1	H_0: Pop prop = $^1/_3$ (or unchanged) H_1: Pop prop < $^1/_3$ (or decreased) $(\frac{2}{3})^{20} + 30(\frac{2}{3})^{19}(\frac{1}{3}) + {}^{20}C_2(\frac{2}{3})^{18}(\frac{1}{3})^2$ $+ {}^{20}C_3(\frac{2}{3})^{17}(\frac{1}{3})^3$ = 0.0604/0.0605 comp "0.0604" with 0.025 No evidence that support decreased or support probably not decreased SC Use Of Normal Standardising with or without cc Obtains z = –1.502 Valid Comparison with z = –1.96 Correct conclusion	B1 M1 A1 M1 A1ft [5] M1 A1 M1 A1ft	Accept p Attempt Bin(20, ⅓) P(≤ 3) Allow one term omitted For comparison of their 0.0604 Correct conclusion no contradictions
2	**(i)** 2-tail; H_1: $\mu \neq 35$	B1 [1]	
	(ii) comp –1.75 with –1.645 (or 1.75 with 1.645) Evidence that μ is not 35 or reject $\mu = 35$	M1 A1 [2]	Allow "Accept $\mu \neq 35$". No contradictions
	(iii) 8	B2 [2]	SR B1 for 4, 8.02, or 92%
3	**(i)** (Approx) normal mean 62 sd = $\frac{8.2}{\sqrt{50}}$ = 1.16 (3 sfs)	B1 B1 B1 [3]	 or var = $\frac{8.2^2}{50}$ = 1.34 (3 sfs)
	(ii) $\frac{64-62}{"1.16"}$ (= 1.725 or 1.724) 1 – Φ("1.725") = (1 – 0.9577) = 0.0423 (3 sfs)	M1 M1 A1 [3]	For standardising ÷ $\sqrt{50}$ essential (no CC) For correct area consistent with their mean

4	**(i)** Mean is 4.8 but ⩽ 1 breakdown	B1 [1]	Accept reduction when none has occurred
	(ii) $e^{-4.8}(1 + 4.8)$ $= 0.0477$	M1 A1 [2]	Poisson attempt at P(0) (+ P(1))
	(iii) $P(X > 1)$ $= 1 - e^{-0.9}(1 + 0.9)$ $= 0.228$ (3 sfs)	M1 M1 A1 [3]	Attempt correct probability for Type II error Allow any λ except 4.8; 1– (P(0)+(P(1))) using Poisson As final answer
5	**(i)** $\int_1^\infty \frac{k}{x^4}\,dx = 1$ $\left[-\frac{k}{3x^3}\right]_1^\infty = 1$ oe $(0 + \frac{k}{3} = 1 \Rightarrow k = 3$ **AG)**	M1 A1 [2]	Attempt integ f(x) & "= 1"; ignore limits Correct integrand & limits leading to AG, no errors seen
	(ii) $\int_1^\infty x \times \frac{3}{x^4}\,dx$ $\left[-\frac{3}{2x^2}\right]_1^\infty$ $= \frac{3}{2}$ $\int_1^\infty x^2 \times \frac{3}{x^4}\,dx$ $\left[-\frac{3}{x}\right]_1^\infty$ (= 3) "3" $- \left("\frac{3}{2}"\right)^2$ $= \frac{3}{4}$	M1 A1 M1* A1 M1*dep A1 [6]	Attempt integ $xf(x)$; ignore limits. CWO Attempt integ $x^2f(x)$; ignore limits. Correct integrand; correct limits dep 2nd M1 attempt $E(X^2) - [E(X)]^2$ cwo

6	**(i)**	$5\times(22.4 + 20.3)$ (= 213.5) & $5\times(4.8^2 + 5.2^2)$ (= 250.4) $z = \frac{180 - "213.5"}{\sqrt{"250.4"}}$ (= –2.117) 1 – Φ("–2.117") = Φ("2.117") = 0.983 (3 sfs)	B1 B1 M1 A1 [4]	For correct expression for new mean For correct expression for new variance Standardising and use of tables (no sd/var mixes + no cc)
	(ii)	P($H - W > 0$) 20.3 – 22.4 (= –2.1) & $4.8^2 + 5.2^2$ (= 50.08) $z = \frac{0 - (-2.1)}{\sqrt{"50.08"}}$ (= 0.297) 1 – Φ("0.297") (= 1 – 0.6168) = 0.383 (3 sfs)	M1 B1 B1 M1 A1 [5]	Or P($W - H < 0$) ± 2.1 Correct expression for new mean Correct expression for new variance Standardising and using tables (no sd/var mixes + no cc)
7	**(i)**	Patients arrive at constant mean rate Patients arrive at random Patients arrive independently Patients arrive singly	B1 B1 [2]	B1 For first correct B1 For second correct Must be in context SR B1 For two correct but not in context
	(ii) **(a)**	$1 - e^{-4.2}$ = 0.985	M1 A1 [2]	Correct expression
	(b)	$4.2 \times {}^{10}/_{15}$ oe $e^{-2.8}\times(1 + 2.8 + \frac{2.8^2}{2!} + \frac{2.8^3}{3!})$ = 0.692	B1 M1 A1 [3]	 Allow extra term $e^{-2.8}\times\frac{2.8^4}{4!}$ Allow incorrect λ (not 4.2)
	(iii)	N(336, 336) stated or implied $\frac{370.5 - 336}{\sqrt{336}}$ (= 1.882) 1 – Φ("1.882") = 0.0300/0.0299	B1 M1 M1 A1 [4]	 ft "336"Allow wrong or no cc or no √ Standardising with correct cc and no √ Allow 0.03