1. A coffee shop provides free internet access for its customers. It is known that the probability that a randomly selected customer is accessing the internet is 0.35, independently of all other customers.

i. 10 customers are selected at random.

A. Find the probability that exactly 5 of them are accessing the internet.

[3]

B. Find the probability that at least 5 of them are accessing the internet.

[2]

C. Find the expected number of these customers who are accessing the internet.

[2]

Another coffee shop also provides free internet access. It is suspected that the probability that a randomly selected customer at this coffee shop is accessing the internet may be different from 0.35. A random sample of 20 customers at this coffee shop is selected. Of these, 10 are accessing the internet.

ii. Carry out a hypothesis test at the 5% significance level to investigate whether the probability for this coffee shop is different from 0.35. Give a reason for your choice of alternative hypothesis.

[9]

iii. To get a more reliable result, a much larger random sample of 200 customers is selected over a period of time, and another hypothesis test is carried out. You are given that 90 of the 200 customers were accessing the internet. You are also given that, if X has the binomial distribution with parameters $n = 200$ and $p = 0.35$, then $P(X \geqslant 90) = 0.0022$. Using the same hypotheses and significance level which you used in part **(ii)**, complete this test.

[2]

2. A researcher is investigating whether people can identify whether a glass of water they are given is bottled water or tap water. She suspects that people do no better than they would by guessing. Twenty people are selected at random; thirteen make a correct identification. She carries out a hypothesis test.

i. Explain why the null hypothesis should be $p = 0.5$, where p represents the probability that a randomly selected person makes a correct identification.

[2]

ii. Briefly explain why she uses an alternative hypothesis of $p > 0.5$.

[1]

iii. Complete the test at the 5% significance level.

[5]

3. It is known that on average 85% of seeds of a particular variety of tomato will germinate. Ramesh selects 15 of these seeds at random and sows them.

i.

A. Find the probability that exactly 12 germinate.

[3]

B. Find the probability that fewer than 12 germinate.

[2]

The following year Ramesh finds that he still has many seeds left. Because the seeds are now one year old, he suspects that the germination rate will be lower. He conducts a trial by randomly selecting n of these seeds and sowing them. He then carries out a hypothesis test at the 1% significance level to investigate whether he is correct.

ii. Write down suitable null and alternative hypotheses for the test. Give a reason for your choice of alternative hypothesis.

[4]

iii. In a trial with $n = 20$, Ramesh finds that 13 seeds germinate. Carry out the test.

[4]

iv. Suppose instead that Ramesh conducts the trial with $n = 50$, and finds that 33 seeds germinate. Given that the critical value for the test in this case is 35, complete the test.

[3]

v. If n is small, there is no point in carrying out the test at the 1% significance level, as the null hypothesis cannot be rejected however many seeds germinate. Find the least value of n for which the null hypothesis can be rejected, quoting appropriate probabilities to justify your answer.

[3]

4. A drug for treating a particular minor illness cures, on average, 78% of patients. Twenty people with this minor illness are selected at random and treated with the drug.

i.

A. Find the probability that exactly 19 patients are cured.

[3]

B. Find the probability that at most 18 patients are cured.

[3]

C. Find the expected number of patients who are cured.

[1]

ii. A pharmaceutical company is trialling a new drug to treat this illness. Researchers at the company hope that a higher percentage of patients will be cured when given this new drug. Twenty patients are selected at random, and given the new drug. Of these, 19 are cured. Carry out a hypothesis test at the 1% significance level to investigate whether there is any evidence to suggest that the new drug is more effective than the old one.

[8]

iii. If the researchers had chosen to carry out the hypothesis test at the 5% significance level, what would the result have been? Justify your answer.

[2]

5. To withdraw money from a cash machine, the user has to enter a 4-digit PIN (personal identification number). There are several thousand possible 4-digit PINs, but a survey found that 10% of cash machine users use the PIN '1234'.

i. 16 cash machine users are selected at random.

(*A*) Find the probability that exactly 3 of them use 1234 as their PIN.

[3]

(*B*) Find the probability that at least 3 of them use 1234 as their PIN.

[2]

(*C*) Find the expected number of them who use 1234 as their PIN.

[1]

An advertising campaign aims to reduce the number of people who use 1234 as their PIN. A hypothesis test is to be carried out to investigate whether the advertising campaign has been successful.

ii. Write down suitable null and alternative hypotheses for the test. Give a reason for your choice of alternative hypothesis.

[4]

iii. A random sample of 20 cash machine users is selected.

(*A*) Explain why the test could not be carried out at the 10% significance level.

[3]

(*B*) The test is to be carried out at the k% significance level. State the lowest integer value of k for which the test could result in the rejection of the null hypothesis.

[1]

iv. A new random sample of 60 cash machine users is selected. It is found that 2 of them use 1234 as their PIN. You are given that, if $X \sim \text{B}(60, 0.1)$, then (to 4 decimal places)

$$\text{P}(X = 2) = 0.0393, \qquad \text{P}(X < 2) = 0.0138, \qquad \text{P}(X \leqslant 2) = 0.0530.$$

v.

Using the same hypotheses as in part **(ii)**, carry out the test at the 5% significance level.

[4]

6. A company operates trains. The company claims that 92% of its trains arrive on time. You should assume that in a random sample of trains, they arrive on time independently of each other.

(a) Assuming that 92% of the company's trains arrive on time, find the probability that in a random sample of 30 trains operated by this company

(i) exactly 28 trains arrive on time, [2]

(ii) more than 27 trains arrive on time. [2]

A journalist believes that the percentage of trains operated by this company which arrive on time is lower than 92%.

(b) To investigate the journalist's belief a hypothesis test will be carried out at the 1% significance level. A random sample of 18 trains is selected. For this hypothesis test,

- state the hypotheses,
- find the critical region.

[5]

7. In this question you must show detailed reasoning.

Mr. Evans is standing for re-election to the local council. At the last election 49% of voters voted for Mr. Evans, but it is thought that the level of support for Mr. Evans may have changed. A random sample of 38 voters are asked about their voting intentions and 13 say they intend to vote for Mr. Evans.

Carry out an appropriate hypothesis test at the 5% level to investigate whether or not the level of support for Mr. Evans has changed. [7]

8. The screenshot in Fig. 8 shows the probability distribution for the discrete random variable X, where $X \sim B(20, 0.9)$.

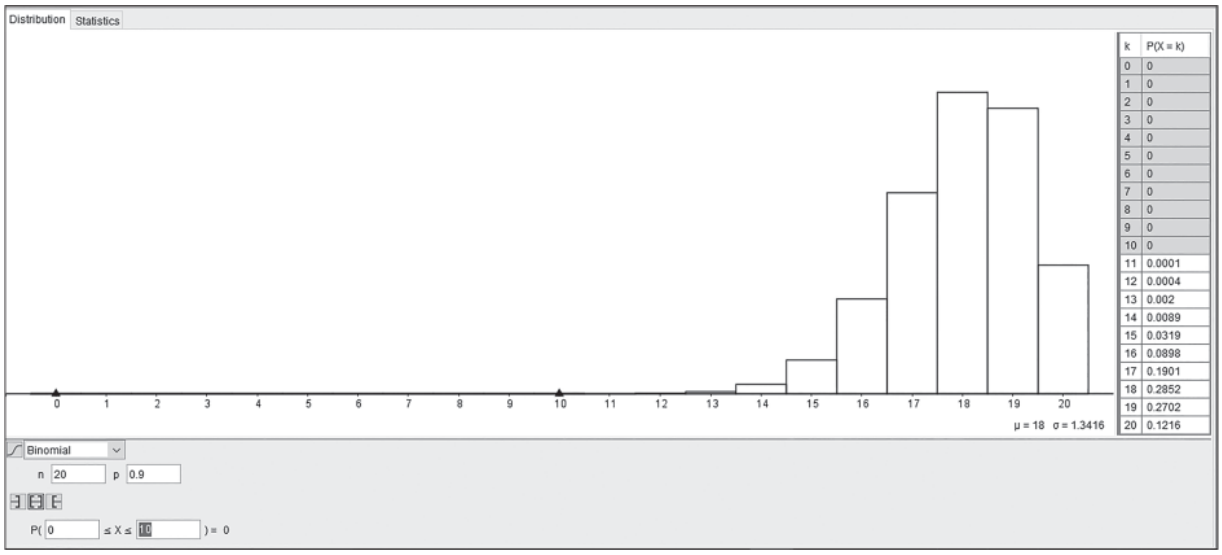

Fig. 8

(a) Describe the shape of the distribution. [1]

(b) Explain why the values of P($X = k$) for $k = 0$ to 10 inclusive are recorded as 0 in the table in the screenshot. [1]

(c) State which of the values from 0 to 20 is

(i) the most likely value of X, [1]

(ii) the least likely value of X. [1]

9. A type of shampoo is known to relieve the symptoms of 75% of dogs who suffer from a particular minor allergy.

(i) 12 dogs who suffer from this allergy are selected at random. Find the probability that the number of these dogs who have their symptoms relieved is

(*A*) exactly 9, [3]

(*B*) at least 9. [2]

A new type of shampoo has been developed to treat the allergy. A hypothesis test is to be carried out to determine whether it relieves the symptoms of a higher proportion of dogs who suffer from the allergy.

(ii) Write down suitable null and alternative hypotheses for the test. Give a reason for your choice of alternative hypothesis. [4]

A random sample of n dogs who suffer from the allergy is selected.

(iii) (*A*) Given that $n = 18$ and the symptoms of 16 dogs are relieved, carry out the test at the 10% significance level. [4]

(*B*) Given instead that $n = 50$ and the symptoms of 42 dogs are relieved, carry out the test at the 10% significance level. You may use the information that, for $X \sim \text{B}(50, 0.75)$,
$\text{P}(X = 41) = 0.0721$, $\text{P}(X = 42) = 0.0463$, $\text{P}(X \leq 41) = 0.9084$, $\text{P}(X \leq 42) = 0.9547$. [4]

10. In this question you must show detailed reasoning.

The manufacturers of "Miracleroot" claim that, as long as their instructions are followed, 80% of cuttings taken from Christmas trees will grow roots and develop into healthy new trees. A horticulturist suspects that this claim is optimistic. He takes 500 cuttings, and after carefully following the manufacturer's instructions, finds that 380 of them developed roots and developed into healthy young trees.

Carry out a hypothesis test at the 1% level to determine whether there is any evidence to suggest that the manufacturer's claim is optimistic. [7]

11. In this question you must show detailed reasoning.

Research showed that in May 2017 62% of adults over 65 years of age in the UK used a certain online social media platform. Later in 2017 it was believed that this proportion had increased. In December 2017 a random sample of 59 adults over 65 years of age in the UK was collected. It was found that 46 of the 59 adults used this online social media platform.

Use a suitable hypothesis test to determine whether there is evidence at the 1% level to suggest that the proportion of adults over 65 in the UK who used this online social media platform had increased from May 2017 to December 2017. [7]

12. Rose packs eggs in boxes of 6, which she then sells at her farm. During the process some eggs are cracked, and Rose randomly selects a sample of boxes and records the number of cracked eggs in each box. The results are summarised in Fig. 16.

Number of cracked eggs	0	1	2	3	4	5	6
Number of boxes	163	103	28	5	0	0	1

Fig.16

(a) Calculate the mean number of cracked eggs per box. [1]

Rose believes that the number of cracked eggs per box may be modelled by a binomial distribution.

(b) State a modelling assumption that is necessary for a binomial distribution to be used to model the number of cracked eggs per box. [1]

Rose defines p as the probability that a particular egg is cracked.

(c) Use your answer to part (a) to find the value of p. [2]

(d) Calculate the expected frequencies of cracked eggs per box according to Rose's model, giving your answers correct to 1 decimal place. [3]

(e) Comment on whether Rose's model is a good fit for the data. [1]

Instead of selling eggs at the farm, Rose decides to sell them to a wholesaler. The eggs are now selected randomly and packed in open trays of 24. Rose believes that this will result in a change in the probability of an egg being cracked. She selects a tray at random and finds that 5 eggs are cracked.

(f) In this question you must show detailed reasoning.

Conduct a hypothesis test to determine whether there is any evidence at the 5% level to suggest that the proportion of cracked eggs has changed. [7]

END OF QUESTION paper

Question			Answer/Indicative content	Marks	Part marks and guidance	
1		i	$X \sim$ B(10, 0.35)	M1	or $0.35^5 \times 0.65^5$	
		i	$\mathrm{P}(5 \text{ accessing internet}) = \binom{10}{5} \times 0.35^5 \times 0.65^5$	M1	For $\binom{10}{5} \times p^5 \times q^5$	With $p + q = 1$ Also for 252×0.0006094
		i	= 0.1536	A1	cao	Allow 0.15 or better NB 0.153 gets A0 See tables at the website http:/www.mei.org.uk/files/pdf/formula_book_mf2.pdf
		i	**OR**			
		i	from tables = 0.9051 – 0.7515 = 0.1536	M2	For 0.9051 – 0.7515	
		i		A1	cao	Accept 0.25 or better – allow 0.248 or 0.249 Calculation of individual probabilities gets B2 if fully correct 0.25 or better, otherwise B0.
		i	$\mathrm{P}(X \geq 5) = 1 - \mathrm{P}(X \leq 4)$			
		i	= 1 – 0.7515	M1	For 0.7515 cao	
					Examiner's Comments	
		i	= 0.2485	A1	Again many fully correct responses were seen. Candidates usually used the correct table but a common wrong answer was 1 - P($X \leq 5$) rather than 1 - P($X \leq 4$). Some candidates used the lengthy method of finding the individual probabilities of 5 or more and then	

					adding, sometimes successfully but in many cases with errors.	
	i	$E(X) = np = 10 \times 0.35$	M1	For 10×0.35 cao		If any indication of rounding to 3 or 4 allow M1A0
	i	$= 3.5$	A1		**Examiner's Comments** Almost all candidates multiplied 0.35 by 10, but about 20% of them either rounded to 4 or truncated to 3, thus losing the second mark.	
	ii	Let $X \sim B(20, 0.35)$	9			
	ii	Let p = probability of a customer using the internet (for population)	B1	For definition of p in context		Minimum needed for B1 is p = probability of using internet. Allow p = P(using internet) Definition of p must include word probability (or chance or proportion or percentage or likelihood but NOT possibility). Preferably as a separate comment. However can be at end of H_0 as long as it is a clear definition 'p = the probability of using internet', Do NOT allow 'p = the probability of using internet is different'
	ii	H_0: $p = 0.35$	B1	For H_0		Allow p = 35%, allow only p or θ or π or ρ. However allow any single symbol if defined (including x) Allow $H_0 = p = 0.35$, Allow H_0: $p = {}^{7}/_{20}$ or $p = {}^{35}/_{100}$ Allow NH and AH in place of H_0 and H_1 Do not allow H_0 : $P(X = x) = 0.35$ Do not allow H_0: = 0.35, = 35%, P(0.35), p(x) = 0.35, $x = 0.35$ (unless x correctly defined as a probability) Do not allow H_0 and H_1 reversed For hypotheses given in words allow Maximum B0B1B1

					Hypotheses in words must include probability (or chance or proportion or percentage) and the figure 0.35 oe Thus eg H_0 : p(using internet) = 0.35, H_1 : p(using internet) ≠ 0.35 gets B0B1B1
ii	H_1: $p \neq 0.35$	B1	For H_1		Allow 'ρ < 0.35 or ρ > 0.35' in place of p ≠ 0.35
ii	H_1 has this form because the test is to investigate whether the proportion is different, (rather than lower or higher).	E1			Do not allow if H_1 wrong.
ii	P($X \geq 10$)	B1	For notation P($X \geq 10$) or P($X > 9$) or 1 – P($X \leq 9$) (as long as no incorrect notation)		This mark may be implied by 0.1218 as long as no incorrect notation. No further marks if point probs used - P($X = 10$) = 0.0686 (do not even give the notation mark for correct notation) DO NOT FT wrong H_1, but see extra notes
ii	= 1 – 0.8782 = 0.1218	B1*	For 0.1218 Allow 0.12		Or for 1 – 0.8782 Indep of previous mark
ii	> 2.5%	M1* dep	For comparison with 2.5%		
ii	So not significant.	A1*			Allow 'accept H_0' or 'reject H_1'
ii	Conclude that there is not enough evidence to indicate that the probability is different. (Must state 'probability', not just 'p')	E1* dep on A1			Must include 'sufficient evidence' or something similar such as 'to suggest that' ie an element of doubt either in the A or E mark.
ii	ALTERNATIVE METHOD FOR FINAL 5 MARKS				
ii	Critical region method				Do not insist on correct notation as candidates have to work out two probabilities for full marks. If only upper tail of CR given (or only upper tail justified), allow max 4/5 for final 5 marks.
ii	LOWER TAIL P($X \leq 2$) = 0.0121 < 2.5% P($X \leq 3$) = 0.0444 > 2.5%	B1	For either probability		

		UPPER TAIL			
	ii	$P(X \geq 11) = 1 - P(X \leq 10) = 1 - 0.9468 = 0.0532 > 2.5\%$ $P(X \geq 12) = 1 - P(X \leq 11) = 1 - 0.9804 = 0.0196 < 2.5\%$	B1	For either probability For either probability cao dep on at least one correct comparison with 2.5%	
	ii	So critical region is {0, 1, 2, 12, 13, 14, 15, 16, 17, 18, 19, 20}	M1*		No marks if CR not justified Condone {0, 1, 2, 12, … 20}, $X \leq 2$, $X \geq 12$, oe but not $P(X \leq 2)$ etc

Examiner's Comments

Most candidates were able to identify that this was a two-tailed test and were able to correctly state the null and alternative hypotheses. However, some candidates failed to define p and others failed to explain why it was two-tailed. Some of the weaker candidates used poor notation when defining their hypotheses. Rather more candidates used the critical region method than finding $P(X \geq 10)$. However, those who used the probability method were generally more successful. Those who tried to find the critical region often included either 3 or 11 and so lost the final three marks. Unfortunately, a significant number of candidates made comparisons with 5% instead of 2.5%, or omitted the comparison altogether and so again lost the last three marks. A disappointing number found $P(X = 10)$ thus losing all of the final 5 marks. It was pleasing to see that the majority of candidates did however realise that justification, with probabilities, is needed whichever method they employ. Conclusions, for those who get this far, were usually correct. However care should be taken to explain *in words* their findings including an *element of doubt* in their conclusion. Those answering by the critical region method should be aware that '10 is not in CR' is not enough, they also need to add 'insufficient evidence to reject the null hypothesis' and then go on to give an answer in context.

		ii	So not significant	A1*		
		ii	Conclude that there is not enough evidence to indicate that the probability is different.	E1* dep on A1		NB If CR found correctly then P($X = 10$) subsequently found but cand says '10 not in CR' then allow up to all last five marks. If do not say '10 not in CR' allow none of last five marks
		iii	0.0022 < 2.5% So reject H_0,	2		
		iii	Significant.	B1	For either reject H_0 or significant, dep on correct comparison Dep on good attempt at correct hypotheses in part (ii)	
		iii	Conclude that there is enough evidence to indicate that the probability is different.	E1* dep	**Examiner's Comments** Under half of the candidature scored either mark in this question. Many did not attempt it. A disappointing proportion compared with 5% even though they had correctly compared with 2.5% in part (ii). A further significant proportion failed to correctly state their conclusion within the context of the question.	If they have H_1: $p > 0.35$, allow SC1 if all correct including comparison with 5%.
			Total	**18**		
2		i	Because if people cannot make a correct identification, then the probability that they guess correctly will be 0.5	E1	For idea of a guess or 'chosen at random'	NB The question includes the sentence 'She suspects that people do no better than they would by guessing.', so this on its own does not get the mark for the idea of a guess
		i	For 'equally likely to guess right or wrong' or 'two outcomes with equal probability' or '50:50 chance of success' or 'right one in two occasions on average' or 'two (equally likely) outcomes' etc	E1	For idea of two outcomes **Examiner's Comments** The wording of the researcher's theory appeared to cause confusion for some of the candidates throughout the question. This was translated into some	

					poorly worded explanations and conclusions in all three parts of the question. Good comprehension skills are required in this type of question and, unfortunately, these skills were not always in evidence. Many candidates scored both marks. Unfortunately a good proportion lost either the first or the second mark by not mentioning 'guess' or only including it when they quoted the question or not mentioning, in any form, the idea of the two possible outcomes. Some candidates simply just re-stated the null hypothesis in words.	
		ii	'Because people may do better than they would by guessing' or similar	B1	For idea of selecting correctly / identifying / knowing <u>Examiner's Comments</u> The wording of the researcher's theory appeared to cause confusion for some of the candidates throughout the question. This was translated into some poorly worded explanations and conclusions in all three parts of the question. Good comprehension skills are required in this type of question and, unfortunately, these skills were not always in evidence. This was not as well answered as part (i). There was a failure to distinguish between guessing and being able to identify between the two types of water. A lot of candidates lost the mark because they gave the reason for the alternative hypothesis as '13 people out of 20 in the researcher's sample identified correctly' which of course is not a valid reason.	No marks if answer implies that it is because there are over half in the sample who make a correct identification
		iii	$P(X \geq 13) = 1 - P(X \leq 12) = 1 - 0.8684 = 0.1316$	M1	For notation $P(X \geq 13)$ or $P(X > 12)$ or $1 - P(X \leq 12)$	Notation $P(X = 13)$ scores M0. If they have the correct $P(X \geq 13)$ then give M1 and ignore any further incorrect notation.
		iii		B1*	For 0.1316	Or for 1 – 0.8684 indep of previous mark

		iii	0.1316 > 0.05	M1* dep	For comparison with 5%	
		iii	So not significant	A1*		Allow 'accept H_0' or 'reject H_1'
		iii	There is insufficient evidence to suggest that people can make a correct identification.	E1* dep	NB Point probabilities score zero.	Must include 'insufficient evidence' or something similar such as 'to suggest that' ie an element of doubt either in the A or E mark. Must be in context to gain E1 mark. Do not allow 'sufficient evidence to suggest proportion making correct identification is 0.5' or similar
		iii	ALTERNATIVE METHOD – follow method above unless some mention of CR seen		Must see some reference to CR to gain any marks	
			Critical region method			
		iii	UPPER TAIL $P(X \geq 14) = 1 - P(X \leq 13) = 1 - 0.9423 = 0.0577 < 5\%$	B1	For either probability	Do not insist on correct notation as candidates have to work out two probabilities for full marks.
		iii	$P(X \geq 15) = 1 - P(X \leq 14) = 1 - 0.9793 = 0.0207 < 5\%$	M1*	For a correct comparison with 5%	Allow comparison in form of statement 'critical region at 5% level is …'
		iii	So critical region is {15,16,17,18,19,20}	M1* dep	cao dep on the two correct probabilities	No marks if CR not justified Condone {15, … 20}, $X \geq 15$, oe but not $P(X \geq 15,)$ etc
		iii	13 not in CR so not significant	A1*	Must include '13 not in CR'	Allow 'accept H_0' or 'reject H_1'
		iii	There is insufficient evidence to indicate that people can make a correct identification.	E1* dep on A1	Ignore any work on lower critical region Examiner's Comments The wording of the researcher's theory appeared to cause confusion for some of the candidates throughout the question. This was translated into some poorly worded explanations and conclusions in all three parts of the question. Good comprehension skills are required in this type of question and, unfortunately, these skills were not always in evidence.	NB If CR found correctly, **then P(X=13) subsequently found**, but cand says '13 not in CR' then allow up to all five marks. If do not say '13 not in CR' allow no marks NOTE RE OVER–SPECIFICATION OF ANSWERS If answers are grossly over-specified, deduct the final answer mark in every case. Probabilities should also be rounded to a sensible degree of accuracy. In general final non probability answers should not be given to more than 4 significant figures. Allow

The most successful way of approaching this hypothesis test was to compare P($X \geq 13$) with the significance level. Several of the candidates, who used this method failed to gain the final mark due to not putting the explanation in the context of the question. Other candidates used incorrect probabilities, usually P($X \geq 12$) or P($X \geq 14$).

Candidates who used the critical region method normally gained the first two marks but then many of them failed to gain any more marks – usually because they had included 14 in the critical region.

Unfortunately some candidates started looking at the two probabilities necessary for the critical region but made no mention of the critical region, or critical value, so did not gain any marks.

It is pleasing to report, on the other hand, that very few candidates tried to use point probabilities. However, although full marks could be obtained by comparing 0.8684 with 95%, many candidates either compared with 5% or made no explicit comparison at all - such candidates were unable to gain any credit.

probabilities given to 5 sig fig.

PLEASE HIGHLIGHT ANY OVER-SPECIFICATION

Please note that there are no G or E marks in scoris, so use B instead

Additional notes

Comparison with 95% method
If 95% seen anywhere then
M1 for P($X \leq 12$)
B1 for 0.8684
M1* for comparison with 95% dep on second B1
A1* for not significant oe
E1*

Comparison with 95% CR method
If 95% seen anywhere then
B1 for 0.9423 or 0.9793
M1 for correct comparison with 95%
M1dep for correct CR provided both probs correct
then follow mark scheme for CR method

Smallest critical region method:
Smallest critical region that 13 could fall into is {13, 14, 15, 16, 17, 18, 19, 20} **gets B1 and has size 0.1316 gets B1, This is > 5% gets M1*, A1*, E1* as per scheme**
NB These marks only awarded if 13 used, not other values.

Use of k method with no probabilities quoted:
This gets zero marks.

Use of k method with one probability quoted:
Mark as per scheme

						Line diagram method and Bar chart method No marks unless correct probabilities shown on diagram, then mark as per scheme..
			Total	**8**		
3		i	(*A*) $X \sim$ B(15, 0.85)	M1	For $0.85^{12} \times 0.15^{3}$	With $p + q = 1$
		i	$\mathrm{P(exactly\ 12\ germinate)} = \binom{15}{12} \times 0.85^{12} \times 0.15^{3}$	M1	For $\binom{15}{12} \times p^{12} \times q^{3}$	Also for 455 × 0.00048
		i	= 0.2184	A1	CAO	Allow 0.22 or better
		i	**OR**	OR		See tables at the website
		i	from tables: 0.3958 – 0.1773	M2	For 0.3958 – 0.1773 CAO	http:/www.mei.org.uk/files/pdf/formula_book_mf2.pdf
		i	= 0.2185	A1	**Examiner's Comments** This was generally very well answered.	
		ii	(*B*) P(X<12) = P($X \leq$ 11) = 0.1773	M1	For P($X \leq$ 11) or P($\leq$11) (With no extras)	Accept 0.18 or better Calculation of individual probabilities gets B2 if fully correct in range 0.177 to 0.18, otherwise B0.
		ii		A1	CAO (as final answer) May see alternative method: 0.3958 – 0.2185 = 0.1773 0.3958 – their wrong answer to part (i) scores M1A0 **Examiner's Comments** Although most candidates answered this correctly,	

					some gave P(X ≤ 12) rather than P(X ≤ 11), and some found the required probability but then subtracted it from 1.	
		iii	Let p = probability of a seed germinating (for the population)	B1	For definition of p in context	
		iii				See below for additional notes
		iii	H_0: $p = 0.85$	B1	For H_0	
		iii	H_1: $p < 0.85$	B1	For H_1 Dep on < 0.85 used in H_1 Do not allow just 'Germination rate will be lower' or similar.	
		iii	H_1 has this form because the test is to investigate whether the proportion of seeds which germinate is lower.	E1	**Examiner's Comments** Most candidates wrote down the correct hypotheses using the correct notation. It is encouraging to report that rather more candidates gave a correct definition of p than was the case in previous years.	For use of 0.15 as P(not germinating), contact team leader E0 for simply stating H_1 in words
		iv	Let $X \sim B(20, 0.85)$			
		iv	$P(X \leq 13) = 0.0219$	M1*	For probability (provided not as part of finding	No further marks if point probs used - $P(X = 13) = 0.0160$
		iv			$P(X = 13)$) Ignore notation	DO NOT FT wrong H1, but see extra notes
		iv	$0.0219 > 1\%$	M1*dep	For comparison	Allow 'accept H_0' or 'reject H1'
		iv	So not enough evidence to reject H_0.	A1*	For not significant oe	Must include 'sufficient evidence' or something similar such as 'to suggest that' ie an element of doubt either in the A or E mark.
		iv	Not significant.			

		iv	Conclude that there is not enough evidence to indicate that the proportion of seeds which have germinated has decreased.	E1*dep	For conclusion in context Must mention decrease, not just change	
		iv	ALTERNATIVE METHOD – follow method above unless some mention of CR seen Critical region method LOWER TAIL			No marks if CR not justified Condone {0,1,2,…, 12}, X ≤ 12, oe but not P(X ≤ 12) etc
		iv	P(X ≤ 13) = 0.0219 > 1%	M1	For either probability	
		iv	P(X ≤ 12) = 0.0059 < 1%			
		iv	So critical region is {0,1,2,3,4,5,6,7,8,9,10,11,12}	A1	cao dep on at least one correct comparison with 1%	Could get M1A0A1E1 if poor notation for CR
		iv	13 not in CR so not significant	A1*		Do not allow just '13 not in CR'
		iv	There is insufficient evidence to indicate that the proportion of seeds which have germinated has decreased.	E1*dep	**Examiner's Comments** Those candidates who calculated P(X ≤ 13) were generally more successful than those using a critical region method. Those who used the latter method often got the critical region wrong, thereby losing credit. In general conclusions were given more clearly than in previous sessions, although not always in context. There was also rather less use of point probabilities than in the past.	- Must say 'not significant' or accept H_0 or similar
		v	33 < 35	M1	For comparison	Allow '33 lies in the CR'
		v	So there is sufficient evidence to reject H_0	A1*		Must include 'sufficient evidence' or something similar such as 'to suggest that' ie an element of doubt either in the A or E mark.
		v				Do not FT wrong H1: In part (iv) ignore any interchanged H_0 and H1 seen in part (ii)

		v	Conclude that there is enough evidence to indicate that the proportion of seeds which have germinated has decreased.	E1*dep	For conclusion in context Must mention decrease, not just change **Examiner's Comments** Many candidates, despite having answered the previous part correctly, reverted to point probabilities in this part, using their calculator to find P(X = 33). This of course gained no credit. Others made a correct comparison (33 < 35) but were not always sure what this meant in the context of the test.	If use a calculator to find $P(X \leq 33) = 0.000661$ and compare with 1% then B2 for $P(X \leq 33) = 0.000661 < 0.01$ so reject H_0 then final E1 as per scheme.
		v				
		vi	For $n = 3$, $P(X \leq 0) = 0.0034 < 0.01$	M1	For $P(X \leq 0) = 0.0034$	Allow 0.003
		vi	For $n = 2$, $P(X \leq 0) = 0.0225 > 0.01$	M1	For $P(X \leq 0) = 0.0225$	
		vi	So the least value of n for which the critical region is not empty and thus H_0 could be rejected is 3.	A1	CAO	Condone just '$n = 3$' for final A mark dep on both M marks If wrong H_1 allow max M2A0 if correct probabilities seen.
		vi				
		vi	ALTERNATIVE METHOD using logs			
		vi	$0.15^n < 0.01$	M1		
		vi	$n >$ log 0.01 / log 0.15	M1		
		vi	$n > 2.427$			
		vi	Least $n = 3$	A1	**Examiner's Comments** Most candidates who knew how to tackle this question wrote down 'for n = 3, P(X = 0) = 0.0034 < 0.01'. However many did not then justify their answer by	

					writing down P(X = 0) for n = 2 and thus only gained one mark. There were very few successful attempts using logarithms.	
			Total	**19**		
4		i	(A) $X \sim$ B(20, 0.78) P(Exactly 19 cured) = $\binom{20}{19} \times 0.78^{19} \times 0.22^{1}$	M1	For $0.78^{19} \times 0.22^{1}$	Allow M2A0 for linear interpolation from tables leading to 0.9918 - 0.9488 = 0.0430 But zero for use of tables with 0.8 leading to 0.9885 - 0.9308 = 0.0577
		i		M1	For $\binom{20}{19} \times p^{19} \times q^{1}$ CAO	With $p + q = 1$ Also for 20×0.00196
		i	= 0.0392 (0.039197)	A1	**Examiner's Comments** This was generally very well-answered.	Allow 0.039 or better Condone 0.03919 but not 0.0391
		i	(*B*) P(Exactly 20 cured) = $\binom{20}{20} \times 0.78^{20} \times 0.22^{0} = 0.0069$	M1	For 0.78^{20} oe	Allow M2 for 0.9488 for linear interpolation from tables or M1 for 1 – 0.9918 = 0.0082 and second M1 for correct FT using answer to (i)(*A*) Zero for use of $p = 0.8$ here
		i	P(At most 18 cured) = 1 – (0.0069 + 0.0392)	M1	For P(19) + P(20) CAO	Not necessarily correct, but both attempts at binomial, including coefficient in (i) and no extra terms (such as P($X = 18$)) Condone use of $p = 0.8$
		i	= 0.954 (0.95385)	A1	**Examiner's Comments**	Allow 0.95 with working

					Although around two-thirds of candidates answered this correctly, some candidates included P(X=18) in their method and thus were only able to gain 1 mark out of 3. CAO **Examiner's Comments** The majority of the candidates found this part straightforward, but a minority lost the mark when they rounded their final answer to 15 or 16.	
		i	(C) E(X) = np =20 × 0.78 = 15.6	B1		Do not allow final answer of 15 or 16 even if correct 15.6 given earlier
		ii	Let X ~ B(20, 0.78) Let p = probability of a patient being cured (for population)	B1	For definition of p	In context See below for additional notes
		ii	H_0: p = 0.78	B1	For H_0	
		ii	H_1: p> 0.78	B1	For H_1	No further marks if point probabilities used
		ii	P(X≥ 19) = 0.0392 + 0.0069	B1	For **NOTATION** P(X ≥ 19) or P(X > 18) or 1 – P(X ≤ 18) or 1 – P(X < 19)	Notation P(X = 19) scores B0. If they have the correct P(X ≥ 19) then give B1 and ignore any further incorrect notation.
		ii	= 0.0461	B1*	CAO For 0.0461 allow 0.0462	FT answer to (i)B for following three marks provided based on 1 – (P(19) + P(20))
		ii	0.0461 > 1%	M1* dep	For comparison with 1%	Dep on sensible attempt at P(X ≥ 19)

		ii	So not significant.	A1		Allow 'accept H_0' or 'reject H_1'
		ii	Conclude that there is not enough evidence to suggest that the new drug is more effective than the old one.	E1		Must include 'insufficient evidence' or something similar such as 'to suggest that' ie an element of doubt either in the A or E mark. Must be in context to gain E1 mark. Do NOT allow 'sufficient evidence to suggest proportion cured is 0.78' or similar 99% method: $P(X \leq 18) = 0.9539$ B1B1* CAO 0.9539 < 99% M1* then as per scheme
		ii	ALTERNATIVE METHOD FOR FINAL 5 MARKS		If combination of methods used, mark both and give higher mark.	No further marks if point probabilities used
		ii	$P(X \geq 19) = 0.0461 > 1\%$	3	For either probability	Do not insist on correct notation as candidates have to work out two probabilities for full marks.
		ii	$P(X \geq 20) = 0.0069 < 1\%$	M1	For at least one comparison with 1%	Allow comparison in form of statement 'critical region at 1% level is …'
		ii	So critical region is {20}	B1*	CAO dep on the two correct probabilities	No marks if CR not justified Condone $X \geq 20$, $X = 20$, oe but not $P(X \geq 20,)$ etc
		ii	(19 not in CR so) not significant.	A1* dep	Dep on correct CR Ignore any work on lower critical region **Examiner's Comments**	Allow 'accept H_0' or 'reject H_1'
		ii	Conclude that there is not enough evidence to suggest that the new drug is more effective than the old one.	E1* dep	In recent years, candidates have been doing better on hypothesis test questions than in the past, and this was again the case this year. Many fully correct responses were seen. Most candidates scored the first three marks for the hypotheses, with most now knowing that they need to define p. The vast majority of successful candidates used the probability method,	

					finding P($X \geq 19$) and then comparing this to 1%. It was pleasing to see that most candidates gave their final answer in context and with an element of doubt stating something to the effect of 'there is not enough evidence to suggest that…'. Those who tried to use the critical region method were less successful on the whole. Again some tried to use point probabilities, being able to gain only the first three marks for the hypotheses. A few candidates tried to use tables and there full marks available for correct interpolation from tables.	
		iii	With a 5% significance level rather than a 1% level, the null hypothesis would have been rejected. OR: 'there would be enough evidence to suggest that the new drug is more effective than the old one.'	B1*	oe	FT their probability from (ii) but NO marks if point probabilities used There must be a sensible attempt to use P($X = 19$) + P($X = 20$) or must have correct CR.
		iii	This is because 0.0461 < 5%	B1* dep	oe **Examiner's Comments** Candidates who gained more or less full marks in part (ii) tended to gain full marks in this part. In this part no marks were available if point probabilities were used.	Dep on correct answer of 0.0461 compared with 5% or 0.9539 compared with 95% or correct CR.
			Total	**17**		
5		i	(*A*) $X \sim B(16, 0.1)$	Enter text here.		
		i	$P(X = 3) = 0.25^4 \times 0.75^{16} \binom{20}{4} \times 0.25^4 \times 0.75^{16} =$ 0.1423	M1	For $0.1^3 \times 0.9^{13}$	With $p + q = 1$

		i		M1	For $\binom{16}{3} \times p^3 \times q^{13}$	Also for 560 × 0.000254.. Allow 0.14 or better
		i		A1	CAO	
		i	Or: From tables	M2	For 0.9316 – 0.7892 CAO	
		i	$P(X \leq 3) - P(X \leq 2) = 0.9316 - 0.7892 = 0.1424$	A1	**Examiner's Comments** This was very well answered.	
		i	(*B*) $P(X \geq 3) = 1 - P(X \leq 2) = 1 - 0.7892 = 0.2108$	M1	For 0.7892 CAO	If calculating $P(X = 0) + P(X = 1) + P(X = 2)$ allow M1 for 0.79 or better and A1 for 0.21 or better.
		i		A1	**Examiner's Comments** Again this was well answered, usually by use of tables, although some candidates did calculate the three probabilities, add and subtract from 1. A few candidates forgot to subtract from 1, and a few just subtracted $P(X = 2)$ from 1. **Examiner's Comments**	
		i	(*C*) Expected number = 16 × 0.1 = 1.6	B1	The majority of the candidates found this part straightforward, but a small minority lost the mark when they rounded their final answer to 1 or 2.	Do not allow final answer of 1 or 2 even if correct 1.6 given earlier
		ii	Let p = probability of a randomly chosen person using 1234 as their PIN (in the population) H_0: $p = 0.1$	B1	For definition of p (in context)	Do NOT allow number in place of probability. See below for additional notes
		ii	H_1: $p < 0.1$	B1		

		ii		B1	For H_0 For H_1 Dep on < 0.1 used in H_1 Do Not allow just 'proportion will be lower' or similar. Minimum needed for B1 is p = probability of using 1234. Allow p = P(using 1234) Definition of p must include word probability (or chance or proportion or percentage or likelihood but NOT possibility, number or amount). Preferably given as a separate comment. However can be at end of H_0 as long as it is a clear definition 'p = the probability of using 1234.' Do NOT allow 'p = the probability of using 1234 is different' Allow p=10%, allow only p or θ or π or ρ. However allow any single symbol if defined (including x)	
		ii	The alternative hypothesis has this form as the advertising campaign aims to reduce the proportion of the population who use 1234 as their PIN.	B1	Allow $H_0 = p$=0.1, Allow H_0 : p=$^1/_{10}$ Allow NH and AH in place of H_0 and H_1 Do not allow H_0 : P($X = x$) = 0.1 Do not allow H_0: =0.1, =10%, P(0.1), p(x) = 0.1, x = 0.1 (unless x correctly defined as a probability) Do not allow H_0 and H_1 reversed For hypotheses given in words allow Maximum B0B1B1 Hypotheses in words must include probability (or chance or proportion or percentage) and the figure 0.1 oe Thus eg H_0 : P(using 1234) = 0.1, H_1 : P(using 1234) < 0.1 gets B0B1B1 **Examiner's Comments** As in recent years, candidates did well on this part, with over 80% gaining at least 3 marks out of 4. Most candidates scored the first two marks for the	For use of 0.9 as P(do not use 1234), contact team leader. E0 for simply stating H_1 in words Condone number instead of proportion.

					hypotheses, with many knowing that they needed to define p, thus scoring the third mark. A valid explanation of the reason for the form of the alternative hypothesis was usually given, even if not always very well worded.	
		iii	(*A*) For $n = 20$, $P(X \leq 0) = 0.1216$	M1*	For sight of 0.1216	Condone $P(X = 0)$ in place of $P(X \leq 0)$ Need to see a comparison with 0.1 or 10% explicitly, not just mentioning significance level.
		iii	0.1216 > 0.10	*M1dep	For > 0.10 or > 10% Do NOT FT wrong H_1 or state 'There is no critical region' oe For A1 need $P(X \leq 0)$ or P(X = 0) somewhere oe	Allow SC2 for clearly indicating use of B(20, 0.1) but with no mention of 0.1216 with convincing reasoning and final answer correct Allow CR is empty but NOT CR is zero
					Examiner's Comments	
		iii	So no point in carrying out the test as H0 could not be rejected (even if nobody in the sample uses 1234 as their PIN). oe	A1	Only about half of the candidates scored any marks here at all. Many candidates did not use any numbers so could not gain all the marks, but were awarded special case 2 if they gave a very convincing explanation. Some of those that did state that $P(X \leq 0) = 0.1216$ then failed to show a comparison with 10% or 0.1 and so only scored 1 mark. Or 13%	
					Examiner's Comments	
		iii	(*B*) Lowest value of *k* is 13	B1	Those candidates who had 0.1216 in the previous part usually gave the correct answer of 13%. Some who did not get marks in the previous part did give the correct answer, so they probably simply did not know how to verbalise the previous answer. However under half	

					scored the mark, some by simply failing to round to an integer.	
		iv	$P(X \leq 2) = 0.0530$	B1	For use of $P(X . 2)$ only	No marks unless H_1 correct
		iv	$0.0530 > 0.05$	M1	For comparison of 0.0530 with 5%	If B0 then no further marks
		iv	So not significant. Do not reject H_0	A1*	Also allow $P(X \leq 2) >$ 0.05, $(P(X \leq 1) < 0.05)$ so CR is {0, 1} for first two marks then A1E1 as usual Condone 'number of people' in conclusion	Allow 'accept H_0' or 'reject H_1'
		iv	Conclude that there is not enough evidence to support the suggestion that the advertising campaign has been successful. Reminder: When you mark this question part, if you 'fit to height' you can check the last page for working or mark it BP if there none	*EI dep	**Examiner's Comments** There were many good, clear answers to this part of the question but there were still a good proportion of candidates that were tempted to use point probabilities. A significant number who did use the correct probability (or probabilities if using a critical region method) failed to give the conclusion of the test in context. Some lost the final mark for commenting that the proportion had not changed instead of had not reduced and some gave a conclusion which was too assertive.	Must include 'insufficient evidence to suggest that' or something similar i.e. an element of doubt either in the A or E mark.
			Total	**18**		
6		a	(*A*) $X \sim B(30, 0.92)$, $P(X = 28)$ $= 0.2696$	**B1(AO3.3)** **B1(AO1.1)** **[2]**	BC	

		a	(*B*) P($X > 27$) = 1 – 0.4346 oe = 0.5654	M1(AO1.1) A1(AO1.1) [2]	OR for sum of at least two correct probabilities from $0.2696 + {}_{30}C_{29} \times 0.92^{29} \times 0.08^{1} + 0.92^{30}$ BC	
		b	Let p = probability that a train arrives on time H_0: $p = 0.92$ H_1: $p < 0.92$ Let $X \sim B(18, 0.92)$ P($X \leq 13$) = 0.0116 [> 1%] P($X \leq 12$) = 0.0021 [< 1%] The critical region is $X \leq 12$	B1(AO2.5) B1(AO1.1) M1(AO1.1) M1(AO1.1) A1(AO2.2a) [5]	For definition of p For H_0 and H_1 For probability P($X \leq$ any whole number value 1 to 18), Both P($X \leq 13$) and P($X \leq 12$) For correct critical region stated	Allow FT from H1: $p < 0.92$ OR H1: $p \neq 0.92$
			Total	**9**		

7			$H_0 : p = 0.49$ $H_1 : p \neq 0.49$ p is the probability that a voter selected at random supports Mr Evans X is the number of voters who support Mr. Evans. Under H_0 $X \sim B(38, 0.49)$ $p(X \leq 13) = 0.047(46439\ldots)$ $0.047 > 0.025$ Not significant There is insufficient evidence at the 5% level to suggest that support for Mr Evans has changed.	B1(AO1.1) B1(AO1.1) B1(AO2.5) B1(AO1.1) M1(AO1.1) A1(AO2.2b) E1(AO2.4) [7]	DR BC Compares their 0.047 with 0.025 Or reject H_0 Conclusion in context	
			Total	7		
8		a	Negative skew	B1(AO 1.2) [1]		
		b	[They are all less than 0.00005] and the table rounds values [to 4 decimal places]	E1(AO 2.4) [1]	Allow equivalent explanation in words	
		c	(A) 18	B1(AO 1.1) [1]		

		d	(*B*) 0	1(AO 2.2a) [1]		
			Total	4		
9	i	(*A*)	$X \sim B(12, 0.75)$ $P(X = 9) = \binom{12}{9} \times 0.75^9 \times 0.25^3 = 0.258\ (0.258103\ldots)$ Or: From tables $P(X \leq 9) - P(X \leq 8) = 0.6093 - 0.3512 = 0.2581$	M1 M1 A1 M2 A1 [3]	For $0.75^9 \times 0.25^3$ For $\binom{12}{9} \times p^9 \times q^3$ With $p + q = 1$ Also for $220 \times 0.00117\ldots$ Allow 0.26 or better with working CAO For 0.6093 – 0.3512 CAO **Examiner's Comments** Around 90% of candidates gained full marks here, with most using the formula, rather than tables.	
	i	(*B*)	$P(X \geq 9) = 1 - P(X \leq 8) = 1 - 0.3512 = 0.6488$	M1 A1 [2]	For 0.3512 CAO Accept 0.649 and 0.65 with working For $P(X=9) + P(X=10) + P(X=11) + P(X=12)$ allow M1A1 for awrt 0.649. Otherwise M0A0. **Examiner's Comments** Again this was well answered, usually by use of cumulative probability tables, although some candidates did calculate the four probabilities, usually summing them correctly. A few candidates forgot to	

					subtract from 1, and a few just subtracted P($X = 8$) from 1 rather than P($X \leq 8$).	
		ii	(Let $X \sim$ B(18, 0.75)) Let p = probability of dog having allergy relieved by the new shampoo (for population) H_0: $p = 0.75$ H_1: $p > 0.75$ H_1 has this form as the test is to determine whether the new shampoo relieves the symptoms of a higher proportion of dogs who suffer from the allergy. For use of B(18, 0.25), please consult your Team Leader	B1 B1 B1 E1 [4]	For definition of p (in context) Do NOT allow number in place of probability. See below for additional notes For H_0 For H_1 Dep on > 0.75 used in H_1 E0 for simply stating H_1 in words Condone number instead of proportion. Do Not allow just 'proportion will be higher' or similar. **Examiner's Comments** Candidates did well on this part, with over 80% gaining at least 3 marks out of 4. Most candidates scored the first two marks for the hypotheses, with many knowing that they needed to define p, thus scoring the third mark, although some definitions were wrong. For example 'p = the probability that dogs suffer from the allergy'. A valid explanation of the reason for the form of the alternative hypothesis was usually given, even if not always very well worded.	
		iii	(*A*) $P(X \geq 16) = 1 - P(X \leq 15) = 1 - 0.8647 = 0.1353$ $0.1353 > 0.1$ So not significant. Accept H_0 Conclude that there is not enough evidence to support the idea that the new shampoo relieves the symptoms of a higher proportion of dogs who suffer from the allergy.	M1* *M1dep A1* E1dep [4]	For sight of 0.1353 or 0.135 For (explicit) comparison with 10% or 0.1 Do NOT FT wrong H_1 but first mark available if H_1 or H_0 wrong For A1 need P($X \geq 16$) somewhere oe eg P(≥ 16) Allow SC2 for clearly indicating use of B(18, 0.75) but with no mention of 0.1353 with convincing reasoning and final answer correct	

	0.8647 < 0.9 scores M2 and can get A1 E1 if P($X \leq 15$) oe seen and all correct ALTERNATIVE METHOD Provided they are using CR method P($X \geq 16$) = 0.1353 P($X \geq 17$) = 0.0395 OR 0.8647 and 0.9605 0.1353 > 0.1 or 0.0395 < 0.1 OR 0.8647 < 0.9 or 0.9605 > 0.9 So critical region is {17, 18} so not significant. or 16 not in CR so not significant Conclude that there is enough evidence to support the idea that the new shampoo relieves the symptoms of a higher proportion of dogs who suffer from the allergy.		No marks if point probabilities used. Do not condone number instead of proportion Must include 'not enough evidence' oe For both probabilities Do not insist on correct notation as candidates have to work out two probabilities for full marks. B1 For at least one comparison with 10% Allow comparison in form of statement 'critical region at 10% level is …' CAO dep on the two correct probabilities M1 Ignore any work on lower critical region No marks if CR not justified. However SC2 above still A1* applies Condone $X \geq 17$, , oe but not P($X \geq 17$) etc Assume using first method unless you are convinced that candidate is using CR method. E1*dep No marks if point probabilities used **Examiner's Comments** Approximately half of the candidates scored full marks in this part and also the final part. Most candidates started off correctly by using 0.1353, but there were still quite a few who used point probabilities, scoring zero. The use of 0.0395 was not uncommon, again scoring zero. There were a few candidates who did not compare their probability to the significance level and so could only be awarded one mark. Some candidates used the critical region method and in this part the two correct probabilities were used most of the time and compared with the significance level. The final mark was often lost due to failure to provide a statement,

		iii	(*B*) $P(X \geq 42) = 1 - P(X \leq 41) = 1 - 0.9084 = 0.0916$ $0.0916 < 0.1$ or $0.9084 > 0.9$ So significant. Reject H_0 Conclude that there is enough evidence to support the idea that the new shampoo relieves the symptoms of a higher proportion of dogs who suffer from the allergy.	B1 M1* A1* E1*dep [4]	failure to include context or failure to include an element of doubt. For use of $P(X \leq 41)$ For comparison with 10% dep on first two marks NB If more than one attempt please mark the final one. Do not penalise 'number' rather than 'proportion' twice in parts A and B NB No marks for critical region method unless find $P(X \leq 40) = 0.9084 - 0.0721 = 0.8363$ in which case follow above scheme for part (iii)(*A*) so should have $0.1637 > 0.1$ and $0.0916 < 0.1$ or $0.8363 < 0.9$ and $0.9084 > 0.9$ etc (giving CR{42, 43, 44, 45, 46, 47, 48, 49, 50}) **Examiner's Comments** The majority of candidates used 0.0916 but there again there were quite a lot of candidates who used point probabilities. Some candidates used a critical region method but there were far too many who didn't use the correct two cumulative probabilities, but just 0.0916 and 0.0453, comparing both to 0.1. To score marks using the critical region method candidates needed to compare both 0.0916 and 0.1637 to 0.1 to justify the critical region.	
			Total	**17**		
10			p is the probability that a cutting treated with Miracleroot develops into a healthy new tree H_0: $p = 0.8$ H_1: $p < 0.8$	**B1(AO2.5)** **B1(AO1.1)**	For definition of p	

			Let $X \sim B(500, 0.8)$ $P(X < 380) = 0.01609$ *their* $0.01609 > 0.01$ so accept H_0 no evidence to suggest that manufacturer's claim is optimistic	B1(AO3.3) M1(AO3.4) M1(AO1.1) E1(AO2.2b) E1(AO3.2a) [7]	For H_0 and H_1 BC	
			Total	7		
11			H_0: $p = 0.62$ H_1: $p > 0.62$ p is the proportion of adults over 65 in the (UK population) who use the onine social media platform $1 - P(X \leq 45) = 0.0068$(1) $0.0068 < 0.01$ Result is significant or "reject H_0"	B1(AO1.1) B1(AO1.1) B1$(AO2.5) B1&(AO1.1) M1&(AO1.1) A1(AO2.2b) E1(AO2.4)	Allow null Allow alternative May be seen in hypotheses Allow probability NB from use of B(59, 0.62) Comparison of their 0.0068 with 0.01 or	Allow for sight of 0.9932, (from 0.99318902)

The evidence suggests that the proportion of adults over 65 (in the UK population) using platform has increased from 62%

[7]

0.68% with 1%; not allowed from point probability Depends on B1&M1& Conclusion in context Depends on all other marks except B1$	Allow 'accept H_1' OR Critical region ≥ 46 B1 46 in critical region, M1, hence conclusion

Examiner's Comments

The majority of candidates made valid attempts at this question. Common errors at the start of the question included defining H_1 as $p < 0.62$ and failing to define p. Some candidates wrongly used the probability that $X \leq 46$ in the test, others wrongly used a point probability. Most candidates who arrived at the correct p value correctly compared it with 0.01 and went on to reject H_0. A small number of otherwise successful candidates did not give a conclusion in the context of the question.

There were a small number of scripts from candidates who either omitted the question completely, or wrote

					vague comments such as 46 out of 59 is about 78%, which is a lot more than 62%.	
			Total	**7**		
12		a	0.6	**B1 (AO1.1)** **[1]**	BC	
		b	each egg has the same (constant) probability of being cracked	**E1 (AO2.4)** **[1]**	OR the probability of any particular egg being cracked is independent of any other egg being cracked oe	
		c	np = their 0.6 p = 0.1	**M1 (AO3.1b)** **A1 (AO1.1)** **[2]**		
		d	159.4, 106.3, 29.5, 4.4, 0.4, 0.0, 0.0	**M1 (AO3.4)** **M1 (AO1.1)** **A1 (AO1.1)** **[3]**	Use of B(6, 0.1) soi Multiplication by 300 All correct	If unsupported, allow **B3** for all frequencies correct, **B2** if one error, **B1** if two errors
		e	The theoretical frequencies are close to the observed values, so Rose's model is a good fit.	**B1 (AO3.2b)** **[1]**		

		f	$H_0: p = 0.1$ $H_0: p \neq 0.1$ p is the probability that an egg selected at random is cracked use of B(24, 0.1) $P(X \leq 5) = 0.9723$ …BC $1 - 0.9723 > 0.025$ not significant oe There is no evidence at the 5% level to suggest that the probability that an egg selected at random is cracked is not 0.1	B1 (AO1.1) B1 (AO2.5) M1 (AO3.3) A1 (AO1.1) M1 (AO3.4) A1 (AO1.1) E1 (E12.2b) [7]	Both hypotheses Comparison of their $1 - p(x \leq 5)$ with 0.025	
			Total	**15**		