < 1$
(c)	M1 for writing or using $1 - P(X \leqslant 1)$ A1 for awrt 0.466 (calc: 0.46606445….)
(d)	1st B1ft for mean = np and variance = $np(1 - p)$ where p = 'their (c)' ft their $0.466 \neq 0.25$ Any ft values must be correct to at least 3sf 1st M1 $\pm\left(\frac{29.5 \text{ or } 30 \text{ or } 30.5 - \text{their mean}}{\text{their sd}}\right)$ 2nd M1 dependent on 1st M1 for using a continuity correction 30 ± 0.5 1st A1ft for (±) correct standardized expression (ft their μ and σ) or z = awrt ± 1.52 2nd A1 awrt 0.064 [Use of $p = 0.25$ giving N(20, 15) can score B0M1M1A1A0 i.e. max 3/5]
NB	Use of binomial (leads to 0.063398… or 0.063477…) but scores 0 marks.

Question Number	Scheme	Marks
6. (a)	$X \sim \mathrm{B}(30, 0.4)$ $\quad$ $X \sim \mathrm{B}(30, 0.4)$	B1
		[1]
(b)	Eg: Any one of either • Constant probabilty of buying insurance • Customers buy insurance independently of each other Any one of these two assumptions in context which refers to insurance.	B1
		[1]
(c)	$\mathrm{P}(X < r) < 0.05$	
	$\{\mathrm{P}(X \leqslant 8) = \mathrm{P}(X < 9)\} = 0.0940$ $\{\mathrm{P}(X \leqslant 7) = \mathrm{P}(X < 8)\} = 0.0435$ For at least one of either 0.094(0) or 0.0435 seen in part (c)	M1
	So $r = 8$ $\quad$ $r = 8$	A1
		[2]
(d)	$\{Y \sim \mathrm{B}(100, 0.4) \approx\} Y \sim \mathrm{N}(40, 24)$ $\quad$ Normal or N	M1
	$(40, 24)$	A1
	$\{\mathrm{P}(Y \geqslant t)\} \approx \mathrm{P}(Y > t - 0.5)$ $\quad$ For either $t - 0.5$ or $t + 0.5$	M1
	$\left\{= \mathrm{P}\left(Z > \frac{(t-0.5)-40}{\sqrt{24}}\right) = 0.938\right\}$	
	$\frac{(t-0.5)-40}{\sqrt{24}} = -1.54$ Standardising $(\pm)$ with their mean and their standard deviation and either $t - 0.5$ or t or $t + 0.5$ or $t - 1.5$	M1
	-1.54 or 1.54 or awrt -1.54 or awrt 1.54	B1
	So, $\{\text{So, } t = 32.955571...\} \Rightarrow \underline{t = 33}$ $\quad$ $\underline{t = 33}$	A1 **cao**
		[6]
(e)	$\mathrm{H}_0 : p = 0.4$, $\mathrm{H}_1 : p < 0.4$ $\quad$ Both hypotheses are stated correctly	B1
	$\{\text{Under } \mathrm{H}_0,\ X \sim \mathrm{B}(25, 0.4)\}$	
	Probability Method: $\mathrm{P}(X \leqslant 6);= 0.0736$ $\quad$ **Critical Region Method**: $\mathrm{P}(X \leqslant 6);= 0.0736$, $\{\mathrm{P}(X \leqslant 7) = 0.1536\}$, $\mathrm{CR} : X \leqslant 6$ $\quad$ $\mathrm{P}(X \leqslant 6)$	M1
	Either 0.0736 or $\mathrm{CR} : X \leqslant 6$ or $\mathrm{CR} : X < 7$	A1
	$\{0.0736 < 0.10\}$	
	Reject H_0 or significant or 6 lies in the CR $\quad$ **Dependent on 1st M1** See notes	dM1
	So **percentage** (or **proportion**) who buy **insurance** has **decreased**.	A1 **cso**
		[5]
		15

Question Number	Scheme	Marks
4. (a)	$P(L > 100) = P\left(Z > \frac{100-\mu}{0.5}\right) = 0.3$	
	$\Rightarrow \frac{100-\mu}{0.5} =, \ 0.5244$	**M1 B1**
	$\mu = 99.7378...$ cm awrt 99.7	**A1**
		(3)
(b)	X represents number more than 100cm. $X \sim B(12, 0.3)$	**B1**
	$P(X \leq 2) = 0.2528$ awrt 0.253	**M1A1**
		(3)
(c)	Normal approximation $\mu = 400 \times 0.3 = 120, \ \sigma^2 = 84$	**M1, A1**
	$P(X > 127) \approx 1 - P(Z < \frac{127.5-120}{\sqrt{84}})$ ± 0.5, standardise	**M1, M1, A1**
	$\approx 1 - P(Z < 0.818\ )$	
	$= 1 - 0.7939$	
	$= 0.206$ or 0.207	**A1**
		(6)
		[12]

	Notes
(a)	M1 standardising ($\pm$) with 100, μ and 0.5 and setting equal to a z value. $0.5 < z < 0.7$
	NB Use of $z = 0.7$ scores M0B0A0
	B1 $z = \pm 0.5244$ or better (Calc. Gives 0.5244005...). Must be used in an equation for μ.
	A1 awrt 99.7. Answer only is 0/3
	NB M1 + answer only of awrt 99.7 scores M1B0A1 but allow B1 for $99.7376 \leq \mu \leq 99.7379$
(b)	B1 writing B(12, 0.3)
	M1 writing $P(X \leq 2)$ May be implied by sight of 0.252 or 0.253.
	NB $P(X < 3)$ alone is M0 unless they show that $P(X < 3) = P(X = 0) + P(X = 1) + P(X = 2)$
	A1 awrt 0.253. Answer only scores 3/3
(c)	1st M1 attempting to use a Normal approx. State $N(\mu, \sigma^2)$ with μ or σ correct
	1st A1 correct mean and var/sd
	2nd M1 continuity correction used: either 127.5 or 126.5 seen
	3rd M1 standardising with their μ and σ and finding correct area. Must lead to P(Z > +ve) (o.e.)
	2nd A1 $\frac{127.5-120}{\sqrt{84}}$ or awrt 0.82
	3rd A1 for awrt 0.206 or 0.207

Question Number	Scheme	Marks
7	$\frac{64.5-\mu}{\sigma}=0.75$	B1 M1 M1 A1
	$\frac{52.5-\mu}{\sigma}=-1.25$	A1
	$64.5-\mu=0.75\sigma$	dM1
	$52.5-\mu=-1.25\sigma$	
	$\sigma = 6$	A1
	$\mu = 60$	A1
	$np = 60$	M1
	$np(1-p) = 36$	M1
	$1-p = 0.6$	
	$p = 0.4$	A1
	$n = 150$	A1
		(12)
		Total (12)
	Notes	
	B1 ± 0.75 and ± 1.25 (or better) seen 1st M1 64 ± 0.5 or 52 ± 0.5 2nd M1 standardising either using 64, 65 or 64 ± 0.5 or 52, 53 or 52 ± 0.5 with μ and σ or np and $\sqrt{np(1-p)}$ (need not be set equal to a z-value) 1st A1 for $\frac{64.5-\mu}{\sigma}=0.75$ (with compatible signs) 2nd A1 for $\frac{52.5-\mu}{\sigma}=-1.25$ (with compatible signs) 3rd M1 solving simultaneous equations dependent on 2nd M1. Must attempt to eliminate μ or σ or np or $\sqrt{np(1-p)}$ 3rd A1 $\sigma = 6$ 4th A1 $\mu = 60$ 4th M1 using $\mu = np$ (may be awarded at any stage in the working) 5th M1 using $\sigma = \sqrt{np(1-p)}$ (may be awarded at any stage in the working)	

Question Number	Scheme	Marks
3. (a)	$\{P(L < 45) = 0.4\} \Rightarrow \frac{45-\mu}{\sigma} = -0.2533$ <u>or</u> $\Rightarrow 45 - \mu = -0.2533\sigma$ (o.e.)	M1
	$45 + 0.2533\sigma = \mu$ **(*)**	A1cso
		(2)
(b)	$P(L < 35) = 0.15 \Rightarrow \frac{35-\mu}{\sigma} = -1.0364$	M1
	e.g. $35 + 1.0364\sigma = \mu$	A1
		(2)
(c)	Solving: $10 - 0.7831\sigma = 0$	M1
	$\sigma = 12.7697\ldots$ awrt **<u>12.8</u>**	A1
	$\mu =$ awrt **<u>48.2</u>**	A1
		(3)
(d)(i)	$P(L > 35 \mid L < 45) = \frac{P(35 < L < 45)}{P(L < 45)} = \frac{0.25}{0.15 + 0.25} = \frac{5}{\underline{8}}$ (o.e.)	A1
		M1
(ii)	$P(L < 45 \mid L > 35) = \frac{P(35 < L < 45)}{P(L > 35)} = \frac{0.25}{0.60 + 0.25} = \frac{5}{\underline{17}}$ or awrt 0.294	A1
		(3)
(e)	Prob. of a yellow stick from Hei is $\frac{5}{8}$ which is > prob. of $\frac{5}{17}$ for Tang	B1ft
	So more likely to be Hei	dB1ft
		(2)
		[Total 12]

	Notes
	Mark parts (a), (b) and (c) as one part but must see the "show that" for (a) somewhere
(a)	M1 for attempting to standardise with 45, μ and σ Allow $\pm$ and allow z = awrt 0.25
	A1cso for sight of $P(L < 45) = 0.4$ (o.e.) and 0.2533 leading to given ans. [0.2533471… from calc]
(b)	M1 for standardising with 35 μ and σ and setting equal to a z value with $1 < \lvert z \rvert < 1.05$
	A1 for any correct equation, $z = 1.04$ or better and correct signs
(c)	M1 for solving their 2 linear equations in μ and σ – reducing to an equation in 1 variable
	1st A1 for $\sigma =$ awrt 12.8 (NB use of 1.04 gives 12.7113… so we penalise that here)
	2nd A1 for $\mu =$ awrt 48.2 [allow 48.3 if 12.8 used in a correct eqn e.g. $35+1.04\times12.8$ or better]
(d)	M1 for a correct expression [num = $P(35 < L < 45)$] with <u>some</u> correct values substituted
	This M1 may be implied by one of the correct probabilities for (i) or (ii)
(i)	1st A1 for $\frac{5}{8}$ or an exact equivalent e.g. 0.625
(ii)	2nd A1 for $\frac{5}{17}$ or awrt 0.294
(e)	1st B1ft for a correct comparison of their <u>probabilities</u> from (d) "probs" $\notin [0, 1]$ is B0
	2nd dB1ft for choosing Hei (dependent on a suitable reason that it is more likely to be hers)
	Allow e.g. "Hei, because her prob is greater" to score B1B1 provided (d)(i) > (d)(ii)
ft	Allow "Tang" if their (d)(i) < their (d)(ii) and a correct comparison stated.

IAL Statistics 1 (WST01) – October 2016

Question Number	Scheme	Marks
1. (a)	[P($X > \mu - a$)] = **0.65**	B1 (1)
(b)	[P($\mu - a < X < \mu + a$)] = $1 - 2 \times 0.35$ or "0.65" – 0.35 or 0.15 + 0.15 = **0.3**	M1 A1 (2)
(c)	[P($X < \mu + a \mid X > \mu - a$)] = $\frac{\text{"(b)"}}{\text{"(a)"}} = \frac{0.3}{0.65}$ = $\frac{6}{13}$ (Allow awrt 0.462)	M1 A1 (2) **[Total 5]**

Notes

(a)

B1 for 0.65 NB you may see P($Z < 0.35$) = 0.6368 which is of course B0

(b)

M1 for a correct numerical expression, ft their answer to part (a) [M0 for a probability < 0]
A1 for 0.3 (Answer only scores both marks)

(c)

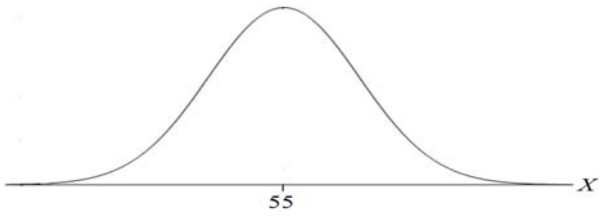
M1 for a correct ratio of probabilities or follow through their answers provided (b) < (a)
A1 for $\frac{6}{13}$ or an exact equivalent and allow awrt 0.462

Question	Scheme	Marks
3. (a)	[Let J = the length of a jump] $P(J < 2.5) = P\left(Z < \frac{2.5-3.3}{0.6}\right)$	M1
	$= P(Z < -1.333\ldots) = 1 - 0.9082$	dM1
	$= \mathbf{\underline{0.0912 \sim 0.0918}}$	A1
		(3)
(b)	$\left[P(J > d) = 0.4 \Rightarrow\right]$ $\frac{d-3.3}{0.6} = 0.2533$	M1 A1
	d = awrt **3.452**	A1
		(3)
(c)	$\left[P(J > m \mid J > d) \Rightarrow\right]$ $\frac{P(J > m)}{0.4} = 0.5$ or $P(J > m) = 0.2$	M1
	$\frac{m-3.3}{0.6} = 0.8416$	M1
	So m = 3.80496 (calc 3.80497274…) awrt **3.80**	A1
		(3)
(d)	$P(J > 4.1) = 0.0918$ (same as (a))	B1ft
	So P(certificate) = $0.4 \times$"(a)"	M1
	$= \mathbf{\underline{0.036 \sim 0.037}}$	A1
		(3)
		(12 marks)

	Notes
(a)	1st M1 for standardising with 2.5, 3.3 and 0.6 Allow $\pm$ 2nd M1 dep on 1st M1 for attempting $1 - p$ where $0.5 < p < 1$ A1 for an answer in the range 0.0912~0.0918 NB calc gives 0.09121128…
(b)	M1 for standardising with "d", 3.3 and 0.6 and setting equal to z $(0.2 < \lvert z \rvert < 0.3)$ 1st A1 for a correct equation with compatible signs with $z = 0.25$ or better, i.e. 0.253 or 0.2533… 2nd A1 for awrt 3.452 (calc gives 3.45200856… use of 0.2533 gives 3.45198)
(c)	1st M1 for a correct probability statement involving 'J' and 'm'(median) only (may be implied by 2nd M1). Use the letter in the standardisation as the one representing the median. 2nd M1 for $\frac{m-3.3}{0.6} = z$ (with compatible signs) where $0.84 \leq z$ _ 0.85 A1 for awrt 3.80 (accept 3.805)
(d)	B1ft for an answer in range 0.0912~0.0918 or the same as part (a) for $P(J > 4.1)$ M1 for $0.4 \times$ their $P(J > 4.1)$ A1 for answer in the range 0.036~0.037 (No fractions) NB $0.4 \times 0.0918 = 0.036712$ and $0.4 \times 0.0912 = 0.03648$

Question Number	Scheme	Marks
7(a)(i)	$P(X > 505) = P\left(Z > \frac{505-503}{1.6}\right)$	M1
	$= 1 - P(Z < 1.25)$ $= 1 - 0.8944$	M1
	$= 0.1056$ awrt **0.106**	A1
		(3)
(ii)	$P(501 < X < 505) = 1 - 2 \times 0.1056$ or $0.8944 - 0.1056$	M1
	$= 0.7888$ awrt **0.789**	A1
		(2)
(b)	$P(X < w) = 0.9713$ or $P(X > w) = 0.0287$ (may be implied by $z = \pm 1.9$)	M1
	$\frac{w-503}{1.6} = 1.9$ or $\frac{(1006-w)-503}{1.6} = -1.9$	M1
	$w = 506.04\ldots$ awrt **506**	A1
		(3)
(c)	$\frac{r-503}{q} = -2.3263$	M1A1
	$\frac{r+6-503}{q} = 1.6449$	M1A1
	$1.6449q - 6 = -2.3263q$	ddM1
	$q = 1.51...$ awrt **1.51**	A1
	$r = 499.48\ldots\ldots$ awrt **499**	A1
		(7)
		Total 15

	Notes
(a)(i)	1st M1 standardising with 505, 503 and 1.6. May be implied by use of 1.25 (Allow ±)
	2nd M1 for $1 - P(Z < 1.25)$ i.e. a correct method for finding $P(Z > 1.25)$, e.g. $1 - p$ where $0.5 < p < 0.99$
(ii)	M1 $1 - 2 \times$ their(i)
(b)	1st M1 for using symmetry to find the area of one tail (may be seen in a diagram)
	2nd M1 a single standardisation with 503, 1.6 and w (or $1006 - w$) and set = $\pm z$ value ($1.8 < \lvert z \rvert < 2$)
	A1 for awrt 506 which must come from correct working. (**Answer only**: 506 scores 0/3, but 506.0…with no working send to review)
(c)	1st M1 $\frac{r-503}{q} = z$ value where $\lvert z \rvert > 2$
	1st A1 $\frac{r-503}{q} =$ awrt -2.3263 (signs must be compatible)
	2nd M1 $\frac{r+6-503}{q} = z$ value where $\lvert z \rvert > 1$
	2nd A1 $\frac{r+6-503}{q} =$ awrt 1.6449 (signs must be compatible)
	Special Case: Less than 4dp z-values: use of awrt 2.32/2.33/2.34 **and** awrt 1.64/1.65 could score M1 A0 M1 and then A1 provided both equations have compatible signs.
	3rd M1 (dep on both Ms) attempt to solve simultaneous equations leading to a value for q or r
	3rdA1 for awrt 1.51
	4thA1 for awrt 499 (allow 499.5)

Question	Scheme	Marks
5.(a)		B1 dB1 (2)
(b)	$P(X > 70) = P\left(Z > \frac{70-55}{20}\right)$ $= P(Z > 0.75)$ $= 1 - 0.7734 = 0.2266$ awrt **0.227/22.7%**	M1 M1A1 (3)
(c)	$P(X > b) = 0.01$ $\frac{b-55}{20} = 2.3263$ $b = 101.526$ **Given answer 102**	M1B1 A1 (3)
(d)	$P(70 < X < m) = 0.1315$ $P(X < m) - P(X < 70) = 0.1315$ $P\left(Z < \frac{m-55}{20}\right) = 0.9049$ $\frac{m-55}{20} = 1.31$ $m = 81.2$	M1 M1B1 A1 (4) **Total 12**

	Notes
(a)	1st B1 for a reasonable sketch of a symmetric, bell shaped curve which does not cross the *x*-axis (ignore any vertical axis drawn) 2nd B1 dependent on previous B1 for 55 labelled at the centre of the *x*-axis
(b)	1st M1 for standardising with 70, 55 , 20 (allow +/–) 2nd M1 Use of $1 - p$ (must be a probability so 1 – 0.67 is M0) A1 awrt 0.227 or 22.7%
(c)	M1 for standardising with 55, 20 and equating to *z*-value $\lvert z\rvert > 2$ B1 for 2.3263 (or better) used and compatible sign with their standardisation. A1 for awrt 102 which must come from a *z*-value in the range $2.32 \leq z \leq 2.34$
(d)	1st M1 for a correct expression for $P(X < m)$ (e.g. 0.1315 + '0.7734') or $P(X > m) = 0.0951$ or sight of 0.9049 (may be implied by sight of 1.31) 2nd M1 for standardising with 55, 20 and equating to a *z*-value $\lvert z\rvert > 1$ B1 1.31 (1.31018…from calc) used and compatible sign with their standardisation. A1 awrt 81.2

Question	Scheme	Marks
7. **(a)**	$[\mathrm{P}(D > 50) =] \mathrm{P}\left(Z > \frac{50-32}{12}\right)$	M1
	$= 1 - \mathrm{P}(Z < 1.5)$ or $1 - 0.9332$	M1
	= **awrt <u>0.0668</u>** or 6.68%	A1cso
		(3)
(b)	$\mathrm{P}(D > d) = 0.191 + 0.0668 = 0.2578$ <u>or</u> $\mathrm{P}(D < d) = 0.7422$	B1
	$\frac{d-32}{12} = 0.65$ (calc gives 0.65014… or 0.65012…)	M1A1
	$d =$ **<u>39.8</u>**	A1
		(4)
(c)	$0.0668 \times 0.191^2 [= 0.0024369...]$	M1
	$[...] \times 3$	M1
	= 0.00731079… = **awrt <u>0.0073</u>**	A1
		(3)
		[10]

	Notes
(a)	1st M1 for standardising with 50, 32 and 12. Allow $\pm$ 2nd M1 for $1 - \mathrm{P}(Z < 1.5)$ seen i.e. a correct method for finding $\mathrm{P}(Z > 1.5)$ e.g. 1 – tables value A1cso for awrt 0.0668 with both Ms scored and no incorrect working seen. Condone incomplete notation and condone use of different letters for Z.
(b)	B1 for awrt 0.2578 (calc = 0.257807..) or awrt 0.7422 (calc = 0.742192..) may be implied by z = awrt 0.65 M1 for standardising with 32 and 12, i.e. $\pm\frac{d-32}{12}$ (equating to a probability is M0) 1st A1 for z = awrt 0.65 **and** a correct equation in d (with compatible signs) 2nd A1 for awrt 39.8
(c)	1st M1 for 0.0668×0.191^2 or sight of awrt 0.0024 (may be seen embedded in part of an expression, e.g. '$n \times 0.0668 \times 0.191^2$') (condone 6.68% × 19.1% ×19.1% if the final answer given is < 1) 2nd M1 for any expression of the form $3pq^2$ where p and q are both probabilities A1 for awrt 0.0073 allow awrt 0.73% but 0.73 is A0

Question Number	Scheme	Marks
7. (a)	$P(G > 174) = P(Z > \frac{174-180}{15}) = P(Z > -0.4)$, $= 0.6554$ **awrt <u>0.655</u>**	**M1, A1** **(2)**
(b)	$P(k < G < 174) = P(G < 174) - P(G < k)$	
	$P(G < k) = (1 - '0.6554') - 0.3196$ or $P(G > k)$ = '0.6554' + 0.3196 [=0.975]	**M1**
	$P(Z < \frac{k-180}{15}) = 0.025 \Rightarrow \frac{k-180}{15} = -1.96$	**M1 B1**
	awrt <u>150.6</u>	**A1** **(4)**
(c)(i)	$P(G > w) = P(B < w) \Rightarrow \frac{w-180}{15} = -\frac{w-216}{30}$	**M1 A1**
	$\Rightarrow 45w = 8640 \Rightarrow$ ***w* =<u>192</u>**	**A1**
(ii)	$P(G > w) = P\left(Z > \frac{"192"-180}{15}\right)$ or $P(B < w) = P\left(Z < \frac{"192"-216}{30}\right)$	**M1**
	$P(Z > 0.8) = 1 - 0.7881 = 0.2119$ ***p* = awrt <u>0.212</u>**	**A1** **(5)** **[11 marks]**

	Notes
(a)	M1 for standardising 174 with 180 and 15 and selecting correct region i.e. P(…> – 0.4) o.e. Just $Z = -0.4$ is M0 unless indicate with > or diagram which region(use of tables may be wrong) A1 awrt 0.655 do not isw [Final answer of awrt 0.655 scores M1A1]
(b)	1st M1 for a correct expression for P($G < k$) (may be seen in diagram or implied) <u>or</u> a correct expression for P($G > k$) ft their "0.6554" from (a). Probability for G may be standardised 2nd M1 for standardising k with 180 and 15 and equating to a z-value $\lvert z \rvert > 1.5$ B1 for (<u>+</u>) 1.96 or better (used as their z value) NB $\frac{k-180}{15} = -1.96$ will imply M1M1B1 A1 for awrt 150.6 (must come from a correct equation)
(c)(i)	M1 for standardising w with 180 and 15 **<u>and</u>** 216 and 30 (allow <u>+</u>) 1st A1 for equating standardisations with correct signs 2nd A1 for 192
(ii)	M1 for correct standardisation of $G > w$ with '192', 180 and 15 <u>or</u> $B < w$ with '192', 216 and 30 A1 for awrt 0.212

Question Number	Scheme	Marks
6. (a)	98% (Condone 0.98)	**B1**
		(1)
(b)	$z = \pm 2.3263$ (or better: calculator gives 2.326347877…)	**B1**
	$\frac{256-250}{\sigma} = 2.3263$	**M1**
	$\sigma = 2.579...$ **awrt 2.58**	**A1**
		(3)
(c)	[P($X < 246 \cup X > 254$) =]	
	$2\times \mathrm{P}\left(Z > \frac{254-250}{"2.579..."}\right)$ or $1-\mathrm{P}\left(\frac{246-250}{"2.579"} < Z < \frac{254-250}{"2.579"}\right)$	**M1**
	$= 2\times \mathrm{P}(Z > 1.55)$ or $1-\mathrm{P}(-1.55 < Z < 1.55) = 0.12(12)$	**A1**
	P(both bags outside range) = $(0.1212)^2$ =, 0.01468… **awrt 0.0146/7**	**dM1, A1**
		(4)
		[8 marks]

	Notes
(b)	B1 for $\pm$ 2.3263 or better seen and used, can be with σ^2 (may be implied by σ = awrt 2.579)
	M1 for standardising with 256 or 244, 250 and σ and equating to a z-value $\lvert z\rvert > 2$
	A1 for awrt 2.58 from correct working.
z = 2.33	Use of z = 2.33 leads to $\sigma = 2.575...$ can score B0M1A1
z = 2.32	Special case: use of z = 2.32 from tables gives 2.586… σ = awrt 2.59 can score B0M1A1
Ans only	B1M1A1 can be awarded for sight of at least σ = awrt 2.5791 or awrt 2.5792
(c)	1st M1 for attempt to find sum of the area above 254 and below 246 or 2 × area above 254 or 2 × area below 246 (2 ×needed) Allow ft of their σ (provided $\sigma > 0$)
	1st A1 for awrt 0.12 (NB 1 – 0.1212 = 0.8788 is A0 here and 1st M0 too)
	2nd dM1 for p^2 dependent on previous M1
	2nd A1 for awrt 0.0146 (use of calculator value) or 0.0147
SC	'B1' for those who use 1 tail only and get 0.06… but then do $(0.06…)^2$ Score as M0A0M1A0
	Do **not** award for $2\times(0.06...)^2$ or $3\times(0.06...)^2$

Question Number	Scheme	Marks
5.(a)	$[\mathrm{P}(H<18)=]\ \mathrm{P}\left(Z<\frac{18-22}{10}\right)=\mathrm{P}(Z<-0.4)$	M1
	$=1-0.6554$	dM1
	$=0.3446$ or awrt **0.345**	A1
		(3)
(b)	$\mathrm{P}(H>50)=\mathrm{P}(Z>2.8)=1-0.9974=0.0026$	M1 A1
	$\mathrm{P}(H>39)=\mathrm{P}(Z>1.7)=1-0.9554=0.0446$	M1 A1
	$\mathrm{P}(H>50\mid H>39)=\frac{\mathrm{P}(H>50)}{\mathrm{P}(H>39)}$ or $\frac{"0.0026"}{"0.0446"}$	M1
	= **0.057~0.0585**	A1
		(5)
(c)	$\frac{18-\mu}{\sigma}=-0.8416$ $\quad$ $\frac{28-\mu}{\sigma}=1$	M1B1A1
	Solving: $10=1.8416\sigma$	M1
	$\sigma=$ awrt **5.43**	A1
	$\mu=$ awrt **22.57**	A1
		(6)
		[14 marks]

	Notes
(a)	1st M1 for standardising with 18, 22 and 10. Allow $\pm\frac{18-22}{10}$
	2nd dM1 dependent on 1st M1 for $1-p$ where $0.6<p<0.7$
	A1 for 0.3446 or better or awrt 0.345. NB Calculator gives 0.3445783…Ans only 3/3
(b)	1st M1 for correct standardisation and $1-q$ (where $q=0.9\ldots$) for one of these probs
	1st A1 for 0.0026 or better (calc 0.0025551…) or $1-0.9974$ (or better)
	2nd A1 for 0.0446 or better (calc 0.0445654…) or $1-0.9554$ (or better)
	2nd M1 for a correct ratio of probability expressions or values (ft their 0.0026 and 0.0446 but if num. > denom. then M0)
	3rd A1 for answer in the range 0.057~0.0585. No fractions but $\frac{13}{223}$ can score M1A1A1M1A0
Ans. only	Can score full marks for either awrt 0.0583 (tables) or awrt 0.0573 (calc) only
(c)	1st M1 for attempt to standardise with μ, σ and 18 or 28 and set equal to a z value ($\pm$) The z values should be in the range (0.8, 0.9) for "18" and (0.95, 1.05) for "28"
	B1 for using $z=0.8416$ or better (allow $\pm$) Calculator gives 0.8416212…
	1st A1 for both equations with ± 1 and ± 0.84 or better
SC	for $\frac{28-\mu}{\sigma}=\pm 0.8416$ and $\frac{18-\mu}{\sigma}=\pm 1$ award M1B1A0 (0.84 instead of 0.8416 loses B1)
	2nd M1 for solving their linear equations in μ & σ. Reducing to an equation in one variable. Correct processes allow one sign slip
	2nd A1 for $\sigma=$ awrt 5.43
	3rd A1 for $\mu=$ awrt 22.57
Calc	No $z=0.8416$ or better seen: can award 6/6 for $\sigma=$ awrt 5.4300 or 5.4301 and $\mu=$ awrt 22.57
No working	For $\sigma=$ awrt 5.43 and $\mu=$ awrt 22.57 award M1B0A1M1A1A1 i.e. 5/6

7.	**(a)**	$P(W > 92) = P(Z > \frac{92-99}{3.6})$	M1
		$= P(Z > -1.94)$ or $P(Z < 1.94)$	A1
		$= 0.9738$ **awrt <u>0.974</u>**	A1
			(3)
	(b)	$P(W < k) = 3P(W > k)$ so $P(W < k) = 0.75$ <u>or</u> $P(W > k) = 0.25$	B1
		$\frac{k-99}{3.6} = 0.67$	M1 B1
		(***<u>k</u>* =) <u>101.4</u>**	A1cao
			(4)
	(c)	k is the upper quartile	B1
			(1)
	(d)	$P(W < P_{20}) = 0.2$	
		$\frac{116-120}{\sigma} = -0.8416$	M1 B1
		$\sigma = 4.7528517\ldots$ **awrt <u>4.75</u>**	A1
			(3)
			(11 marks)

Notes

(a)
M1 for standardising with 92, 99 and 3.6
1st A1 for either correct probability statement and z awrt $\pm$ 1.94(may be seen as a correct shading on a diagram).
2nd A1 for awrt 0.974

NB They may get $z = 1.945$ and round to 1.95 leading to 0.9744 (score M1A0A1)

(b)
1st B1 for $P(W < k) = 0.75$ or $P(W > k) = 0.25$(o.e.)[May be implied by k = awrt 101.4]

NB B0M1B1A1 is possible if an incorrect statement e.g. $P(W < k) = 0.25$ is seen

M1 for an attempt to standardise with k (or any letter), 99 and 3.6 and set equal to $\pm$ a z-value in range 0.6 ~0.7
2nd B1 for $\pm$ 0.67 or better i.e. z in 0.670 ~ 0.678 (calc gives 0.674489...)
NB e.g. 0.68 is B0 but could score A1.
A1cao for 101.4 (**must be given to 1dp**) and must follow from compatible signs

Ans. only If z value not given and a value in [101.41, 101.43] is seen score B1M1B1 otherwise B1M1B0 for awrt 101.4 (and A1 when 101.4 given as final answer)

(c)
B1 for Upper quartile (allow Q_3 <u>or</u> third quartile <u>or</u> 75th percentile)

(d)
M1 for an attempt to standardise and set equal to $\pm$ a z-value in 0.8~0.9
B1 for $\pm$ 0.8416 or better (calc gives 0.84162123...). Value must be <u>used</u> as a z value
NB 0.84 scores B0 but see **SC**
A1 for awrt 4.75 following from an equation with compatible signs

SC If they use $z = 0.84$ and get an answer of awrt 4.76 (with correct working) score M1B0A1

Question Number	Scheme	Marks
6. (a)	$\left[X \sim \mathrm{N}(1.04,\ 0.17^2)\right]$	
	$\mathrm{P}(X<1)=\mathrm{P}\left(Z<\dfrac{1-1.04}{0.17}\right)$	M1
	$=\mathrm{P}(Z<-0.23529...)$	
	$=1-0.5948=0.4052$ (Accept 0.405-0.407)	M1A1
		(3)
(b)	$\mathrm{P}(Y<1)=0.05$ $\left[Y \sim \mathrm{N}(\mu,\ 0.17^2)\right]$	
	$\dfrac{1-\mu}{0.17}=-1.6449$	M1 B1
	$\mu=1+1.6449\times 0.17=1.2796\ldots$ awrt 1.28	A1
		(3)
(c)	$\mathrm{P}(S<1)=0.01$ $\left[S \sim \mathrm{N}(1.04,\ \sigma^2)\right]$	
	$\dfrac{1-1.04}{\sigma}=-2.3263$	M1B1
	$\sigma=\dfrac{0.04}{2.3263}=0.0171946...$ awrt 0.0172	A1
		(3)
		Total 9

	Notes
(a)	1st M1 for attempting to standardise with 1, 1.04 and 0.17 Allow $\pm$ 2nd M1 for attempting $1-p$ where $(0.5<p<0.6)$ A1 for answers in the range 0.405 ~ 0.407 (Calc gives 0.4069902…)
	Allow any alternative letters to μ and σ in parts (b) and (c)
(b)	M1 for an attempt to standardise (allow $\pm$) with 1, 0.17 and μ and set = $\pm$ any z value ($\lvert z\rvert > 1$) B1 for $z = \pm$ 1.6449 (or better. Calc gives 1.6448536..) used as a z value. Do not allow 1 − 1.6449 [May be implied by answer that rounds to 1.2796] A1 for awrt 1.28 (can be scored for using a z value of 1.64 or 1.65) Must follow from correct working but a range of possible z values are OK
Ans only	If answer is awrt 1.28 score M1B0A1 (unless of course z = 1.6449 seen) but awrt 1.2796 scores 3/3
(c)	M1 for an attempt to standardise with 1, 1.04 and σ and set = $\pm$ any z value ($\lvert z\rvert > 2$) B1 for $z = \pm$ 2.3263 (or better) (Calc gives 2.3263478…) used as a z value If B0 scored in (b) for using a value in [1.64, 1.65] but not 1.6449 or better, allow awrt 2.32 or 2.33 here A1 for awrt 0.0172 Must follow from correct working but a range of possible z values are OK
Ans only	If answer is awrt 0.0172 score M1B0A1 (unless of course z = 2.3263 or better is seen) If B1 scored in (b) and z = 2.3263 or better is not seen here then require an answer in the range $0.17194 < \sigma < 0.17195$ to award 3/3

Question Number	Scheme		Marks
5.(a)	$H_0 : p = 0.35$ $H_1 : p > 0.35$		B1
	$V \sim B(40, 0.35)$ $P(V \geq 18) = 1 - P(V \leq 17)$	or $P(V \geq 19) = 0.0699$	M1
	$= 1 - 0.8761$	$P(V \geq 20) = 0.0363$	
	$= 0.1239$	CR $V \geq 20$	A1
	Accept H_0 or not Significant or 18 does not lie in the critical region		M1d
	There is insufficient evidence that the **proportion/amount/number/ percentage** of customers who bought **organic vegetables** has increased.		A1cso (5)
(b)	$E \sim B(50, 0.35)$		M1
	$P(E \leq 10) = 0.0160$	$P(E \geq 25) = 0.0207$	
	$P(E \leq 11) = 0.0342$	$P(E \geq 24) = 0.0396$	
	CR $E \leq 10$	$E \geq 25$	A1A1 (3)
(c)	The **manager's claim** is supported or there is sufficient evidence that the proportion of customers buying organic **eggs** is different from those buying organic **vegetables**.		B1ft (1)
(d)	0.016 + 0.0207 = 0.0367 or 3.67%	awrt 0.0367 or 3.67%	B1 (1)
(e)	$F \sim N(40, 32)$		M1 A1
	$P(F < n) = P\left(Z < \frac{n - 0.5 - 40}{\sqrt{32}}\right)$		M1M1d
	$\frac{n - 0.5 - 40}{\sqrt{32}} = -1.68$		B1
	$n = 31$		A1cso (6)
	Notes		**Total 16**
(a)	B1 both hypotheses correct with p or π M1 writing or using $V \sim B(40, 0.35)$ **and** $1 - P(V \leq 17)$ or $P(V \leq 17) = 0.8761$ or awrt 0.124 **OR** writing $P(V \geq 19) = 0.0699$ or $P(V \geq 20) = 0.0363$ **leading to a CR**. Implied by correct CR A1 awrt 0.124 or $V \geq 20$ or $V > 19$ allow any letter M1d dep on previous M being awarded. ft their CR or probability. A correct statement – do not allow contradicting non-contextual comments A1 cso all previous marks must be awarded. A correct statement in context. Need **Bold words. NB** award M1A1 for a correct contextual statement on its own. If there are no hypotheses or they are the wrong way around, then M0A0		
(b)	M1 writing $E \sim B(50, 0.35)$ **or** a correct probability or one tail of the CR correct A1 $E \leq 10$ **oe** A1 $E \geq 25$ **oe**, allow any letter. Condone missing letter **NB** If CR written as probabilities and both are correct or CR written as $10 \geq E \geq 25$ oe award M1A1A0. If just give CV 10 and 25 given award M1A0A0		
(c)	B1 A correct statement including the words **managers claim** or **eggs** and **vegetable**(s) (or **veg**) ft their 2 tail CR. Cannot be awarded if no CR given in (b)		
(e)	M1 writing/using normal approximation with mean = 40 A1 writing/using normal approximation with mean = 40 and var = 32 M1 $\pm\left(\frac{(n \text{ or } n - 0.5 \text{ or } n + 0.5) - \textit{their mean}}{\textit{their sd}}\right)$ if no mean or sd given they must be correct here. M1 dep on previous method mark being awarded. Using continuity correction $n - 0.5$ **B1** ± 1.68 **A1** 31 cso all previous marks must be awarded. **NB** 31 with no working gains no marks		

5(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** ± 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
5.(a)	n is large and p close to 0.5	B1B1 (2)
(b)	There would be no pea seeds left	B1 (1)
(c)	H_0: $p = 0.55$ H_1 : $p \neq 0.55$	B1 (1)
(d)	X~N(121, 54.45)	B1
	$P(X \geq 134.5) = P\left(Z \geq \frac{134.5-121}{\sqrt{54.45}}\right)$ or $\pm\frac{x-0.5-121}{\sqrt{54.45}} = 1.96$	M1M1A1
	$= P(Z \geq 1.8295..)$	
	$= 1 - 0.9664$	
	$= 0.0336/0.0337$ $x = 135.96$	A1
	Accept H_0 not in CR, not significant	M1
	The **company's claim** is justified **or** **55**% of its pea **seeds germinate**	A1cso (7)
	Alternative	
	X~N(99, 54.45)	B1
	$P(X \leq 85) = P\left(Z \leq \frac{85.5-99}{\sqrt{54.45}}\right)$ or $\pm\frac{x+0.5-99}{\sqrt{54.45}} = 1.96$	M1 M1 A1
	$= P(Z \geq 1.8295..)$	
	$= 1 - 0.9664$	
	$= 0.0336/0.0337$ $x = 107.5$	
	Accept H_0 not in CR, not significant	M1
	The **company's claim** is justified **or** **55**% of its pea **seeds germinate**	A1cso [11]
	Notes	
(a)	B1 accept $n > 50$ (or any number bigger than 50) B1 p close to 0.5 NB Do not accept $np > 5$, $nq > 5$.	
(b)	Must have the idea of no peas left. They must mention either **pea** or **seeds**.	
(c)	B1 both hypotheses correct. Must use p or π and 0.55 oe. Accept the hypotheses in part (d).	
(d)	B1 correct mean and Var, may be seen in the standardiation formula as 121 and $\sqrt{54.45}$ or 7.38 to 2dp or implied by a correct answer M1 for attempting a continuity correction (Method 1:135/85 $\pm$ 0.5 / Method 2:$x \pm 0.5$) M1 for standardising using their mean and their standard deviation and using either Method 1 [134.5, 135, 135.5, 85, 85.5 or 84.5 accept $\pm z$.] Method 2 [($x \pm 0.5$) and equal to a $\pm$ z value] A1 correct z value awrt $\pm$ 1.83 **or** $\pm\frac{134.5-121}{\sqrt{54.45}}$ $\left(\frac{85.5-99}{\sqrt{54.45}}\right)$ or $\pm\frac{x-0.5-121}{\sqrt{54.45}} = 1.96$ $\left(\pm\frac{x+0.5-99}{\sqrt{54.45}} = 1.96\right)$ or(allow 1.6449 if 1 tail test in (c)) A1 awrt 0.0336/0.0337 **or** awrt 136 (allow 126 if one tail test in (c)) or a comparison of awrt1.83 with 1.96 (1.6449) M1 A correct statement. Accept H_0, oe if a 2-tailed test in (c), reject H_0, oe if a 1-tailed test in (c). Allow for a correct contextual statement. Do not allow contradictions of non-contextual statements. A1 A correct contextual statement to include words in bold/underlined for a 2-tailed test. This is not a follow through mark. **NB** if finding $P(X = 135)$ they can get B1 M1 M1 A0 A0 M0 A0	