1. The amount of data, X megabytes, arriving at an internet server per second during the afternoon is modelled by the Normal distribution with mean 435 and standard deviation 30.

i. Find

A. $P(X < 450)$,

[3]

B. $P(400 < X < 450)$.

[3]

ii. Find the probability that, during 5 randomly selected seconds, the amounts of data arriving are all between 400 and 450 megabytes.

[2]

The amount of data, Y megabytes, arriving at the server during the evening is modelled by the Normal distribution with mean μ and standard deviation σ.

iii. Given that $P(Y < 350) = 0.2$ and $P(Y > 390) = 0.1$, find the values of μ and σ.

[5]

iv. Find values of a and b for which $P(a < Y < b) = 0.95$.

[4]

2. The wing lengths of native English male blackbirds, measured in mm, are Normally distributed with mean 130.5 and variance 11.84.

i. Find the probability that a randomly selected native English male blackbird has a wing length greater than 135 mm.

[3]

ii. Given that 1% of native English male blackbirds have wing length more than k mm, find the value of k.

[3]

iii. Find the probability that a randomly selected native English male blackbird has a wing length which is 131 mm correct to the nearest millimetre.

[3]

It is suspected that Scandinavian male blackbirds have, on average, longer wings than native English male blackbirds. A random sample of 20 Scandinavian male blackbirds has mean wing length 132.4 mm. You may assume that wing lengths in this population are Normally distributed with variance 11.84 mm^2.

iv. Carry out an appropriate hypothesis test, at the 5% significance level.

[8]

v. Discuss briefly one advantage and one disadvantage of using a 10% significance level rather than a 5% significance level in hypothesis testing in general.

[2]

3. The random variable X represents the weight in kg of a randomly selected male dog of a particular breed. X is Normally distributed with mean 30.7 and standard deviation 3.5.

i. Find

A. P (X < 30),

[3]

B. P(25 < X < 35).

[3]

ii. Five of these dogs are chosen at random. Find the probability that each of them weighs at least 30 kg.

[2]

iii. The weights of females of the same breed of dog are Normally distributed with mean 26.8 kg. Given that 5% of female dogs of this breed weigh more than 30 kg, find the standard deviation of their weights.

[4]

iv. Sketch the distributions of the weights of male and female dogs of this breed on a single diagram.

[4]

4. Many types of computer have cooling fans. The random variable X represents the lifetime in hours of a particular model of cooling fan. X is Normally distributed with mean 50 600 and standard deviation 3400.

i. Find $P(50000 < X < 55000)$.

[3]

ii. The manufacturers claim that at least 95% of these fans last longer than 45000 hours. Is this claim valid?

[3]

iii. Find the value of h for which 99.9% of these fans last h hours or more.

[3]

iv. The random variable Y represents the lifetime in hours of a different model of cooling fan. Y is Normally distributed with mean μ and standard deviation σ. It is known that $P(Y < 60000) = 0.6$ and $P(Y > 50000) = 0.9$. Find the values of μ and σ.

[5]

v. Sketch the distributions of lifetimes for both types of cooling fan on a single diagram.

[4]

5. Each day, for many years, the maximum temperature in degrees Celsius at a particular location is recorded. The maximum temperatures for days in October can be modelled by a Normal distribution; the appropriate Normal curve is shown in Fig. 6.

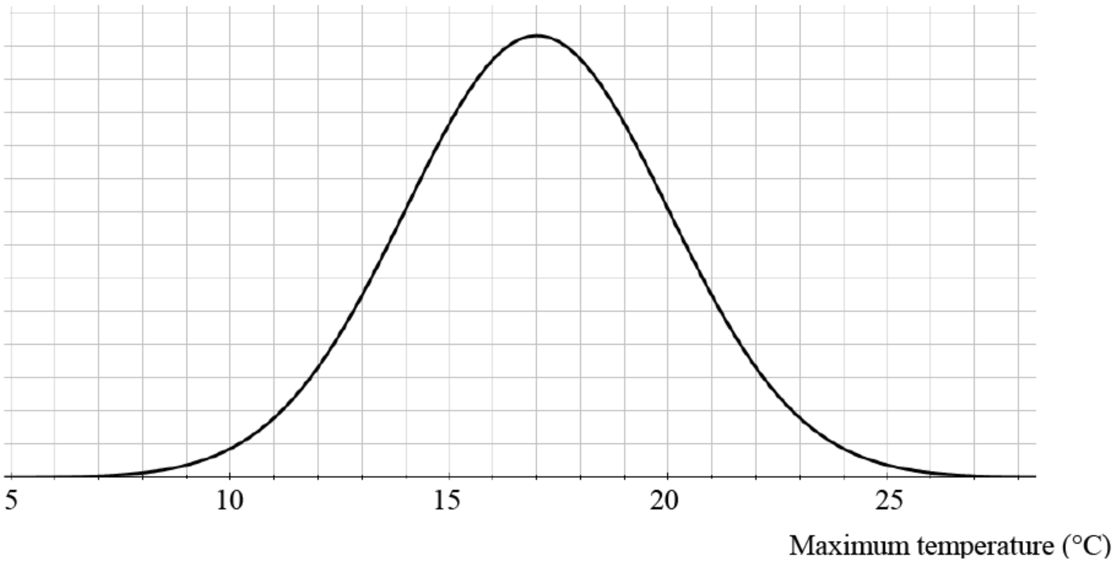


Fig. 6

(a) (i) Use the model to write down the mean of the maximum temperatures.

(ii) Explain why the curve indicates that the standard deviation is approximately 3 degrees Celsius. [2]

Temperatures can be converted from Celsius to Fahrenheit using the formula $F = 1.8C + 32$, where F is the temperature in degrees Fahrenheit and C is the temperature in degrees Celsius.

(b) For maximum temperature in October in degrees Fahrenheit, estimate

- the mean,
- the standard deviation.

[2]

6. (a) The response time to a roadside callout from a breakdown recovery firm may be modelled by a Normal distribution. Over a long period it has been noted that 8% of the response times are less than 58 minutes and 19% of the response times are greater than 86 minutes. Determine estimates of the mean and standard deviation of the response time. [7]

(b) The recovery firm claim that 95% of their response times are less than 90 minutes. Investigate this claim. [2]

7. The screenshot in Fig. 10 shows the probability distribution for the continuous random variable X, where
$X \sim N(\mu, \sigma^2)$.

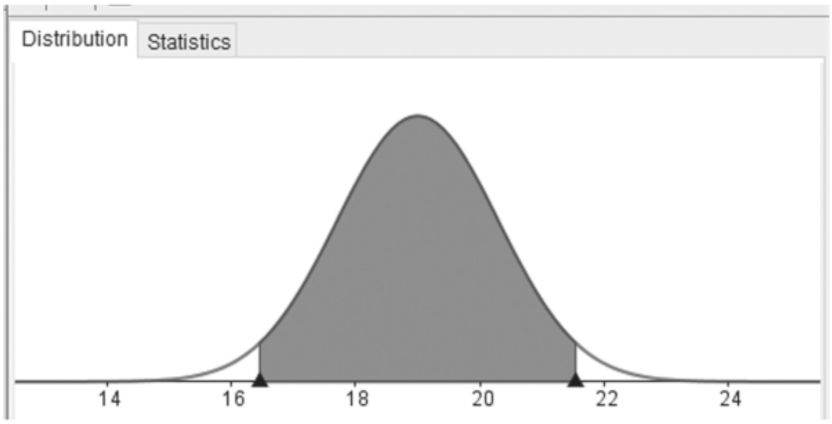


Fig. 10

The area of each of the unshaded regions under the curve is 0.025. The lower boundary of the shaded region is at 16.452 and the upper boundary of the shaded region is at 21.548.

(a) Calculate the value of μ. [1]

(b) Calculate the value of σ^2. [3]

(c) Y is the random variable given by $Y = 4X + 5$.

(i) Write down the distribution of Y. [3]

(ii) Find $P(Y > 90)$. [1]

8. Two siblings, Layla and Wilson, have identical smart phones with an app called "Screen Time" which provides the user with statistics concerning the amount of time spent using the screen per day. The statistics for several months of use for Layla's phone are shown in Fig. 8. Time is measured in minutes.

Number of days	120
Shortest time	12.2
Lower Quartile	46.4
Median	56.1
Upper Quartile	66.1
Mean	56.2
Standard deviation	14.5
Longest time	99.8

Fig. 8

Layla believes that X, the amount of screen time she uses per day on her smart phone, may be modelled by the Normal distribution.

(a) **Without** doing any calculation, state one feature of the data in Fig. 8 which suggests that Layla may be correct. [1]

(b) Verify that the values for the quartiles are consistent with the model

$X \sim N(56.2, 14.5^2)$. [2]

(c) Calculate $P(X > 90)$. [1]

Layla believes that Y, the amount of screen time used per day by Wilson on his smart phone, may be modelled by $Y = 2X$.

(d) Use this model to calculate $P(Y > 90)$. [2]

Each night Layla and Wilson leave their phones on the kitchen table before going to bed. On one occasion their father picked up one of the phones and said:

"This phone has been used for more than an hour and a half today. There is a 99% chance that this is Wilson's phone."

(e) Use Layla's models for the distributions of X and Y to determine whether Layla and Wilson's father's statement is correct. [2]

END OF QUESTION paper

Mark scheme

Question			Answer/Indicative content	Marks	Part marks and guidance	
1		i	$\mathrm{P}(X < 450) = \mathrm{P}\left(Z < \frac{450-435}{30}\right)$	M1	For standardising. M0 if 'continuity correction' applied	
		i	$= \mathrm{P}(Z < 0.5) = \Phi(0.5)$	M1	For correct structure CAO Allow 0.692	
		i	= 0.6915	A1	**Examiner's Comments** Well answered, though inappropriate "continuity corrections" were seen on occasion.	
		i	$\mathrm{P}(400 < X < 450)$ $= \mathrm{P}\left(\frac{400-435}{30} < Z < \frac{450-435}{30}\right)$ $= \mathrm{P}(-1.1667 < X < 0.5)$ $= \Phi(0.5) - \Phi(-1.1667)$	M1	For correct structure	
		i	= 0.6915 – 0.1216	B1	For use of difference column to obtain 0.8784, 0.8783, 0.1216 or 0.1217. Condone 0.8782 or 0.1218 FT "their 0.6915" – 0.1216 (or 0.1217) **Examiner's Comments**	
		i	= 0.5699	A1	Well answered, though arithmetic errors were quite common. In several cases, –1.667 was used rather than –1.1667 often as a result of candidates misreading their own figures. A few candidates lost accuracy by prematurely rounding their *z*-value before using the Normal tables.	

		ii	P(all 5 between 400 and 450)			
		ii	$= 0.5699^5$	M1		
		ii	$= 0.0601$	A1	FT Allow 0.060 **Examiner's Comments** Very well answered. Most candidates scored both marks.	
		iii	$P(Y < 350) = 0.2$, $P(Y > 390) = 0.1$ $P(Z < \frac{350-\mu}{\sigma}) = 0.2$ $\Phi^{-1}(0.2) = -0.8416$			
		iii	$\frac{350-\mu}{\sigma} = -0.8416$ $P(Z > \frac{390-\mu}{\sigma}) = 0.1$	M1	For equation as seen or equivalent with their –ive z value	If 'continuity corrections' applied allow M marks but do not award final A marks
		iii	$\Phi^{-1}(0.9) = 1.282$	B1	For 1.282 or –0.8416	
		iii	$\frac{390-\mu}{\sigma} = 1.282$ $350 = \mu - 0.8416\sigma$ $390 = \mu + 1.282\sigma$ $2.1236\sigma = 40$	M1	For equation as seen or equivalent with their +ive z value	
		iii	$\sigma = 18.84$	A1	Allow 18.8	Answers to max 2 d.p.
		iii	$\mu = 350 + (0.8416 \times 18.84) = 365.85$	A1	Allow 365.86, 366, 365.9 **Examiner's Comments**	

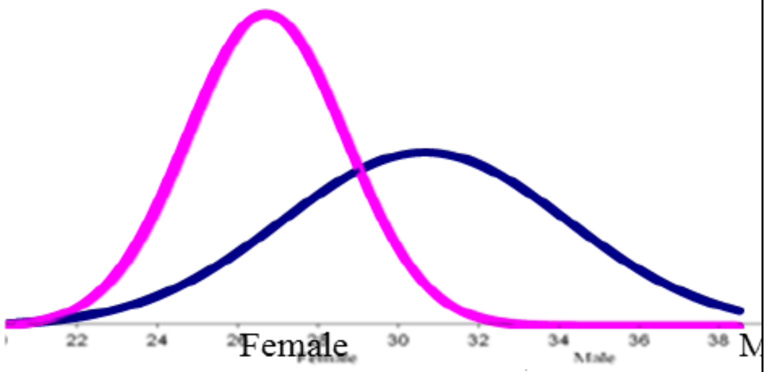
					On the whole, this was well answered. Many candidates provided clear, accurate methods leading to correct final answers. Some candidates started out with one of the required equations containing a sign error which was not picked up, even when the error led to a negative value for σ. Most candidates identified the correct *z*-values. In the poorest answers, continuity corrections were attempted and *z*-values were changed to absurd values, such as "1 − 0.8416", before substitution into equations. Over-specification of final answers was seen, on occasion, here.	
		iv	$\Phi^{-1}(0.975) = 1.96$	B1	For using a suitable pair of *z* values e.g. ± 1.96	
		iv	$a = 365.85 - (1.96 \times 18.84)$	M1	For either equation provided that a suitable pair of *z*-values is used. e.g. +2.326 and −1.751 FT their μ and σ to 2 d.p. (A0 if 'continuity correction' used)	
		iv	$= 328.9$	A1	**Examiner's Comments** Though one of the more challenging parts, many candidates scored full marks here. A variety of correct, "non-symmetrical" solutions were seen though most opted to use *z*-values of ± 1.96.	Accept any correct values of *a* and *b*.
		iv	$b = 365.85 + (1.96 \times 18.84)$ $= 402.8$	A1	FT their μ and σ to 2 d.p. (A0 if 'continuity correction' used)	
			Total	17		
2		i	$P(X > 135) = P\left(Z > \dfrac{135 - 130.5}{\sqrt{11.84}}\right)$	M1	For standardising. Penalise use of "continuity corrections"	
		i	$= P(Z > 1.308) = 1 - \Phi(1.308) = 1 - 0.9045$	M1	For correct structure i.e. finding the area to the right of their *z*	
		i	$= 0.0955$ (3s.f.)	A1	CAO inc use of diff tables Allow 0.0954 and 0.0956	

					If numerator reversed, give BOD only if P(Z < −1.308) is used **Examiner's Comments** Was found to be easy, though some candidates confused the exact and approximate values in calculating the relative error, thereby losing a mark.	
		ii	From tables Φ^{-1} (0.99) = 2.326	B1	±2.326 or (better) seen, not ±2.33	
		ii	$\frac{k-130.5}{\sqrt{11.84}} = 2.326$ oe	M1	For sensible equation in k with their z **value**. Note that use of z = 0.8389 from Φ (0.99) gets B0M0A0, as 0.8389 is clearly a **probability**. Allow use of −2.326 (or their negative z) with numerator reversed. Condone use of σ = 11.84 if also used in part (i). Condone use of "k ± 0.5" for k in equation. 0/3 for trial and improvement	
		ii	$k = 130.5 + \left(2.326 \times \sqrt{11.84}\right) = 138.50$	A1	CAO Allow 138.504. Accept 138.5 Do not accept final answers of 139 or 138. **Examiner's Comments** Was found hard. Very few candidates spotted that squaring and cubing gave double and triple the relative errors.	
		iii	P(Wing length = 131) = $\mathrm{P}\left(\frac{130.5-130.5}{\sqrt{11.84}} \le Z \le \frac{131.5-13}{\sqrt{11.84}}\right.$	B1	For both limits correct, soi. e.g. use of 0.5 in probability calculation implies correct lower limit.	
		iii	= P(0 < Z < 0.2906) = Φ(0. 2906) − Φ(0) = 0.6143 − 0.5	M1	For **correct structure** using their standardised values. i.e. **Finding the area between their z values found using μ = 130.5** Condone use of σ = 11.84 if also used in part (i) or part (ii).	
		iii	= 0.1143	A1	CAO inc use of diff tables Allow 0.1145 Allow 0.114 www	

		iv	H_0: $\mu = 130.5$ H_1: $\mu > 130.5$	B1	For both correct Hypotheses in words must refer to population. Do not allow other symbols unless clearly defined as population mean	
		iv	Where μ denotes the **mean wing length** (in the population) (of Scandinavian male blackbirds).	B1	For definition of μ in context. Do not allow "sample mean wing length" or "mean wing length of English blackbirds"	
		iv	$\text{Test statistic} = \dfrac{132.4-130.5}{\sqrt{11.84}/\sqrt{20}} = \dfrac{1.90}{0.7694}$	M1*	must include $\sqrt{20}$ Condone use of σ = 11.84 if also used in part (i), part (ii) or part (iii). Condone numerator reversed for max M1*A0B1M0depA0A0 (max 4/8)	
		iv	= 2.469	A1	Allow 2.47	
		iv	Upper 5% level 1 tailed critical value of z = 1.645	B1	For 1.645. Must be positive. B0 if −1.645 seen. No further A marks from here if wrong.	
		iv	2.469 > 1.645	M1dep*	For sensible comparison leading to a conclusion.	
		iv	The result is significant. There is sufficient evidence to reject H_0	A1	For correct conclusion. e.g. for "significant" oe FT only candidate's test statistic if cv = 1.645	
		iv	There is sufficient evidence to **suggest** that the mean wing length (of this population of birds) is greater (than 130.5 mm).	A1	For **non-assertive** conclusion in context, consistent with their result Condone use of "average" for "mean" FT only candidate's test statistic if cv = 1.645	
		v	With a 10% significance level rather than a 5% significance level, Advantage: One is less likely to accept the null hypothesis when it is false.	E1	Accept equivalent wording.	
		v	Disadvantage: One is more likely to reject the null hypothesis when it is true.	E1	Note — Unless stated otherwise, assume the first comment relates to an advantage and the second comment relates to a disadvantage.	
			Total	19		

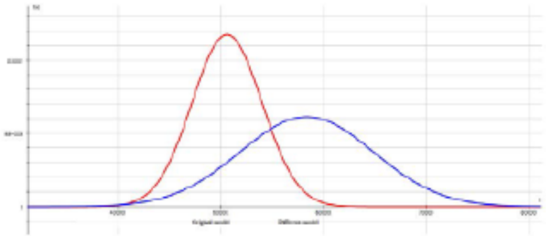
3		i	*(A)* $P(X < 30)$			
		i	$= P\left(Z < \frac{30 - 30.7}{3.5}\right)$	M1	For standardising	
		i	$P(Z < -0.20)$			
		i	$= \Phi(-0.20)$			
		i	$= 1 - \Phi(0.20)$ $= (1 - 0.5793)$	M1	For correct structure	$1 - \Phi$(positive z)
		i	$= 0.4207$	A1	CAO **Examiner's Comments** The majority of candidates correctly standardised the given value then found the correct probability. Some candidates made good use of diagrams to indicate their intent.	Allow 0.421 www
		i	*(B)* $P(25 < X < 35)$			
		i	$= P\left(\frac{25 - 30.7}{3.5} < Z < \frac{35 - 30.7}{3.5}\right)$	M1	Correctly standardising both.	Penalise erroneous continuity corrections and wrong sd. Condone both numerators reversed.
		i	$= P(-1.629 < X < 1.229)$ $= \Phi(1.229) - \Phi(-1.629)$			
		i	$= 0.8904 - (1 - 0.9483) = 0.8904 - 0.0517$	M1	For correct structure Use of differences column required	$\Phi(1.23) - \Phi(-1.63)$ leads to $0.8907 - 0.0516 = 0.8391$
		i	$= 0.8387$	A1	**Examiner's Comments** For a question that had potential for many errors, either in standardising, approximating too early, or looking up values incorrectly, this question	Only allow 0.839 if 0.8387 is seen.

					was answered well. This part was in general done rather better than part (iA).	
		ii	P(all 5 weigh at least 30kg)			
		ii	$= 0.5793^5$	M1	Allow FT (1 – their (i)(*A*))^5 or [their P($X \geq 30$)]^5 FT only (1 – their (i)(*A*))^5	
		ii	$= 0.0652$	A1	**Examiner's Comments** The binomial situation, within a question fundamentally on the Normal distribution, was dealt with well by many candidates. The errors that did occur were often about forgetting that (iA) found p(X < 30) whereas this part asked for all five dogs to weigh *more than* 30 kg.	Allow 0.06524, allow 0.065 www
			P(weight > 30) = 0.05			
		iii	$P(Z > \frac{30-26.8}{\sigma}) = 0.05$			
		iii	$\Phi^{-1}(0.95) = 1.645$	B1	For 1.645. B0 for 1 - 1.645 or 0.1645	NOTE use of –1.645 allowed only if numerator
		iii	$\frac{30-26.8}{\sigma} = 1.645$	M1*	For equation as seen or equivalent, with their $z > 1$.	reversed. Condone use of spurious c.c. if already penalised in parts (i)(*A*) or (i)(*B*). See additional guidance notes. Allow σ = 1.95 www
		iii	$\sigma = \frac{30-26.8}{1.645} = 1.945$ kg	M1dep*	Rearranging for σ	
		iii		A1	CAO **Examiner's Comments** Few candidates used the wrong tail for this calculation, most correctly	**Additional Notes for (iii)** M1* is for forming a suitable equation using their z-value but it must be reasonably clear that the value used is a z-value – for example

					identifying that +1.645 was the appropriate value to use as 5% weighed *more than* 30 kg.	we do not allow 0.05 or 0.95 to be treated as z-values here. The M1dep* can be awarded if the candidate correctly rearranges their equation to find σ. Hence, use of an incorrect z-value could earn max B0M1*M1dep*A0. However, if it is clear that the z-value is from the wrong tail (e.g. -1.645 used in place of +1.645) then award 0/4. In cases where -1.645 is used and the numerator of the equation is reversed allow full credit and annotate with BOD.
		iv		G1	For two Normal shapes including attempt at asymptotic behaviour with horizontal axis at each of the four ends	Penalise clear asymmetry
		iv		G1	For means, shown explicitly or by scale **on a single diagram**	If shown explicitly, the positions must be consistent with horizontal scale if present.
		iv		G1	For lower max height for Male	If not labelled, assume the larger mean represents Male
		iv		G1	For visibly greater width for Male <u>Examiner's Comments</u> This part of the question tested most candidates. Thus many found dealing with the correct shape and the various relative constraints on the curves difficult. The mark scheme will help with interpretation of the requirements.	If not labelled, assume the larger mean represents Male

			Total	16		
4		i	P(50000 < X< 55000) = $P\left(Z \geq \frac{750-751.4}{2.5}\right)\left(\frac{50000-50600}{3400} < Z < \frac{55000-5060}{3400}\right.$	M1	For standardising both. SOI. Penalise erroneous continuity corrections and wrong sd. Condone numerator(s) reversed.	
		i	= P(−0.176 < Z< 1.294) = Φ(1.294) − (1 − Φ(0.176)) = 0.9022 − 1 + 0.5699	M1	For correct structure Φ(positive z) - Φ(negative z) CAO including use of difference tables (Answer from calculator 0.4722 and from tables interpolated 0.4723)	
		i	= 0.4721	A1	**Examiner's Comments** Well answered. Errors caused by lack of accuracy reading Normal tables were seen fairly regularly. Most candidates used the correct probability structure with their z values.	
		ii	P(X> 45000) = $P\left(Z \geq \frac{750-751.4}{2.5}\right)$ $\left(Z > \frac{45000-50600}{3400}\right)$ = P(Z> −1.647)	B1*	For − 1.647 or -Φ^{-1}(0.95) = −1.645 or 1.647 seen with P(X< 56200) or numerator reversed	
		ii	= Φ(1.647) = 0.9502	B1*	For 0.9502 or 45007 or 0.0498, or B1 for −1.645 if B1 for −1.647 already awarded. **For comparison seen** e.g. −1.647 < −1.645 or 0.0498 < 0.05 or 1.647 > 1.645 or 95% last longer than 45007 hours, **and correct conclusion**. Dependent on B1, B1 awarded	
		ii	0.9502 > 95% so agree with claim	depE1*	**Examiner's Comments** This was well done on the whole though many candidates did not provide the required comparison to justify their conclusion. In most cases the working provided was clear – diagrams were helpful to	

					examiners in conveying the candidates' intentions – often more successfully than their wording.	
		iii	From tables $\Phi^{-1}(0.999) = 3.09$	B1	±3.09 seen	
		iii	$\frac{h-50600}{3400} = -3.09$	M1	For equation as seen with their negative z-value	
		iii	$k = 50600-(3.09 \times 3400) = 40100$ www	A1	CAO Allow 40094, 40090 **Examiner's Comments** Many correctly identified the *z* value of −3.09 and went on to find the appropriate value for *h*, rounded to a suitable level of accuracy.	
		iv	$P(Y < 60000) = 0.6 \Rightarrow P\left(Z < \frac{60000-\mu}{\sigma}\right) = 0.6$	B1	For ±0.2533 or ±1.282 seen	
		iv	$\Rightarrow \frac{60000-\mu}{\sigma} = \Phi^{-1}(0.6) = 0.2533$	M1	For an equation ito μ, σ, *z* and *y* formed. NB using $z = \pm 0.2533$ with $y = 60000$ or ± 1.282 with $y = 50\,000$	
		iv	$\Rightarrow 60000 = \mu + 0.2533\sigma$			
		iv	$P(Y > 50000) = 0.9 \Rightarrow P\left(Z > \frac{50000-\mu}{\sigma}\right)$ $= 0.9$			
		iv	$\Rightarrow \frac{50000-\mu}{\sigma} = \Phi^{-1}(0.1) = -1.282$	A1	For two correct equations seen.	
		iv	$\Rightarrow 50000 = \mu - 1.282\sigma$ $1.5353\sigma = 10000$			

		iv	$\sigma = 6513$	A1	CAO Allow 6510, 6515	
		iv	$\Rightarrow \mu = 50000 + (1.282 \times 6513) = 58350$	A1	CAO Allow 58400 **Examiner's Comments** There were some pleasing attempts at this question, marred only by an inappropriate degree of accuracy for the final answers. It was good to see that once the initial equations had been established with the correct *z* values, many could still solve the simultaneous equations. A few candidates failed to identify, for the given probabilities, the *z* values needed for the simultaneous equations.	
		v		G1	For two Normal shapes including attempt at asymptotic behaviour with horizontal axis at each of the four ends. Penalise clear asymmetry.	
		v		G1	For means, shown explicitly or by scale **on a single diagram**. If shown explicitly, the positions must be consistent with horizontal scale if present. FT part (iv).	
		v		G1	For greater width (variance) for Different model. FT part (iv).	
		v		G1	For lower max height for Different model. FT part (iv) If not labelled assume the larger mean represents Different model. FT part (iv). **Examiner's Comments** This was answered well, though many candidates could have made a greater effort to include symmetry in their sketches and to pay more attention to the asymptotic nature. Spurious labelling of axes was seen but only rarely.	

			Total	18		
5		a	*i* Mean = 17	B1(AO3.4)		
		a	*ii* **Either** Points of inflection are approx. 3 above and below mean so SD = approx. 3 **Or** Limits are approx. 9 above and below mean so SD = 9 ÷ 3 = 3	E1(AO2.4) E1(AO2.4) [2]	AG AG	
		b	Mean in Fahrenheit = 1.8 × 17 + 32 = 62.6 SD in Fahrenheit = 1.8 × 3 = 5.4	B1(AO1.1) B1(AO1.1) [2]	FT their mean	
			Total	4		
6		a	$\Phi^{-1}(0.08) = -1.4051$ BC $\Phi^{-1}(0.81) = 0.8779$ BC their $-1.4051 = \frac{58-\mu}{\sigma}$ their $0.8779 = \frac{86-\mu}{\sigma}$ obtaining a value for μ or σ from their equations	B1(AO1.1) B1(AO 1.1) M1(AO 2.1) M1(AO 1.1) M1(AO 2.5)		

			$\sigma = 12.3$ $\mu = 75.2$	A1(AO 2.4) A1(AO 1.1) [7]	allow 2 or 3 s.f. | NB 12.2647368787 and 75.2328329886	
		b	$P(X < 90) = 0.849$ FT their μ and σ BC which is less than 0.95 so claim not justified	M1(AO 3.1a) A1(AO 3.2a) [2]	their 12.3 × 1.645 + their 75.2 > 90 which is greater than 90 so claim not justified	
			Total	9		
7		a	[μ =]19	B1 (AO 1.1) [1]	**Examiner's Comments** Candidates who did well in this question wrote down the mean by symmetry.	
		b	$1.96 = \dfrac{21.548 - 19}{\sigma}$ [σ =] awrt 1.3	M1 (AO 3.1a) A1	or $-1.96 = \dfrac{16.452 - 19}{\sigma}$ | NB 1.959963985…rounded to 3 or more sf	

				Marks	Guidance	
			$[\sigma^2 =]$ awrt 1.69	(AO 1.1) A1 (AO 1.1) [3]	may be implied by final answer allow **B3** for awrt 1.69 unsupported | **M0** if $z = 2$ Examiner's Comments Candidates who did well on this part made efficient use of the standard Normal variable to find the variance. Candidates who did less well confused the mean with the variance, or used a wrong value for z (usually 1.645) to find the variance.	
		c	**(i)** $[\mu =]\ 4 \times$ *their* $19 + 5$ $[\sigma^2 =]\ 4^2 \times$ *their* 1.69 or $\sigma = 4 \times$ *their* 1.3 $[Y \sim]\mathrm{N}(81, 5.2^2)$ oe	M1 (AO 2.1) M1 (AO 1.1) A1 (AO 1.1) [3]	NB 27.04 Examiner's Comments A common error in this part was to calculate 4 × 1.69 or 16 × 1.69 + 5 instead of 16 × 1.69 .	
			(ii) 0.04175 or 0.0417 or 0.042 BC	B1 (AO 1.1) [1]	NB 0.0417462427103 Examiner's Comments	

					This part required efficient use of the calculator.	
			Total	8		
8		a	eg median ≈ mean eg extreme values and/or quartiles symmetrical about mean oe	B1 (AO 2.4) [1]		
		b	$P(X < 46.4) = 0.24956..\approx 0.25$ $P(X < 66.1) = 0.75262..\approx 0.75$ So both values are consistent	M1 (AO 3.3) A1 (AO 2.4) [2]	BC — or invNorm(0.25, 56.2, 14.5) = 46.4199…≈ 46.4 Must follow from correct calc. values — `invNorm`(0.75, 56.2, 14.5) = 65.98…≈66.1	
		c	0.00987574855 …	B1 (AO 1.1) [2]	BC to 3 or more sf	
		d	Use of $N(112.4, 29^2)$ soi 0.780065376569…	M1 (AO 3.1a) A1(AO 1.1) [2]	BC to 3 or more sf	
		e	their $\dfrac{0.78006..}{0.00987...+0.78006...}$ 0.98750…so approximately a 99% chance the phone is Wilsons so their father's statement is justifiable	M1 (AO 2.1) A1(AO 2.2b)	their $\dfrac{0.00987..}{0.00987...+0.78006...}$ 0.0125…so approximately a 1%	

				[2]	chance the phone is Chidera's so their father's statement is justifiable	Normal Distribution
			Total	8		