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EDEXCEL A LEVEL MATHEMATICS: QUESTIONS BY TOPIC

Probability (13)

A Level Mathematics Topic 13

22 questions · 207 marks · Mark schemes included

Pearson Edexcel A Level Mathematics (9MA0), June 2018 - June 2025

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HOW TO USE THIS BOOKLET

Questions are grouped by specification sub-topic and run from the lowest mark tariff to the highest within each one.

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.

Diagrams, graphs, tables and data are printed exactly as they appeared in the original papers.

QUESTION	SOURCE	MARKS	PAGE
13.1	MUTUALLY EXCLUSIVE AND INDEPENDENT EVENTS	13 Qs · 116 marks	3
1. Q1	Paper 3: Statistics and Mechanics June2022	6	4
2. Q1	Paper 3: Statistics and Mechanics June2023	6	6
3. Q4 <i>also Topic 11 & 15</i>	Paper 3: Statistics and Mechanics June2022	6	8
4. Q4 <i>also Topic 11 & 15</i>	Paper 3: Statistics and Mechanics June2024	6	10
5. Q1 <i>also Topic 11</i>	Paper 3: Statistics and Mechanics November2021	7	12
6. Q6 <i>also Topic 14</i>	Paper 3: Statistics and Mechanics November2021	7	14
7. Q5 <i>also Topic 14</i>	Paper 3: Statistics and Mechanics June2023	8	17
8. Q2 <i>also Topic 11</i>	Paper 3: Statistics and Mechanics June2023	9	21
9. Q4 <i>also Topic 11 & 12 & 14</i>	Paper 3: Statistics and Mechanics June2019	9	25
10. Q4 <i>also Topic 14</i>	Paper 3: Statistics and Mechanics October2020	10	29
11. Q5 <i>also Topic 11 & 12 & 14</i>	Paper 3: Statistics and Mechanics June2019	13	33
12. Q5 <i>also Topic 11 & 12 & 14</i>	Paper 3: Statistics and Mechanics June2018	14	36
13. Q5 <i>also Topic 11 & 12 & 14 & 15</i>	Paper 3: Statistics and Mechanics October2020	15	40
13.2	CONDITIONAL PROBABILITY	8 Qs · 80 marks	45
14. Q1	Paper 3: Statistics and Mechanics June2019	8	46
15. Q1	Paper 3: Statistics and Mechanics October2020	8	50
16. Q5	Paper 3: Statistics and Mechanics June2022	10	52
17. Q4	Paper 3: Statistics and Mechanics November2021	11	56
18. Q5 <i>also Topic 11 & 12</i>	Paper 3: Statistics and Mechanics November2021	11	60
19. Q6	Paper 3: Statistics and Mechanics June2024	11	64
20. Q2 <i>also Topic 11 & 12</i>	Paper 3: Statistics and Mechanics June2022	12	67
21. Q1	Paper 3: Statistics and Mechanics June2025	9	71
13.3	PROBABILITY MODELS	1 Qs · 11 marks	73
22. Q3	Paper 3: Statistics and Mechanics June2018	11	74



QUESTIONS

22 questions · 207 marks · 3 sub-topics



SUB-TOPIC 13.1

MUTUALLY EXCLUSIVE AND INDEPENDENT EVENTS

Sub-topic 13.1 · 13 questions · 116 marks · lowest tariff first



- George throws a ball at a target 15 times.
Each time George throws the ball, the probability of the ball hitting the target is 0.48

The random variable X represents the number of times George hits the target in 15 throws.

- (a) Find

(i) $P(X = 3)$

(ii) $P(X \geq 5)$

(3)

George now throws the ball at the target 250 times.

- (b) Use a normal approximation to calculate the probability that he will hit the target more than 110 times.

(3)

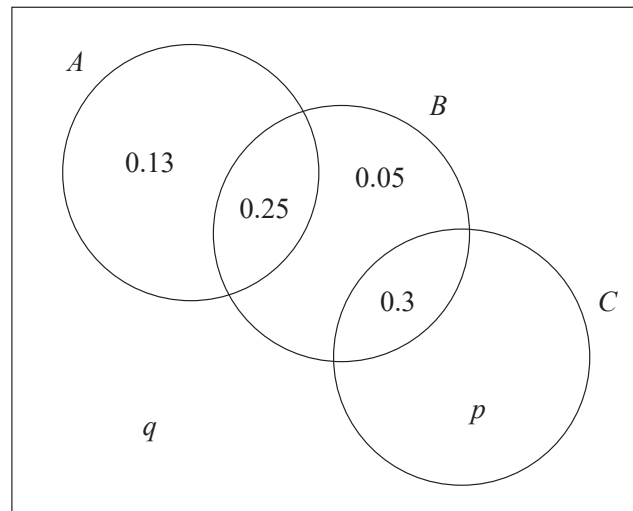


Question 1 continued

(Total for Question 1 is 6 marks)



1. The Venn diagram, where p and q are probabilities, shows the three events A , B and C and their associated probabilities.



- (a) Find $P(A)$

(1)

The events B and C are independent.

- (b) Find the value of p and the value of q

(3)

- (c) Find $P(A|B')$

(2)

Question 1 continued

(Total for Question 1 is 6 marks)



Question 4 continued

(Total for Question 4 is 6 marks)



4. The proportion of left-handed adults in a country is 10%
 Freya believes that the proportion of left-handed adults under the age of 25 in this country is different from 10%
 She takes a random sample of 40 adults under the age of 25 from this country to investigate her belief.

- (a) Find the critical region for a suitable test to assess Freya's belief.

You should

- state your hypotheses clearly
- use a 5% level of significance
- state the probability of rejection in each tail

(4)

- (b) Write down the actual significance level of your test in part (a)

(1)

In Freya's sample 7 adults were left-handed.

- (c) With reference to your answer in part (a) comment on Freya's belief.

(1)

[illegible]

Question 4 continued

(Total for Question 4 is 6 marks)



1. (a) State one disadvantage of using quota sampling compared with simple random sampling.

(1)

In a university 8% of students are members of the university dance club.

A random sample of 36 students is taken from the university.

The random variable X represents the number of these students who are members of the dance club.

- (b) Using a suitable model for X , find

(i) $P(X = 4)$

(ii) $P(X \geq 7)$

(3)

Only 40% of the university dance club members can dance the tango.

- (c) Find the probability that a student is a member of the university dance club and can dance the tango.

(1)

A random sample of 50 students is taken from the university.

- (d) Find the probability that fewer than 3 of these students are members of the university dance club and can dance the tango.

(2)

Question 1 continued.

(Total for Question 1 is 7 marks)



6. The discrete random variable X has the following probability distribution

x	a	b	c
$P(X=x)$	$\log_{36} a$	$\log_{36} b$	$\log_{36} c$

where

- a, b and c are distinct integers ($a < b < c$)
- all the probabilities are greater than zero

(a) Find

- (i) the value of a
- (ii) the value of b
- (iii) the value of c

Show your working clearly.

(5)

The independent random variables X_1 and X_2 each have the same distribution as X

(b) Find $P(X_1 = X_2)$

(2)



Question 6 continued.



(Total for Question 6 is 7 marks)



5. Tisam is playing a game.
She uses a ball, a cup and a spinner.

The random variable X represents the number the spinner lands on when it is spun.
The probability distribution of X is given in the following table

x	20	50	80	100
$P(X = x)$	a	b	c	d

where a , b , c and d are probabilities.

To play the game

- the spinner is spun to obtain a value of x
- Tisam then stands x cm from the cup and tries to throw the ball into the cup

The event S represents the event that Tisam successfully throws the ball into the cup.

To model this game Tisam assumes that

- $P(S | \{X = x\}) = \frac{k}{x}$ where k is a constant
- $P(S \cap \{X = x\})$ should be the same whatever value of x is obtained from the spinner

Using Tisam's model,

(a) show that $c = \frac{8}{5}b$ (2)

(b) find the probability distribution of X (5)

Nav tries, a large number of times, to throw the ball into the cup from a distance of 100 cm.

He successfully gets the ball in the cup 30% of the time.

(c) State, giving a reason, why Tisam's model of this game is not suitable to describe Nav playing the game for all values of X (1)

Question 5 continued



Question 5 continued



Question 5 continued

(Total for Question 5 is 8 marks)



2. A machine fills packets with sweets and $\frac{1}{7}$ of the packets also contain a prize.

The packets of sweets are placed in boxes before being delivered to shops.
There are 40 packets of sweets in each box.

The random variable T represents the number of packets of sweets that contain a prize in each box.

- (a) State a condition needed for T to be modelled by $B(40, \frac{1}{7})$ (1)

A box is selected at random.

- (b) Using $T \sim B(40, \frac{1}{7})$ find
- (i) the probability that the box has exactly 6 packets containing a prize,
 - (ii) the probability that the box has fewer than 3 packets containing a prize.
- (2)**

Kamil's sweet shop buys 5 boxes of these sweets.

- (c) Find the probability that exactly 2 of these 5 boxes have fewer than 3 packets containing a prize. (2)

Kamil claims that the proportion of packets containing a prize is less than $\frac{1}{7}$

A random sample of 110 packets is taken and 9 packets contain a prize.

- (d) Use a suitable test to assess Kamil's claim.
You should
- state your hypotheses clearly
 - use a 5% level of significance
- (4)**

Question 2 continued



Question 2 continued



Question 2 continued

(Total for Question 2 is 9 marks)



4. Magali is studying the mean total cloud cover, in oktas, for Leuchars in 1987 using data from the large data set. The daily mean total cloud cover for all 184 days from the large data set is summarised in the table below.

Daily mean total cloud cover (oktas)	0	1	2	3	4	5	6	7	8
Frequency (number of days)	0	1	4	7	10	30	52	52	28

One of the 184 days is selected at random.

- (a) Find the probability that it has a daily mean total cloud cover of 6 or greater.

(1)

Magali is investigating whether the daily mean total cloud cover can be modelled using a binomial distribution.

She uses the random variable X to denote the daily mean total cloud cover and believes that $X \sim B(8, 0.76)$

Using Magali's model,

- (b) (i) find $P(X \geq 6)$

(2)

- (ii) find, to 1 decimal place, the expected number of days in a sample of 184 days with a daily mean total cloud cover of 7

(2)

- (c) Explain whether or not your answers to part (b) support the use of Magali's model.

(1)

There were 28 days that had a daily mean total cloud cover of 8

For these 28 days the daily mean total cloud cover for the **following** day is shown in the table below.

Daily mean total cloud cover (oktas)	0	1	2	3	4	5	6	7	8
Frequency (number of days)	0	0	1	1	2	1	5	9	9

- (d) Find the proportion of these days when the daily mean total cloud cover was 6 or greater.

(1)

- (e) Comment on Magali's model in light of your answer to part (d).

(2)



Question 4 continued

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Question 4 continued

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Question 4 continued

(Total for Question 4 is 9 marks)



Question 4 continued



Question 4 continued



Question 4 continued

(Total for Question 4 is 10 marks)



5. A machine puts liquid into bottles of perfume. The amount of liquid put into each bottle, D ml, follows a normal distribution with mean 25 ml

Given that 15% of bottles contain less than 24.63 ml

- (a) find, to 2 decimal places, the value of k such that $P(24.63 < D < k) = 0.45$

(5)

A random sample of 200 bottles is taken.

- (b) Using a normal approximation, find the probability that fewer than half of these bottles contain between 24.63 ml and k ml

(3)

The machine is adjusted so that the standard deviation of the liquid put in the bottles is now 0.16 ml

Following the adjustments, Hannah believes that the mean amount of liquid put in each bottle is less than 25 ml

She takes a random sample of 20 bottles and finds the mean amount of liquid to be 24.94 ml

- (c) Test Hannah's belief at the 5% level of significance.
You should state your hypotheses clearly.

(6)

Question 5 continued

[illegible]

Question 5 continued

(Total for Question 5 is 13 marks)



Question 5 continued



Question 5 continued



Question 5 continued

(Total for Question 5 is 14 marks)



Question 5 continued



Question 5 continued



Question 5 continued



Question 5 continued

(Total for Question 5 is 15 marks)



SUB-TOPIC 13.2

CONDITIONAL PROBABILITY

Sub-topic 13.2 · 8 questions · 80 marks · lowest tariff first



- Bag *A* contains 1 red marble and 9 green marbles only
 Bag *B* contains 1 red marble and 4 green marbles only
 Bag *C* contains 1 red marble and 2 green marbles only

If the marble is green, he continues by selecting at random one marble from bag C .

- (2)

- (2)

- (2)

- (2)

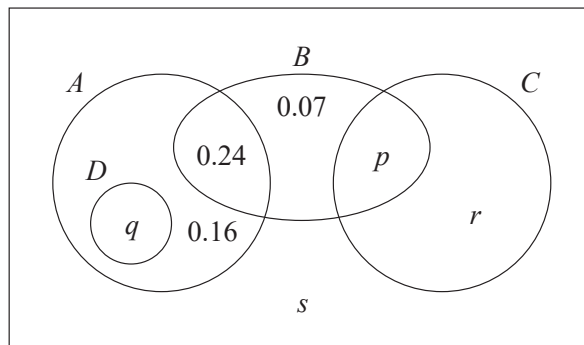
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This image shows a full page of blank, lined paper. It features approximately 28 horizontal blue or grey lines spaced evenly apart, typical of notebook paper. The lines extend across the entire width of the page, leaving small margins at the top and bottom. There are no vertical lines, text, or other markings on the page.

(Total for Question 1 is 8 marks)

1. The Venn diagram shows the probabilities associated with four events, A , B , C and D



- (a) Write down any pair of mutually exclusive events from A , B , C and D

(1)

Given that $P(B) = 0.4$

- (b) find the value of p

(1)

Given also that A and B are independent

- (c) find the value of q

(2)

Given further that $P(B' | C) = 0.64$

- (d) find

- (i) the value of r
- (ii) the value of s

(4)

(Total for Question 1 is 8 marks)



5. A company has 1825 employees.
The employees are classified as professional, skilled or elementary.

The following table shows

- the number of employees in each classification
- the two areas, A or B , where the employees live

	A	B
Professional	740	380
Skilled	275	90
Elementary	260	80

An employee is chosen at random.

Find the probability that this employee

(a) is skilled,

(1)

(b) lives in area B and is not a professional.

(1)

Some classifications of employees are more likely to work from home.

- 65% of professional employees in both area A and area B work from home
- 40% of skilled employees in both area A and area B work from home
- 5% of elementary employees in both area A and area B work from home
- Event F is that the employee is a professional
- Event H is that the employee works from home
- Event R is that the employee is from area A

(c) Using this information, complete the Venn diagram on the opposite page.

(4)

(d) Find $P(R' \cap F)$

(1)

(e) Find $P([H \cup R]')$

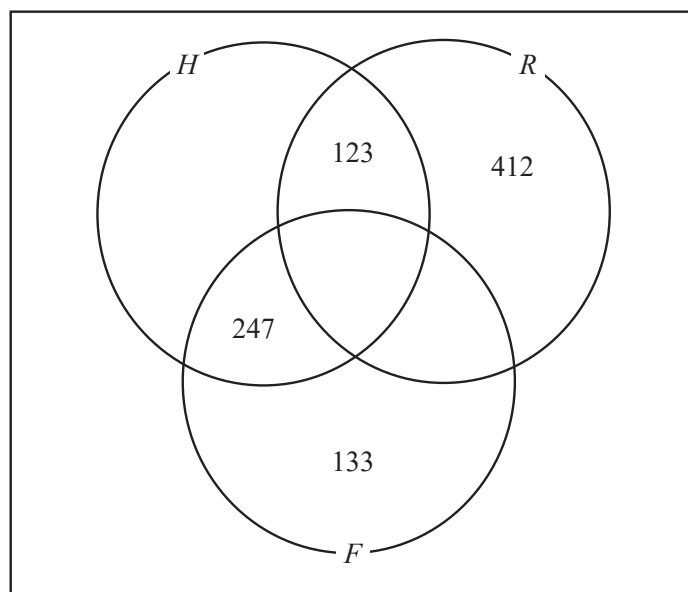
(1)

(f) Find $P(F | H)$

(2)



Question 5 continued

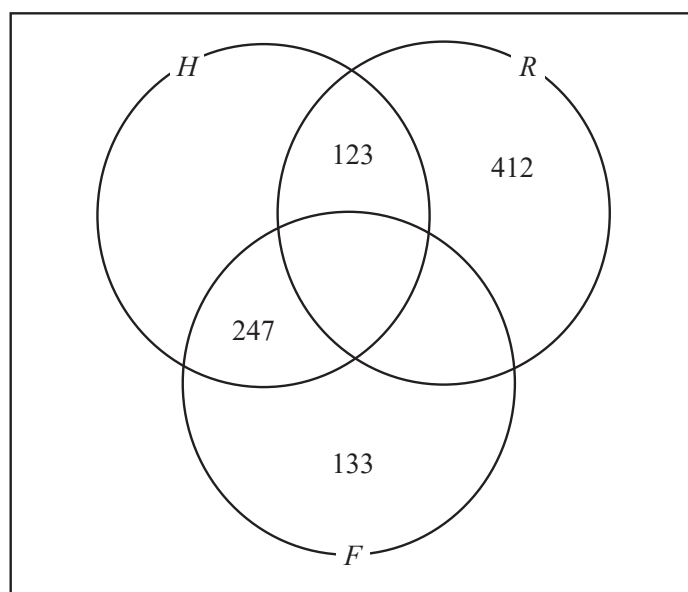


Turn over for a spare diagram if you need to redraw your Venn diagram.



Question 5 continued

Only use this diagram if you need to redraw your Venn diagram.



(Total for Question 5 is 10 marks)

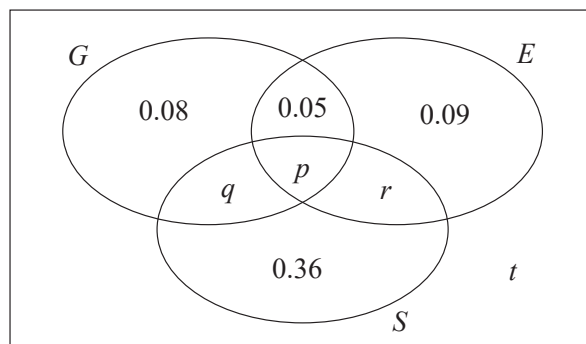
4. A large college produces three magazines. One magazine is about green issues, one is about equality and one is about sports. A student at the college is selected at random and the events G , E and S are defined as follows

G is the event that the student reads the magazine about green issues

E is the event that the student reads the magazine about equality

S is the event that the student reads the magazine about sports

The Venn diagram, where p , q , r and t are probabilities, gives the probability for each subset.



- (a) Find the proportion of students in the college who read exactly one of these magazines.

(1)

No students read all three magazines and $P(G) = 0.25$

- (b) Find

(i) the value of p

(ii) the value of q

(3)

Given that $P(S | E) = \frac{5}{12}$

- (c) find

(i) the value of r

(ii) the value of t

(4)

- (d) Determine whether or not the events $(S \cap E')$ and G are independent. Show your working clearly.

(3)



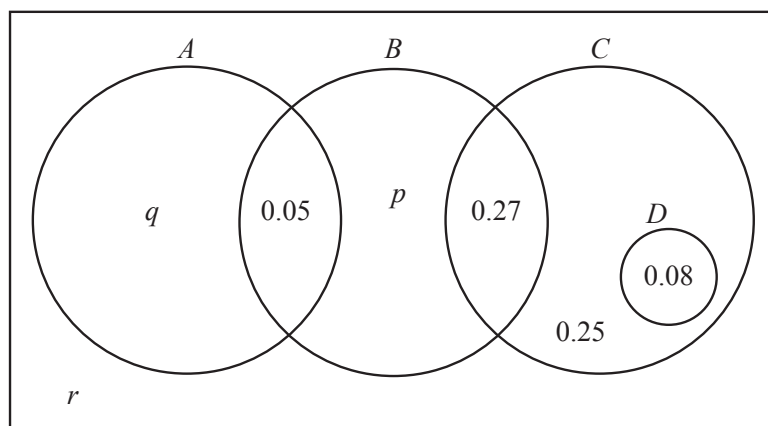


(Total for Question 4 is 11 marks)





6. The Venn diagram, where p , q and r are probabilities, shows the events A , B , C and D and associated probabilities.



- (a) State any pair of mutually exclusive events from A , B , C and D

(1)

The events B and C are independent.

- (b) Find the value of p

(2)

- (c) Find the greatest possible value of $P(A | B')$

(3)

Given that $P(B | A') = 0.5$

- (d) find the value of q and the value of r

(3)

- (e) Find $P\left([A \cup B]' \cap C\right)$

(1)

- (f) Use set notation to write an expression for the event with probability p

(1)

[illegible]



(Total for Question 6 is 11 marks)

(Total for Question 6 is 11 marks)





(Total for Question 2 is 12 marks)

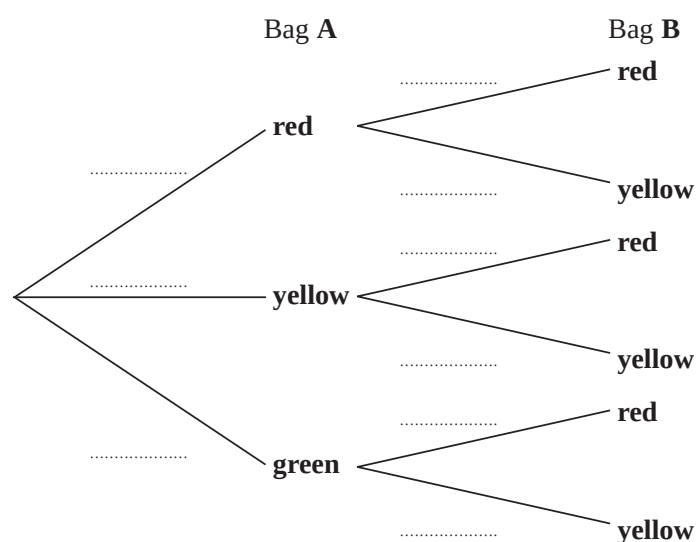
1. Bag **A** contains 5 red, 4 yellow and 3 green beads.

Bag **B** only contains red and yellow beads.

A bead is selected at random from bag **A** and a second bead is selected at random from bag **B**

Given that the probability that both beads selected are yellow is $\frac{3}{16}$

- (a) (i) find the probability of selecting a yellow bead from bag **B** (2)
- (ii) Hence complete the tree diagram below by finding the probability on each branch.



(2)

- (b) Find the exact probability that at least one of the two beads selected is yellow.

(3)

The event X is that at least one of the beads selected is yellow.

The event W is that a green bead is selected.

- (c) Find the exact value of $P(W|X)$ (2)

(Total for Question 1 is 5 marks)



SUB-TOPIC 13.3

PROBABILITY MODELS

Sub-topic 13.3 · 1 question · 11 marks · lowest tariff first







MARK SCHEMES

official mark schemes



Question	Scheme		Marks	AOs
1(a)(i)	$X \sim B(15, 0.48)$		M1	3.3
	$P(X = 3) = 0.019668...$ awrt 0.0197		A1	3.4
(ii)	$[P(X \geq 5) = 1 - P(X \leq 4)] = 0.92013...$ awrt 0.920		A1	1.1b
			(3)	
(b)	Y is the number of hits	M is the number of misses		
	$Y \sim N(120, 62.4)$	$M \sim N(130, 62.4)$	B1	3.3
	$P(X > 110) \approx P(Y > 110.5)$	$P(X > 110) \approx P(M < 139.5)$	M1	3.4
	$\left[=P\left(Z > \frac{110.5 - "120"}{\sqrt{"62.4"}}\right) \right]$	$\left[=P\left(Z < \frac{139.5 - "130"}{\sqrt{"62.4"}}\right) \right]$		
	$= 0.88544...$		A1	1.1b
			(3)	
(6 marks)				
Notes:				
(a)	M1	Writing or using the binomial distribution in (i) or (ii) Allow for sight of B(15, 0.48) or in words: <u>binomial</u> with <u>$n = 15$</u> and <u>$p = 0.48$</u> may be implied in (i) or (ii) by one correct answer to 3sf <u>or</u> sight of $P(X \leq 4) = 0.07986...$ i.e. awrt 0.0799. Allow for ${}^{15}C_3 \times 0.48^3 \times 0.52^{12}$ as this is "correct use" Condone B(0.48, 15)		
(i)	A1	awrt 0.0197		
(ii)	A1	awrt 0.920 (Allow 0.92)		
(b)	B1	Setting up a correct Normal model. Allow sight of $N(120, 62.4)$ or $N(130, 62.4)$ or $N\left(120, \frac{312}{5}\right)$ or $N\left(130, \frac{312}{5}\right)$ or may be awarded if used correctly in standardisation or in words: <u>Normal</u> with <u>mean = 120/130</u> and <u>variance = 62.4</u> or sd = $\sqrt{62.4}$ condone $N(120, \sqrt{62.4})$ or $N(130, \sqrt{62.4})$ or sd = 62.4 Look out for $\sigma = \frac{\sqrt{1560}}{5}$ or $\frac{2\sqrt{390}}{5}$ or awrt 7.90 (condone 7.9) This may be implied by sight of 0.897 or 0.8854...		
	M1	Sight of the continuity correction with a normal distribution		
		110.5 or 111.5 or 109.5	139.5 or 140.5 or 138.5	
		NB we will also allow 129.5 or 130.5 or 128.5	NB we will also allow 120.5 or 119.5 or 121.5	
		Continuity correction may be seen in standardisation NB No continuity correction(CC) gives awrt 0.897 which is M0 unless CC seen		
	A1	awrt 0.8854 or awrt 0.885 dependent on sight of >110.5 or <129.5 or <139.5 or >120.5 Allow $\leq$ or $\geq$ instead of $<$ or $>$ NB 0.885548... from B(250, 0.48) scores M0A0		

Qu 1	Scheme	Marks	AO
(a)	$[0.13 + 0.25 =]$ <u>0.38</u>	B1 (1)	1.1b
(b)	Independence implies: e.g. $[P(B \cap C) = P(B) \times P(C) \Rightarrow] \quad 0.3 = (0.3 + 0.05 + 0.25) \times (0.3 + p)$ So $p = \underline{0.2}$ [Sum of probabilities = 1 gives] $q = \underline{0.07}$	M1 A1 B1ft (3)	1.1b 1.1b 1.1b
(c)	$[P(A B') =] \frac{P(A \cap B')}{P(B')} \text{ or } \frac{0.13}{(1 - 0.6) \text{ or } (0.13 + "0.2" + "0.07")}$ $= \frac{13}{40} \text{ or } \underline{\underline{0.325}}$	M1 A1 (2)	1.1b 1.1b
(6 marks)			
Notes			
(a)	B1 for 0.38 (or exact equivalent) If answers are given on Venn Diagram <u>and</u> in the script then the script takes precedence.		
(b)	M1 for a correct equation in p or $P(C)$ only. May be implied by an answer of $p = 0.2$ provided this does not come from incorrect working. Condone missing brackets if they get 0.2 Other rules for independence will give simple rearrangements of this equation.		
Beware	If $p = 0.2$ comes from incorrect working, we've seen $p = \frac{0.6}{0.3} = 0.2$, score M0A0		
	A1 for $p = 0.2$ (or exact equivalent) B1ft for $q = 0.07$ (or exact equivalent) ft their p i.e. $q = 0.27 - "0.2"$ where $0 \leq p \leq 0.27$		
(c)	M1 for a correct ratio of probability expressions <u>or</u> a correct ratio of probabilities ft their values of p and q (provided both probabilities) <u>or</u> letters p and q A1 for 0.325 or exact equivalent. Correct answer only will score 2/2 NB on open this is labelled M1 but treat it as A1		

Question		Scheme	Marks	AOs
4(a)		$H_0: p = 0.1$ $H_1: p \neq 0.1$	B1	2.5
			(1)	
(b)		Use of $X \sim B(50, 0.1)$ implied by sight of one of awrt 0.0052 or awrt 0.9755 or awrt 0.0245	M1	3.4
		Critical regions $X = 0$ or $X \geq 10$	A1	1.1b
		$X = 0$ and $X \geq 10$ plus $P(X = 0) = \text{awrt } 0.0052$ and $P(X \geq 10) = \text{awrt } 0.0245$	A1	1.1b
		SC: Both CR correct with no probabilities and no distribution seen scores M0A1A0		
			(3)	
(c)		0.0297	B1ft	1.1b
			(1)	
(d)		15 is <u>in the critical region</u> therefore there is evidence to support the <u>manager's</u> belief	B1ft	2.2b
			(1)	
(6 marks)				
Notes				
(a)	B1	For both hypotheses in terms of p or π . Connected to H_0 and H_1 correctly Condone 10% but not 10		
(b)	M1	Using correct distribution to find the probability associated with one tail of the CR If the correct distribution is <u>stated</u> (may be seen in part(a)) allow for one tail of the correct CR or one of (awrt 0.025 or awrt 0.005 or awrt 0.975) seen connected to a correct probability statement		
	A1	Lower CR $X = 0$ / $X < 1$ / $X \leq 0$ / [condone eg $P(X = 0)$ labelled as CR] Or Upper CR $X \geq 10$ or $X > 9$ [condone $P(X \geq 10)$ oe labelled as CR]		
	A1	Both CR's correct with the relevant probabilities Allow $\cup$ for "and" and $X > 9$, $X < 1$, $X \leq 0$ [do not allow $P(X = 0)$ or $P(X \geq 10)$ oe] Allow CR in different form eg $(9, \infty)$, $[10, \infty)$		
(c)	B1ft	awrt 0.0297 or 2.97% or ft for the sum of the probabilities in (b) for "their 2 critical regions" if seen. If none seen it must be awrt 0.0297 SC M0 in (b) for a one tail test Allow B1ft for their one tail CR in (b) eg 0.0338 or 0.0245 or 0.0579		
(d)	B1ft	A correct statement about 15 and "their CR" or sight $P(X \geq 15) = 0.0000738...$ and comparison with "their 0.0245" and a compatible correct statement in context. eg There is evidence that there has been a change in the <u>proportion/probability</u> arriving <u>late</u> Condone increase rather than change Do not allow contradicting statements. NB No CR given in (b) then B0		



Qu 4	Scheme	Marks	AO
(a)	$H_0 : p = 0.1$ $H_1 : p \neq 0.1$ [Allow 10% for 0.1]	B1	2.5
	$[X \sim B(40, 0.1)] \Rightarrow P(X = 0) = 0.0148$ [Allow any letter for X]	M1	3.3
	$P(X \geq 9) = 1 - P(X \leq 8) = 1 - 0.9845 = 0.0155$	A1	1.1b
	Critical region is $\{X = 0\} \cup \{X \geq 9\}$ (o.e.)	A1	1.1b
		(4)	
(b)	[“0.0148” + “0.0155”] = 0.0303	B1ft	1.1b
		(1)	
(c)	[Provided 7 is not in their CR]	B1	2.2b
	insufficient evidence to support Freya’s belief	(1)	
		(6 marks)	
Notes			
(a)	Mark (a) and (b) together for sight of the probabilities.		
B1	for both hypotheses in terms of p or π . Must be attached to H_0 and H_1		
M1	for <u>use</u> of the correct model. Implied by sight of at least one probability truncated or rounded to at least 2sf from: 0.0155, 0.0148, 0.0805, 0.9845, 0.9581, 0.9949 Implied by sight of fully correct CR (with no probs) so e.g. $X = 0$, $X > 8$ scores M1A0A0		
1 st A1	for at least one correct probability (to at least 3sf) with its probability statement i.e. for $P(X = 0) = \text{awrt } 0.0148$ <u>or</u> $P(X \geq 9) = \text{awrt } 0.0155$		
2 nd A1	(dep on M1 and 1 st A1 but not on B1) for both correct probs (to at least 3 sf) <u>and</u> the correct critical region Do not need set notation. Allow $X < 1$ and $X > 8$ <u>or</u> words e.g. “0 or greater than 8” etc Allow “,” <u>or</u> “and” <u>or</u> “or” <u>or</u> “ $\cap$ ” between $X \leq 0$ and $X \geq 9$ $P(X = 0)$ and $P(X \geq 9)$ is 2 nd A0		
(b)	B1ft	for awrt 3.03% <u>or</u> correct sum of their two probabilities (provided each is less than 0.5) Their probabilities must be to at least 2sf and relate to their CR	
To score in (c) they must have a CR of the form $(X = 0 \text{ or } X < a)$ and $X > b$, where b is ≥ 7 May be implied by $P(X < a)$ and $P(X > b)$ i.e. 2nd A0 in (a) but correct form. Need $b > a$			
(c)	B1	for a suitable comment in context that suggests <u>no support</u> for Freya’s <u>belief/claim</u> or e.g. <u>insufficient</u> evidence of change in <u>proportion/percentage</u> of <u>left-handed</u> adults or e.g. <u>proportion/percentage</u> of <u>left-handed</u> adults is <u>not different</u> from 10% (or ...is 10%) or e.g. <u>10%</u> of adults in the country are <u>left-handed</u> Do not allow contradictory comments e.g. “in CR so no support for Freya’s belief” is B0	
NB	A correct contextual answer in (c) using an acceptance region please send to review.		



Qu 1	Scheme	Marks	AO												
(a)	Disadvantage: e.g. Not random; cannot use (reliably) for inferences	B1	1.1b												
(b)	[Sight or correct use of] $X \sim B(36, 0.08)$	M1	3.3												
(i)	$P(X = 4) = 0.167387\dots$ awrt <u>0.167</u>	A1	1.1b												
(ii)	$[P(X \dots 7) = 1 - P(X \dots 6) =]$ 0.022233... awrt <u>0.0222</u>	A1	1.1b												
(c)	$P(\text{In dance club and dance tango}) = 0.4 \times 0.08 = \underline{\underline{\mathbf{0.032}}}$ or $\frac{4}{125}$ or <u>3.2%</u>	B1	1.1b												
(d)	[Let T = those who can dance the Tango. Sight or use of] $T \sim B(50, \text{"0.032"})$ $[P(T < 3) = P(T \dots 2) =]$ 0.7850815... awrt <u>0.785</u>	M1 A1	3.3 1.1b												
		(1) (2) (7 marks)													
Notes															
(a)	B1 for a suitable disadvantage: <table><tr><th>Allow (B1)</th><th>Do NOT allow (B0)</th></tr><tr><td>Not random <u>or</u> less random (o.e.)</td><td>Not representative</td></tr><tr><td>Cannot use (reliably) for inferences</td><td>Less accurate</td></tr><tr><td>(More likely to be) biased</td><td>Any comment based on time or cost</td></tr><tr><td></td><td>Any mention of skew</td></tr><tr><td></td><td>Any mention of non-response</td></tr></table>			Allow (B1)	Do NOT allow (B0)	Not random <u>or</u> less random (o.e.)	Not representative	Cannot use (reliably) for inferences	Less accurate	(More likely to be) biased	Any comment based on time or cost		Any mention of skew		Any mention of non-response
Allow (B1)	Do NOT allow (B0)														
Not random <u>or</u> less random (o.e.)	Not representative														
Cannot use (reliably) for inferences	Less accurate														
(More likely to be) biased	Any comment based on time or cost														
	Any mention of skew														
	Any mention of non-response														
(b)	M1 for sight of $B(36, 0.08)$ Allow in words: <u>binomial</u> with $n = 36$ and $p = 0.08$ may be implied by one correct answer to 2sf <u>or</u> sight of $P(X \dots 6) = 0.97776\dots$ i.e. awrt 0.98 Allow for $36C4 \times 0.08^4 \times 0.92^{32}$ as this is "correct use"														
(i)	1 st A1 for awrt 0.167 NB An answer of just awrt 0.167 scores M1($\Rightarrow$) 1 st A1														
(ii)	2 nd A1 for awrt 0.0222														
(c)	B1 for 0.032 o.e. (Can allow for sight of 0.4×0.08)														
(d)	M1 for sight of $B(50, \text{"0.032"})$ ft their answer to (c) provided it is a probability $\neq 0.08$ may be implied by correct answer <u>or</u> sight of $[P(T \dots 3)] = 0.924348\dots$ i.e. awrt 0.924 or $P(T \dots 2)$ as part of $1 - P(T \dots 2)$ calc. A1 for awrt 0.785														
MR	Allow MR of 50 (e.g. 30) provided clearly attempting $P(T \dots 2)$ and score M1A0														

Qu 6	Scheme	Marks	AO	
(a)	[Sum of probs = 1 implies] $\log_{36} a + \log_{36} b + \log_{36} c = 1$	M1	3.1a	
	$\Rightarrow \log_{36}(abc) = 1$ so $abc = 36$	A1	3.4	
	All probabilities greater than 0 implies each of a , b and $c > 1$	B1	2.2a	
	$36 = 2^2 \times 3^2$ (or 3 numbers that multiply to give 36 e.g. 2, 2, 9 etc)	dM1	2.1	
	Since a , b and c are distinct must be <u>2, 3, 6</u> (<u>$a = 2, b = 3, c = 6$</u>)	A1	3.2a	
(b)	$(\log_{36} a)^2 + (\log_{36} b)^2 + (\log_{36} c)^2$ [= 0.0374137...+ 0.09398737...+0.25] = 0.38140... awrt <u>0.381</u>	(5)		
		M1	3.4	
		A1	1.1b	
		(2)		
		(7 marks)		
Notes				
(a)	1 st M1 for a start to the problem using sum of probabilities leading to eq'n in a , b and c			
	1 st A1 for reducing to the equation $abc = 36$ [Must follow from their equation.]			
	NB Can go straight from $abc = 36$ to the answer for full marks for part (a).			
	B1 for deducing that each value > 1 (may be implied by 3 integers all > 1 in the next line)			
	2 nd dM1 (dep on M1A1) for writing 36 as a product of prime factors <u>or</u> 3 values with product = 36 and none = 1			
SC	2 nd A1 for 2, 3 and 6 as a list or $a = 2, b = 3$ and $c = 6$			
	M0M0 If no method marks scored but a correct answer given score: M0A0B1M0A1 (2/5)			
	Ans only This gets the SC score of 2/5 [Question says show your working clearly]			
	(b)	M1 for a correct expression in terms of a , b and c or values; ft their integers a , b and c Condone invisible brackets if the answer implies they are used.		
		A1 for awrt 0.381		

G.B. Attwood 26/10/2021



Qu 5	Scheme	Marks	AO
(a)	$P(S \cap \{X = 50\}) = P(S \cap \{X = 80\}) [= \text{a constant, } V] \Rightarrow b \times \frac{k}{50} = c \times \frac{k}{80}$	M1	3.1a
	May see: $\frac{k}{50} = \frac{V}{b}$ <u>and</u> $\frac{k}{80} = \frac{V}{c}$ (condone any <u>letter</u> for V even S)		
	So $\underline{c = \frac{8}{5}b} \quad *$	A1cso*	1.1b
	(2)		
	(b)	$d = 2b$ or $a = \frac{2}{5}b$ or $c = 4a$ or $d = 5a$ or $d = \frac{5}{4}c$	M1 A1
	$\frac{2}{5}b + b + \frac{8}{5}b + 2b = 1$	M1	2.1
	$\Rightarrow 5b = 1$ so $b = \frac{1}{5}$ (o.e.)	A1	1.1b
	$\underline{a = \frac{2}{25} \quad b = \frac{1}{5} \quad c = \frac{8}{25} \quad d = \frac{2}{5}}$	A1	3.2a
	(5)		
	(c)	[Experiment suggests for Nav] $P(S \mid \{X = 100\}) = 0.3 \Rightarrow k = 30$ or $0.3 = \frac{V}{0.4} \Rightarrow V = 0.12$ So model won't work since $P(S \mid X = 20) = \frac{30}{20}$ <u>or</u> $\frac{0.12}{0.08}$ and so would be greater than 1	B1
		(1)	
		(8 marks)	
Notes			
(a)	M1 for use of $P(S \mid X = x) \times P(X = x)$ for $x = 50$ <u>and</u> $x = 80$ (Must see k or their V) Any expression or equation MUST be based on the probability statements in qu.		
*	A1cso for rearranging to required result, no incorrect work seen, condone poor notation		
NB	Use of values e.g. $b = \frac{50}{20 + 50 + 80 + 100}$ to prove (a) is M0A0 but scores 2 nd M1A1 in (b)		
Marks for (b) may be awarded for work seen in (a)			
(b)	1 st M1 for at least one other relationship (either probability the subject) from the list. 1 st A1 for a second different relationship (either probability the subject) from the list. <u>or</u> Allow for: $\frac{ak}{20} = \frac{bk}{50} = \frac{ck}{80} = \frac{dk}{100}$ for 1 st M1 1 st A1 2 nd M1 for using or stating sum of prob's = 1 May be implied by one correct probability. 2 nd A1 for one correct probability e.g. $b = \frac{1}{5}$ or exact equivalent such as 0.2 3 rd A1 for all correct probabilities. Allow exact equivalents e.g. $c = 0.32$ Sight of correct distribution or list of probs with no obvious incorrect working is 5/5		
(c)	B1 for deducing $k = 30$ and giving a suitable example to show model breaks down		



Qu 2	Scheme	Marks	AO
(a)	Comment in context about either independence or random packing e.g. “prizes must be placed in <u>packets</u> at <u>random/independently</u> of each other” or about constant probability e.g. “the <u>probability</u> of a <u>packet</u> containing a <u>prize</u> is <u>constant/ the same/fixed</u> ”	B1 (1)	3.5b
(b)(i)	$P(T = 6) =]$ 0.17273... awrt 0.173	B1	1.1b
(ii)	$P(T < 3) = P(T \leq 2) =]$ 0.061587... awrt 0.0616	B1 (2)	1.1b
(c)	[K = no. of boxes with fewer than 3 packets containing a prize] $K \sim B(5, “0.0616”)$ $P(K = 2) = 0.031344...$ in the range [0.0313~0.0314]	M1 A1 (2)	1.1b 1.1b
(d)	$H_0 : p = \frac{1}{7}$ $H_1 : p < \frac{1}{7}$ [X = no of packets containing a prize] $X \sim B(110, \frac{1}{7})$ $P(X \leq 9) = 0.038292...$ [Significant result or reject H_0] E.g. there <u>is</u> evidence to <u>support</u> Kamil’s <u>claim</u>	B1 M1 A1 A1 (4)	2.5 3.3 3.4 2.2b
(9 marks)			
Notes			
(a)	B1 May use idea of independent events: a suitable reason, in context , covering idea of <u>random</u> packing or packets filled <u>independently</u> . Should mention key words/ideas of: <u>prizes in packets</u> or <u>packets in boxes</u> May use idea of constant probability. Must see key words underlined in scheme. Idea of probability with “independence” or “not affected by other packets” is B0 B0 for: Idea of only 2 cases. E.g. <u>Packet</u> contains a <u>prize</u> or not or Idea of a fixed number of trials. E.g. Need a <u>fixed</u> number of <u>packets</u> in each <u>box</u>		
(b)(i)	B1 for awrt 0.173		
(ii)	B1 for awrt 0.0616		
(c)	M1 for sight of $B(5, “0.0616”)$ or ${}^5C_2 (“0.0616”)^2 (1 - “0.0616”)^3$ ft their answer to (b)(ii). A1 for an answer in the range [0.0313 to 0.0314] Use of 0.0616 gives 0.031356..ans only 2/2		
(d)	B1 for both hypotheses correct in terms of p or π M1 for selecting an appropriate model, may be implied by 1 st A1 or $P(X = 9) = 0.0199(2...)$ 1 st A1 for 0.038 or better or allow 0.04 with sight of $P(X \leq 9)$		
ALT	Critical Region. Allow CR of $X \leq 9$ (or $X < 10$) provided a supporting probability is seen e.g. A1 for correct CR plus $P(X \leq 10) = 0.0718...$ (accept 2sf or 1sf if prob statement seen) 2 nd A1 (dep on 1 st A1 but indep of hyp’s) for a suitable conclusion in context that suggests <u>support</u> for (Kamil’s) <u>claim</u> or states that there is evidence that <u>proportion</u> / <u>probability/chance</u> of packets containing a <u>prize</u> is less than $\frac{1}{7}$		
Normal	Do not award 2 nd A1 for contradictory statements e.g. “not significant” so “supports claim” Sight of $N\left(\frac{110}{7}, \frac{660}{49}\right)$ or awrt 13.5 or probability of 0.045(20..) or 0.033(66..) scores M1		

Question	Scheme	Marks	AOs
4 (a)	$\frac{132}{184} = 0.71739...$ awrt 0.717	B1	1.1b
		(1)	
(b)(i)	$P(X \geq 6) = 1 - P(X \leq 5)$ or $P([X =]6) + P([X =]7) + P([X =]8)$	M1	3.4
	$= 1 - 0.296722...$ awrt 0.703	A1	1.1b
		(2)	
(b)(ii)	$184 \times P(X = 7)$ [= $184 \times 0.2811...$]	M1	1.1b
	$= 51.7385...$ awrt 51.7	A1	1.1b
		(2)	
(c)	Part (a) and part (b)(i) are similar and the expected number of 7s (51.7 or 0.281) matches with the number of 7s found in the data set (52 or 0.283) so Magali's model is supported.	B1ft	3.5a
		(1)	
(d)	$\frac{23}{28} = 0.82142...$ awrt 0.821	B1	1.1b
		(1)	
(e)	Any one of... - Part (d)/'0.821' differs from part (a)/(b)(i)/(0.7...) - there is a greater/different probability of high cloud cover/more likely to have high cloud cover if the previous day had high cloud cover independence(o.e.) does not hold	B1	2.4
	...therefore Magali's (binomial) model may not be suitable.	dB1	3.5a
		(2)	
(9 marks)			
Notes			
	Allow fractions, decimals or percentages throughout this question.		
(a)	Allow equivalent fraction, e.g. $\frac{33}{46}$		
(b)(i)	M1: for writing or using $1 - P(X \leq 5)$ or $P(X = 6) + P(X = 7) + P(X = 8)$ A1: awrt 0.703 (correct answer scores 2 out of 2)		
(b)(ii)	M1: for $184 \times P(X = 7)$ o.e. e.g., $184 \times [P(X \leq 7) - P(X \leq 6)]$ A1: awrt 51.7		
(c)	B1ft: comparing '0.717' with '0.703' <u>and</u> '51.7' or '0.281' with 52 or 0.283 and concluding that Magali's model is supported (must be comparing prob. with prob. <u>and</u> days with days). Allow not supported or mixed conclusions if consistent with their f.t. answers in (a) and (b)		
(e)	B1: Any bullet point dB1: (dep on previous B1) for Magali's model may not be suitable (o.e.) Condone not accurate for not suitable SC: part (d) is similar to part (a)/(b)(i) and a compatible conclusion (i.e. Magali's model is supported) to score B1B1.		



Qu 4	Scheme	Marks	AO
(a)	$\frac{k}{10} + \frac{k}{20} + \frac{k}{30} + \frac{k}{40} + \frac{k}{50} = 1$ or $\frac{1}{600}(60k + 30k + 20k + 15k + 12k) = 1$ $\text{So } k = \frac{600}{137} \quad (*)$	M1 A1cso	1.1b 1.1b
(b)	(Cases are:) $D_1 = 30, D_2 = 50$ and $D_1 = 50, D_2 = 30$ and $D_1 = 40, D_2 = 40$ $P(D_1 + D_2 = 80) = \frac{k}{50} \times \frac{k}{30} \times 2 + \left(\frac{k}{40}\right)^2$ $= 0.0375619... \text{ awrt } \underline{\underline{0.0376}}$	M1 M1 A1	2.1 3.4 1.1b
(c)	Angles are: $a, a + d, a + 2d, a + 3d$ $S_4 = a + (a + d) + (a + 2d) + (a + 3d) = 360$ $2a + 3d = 180 \text{ (o.e.)}$ Smallest angle is $a > 50$ consider cases: $d = 10$ so $a = 75$ <u>or</u> $d = 20$ so $a = 60$ [$d = 30$ gives $a = 45$ no good] $P(D = 10 \text{ or } 20) = \frac{3k}{20} = \frac{90}{137}$	M1 M1 A1 M1 A1	3.1a 2.1 2.2a 3.1b 1.1b
(5)			
(10 marks)			
Notes			
(a)	M1 for clear use of sum of probabilities = 1 (all terms seen) A1 cso (*) M1 scored and no incorrect working seen. Verify (Assume $k = \frac{600}{137}$) to score the final A1 they must have a <u>final</u> comment " $\therefore k = \frac{600}{137}$ "		
(b)	1 st M1 for selecting at least 2 of the relevant cases (may be implied by their correct probs) e.g. allow 30, 50 and 50,30 i.e. D_1 and D_2 labels not required 2 nd M1 for using the model to obtain a correct expression for two different probabilities. May use letter k or their value for k . $\text{Allow for } \frac{k}{50} \times \frac{k}{30} + \left(\frac{k}{40}\right)^2 \text{ or } 2 \times \left(\frac{k}{50} \times \frac{k}{30} + \left(\frac{k}{40}\right)^2\right)$ A1 for awrt 0.0376 (exact fraction is $\frac{705}{18769}$)		
(c)	1 st M1 for recognising the 4 angles and finding expressions in terms of d and their a 2 nd M1 for using property of quad with these 4 angles (equation can be un-simplified) Allow these two marks for use of a (possible) value of d e.g. $a + a + 10 + a + 20 + a + 30 = 360$ (If at least 3 cases seen allow A1 for e.g. $4a = 300$) <u>or</u> allow M1M1 for a set of 4 angles with sum 360 and possible value of d (3 cases for A1) e.g. (for $d = 20$) 60, 80, 100, 120 1 st A1 for $2a + 3d = 180$ condition (o.e.) [Must be in the form $pa + qd = N$] 3 rd M1 for examining cases and getting $d = 10$ and $d = 20$ only 2 nd A1 for $\frac{90}{137}$ or exact equivalent The correct answer and no obviously incorrect working will score 5/5 A final answer of awrt 0.657 (0.65693...) with no obviously incorrect working scores 4/5		

Question	Scheme	Marks	AOs
5(a)	$\frac{24.63 - 25}{\sigma} = -1.0364$	M1	3.1b
	$[\sigma =]0.357$ (must come from compatible signs)	A1	1.1b
	$P(D > k) = 0.4$ or $P(D < k) = 0.6$	B1	1.1b
	$\frac{k - 25}{0.357} = 0.2533$	M1	3.4
	$k = \text{awrt } \underline{25.09}$	A1	1.1b
		(5)	
(b)	$[Y \sim B(200, 0.45) \rightarrow] W \sim N(90, 49.5)$	B1	3.3
	$P(Y < 100) \approx P(W < 99.5) \left[= P\left(Z < \frac{99.5 - 90}{\sqrt{49.5}}\right) \right]$	M1	3.4
	$= 0.9115...$ awrt <u>0.912</u>	A1	1.1b
		(3)	
(c)	$H_0 : \mu = 25$ $H_1 : \mu < 25$	B1	2.5
	$[\bar{D} \sim N\left(25, \frac{0.16^2}{20}\right)]$	M1	3.3
	$P(\bar{D} < 24.94) [= P(Z < -1.677...)] = 0.046766...$	A1	3.4
	$p = 0.047 < 0.05$ or $z = -1.677... < -1.6449$ or $24.94 < 24.94115...$ or reject H_0 /in the critical region/significant	M1	1.1b
	There is sufficient evidence to support <u>Hannah's belief</u> .	A1	2.2b
		(5)	
(13 marks)			
Notes			
(a)	M1: for standardising 24.63, 25 and ' σ ' (ignore label) and setting = to z where $1 < z < 2$ A1: $[\sigma =]$ awrt 0.36. Do not award this mark if signs are not compatible. B1: for either correct probability statement (may be implied by correct answer) this mark may be scored for a correct region shown on a diagram M1: for a correct expression with $z =$ awrt 0.253 (may be implied by correct answer) A1: awrt 25.09 (Correct answer with no incorrect working scores 5 out of 5)		
(b)	B1: setting up normal distribution approximation of binomial $N(90, 49.5)$ (may be implied by a correct answer) Look out for e.g. $\sigma = \frac{3\sqrt{22}}{2}$ or $\sigma = \text{awrt } 7.04$ M1: attempting a probability using a continuity correction i.e. $P(W < 100.5)$, $P(W < 99.5)$ or $P(W < 98.5)$ condone $\leq$ (The continuity correction may be seen in a standardisation). A1: awrt 0.912 [Note: 0.911299... from binomial scores 0 out of 3]		
(c)	B1: for both hypotheses in terms of μ M1: selecting suitable model must see $N(\text{ormal})$, mean 25, $sd = \frac{0.16}{\sqrt{20}}$ (o.e.) or $var = \frac{4}{3125}$ (o.e.) Condone $N(25, \frac{0.16}{\sqrt{20}})$ if $\frac{0.16}{\sqrt{20}}$ then used as s.d. A1: p value = awrt 0.047 or test statistic awrt -1.68 or CV awrt 24.941 (any of these values imply the M1 provided they do not come from Normal mean = 24.94) M1: a correct comparison (including compatible signs) or correct non-contextual conclusion (f.t. their p value, test statistic or critical value in the comparison) M1 may be implied by a correct contextual statement NB Any contradictory non contextual statements/comparisons score M0A0 e.g. ' $p < 0.05$, not significant' A1: correct conclusion in context mentioning <u>Hannah's belief</u> or the mean <u>amount/liquid</u> in each bottle is now <u>less than 25ml</u> (dep on M1A1M1)		



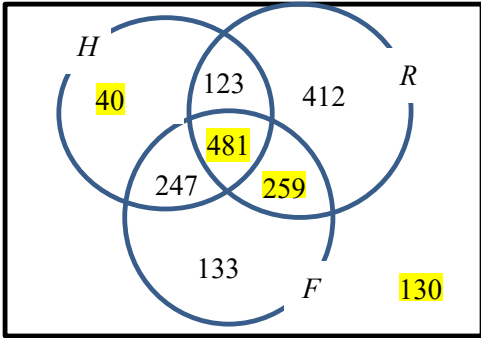
Qu 5	Scheme	Marks	AO
(a)	$P(L > 16) = 0.69146...$ awrt 0.691	B1 (1)	1.1b
(b)	$P(L > 20 L > 16) = \frac{P(L > 20)}{P(L > 16)}$ $= \frac{0.308537...}{(a)} \text{ or } \frac{1-(a)}{(a)}, = 0.44621...$ For calc to work require $(0.44621...) ^4 = 0.03964...$ awrt 0.0396	M1 A1ft, A1 dM1 A1 (5)	3.1b 1.1b 1.1b 2.1 1.1b
(c)	Require: $[P(L > 4)]^2 \times [P(L > 20 L > 16)]^2$ $= (0.99976...) ^2 \times ("0.44621...")^2$ $= 0.19901...$ awrt 0.199 (*)	M1 A1ft A1cso* (3)	1.1a 1.1b 1.1b
(d)	$H_0 : \mu = 18 \quad H_1 : \mu > 18$ $\bar{L} \sim N\left(18, \left(\frac{4}{\sqrt{20}}\right)^2\right)$ $P(\bar{L} > 19.2) = P(Z > 1.3416...) = 0.089856...$ (0.0899 > 5%) or (19.2 < 19.5) or $1.34 < 1.6449$ so not significant Insufficient evidence to support Alice's claim (or belief)	B1 M1 A1 A1 A1 (5)	2.5 3.3 3.4 1.1b 3.5a
(14 marks)			
Notes			
(a)	B1 for evaluating probability using their calculator (awrt 0.691) Accept 0.6915		
(b)	1st M1 for a first step of identifying a suitable conditional probability (either form) 1st A1ft for a ratio of probabilities with numerator = awrt 0.309 or $1 - (a)$ and denom = their (a) 2nd A1 for awrt 0.446 (o.e.) Accept 0.4465 (from $\frac{0.3085}{0.691} = 0.44645...$) NB $\frac{P(16 < L < 20)}{P(L > 16)} = 0.5538...$ scores M1A1A1 when they do $1 - 0.5538 = 0.4462...$ 2nd M1 (dep on 1st M1) for 2nd correct step i.e. (their 0.446...) ⁴ or $X \sim B(4, "0.446")$ and $P(X = 4)$ 3rd A1 for awrt 0.0396		
(c)	1st M1 for a correct approach to solving the problem (May be implied by A1ft) 1st A1ft for $P(L > 4) =$ awrt 0.9998 used <u>and</u> ft their 0.44621 in correct expression If use $P(L > 20) = 0.3085..$ as 0.446.. in (b) then M1 for $(0.3085..) ^2 \times [P(L > 4)]^2$; A1ft as above * 2nd A1cso for 0.199 or better with clear evidence of M1 [NB $(0.4662..) ^2 = 0.199...$ is M0A0A0] Must see M1 scored by correct expression in symbols or values (M1A1ft)		
(d)	B1 for both hypotheses in terms of μ. M1 for selecting a suitable model. Sight of <u>normal</u>, <u>mean</u> 18, <u>sd</u> $\frac{4}{\sqrt{20}}$ (o.e.) or <u>variance</u> = 0.8 1st A1 for using the model correctly. Allow awrt 0.0899 or 0.09 from correct prob. statement		
ALT	CR $(\bar{L}) > 19.471...$ (accept awrt 19.5) or CV of 1.6449 (or better: calc 1.6448536..) 2nd A1 for correct non-contextual conclusion. Wrong comparison or contradictions A0 Error giving 2nd A0 implies 3rd A0 but just a correct contextual conclusion can score A1A1 3rd A1 dep on M1 and 1st A1 for a correct contextual conclusion mentioning <u>Alice's claim</u> /<u>belief</u> or there is insufficient evidence that the mean <u>lifetime</u> is more than 18 hours		

Qu 5	Scheme	Marks	AO
(a)	{ Let X = time spent, $P(X > 15) = \dots$ awrt 0.106	B1 (1)	1.1b
(b)	$H_0: \mu = 10$ $H_1: \mu > 10$ $\bar{X} \sim N\left(10, \left(\frac{4}{\sqrt{20}}\right)^2\right)$; $P(\bar{X} > 11.5) = 0.046766\dots$ [Condone 0.9532...] [This is significant (< 5%) so] there is evidence to support the complaint	B1 M1;A1 A1 (4)	2.5 3.3;3.4 2.2b
(c)(i)	$[P(T < 2) = \dots]$ 0.1956... awrt 0.196	B1 (1)	1.1b
(ii)	Require $\frac{P(0 < T < 2)}{P(T > 0)} = \frac{0.119119\dots}{0.923436\dots}$; = 0.1289955... awrt 0.129	M1 A1;A1 (3)	3.4 1.1bx2
(iii)	The current model suggests non-negligible probability of T values < 0 which is impossible	B1 (1)	3.5b
(d)	Require t such that $P(T > t T > 2) = 0.5$ or $P(T < t T > 2) = 0.5$ e.g. $\frac{P(T > t)}{P(T > 2)} = 0.5$; so $P(T > t) = 0.5 \times [1 - (c)(i)]$ or $P(T > t) = 0.5 \times 0.8043\dots$ [i.e. $P(T > t) = 0.40\dots$ implies] $\frac{t-5}{3.5} = 0.2533$ or $P(T < t) = "0.5978\dots"$ $t = 5.886\dots$ or from calculator 5.867... so awrt 5.9	M1 M1; A1ft M1 A1 (5)	3.1b 1.1b 3.4 1.1b 1.1b
(15 marks)			
Notes			
(a)	B1 for awrt 0.106 (from calculator) [Allow 10.6%]		
(b)	B1 for both hypotheses correct in terms of μ . M1 for selection of a correct model (sight or use of correct normal- may not have label $\bar{X}$) 1 st A1 for use of this model to get probability allow 0.046~0.047 [Condone awrt 0.953]		
ALT	OR test statistic $z = 1.677\dots$ (awrt 1.68) and cv of 1.64 (or better) or CR $\bar{X} > 11.47\dots$		
	2 nd A1 (dep on 1 st A1 or at least $P(\bar{X} > 11.5) < 0.05$ (o.e.))		
	for a correct conclusion in context -must mention complaint /claim or time /mins is > 10		
SC	(M0 for $\bar{X} \sim N(11.5, \dots)$ for correct probability and conclusion (score M0A0A1 on open)		
(c)(i)	B1 for awrt 0.196 (from calculator) [Allow 19.6%]		
(ii)	M1 for a correct probability ratio expression (may be implied by 1 st A1 scored) 1 st A1 for a correct ratio of probabilities (both correct or truncated to 2 dp) 2 nd A1 for awrt 0.129		
(iii)	B1 for a suitable explanation of why model is not suitable based on negative T values Must say that a significant proportion of values < 0 (o.e.) e.g. $P(T > 0)$ should be closer to 1 or Difference between $P(T < 2 T > 0)$ and $P(T < 2)$ is too big (o.e.)		
(d)	1 st M1 for a correct conditional probability statement to start the problem or $0.5 \times P(T > 2)$ 2 nd M1 for correct ratio of probability expressions [Must have $P(T > t)$ or $P(2 < T < t)$] 1 st A1ft for a correct equation for $P(T > t)$ (o.e.) ft their answer to part (c)[May be in a diagram] 3 rd M1 for attempt to find t (standardising and sight of 0.2533) or prepare to use calc (ft) Arriving at $P(T < \text{median}) = 1 - 0.5 \times \text{their } 0.8043$ will score 1 st 4 marks 2 nd A1 for awrt 5.9 Sight of awrt 5.9 and at least one M mark scores 5/5 [Answer only send to review]		



Question	Scheme	Marks	AOs
1(a)		B1	1.1b
		dB1	1.1b
		(2)	
(b)	$\frac{9}{10} \times \frac{4}{5} \times \frac{2}{3}$	M1	1.1b
	$= \frac{12}{25} (= 0.48)$	A1	1.1b
		(2)	
(c)	$\frac{9}{10} \times \frac{1}{5} + \frac{9}{10} \times \frac{4}{5} \times \frac{1}{3}$ or $1 - \left(\frac{1}{10} + \frac{9}{10} \times \frac{4}{5} \times \frac{2}{3} \right)$	M1	3.1b
	$= \frac{21}{50} (= 0.42)$	A1	1.1b
		(2)	
(d)	$[P(\text{Red from B} \text{Red selected})] = \frac{\frac{9}{10} \times \frac{1}{5}}{\frac{1}{10} + \frac{9}{10} \times \frac{1}{5} + \frac{9}{10} \times \frac{4}{5} \times \frac{1}{3}} \left[= \frac{\frac{9}{50}}{\frac{13}{25}} \right]$	M1	3.1b
	$= \frac{9}{26}$	A1	1.1b
		(2)	
(8 marks)			
Notes			
	Allow decimals or percentages throughout this question.		
(a)	B1: for correct shape (3 pairs) and at least one label on at least two pairs G(reen) and R(ed) allow G and G' or R and R' as labels, etc. condone 'extra' pairs if they are labelled with a probability of 0 dB1: (dep on previous B1) all correct i.e. for all 6 correct probabilities on the correct branches with at least one label on each pair		
(b)	M1: Multiplication of 3 correct probabilities (allow ft from their tree diagram) A1: $\frac{12}{25}$ oe		
(c)	M1: Either addition of only two correct products (product of two probs + product of three probs) which may ft from their tree diagram or for $1 - (' \frac{1}{10} ' + ' (b) ')$ A1: $\frac{21}{50}$ oe		
(d)	M1: Correct ratio of probabilities or correct ft ratio of probabilities e.g. $\frac{' \frac{9}{10} ' \times ' \frac{1}{5} '}{1 - ' (b) '}$ or $\frac{' \frac{9}{10} ' \times ' \frac{1}{5} '}{' \frac{1}{10} ' + ' (c) '}$ with num < den A1: $\frac{9}{26}$ (allow awrt 0.346)		

Qu 1	Scheme	Marks	AO
(a)	A, C <u>or</u> D, B <u>or</u> D,C	B1 (1)	1.2
(b)	$[p = 0.4 - 0.07 - 0.24 =]$ <u>0.09</u>	B1 (1)	1.1b
(c)	A and B independent implies $P(A) \times 0.4 = 0.24$ <u>or</u> $(q + 0.16 + 0.24) \times 0.4 = 0.24$ so $P(A) = 0.6$ and $q =$ <u>0.20</u>	M1 A1cso (2)	1.1b 1.1b
(d)(i)	$P(B' C) = 0.64$ gives $\frac{r}{r + p} = 0.64$ <u>or</u> $\frac{r}{r + "0.09"} = 0.64$ $r = 0.64r + 0.64 "p"$ so $0.36r = 0.0576$ so $r =$ <u>0.16</u>	M1 A1	3.1a 1.1b
(ii)	Using sum of probabilities = 1 e.g. “0.6” + 0.07 + “0.25” + s = 1 so s = <u>0.08</u>	M1 A1 (4)	1.1b 1.1b
		(8 marks)	
Notes			
(a)	B1 for one correct pair. If more than one pair they must all be correct. Condone in a correct probability statement such as $P(A \cap C) = 0$ or correct use of set notation e.g. $A \cap C = \emptyset$ BUT e.g. “P(A) and P(C) are mutually exclusive” alone is B0		
(b)	B1 for $p = 0.09$ (Maybe stated in Venn Diagram [VD]) [If values in VD and text conflict, take text or a value <u>used</u> in a later part]		
(c)	M1 for a correct equation in one variable for P(A) or q using independence <u>or</u> for seeing both $P(A \cap B) = P(A) \times P(B)$ <u>and</u> $0.24 = 0.6 \times 0.4$ A1cso for $q = 0.20$ or exact equivalent (dep on correct use of independence) Use of $P(A) = 1 - P(B) = 0.6$ leading to $q = 0.2$ scores M0A0		
Beware			
(d)(i)	1 st M1 for use of $P(B' C) = 0.64$ leading to a correct equation in r and possibly p. Can fit their p provided $0 < p < 1$ 1 st A1 for $r = 0.16$ or exact equivalent		
(ii)	2 nd M1 for use of total probability = 1 to form a linear equation in s. Allow p, q, r etc Can follow through their values provided each of p, q, r are in [0, 1) 2 nd A1 for s = 0.08 or exact equivalent		

Question	Scheme	Marks	AOs
5(a)	$\frac{365}{1825}$ or $\frac{1}{5}$ or 0.2 oe	B1	1.1b
		(1)	
(b)	$\frac{170}{1825}$ or $\frac{34}{365}$ or awrt 0.093	B1	1.1b
		(1)	
(c)	$90 \times 0.4 + 80 \times 0.05 [= 40]$ or $90 \times 0.6 + 80 \times 0.95 [= 130]$ or $740 \times 0.65 [= 481]$ or $740 \times 0.35 [= 259]$ 	M1	3.1b
		B1 B1 A1	1.1b 1.1b 1.1b
		(4)	
(d)	$P(R' \cap F) = \frac{380}{1825} \left[= \frac{76}{365} = 0.208... \right]$ oe awrt 0.208	B1	1.1b
		(1)	
(e)	$\left[\frac{133 + "130"}{1825} = \right] \frac{"263"}{1825}$ awrt 0.144	B1ft	1.1b
		(1)	
(f)	$\frac{247 + "481"}{247 + "481" + 123 + "40"}$ $= \frac{728}{891}$ awrt 0.817	M1 A1	3.4 1.1b
		(2)	
Notes: (10 marks)			
		Look out for answers given in the question. If you see answers in the question and in the answer space those in the answer space take precedence.	
(a)	B1	Allow equivalent	
(b)	B1	Allow equivalent	
(c)	M1	Correct method to find one of the values 40 or 130 or 481 or 259 Implied by 40, 481, 259 or 130 seen in correct place on diagram	
	B1	One of the highlighted correct	
	B1	A second value highlighted correct or their ("259" + "481") = 740 or their ("40" + "481") = 521 or their ("40" + "130") = 170	
	A1	Fully correct	
(d)	B1	380/1825 oe or awrt 0.208	
(e)	B1ft	Correct answer or Ft their 130 (> 0) do not allow if blank Allow ft correct to 3 sf.	
(f)	M1	For a single fraction with the numerator < denominator and n is an integer we will award for n/ 891 or n/(sum of their 4 values in H, each > 0) or awrt 0.817	
	A1	728/891 oe or awrt 0.817	

Qu 4	Scheme	Marks	AO
(a)	$0.08 + 0.09 + 0.36 = \underline{0.53}$	B1 (1)	1.1b
(b)(i)	$[P(G \cap E \cap S) = 0 \Rightarrow] \underline{p = 0}$	B1	1.1b
(ii)	$[P(G) = 0.25 \Rightarrow] 0.08 + 0.05 + q + "p" = 0.25$ $\underline{q = 0.12}$	M1 A1 (3)	1.1b 1.1b
(c)(i)	$[P(S E) = \frac{5}{12} \Rightarrow] \frac{r + "p"}{r + "p" + 0.09 + 0.05} = \frac{5}{12}$ $[12r = 5r + 5 \times 0.14 \Rightarrow] \underline{r = 0.10}$	M1 A1ft A1	3.1a 1.1b 1.1b
(ii)	$[0.08 + 0.05 + "0.12" + "0" + 0.09 + "0.10" + 0.36 + t = 1 \Rightarrow] \underline{t = 0.20}$	B1ft (4)	1.1b
(d)	$P(S \cap E') = 0.36 + "q" [= 0.48]$ $P([(S \cap E')] \cap G) = "q" [= 0.12] \text{ and } P(G) = 0.25 \text{ and}$ $P(S \cap E') \times P(G) = "0.48" \times \frac{1}{4} \underline{\text{or}} 0.12$ $P(S \cap E') \times P(G) = 0.12 = P([(S \cap E')] \cap G) \text{ so are independent}$	B1ft M1 A1 (3)	1.1b 2.1 2.2a
(11 marks)			
Notes			
(a)	B1 for 0.53 (or exact equivalent) [Allow 53%]		
(b)(i)	B1 for $p = 0$ (may be placed in Venn diagram)		
(ii)	M1 for a linear equation for q (ft letter " p " or their value if $0, p, 0.12$) $\Rightarrow$ by $p + q = 0.12$ A1 for $q = 0.12$ (may be placed in Venn diagram)		
(c)(i)	M1 for a ratio of probabilities (r on num and den) (on LHS) with num < den and num <u>or</u> den correct ft. Allow ft of letter " p " <u>or</u> their p where $0, p < 0.86$ but "+ 0" is not required. 1 st A1ft for a correct ratio of probabilities (on LHS) allowing ft of their p where $0, p < 0.86$ 2 nd A1 for $r = 0.1(0)$ or exact equivalent (may be in Venn diagram) Ans only 3/3		
(ii)	B1ft for $t = 0.2(0)$ (o.e.) <u>or</u> correct ft i.e. $0.42 - (p + q + r)$ where p, q, r and t are all probs		
(d)	B1ft for $P(S \cap E') = 0.48$ (with label) (ft letter " q " or their value if $0, q, 0.12$) M1 for attempting all required probs (labelled) <u>and</u> using them in a correct test (allow ft of q) A1 for all probs correct and a correct deduction (no ft deduction here)		
SC	No "P" If correct argument seen apart from P for probability for all 3 marks, award (B0M1A1) If unsure about an attempt using conditional probabilities, please send to review.		

Qu 5	Scheme	Marks	AO
(a)	$\left[\text{Let } F \sim N(166.5, 6.1^2) \right] \quad P(F < k) = 0.01 \Rightarrow \frac{k - 166.5}{6.1} = -2.3263$ $k = 152.309... \quad \underline{152} \text{ or awrt } \underline{152.3}$	M1 A1 (2)	3.4 1.1b
(b)	$P(150 < F < 175) = 0.914840... \quad \text{awrt } \underline{0.915}$	B1 (1)	1.1b
(c)	$P(F > 160 \mid 150 < F < 175)$ $= \frac{P(160 < F < 175)}{P(150 < F < 175)} \quad \text{or} \quad \frac{P(160 < F < 175)}{"(b)"} \\ = \frac{0.7749487...}{"0.914840..."} \\ = 0.84708... \text{ awrt } \underline{0.847}$	M1 M1 A1ft A1 (4)	3.1b 1.1b 1.1b 1.1b
(d)	$H_0: \mu = 166.5 \quad H_1: \mu < 166.5$ $[\text{Let } \bar{X} = \text{height of female from 2}^{\text{nd}} \text{ country}] \quad \bar{X} \sim N\left(166.5, \left(\frac{7.4}{\sqrt{50}}\right)^2\right)$ $P(\bar{X} < 164.6) = 0.03472...$ $[0.0347... < 0.05 \text{ so significant or reject } H_0]$ There is evidence to support Mia's belief	B1 M1 A1 dA1 (4)	2.5 3.3 3.4 2.2b
Notes			
(a)	M1 for standardising (allow $\pm$) with k , 166.5 and 6.1 and set equal to a z value $2.3 < z < 2.4$ A1 for 152 or awrt 152.3 Ans only 2/2 [Condone poor use of notation e.g. $P(\frac{k-166.5}{6.1}) = -2.3263$] Allow percentages instead of probabilities throughout.		
(b)	B1 for awrt 0.915		
(c)	1 st M1 for interpreting demand as an appropriate conditional probability ($\Rightarrow$ by 2 nd M1) 2 nd M1 for correct ratio of expressions (can fit their (b) on denominator) ($\Rightarrow$ by 1 st A1ft) 1 st A1ft for a correct ratio of probs (can fit their "0.9148..." to 3sf from (b) if > 0.775) 2 nd A1 for awrt 0.847		
(d)	B1 for both correct hypotheses in terms of μ 1 st M1 for selecting the correct model (needn't use $\bar{X} \Rightarrow$ by standardisation or 1 st A1) 1 st A1 for correct use of the correct model i.e. awrt 0.035 (allow 0.04 if $P(\bar{X} < 164.6)$ seen) Condone $P(\bar{X} > 164.6) = 0.9652$ or awrt 0.97 <u>only if</u> comparison with 0.95 is made		
ALT	Use of z value: Need to see $Z = -1.8(15...)$ and cv of ± 1.6449 (allow 1.64 or better) for 1 st A1		
ALT	Use of CR or CV for $\bar{X}$: Need to see " $\bar{X} > 164.7786...$ or $CV = ...$ (awrt 164.8) for 1 st A1 Condone truncation i.e 164.7 or better 2 nd dA1 (dep on M1A1 only) for a correct inference in context. Must mention <u>Mia's belief</u> or <u>mean height of females/women</u> Do NOT award if contradictory statements about hypotheses made e.g. "not sig"		
SC	M0 for $\bar{X} \sim N(164.6, ...)$ If they achieve $p =$ awrt 0.035 (o.e. with z -value or CV of 166.3) and a correct conclusion in context is given score M0A0A1 [and SC for awrt 0.97 > 0.95 case]		

Qu 6	Scheme	Marks	AO
(a)	A, C or A, D or B, D [Allow things like $A \cap D$]	B1 (1)	1.2
(b)	$P(C) = 0.6$ and $P(B) = p + 0.32$ and $P(B \cap C) = 0.27$ or $(0.08 + 0.25 + 0.27) \times (0.27 + 0.05 + p) = 0.27$ or $0.27 + 0.05 + p = \frac{0.27}{0.6} = 0.45$ [$p + 0.32 = 0.45$ so] $p = \underline{0.13}$	M1 A1 (2)	1.1b 2.2a
(c)	$[P(A B')] = \frac{q}{q+r+0.25+0.08}$ or $\frac{q}{1-(0.05+"0.13"+0.27)}$ or $\frac{q}{0.55}$ $q + r = 1 - 0.65 - "0.13" [= 0.22]$ Since $r \geq 0$ the greatest value of q is "0.22" so $P(A B') \leq \underline{0.4}$ or $\frac{2}{5}$	M1 M1 A1 (3)	2.1 1.1b 2.2a
(d)	$[P(B A')] = \frac{0.27+"0.13"}{0.6+"0.13"+r} = 0.5$ or $\frac{0.27+"0.13"}{1-(q+0.05)} = 0.5$ $r = \underline{0.07}$, $q = \underline{0.15}$	M1 A1 A1ft (3)	1.1b 1.1b 1.1b
(e)	$[P((A \cup B)' \cap C)] = [0.25 + 0.08] = \underline{0.33}$	B1 (1)	1.1b
(f)	e.g. $B \cap [A \cup C]'$ or $B \cap A' \cap C'$ or $(B \cap A') \cap (B \cap C')$ o.e.	B1 (1)	1.1b
(11 marks)			
Notes			
(a)	B1 for a correct pair. If more than one pair is given then all must be correct. $P(A)$ and $P(C)$ etc is B0 $P(A \cap C) = 0$ is B0 but condone things like $A \cap C = \emptyset$		
	In parts (b) – (d) we will condone poor notation and mark equations/expressions		
(b)	M1 for all relevant labelled probabilities listed or a correct equation/expression for p A1 for $p = 0.13$		
	In parts (c) and (d) they can use letter p or we ft their value for p provided a probability		
(c)	1 st M1 for a correct method for $P(A B')$ in q (and r) ft their p . May be done in stages e.g. find correct expression for $P(B')$, simplify incorrectly then use q over this 2 nd M1 for a correct equation for $q + r$ (o.e.) (ft their p) Can accept $r = 0$ and $q = 0.22$ NB sight of $\frac{0.22}{0.55}$ will score M1M1 A1 for 0.4 i.e. deducing the maximum value of $P(A B')$. Allow ≤ 0.4 or $P(A B') = 0.4$ Can award 3/3 for $P(A B') = 0.4$ but not 0.4 alone as it can come from e.g. $P(C')$		
(d)	M1 for a correct equation for r (or q) only can have p or ft their value for p . May be in stages e.g. find $P(A') = 0.27 + 0.25 + 0.08 + p + r$ but make a slip in getting 0.6 then use this. 1 st A1 for $r = 0.07$ or $q = 0.15$ 2 nd A1ft for $r = 0.07$ and $q = 0.15$ or values giving $q + r = 0.22$ provided both q and r are probabilities. Obviously, 2 nd A1ft is dependent on the M1		
(e)	B1 for 0.33		
(f)	B1 for any correct expression. Do not condone $P(\dots$		

Qu	Scheme	Marks	AOs
2(a)	$\left[P(L < 7.902) = 0.025 \Rightarrow \right] \frac{7.902 - 8}{x} = -1.96 \text{ oe}$	M1	3.4
	$[x =] 0.05^*$	A1cso*	1.1b
	SC B1(mark as M0A1) for $\frac{7.902 - 8}{0.05} = -1.96 \Rightarrow 0.024998$		
		(2)	
(b)	$P(7.94 \leq L \leq 8.09) = 0.8490\dots$ awrt 0.849	B1	1.1b
		(1)	
(c)	$[P(L < 7.94) =] 0.115069\dots$ (awrt 0.115) or $[P(L > 8.09) =] 0.03593\dots$ (awrt 0.036)	B1	1.1b
	$[P(L < 7.94) =] 0.115069\dots$ (awrt 0.115) & $[P(L > 8.09) =] 0.03593\dots$ (awrt 0.036)	B1	1.1b
	Expected income per 500 rods = $\sum (\text{Income} \times \text{probability} \times 500)$ $(500 \times "0.849" \times 0.5) + (500 \times "0.1150\dots" \times 0.05) + (500 \times "0.03593\dots" \times 0.4)$ or Expected profit per rod = $\sum (\text{Profit} \times \text{probability})$ $0.30 \times "0.849" + -0.15 \times "0.1150\dots" + 0.20 \times "0.03593\dots" [= 0.2446\dots]$ Expected profit per 500 rods $500 \times \sum (\text{Profit} \times \text{probability})$ or $\sum (\text{Income} \times \text{probability} \times 500) - 500 \times 0.2$ $= 500 \times "0.2446\dots"$ or $= "222.3" - 500 \times 0.2$	M1	3.4
	$= [\text{£}]122.3\dots$ awrt [£]122	M1d	3.1b
		A1	1.1b
		(5)	
(d)	Let $X \sim B(200, 0.015)$	M1	3.3
	$P(X \leq 5) =$	M1	1.1b
	$P(X \geq 6) =$	A1	1.1b
	Manufacturer is unlikely to achieve their aim since $0.9176 < 0.95$	A1ft	2.4
	Manufacturer is unlikely to achieve their aim since $0.0824 > 0.05$		
		(4)	
Notes: (12 marks)			
(a)	M1	Using the normal distribution to set up equation. Allow σ for x and awrt ± 1.96	
	A1*	cso For a correct expression for x followed by 0.05 or 0.05000... No incorrect working seen	
(b)	B1	awrt 0.849	
(c)	B1	awrt 0.115 (Implied by awrt 57.5 for number of rods) or awrt 0.036 (Implied by awrt 18 for number of rods)	
	B1	awrt 0.115 (Implied by awrt 57.5 for number of rods) and awrt 0.036 (Implied by awrt 18 for number of rods)	
	M1	Correct method to find the total income of 500 rods. Attempt at all 3 with at least two correct and no extras or Correct method to find sum of all three profits with at least two of 30, -15 or 20 correct. May work in pence but need to be consistent. Allow awrt 24.5 or 0.245	
	M1d	Dep on previous method for finding profit for 500 rods. May work in pence but need to be consistent. Allow "0.2446..." $\times 500$ or "their income" for 500 rods $- 500 \times 0.2$ (accept 499 or 501)	
	A1	All previous marks must be awarded for awrt 122 awrt 12200p NB if uses any integer values for numbers of rods then it is A0 other than for 18 for $L > 8.09$	
(d)	M1	Selecting the appropriate model. May be seen or used. Allow $B(200, 0.985)$ or $Po(3)$ Condone $B(0.015, 200)$ or $B(0.985, 200)$.	
	M1	Writing or using $P(X \leq 5)$ Do not accept $P(X < 6)$ unless found $P(X \leq 5)$	Writing or using $P(X \geq 6)$ Do not accept $P(X > 5)$ unless found $P(X \geq 6)$
	A1	0.92 (Poisson 0.916...)	0.08 or better
	A1ft	Need at least one of the method marks to be awarded. Correct conclusion with the comparison (may be in words). Ft "their $p = 0.9176\dots$ " as long as $p > 0.9$ If "their $0.9176\dots < 0.95$ must ... be unlikely... If "their $0.9176\dots > 0.95$ they must say ... be likely... To fit the alternative then $p < 0.1$	

Question	Scheme		Marks	AOs
1(a)(i)	[Let p = probability of yellow from bag B] $P(YY) = \frac{4}{12} \times p$		M1	1.1b
	$\left[\frac{4}{12} \times p = \frac{3}{16} \right]$ so $p = \frac{9}{16}$ (Allow 0.5625 and condone 0.563)		A1	1.1b
			(2)	
1(a)(ii)			B1	1.1b
			B1ft	1.1b
			(2)	
1(b)	e.g. $P(RY) + P(Y) + P(GY)$ or $1 - P(RR) - P(GR)$ or $P(\dots Y) + P(YR)$		M1	2.1
	$\frac{5}{12} \times \frac{9}{16} + \frac{4}{12} + \frac{3}{12} \times \frac{9}{16}$ or $1 - \left[\frac{5}{12} \times \frac{7}{16} + \frac{3}{12} \times \frac{7}{16} \right]$ or $\frac{9}{16} + \frac{1}{3} \times \frac{7}{16}$		A1ft	1.1b
	$= \frac{136}{192} = \frac{17}{24} = 0.708\dot{3}$		A1	1.1b
			(3)	
1(c)	$[P(W X) =] \frac{P(W \cap X)}{P(X)}$ or $\frac{\frac{3}{12} \times \frac{9}{16}}{\text{"(b)"}}$		M1	1.1b
	$= \frac{27}{136}$		A1	1.1b
			(2)	
(9 marks)				
Notes:				
(a)(i)	M1	for a suitable expression (in their p) for the probability both are yellow.		
	A1	for correct probability of yellow from B . Can be implied by values on tree diagram.		
(a)(ii)	B1	for a correct 1 st column of tree diagram (probabilities from A)		
	B1ft	(dep on M1 in (i)) for correct 2 nd column of tree diagram (ft their $\frac{9}{16}$ and $1 - \frac{9}{16}$)		
(b)	M1	for selection of <u>all</u> correct cases (including the 1 – if required). Don't need $P(\dots)$ may be implied by correct probability products seen (ft their tree diagram)		
	A1ft	for a correct complete probability expression (ft their tree diagram) or awrt 0.708 Must see product pairs (for ft) or implied by correct values e.g. $\frac{15}{64} + \frac{7}{48} + \frac{3}{16} + \frac{9}{64}$ May see $1 - P(\bar{Y}\bar{Y})$ (M1) and $1 - \frac{2}{3} \times \frac{7}{16}$ (A1ft)		
	A1	for an exact answer ...fraction needn't be simplified but decimal must have ... $\dot{3}$		
(c)	M1	for a correct ratio of probabilities expression (in symbols) or ft their values seen		
	A1	for an exact answer NB an answer of awrt 0.199 (0.198529411...) implies M1		
Acc	If scored 2 nd A0 in (b) for 0.708 (or better) then allow A1 in (c) for awrt 0.199			

Qu 3	Scheme	Marks	AO										
(a)	The <u>probability</u> of a dart hitting the target is <u>constant</u> (from child to child and for each throw by each child) (o.e.) The <u>throws</u> of each of the darts are <u>independent</u> (o.e.)	B1 B1 (2)	1.2 1.2										
(b)	$[P(H \geq 4) = 1 - P(H \leq 3) = 1 - 0.9872 = 0.012795.. =]$ awrt 0.0128	B1 (1)	1.1b										
(c)	$P(F = 5) = 0.9^4 \times 0.1, = 0.06561$ = awrt 0.0656	M1, A1 (2)	3.4 1.1b										
(d)	<table border="1"><tr><td>n</td><td>1</td><td>2</td><td>...</td><td>10</td></tr><tr><td>$P(F = n)$</td><td>0.01</td><td>$0.01 + \alpha$</td><td>...</td><td>$0.01 + 9\alpha$</td></tr></table> Sum of probs = 1 $\Rightarrow \frac{10}{2}[2 \times 0.01 + 9\alpha] = 1$ [i.e. $5(0.02 + 9\alpha) = 1$ or $0.1 + 45\alpha = 1$] so $\alpha = \mathbf{0.02}$	n	1	2	...	10	$P(F = n)$	0.01	$0.01 + \alpha$	...	$0.01 + 9\alpha$	M1 M1A1 A1 (4)	3.1b 3.1a 1.1b 1.1b
n	1	2	...	10									
$P(F = n)$	0.01	$0.01 + \alpha$	...	$0.01 + 9\alpha$									
(e)	$P(F = 5 \text{ Thomas' model}) = \mathbf{0.09}$	B1ft (1)	3.4										
(f)	<u>Peta's</u> model assumes the <u>probability</u> of hitting target is <u>constant</u> (o.e.) and <u>Thomas's</u> model assumes this <u>probability increases</u> with each attempt(o.e.)	B1 (1)	3.5a										
		(11 marks)											
Notes													
(a)	1 st B1 for stating that the <u>probability</u> (or possibility or chance) is <u>constant</u> (or fixed or same) 2 nd B1 for stating that <u>throws</u> are <u>independent</u> ["trials" are independent is B0]												
(b)	B1 for awrt 0.0128 (found on calculator)												
(c)	M1 for a probability expression of the form $(1 - p)^4 \times p$ where $0 < p < 1$ A1 for awrt 0.0656 SC Allow M1A0 for answer only of 0.066												
(d)	1 st M1 for setting up the distribution of F with at least 3 correct values of n and $P(F = n)$ in terms of α . (Can be implied by 2 nd M1 or 1 st A1) 2 nd M1 for use of sum of probs = 1 and clear summation or use of arithmetic series formula (allow 1 error or missing term). (Can be implied by 1 st A1) 1 st A1 for a correct equation for α 2 nd A1 for $\alpha = 0.02$ (must be exact and come from correct working)												
(e)	B1ft for value resulting from $0.01 + 4 \times \text{"their } \alpha \text{"}$ (provided α and the answer are probs) Beware If their answer is the same as their (c) (or a rounded version of their (c)) score B0												
(f)	B1 for a suitable comment about the <u>probability</u> of hitting the target ALT Allow idea that Peta's model suggests the dart may never hit the target but Thomas' says that it will hit at least once (in the first 10 throws).												