1 **(i)**	$X \sim B(17, 0.2)$ $P(X \geq 4) = 1 - P(X \leq 3)$ $= 1 - 0.5489 = 0.4511$	B1 for 0.5489 M1 for 1 – their 0.5489 A1 CAO	**3**
(ii)	$E(X) = np = 17 \times 0.2 = 3.4$	M1 for product A1 CAO	**2**
(iii)	$P(X = 2) = 0.3096 - 0.1182 = 0.1914$ $P(X = 3) = 0.5489 - 0.3096 = 0.2393$ $P(X = 4) = 0.7582 - 0.5489 = 0.2093$ So 3 applicants is most likely	B1 for 0.2393 B1 for 0.2093 A1 CAO *dep* on both B1s	**3**
(iv)	(*A*) Let *p* = probability of a randomly selected maths graduate applicant being successful (for population) H_0: $p = 0.2$ H_1: $p > 0.2$ (*B*) $_1$ has this form as the suggestion is that mathematics graduates are <u>more</u> likely to be successful.	B1 for definition of *p* in context B1 for H_0 B1 for H_1 E1	**4**
(v)	Let $X \sim B(17, 0.2)$ $P(X \geq 6) = 1 - P(X \leq 5) = 1 - 0.8943 = 0.1057 > 5\%$ $P(X \geq 7) = 1 - P(X \leq 6) = 1 - 0.9623 = 0.0377 < 5\%$ So critical region is {7,8,9,10,11,12,13,14,15,16,17}	B1 for 0.1057 B1 for 0.0377 M1 for at least one comparison with 5% A1 CAO for critical region *dep* on M1 and at least one B1	**4**
(vi)	Because $P(X \geq 6) = 0.1057 > 10\%$ Either: comment that 6 is still outside the critical region Or comparison $P(X \geq 7) = 0.0377 < 10\%$	E1 E1	**2**
		TOTAL	**18**

2 **(i)**	(*A*) P(both) = $\left(\frac{2}{3}\right)^2 = \frac{4}{9}$ (*B*) P(one) = $2\times\frac{2}{3}\times\frac{1}{3}=\frac{4}{9}$ (*C*) P(neither) = $\left(\frac{1}{3}\right)^2 = \frac{1}{9}$	B1 CAO B1 CAO B1 CAO	**3**
(ii)	Independence necessary because otherwise, the probability of one seed germinating would change according to whether or not the other one germinates. May not be valid as the two seeds would have similar growing conditions eg temperature, moisture, etc. *NB Allow valid alternatives*	E1 E1	**2**
(iii)	Expected number = 2 × $\frac{2}{3}=\frac{4}{3}$ (= 1.33) E(X^2) = $0\times\frac{1}{9}+1\times\frac{4}{9}+4\times\frac{4}{9}=\frac{20}{9}$ Var(X) = $\frac{20}{9}-\left(\frac{4}{3}\right)^2=\frac{4}{9}$ = 0.444 *NB use of npq scores M1 for product, A1CAO*	B1 FT M1 for E(X^2) A1 CAO	**3**
(iv)	Expect $200\times\frac{8}{9}=177.8$ plants So expect 0.85 × 177.8 = 151 onions	M1 for 200 × $\frac{8}{9}$ M1 dep for × 0.85 A1 CAO	**3**
(v)	Let X ~ B(18, p) Let p = probability of germination (for population) H_0: p = 0.90 H_1: p < 0.90 P($X \le 14$) = 0.0982 > 5% So not enough evidence to reject H_0 Conclude that there is not enough evidence to indicate that the germination rate is below 90%. Note: use of critical region method scores M1 for region {0,1,2,…, 13} M1 for 14 does not lie in critical region then A1 E1 as per scheme	B1 for definition of p B1 for H_0 B1 for H_1 M1 for probability M1 dep for comparison A1 E1 for conclusion in context	**7**
		TOTAL	**18**

3 **(i)**	$P(X=2)=\binom{3}{2}\times 0.87^2\times 0.13=0.2952$	M1 0.87^2 x 0.13 M1 $\binom{3}{2}$ x p^2q **with p+q=1** A1 CAO	**3**
(ii)	In 50 throws expect 50 (0.2952) = 14.76 times	B1 FT	**1**
(iii)	P (two 20's twice) = $\binom{4}{2}\times 0.2952^2\times 0.7048^2=0.2597$	M1 $0.2952^2\times 0.7048^2$ A1 FT their 0.2952	**2**
		TOTAL	**6**

4 (i)	$X \sim B(20, 0.1)$ **(*A*)** $P(X = 1) = \binom{20}{1} \times 0.1 \times 0.9^{19} = 0.2702$ OR from tables $0.3917 - 0.1216 = 0.2701$ **(*B*)** $P(X \geq 1) = 1 - 0.1216 = 0.8784$	M1 0.1×0.9^{19} M1 $\binom{20}{1} \times pq^{19}$ A1 CAO OR: M2 for 0.3917 – 0.1216 A1 CAO M1 P(X=0) *provided that P(X≥1)=1–P(X≤1) not seen* M1 1-P(X=0) A1 CAO	**3** **3**
(ii)	EITHER: $1 - 0.9^n \geq 0.8$ $0.9^n \leq 0.2$ Minimum $n = 16$ OR (using trial and improvement): Trial with 0.9^{15} or 0.9^{16} or 0.9^{17} $1 - 0.9^{15} = 0.7941 < 0.8$ and $1 - 0.9^{16} = 0.8147 > 0.8$ Minimum $n = 16$ NOTE: $n = 16$ unsupported scores SC1 only	M1 for 0.9^n M1 for inequality A1 CAO M1 M1 A1 CAO	**3**
(iii)	**(*A*)** Let p = probability of a randomly selected rock containing a fossil (for population) H_0: $p = 0.1$ H_1: $p < 0.1$ **(*B*)** Let $X \sim B(30, 0.1)$ $P(X \leq 0) = 0.0424 < 5\%$ $P(X \leq 1) = 0.0424 + 0.1413 = 0.1837 > 5\%$ So critical region consists only of 0. **(*C*)** 2 does not lie in the critical region. So there is insufficient evidence to reject the null hypothesis and we conclude that it seems that 10% of rocks in this area contain fossils.	B1 for definition of p B1 for H_0 B1 for H_1 M1 for attempt to find P(X ≤ 0) or P(X ≤ 1) using binomial M1 for both attempted M1 for comparison of either of the above with 5% A1 for critical region dep on both comparisons **(NB Answer given)** M1 for comparison A1 for conclusion **in context**	**3** **4** **2**
		TOTAL	**18**