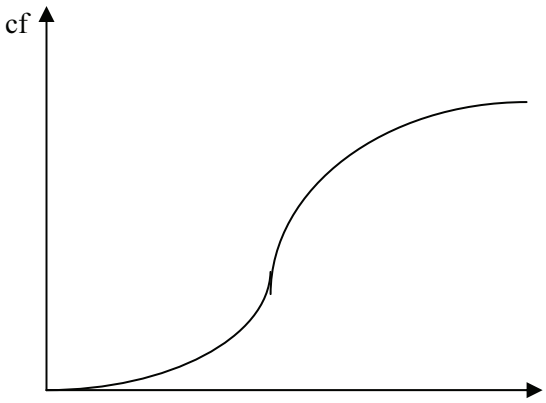
1	$20p = 4.8 \quad p = 0.24$ or $4.8/20$ $P(0, 1, 2) = (0.76)^{20} + {}^{20}C_1(0.24)^1(0.76)^{19}$ $+ {}^{20}C_2(0.25)^2(0.76)^{18}$ $= 0.109$ SR max 3 out of 4	B1 M1 A1 A1 **[4]** B1 M1 A1	Correct value for p Summing 2 or 3 binomial probs o.e., any p, $n = 5$ or 20 Correct unsimplified answer Correct answer As above Using N(4.8, 3.648) with cc 2.5 or 3.5 0.114 seen
2	**(i)** $np = 24$, $npq = 4.8$ $z = \pm\left(\frac{24.5 - 24}{\sqrt{4.8}}\right) = 0.228$ Prob = 0.590	B1 M1 M1 A1 **[4]**	24 and 4.8 or $\sqrt{4.8}$ seen can be unsimplified Standardising, need sq rt, cc not necessary Continuity correction 24.5 or 25.5 used Correct answer must be from 24.5
	(ii) np and nq both > 5.	B1 **[1]**	Need both
3	**(i)** Mean = $45 - 148/36 = 40.9$ or $1472/36$ *EITHER* Var = $3089/36 - (-148/36)^2 = 68.9$ sd = 8.30 *OR* $\Sigma x^2 = 3089 - 36 \times 45^2 + 90 \times 1472 = 62669$ Var = $\left(\frac{62669}{36} - \left(\frac{1472}{36}\right)^2\right)$ sd = 8.30	B1 M1 A1 **[3]** M1 A1	Correct answer $3089/36 - (\pm$ their coded mean$)^2$ Correct answer Expanding $\Sigma(x - 45)^2$ with at least 2 terms correct and solving, then substituting their Σx^2 in correct variance formula with their mean^2 subt numerically Correct answer
	(ii) New $\Sigma(x - 45) = -148 - 16 = -164$ New $\Sigma(x - 45)^2 = 3089 + 16^2 = 3345$ New sd = $\sqrt{3345/37 - (-164/37)^2}$ = 8.41 *OR* $\Sigma x = 36 \times 45 - 148 = 1472$ New $\Sigma x = 1472 + 29 = 1501$ $\Sigma x^2 = 3089 - 36 \times 45^2 + 90 \times 1472 = 62669$ New $\Sigma x^2 = 62669 + 29^2$ (= 63510) New sd = $\sqrt{63510/37 - (1501/37)^2}$ = 8.41	M1 M1 M1 A1 **[4]** M1 M1 M1 A1	Adding their coded new value to – 148 Adding their (coded value)^2 to 3089 Subst in coded var formula, can have one of 29 and one of –16 here Correct answer Finding Σx and adding 29 Finding Σx^2 and adding 29^2, at least 2 terms of 3089, 36×45^2, 90×1472 Subst their values in correct var formula Correct answer

4 (i)	90720	B1 **[1]**	Not 9!/2!2!
(ii)	3 vowels together $= 3! \times 7!/2!2! = 7560$	B1 B1	3! oe seen multiplied by integer oe 7 or 6! seen multiplied as a num
	Prob(not together) $= \frac{90720 - 7560}{90720} = \frac{83160}{90720}$	M1	Subt from their **(i)** or dividing by their **(i)** or 1 – prob
	$= 0.917$ (=11/12)	A1 **[4]**	Correct answer from correct working
(iii)	One S in ${}^5C_3$ ways = 10 SS in ${}^5C_2$ ways = 10 Total = 20	M1 M1 A1 **[3]**	${}^5C_3$ seen added ${}^5C_2$ seen added Correct answer
	OR ${}^6C_3$	M1	${}^6C_3 \times 2$ or $\div 2$ or $\times 1$ seen
		M1	${}^6C_3$ only
	$= 20$	A1	Correct answer
5 (i)	cf  Number of rooms	M1 M1 M1 A1 **[4]**	Attempt at cf table (up to 200) Linear scale minimum 0 to 200 and 20 to 80, and labels Attempt to plot points at (20.5, 10), (40.5, 42), (50.5, 104), (60.5, 154), (70.5, 182), (90.5, 200), accept (20, 10), (40, 42) or (21, 10), (41, 42) etc All points correct and joined up, allow (0, 0) or (0.5, 0)
(ii)	Line on graph up from 30	M1	Line or mark seen, can be implied if matches graph and in range
	$200 - 20 = 180$	A1 **[2]**	Accept 174 – 180 if reading from graph
	OR using lin int $10 + \frac{(30 - 20.5)}{20} \times 32 = 25.2$	M1	Can have 20 or 20.5
	$= 174.8$	A1	Accept decimals, 174 – 175 if using lin int
(iii)	Line on graph across from 150	M1	Line or mark seen, can be implied if matches graph and in range. 150 seen and line between 140 and 160
	59 rooms	A1 **[2]**	Accept 58 – 60
	OR lin int $50.5 + 46/50 \times 10$ $= 59$ or 60	M1 A1	Can have 50 or 50.5 Must be integer

6 **(i)**	$z = -1.282$	B1	± 1.282 or ± 1.281 seen
	$P(x < 20) = P\left(z < \frac{20-\mu}{0.8}\right)$	M1	Standardising, no cc, must have 0.8, must be a z-value
	$-1.282 = \frac{20-\mu}{0.8}$		
	$\mu = 21.0$ cm (21.0256)	A1 **[3]**	Correct answer
(ii)	$P(21.5 < x < 22.5)$		
	$= P\left(\frac{21.5-21.03}{0.8}\right) < z < \left(\frac{22.5-21.03}{0.8}\right)$	M1	2 attempts at standardising with their mean, must have 0.8 oe
	$= \Phi(1.8375) - \Phi(0.5875)$	M1	Subtracting 2 Φs ft their mean
	$= 0.9670 - 0.7217$		
	$= 0.2453$	A1	Needn't be entirely accurate, rounding to 0.24 or 0.25
	$P(< 2) = P(0) + P(1)$		
	$= (0.7547)^4 + (0.2453)^1(0.7547)^3\ {}^4C_1$	M1	Binomial term with ${}^4C_r p^r (1-p)^{4-r}$ seen $r \neq 0$, any $p < 1$
		M1	Bin expression for P(0) + P(1), any $p < 1$
	$= 0.746$	A1 **[6]**	Accept 3sf rounding to 0.75
7 **(i)**	$P(6) = P(3, 9) + P(9, 3) = 2/25 = 0.08$ AG	B1 **[1]**	Accept 2/25 seen
(ii)			

x	0	1	2	3	4	5	6
Prob	0.2	0.24	0.08	0.08	0.16	0.16	0.08

	M1	Values 0 – 6 seen could be in list
	A1 **[2]**	All correct
(iii) Mean = $\Sigma xp = 2.56$ (64/25)	B1 **[1]**	
(iv) $P(4, 5, 6) = 0.4(10/25)$ or $0.16 + 0.16 + 0.08$	B1 ft	ft their P(4, 5, 6) providing $p < 1$
$=$ P(draw) $\times$ 0.4	M1	Multiplying by their P(draw) providing $p < 1$
$= 0.2 \times 0.4 = 0.08$ (2/25)	A1ft **[3]**	Correct answer
(v) P(J wins on nth go)	M1	Mult by any p^n or p^{n-1}, $p < 1$
$= (0.2)^{n-1} \times 0.4$ oe	A1ft **[2]**	ft their probs