1	**(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
			P(At most 18 cured) = 1 – (0.0069 + 0.0392)	M1	For P(19) + P(20)	Not necessarily correct, but both attempts at binomial, including coefficient in (i) and no extra terms (such as P(X=18)) Condone use of $p = 0.8$
			= 0.954 (0.95385)	A1 **[3]**	CAO	Allow 0.95 with working
	(i)	(*C*)	E(X) = $np = 20 \times 0.78 = 15.6$	B1 **[1]**	CAO	Do not allow final answer of 15 or 16 even if correct 15.6 given earlier
	(ii)		Let $X \sim B(20, 0.78)$			
			Let p = probability of a patient being cured (for population)	B1	For definition of p	In context See below for additional notes
			H_0: $p = 0.78$ H_1: $p > 0.78$	B1 B1	For H_0 For H_1	
						No further marks if point probabilities

			$P(X \geq 19) = 0.0392 + 0.0069$	B1	For **NOTATION** $P(X \geq 19)$ or $P(X > 18)$ or $1 - P(X \leq 18)$ or $1 - P(X < 19)$	used Notation $P(X = 19)$ scores B0. If they have the correct $P(X \geq 19)$ then give B1 and ignore any further incorrect notation.
			$= 0.0461$	B1*	CAO For 0.0461 allow 0.0462	FT answer to (i)B for following three marks provided based on $1 - (P(19) + P(20))$
			$0.0461 > 1\%$	M1* dep	For comparison with 1%	Dep on sensible attempt at $P(X \geq 19)$
			So not significant.	A1		Allow 'accept H_0' or 'reject H_1'
			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 <u>99% method:</u> $P(X \leq 18) = 0.9539$ B1B1* CAO $0.9539 < 99\%$ M1* then as per scheme
				[8]		
			ALTERNATIVE METHOD FOR FINAL 5 MARKS		If combination of methods used, mark both and give higher mark.	No further marks if point probabilities used
			$P(X \geq 19) = 0.0461 > 1\%$	B1	For either probability	Do not insist on correct notation as candidates have to work out two probabilities for full marks.

Question			Answer	Marks	Guidance	
			$P(X \geq 20) = 0.0069 < 1\%$	M1	For at least one comparison with 1%	Allow comparison in form of statement 'critical region at 1% level is …'
			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
			(19 not in CR so) not significant.	A1* dep	Dep on correct CR	Allow 'accept H_0' or 'reject H_1'
			Conclude that there is not enough evidence to suggest that the new drug is more effective than the old one.	E1* dep	Ignore any work on lower critical region	
1	**(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.
			This is because $0.0461 < 5\%$	B1* dep **[2]**	oe	Dep on correct answer of 0.0461 compared with 5% or 0.9539 compared with 95% or correct CR.

2	**(i)**	(*A*)	$X \sim \text{B}(15, 0.85)$ P(exactly 12 germinate) = $\binom{15}{12} \times 0.85^{12} \times 0.15^{3}$ = 0.2184	M1 M1 A1	For $0.85^{12} \times 0.15^{3}$ For $\binom{15}{12} \times p^{12} \times q^{3}$ CAO	
			OR	**OR**		
			from tables: 0.3958 – 0.1773 = 0.2185	M2 A1 **[3]**	For 0.3958 – 0.1773 CAO	
2	**(i)**	(*B*)	P(X <12) = P($X \leq 11$) = 0.1773	M1 A1 **[2]**	For P($X \leq 11$) or P($\leq$11) (With no extras) CAO (as final answer) May see alternative method: 0.3958 – 0.2185 = 0.1773 0.3958 - their wrong answer to part (i) scores M1A0	

Question			Answer	Marks	Guidance	
2	(ii)		Let p = probability of a seed germinating (for the population)	B1	For definition of p	See below for additional notes
			H_0: $p = 0.85$	B1	For H_0	
			H_1: $p < 0.85$	B1	For H_1	
			H_1 has this form because the test is to investigate whether the proportion of seeds which germinate is lower.	E1 **[4]**	Dep on < 0.85 used in H_1 Do not allow just 'Germination rate will be lower' or similar.	For use of 0.15 as P(not germinating), contact team leader E0 for simply stating H_1 in words
	(iii)		Let $X \sim$ B(20, 0.85) P($X \leq 13$) = 0.0219	M1*	For probability (provided not as part of finding P($X = 13$)) Ignore notation	No further marks if point probs used - P($X = 13$) = 0.0160 DO NOT FT wrong H_1, but see extra notes Allow 'accept H_0' or 'reject H_1' Must include 'sufficient evidence' or something similar such as 'to suggest that' ie an element of doubt either in the A or E mark.
			0.0219 > 1%	M1* dep	For comparison	
			So not enough evidence to reject H_0. Not significant.	A1*	For not significant oe	
			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	
			ALTERNATIVE METHOD – follow method above unless some mention of CR seen Critical region method			No marks if CR not justified Condone {0,1,2,…, 12}, X ≤ 12, oe but not P(X ≤ 12) etc
			LOWER TAIL P(X ≤ 13) = 0.0219 > 1% P(X ≤ 12) = 0.0059 < 1%	M1	For either probability	Could get M1A0A1E1 if poor notation for CR Do not allow just '13 not in CR' - Must say 'not significant' or accept H_0 or similar
			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%	
			13 not in CR so not significant	A1*		
			There is insufficient evidence to indicate that the proportion of seeds which have germinated has decreased.	E1* dep **[4]**		

Question			Answer	Marks	Guidance	
2	(iv)		33 < 35	M1	For comparison	Allow '33 lies in the CR' Must include 'sufficient evidence' or something similar such as 'to suggest that' ie an element of doubt either in the A or E mark.
			So there is sufficient evidence to reject H_0	A1*		Do not FT wrong H_1: In part (iv) ignore any interchanged H_0 and H_1 seen in part (ii)
			Conclude that there is enough evidence to indicate that the proportion of seeds which have germinated has decreased.	E1* dep **[3]**	For conclusion in context Must mention decrease, not just change	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)		For $n = 3$, $P(X \leq 0) = 0.0034 < 0.01$ For $n = 2$, $P(X \leq 0) = 0.0225 > 0.01$	M1 M1	For $P(X \leq 0) = 0.0034$ For $P(X \leq 0) = 0.0225$	Allow 0.003 Condone just '$n = 3$' for final A mark dep on both M marks
			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	If wrong H_1 allow max M2A0 if correct probabilities seen.
			ALTERNATIVE METHOD using logs $0.15^n < 0.01$ $n > \log 0.01 / \log 0.15$ $n > 2.427$ Least $n = 3$	 M1 M1 A1 **[3]**		

3	**(i)**		$\binom{11}{3}$ = 165	M1 A1 **[2]**	Seen Cao	
	(ii)		$\frac{\binom{5}{2}\times\binom{6}{1}}{\binom{11}{3}}+\frac{\binom{5}{3}\times\binom{6}{0}}{\binom{11}{3}}=\frac{60}{165}+\frac{10}{165}=\frac{70}{165}=\frac{14}{33}=0.424$ Alternative $1 - P(1 \text{ or } 0) = 1 - 3\times\frac{5}{11}\times\frac{6}{10}\times\frac{5}{9}-\frac{6}{11}\times\frac{5}{10}\times\frac{4}{9}$ $= 1-\frac{5}{11}-\frac{4}{33} = \frac{14}{33}$ M1 for 1 – P(1 or 0) , M1 for first product, M1 for ×3, M1 for second product, A1	M1 M1 M1 M1 A1 **[5]**	For intention to add correct two fractional terms For numerator of first term For numerator of sec term Do not penalise omission of $\binom{6}{0}$ For correct denominator cao	**Or** For attempt at correct two terms For prod of 3 correct fractions =4/33 For whole expression ie $3\times\frac{5}{11}\times\frac{4}{10}\times\frac{6}{9}\left(=\frac{4}{11}\right)$ (= 3 × 0.1212…) For attempt at $\frac{5}{11}\times\frac{4}{10}\times\frac{3}{9}\left(=\frac{2}{33}\right)$ cao Use of binomial can get max first M1