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EDEXCEL INTERNATIONAL A LEVEL MATHS: QUESTIONS BY TOPIC

Populations & Sampling (S2.4)

International A Level Mathematics · S2: Statistics 2 (WST02)

16 questions · 155 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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4. Q6	IAL S2 (WST02) January 2024	9	11
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QUESTIONS

16 questions · 155 marks · 1 sub-topic

SUB-TOPIC S2.4a

POPULATIONS, SAMPLES & SAMPLING DISTRIBUTIONS

Sub-topic S2.4a · 16 questions · 155 marks · lowest tariff first



Question 2 continued

(Total for Question 2 is 4 marks)



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5. A bag contains a large number of counters.

40% of the counters are numbered 1

35% of the counters are numbered 2

25% of the counters are numbered 3

In a game Alif draws two counters at random from the bag. His score is 4 times the number on the first counter minus 2 times the number on the second counter.

- (a) Show that Alif gets a score of 8 with probability 0.0875 (1)
- (b) Find the sampling distribution of Alif's score. (5)
- (c) Calculate Alif's expected score. (2)

Question 5 continued

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Lined area for writing the answer to Question 5.

(Total 8 marks)

Q5

Marking box for Q5.







Question 6 continued

Lined area for writing the answer to Question 6.

(Total for Question 6 is 9 marks)



Question 6 continued



Question 6 continued

Question 6 continued

(Total for Question 6 is 9 marks)



Question 4 continued



Question 4 continued

Lined area for writing the answer to Question 4 continued.



Question 4 continued

Lined area for writing the answer to Question 4.

(Total for Question 4 is 9 marks)



Question 6 continued

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Question 6 continued

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Q6

(Total 10 marks)

TOTAL FOR PAPER: 75 MARKS

END



4. A bag contains a large number of balls, each with one of the numbers 1, 2 or 5 written on it in the ratio 2:3:4 respectively.

A random sample of 3 balls is taken from the bag.

The random variable B represents the range of the numbers written on the balls in the sample.

- (i) Find $P(B = 4)$
- (ii) Find the sampling distribution of B .

(10)

Question 4 continued



Question 4 continued

Lined area for writing the answer to Question 4 continued.



Question 4 continued

(Total for Question 4 is 10 marks)



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- 6 (a) Explain what you understand by the sampling distribution of a statistic.

(1)

At Sam's cafe a standard breakfast consists of 6 breakfast items. Customers can then choose to upgrade to a medium breakfast by adding 1 extra breakfast item or they can upgrade to a large breakfast by adding 2 extra breakfast items. Standard, medium and large breakfasts are sold in the ratio 6:3:2 respectively.

A random sample of 2 customers is taken from customers who have bought a breakfast from Sam's cafe on a particular day.

- (b) Find the sampling distribution for the total number, T , of breakfast items bought by these 2 customers. Show your working clearly.

(7)

- (c) Find $E(T)$

(2)

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Question 6 continued

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Question 6 continued

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(Total 10 marks)

Q6



5. The number of particles per millilitre in a solution is modelled by a Poisson distribution with mean 0.15

A randomly selected 50 millilitre sample of the solution is taken.

- (a) Find the probability that

- (i) exactly 10 particles are found,
- (ii) between 6 and 11 particles (inclusive) are found.

(4)

Petra takes 12 independent samples of m millilitres of the solution.

The probability that at least 2 of these samples contain no particles is 0.1184

- (b) Using the Statistical Tables provided, find the value of m

(6)

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 continued.



Question 5 continued

(Total for Question 5 is 10 marks)



4. A manufacturer makes t-shirts in 3 sizes, small, medium and large.

20% of the t-shirts made by the manufacturer are small and sell for £10

30% of the t-shirts made by the manufacturer are medium and sell for £12

The rest of the t-shirts made by the manufacturer are large and sell for £15

- (a) Find the mean value of the t-shirts made by the manufacturer.

(2)

A random sample of 3 t-shirts made by the manufacturer is taken.

- (b) List all the possible combinations of the individual selling prices of these 3 t-shirts.

(2)

- (c) Find the sampling distribution of the **median** selling price of these 3 t-shirts.

(6)







(Total for Question 4 is 10 marks)

- 4 A bag contains 50 counters, each with one of the numbers 4, 7 or 10 written on it in the ratio 2:3:5 respectively.

A random sample of 2 counters is taken from the bag. The numbers on the 2 counters are recorded as D_1 and D_2 .

The random variable M represents the mean of D_1 and D_2

- (a) Show that $P(M = 4) = \frac{9}{245}$ (1)

- (b) Find the sampling distribution of M (6)

A random sample of n sets of 2 counters is taken. The random variable T represents the number of these n sets of 2 counters that have a mean of 4

Given that each set of 2 counters is replaced after it is drawn,

- (c) calculate the minimum value of n such that $P(T = 0) < 0.15$ (3)

Question 4 continued

Lined area for writing the answer to Question 4 continued.



Question 4 continued



Question 4 continued

(Total for Question 4 is 10 marks)



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6. (a) Explain what you understand by the sampling distribution of a statistic. (1)

A factory produces beads in bags for craft shops. A small bag contains 40 beads, a medium bag contains 80 beads and a large bag contains 150 beads. The factory produces small, medium and large bags in the ratio 5:3:2 respectively.

A random sample of 3 bags is taken from the factory.

- (b) Find the sampling distribution for the range of the number of beads in the 3 bags in the sample. (7)

A random sample of n sets of 3 bags is taken. The random variable Y represents the number of these n sets of 3 bags that have a range of 70

- (c) Calculate the minimum value of n such that $P(Y = 0) < 0.2$



Question 6 continued

Leave
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Q6

(Total 11 marks)

TOTAL FOR PAPER: 75 MARKS

END



Question 2 continued



Question 2 continued

Question 2 continued

(Total for Question 2 is 11 marks)





Question 6 continued

(Total for Question 6 is 11 marks)



2. (i) Nima wants to investigate the distribution of a discrete random variable X

The unknown mean of the distribution is μ

Nima takes a sample and finds the sample mean, $\bar{x}$

For **each** of the following, state whether or not it is a statistic. Give a reason for your answer in each case.

(a) μ

(b) $\bar{x}$

(2)

- (ii) A discrete random variable Y has the sampling distribution given in the table below.

y	2	5	6
$P(Y = y)$	$\frac{1}{3}$	$\frac{1}{4}$	$\frac{5}{12}$

Two random independent observations of Y are taken.

Find the probability that the value of the first observation of Y is smaller than the value of the second observation of Y

(3)

- (iii) A bag contains three counters, numbered 3, 4 and 5 respectively. Two counters are drawn at random, one after the other without replacement.

(a) List all the possible combinations of the scores on the two counters.

(1)

The random variable T is defined as

$$T = \text{number on the first counter} + (2 \times \text{number on the second counter})$$

(b) List all the possible values of T

(2)

(c) Find the sampling distribution of T

(3)

Question 2 continued



Question 2 continued



(Total for Question 2 is 11 marks)



Question 7 continued

Lined area for writing the answer to Question 7 continued.



Question 7 continued

Lined area for writing the answer to Question 7.

(Total for Question 7 is 12 marks)

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END

TOTAL FOR PAPER: 75 MARKS



MARK SCHEMES

official mark schemes, in the same order as the questions



Question Number	Scheme	Marks
2. (a)	e.g. Population is small	B1 (1)
(b)(i)	list/register/database of all members (of the leisure centre)	B1
(ii)	A member (of the leisure centre)	B1 (2)
(c)	C is the statistic as it is (a quantity) based only on <u>values</u> (oe) taken from the <u>sample</u> /it contains <u>no unknown parameters/population values</u>	B1 (1)
		[4 marks]
	Notes	
(a)	B1 any correct characteristic of the population that makes a census a practical alternative to a sample (accessible, finite, well-defined)	
(b)(i)	B1 idea of list (oe) <u>and</u> idea of all members (e.g. list of each member of the leisure centre))	
(ii)	B1 a single member Condone members Also condone One of the members in the sample The opinion/view of one of the members is B0	
(c)	B1 choosing C (or clearly identifying C in words) only with a correct supporting reason which must include value (oe) and sample <u>or</u> no unknown parameters For values allow e.g. information, observations, calculations, function, numerical data, etc.	

Question Number	Scheme							Marks																												
5(a)	P(score 8) = 0.25 × 0.35 = 0.0875							B1																												
								(1)																												
(b)	<table><tr><th>sample</th><th>Score (y)</th><th>calculation</th><th>P(Y = y)</th></tr><tr><td>(1,3)</td><td>−2</td><td>0.4 × 0.25</td><td>0.1</td></tr><tr><td>(1,2)</td><td>0</td><td>0.4 × 0.35</td><td>0.14</td></tr><tr><td>(1,1) (2,3)</td><td>2</td><td>0.4² + 0.35 × 0.25</td><td>0.2475</td></tr><tr><td>(2,2)</td><td>4</td><td>0.35²</td><td>0.1225</td></tr><tr><td>(2,1) (3,3)</td><td>6</td><td>0.35 × 0.4 + 0.25²</td><td>0.2025</td></tr><tr><td>(3,1)</td><td>10</td><td>0.25 × 0.4</td><td>0.1</td></tr></table>							sample	Score (y)	calculation	P(Y = y)	(1,3)	−2	0.4 × 0.25	0.1	(1,2)	0	0.4 × 0.35	0.14	(1,1) (2,3)	2	0.4 ² + 0.35 × 0.25	0.2475	(2,2)	4	0.35 ²	0.1225	(2,1) (3,3)	6	0.35 × 0.4 + 0.25 ²	0.2025	(3,1)	10	0.25 × 0.4	0.1	B1 M1 M1 M1
sample	Score (y)	calculation	P(Y = y)																																	
(1,3)	−2	0.4 × 0.25	0.1																																	
(1,2)	0	0.4 × 0.35	0.14																																	
(1,1) (2,3)	2	0.4 ² + 0.35 × 0.25	0.2475																																	
(2,2)	4	0.35 ²	0.1225																																	
(2,1) (3,3)	6	0.35 × 0.4 + 0.25 ²	0.2025																																	
(3,1)	10	0.25 × 0.4	0.1																																	
	<table><tr><th>Y</th><th>−2</th><th>0</th><th>2</th><th>4</th><th>6</th><th>8</th><th>10</th></tr><tr><td>P(Y = y)</td><td>0.1 $\left[\frac{1}{10}\right]$</td><td>0.14 $\left[\frac{7}{50}\right]$</td><td>0.2475 $\left[\frac{99}{400}\right]$</td><td>0.1225 $\left[\frac{49}{400}\right]$</td><td>0.2025 $\left[\frac{81}{400}\right]$</td><td>0.0875 $\left[\frac{7}{80}\right]$</td><td>0.1 $\left[\frac{1}{10}\right]$</td></tr></table>							Y	−2	0	2	4	6	8	10	P(Y = y)	0.1 $\left[\frac{1}{10}\right]$	0.14 $\left[\frac{7}{50}\right]$	0.2475 $\left[\frac{99}{400}\right]$	0.1225 $\left[\frac{49}{400}\right]$	0.2025 $\left[\frac{81}{400}\right]$	0.0875 $\left[\frac{7}{80}\right]$	0.1 $\left[\frac{1}{10}\right]$	A1												
Y	−2	0	2	4	6	8	10																													
P(Y = y)	0.1 $\left[\frac{1}{10}\right]$	0.14 $\left[\frac{7}{50}\right]$	0.2475 $\left[\frac{99}{400}\right]$	0.1225 $\left[\frac{49}{400}\right]$	0.2025 $\left[\frac{81}{400}\right]$	0.0875 $\left[\frac{7}{80}\right]$	0.1 $\left[\frac{1}{10}\right]$																													
								(5)																												
(c)	E(Y) = −2 × "0.1" + [0 × "0.14"] + 2 × "0.2475" + 4 × "0.1225" + 6 × "0.2025" + 8 × 0.0875 + 10 × "0.1"							M1																												
	= 3.7							A1																												
								(2)																												
								Total 8																												
		Notes																																		
(a)	B1	A correct calculation shown followed by 0.0875																																		
(b)	B1	For identifying the correct set of y values. Any extras must have a probability of 0																																		
		May be split eg 2 may appear twice																																		
	M1	For at least two correct calculations or probs from P(Y = −2), P(Y = 0) , P(Y = 4) or P(Y = 10)																																		
	M1	For at least one correct calculation or prob for P(Y = 2) or P(Y = 6)																																		
	M1	For at least four correct calculations or probs attached to the correct value of y or sample																																		
(c)	A1	A fully correct answer																																		
	M1	Correct expression ft their table																																		
	A1	3.7 or exact equivalent																																		
		Alternative for (c) M1																																		
		E(X) = 0.4 + 2 × 0.35 + 3 × 0.25 [= 1.85] and E(Y) = 4 × "1.85" − 2 × "1.85"																																		

Question Number	Scheme					Marks						
6(a)	$\left(2 \times \frac{a}{a+7} \times \frac{1}{4} \times \frac{3}{4}\right) + \left(\frac{a}{a+7} \times \frac{1}{4} \times \frac{1}{4}\right) = \frac{63}{256} \text{ or } \frac{a}{a+7} \times \left(1 - \left(\frac{3}{4}\right)^2\right) = \frac{63}{256} \text{ or}$ $\frac{a}{a+7} \times \left[\left(\frac{1}{4}\right)^2 + 2 \times \frac{1}{4} \times \frac{3}{4}\right] = \frac{63}{256}$ $\frac{a}{7+a} = \frac{63}{256} \div \frac{7}{16} \text{ or } \frac{a}{7+a} = \frac{9}{16} \quad \therefore a = 9 *$					M1 M1 A1*						
						(3)						
(b)	Range (R) 0, 5, 10 (and 15)					B1						
	Bag: $P(20) = \frac{9}{16}$ and $P(5) = \frac{5}{16}$ and $P(10) = \frac{2}{16}$					B1						
	$[P(R = 0) =] \frac{5}{16} \times \frac{1}{4} \times \frac{1}{4} + \frac{2}{16} \times \frac{3}{4} \times \frac{3}{4}$					M1 M1 M1						
	$[P(R = 5) =] 2 \times \frac{5}{16} \times \frac{1}{4} \times \frac{3}{4} + \frac{5}{16} \times \frac{3}{4} \times \frac{3}{4} + 2 \times \frac{2}{16} \times \frac{1}{4} \times \frac{3}{4} + \frac{2}{16} \times \frac{1}{4} \times \frac{1}{4}$											
	$[P(R = 10) =] \frac{9}{16} \times \frac{3}{4} \times \frac{3}{4}$											
	<table><tr><td>R</td><td>0</td><td>5</td><td>10</td><td>15</td></tr><tr><td>r</td><td>$\frac{23}{256}$</td><td>$\frac{89}{256}$</td><td>$\frac{81}{256}$</td><td>$\frac{63}{256}$</td></tr></table>	R	0	5	10	15	r	$\frac{23}{256}$	$\frac{89}{256}$	$\frac{81}{256}$	$\frac{63}{256}$	
R	0	5	10	15								
r	$\frac{23}{256}$	$\frac{89}{256}$	$\frac{81}{256}$	$\frac{63}{256}$								
					(6)							
Notes						Total 9						
(a)	M1	For use of $\frac{a}{a+7}$ in an equation										
	M1	Setting up a correct equation to find the value of a										
	A1*	$a = 9$ with at least one further correct line of working										
(b)	B1	For the 3 ranges 0, 5 and 10 and no extra incorrect ones or all extras have probability of 0										
	B1	For the correct 3 probabilities written or used for the bag $\frac{2}{16}$ and/or $\frac{5}{16}$ may be implied by a correct answer for $P(R = 0)$ or $P(R = 5)$ and $\frac{9}{16}$ may be implied by a correct answer for $P(R = 10)$										
		NB p and q must be consistent for the next 3 method marks										
	M1	A correct method to find one probability for $P(R = 0)$ or $P(R = 5)$ or $P(R = 10)$ allow $p \times q \times q + r \times (1 - q) \times (1 - q)$ or $2 \times p \times q \times (1 - q) + p \times (1 - q) \times (1 - q) + 2 \times r \times q \times (1 - q) + r \times q \times q$ or $m \times (1 - p) \times (1 - p)$ where m, p, q and r are probabilities. (May be implied by $\frac{23}{256}$ or $\frac{89}{256}$ or $\frac{81}{256}$)										
	M1	A correct method to find two probabilities from $P(R = 0)$ or $P(R = 5)$ or $P(R = 10)$ allow $p \times q \times q + r \times (1 - q) \times (1 - q)$ or $2 \times p \times q \times (1 - q) + p \times (1 - q) \times (1 - q) + 2 \times r \times q \times (1 - q) + r \times q \times q$ or $m \times (1 - p) \times (1 - p)$ where m, p, q and r are probabilities. (May be implied by 2 from $\frac{23}{256}$ or $\frac{89}{256}$ or $\frac{81}{256}$)										
	M1	A correct method to find all 3 probability for $P(R = 0)$ and $P(R = 5)$ and $P(R = 10)$ allow $p \times q \times q + r \times (1 - q) \times (1 - q)$ or $2 \times p \times q \times (1 - q) + p \times (1 - q) \times (1 - q) + 2 \times r \times q \times (1 - q) + r \times q \times q$ or $m \times (1 - p) \times (1 - p)$ where m, p, q and r are probabilities. (May be implied by $\frac{23}{256}$ and $\frac{89}{256}$ and $\frac{81}{256}$) or these 3 probabilities that sum to $\frac{193}{256}$										

Question Number	Scheme						Marks							
6(a)	8, 11, 14, 17, 20						M1							
	$\left[P(\text{even}) = \right] \frac{1}{5}$ and $\left[P(\text{odd}) = \right] \frac{4}{5}$						M1							
	$\left[P(X = 8) = \right] \left(\frac{4}{5} \right)^4$ or $\left[P(X = 20) = \right] \left(\frac{1}{5} \right)^4$						M1							
	$\left[P(X = 11) = \right] 4 \times \left(\frac{1}{5} \right) \left(\frac{4}{5} \right)^3$ or $\left[P(X = 17) = \right] 4 \times \left(\frac{4}{5} \right) \left(\frac{1}{5} \right)^3$						M1							
	$\left[P(X = 14) = \right] {}^4C_2 \times \left(\frac{1}{5} \right)^2 \left(\frac{4}{5} \right)^2$						M1							
	<table><tr><td>X</td><td>8</td><td>11</td><td>14</td><td>17</td><td>20</td></tr><tr><td>$P(X = x)$</td><td>$\frac{256}{625}$ (0.4096)</td><td>$\frac{256}{625}$ (0.4096)</td><td>$\frac{96}{625}$ (0.1536)</td><td>$\frac{16}{625}$ (0.0256)</td><td>$\frac{1}{625}$ (0.0016)</td></tr></table>	X	8	11	14	17	20	$P(X = x)$	$\frac{256}{625}$ (0.4096)	$\frac{256}{625}$ (0.4096)	$\frac{96}{625}$ (0.1536)	$\frac{16}{625}$ (0.0256)	$\frac{1}{625}$ (0.0016)	A1
	X	8	11	14	17	20								
$P(X = x)$	$\frac{256}{625}$ (0.4096)	$\frac{256}{625}$ (0.4096)	$\frac{96}{625}$ (0.1536)	$\frac{16}{625}$ (0.0256)	$\frac{1}{625}$ (0.0016)									
(6)														
(b)	$1 - (1 - "0.1536")^n > 0.95$ or $("0.8464")^n < 0.05$						M1							
	$n > 17.96$ or $n > \frac{\log(0.05)}{\log("0.8464")}$ or $n > \log_{"0.8464"}(0.05)$						M1							
	$n = 18$						A1							
							(3)							
	Notes						Total 9							
(a)	M1	For at least 2 scores correct and no more than 3 incorrect												
	M1	for writing or using $\frac{4}{5}$ and $\frac{1}{5}$. May be implied by a correct probability												
	M1	for p^4 where $0 < p < 1$												
	M1	for $4 \times (1 - p)p^3$ where $0 < p < 1$												
	M1	for $6 \times (1 - p)^2 p^2$ where $0 < p < 1$ or probabilities that add to 1 (at least 2 but not more than 5)												
	A1	for all 5 probabilities correct and associated with the correct values. Need not be in a table but probabilities must be attached to the correct total												
(b)	M1	for using $1 - (1 - P(Y = 0))^n > 0.95$ allow = instead of $>/\geq$. condone $</\leq$ or allow for at least 2 trials for n between 10 and 20 ft their $P(X = 14)$												
	M1	for $n > \text{awrt } 17.96$ or $n > \frac{\log(0.05)}{\log("0.8464")}$ ft their 0.8464 or $n > \log_{"0.8464"}(0.05)$ ft their 0.8464 or for the two trials for $n = 17$ and 18 Allow = instead of $>/\geq$. condone $</\leq$ May be implied by a correct answer ft their 0.8464												
	A1	Cao (Do not allow any inequality for this mark)												

Question Number	Scheme					Marks					
4(a)	3, 6, 9, 12					B1					
	$[P(\text{black})=]\frac{2}{7}$ and $[P(\text{white})=]\frac{5}{7}$					B1					
	$[P(X = 3)]=\left(\frac{5}{7}\right)^3$ or $[P(X = 12)]=\left(\frac{2}{7}\right)^3$					M1					
	$[P(X = 6)]=3\times\left(\frac{5}{7}\right)^2\times\frac{2}{7}$					M1					
	$[P(X = 9)]=3\times\frac{5}{7}\times\left(\frac{2}{7}\right)^2$					M1					
	<table><tr><td>X</td><td>3</td><td>6</td><td>9</td><td>12</td></tr><tr><td>P(X = x)</td><td>$\frac{125}{343}$ (0.3644...)</td><td>$\frac{150}{343}$ (0.4373...)</td><td>$\frac{60}{343}$ (0.1749...)</td><td>$\frac{8}{343}$ (0.0233...)</td></tr></table>	X	3	6	9	12	P(X = x)	$\frac{125}{343}$ (0.3644...)	$\frac{150}{343}$ (0.4373...)	$\frac{60}{343}$ (0.1749...)	$\frac{8}{343}$ (0.0233...)
X	3	6	9	12							
P(X = x)	$\frac{125}{343}$ (0.3644...)	$\frac{150}{343}$ (0.4373...)	$\frac{60}{343}$ (0.1749...)	$\frac{8}{343}$ (0.0233...)							
						(6)					
(b)	$\left(\frac{283}{343}\right)^n < 0.05$ oe					M1					
	$n > 15.57\dots$ or $n > \frac{\log(0.05)}{\log\left(\frac{283}{343}\right)}$ or $n > \log_{\left(\frac{283}{343}\right)}(0.05)$					dM1					
	$n = 16$					A1					
						(3)					
Notes						Total 9					
(a)	B1	for all 4 possible outcomes and no extras									
	B1	for writing or using $\frac{5}{7}$ and $\frac{2}{7}$. May be implied by a correct probability for $P(X = 6)$ or $P(X = 9)$ or $P(X = 3)$ and $P(X = 12)$ Allow awrt 0.714 and awrt 0.286									
	M1	for p^3 where $0 < p < 1$ May be implied by $\frac{125}{343}$ or awrt 0.364 or $\frac{8}{343}$ or awrt 0.023									
	M1	for $3 \times p^2 \times (1 - p)$ where $0 < p < 1$ May be implied by $\frac{150}{343}$ or awrt 0.437 or $\frac{60}{343}$ or awrt 0.175									
	M1	for $3 \times p \times (1 - p)^2$ where $0 < p < 1$ May be implied by $\frac{150}{343}$ or awrt 0.437 and $\frac{60}{343}$ or awrt 0.175 or 4 probabilities that add to 1									
	A1	for all 4 probabilities correct and associated with the correct values. Need not be in a table but probabilities must be attached to the correct total. If decimals are used then they must be awrt 0.364, awrt 0.437, awrt 0.175 and awrt 0.023									
(b)	M1	for $\left(1 - \frac{60}{343}\right)^n < 0.05$ oe Condone $=/\leq$ instead of $<$									
	dM1	Dependent on the previous M mark for $n > \text{awrt } 15.6$ or $n > \frac{\log(0.05)}{\log\left(\frac{283}{343}\right)}$ ft their $\frac{283}{343}$ or $n > \log_{\left(\frac{283}{343}\right)}(0.05)$ ft their $\frac{283}{343}$ or for the two trials between $n = 15$ and 16 Allow $=$ instead of $>/\geq$. Condone $</\leq$									
	A1	cao (do not allow an inequality)									

Question Number	Scheme		Marks														
6(a)	Taking a random sample is quicker/cheaper/easier (compared to asking all of the youth club members).		B1														
			(1)														
(b)	A <u>list/register/database</u> of <u>all</u> the youth club <u>members</u>		B1														
			(1)														
(c)	The <u>members</u>		B1														
			(1)														
(d)	$p^2 = \frac{25}{64}$		M1														
	$p = \frac{5}{8}$		A1														
	$\frac{5}{8} + q + r = 1$ or $2qr = \frac{1}{16}$ or $\frac{25}{64} + 2\frac{5}{8}q + 2\frac{5}{8}r + q^2 + \frac{1}{16} + r^2 = 1$		B1														
	Any two equations from above		B1														
	$\frac{3}{8}q - q^2 = \frac{1}{32}$		dM1														
	$q = \frac{1}{4}$		A1														
	$P(M = 50) = \frac{1}{4} \times \frac{1}{4} = \frac{1}{16}$ *		A1cso*														
			(7)														
			Total 10														
Notes																	
(a)	B1	Any one of the given reasons. Ignore extraneous non-contradictory reasons.															
(b)	B1	Idea of list(oe). Need all (oe) (eg complete list) and members.															
(c)	B1	The members/a member															
(d)	M1	Correct method, may be implied															
	A1	$p = \frac{5}{8}$ or $P(X = 20) = \frac{5}{8}$															
	B1	One equation in q and r from use of $p + q + r = 1$, $P(M = 60)$ or $\sum P(M=m) = 1$ see Note (allow ft on their value of p)															
	B1	Two correct equations in q and r Some will substitute directly into the third equation so may see: $\frac{25}{64} + \frac{5}{4}q + \frac{5}{128q} + q^2 + \frac{1}{16} + \frac{1}{1024q^2} = 1$ which is correct and scores B1B1															
	dM1	(dep on 1 st B1) Correct method to solve simultaneous equation leading to a probability for q or r (may be implied by $q = \frac{1}{4}$ or $r = \frac{1}{8}$ provided B1B1 scored)															
	A1	Correct probability for q (dependent on all previous marks in part (d))															
	A1cso*	Correct solution with use of $P(M = 50) = q^2$ and all previous marks awarded.															
	Note:	<table><tr><td>m</td><td>20</td><td>35</td><td>45</td><td>50</td><td>60</td><td>70</td></tr><tr><td>$P(M=m)$</td><td>$\frac{25}{64}$</td><td>$2pq$</td><td>$2pr$</td><td>q^2</td><td>$\frac{1}{16}$</td><td>r^2</td></tr></table>		m	20	35	45	50	60	70	$P(M=m)$	$\frac{25}{64}$	$2pq$	$2pr$	q^2	$\frac{1}{16}$	r^2
m	20	35	45	50	60	70											
$P(M=m)$	$\frac{25}{64}$	$2pq$	$2pr$	q^2	$\frac{1}{16}$	r^2											
		$\frac{25}{64} + 2pq + 2pr + q^2 + \frac{1}{16} + r^2 = 1$															

Question Number	Scheme	Marks										
4.	[A = the number on the ball] $P(A=1)=\frac{2}{9}$ $P(A=2)=\frac{1}{3}$ $P(A=5)=\frac{4}{9}$	B1										
(i)	Possible samples with a range of 4 are: (1,1,5) (1,2,5) (1,5,5) (1,1,5) $\frac{2}{9} \times \frac{2}{9} \times \frac{4}{9} \times 3 = \frac{16}{243}$ or (1,5,5) $\frac{2}{9} \times \frac{4}{9} \times \frac{4}{9} \times 3 = \frac{32}{243}$ (1,2,5) $\frac{2}{9} \times \frac{1}{3} \times \frac{4}{9} \times 6 = \frac{16}{81}$ $P(B=4)=\frac{16}{243}+\frac{32}{243}+\frac{16}{81}=\frac{32}{81}$	M1 M1 M1 A1										
(ii)	$P(B=0)=\left(\frac{2}{9}\right)^3+\left(\frac{1}{3}\right)^3+\left(\frac{4}{9}\right)^3=\frac{11}{81}$ $P(B=1)=3\times\frac{2}{9}\times\left(\frac{1}{3}\right)^2+3\times\frac{1}{3}\times\left(\frac{2}{9}\right)^2=\frac{10}{81}$ or $P(B=3)=3\times\frac{1}{3}\times\left(\frac{4}{9}\right)^2+3\times\frac{4}{9}\times\left(\frac{1}{3}\right)^2=\frac{28}{81}$ $1-\frac{11}{81}-\frac{10}{81}-\frac{32}{81}=\frac{28}{81}$ or $1-\frac{11}{81}-\frac{28}{81}-\frac{32}{81}=\frac{10}{81}$ <table><tr><td>b</td><td>0</td><td>1</td><td>3</td><td>4</td></tr><tr><td>$P(B=b)$</td><td>$\frac{11}{81}$</td><td>$\frac{10}{81}$</td><td>$\frac{28}{81}$</td><td>$\frac{32}{81}$</td></tr></table>	b	0	1	3	4	$P(B=b)$	$\frac{11}{81}$	$\frac{10}{81}$	$\frac{28}{81}$	$\frac{32}{81}$	M1 M1 M1 B1 A1
b	0	1	3	4								
$P(B=b)$	$\frac{11}{81}$	$\frac{10}{81}$	$\frac{28}{81}$	$\frac{32}{81}$								
		(10)										
		Total 10										
	Notes											
(i)	B1: for writing or using the 3 correct probabilities 1st M1: for identifying the 3 possible samples 2nd M1: for $p \times p \times q \times 3$ or $p \times q \times q \times 3$ where p and q are probabilities with $(p+q) < 1$ 3rd M1: for $p \times q \times r \times 6$ where p, q and r are probabilities with $(p+q+r) = 1$ A1: for $\frac{32}{81}$ or awrt 0.395 [Calc: 0.3950617...]											
(ii)	1st M1: for $p^3+q^3+r^3$ (for their p, q and r) 2nd M1: for $3 \times p \times (q)^2+3 \times q \times (p)^2$ or $3 \times q \times (r)^2+3 \times r \times (q)^2$ (for their p, q and r) 3rd M1: for use of all probabilities of $P(B=b)$ adding to 1 [Must have 3, 4 or 5 values for b] B1: for ranges 0, 1, 3 and 4 with none omitted and no extras. Allow extras if assigned probability of 0 A1: for a fully correct probability distribution.											
SC A0 in (i)	If A0 scored in (i) <u>and</u> all other marks scored in (ii) <u>and</u> correct prob's for 2 values of b : award A1 in (ii)											

Question Number	Scheme					Marks												
6 (a)	A sampling distribution is all the values of a statistic (obtained from a random sample) and the associated probabilities or the probability distribution of the statistic (under random sampling).					B1 (1)												
(b)	$P(6) = \frac{6}{11} \quad P(7) = \frac{3}{11} \quad P(8) = \frac{2}{11}$					B1												
	Totals (<i>T</i>) 12, 13, 14, 15, 16					B1												
	(6, 6) (6, 7) (6, 8) (7, 6) (7, 7) (7, 8) (8, 6) (8, 7) (8, 8)					B1												
	$[P(T = 12) =] \left(\frac{6}{11}\right)^2 = \left[\frac{36}{121}\right]$					M1 M1 M1												
	$[P(T = 13) =] 2 \times \left(\frac{6}{11}\right) \times \left(\frac{3}{11}\right) = \left[\frac{36}{121}\right]$																	
	$[P(T = 14) =] 2 \times \left(\frac{6}{11}\right) \times \left(\frac{2}{11}\right) + \left(\frac{3}{11}\right)^2 = \left[\frac{33}{121}\right]$																	
	$[P(T = 15) =] 2 \times \left(\frac{3}{11}\right) \times \left(\frac{2}{11}\right) = \left[\frac{12}{121}\right]$																	
	$[P(T = 16) =] \left(\frac{2}{11}\right)^2 = \left[\frac{4}{121}\right]$																	
	<table><tr><td><i>T</i></td><td>12</td><td>13</td><td>14</td><td>15</td><td>16</td></tr><tr><td><i>P(T = t)</i></td><td>$\frac{36}{121}$</td><td>$\frac{36}{121}$</td><td>$\frac{33}{121}$</td><td>$\frac{12}{121}$</td><td>$\frac{4}{121}$</td></tr></table>					<i>T</i>	12	13	14	15	16	<i>P(T = t)</i>	$\frac{36}{121}$	$\frac{36}{121}$	$\frac{33}{121}$	$\frac{12}{121}$	$\frac{4}{121}$	A1 (7)
<i>T</i>	12	13	14	15	16													
<i>P(T = t)</i>	$\frac{36}{121}$	$\frac{36}{121}$	$\frac{33}{121}$	$\frac{12}{121}$	$\frac{4}{121}$													
(c)	$E(T) = "12" \times \frac{36}{121} + "13" \times \frac{36}{121} + "14" \times \frac{33}{121} + "15" \times \frac{12}{121} + "16" \times \frac{4}{121}$					M1												
	$= \frac{1606}{121} = \frac{146}{11} = 13.272...$ awrt 13.3					A1 (2)												
	Notes					Total 10												
6 (a)	B1	A correct explanation with the words in bold																
(b)	B1	Correct probabilities – may be seen in an equation or implied by a correct probability for <i>T</i> = 14																
	B1	All 5 totals correct with no extras																
	B1	All 6 basic combinations correct, either seen or used (may be implied by correct probabilities) Allow S for 6, M for 7 and L for 8																
	M1	Correct method for one probability ft their <i>P</i> (6), <i>P</i> (7) and <i>P</i> (8) If these are not stated then they must be correct																
	M1	Correct method for three of the five probabilities ft their <i>P</i> (6), <i>P</i> (7) and <i>P</i> (8) If these are not stated then they must be correct																
	M1	Correct method for all five probabilities ft their <i>P</i> (6), <i>P</i> (7) and <i>P</i> (8) If these are not stated then they must be correct or 5 probabilities that add up to 1																
	A1	cao Need not be in a table but probabilities must be attached to the correct total																
(c)	M1	Use of $\sum tP(T = t)$ two or more products ft their table																
	A1	awrt 13.3 (Allow $\frac{146}{11}$ oe)																

Question	Scheme	Marks
5. (a)	$X \sim \text{Po}(7.5)$	B1
(i)	$P(X = 10) [= 0.8622 - 0.7764 = \frac{e^{-7.5}(7.5)^{10}}{10!}] = 0.0858\dots$ awrt 0.0858	B1
(ii)	$P(6 \leq X \leq 11) = P(X \leq 11) - P(X \leq 5) [= 0.9208 - 0.2414]$	M1
	$= 0.6794$ awrt 0.679	A1
		(4)
(b)	$Y = \text{number of samples that contain 0 particles}$	
	$Y \sim B(12, p)$ or $B(12, e^{-0.15m})$ or $B(12, e^{-\lambda})$	M1
	$[P(Y \leq 2) =] 1 - P(Y \leq 1) = 0.1184$	M1
	$P(Y \leq 1) = 0.8816 \rightarrow \text{from tables } [p =] 0.05$	A1
	$S = \text{number of particles per } m \text{ millilitres}$	
	$S \sim \text{Po}(0.15m)$	M1
	$P(S = 0) = 0.05$ or $e^{-0.15m} = "0.05"$	M1
	$-0.15m = \ln(0.05) \rightarrow m = 19.9715\dots$ awrt 20.0	A1
		(6)
		[10 marks]
	Notes	
(a)	1 st B1 writing or using $\text{Po}(7.5)$ May be implied by a correct probability	
(i)	2 nd B1 awrt 0.0858 [calc = 0.0858303...]	
(ii)	M1 writing or using $P(X \leq 11) - P(X \leq 5)$	
	A1 awrt 0.0679 [calc = 0.06793222...]	
(b)	1 st M1 writing or using $B(12, p)$ Allow Binomial with $n = 12$ or $B(12, \dots)$ May be implied by 0.05	
	2 nd M1 for $1 - P(Y \leq 1) = 0.1184$ (or better) or $P(Y \leq 1) = 0.8816$ oe eg $(1 - p)^{12} + 12p(1 - p)^{11} = 0.8816$ Implied by 0.05	
	1 st A1 0.05(seen)	
	3 rd M1 writing or using $\text{Po}(0.15m)$ May be implied by $e^{-0.15m}$	
	4 th M1 ft their p ($0 < p < 1$) for an equation of the form $e^{-0.15m} = "0.05"$ (allow $e^{-\lambda} = "0.05"$) Allow $0.15m = 3$	
	2 nd A1 Allow 20 or awrt 20.0 Allow trial and error to solve their equation	

Question Number	Scheme		Marks
3 (a)(i) (ii)	3 + [0] + 29 = 32*		B1*
	3 + 15 + 29 = 47*		B1*
			(2)
(b)	$f(t) = \begin{cases} \frac{1}{15} & 32 \leq t \leq 47 \\ 0 & \text{otherwise} \end{cases}$		M1 A1
			(2)
(c) (i)	[E(T) =] 39.5 oe		B1
(ii)	$[\text{Var}(T) =] \frac{(47 - 32)^2}{12}$		M1
	$\frac{75}{4} = 18.75$		A1
			(3)
(d)	$(40 - 32) \times \frac{1}{15}$		M1
	$= \frac{8}{15}$		A1
			(2)
	Notes		Total 9
(a)(i)	B1*	For 3 + [0] + 29	
(ii)	B1*	For 3 + 15 + 29 Allow 32 + 15	
(b)	M1	For $f(t) = \frac{1}{15} \quad 32 \leq t \leq 47$ Allow use of < instead of one/both $\leq$ signs. Allow the use of any letter for f(t) and t (Condone inconsistent use of letters) but we must have f(t) and an inequality	
	A1	Fully correct pdf $f(t) = \begin{cases} \frac{1}{15} & 32 \leq t \leq 42 \\ 0 & \text{otherwise} \end{cases}$ Must be f(t) and t. Condone f(T) and T Allow use of < instead of one/both $\leq$ signs Allow equivalent for the 0 otherwise.	
(c)(i)	B1	For 39.5 oe	
(ii)	M1	For use of $\text{Var}(T) = \frac{(\beta - \alpha)^2}{12}$	
	A1	For 18.75 oe	
(d)	M1	For use of $(40 - \alpha) \times \frac{1}{\beta - \alpha}$	
	A1	For $\frac{8}{15}$ oe Allow awrt 0.533	

Question Number	Scheme				Marks								
4 (a)	0.2×£10+0.3×£12+0.5×£15				M1								
	= [£]13.10				A1								
					(2)								
(b)	10 10 10	12 12 12	15 15 15		B1 B1								
	10 10 12 (×3)	12 12 15 (×3)	12 15 15 (×3)										
	10 10 15 (×3)	10 12 12 (×3)	10 15 15 (×3)										
	10 12 15 (×6)												
					(2)								
(c)	P(10) = 0.2 P(12) = 0.3 P(15) = 0.5				B1								
	Median can be 10, 12 or 15				B1								
	P(M = 10) = 0.2 ³ + 0.2 ² × 0.3 × 3 + 0.2 ² × 0.5 × 3 or 1 – 0.8 ³ – 3 × 0.8 ² × 0.2				M1								
	P(M = 12) = 0.3 ³ + 0.3 ² × 0.5 × 3 + 0.3 ² × 0.2 × 3 + 0.2 × 0.3 × 0.5 × 6				M1								
	P(M = 15) = 0.5 ³ + 0.5 ² × 0.3 × 3 + 0.5 ² × 0.2 × 3 or 1 – 0.5 ³ – 3 × 0.5 ² × 0.5				M1								
	<table><tr><td>M</td><td>10</td><td>12</td><td>15</td></tr><tr><td>P(M = m)</td><td>$\frac{13}{125} = 0.104$</td><td>$\frac{99}{250} = 0.396$</td><td>$\frac{1}{2} = 0.5$</td></tr></table>				M	10	12	15	P(M = m)	$\frac{13}{125} = 0.104$	$\frac{99}{250} = 0.396$	$\frac{1}{2} = 0.5$	A1
	M	10	12	15									
P(M = m)	$\frac{13}{125} = 0.104$	$\frac{99}{250} = 0.396$	$\frac{1}{2} = 0.5$										
					(6)								
Notes					Total 10								
(a)	M1	For 0.2×10+0.3×12+0.5×15 May be implied by a correct answer											
	A1	Cao Allow 13.1											
(b)	B1	B1 for at least 5 possible combinations. Ignore repeats. May be seen in part c											
	B1	For all 10 possible combinations. Ignore repeats. May be seen in part c											
(c)	B1	Correct probabilities – may be seen in an equation or implied by a correct probability											
	B1	All 3 medians and no extras											
	M1	A correct method for one of the probabilities (May be implied by a correct probability)											
	M1	A correct method for two of the probabilities (May be implied by 2 correct probabilities)											
	M1	A correct method for all three probabilities (May be implied by 3 correct probabilities) or 3 probabilities that add to 1											
	A1	Cao Need not be in a table but probabilities must be attached to the correct median											

Question	Scheme						Marks																								
4(a)	$\frac{10}{50} \times \frac{9}{49} \left[= \frac{9}{245} * \right]$						B1cso																								
							(1)																								
(b)	number of counters numbered 4 = 10 numbered 7 = 15 numbered 10 = 25						M1																								
	$M = 4, 5.5, 7, 8.5, 10$						B1																								
	$P(M = 5.5) = 2 \times \frac{10}{50} \times \frac{15}{49} \left[= \frac{6}{49} \right]$						M1																								
	$P(M = 7) = 2 \times \frac{10}{50} \times \frac{25}{49} + \frac{15}{50} \times \frac{14}{49} \left[= \frac{71}{245} \right]$						M1																								
	$P(M = 8.5) = 2 \times \frac{15}{50} \times \frac{25}{49} \left[= \frac{15}{49} \right]$						M1																								
	$P(M = 10) = \frac{25}{50} \times \frac{24}{49} \left[= \frac{12}{49} \right]$																														
	<table><tr><td>m</td><td>4</td><td>5.5</td><td>7</td><td>8.5</td><td>10</td></tr><tr><td>$P(M = m)$</td><td>$\frac{9}{245}$</td><td>$\frac{6}{49}$</td><td>$\frac{71}{245}$</td><td>$\frac{15}{49}$</td><td>$\frac{12}{49}$</td></tr><tr><td></td><td>(awrt)</td><td>(awrt)</td><td>(awrt)</td><td>(awrt)</td><td>(awrt)</td></tr><tr><td></td><td>(0.037)</td><td>(0.122)</td><td>(0.290)</td><td>(0.306)</td><td>(0.245)</td></tr></table>						m	4	5.5	7	8.5	10	$P(M = m)$	$\frac{9}{245}$	$\frac{6}{49}$	$\frac{71}{245}$	$\frac{15}{49}$	$\frac{12}{49}$		(awrt)	(awrt)	(awrt)	(awrt)	(awrt)		(0.037)	(0.122)	(0.290)	(0.306)	(0.245)	A1
m	4	5.5	7	8.5	10																										
$P(M = m)$	$\frac{9}{245}$	$\frac{6}{49}$	$\frac{71}{245}$	$\frac{15}{49}$	$\frac{12}{49}$																										
	(awrt)	(awrt)	(awrt)	(awrt)	(awrt)																										
	(0.037)	(0.122)	(0.290)	(0.306)	(0.245)																										
							(6)																								
(c)	$\left(1 - \frac{9}{245}\right)^n < 0.15$						M1																								
	$n = 50.689... \text{ or } n = 50 \text{ is } 0.1539... \text{ or } n = 51 \text{ is } 0.148... \text{ or } [n >] \frac{\log 0.15}{\log(1 - \frac{9}{245})}$						M1																								
	$n = 51$						A1																								
							(3)																								
	Notes						Total 10																								
(a)	B1	A correct equivalent expression																													
(b)	M1	For 10, 15 and 25 - may be seen in (a) or may be seen in probability expressions																													
	B1	all means correct with no incorrect extra unless they have a probability of 0																													
	M1	One correct probability (not including 9/245)																													
	M1	Two correct probabilities (not including 9/245)																													
	M1	Three correct probabilities (not including 9/245)																													
	A1	fully correct. need not be in a table but must have correct probability associated with correct mean																													
	SC	With replacement using probabilities $\frac{10}{50}, \frac{15}{50}, \frac{25}{50}$ gives $\frac{3}{25}, \frac{29}{100}, \frac{3}{10}, \frac{1}{4}$ can score maximum M1B1M1(two correct)M1(four correct)M0A0																													
(c)	M1	Setting up a correct inequality (allow any inequality or equal sign here)																													
	M1	for a value $n = \text{awrt } 50.7 \text{ or } \text{awrt } 0.154 \text{ or } \text{awrt } 0.148$ or correct log expression for n																													
	A1	51 cao do not allow $n \dots 51$																													

Question Number	Scheme					Marks										
6(a)	A sampling distribution is all the values of a statistic and the associated probabilities or the probability distribution of the statistic .					B1										
						(1)										
(b)	P(small(40)) = 0.5, P(medium(80)) = 0.3, P(large(150)) = 0.2					B1										
	Range (R) 0, 40, 70, 110					B1										
	$[P(R=0) =]0.5^3 + 0.3^3 + 0.2^3 = 0.16$					M1										
	(40,40,80) (40,80,80) (80,80,150) (80,150,150) (40,40,150) (40,80,150) (40,150,150)					B1										
	$[P(R=40) =]3 \times (0.5^2 \times 0.3) + 3 \times (0.5 \times 0.3^2)$					M1 M1										
	$[P(R=70) =]3 \times (0.3^2 \times 0.2) + 3 \times (0.3 \times 0.2^2) = 0.09$															
	$[P(R=110) =]3 \times (0.5^2 \times 0.2) + 3 \times (0.5 \times 0.2^2) + 6 \times (0.5 \times 0.3 \times 0.2) = 0.39$															
	<table><tr><td>R</td><td>0</td><td>40</td><td>70</td><td>110</td></tr><tr><td>r</td><td>0.16</td><td>0.36</td><td>0.09</td><td>0.39</td></tr></table>	R	0	40	70	110	r	0.16	0.36	0.09	0.39					A1cao
	R	0	40	70	110											
r	0.16	0.36	0.09	0.39												
					(7)											
(c)	$(1 - 0.09)^n < 0.2$ or $(0.91)^n < 0.2$					M1										
	$[n >]17.065...$					M1										
	$n = 18$					A1										
						(3)										
Notes						Total 11										
6(a)	B1	A correct explanation with the words in bold. Allow equivalent words eg outcomes for values														
(b)	B1	Correct probabilities – may be seen in an equation or implied by a correct probability for $R = 0$ or for 2 correct probabilities from those for $R = 40, R = 70, R = 110$														
	B1	All four ranges correct with no extra.														
	M1	Correct method for finding $P(R = 0)$														
	B1	All the correct combinations for $R = 40, 70$ and 110 . $R = 0$ combinations are not required but no incorrect combinations must be seen (may use bag size rather than numbers in bag) May be implied by a correct probability for $P(R = 40)$, $P(R = 70)$ and $P(R = 110)$ or by correct working seen for each of the 7 combinations (no need for the number of ways of arranging ie $3 \times$ or $6 \times$) eg $(40,40,80) = 0.5^2 \times 0.3$														
	M1	Correct method for one of the probabilities for $P(R = 40)$, $P(R = 70)$, $P(R = 110)$														
	M1	Correct method for a second probability for $P(R = 40)$, $P(R = 70)$, $P(R = 110)$ or the 4 probabilities add up to 1.														
	A1	Correct answer only. Allow answers as a fraction. Need not be in a table but probabilities must be attached to the correct range														
(c)	M1	Setting up a correct inequality using their 0.09 Allow written as an equation.														
	M1	For 17.1 or better allow $\frac{\log 0.2}{\log 0.91}$ or $\log_{0.91} 0.2$ oe If inequality/equation is incorrect but of the form $(p)^n < 0.2$ $(p)^n = 0.2$ where $0 < p < 1$ this mark can be awarded if working is shown														
	A1	18 do not accept $n > 18$ or $n < 18$ if final answer														

Question Number	Scheme				Marks
2 (a)	20, 20, 20	20, 20, 50 (×3)	20, 50, 50 (×3)	50, 50, 50	B2
					(2)
(b)	$a = 30$ and $b = 40$				B1
					(1)
(c)	$p^3 = \frac{4913}{8000}$ or $q^3 = \frac{27}{8000}$				M1
	$p = \frac{17}{20}$ (0.85) and $q = \frac{3}{20}$ (0.15)				A1
					(2)
(d)	$[P(30)] = 3 \times p^2 \times q$ $[P(40)] = 3 \times p \times q^2$				M1 M1
	$c = \frac{2601}{8000}$ $d = \frac{459}{8000}$				A1
					(3)
(e)	M	20	50		B1 M1 A1ft
	$P(M = m)$	$\frac{3757}{4000}$	$\frac{243}{4000}$		
					(3)
Notes					Total 11
(a)	B2	For all 4 correct combinations (B1 for 3 correct combinations) Ignore extraneous repetitions of any of the given combinations			
(b)	B1	For $a = 30$ and $b = 40$			
(c)	M1	Either $p^3 = \frac{4913}{8000}$ or $q^3 = \frac{27}{8000}$			
	A1	$p = 0.85$ oe and $q = 0.15$ oe			
(d)	M1	$[P(30)] = 3 \times (\text{their } p)^2 \times (\text{their } q)$ or $[P(40)] = 3 \times (\text{their } p) \times (\text{their } q)^2$ must see values substituted and must be using their values from part (c)			
	M1	$[P(30)] = 3 \times (\text{their } p)^2 \times (\text{their } q)$ and $[P(40)] = 3 \times (\text{their } p) \times (\text{their } q)^2$ or use of sum of probabilities = 1 i.e. $c + d = \frac{153}{400}$			
	A1	For $c = \frac{2601}{8000}$ (= 0.325125) and $d = \frac{459}{8000}$ (= 0.057375)			
(e)	B1	For 20 and 50 only (ignore notation used for M)			
	M1	Either $\frac{4913}{8000} + \text{their } c$ or $\frac{27}{8000} + \text{their } d$ for ft answers only values will need to be checked			
	A1ft	For $\frac{3757}{4000}$ oe and $\frac{243}{4000}$ oe Follow through their values for c and d but $P(M = 20) + P(M = 50)$ must sum to 1 (A table is not required).			
	NB	If a and b are reversed then allow $a = 40$ and $b = 30$ – this will mean $p = 0.15$ and $q = 0.85$, $c = \frac{459}{8000}$ $d = \frac{2601}{8000}$			

Question Number	Scheme						Marks														
6 (a)	Box A: $P(1) = \frac{1}{4}$ $P(2) = \frac{3}{4}$ Box B: $P(2) = \frac{1}{5}$ $P(5) = \frac{4}{5}$						B1														
	Totals (T) 5, 6, 8, 9, 11, 12						B1														
	(1, 2, 2) (1, 2, 5) (1, 5, 5) (2, 2, 2) (2, 2, 5) (2, 5, 5) [(1, 5, 2)] [(2, 5, 2)]						B1														
	$[P(T = 5) =]\frac{1}{4} \times \frac{1}{5} \times \frac{1}{5} = \left[\frac{1}{100}\right]$ $[P(T = 6) =]\frac{3}{4} \times \frac{1}{5} \times \frac{1}{5} = \left[\frac{3}{100}\right]$						M1 M1 M1														
	$[P(T = 8) =]2 \times \frac{1}{4} \times \frac{1}{5} \times \frac{4}{5} = \left[\frac{8}{100}\right]$ $[P(T = 9) =]2 \times \frac{3}{4} \times \frac{1}{5} \times \frac{4}{5} = \left[\frac{24}{100}\right]$																				
	$[P(T = 11) =]\frac{1}{4} \times \frac{4}{5} \times \frac{4}{5} = \left[\frac{16}{100}\right]$ $[P(T = 12) =]\frac{3}{4} \times \frac{4}{5} \times \frac{4}{5} = \left[\frac{48}{100}\right]$																				
	<table><tr><td>t</td><td>5</td><td>6</td><td>8</td><td>9</td><td>11</td><td>12</td></tr><tr><td>P(T = t)</td><td>$\frac{1}{100}$</td><td>$\frac{3}{100}$</td><td>$\frac{8}{100} \left[= \frac{2}{25} \right]$</td><td>$\frac{24}{100} \left[= \frac{6}{25} \right]$</td><td>$\frac{16}{100} \left[= \frac{4}{25} \right]$</td><td>$\frac{48}{100} \left[= \frac{12}{25} \right]$</td></tr></table>						t	5	6	8	9	11	12	P(T = t)	$\frac{1}{100}$	$\frac{3}{100}$	$\frac{8}{100} \left[= \frac{2}{25} \right]$	$\frac{24}{100} \left[= \frac{6}{25} \right]$	$\frac{16}{100} \left[= \frac{4}{25} \right]$	$\frac{48}{100} \left[= \frac{12}{25} \right]$	A1
	t	5	6	8	9	11	12														
P(T = t)	$\frac{1}{100}$	$\frac{3}{100}$	$\frac{8}{100} \left[= \frac{2}{25} \right]$	$\frac{24}{100} \left[= \frac{6}{25} \right]$	$\frac{16}{100} \left[= \frac{4}{25} \right]$	$\frac{48}{100} \left[= \frac{12}{25} \right]$															
						(7)															
(b)	$m = 2$ $m = 5$						B1														
	$[P(M = 2) =]\frac{1}{100} + \frac{8}{100} + \frac{3}{100} + \frac{24}{100} = \left[\frac{36}{100}\right]$						M1														
	$[P(M = 5) =]\frac{16}{100} + \frac{48}{100} = \left[\frac{64}{100}\right]$ or $P(M = 5) = 1 - P(M = 2)$						M1														
	<table><tr><td>m</td><td>2</td><td>5</td></tr><tr><td>P(M = m)</td><td>$\frac{36}{100}$</td><td>$\frac{64}{100}$</td></tr></table>						m	2	5	P(M = m)	$\frac{36}{100}$	$\frac{64}{100}$	A1								
m	2	5																			
P(M = m)	$\frac{36}{100}$	$\frac{64}{100}$																			
						(4)															
Notes						Total 11															
(a)	B1	All 4 correct probabilities – may be seen in an equation																			
	B1	All 6 totals correct with no extras (ignore units if stated) (condone 8 or 9 listed twice)																			
	B1	All 6 basic combinations correct, either seen or used (implied by the 3 rd M1 mark) Condone any permutation of the 6 basic combinations for this mark																			
	M1	Correct method for one probability (ft their probabilities)																			
	M1	Correct method for five probabilities (ft their probabilities)																			
	M1	Correct method for all six probabilities (ft their probabilities)																			
	A1	cao Need not be in a table but probabilities must be attached to the correct total																			
(b)	B1	For both values of m (no extras) If m = 1 is stated it must be stated that its probability is 0																			
	M1	Ft part (a) For a correct method to find P(M = ‘2’) For this mark there must only be 2 probability calculations																			
	M1	Ft part (a) For a correct method to find P(M = ‘5’) For this mark there must only be 2 probability calculations																			
	A1	cao Need not be in a table but probabilities must be attached to the correct total																			

Question Number	Scheme				Marks
2(i)(a)	μ is not (a statistic) as it is an unknown (parameter)				B1
(b)	$\bar{x}$ is (a statistic) as it is based on (known) observations .				B1
					(2)
(ii)	Outcomes $Y_1 = 2, Y_2 = 5$ or $Y_1 = 2, Y_2 = 6$ or $Y_1 = 5, Y_2 = 6$ oe only				M1
	$P(Y_1 < Y_2) = \frac{1}{3} \times \frac{1}{4} + \frac{1}{3} \times \frac{5}{12} + \frac{1}{4} \times \frac{5}{12} \left(= \frac{1}{3} \times \frac{2}{3} + \frac{1}{4} \times \frac{5}{12} \right)$				M1
	$= \frac{47}{144} = 0.32638\dots$				A1
	awrt 0.326				
					(3)
(iii)(a)	Possible ordered outputs (3, 4), (3, 5), (4, 3), (4, 5), (5, 3), (5, 4)				B1
					(1)
(b)	{10, 11, 13, 14}				M1, A1
					(2)
(c)	Probability of any one outcome $= \frac{1}{6}$ oe				B1
	t	10	11	13	14
	$P(T = t)$	$\frac{1}{6}$	$\frac{1}{3}$	$\frac{1}{3}$	$\frac{1}{6}$
					M1A1
					(3)
Notes					Total 11
		Mark (i)(a) and (i)(b) together			
(i)(a)	B1	correct answer and valid reason that μ is either (usually) unknown or a population parameter oe			
(i)(b)	B1	correct answer and valid reason suggests one of the following that $\bar{x}$ is - based (solely) on observations/calculations/values/information/data/a function oe - contains no unknown population parameters - calculated/measured - numerical property of a sample/derived from a sample Do not allow “it is a statistic because it is known”			
		SC B1B0 for μ is not a statistic and $\bar{x}$ is a statistic stated or with insufficient/incorrect reasoning			
(ii)	M1	correct outcomes stated or implied and no extras. Accept (2, 5) (2, 6) (5, 6) or e.g. $2 < 5, 2 < 6, 5 < 6$ May consider all outcomes but indicate the rows which are required. Condone the order the other way round for the pairs i.e. (5, 2) (6, 2) (6, 5)			
	M1	at least two correct products. If $\frac{1}{3} \times \frac{2}{3}$ oe is seen then this is sufficient for M1			
	A1	awrt 0.326 Correct answer 3/3			
		Mark (iii)(a), (iii)(b) and (iii)(c) together			
(iii)(a)	B1	Ordered outputs stated or may be seen e.g. in a list/table but not within calculations and no extras. Cannot be implied by their final table in (c). Check by the question for their combinations. Isw if the 6 combinations are stated but they subsequently write 7, 8 and 9 (the sums of the combinations). Do not accept (3, 4) $\times$ 2 (3, 5) $\times$ 2, (5, 4) $\times$ 2			

(iii)(b)	M1	at least 2 correct values from 10, 11, 13 and 14 (accept any list form or within a table as part of their calculations). Condone repeats/extras <i>Condone with replacement at least 2 correct values from 9, 10, 11, 12, 13, 14 and 15</i>						
	A1	all correct and no extras/repeats removed. May be implied by final table in (c)						
(iii)(c)	B1	probability of $\frac{1}{6}$ or equivalent calculation eg $\frac{1}{3} \times \frac{1}{2}$. May be implied by a correct probability for one of the values in the table.						
	M1	at least 2 correct probabilities or calculations correctly paired with the correct values of t <i>Condone with replacement at least 2 from:</i>						
		t	9	10	11	12	13	14
	A1	$P(T=t)$	$\frac{1}{9}$	$\frac{1}{9}$	$\frac{2}{9}$	$\frac{1}{9}$	$\frac{2}{9}$	$\frac{1}{9}$
		fully correct. Need not be in a table but must have a correct probability associated with correct value. Condone a different variable to T eg X a correct table with no incorrect working seen implies full marks for (iii)(b) and (iii)(c)						

Question	Scheme	Marks						
7. (a)	$Y \sim B(20, p)$ $p = P(\text{sample contains counter with a 9 on it})$ $p = \left(1 - \frac{9}{10} \times \frac{8}{9} \times \frac{7}{8}\right)$ oe or $\left(\frac{1}{10} \times \frac{9}{9} \times \frac{8}{8} \times 3\right)$ oe or $\left(\frac{6}{10} \times \frac{5}{9} \times \frac{1}{8} \times 3 + \frac{6}{10} \times \frac{3}{9} \times \frac{1}{8} \times 6 + \frac{3}{10} \times \frac{2}{9} \times \frac{1}{8} \times 3\right)$ oe $\left[= \frac{3}{10} \right]$	M1A1						
(i)	$E(Y) = 20 \times \frac{3}{10} = 6$	B1						
(ii)	$\text{Var}(Y) = 20 \times \frac{3}{10} \times \left(1 - \frac{3}{10}\right) = 4.2$	M1A1						
		(5)						
(b)	$(7, 7, 7)$ $(7, 7, 8), [(7, 8, 7), (8, 7, 7)]$ $(7, 7, 9), [(7, 9, 7), (9, 7, 7)]$	B2						
		(2)						
(c)	<table border="1"> <tr> <td>m</td><td>7</td><td>8</td></tr> <tr> <td>$P(M = m)$</td><td> $\frac{6}{10} \times \frac{5}{9} \times \frac{4}{8} + 3 \times \frac{6}{10} \times \frac{5}{9} \times \frac{3}{8} + 3 \times \frac{6}{10} \times \frac{5}{9} \times \frac{1}{8}$ $= \frac{2}{3}$ </td><td> $1 - P(M = 1)$ $= \frac{1}{3}$ </td></tr> </table>	m	7	8	$P(M = m)$	$\frac{6}{10} \times \frac{5}{9} \times \frac{4}{8} + 3 \times \frac{6}{10} \times \frac{5}{9} \times \frac{3}{8} + 3 \times \frac{6}{10} \times \frac{5}{9} \times \frac{1}{8}$ $= \frac{2}{3}$	$1 - P(M = 1)$ $= \frac{1}{3}$	B1 M1 M1 A1 A1 (5)
m	7	8						
$P(M = m)$	$\frac{6}{10} \times \frac{5}{9} \times \frac{4}{8} + 3 \times \frac{6}{10} \times \frac{5}{9} \times \frac{3}{8} + 3 \times \frac{6}{10} \times \frac{5}{9} \times \frac{1}{8}$ $= \frac{2}{3}$	$1 - P(M = 1)$ $= \frac{1}{3}$						
	Notes	[Total 12]						
(a)	1 st M1 For all methods condone missing $\times 3$ and/or $\times 6$ Allow $\frac{{}^1C_1 {}^9C_2}{{}^{10}C_3}$ oe Condone with replacement - condone missing $\times 3$ and/or $\times 6$ $1 - \left(\frac{9}{10}\right)^3$ or $\left(\frac{6}{10}\right)^2 \times \frac{1}{10} \times 3 + \frac{6}{10} \times \frac{3}{10} \times \frac{1}{10} \times 6 + \left(\frac{3}{10}\right)^2 \times \frac{1}{10} \times 3 + \dots$ [=0.271] 1 st A1 A fully correct expression without replacement or 0.3 NB $E(Y) = 6$ implies the 1 st M1 1 st A1 (i) B1 for $20 \times$ probability – no need to calculate and (ii) 2 nd M1 Use of $np(1-p)$ or $np\left(1 - \frac{np}{20}\right)$ 2 nd A1 variance = 4.2							
(b)	B1B1 all 3 correct (with none incorrect – ignore arrangements of the correct numbers) (B1B0 any one correct and no incorrect or 2 or 3 correct and only one incorrect) These can be awarded in part (c) provided that they are clearly identified as having a median of 7 More than one incorrect is B0B0							
(c)	B1 for identifying that the only possible medians are 7 and 8. Allow 9 if it has a probability of 0 1 st M1 correct expression for $P(M = 7)$ Implied by $2/3$ or $P(M = 8)$ Implied by $1/3$ $P(M = 8) = \frac{3}{10} \times \frac{2}{9} \times \frac{1}{8} + 3 \times \frac{6}{10} \times \frac{3}{9} \times \frac{2}{8} + 3 \times \frac{3}{10} \times \frac{2}{9} \times \frac{1}{8} + 6 \times \frac{6}{10} \times \frac{3}{9} \times \frac{1}{8}$ Condone with replacement $P(M = 7) = \left(\frac{6}{10}\right)^3 + 3 \times \left(\frac{6}{10}\right)^2 \times \frac{3}{10} + 3 \times \left(\frac{6}{10}\right)^2 \times \frac{1}{10} \left[= \frac{81}{125} = 0.648 \right]$ or $P(M = 8) = \left(\frac{3}{10}\right)^3 + 3 \times \frac{6}{10} \times \left(\frac{3}{10}\right)^2 + 3 \times \left(\frac{3}{10}\right)^2 \times \frac{1}{10} + 6 \times \frac{6}{10} \times \frac{3}{10} \times \frac{1}{10} \left[= \frac{81}{250} = 0.324 \right]$ 2 nd M1 Total of the 2 probabilities for 7 and 8 = 1 or a correct expression without replacement for both $P(M = 7)$ and $P(M = 8)$ condone with replacement 1 st A1 $P(M = 7) = \frac{2}{3}$ oe 2 nd A1 $P(M = 8) = \frac{1}{3}$ oe							