1 **(i)**	$X \sim B(10, 0.8)$ (***A***) *Either* $P(\boldsymbol{X} = 8) = \binom{10}{8} \times 0.8^8 \times 0.2^2 = 0.3020$ (awrt) *or* $P(X = 8) = P(X \le 8) - P(X \le 7)$ $= 0.6242 - 0.3222 = 0.3020$ (***B***) *Either* $P(X \ge 8) = 1 - P(X \le 7)$ $= 1 - 0.3222 = 0.6778$ *or* $P(X \ge 8) = P(X = 8) + P(X = 9) + P(X = 10)$ $= 0.3020 + 0.2684 + 0.1074 = 0.6778$	M1 $0.8^8 \times 0.2^2$ or 0.00671… M1 $\binom{10}{8} \times p^8 q^2$; (p +q =1) Or $45 \times p^8 q^2$; (p +q =1) A1 CAO **(0.302) not 0.3** OR: M2 for 0.6242 – 0.3222 A1 CAO M1 for 1 – 0.3222 (s.o.i.) A1 CAO awfw 0.677 – 0.678 or M1 for sum of 'their' p(X=8) plus correct expressions for p(x=9) and p(X=10) A1 CAO awfw 0.677 – 0.678	**3** **2**
(ii)	Let $X \sim B(18, p)$ Let p = probability of delivery (within 24 hours) (for population) H_0: $p = 0.8$ H_1: $p < 0.8$ $P(X \le 12) = 0.1329 > 5\%$ ref: [pp =0.0816] So not enough evidence to reject H_0 Conclude that there is not enough evidence to indicate that less than 80% of orders will be delivered within 24 hours Note: use of critical region method scores M1 for region {0,1,2,…,9, 10} M1dep for 12 does not lie in critical region then A1dep E1dep as per scheme	B1 for definition of p B1 for H_0 B1 for H_1 M1 for probability 0.1329 M1dep strictly for comparison of 0.1329 with 5% (seen or clearly implied) A1dep on both M's E1dep on M1,M1,A1 for conclusion in context	**7**

(iii)	Let $X \sim B(18, 0.8)$ H_1: $p \neq 0.8$ LOWER TAIL $P(X \leq 10) = 0.0163 < 2.5\%$ $P(X \leq 11) = 0.0513 > 2.5\%$ UPPER TAIL $P(X \geq 17) = 1 - P(X \leq 16) = 1 - 0.9009 = 0.0991 > 2.5\%$ $P(X \geq 18) = 1 - P(X \leq 17) = 1 - 0.9820 = 0.0180 < 2.5\%$ So critical region is {0,1,2,3,4,5,6,7,8,9,10,18} o.e. Condone $X \leq 10$ and $X \geq 18$ or X = 18 but **not** $p(X \leq 10)$ and $p(X \geq 18)$ Correct CR without supportive working scores SC2 max after the 1st B1 (SC1 for each fully correct tail of CR)	B1 for H_1 B1 for 0.0163 or 0.0513 seen M1dep for either correct comparison with **2.5% (not 5%)** (seen or clearly implied) A1dep for correct lower tail CR (must have zero) B1 for 0.0991 or 0.0180 seen M1dep for either correct comparison with **2.5% (not 5%)** (seen or clearly implied) A1dep for correct upper tail CR	**7**
		TOTAL	**19**

2 (i)	$(\boldsymbol{A})$ $0.5 + 0.35 + \boldsymbol{p} + \boldsymbol{q} = 1$ so $\boldsymbol{p} + \boldsymbol{q} = 0.15$ $(\boldsymbol{B})$ $0 \times 0.5 + 1 \times 0.35 + 2\boldsymbol{p} + 3\boldsymbol{q} = 0.67$ so $2\boldsymbol{p} + 3\boldsymbol{q} = 0.32$ $(\boldsymbol{C})$ from above $2\boldsymbol{p} + 2\boldsymbol{q} = 0.30$ so $\boldsymbol{q} = 0.02$, $\boldsymbol{p} = 0.13$	B1 p + q in a correct equation before they reach p + q =0.15 B1 2p + 3q in a correct equation before they reach 2p + 3q = 0.32 (B1) for any 1 correct answer B2 for both correct answers	**1** **1** **2**
(ii)	$E(X^2) = 0 \times 0.5 + 1 \times 0.35 + 4 \times 0.13 + 9 \times 0.02 = 1.05$ Var(X) = 'their 1.05' – 0.67^2 = 0.6011 (awrt 0.6) (M1, M1 can be earned with their p^+ and q^+ but not A mark)	M1 $\Sigma x^2 p$ (at least 2 non zero terms correct) M1dep for (– 0.67^2), provided Var(X) > 0 A1 cao (No n or n-1 divisors)	**3**
		TOTAL	**7**

3 (i)	Let p = probability of remembering or naming all items (for population) (whilst listening to music.) H_0: $p = 0.35$ H_1: $p > 0.35$ H_1 has this form since the student believes that the probability will be increased/ improved/ got better /gone up.	B1 for definition of p B1 for H_0 B1 for H_1 E1dep on p>0.35 in H_0 In words not just because p > 0.35	**4**
(ii)	Let $X \sim B(15, 0.35)$ ***Either***: $P(X \geq 8) = 1 - 0.8868 = 0.1132 > 5\%$ Or $0.8868 < 95\%$ So not enough evidence to reject H_0 (Accept H_o) Conclude that there is not enough evidence to indicate that the probability of remembering all of the items is improved / improved/ got better /gone up. (when listening to music.) -- ***Or***: Critical region for the test is {9,10,11,12,13,14,15} 8 does not lie in the critical region. So not enough evidence to reject H_0 Conclude that there is not enough evidence to indicate that the probability of remembering all of the items is improved / improved/ got better /gone up. (when listening to music.) -- ***Or*:** The smallest critical region that 8 could fall into is {8, 9, 10, 11, 12, 13, 14, and 15}. The size of this region is 0.1132 0.1132 > 5% So not enough evidence to reject H_0 Conclude that there is not enough evidence to indicate that the probability of remembering all of the items is improved (when listening to music)	***Either:*** M1 for probability (0.1132) M1**dep** for comparison A1**dep** E1**dep on all previous marks** for conclusion in **context** ---------------------------- ***Or***: M1 for correct CR(no omissions or additions) M1**dep** for 8 does not lie in CR A1**dep** E1**dep on all previous marks** for conclusion in **context** **----------------------------** **Or**: M1 for CR{8,9,…15}**and** size = 0.1132 M1 **dep** for comparison A1**dep** E1**dep on all previous marks** for conclusion in **context**	**4**
		TOTAL	**8**

4 (i)	$X \sim B(12, 0.05)$ (*A*) $P(X = 1) = \binom{12}{1} \times 0.05 \times 0.95^{11} = 0.3413$ OR from tables $0.8816 - 0.5404 = 0.3412$ (*B*) $P(X \geq 2) = 1 - 0.8816 = 0.1184$ (*C*) Expected number $E(X) = np = 12 \times 0.05 = 0.6$	M1 0.05×0.95^{11} M1 $\binom{12}{1} \times pq^{11}$ (p+q) = 1 A1 cao OR: M1 for 0.8816 seen and M1 for subtraction of 0.5404 A1 cao M1 for 1 – P(X ≤ 1) A1 cao M1 for 12×0.05 A1 cao (= 0.6 seen)	**3** **2** **2**
(ii) **(iii)**	*Either*: $1 - 0.95^n \leq ⅓$ $0.95^n \geq ⅔$ $n \leq \log ⅔ / \log 0.95$, so $n \leq 7.90$ Maximum $n = 7$ *Or:* (using tables with $p = 0.05$): $n = 7$ leads to $P(X \geq 1) = 1 - P(X = 0) = 1 - 0.6983 = 0.3017$ (< ⅓) or 0.6983 (> 2/3) $n = 8$ leads to $P(X \geq 1) = 1 - P(X = 0) = 1 - 0.6634 = 0.3366$ (> ⅓) or 0.6634 (< 2/3) Maximum $n = 7$ (total accuracy needed for tables) *Or:* (using trial and improvement): $1 - 0.95^7 = 0.3017$ (< ⅓) or $0.95^7 = 0.6983$ (> 2/3) $1 - 0.95^8 = 0.3366$ (> ⅓) or $0.96^8 = 0.6634$ (< 2/3) Maximum $n = 7$ (3 sf accuracy for calculations) NOTE: $n = 7$ unsupported scores SC1 only Let $X \sim B(60, p)$ Let p = probability of a bag being faulty H_0: $p = 0.05$ H_1: $p < 0.05$ $P(X \leq 1) = 0.95^{60} + 60 \times 0.05 \times 0.95^{59} = 0.1916 > 10\%$ So not enough evidence to reject H_0 Conclude that there is not enough evidence to indicate that the new process reduces the failure rate or scientist incorrect/ wrong.	M1 for equation in *n* M1 for use of logs A1 cao M1indep M1indep A1 cao dep on both M's M1indep (as above) M1indep (as above) A1 cao dep on both M's B1 for definition of *p* B1 for H_0 B1 for H_1 M1 A1 for probability M1 for comparison A1 E1	 **3** **8**
		TOTAL	**18**