1 **(i)**	$X \sim B(10,0.2)$ $P(X < 4) = P(X \le 3) = 0.8791$ OR attempt to sum $P(X = 0,1,2,3)$ using $X \sim B(10,0.2)$ can score M1, A1	M1 for $X \le 3$ A1	**2**
(ii)	Let p = the probability that a bowl is imperfect $H_0 : p = 0.2 \quad H_1 : p < 0.2$ $X \sim B(20,0.2)$ $P(X \le 3) = 0.2061$ $0.2061 > 5\%$ Cannot reject H_0 and so insufficient evidence to claim a reduction. OR using critical region method: CR is {0} B1, 2 not in CR M1, A1 as above	B1 Definition of p B1, B1 B1 for 0.2061 seen M1 for this comparison A1 *dep* for comment <u>in context</u>	**3** **3**
		TOTAL	**8**

2 (i)	$X \sim B\left(15, \frac{1}{6}\right)$ $P(X = 0) = \left(\frac{5}{6}\right)^{15} = 0.065$	M1 A1 cao	$\left(\frac{5}{6}\right)^{15}$
(ii)	$P(X = 4) = \binom{15}{4} \times \left(\frac{1}{6}\right)^4 \times \left(\frac{5}{6}\right)^{11}$	M1	$\left(\frac{1}{6}\right)^4 \left(\frac{5}{6}\right)^{11}$
	= 0.142 (or 0.9102-0.7685)	M1 A1 cao	multiply by $\binom{15}{4}$

(iii)	$P(X > 3) = 1 - P(X \le 3)$ $= 1 - 0.7685 = 0.232$	M1 A1	
(iv) (*A*)	Let p = probability of a six on any throw $H_0 : p = \frac{1}{6}$ $H_1 : p < \frac{1}{6}$ $X \sim B\left(15, \frac{1}{6}\right)$ $P(X = 0) = 0.065$ 0.065 < 0.1 and so reject H_0 Conclude that there is sufficient evidence at the 10% level that the dice are biased against sixes.	B1 B1 M1 M1 dep E1 dep	Definition of p Both hypotheses 0.065 Comparison
(*B*)	Let p = probability of a six on any throw $H_0 : p = \frac{1}{6}$ $H_1 : p > \frac{1}{6}$ $X \sim B\left(15, \frac{1}{6}\right)$ $P(X \ge 5) = 1 - P(X \le 4) = 1 - 0.910 = 0.09$ 0.09 < 0.1 and so reject H_0 Conclude that there is sufficient evidence at the 10% level that the dice are biased in favour of sixes.	B1 M1 M1 dep E1 dep	Both hypotheses 0.09 Comparison
(v)	Conclusions contradictory. Even if null hypothesis is true, it will be rejected 10% of the time purely by chance. Or other sensible comments.	E1 E1	Contradictory By chance

3	Number not turning up X~B(16,0.2)		
(i)	$P(X = 0) = 0.8^{16} = 0.0281$	M1 A1	0.8^{16} or tables
(ii)	$P(X > 3) = 1 - P(X \le 3)$ or $P(X \le 12)$ $= 1 - 0.5981 = 0.4019$	M1 M1 A1	Manipulation Use of tables
(iii)	X~B(17,0.2) $\rightarrow P(X \ge 1) = 0.9775$ Greater than 0.9 so acceptable	M1 A1 E1	B(17,0.2) 0.9775
(iv)	X~B(18,0.2) $\rightarrow P(X \ge 2) = 0.9009$ Can make 18 appointments X~B(19,0.2) $\rightarrow P(X \ge 3) = 0.7631$	M1 A1 A1 M1	18 and ≥ 2 0.9009 18 ok 19 and ≥ 3
(v)	Now X ~ B(20,p) Let p be probability of not turning up. H_0: p = 0.2 H_1: p $\neq$ 0.2 $P(X \le 1) = 0.0692 > 2.5\%$ cannot reject H_0 conclude that the proportion of patients not turning up is unchanged.	B1 B1 B1 M1 M1 A1 E1	0.0692 correct comparison cannot reject H_0