Note: "(3 sfs)" means "answer which rounds to ... to 3 sfs". If correct ans seen to ≥ 3sfs, ISW for later rounding. Penalise < 3 sfs only once in paper.

1 (i)	One of each is more likely P(one of each = 0.5), P(HH) = 0.25	B1 B1 [2]	or P(TT) = 0.25	
(ii)	Choose Charlie only if H then T Throw again if T then H	B1 B1 [2]	or similar e.g. HH for A, HT for B, TT for C or vice versa	
2	H_0: Pop mean = 17 H_1: Pop mean ≠ 17	B1	Both correct. Allow μ, but not just "mean"	
	$\frac{18.2-17}{\frac{2.4}{\sqrt{5}}}$	M1	Allow incorrect 18.2. Must have √5	$17 \pm 1.96\frac{2.4}{\sqrt{5}}$ M1
	= 1.12 (3 sf)	A1		= (14.9, 19.1) A1
	'1.12' < 1.96 oe	M1	Comp '1.12' with 1.96 or area '0.132' with 0.025	'14.9'<18.2<'19.1' M1
	Claim can be accepted	A1ft [5]	ft their '1.12' If H_1: μ > 17 and cf 1.645: can score max B0M1A1M1A1ft	
3	Var(total) = $6(3.2^2 + 2.6^2)$ (+ 0)) (= 102) Total ~ N(1528, 102))	B1 B1	For mean (1528)oe and for variance (102) May be implied by use of N(1528, 10.1^2)	
	$\frac{1550-\text{"1528"}}{\sqrt{\text{"102"}}}$ (= 2.178)	M1	For standardising. No SD/Var mix	
	1 – Φ("2.178") = 0.0147 (3 sf)	M1 A1 [5]	For correct area consistent with working	
4 (i)	est(μ) = 2005/200 = (10.025)	B1		
	est(σ^2) = $\frac{1}{99}$20175 – $\frac{2005^2}{200}$)	M1	Correct subst in correct formula	
	= 0.376 (3 sf)	A1 [3]		
(ii)	$\frac{10-\text{'}10.025\text{'}}{\sqrt{\frac{\text{'}0.376256\text{'}}{50}}}$ (= –0.288)	M1	Allow without √, but ÷√50 essential	
	1 – Φ('0.288') = 0.387 (3 sf)	M1 A1 [3]	(Use of 'biased' variance can still score fully in (ii))	

	(iii)	Yes; (assumed distr of $\overline{X}$ normal) although distr of X unknown	B1 B1 [2]	
5	**(i)**	B(520, 0.008) Po(4.16) $n = 500$ which is large, $np = 4.16$ which is < 5 or p small <0.1	B1 B1B1 B1 [4]	 Po: B1, $\lambda = 4.16$: B1 Both needed
	(ii)	**(a)** $1 - e^{-4.16}(1 + 4.16 + \frac{4.16^2}{2} + \frac{4.16^3}{3!})$ $= 0.597$ (3 sf)	M1 A1 [2]	1–P(0,1,2,3) any λ allow one end error
		(b) $e^{-4.16} \times \frac{4.16^n}{n!} > e^{-4.16} \times \frac{4.16^{n+1}}{(n+1)!}$ $1 > \frac{4.16}{n+1}$ $n > 3.16$ Smallest n is 4	M1 A1 A1 [3]	any λ or equiv equn without e and without factorials (Calculation of P(0), P(1),....P(5) scores M1for at least 3 attempted, A1 all correct, A1 for n = 4)
6	**(i)**	$\frac{1}{2}\int_4^t \frac{1}{\sqrt{t}}dt = 0.9$ or $\frac{1}{2}\int_t^9 \frac{1}{\sqrt{t}}dt = 0.1$ $\left[\sqrt{t}\right]_4^t = 0.9$ or $\left[\sqrt{t}\right]_t^9 = 0.1$ $((\sqrt{t} - 2) = 0.9$ or $(3 - \sqrt{t}) = 0.1)$ $t = 8.41$ (mins) (3 sf)	M1 A1 A1 [3]	Attempt integ f(t) with unknown limit and 0.9/0.1. Correct integration & limits = 0.9 or 0.1.
	(ii)	$\frac{1}{2}\int_4^9 \frac{t}{\sqrt{t}}dt$ oe $\frac{1}{2}\left[\frac{t1.5}{1.5}\right]_4^9$ oe $= \frac{19}{3}$ $\frac{1}{2}\int_4^9 \frac{t2}{\sqrt{t}}dt$ oe $(= \frac{1}{2}\left[\frac{t2.5}{2.5}\right]_4^9 = \frac{211}{5})$ $= \frac{'211'}{5} - (\frac{'19'}{3})^2$ $= \frac{94}{45}$ or 2.09 (3 sf)	M1 A1 A1 M1 M1 A1 [6]	Attempt integ tf(t). Ignore limits Correct integration & limits Attempt integ t^2f(t). Ignore limits integ t^2f(t) – (integ tf(t))^2 attempted

7	(i)	Conclude die is biased when it isn't oe ${}^5C_3\left(\frac{1}{6}\right)^3\left(\frac{5}{6}\right)^2 + 5\left(\frac{1}{6}\right)^4\left(\frac{5}{6}\right) + \left(\frac{1}{6}\right)^5$ + 5 $= \frac{23}{648}$ or 0.0355 (3 sf)	B1 M1 A1 [3]	In context or $1 - \left({}^5C_2\left(\frac{1}{6}\right)^2\left(\frac{5}{6}\right)3 + 5\left(\frac{1}{6}\right)\left(\frac{5}{6}\right)^4 + \left(\frac{5}{6}\right)^5\right)$ allow 1 end error
	(ii)	State or attempt P(0, 1, 2) with $p = \frac{2}{3}$ ${}^5C_2\left(\frac{2}{3}\right)^2\left(\frac{1}{3}\right)^3 + 5\left(\frac{2}{3}\right)\left(\frac{1}{3}\right)^4 + \left(\frac{1}{3}\right)^5$ $= \frac{17}{81}$ or 0.210 (3 sf)	M1 M1 A1 [3]	Or 1– P(3,4,5) Attempt at correct expression Allow 0.21
	(iii)	Est Var(P_s) = $\frac{0.625\times(1-0.625)}{80}$ $(=\frac{3}{1024})$ z = 2.054 (or 2.055) $0.625 \pm z\times\sqrt{\frac{'3'}{1024}}$ = 0.514 to 0.736 (3 sf)	M1 B1 M1 A1 [4]	 Any z