1. Ten cuttings were taken from each of 100 randomly selected garden plants. The numbers of cuttings that did not grow were recorded.

The results are as follows

No. of cuttings which did not grow	0	1	2	3	4	5	6	7	8, 9 or 10
Frequence	11	21	30	20	12	3	2	1	0

(a) Show that the probability of a randomly selected cutting, from this sample, not growing is 0.223

(2)

A gardener believes that a binomial distribution might provide a good model for the number of cuttings, out of 10, that do not grow.

He uses a binomial distribution, with the probability 0.2 of a cutting not growing. The calculated expected frequencies are as follows

No. of cuttings which did not grow	0	1	2	3	4	5 or more
Expected frequence	*r*	26.84	*s*	20.13	8.81	*t*

(b) Find the values of *r*, *s* and *t*.

(4)

(c) State clearly the hypotheses required to test whether or not this binomial distribution is a suitable model for these data.

(2)

The test statistic for the test is 4.17 and the number of degrees of freedom used is 4.

(d) Explain fully why there are 4 degrees of freedom.

(2)

(e) Stating clearly the critical value used, carry out the test using a 5% level of significance.

(3)

(Total 13 marks)

1. (a) $p = \dfrac{0\times11+1\times21+...}{10\times(11+21+...)\text{ or }10\times100}, = \dfrac{223}{1000} = 0.223(*)$ Accept $\dfrac{223}{1000}$ M1, A1cso 2

M1 Must show clearly how to get either 223 or 1000.
As printed or better.

A1cso for showing how to get <u>both</u> 223 and 1000 and reaching $p = 0.223$

(b) $r = (0.8)^{10} \times 100 = 10.7374$ awrt **10.74** M1A1

$s = \binom{10}{2}(0.8)^8 \times (0.2)^2 \times 100 = 30.198...$ awrt **30.2** A1

$t = 100 – [r + s + 26.84 + 20.13 + 8.81] =$ awrt **3.28** A1cao 4

M1 for any correct method (a correct expression) seen for r or s.

1st A1 for correct value for r awrt 10.74

2nd A1 for s = awrt 30.2

3rd A1 for t = 3.28 only

(c) H_0 : Binomial ([n =10], p = 0.2) is a suitable model for these data B1

H_1 : Binomial ([n =10], p = 0.2) is NOT a suitable model for these data B1 2

B1 for each. The value of p must be mentioned at least once.
Accept B(10, 0.2)

If hypotheses are correct but with no value of p then score B0B1

Minimum is X~B(10, 0.2). If just B(10, 0.2) and not B(10, 0.2) award B1B0

(d) Since $t < 5$, the last two groups are combined M1

and $v = 4 = 5 – 1$ A1 2

M1 for combining groups (must be stated or implied by a new table with combined cell seen)

A1 for the calculation 4 = 5 – 1

(e)	Critical value $\chi_4^2(5\%) = 9.488$	B1	
	Not significant or do not reject null hypothesis	M1	
	The binomial distribution with $p = 0.2$ is a suitable model for the number of cuttings that do not grow	A1	3

M1 for a correct statement based on 4.17 and their cv(context not required) (may be implied)
Use of 4.17 as a critical value scores B0M0A0

A1 for a correct interpretation in context and $p = 0.2$ and cuttings mentioned.

[13]

1. Part (a) was a "Show that…" and many candidates failed to provide sufficient evidence. Some 223clearly showed where the 223 came from but an alarming number thought that $\frac{223}{100}$ = 0.223, others assumed the 223 but did show that the denominator was 10 ×100 with only the most careful students explaining how both numerator and denominator were found and securing both marks. Part (b) was well done although some did not give answers to 2 decimal places as in the table. Most stated the hypotheses correctly but some failed to include the value of $p = 0.2$. Part (d) caught out a few candidates who failed to realise that the final two classes needed merging leading to the calculation 5-1=4, the common error was to assume that p had been estimated and $4 = 6 – 1 – 1$. A number of candidates decided to calculate the test statistic themselves rather than using the value of 4.17 given in the question but they usually made a correct comparison with the critical value although few remembered to mention the "cuttings" in their final conclusion.