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EDEXCEL INTERNATIONAL A LEVEL MATHS: QUESTIONS BY TOPIC

The Normal Distribution (S1.5)

International A Level Mathematics · S1: Statistics 1 (WST01)

17 questions · 202 marks · Mark schemes included

Past papers October 2020 - June 2025 · 1 sub-topic

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HOW TO USE THIS BOOKLET

Questions are grouped by sub-topic and run from the lowest to the highest mark tariff, then oldest paper first.

Click any row below to jump straight to that sub-topic or question.

On every question page, click ANSWER in the top-right corner to jump to its mark scheme; < QUESTION brings you back.

A gold bar in the left margin marks exactly where the question sits on the original page.

Diagrams, graphs, grids and tables are printed exactly as they appear in the original papers.

Each question is filed under its main topic; longer questions may also test skills from other topics.

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S1.5a THE NORMAL DISTRIBUTION		17 Qs · 202 marks	2
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QUESTIONS

17 questions · 202 marks · 1 sub-topic

SUB-TOPIC S1.5a

THE NORMAL DISTRIBUTION

Sub-topic S1.5a · 17 questions · 202 marks · lowest tariff first



- In this question you must show all stages of your working. Solutions relying entirely on calculator technology are not acceptable.**

The distances, m miles, a motorbike travels on a full tank of petrol can be modelled by a normal distribution with mean 170 miles and standard deviation 16 miles.

- (a) Find the probability that, on a randomly selected journey, the motorbike could travel at least 190 miles on a full tank of petrol.

(2)

The probability that, on a randomly selected journey, the motorbike could travel at least d miles on a full tank of petrol is 0.9

- (b) Find the value of d

(3)

Question 4 continued

Lined area for writing the answer to Question 4.

(Total for Question 4 is 5 marks)

- (2)

(5)



Question 5 continued

Handwriting practice area with horizontal lines.

(Total for Question 5 is 7 marks)

- Given that

(a) find the value of k

(4)

Given that

$$2\mu = 3\sigma^2 \quad \text{and} \quad P\left(Y > \frac{3}{2}\mu\right) = 0.0668$$

- (b) find the value of μ and the value of σ

(5)



Question 8 continued

Lined area for writing the answer to Question 8 continued.

Question 8 continued

Lined area for writing the answer to Question 8.

(Total for Question 8 is 9 marks)

TOTAL FOR PAPER IS 75 MARKS



Question 5 continued

Lined area for writing the answer to Question 5 continued.



Question 5 continued

Lined area for writing the answer to Question 5.



(Total for Question 3 is 10 marks)









TOTAL FOR PAPER IS 75 MARKS



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5. Jia writes a computer program that randomly generates values from a normal distribution.

He sets the mean as 40 and the standard deviation as 2.4

- (a) Find the probability that a particular value generated by the computer program is less than 37

(3)

Jia changes the mean to m but leaves the standard deviation as 2.4

The computer program then randomly generates 2 independent values from this normal distribution.

The probability that both of these values are greater than 32 is 0.16

- (b) Find the value of m , giving your answer to 2 decimal places.

(4)

Jia now changes the mean to 4 and the standard deviation to 8

The computer program then randomly generates 5 independent values from this normal distribution.

- (c) Find the probability that at least one of these values is negative.

(4)



Question 5 continued

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Question 5 continued

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Question 5 continued

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(Total 11 marks)

Q5





Question 6 continued

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(Total for Question 6 is 11 marks)

TOTAL FOR PAPER: 75 MARKS







Question 5 continued

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(Total for Question 5 is 12 marks)



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3. The distance achieved in a long jump competition by students at a school is normally distributed with mean 3.8 metres and standard deviation 0.9 metres.

Students who achieve a distance greater than 4.3 metres receive a medal.

- (a) Find the proportion of students who receive medals. (3)

The school wishes to give a certificate of achievement or a medal to the 80% of students who achieve a distance of at least d metres.

- (b) Find the value of d . (3)

Of those who received medals, the $\frac{1}{3}$ who jump the furthest will receive gold medals.

- (c) Find the shortest distance, g metres, that must be achieved to receive a gold medal. (4)

A journalist from the local newspaper interviews a randomly selected group of 3 medal winners.

- (d) Find the exact probability that there is at least one gold medal winner in the group. (3)



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Q3

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Question 3 continued

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(Total 13 marks)

Q3

Grading boxes for Q3.



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4. Kris works in the mailroom of a large company and is responsible for all the letters sent by the company. The weights of letters sent by the company, W grams, have a normal distribution with mean 165 g and standard deviation 35 g.

- (a) Estimate the proportion of letters sent by the company that weigh less than 120 g. (3)

Kris splits the letters to be sent into 3 categories: heavy, medium and light, with $\frac{1}{3}$ of the letters in each category.

- (b) Find the weight limits that determine medium letters. (4)

A heavy letter is chosen at random.

- (c) Find the probability that this letter weighs less than 200 g. (3)

Kris chooses a random sample of 3 letters from those in the mailroom one day.

- (d) Find the probability that there is one letter in each of the 3 categories. (3)



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Q4





(Total for Question 3 is 15 marks)





Question 7 continued

Lined area for writing the answer to Question 7.





Question 7 continued

Lined area for writing the answer to Question 7.

(Total for Question 7 is 14 marks)

TOTAL FOR PAPER IS 75 MARKS



6. A company produces small bags of flour and large bags of flour.

The weight, X grams, of flour in a small bag is normally distributed with mean 502 and standard deviation 3

One of these small bags of flour is selected at random.

- (a) (i) Using standardisation find $P(X > 508)$

(2)

- (ii) Hence, find $P(496 < X < 508)$

(2)

A random sample of 4 small bags of flour is taken.

- (b) Find the probability that exactly 2 of these small bags each contain more than 508 grams of flour.

(3)

The weight, Y grams, of flour in a large bag is normally distributed with mean 1024 and standard deviation σ

The 85th percentile for the weight of flour in a large bag is 1038.51 to 2 decimal places.

- (c) Show that $\sigma = 14$ to the nearest gram.

(2)

Given that $P(X > k) = P(Y < 2k) = p$, where k and p are constants,

- (d) (i) find the value of k

- (ii) find the value of p

(5)

Question 6 continued

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Question 6 continued

Lined area for writing the answer to Question 6.

(Total for Question 6 is 14 marks)



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Q6

TOTAL FOR PAPER: 75 MARKS





(Total for Question 3 is 15 marks)







(Total for Question 5 is 17 marks)



MARK SCHEMES

official mark schemes, in the same order as the questions



Question Number	Scheme		Marks
4 (a)	$X \sim N(170, 16^2)$		
	$P(X > 190) = P\left(Z > \frac{190-170}{16}\right) [= P(Z > 1.25)]$		M1
	$[= 1 - 0.8944] = 0.1056$	awrt 0.106	A1
			(2)
(b)	$P(X > d) = 0.9$		
	$\frac{d-170}{16} = -1.2816$ or $\frac{170-d}{16} = 1.2816$	(Calc value $\pm 1.28155\dots$)	M1 A1
	$d = 149.494\dots$	awrt 149	dA1
			(3)
	Notes		Total 5
	NB correct answers with no working scores no marks		
(a)	M1	For standardising using 190, 170 and 16 (May be implied by 1.25)	
	A1	awrt 0.106 Do not ISW	
(b)	M1	For standardising and setting = z value, where $1 < z < 2$	
	A1	A fully correct standardisation = a correct compatible z value to 4 dp or better.	
	dA1	Dependent on previous A1 149.5 or awrt 149	

Question Number	Scheme		Marks
5 (a)	$P(X < 38.8) = P\left(Z < \frac{38.8 - 40}{4}\right) [= P((Z < -0.3))]$		M1
	$= 1 - 0.6179 = 0.3821^*$		A1*
			(2)
(b)	$P(\text{Qualify}) = 1 - (0.3821)^3$ or $1 - 0.3821 + 0.3821 \times (1 - 0.3821) + 0.3821^2 \times (1 - 0.3821)$		M1
	$[= 0.9442]$		
	$P(X > 44) = P\left(Z > \frac{44 - 40}{4}\right) [= P((Z > 1))]$		M1
	$[= 1 - 0.8413] = 0.1587$		A1
	$P(X > 44 \text{ on 2nd attempt} \text{Qualify}) = \frac{0.3821 \times '0.1587'}{'0.9442'}$		M1
	$0.06422\dots$ awrt 0.0642		A1
			(5)
Notes			Total 7
(a)	M1	For standardising using 38.8, 40 and 4 (allow $\pm$)	
	A1*	Must see $1 - 0.6179$ or we must see 0.38209 or 0.38208... or better Answer is given so no incorrect working can be seen (but condone poor probability notation)	
(b)	M1	For a correct method to find the probability of qualifying	
	M1	For standardising using 44, 40 and 4 (implied by $1 - 0.8413$ or awrt 0.1587)	
	A1	awrt 0.16	
	M1	For a correct ratio of probabilities ft their 0.1587 and their 0.9442. Use of 0.6179 in the denominator is M0	
	A1	awrt 0.0642	

Question Number	Scheme						Marks		
7 (a)	$\frac{k+4}{8} = 1$ [$k = 4$ *]						B1*		
							(1)		
(b)	x	1	2	3	4		M1 M1 A1		
	P(X = x)	$\frac{1}{13}$	$\frac{7}{26} - \frac{1}{13} = \frac{5}{26}$	$\frac{15}{26} - \frac{7}{26} = \frac{4}{13}$	$1 - \frac{15}{26} = \frac{11}{26}$				
							(3)		
(c)	4						B1ft		
							(1)		
(d)	$E(X) = 1 \times \frac{1}{13} + 2 \times \frac{5}{26} + 3 \times \frac{4}{13} + 4 \times \frac{11}{26} \left[= \frac{40}{13} \right]$			Y	7	20	33	46	M1
				P(Y = y)	$\frac{1}{13}$	$\frac{5}{26}$	$\frac{4}{13}$	$\frac{11}{26}$	
	$E(X^2) = 1^2 \times \frac{1}{13} + 2^2 \times \frac{5}{26} + 3^2 \times \frac{4}{13} + 4^2 \times \frac{11}{26} \left[= \frac{135}{13} \right]$			$E(Y) = 7 \times \frac{1}{13} + 20 \times \frac{5}{26} + 33 \times \frac{4}{13} + 46 \times \frac{11}{26} \left[= 34 \right]$					M1
	$\text{Var}(X) = \frac{135}{13} - \left(\frac{40}{13} \right)^2 \left[= \frac{155}{169} \right]$			$E(Y^2) = 7^2 \times \frac{1}{13} + 20^2 \times \frac{5}{26} + 33^2 \times \frac{4}{13} + 46^2 \times \frac{11}{26} \left[= 1311 \right]$					M1
	$\text{Var}(13X - 6) = 13^2 \times \frac{155}{169}$			$\text{Var}(13X - 6) = '1311' - '34'^2$					M1
	$= 155$						A1		
							(5)		
	Notes						Total 10		
(a)	B1*	$\frac{k+4}{8} = 1$ oe Allow verification method $\frac{4+4}{8} = 1$ provided they conclude $k = 4$							
(b)	M1	For a correct method to find one probability from $x = 2$, $x = 3$ or $x = 4$ (implied by any one correct probability from $x = 2$, $x = 3$ or $x = 4$)							
	M1	For a correct method to find a second probability from $x = 2$, $x = 3$ or $x = 4$ (implied by any two correct probabilities from $x = 2$, $x = 3$ or $x = 4$)							
	A1	For a fully correct probability distribution. Need not be in a table, but 1, 2, 3 and 4 must be associated with correct probability							
(c)	B1ft	Must be consistent with the highest probability in their distribution in part (b). If no distribution is found, then the answer must be 4							
(d)	M1	For a correct method to find $E(X)$ (implied by awrt 3.08) ft their table use of $\sum xF(x)$ is M0 or for a correct probability distribution for $13X - 6$ ft their probabilities in (b)							
	M1	For a correct method to find $E(X^2)$ (implied by awrt 10.4) ft their table use of $\sum x^2F(x)$ is M0 or for a correct method to find $E(Y)$ ft their table							
	M1	Use of $E(X^2) - E(X)^2$ ft their $E(X^2)$ and their $E(X)$ or for a correct method to find $E(Y^2)$ ft their table							
	M1	Use of $13^2 \text{Var}(X)$ ft their $\text{Var}(X)$ or use of $E(Y^2) - E(Y)^2$ ft their $E(Y^2)$ and their $E(Y)$							
	A1	Cao							



Question Number	Scheme		Marks
8 (a)	$P(X > \mu + 2k) = 0.2$	or $P(X < \mu - 2k) = 0.2$	M1
	or $P(X < \mu + 2k) = 0.8$	or $P(X > \mu - 2k) = 0.8$	
	$\frac{\mu + 2k - \mu}{6} = 0.8416$	or $\frac{\mu - 2k - \mu}{6} = -0.8416$	M1 A1
	$k = 2.5248...$	awrt 2.52	A1
			(4)
(b)	$P\left(Y > \frac{3}{2}\mu\right) \Rightarrow P\left(Z > \frac{\frac{3}{2}\mu - \mu}{\sigma}\right) \Rightarrow P\left(Z > \frac{\frac{1}{2}\mu}{\sigma}\right)$		M1
	$\mu = \frac{3}{2}\sigma^2 \Rightarrow P\left(Z > \frac{\frac{1}{2}\left(\frac{3}{2}\sigma^2\right)}{\sigma}\right) \left[= P\left(Z > \frac{3}{4}\sigma\right) \right]$		M1
	or		
	$\sigma = \sqrt{\frac{2\mu}{3}} \Rightarrow P\left(Z > \frac{\frac{1}{2}\mu}{\sqrt{\frac{2\mu}{3}}}\right) = \left[P\left(Z > \frac{1}{2}\sqrt{\frac{3\mu}{2}}\right) \right]$		
	$\frac{1}{2}\mu$ or $\frac{\frac{1}{2}\mu}{\sigma} = k$ and $2\mu = 3\sigma^2$		
	$\frac{3}{4}\sigma = 1.5$ or $\frac{1}{2}\sqrt{\frac{3\mu}{2}} = 1.5$ or $3\sigma^2 = 6\sigma$		M1
	$\mu = 6$ only, $\sigma = 2$ only		A1 A1
			(5)
	Notes		Total 9
(a)	M1	For any of the given tail probability statements which may be seen on a diagram Also may be implied by awrt ± 0.84 seen	
	M1	For standardising using μ and 6 and setting = to z value, where $0.8 < z < 0.9$ Implied by $(\pm)\frac{k}{3} = (\pm)0.84$ or better	
	A1	For a fully correct standardisation with a compatible z value. $ z $ must be 0.8416 or better	
	A1	awrt 2.52 (Allow 2.525) Answer only 2.52 is M1M1A0A1 Answer only 2.5248 is M1M1A1A1	
(b)	M1	For standardising using $\frac{3}{2}\mu$, μ and σ	
	M1	For substitution of $\mu = \frac{3}{2}\sigma^2$ into their standardisation or setting up two equations in μ and σ	
	M1	For their expression for σ only or μ only used with ± 1.5	
	A1	$\mu = 6$ or $\sigma = 2$	
	A1	$\mu = 6$ and $\sigma = 2$ must reject any other values if found	

Question	Scheme		Marks
5 (a)	$P(X < 18) = P\left(Z < \pm \left(\frac{18-15}{2}\right) [= \pm 1.5]\right)$		M1
	$= 0.9332$		A1
	awrt 0.933		(2)
(b)	$\frac{x-15}{2} = 0.2533$		M1B1
	$x = 15.506...$ awrt 15.5		A1
			(3)
(c)	$P(T > \mu - 10) = 0.975$		M1
	$\frac{(\mu \pm 10) - \mu}{\sigma} = \pm 1.96 \Rightarrow \sigma = \frac{10}{1.96} [= 5.10...]$		M1
	$P(T > \mu - 5) = P\left(Z > \frac{\mu - 5 - \mu}{"5.10..."} [= -0.98]\right) [= 0.836...]$		M1
	$P(T > \mu - 5 \mid T > \mu - 10) = \frac{"0.836..." }{"0.975"}$		M1
	$= 0.8579...$ awrt 0.858		A1
			(5)
Notes			Total 10
(a)	M1	for standardising correctly May be implied by ± 1.5	
	A1	awrt 0.933 (Do not ISW)	
(b)	M1	for correct standardisation = to a z value such that 0.25 ,, $ z $,, 0.26	
	B1	for use of awrt ± 0.2533	
	A1	awrt 15.5	
(c)	M1	for the correct probability of 0.975 – may be seen as the denominator of the fraction. May be implied by use of $ z = 1.96$ or better	
	M1	For $\frac{\mu + 10 - \mu}{\sigma} = 1.96$ or $\frac{\mu - 10 - \mu}{\sigma} = -1.96$, leading to a value for σ May be implied by ± 0.98	
	M1	for a correct method to find $P(T > \mu - 5)$ using their value for σ May be implied by -0.98 If $P(T < \mu + 5)$ is calculated then this may be implied by 0.98	
	M1	for $\frac{p}{0.975}$ where $0.5 < p < 0.975$ (must be a probability not their z value) If the denominator is incorrect only follow through their $P(T > \mu - 10)$ if clearly labelled and > 0.95	
	A1	awrt 0.858	

Question Number	Scheme		Marks
8 (a)	$\frac{162 - \mu}{\sigma} = -1.2816$ (Calculator gives $-1.28155\dots$)		M1 A1 A1
	or $\frac{175 - \mu}{\sigma} = 1.04$ (Calculator gives $1.03987\dots$)		
	$\mu - 1.2816\sigma = 162$		
	$\mu + 1.04\sigma = 175$		
	$2.3216\sigma = 13$		dM1
	$\sigma = 5.5995\dots$ awrt 5.6 $\mu = 169.1764\dots$ awrt 169		A1
			(5)
(b)	$Q_1 = 208.26$ or $Q_3 - Q_1 = 13.48$		B1
	$221.74 + 1.5(221.74 - 'Q_1')[= 241.96]$ or $'Q_1' - 1.5(221.74 - 'Q_1')[= 188.04]$		M1
	Probability of an outlier	1 – Probability of not an outlier	
	$[P(B > '241.96') =]$	$[P('188.04' < B < '241.96') =]$ $P\left(\frac{'188.04' - 215}{10} < Z < \frac{'241.96' - 215}{10}\right)$ [$= P(-2.70) < Z < P(2.70)$]	dM1
	$P\left(Z > \frac{'241.96' - 215}{10}\right)[= P(Z > 2.70)]$		
	or $[P(B < '188.04') =]$		
	$P\left(Z < \frac{'188.04' - 215}{10}\right)[= P(Z < -2.70)]$		
	or $= 0.0035$ (Calculator gives $0.0034883\dots$)	$= 0.993$ (Calculator gives $0.99298\dots$)	
	$P(\text{Outlier}) = 2 \times '0.0035'$	$P(\text{Outlier}) = 1 - '0.993'$	M1
	$= 0.007$ (Calculator gives $0.006976\dots$) awrt 0.007	$= 0.007$ (Calculator gives $0.007017\dots$) awrt 0.007	A1
		(5)	
Notes			Total 10
(a)	M1	For standardising with μ and σ and setting $=$ to a z value with $ z > 1$	
	A1	For one correct equation in any form with correct z value as given or better	
	A1	For a 2 nd correct equation in any form allow 2dp or better for the z value	
	dM1	Dependent on previous M1. For solving their 2 linear simultaneous equations (Can be implied by both correct answers) If answers are incorrect then we need to see evidence of correct working	
	A1	For $\mu =$ awrt 169 and $\sigma =$ awrt 5.6	
(b)	B1	For $Q_1 = 208.26$ or $Q_3 - Q_1 = 13.48$ Do not accept rounded values	
	M1	For a correct method for finding 1 outlier limit, ft their Q_1 or their IQR. You will need to check that these are correct if no working shown.	
	dM1	Dependent on previous M1. For standardising using their limit(s), 215 and 10 (allow $\pm$) May be implied by $\pm$ awrt 2.70 or awrt 0.0035 or awrt 0.993 or final answer of awrt 0.007	
	M1	If using the LHS of the MS: for multiplying their probability by 2 or If using the RHS of the MS: for $1 -$ their probability May be implied by awrt 0.007	
	A1	awrt 0.007	

Question Number	Scheme	Marks												
4. (a)	$\frac{2}{5}$	B1 (1)												
(b)	$E(W) = 3$ $E(5 - 2W) = 5 - 2E(W)$ $E(X) = -1$	B1 M1 A1 (3)												
(c)	$P(X < W) = P(5 - 2W < W) = P(W > \frac{5}{3})$ or $P(W \geq 2)$ $= \frac{4}{5}$	M1 A1 (2)												
(d)(i)	<table border="1"><tr><td>[y]</td><td>1</td><td>$\frac{1}{2}$</td><td>$\frac{1}{3}$</td><td>$\frac{1}{4}$</td><td>$\frac{1}{5}$</td></tr><tr><td>[p]</td><td>$\frac{1}{5}$</td><td>$\frac{1}{5}$</td><td>$\frac{1}{5}$</td><td>$\frac{1}{5}$</td><td>$\frac{1}{5}$</td></tr></table>	[y]	1	$\frac{1}{2}$	$\frac{1}{3}$	$\frac{1}{4}$	$\frac{1}{5}$	[p]	$\frac{1}{5}$	$\frac{1}{5}$	$\frac{1}{5}$	$\frac{1}{5}$	$\frac{1}{5}$	B1
[y]	1	$\frac{1}{2}$	$\frac{1}{3}$	$\frac{1}{4}$	$\frac{1}{5}$									
[p]	$\frac{1}{5}$	$\frac{1}{5}$	$\frac{1}{5}$	$\frac{1}{5}$	$\frac{1}{5}$									
(ii)	$E(Y) = \frac{1}{5} \left(1 + \frac{1}{2} + \dots + \frac{1}{5} \right)$ or $\frac{1}{5} + \frac{1}{10} + \frac{1}{15} + \frac{1}{20} + \frac{1}{25} \left[= \frac{137}{300} = 0.4566... \right]$ $E(Y^2) = \frac{1}{5} \left(1^2 + \left(\frac{1}{2} \right)^2 + \dots + \left(\frac{1}{5} \right)^2 \right)$ or $\frac{1}{5} + \frac{1}{20} + \frac{1}{45} + \frac{1}{80} + \frac{1}{125} \left[= \frac{5269}{18000} = 0.2927... \right]$ $\text{Var}(Y) = '0.2927...' - ('0.4566...')^2$ awrt <u>0.0842</u>	M1 M1 M1 A1 (5)												
(e)	$\text{Var}(2 - 3Y) = (-3)^2 \text{Var}(Y)$ awrt <u>0.758</u>	M1 A1ft (2)												
Notes														
[13]														
(a)	B1 oe													
(b)	B1 sight of $E(W) = 3$ or the x values 3, 1, -1, -3, -5 (they may be added) M1 use of $E(5 - 2W) = 5 - 2E(W)$ or $\frac{1}{5}(3 + 1 + \dots + -5)$ Condone use of X instead of W A1 cao and labelled $E(X)$													
(c)	M1 for identifying $W > \frac{5}{3}$ or $W \geq 2$ eg $1 - P(W = 1) \geq 2$ or $1 - P(W \leq 1) \geq 2$ A1 oe													
(d)(i)	B1 Correct distribution (probabilities may be implied by correct use). May be seen in any part													
(ii)	M1 attempt at expression for $E(Y)$ using their values of y and p (at least 2 terms seen) or awrt 0.457 (0.45 if have 0.3 rather than 1/3) Condone incorrect labelling M1 attempt at expression for $E(Y^2)$ using their values of y and p (at least 2 terms seen) or awrt 0.293 (0.2885 if have 0.3 rather than 1/3) Condone incorrect labelling M1 For use of " $E(Y^2)$ " - " $(E(Y))^2$ " ft their values for $E(Y^2)$ and $E(Y)$ A1 awrt 0.0842 or $\frac{947}{11250}$													
(e)	M1 for use of $(-3)^2 \text{Var}(Y)$ with their $\text{Var}(Y) > 0$ condone $(3)^2 \text{Var}(Y)$ A1ft $\frac{947}{1250}$ or $9 \times$ "their part (d) > 0" evaluated correctly to 3sf or exact fraction													

Question Number	Scheme	Marks
5. (a)	$P(X < 37) = P\left(Z < \frac{37-40}{2.4}\right) = P(Z < -1.25)$ $= 1 - 0.8944 \quad ; = 0.105649... \quad \text{awrt } \underline{0.106}$	M1 M1; A1 (3)
(b)	$P(\text{one value is greater than } 32) = \sqrt{0.16} [=0.4]$ $\frac{32-m}{2.4} = 0.2533$ $m = 31.392... \quad \text{awrt } \underline{31.4}$	M1 M1 B1 A1 (4)
(c)	$P(Y < 0) = P\left(Z < \frac{0-4}{8}\right) = P(Z < -0.5) [=0.3085]$ Let X be the number of negative values $P(X \geq 1) = 1 - P(X = 0) \text{ oe}$ $= 1 - (0.6915)^5$ $= 0.84188... \quad \text{awrt } \underline{0.842}$	M1 M1 M1 A1 (4)
Notes		
(a)	1 st M1 standardising 37 (or 43) with 40 and 2.4 (allow $\pm$) 2 nd M1 for $1 - p$ (where $0.88 < p < 0.90$) Implied by correct answer. A1 for awrt 0.106 (calc. 0.105649.....)	
(b)	1 st M1 correct expression for one value > 32 (may be implied by sight of 0.2533... Allow any value between 0.25 and 0.26 inclusive) 2 nd M1 standardising 32 with m and 2.4 and setting equal to z value $0.2 < z < 0.3$ B1 for $z = \pm 0.2533$ or better (calc gives 0.2533470931.....) used in a linear equation for m A1 awrt 31.4 or better SC [using 0.16] Allow M0M1 B0 A0 for $\frac{32-m}{2.4} = z$ where $0.99 \leq z < 1.04$	
(c)	1 st M1 standardising 0 with 4 and 8 (allow $\pm$) or seeing 0.3085 or 0.6915 2 nd M1 realising they need to find $1 - P(X = 0)$ ie writing or using $1 - P(\text{no negative values})$ oe May be implied by $1 - p^5$ $0 < p < 1$ 3 rd M1 use of $1 - p^5$ where p is $1 - P\left(Z < \frac{0-4}{8}\right)$ A1 awrt 0.842 (tables: 0.8418894... calculator: 0.84193233....) NB If they use Binomial - and get 0.842 full marks. - and get 0.125 then award M1M1M0A0 - otherwise send to Review	

Question Number	Scheme		Marks
6(a)	$P(V > 104.9) = P\left(Z > \frac{104.9 - 100}{2.5}\right)$		M1
	$= 1 - 0.975$		M1
	$= 0.0250$	0.025 or awrt 0.0250	A1
			(3)
(b)	Expected number = $150 \times "0.025"$		M1
	$= 3.75$	awrt 3.75	A1
			(2)
(c)	$[P(V > v V < 104.9)] = \frac{[P(v < V < 104.9)]}{P(V < 104.9)} = 0.2801$		M1
	$P(v < V < 104.9) = (1 - "0.025") - P(V < v)$		M1
	$P(V < v) = (1 - "0.025") - (1 - "0.025") \times 0.2801 [=0.7019] \text{ oe}$		dM1
	$\frac{v - 100}{2.5} = 0.53$		M1A1
	$v = 101.325$	awrt 101.32 or awrt 101.33	A1
			(6)
Notes			Total 11
(a)	M1	Standardising with 104.9, 100 and 2.5 (allow $\pm$) implied by 1.96 seen	
	M1	For use of $1 - p$ with $0.9 < p < 1$ condone answer of 0.0249 for this mark	
	A1	Allow 0.025 or awrt 0.0250 (NB calculator answer is 0.02499....) (answer only scores M1M1A1)	
(b)	M1	For $150 \times$ "their part (a)"	
	A1	awrt 3.75 isw after answer of 3.75 seen. If 3.75 not seen, allow 4 if the method mark is awarded.	
(c)	M1	For writing or using a ratio of probabilities with denominator $P(V < 104.9)$ oe and equating to 0.2801 $\frac{P}{P(V < 104.9)} = 0.2801$ implied by awrt 0.273 Use of independence is M0 e.g. $\frac{x \times P(V < 104.9)}{P(V < 104.9)} = 0.2801$	
	M1	For writing or using $P(V > v \cap V < 104.9) = P(V < 104.9) - P(V < v) [= (1 - "0.025") - P(V < v)]$	
	ALT	For first two M marks $\frac{P(V < v)}{P(V < 104.9)} = 1 - 0.2801$ scores M1M1, then follow scheme.	
	dM1	(dep M1) Dependent on previous M1 for rearranging to find $P(V < v)$ Allow equivalent oe $(1 - "their(a)") (1 - 0.2801)$ NB: $[P(V < v) =]$ awrt 0.702 implies M1M1M1 or $[P(V > v) =]$ awrt 0.298 implies M1M1M1	
	M1	Standardising with 100, 2.5 and equating to a z-value, $\frac{v - 100}{2.5} = z$ $0.4 < z < 0.6$ Watch out for $\frac{v - 100}{2.5} =$ probability which is M0	
	A1	Correct equation with compatible signs	
	A1	awrt 101.33 (allow awrt 101.32 from use of calculator)	

Question Number	Scheme	Marks
5. (a)	$P(W > 70) = P\left(Z > \frac{70-80}{8} [= -1.25]\right)$ $= P(Z > -1.25) \text{ or } P(Z < 1.25)$ $= 0.8944$ awrt 0.894	M1 A1 A1 (3)
(b)	$P(W < k) = 0.85 \text{ or } P(W > k) = 0.15$ $\pm \left(\frac{k-80}{8}\right) = \underline{\underline{1.0364}}$ $k = 88.29\dots$ awrt 88.3	B1 M1 B1 A1 (4)
(c)	$P(W < 66) = P\left(Z < \frac{66-80}{8} [= -1.75]\right) [= 0.0401 \text{ (calc 0.040059...)}]$ $0.25 \times P(Z < -1.75) [= 0.010025 \text{ (calc 0.0100147...)}] \text{ or } 0.25 \times (1 - P(Z < 1.75))$ $\frac{y-80}{8} = \underline{\underline{-2.32(63)}}$ $y = 61.389\dots$ awrt 61.4	M1 dM1 M1 A1 A1 (5)
Notes		Total 12
(a)	M1 for standardising with 70, 80 and 8 (allow $\pm$) 1 st A1 $z = \pm 1.25$ 2 nd A1 awrt 0.894 (calc 0.894350...) NB do not ISW so an answer of 0.1056 is A0	
(b)	1 st B1 for either correct probability statement. Allow „ for < and ...for > (may be implied by $z = \text{awrt } 1.04$) M1 standardising with 80, 8 and equating to z , where $1 < z < 2$ 2 nd B1 $z = \pm 1.0364$ or better (calc 1.036432...) A1 awrt 88.3 (calc 88.291459...) NB awrt 88.3 implies 1 st B1 and M1 but not the 2 nd B1 they could get B1M1B0A1 (Answer only 88.291 to 88.292 scored 4 out of 4)	
(c)	1 st M1 standardising with 66, 80 and 8 (allow $\pm$) or seeing awrt 0.0401 in working 2 nd dM1 (dep on 1 st M1) $0.25 \times$ "their $P(Z < -1.75)$ " or $0.0401 - 0.030075$ or seeing $[0.75 \times 0.0401 + 0.9599 =] 0.9899\dots$ 3 rd M1 for standardising and equating to z , where $ z > 2$ 1 st A1 correct standardisation equation with compatible signs and 2.32 „ $ z $ „ 2.34 2 nd A1 awrt 61.4 (allow awrt 61.3)	

Question Number	Scheme	Marks
3. (a)	$[D = \text{distance achieved}] P(D > 4.3) = P\left(Z > \frac{4.3 - 3.8}{0.9}\right) \quad \text{or} \quad P(Z > 0.555\dots)$ $= 1 - 0.7123 \text{ (tables)}$ $= 0.2877 \text{ (tables) or } 0.289257\dots \text{ (calc) awrt } \underline{0.288} \text{ or awrt } \underline{0.289}$	M1 M1 A1 (3)
(b)	$\frac{d - 3.8}{0.9} = -0.8416 \quad (\text{calc } -0.84162123\dots)$ $d = 3.0425\dots$	M1 ; B1 A1 (3)
(c)	$P(D > g \mid D > 4.3) = \frac{P(D > g)}{P(D > 4.3)} \quad \text{or} \quad (a) \quad \left[= \frac{1}{3} \right] \quad (\text{o.e.})$ $\therefore P(D > g) = \frac{1}{3}(a) = 0.096419\dots$ $\frac{g - 3.8}{0.9} = 1.302228\dots$ so $g = 4.97200\dots$	M1 A1ft (o.e) dM1 A1 (4)
(d)	$P(\text{no gold medals}) = \left(\frac{2}{3}\right)^3$ $P(\text{at least one gold}) = 1 - \left(\frac{2}{3}\right)^3$ $= \underline{\underline{\frac{19}{27}}}$	M1 M1 A1 (3)
[13]		
Notes		
(a)	1 st M1 for standardising 4.3 with 3.8 and 0.9 (allow $\pm$) 2 nd M1 for $1 - p$ (where $0.7 < p < 0.8$) A1 for awrt 0.288 or 0.289 (calc. 0.289257) (correct answer only 3/3)	
(b)	M1 for standardising with d , 3.8 and 0.9 and setting equal to a z value $0.8 < z < 0.9$ B1 for $z = \pm 0.8416$ or better used A1 for awrt 3.04 (condone $d \geq \dots$) For awrt 3.0425 or 3.0426 score 3/3 For awrt 3.04 score M1B0A1	
Ans only		
(c)	1 st M1 for either expression for the conditional prob. [or sight of $\frac{1}{3}(a)$] (ft their answer to (a) to 2 sf) 1 st A1ft for $P(D > g) = 0.096$ or better (0.289 gives 0.09633... calc 0.096419...) The $P(D > g)$ may be clearly shown on a diagram. 1 st M1A1 can be awarded for $P(D > g) = \frac{1}{3}(a)$ or for $P(D < g) = 1 - \frac{1}{3}(a)$ [ft their (a) to 2 sf] 2 nd dM1 (dep on 1 st M1) for standardising with g , 3.8 and 0.9 and put equal to a z value where $ z > 1$ 2 nd A1 for awrt 4.97 or 4.98 (Correct answer with no incorrect working seen 4/4) (condone $g \geq \dots$)	
SC	(Medals v Certificates) 1 st B1 for $[P(D > g) =] \frac{1}{3} \times 0.8 = \frac{4}{15}$ or 0.267 (score as 1 st M0 1 st A1) 2 nd B1 for $g = \text{awrt } 4.36$ (4.358 tables, 4.3606..calc) (score as 2 nd M0 2 nd A1)	
(d)	1 st M1 for a correct probability of no gold medals or 2 of: $3\left(\frac{2}{3}\right)^2 \times \frac{1}{3}$ or $3\left(\frac{1}{3}\right)^2 \times \frac{2}{3}$ or $\left(\frac{1}{3}\right)^3$ 2 nd M1 for $1 - p^3$ or $3(p)^2(1-p) + 3p(1-p)^2 + (1-p)^3$ where $0 < p < 1$ A1 for $\frac{19}{27}$ (or exact equivalent) only e.g. $0.\dot{7}0\dot{3}$	

Question Number	Scheme	Marks
3. (a)	[W = weight of a package delivered to factory $W \sim N(18, 5.4^2)$] $P(W < 18) = P\left(Z < \frac{10-18}{5.4}\right)$ <u>or</u> $P(Z < -1.481\dots)$ $= 1 - 0.9306$ (calc: 0.069239...) $= 0.0694$ [0.0692, 0.0694]	M1 M1 A1 (3)
(b)	[$P(W > j) = 0.15$ implies] $\frac{j-18}{5.4} = 1.0364$ $j = 23.596\dots$ awrt 23.6	M1B1 A1 (3)
(c)	[$P(W > 18 \mid W < "23.59\dots") = \frac{P(18 < W < "23.6")}{P(W < "23.6")}$ $= \frac{0.5 - 0.15}{0.85}$ <u>or</u> $\frac{0.85 - 0.5}{0.85}; = \frac{0.35}{0.85}$ $= \frac{35}{85} = \frac{7}{17}$ or allow awrt 0.412	M1 M1;A1 A1 (4)
(d)	$0.85^2 \times 0.15^2 \times 6$ $= 0.0975375$ awrt 0.0975	M1dM1 A1 (3)
[13 marks]		
Notes		
(a)	1st M1 for standardising 10 with 18 and 5.4 (allow $\pm$) 2nd M1 for $1 - p$ (where $0.91 < p < 0.95$) A1 for answer in the range $0.0692 \leq \text{ans} \leq 0.0694$ (calc. 0.069239...) Ans only 3/3	
(b)	M1 for standardising their letter j with 18 and 5.4 and setting equal to z value $1 < z < 2$ Condone use of 10 instead of 18 for the M1 mark B1 for use of $z = \pm 1.0364$ or better (calc 1.03643338...) A1 for awrt 23.6 (calc 23.596740...) Ans only [awrt 23.60 scores 3/3 23.6 scores M1B0A1 unless 1.0364 or better is seen]	
(c)	1st M1 for a correct ratio of probability expressions ft their answer to (b) i.e. their j either the letter or their value provided > 18 May be implied by 2nd M1 2nd M1 for a ratio of probs of the form $\frac{q}{0.85}$ where $0.15 < q < 0.5$ Allow recalculation of 0.85 provided awrt 0.85 1st A1 for a correct ratio i.e. using $q = 0.35$ 2nd A1 for $\frac{7}{17}$ or exact equivalent or allow awrt 0.412 (0.4117647...)	
(d)	1st M1 for $p^2 \times (1-p)^2 \times k$ for any positive integer k (allow $k = 1$) and any probability p 2nd dM1 dep on 1st M1 for $k = 6$ <u>or</u> $3!$ <u>or</u> 3×2 <u>or</u> $4C2$ A1 for awrt 0.0975 NB allow exact fraction $\frac{7803}{80000}$ Ans only 3/3	

Question Number	Scheme	Marks
4. (a)	$P(W < 120) = P\left(Z < \frac{120-165}{35}\right)$ $= P(Z < -1.2857...) = 1 - 0.9015 \text{ or } 1 - 0.9007285...$ $= 0.09927... = \text{awrt } \underline{0.0985\sim0.0994}$	M1 M1 A1 (3)
(b)	e.g. $P(W > x) = \frac{1}{3}$ gives $\frac{x-165}{35} = \pm 0.43$ (calculator 0.430727...) Limits 149.9245... to 180.0754... awrt <u>150</u> to <u>180</u>	M1B1 A1, A1 (4)
(c)	$P(W < 200 \mid W > "180") \text{ or } \frac{P("180" < W < 200)}{P(W > "180") \text{ or } \frac{1}{3}}$ $= \frac{0.8413(44739...) - \frac{2}{3}}{\frac{1}{3}}$ $= 0.52403... \text{ } \underline{(0.523\sim0.5264)}$	M1 A1 (num) A1 (3)
(d)	$\frac{1}{3} \times \frac{1}{3} \times \frac{1}{3} \times 3!$ $= \underline{\frac{2}{9}}$	M1;M1 A1 (3)
[13 marks]		
Notes		
(a)	1 st M1 for standardising with 120 (allow 210), 165 and 35. Accept $\pm$ 2 nd M1 for attempting $1 - p$ [where $0.85 < p < 0.95$] A1 for awrt 0.0985~0.0994 (Correct ans only 3/3)	
(b)	M1 for standardising with x (o.e.) 165 and 35 and setting equal to a z value, $0.4 < z < 0.5$ (Accept $\frac{165-x}{35} = \pm z$ where $0.4 < z < 0.5$) B1 for use of $z = 0.43$ or better We must see 0.43 or better. 1 st A1 for lower limit of awrt 150 2 nd A1 for upper limit of awrt 180 SC A0A1 for two limits symmetrically placed about 165 provided M1 scored NB: correct answers with no working can score M1B0A1A1	
(c)	M1 for a correct probability statement (either form) ft their 180 or a correct ratio 1 st A1 for a correct numerator (awrt 0.175) 2 nd A1 for an answer in the range awrt 0.523~0.5264 (use of 180 gives 0.5263869...)	
(d)	1 st M1 for $\left(\frac{1}{3}\right)^3$ (or equivalent) 2 nd M1 for $p \times 3!$ (or equivalent) where $0 < p < \frac{1}{6}$ A1 for $\frac{2}{9}$ or any exact equivalent	

Question Number	Scheme		Marks
5(a)(i)	$P(S > 640) = P\left(Z > \frac{640 - 700}{50}\right)$		M1
	awrt 0.885		A1 (2)
(ii)	$675 < S < 725$		M1
	$P(675 < S < 725) = P(S < 725) - P(S < 675)$ or use of symmetry to find correct area		M1
	$P(S < 725) = P\left(Z < \frac{725 - 700}{50}\right)$ or $P(S < 675) = P\left(Z < \frac{675 - 700}{50}\right)$		M1
	$P(-0.5 < Z < 0.5) = 0.6915 - (1 - 0.6915)$ or $1 - 2 \times 0.3085$ or $2 \times (0.6915 - 0.5)$		A1
	$= 0.383$		awrt 0.383 A1
			(5)
(b)(i)	$\frac{680 - \mu}{\sigma} = 1.5$ $\frac{599 - \mu}{\sigma} = -0.5244$		M1A1 A1
			(3)
(ii)	$(680 - \mu) - (599 - \mu) = 1.5\sigma - (-0.5244)\sigma$		M1
	$(81 = 2.0244\sigma)$		
	$\sigma = 40.01185$ $\mu = 619.98...$ awrt 40 (to 2sf) awrt 620 (to 3sf)		A1A1
			(3)
			Total 13
(a)(i)	M1	Attempt to standardise with 640, 700 and 50 allow $\pm$ (not implied by ± 1.2 on its own)	
	A1	awrt 0.885 (calc gives 0.884930...) answer only is M0A0 must see standardisation do not isw if $1 - 0.8849$ is then found	
(ii)	M1	Sight of 675 or 725	
	M1	Use of $P(675 < S < g) = P(S < g) - P(S < 675)$ where $724 \leq g \leq 725$ or correct use of symmetry eg $P(675 < S < 725) = 2(P(S < 725) - 0.5)$ or eg $P(675 < S < 725) = 1 - 2P(S < 675)$	
	M1	One correct standardisation seen of 675 or g with 700 and 50 where $724 \leq g \leq 725$ Allow for just ± 0.5 or seen as a z-value (not a probability)	
	A1	(dep on 3 rd M1) sight of awrt 0.69 or awrt 0.31	
	A1	(dep on 3 rd M1) awrt 0.383	
	SC Use of 650 and 750	Use of 650 and 750 scores a maximum of 4 out of 5 [Must be 650 and 750 to apply SC] M0 M1 Use of $P(650 < S < 750) = P(S < 750) - P(S < 650)$ or use of symmetry to find correct area M1 standardising 650 or 750 with 700 and 50 or just ± 1 seen as a z-value (not a probability) A1 (dep on 3 rd M1) sight of awrt 0.84 or awrt 0.16 A1 (dep on 3 rd M1) awrt 0.683	
		Mark parts (b)(i) and (b)(ii) together	
(b)(i)	M1	$\pm \frac{680 - \mu}{\sigma} = z$ with $1 < z < 2$ or $\pm \frac{599 - \mu}{\sigma} = z$ with $0.5 < z < 0.6$	
	A1	1 correct equation with $z = 1.5$ or better (calc gives 1.5000556...) or $z = -0.5244$ or better (calc gives -0.5244004...)	
	A1	Both equations correct require both 1.5 or better and -0.5244 or better	
(ii)	M1	Attempt to eliminate μ or σ from the 2 equations (implied by awrt $\mu = 620$ and awrt $\sigma = 40$)	
	A1	awrt $\mu = 620$ (3sf) or awrt $\sigma = 40$ (2sf)	
	A1	awrt $\mu = 620$ (3sf) and awrt $\sigma = 40$ (2sf)	

Qu	Scheme	Marks
7(a)(i)	$P(J > 510) = P\left(Z > \frac{510 - 500}{25}\right)$ or $P(Z > 0.4)$	M1
	$= 1 - 0.6554 \Rightarrow 0.3446 *$	A1*
		(2)
(ii)	$\frac{d - 500}{25} = -1.4$ (calc -1.3997...)	M1B1
	$d = 465$ (calc 465.007)	dA1
		(3)
(b)	$(1 - 0.3446)^5$	M1
	$= 0.1209...$ awrt 0.121	A1
		(2)
(c)	$\frac{r - 520}{k} = -1.0364$	M1A1
	$\frac{3r - 800 - 520}{k} = 2.5758$	M1A1
	$-240 = (3 \times -1.0364k) - 2.5758k$ or $\frac{r - 520}{-1.0364} = \frac{3r - 1320}{2.5758}$ oe	ddM1
	$k = 42.216...$ awrt 42	A1
	$r = 476.246...$ awrt 476	dA1
		(7)
	Notes	Total 14
(a)(i)	M1 for standardising using 500 and 25. Allow for 0.4	
	A1* M1 must be awarded. For $1 - 0.6554 = 0.3446$ or using calc $0.34457... = 0.3446$ or better	
(ii)	M1 correct standardisation using 500 and 25 equated to a z value where $1 < z < 2$	
	B1 correct expression with compatible signs eg $\frac{500 - d}{25} = 1.4$ (calc 1.3997...) or allow incompatible signs with $500 - ("535" - 500)$	
	SC $\frac{510 - d}{25} = 1.4$ (calc 1.3997...) can get M0B1A0	
	dA1 dependent on M1 awarded for 465 or 465.007...	
(b)	M1 for $(p)^5$ where $0 < p < 1$	
	A1 awrt 0.121	
(c)	M1 $\frac{r - 520}{k} = z$ value where $ z > 1$	
	1 st A1 $\frac{r - 520}{k} = \text{awrt } -1.0364$ (calc 1.036433...) (signs must be compatible)	
	2 nd M1 $\frac{3r - 800 - 520}{k} = z$ value where $ z > 2$	
	2 nd A1 $\frac{3r - 800 - 520}{k} = \text{awrt } 2.5758$ (calc 2.5758293...) (signs must be compatible)	
	3 rd M1 (dep on both Ms) for forming a correct equation in k or r only using their z values . ISW once correct equation seen eg $-5.685k = -240$ or $\frac{3(-1.0364k + 520) - 800 - 520}{k} = 2.5758$ Implied by r and k correct	
	3 rd A1 for awrt 42	
	4 th A1 for awrt 476 Must come from equations with compatible signs	
	NB awrt 476 and awrt 42 does not mean full marks. They could get M1A0M1A0 M1A1A1 if they do not have accurate z values	

Question	Scheme	
6(a)(i)	$P(X > 508) = P\left(Z > \frac{508-502}{3} [=2]\right)$	M1
	$= 0.0228$ awrt 0.0228	A1
		(2)
(ii)	$P(496 < X < 508) = 1 - 2 \times "0.0228" \text{ or } "0.9772" - (1 - "0.9772")$	M1
	$= 0.9544$ awrt 0.954	A1ft
		(2)
(b)	$"0.0228" \times (1 - "0.0228")^2 \times 6$	M1 dM1
	$= 0.002978... \text{ (calc gives } 0.002965...)$ awrt 0.00297 or awrt 0.00298	A1
		(3)
(c)	$\frac{1038.51-1024}{\sigma} = 1.0364$	M1
	$\sigma = \frac{1038.51-1024}{1.0364} = 14.000.. \text{ (calc } 13.999...)^*$	A1*
		(2)
(d)(i)	$\pm\left(\frac{k-502}{3}\right) \quad \text{and} \quad \pm\left(\frac{1024-2k}{14}\right)$	M1
	$\frac{k-502}{3} = \frac{1024-2k}{14} \text{ oe e.g. } 14k - 7028 = 3072 - 6k$	M1
	$k = 505$	A1
(ii)	$P(X > 505) = P\left(Z > \frac{"505"-502}{3} [=1]\right)$	M1
	$= 0.1587$ awrt 0.159	A1
		(5)
Notes		Total 14
(a)(i)	M1 for standardising with 508, 502 and 3 allow $\pm$	
	A1 awrt 0.0228 (dependent on M1 scored for standardising). Answer must be in part (a)(i).	
(ii)	M1 ft their 0.0228	
	A1ft awrt 0.954 or from calculator 0.954499... so allow 0.9545 Correct answer scores 2 out of 2. ft their part (a) i.e. $1 - 2 \times \text{"their (a)"}$ provided $0 < \text{"their (a)"}$ < 0.5	
(b)	M1 For an expression in the form $p^2 \times (1-p)^2 \times A$ where A is an integer, $A \dots 1$ and p is a probability	
	Allow A written in alternative forms eg ${}^4C_2$	
	M1 dep on first M1 for $A=6$ oe	
	A1 awrt 0.00297 or awrt 0.00298 (allow in standard form). Correct answer scores 3 out of 3.	
(c)	M1 an equation in the form $\frac{1038.51-1024}{\sigma} = z$ or $\frac{14.51}{\sigma} = z$ with 1.03,, z ,, 1.04	
	A1* for a correct expression for σ with $z = 1.0364$ or better (calc 1.036433...) seen and awrt 14	
(d)(i)	M1 for both standardisations seen or used in an equation Allow use of their 14 from part (c)	
	M1 Correct equation with compatible signs - need not be simplified Allow use of their 14 from part(c)	
	A1 505 (allow awrt 505 coming from "their 14" used).	
(ii)	M1 for standardising with "505", 502 and 3 or with "1010", 1024 and 14 allow $\pm$, ft their value of k may be implied by a correct answer	
	A1 awrt 0.159 Correct answer scores M1A1 in (d)(ii)	



Question Number	Scheme	Marks
6. (a)	$H \sim N(25.1, 5.5^2)$ $P(H > 30.8) = P\left(Z > \frac{30.8 - 25.1}{5.5}\right)$ or $P(Z > 1.03636\dots)$ $= 1 - 0.8508$ $= 0.1492$ or better (calc: 0.1500...)	M1 M1 A1cso (3)
(b)	$[P(H < y) = 0.05 \text{ implies}] \quad \frac{y - 25.1}{5.5} = -1.6449$ $y = 16.053\dots$ so range is awrt 16.1 ~ 30.8	M1B1 A1 (3)
(c)(i)	$P(H < d) = 0.05 + 0.2 + 0.3 [= 0.55]$ $\frac{d - 25.1}{5.5} = 0.13$ (Calc 0.12566) $d = 0.13 \times 5.5 + 25.1 = 25.815$ (25.791... calc)	M1 M1 A1cso (3)
(ii)	$P(H < m) = 0.05 + 0.2 [= 0.25]$ $\frac{m - 25.1}{5.5} = -0.67$ (Calc 0.674489) $m = \text{awrt } \mathbf{21.4}$	M1 M1M1 A1 (4)
(d)	Height = $2 \times "m" + 3 \times 25.8 + 3 \times 30.8$ [+8] $= 220.6$ awrt 221 (cm)	M1 A1 (2)
[15]		
Notes		
(a)	1 st M1 for standardising 30.8 with 25.1 and 5.5 (allow $\pm$) Allow use of $z = 1.04$ 2 nd M1 for $1 - p$ (where $0.84 < p < 0.86$) A1cso for an answer of 0.1492... or better (calc: 0.1500...) with evidence of both M's seen	
(b)	M1 for standardising their letter y with 25.1 and 5.5 and setting equal to z value $1 < z < 2$ B1 for use of $z = \pm 1.6449$ or better (calc 1.6448536...) with the correct standardisation. A1 for awrt 16.1 (ISW)(calc 16.053305...) or range [16.1, 30.8](Allow $30.8 - 16.1 = 14.7$ [5]) [awrt 16.05 scores 3/3 16.1 scores M1B0A1 unless 1.6449 or better is seen]	
Ans only		
(c)(i)	1 st M1 for a correct method to calculate $P(H < d)$ implied by $z = \text{awrt } 0.13$ Allow $0.05 + \text{awrt } 0.200 + \text{awrt } 0.300 [= 0.5505]$ 2 nd M1 for a correct standardisation $= z$ where $0.125 \leq z \leq 0.13$ A1cso both method marks awarded, no errors seen and awrt 25.82 or awrt 25.79 or $d = \text{awrt } 0.13 \times 5.5 + 25.1 = \text{awrt } 25.8$	
ALT	Verification 2 nd M1 allow $\frac{25.8 - 25.1}{5.5} = 0.127\dots$ or 0.13 A1 for 0.55 and 0.5517 (calc 0.5506 or better) seen	
(ii)	1 st M1 correct method for $P(H < m)$ Allow $0.05 + \text{awrt } 0.200$ implied by $ z = [0.67 - 0.68]$ 2 nd M1 for standardising m with 25.1 and 5.5 and setting equal to z value $(0.65 \leq z \leq 0.69)$ 3 rd M1 for standardising m with 25.1 and 5.5 and setting equal to awrt -0.67 oe A1 for $m = \text{awrt } 21.4$ (use of $z = 0.67$ gives 21.415... and $z = 0.68$ gives 21.36...)	
	No need for 3 rd M1 to be awarded Answer only 21.4 gets M1M1M0A1. 21.39 gets 4/4	
(d)	M1 for $2 \times "m" + 3 \times 25.8 + 3 \times 30.8$ [+ n] where n is an integer $\square 0$ Allow m or ft their m A1 for awrt 221 (cm)	

Question Number	Scheme	Marks
ALT 1 (c)(i)	e.g. $P(H > 25.8 \mid "16.1" < H < 30.8)$ or $\frac{P(25.8 < H < 30.8)}{1 - (0.15 + 0.05)}$ $= \frac{0.8508 - 0.5517}{0.8}$ (tables) or $\frac{0.299345...}{0.8}$ (calc) $\approx \frac{3}{8}$	M1 M1 A1 cso (3)
Notes		
(c)(i)	1 st M1 for a correct conditional probability statement ft their answer to (b) i.e. their y 2 nd M1 for a ratio of probs of the form $\frac{q}{0.8}$ where $q = 0.3$ to 1sf A1 for probability of approx $\frac{3}{8}$	

Question Number	Scheme		Marks
5 (a)	$X \sim N(210, 25^2)$		
	$P(X < 240) = P\left(Z < \frac{240 - 210}{25}\right) [= P(Z < 1.2)]$		M1
	$= 0.8849^*$		A1*
			(2)
(b)	$P(190 < X < 240) = 0.8849 - P\left(Z < \frac{190 - 210}{25}\right) [= 0.8849 - P(Z < -0.8)]$		M1
	$0.8849 - 0.2119 = 0.673$		awrt
	0.673		A1
			(2)
(c)	$\frac{210 + k - 210}{25} = 1.96$ or $\frac{210 - k - 210}{25} = -1.96$		M1 B1
	$k = 49$		awrt 49
			A1
			(3)
(d)	$P(X < S) = 0.15 \Rightarrow \frac{S - 210}{25} = -1.0364$		M1 B1
	$S = 184.09$		awrt 184
			A1
			(3)
(e)	$Y \sim N(\mu, \sigma^2)$		
	$P(Y < 152) = 0.05 \Rightarrow \frac{152 - \mu}{\sigma} = -1.6449$		M1 A1
	$P(Y > 180) = 0.40 \Rightarrow \frac{180 - \mu}{\sigma} = 0.2533$		A1
	$28 = 1.8982\sigma$		dM1
	$\sigma = 14.75... \quad \text{and} \quad \mu = 176.26...$		A1
			(5)
	Notes		Total 15
(a)	M1	For standardising using 240, 210 and 25	
	A1*	Cao As the answer is given then no incorrect working should be seen	
(b)	M1	For standardising using 190/230, 210 and 25 and subtracting from 0.8849 May be implied by $\Phi(1.2) + \Phi(0.8) - 1$ or $0.8849 + 0.7881 - 1$	
	A1	awrt 0.673	
(c)	M1	For standardising and setting equal to a z value, where $1.9 < z < 2$	
	B1	For $ z = 1.96$ or better	
	A1	awrt 49	
(d)	M1	For standardising using S (allow any letter) and setting equal to a z value, where $1 < z < 1.1$	
	B1	For $z = -1.0364$	
	A1	awrt 184	
(e)	M1	For a correct method to form an equation in μ and σ set equal to a z value, where $-1.6 < z < -1.7$ or $0.2 < z < 0.3$ (Signs must be compatible)	
	A1	For a correct equation for $P(Y < 152)$	
	A1	For a correct equation for $P(Y > 180)$	
	dM1	Dependent on previous M mark. For solving the 2 equations simultaneously. If answers are incorrect then working must be shown. May be implied by $\sigma =$ awrt 14.8 and $\mu =$ awrt 176	
	A1	For $\sigma =$ awrt 14.8 and $\mu =$ awrt 176	

Question	Scheme		Marks
4 (i)(a)	$p + q = \frac{7}{25}$ oe $q + r = \frac{1}{5}$ oe $p + r = \frac{8}{25}$ oe		M1 M1 M1
	$2p + 2q + 2r = \frac{7}{25} + \frac{1}{5} + \frac{8}{25} \left[= \frac{4}{5} \right]^*$		A1* (4)
(i)(b)	eg $p + q + r + s = 1$		M1
	$p = \frac{1}{5}$ oe $q = \frac{2}{25}$ oe $r = \frac{3}{25}$ oe $s = \frac{3}{5}$ oe		A1 A1 A1 A1
			(5)
(ii)	$\frac{x}{x+5} + \frac{5}{x} = \frac{x^2 + 5(x+5)}{x(x+5)}$ or $\frac{x}{x+5} + \frac{5}{x} = \frac{x+5-5}{x+5} + \frac{5}{x}$		M1
	$= \frac{x^2 + 5x + 25}{x^2 + 5x}$ oe or $= 1 - \frac{5}{x+5} + \frac{5}{x}$		M1
	$= 1 + \frac{25}{x^2 + 5x}$ or as $x^2 + 5x + 25 > x^2 + 5x$ $P(C) + P(D) > 1$ or As $x + 5 > x$ then		A1
	$\frac{5}{x+5} < \frac{5}{x} \Rightarrow -\frac{5}{x+5} + \frac{5}{x} > 0$ So $P(C) + P(D) > 1$		
	$P(C \cup D) > 1$ or $P(C \cap D) > 0$		A1 cso
			(4)
Notes			Total 13
NB In (i) Allow the use of exact decimals throughout and mark (a) and (b) together			
(i)(a)	M1	for $p + q = \frac{7}{25}$ oe or $p + q = P(A)$	
	M1	for $q + r = \frac{1}{5}$ oe or $q + r = P(B)$	
	M1	for $p + r = \frac{8}{25}$ oe or $p + r = P[(A \cap B') \cup (A' \cap B)]$	
	A1*	we must see $2p + 2q + 2r = \frac{7}{25} + \frac{1}{5} + \frac{8}{25}$ and no errors	
(i)(b)	M1	any correct equation involving at least two of p, q, r and s . May be implied by two correct values. Do not allow just $2p + 2q + 2r = \frac{4}{5}$ This mark may be awarded in part (a)	
	A1	for $\frac{1}{5}$ or 0.2 oe This mark may be awarded in part (a)	
	A1	for $\frac{2}{25}$ or 0.08 oe This mark may be awarded in part (a)	
	A1	for $\frac{3}{25}$ or 0.12 oe This mark may be awarded in part (a)	
	A1	for $\frac{3}{5}$ oe This mark may be awarded in part (a)	
	SC	for one correct value M0 A1 A0 A0 A0	
(ii)	M1	For an attempt to add $P(C)$ and $P(D)$ e.g. $\frac{x^2}{x(x+5)} + \frac{5(x+5)}{x(x+5)}$ May be implied by $\frac{x^2 + 5x + 25}{x^2 + 5x}$ or $1 - \frac{5}{x+5} + \frac{5}{x}$	
	M1	For $\frac{x^2 + 5x + 25}{x^2 + 5x}$ oe or $1 - \frac{5}{x+5} + \frac{5}{x}$	
	A1	for recognising that $P(C) + P(D)$ is > 1	
	A1 cso	a fully correct solution showing that C and D cannot be mutually exclusive	

Question	Scheme		Marks
5 (a)	$P(L < 3.86) = P\left(Z < \pm \frac{3.86 - 4.5}{0.4}\right)$		M1
	$= P(Z < -1.6) = 1 - 0.9452 \quad \text{or} \quad 1 - 0.945200\dots = 0.0548 \quad \text{awrt } 0.0548$		M1 A1 (3)
(b)(i)	$P(L < Q_3) = 0.75 \text{ gives } \frac{Q_3 - 4.5}{0.4} = 0.67 \text{ or } P(L < Q_1) = 0.25 \text{ gives } \frac{Q_1 - 4.5}{0.4} = -0.67$		M1 B1
	$[Q_3 =]4.768 \quad \text{awrt } 4.77 \quad \text{or} \quad Q_1 = 4.232 \quad \text{awrt } 4.23$		A1
(ii)	$[Q_1 =]'4.232' \quad \text{awrt } 4.23 \quad \text{or} \quad [Q_3 =]'4.768' \quad \text{awrt } 4.77$		B1 ft (4)
(c)	$1.5('Q_3' - 'Q_1')[= 0.804] \quad (0.81)$		M1
	Lower limit = 3.428 (3.42 – 3.43) Upper limit = 5.572 (5.57 – 5.58)		A1 A1 (3)
(d)	$P('3.42' < L < '5.58') = P\left(\frac{'3.42' - 4.5}{0.4} < Z < \frac{'5.58' - 4.5}{0.4}\right)$ $= [P(-2.7 < Z < 2.7)] = 0.9930^*$ (Calculator gives 0.99306...)		M1 A1ft A1* (3)
	$P(5 < L < '5.58') = P\left(\frac{5 - 4.5}{0.4} < Z < \frac{'5.58' - 4.5}{0.4}\right) = 0.1021$ (Calculator gives 0.10218...) $P(L > 5 '3.42' < L < '5.58') = \frac{P(5 < L < '5.58')}{P('3.42' < L < '5.58')} \left[= \frac{'0.102'}{0.993} \right]$ $= 0.1027 \quad \text{awrt } 0.103$		M1 A1 M1 (4)
Notes			Total 17
(a)	M1	for standardising with 3.86, 4.5 and 0.4	
	M1	for $1 - p$ where $0.5 < p < 1$	
	A1	for awrt 0.0548 (NB awrt 0.0548 scores 3/3)	
(b)(i)	M1	for standardising with Q_3 or Q_1 (o.e.), 4.5 and 0.4 and setting equal to a z value, $0.65 < z < 0.7$	
	B1	for use of 0.67,, $ z $,, 0.675 This may be implied by a final answer of 4.769... or 4.2302...	
	A1	awrt 4.77 or awrt 4.23 for Q_1 correctly labelled NB it is possible to score M1B0A1	
(b)(ii)	B1ft	awrt 4.23 if Q_3 given in (i) or awrt 4.77 if Q_1 given in (i) ft their part (b)(i) You will need to check whether $Q_1 + Q_3 = 9$	
(c)	M1	use of $1.5(Q_3 - Q_1)$ ft their Q_3 and Q_1 If these are not correct then working must be shown	
	A1	for lower limit awrt 3.42 to 3.43	
	A1	for upper limit awrt 5.57 to 5.58	
(d)	M1	for a correct standardisation for either their 3.42 or their 5.58 May be implied by awrt -2.7 or awrt 2.7 If lower/upper limits are incorrect then the standardisation must be shown	
	A1ft	for a correct standardisation for their 3.42 and their 5.58 May be implied by awrt -2.7 and awrt 2.7 If lower/upper limits are incorrect then the standardisation must be shown or clear use of symmetry e.g. $(0.9965 - 0.5) \times 2$ Do not allow use of negative limits	
	A1*	answer is given so there must be a fully correct solution given with no errors Allow 0.9930... or better or $0.9965 - 0.0035$ oe or $1 - 0.0035 - 0.0035$ oe	
(e)	M1	for writing or using $P(5 < L < '5.58')$ Maybe implied by awrt 0.102	
	A1	awrt 0.102	
	M1	for a correct probability statement in either form or a correct ratio ft their lower and upper limits Allow $\frac{P(5 < L < '5.58')}{0.993}$	
	A1	awrt 0.103	