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)	H_0: Pop mean = 3 H_1: Pop mean > 3	B1 [1]	Allow or μ or λ, but not just 'mean'
(ii)	0.0683 > 0.05 No evidence that pop mean increased	M1 A1ft [2]	For inequality stated or clearly shown on dig. Allow 'No increase in mean'
		[Total: 3]	
2 (i)	7, $^3/_{\sqrt{n}}$	B1, B1 [2]	oe
(ii) (a)	Pop is normal	B1 [1]	Allow X is normal
(b)	Large sample	B1 [1]	or large n (can be implied by n ≥ 30)
		[Total: 4]	
3 (i)	$p = {}^{18}/_{50}$ or 0.36 oe $z = 2.326$ $0.36 \pm z\sqrt{\frac{0.36\times(1-0.36)}{50}}$ = 0.202 to 0.518 (3 sfs)	B1 B1 M1 A1 [4]	 Allow any z ($\neq$ 0 or 1) Allow any brackets or none
(ii)	Sample random	B1 [1]	oe
		[Total: 5]	
4 (i)	$\lambda = 8 \times 0.32 + 12 \times 0.45$ (= 7.96) $1 - e^{-7.96}(1 + 7.96 + \frac{7.96^2}{2})$ = 0.986 (3 sfs)	M1 M1 A1 [3]	 1 – P($X \leq 2$), any λ allow one end error
(ii)	$\lambda = 155 \times 0.32 = 49.6$ N('49.6', '49.6') $\frac{34.5-\text{'}49.6\text{'}}{\sqrt{\text{'}49.6\text{'}}}$ (= –2.144) Φ('–2.144') = 1 – Φ('2.144') = 0.016(0)	B1 M1 M1 M1 A1 [5]	 N (λ λ) any λ. May be implied Allow no or wrong cc & no √ Correct area consistent with their working
		[Total: 8]	
5 (i)	$F + J \sim N(24, 2.8^2 + 2.6^2)$ $\frac{30-24}{\sqrt{\text{'}14.6\text{'}}}$ (= 1.570) P($F + J < 30$) = Φ('1.570') 0.942 (3 sfs)	B1 M1 M1 A1 [4]	or N(24, 14.6) for correct mean and variance Allow without √ (ignore false cc) Correct area consistent with their working

(ii)	$F - 2J \sim N(-11.4, 2.8^2 + 4 \times 2.6^2)$	B1	or N(–11.4, 34.88) for correct mean and variance
	$\frac{0-(-11.4)}{\sqrt{'34.88'}}$ (= 1.930)	M1	Allow without √ (ignore false cc)
	$P(F - 2J) > 0$ $= 1 - \Phi('1.930')$	M1	Correct area consistent with their working or similar scheme using $2J - F$
	= 0.0268 (3 sfs)	A1 [4]	
	[Total: 8]		
6 (i)	$\int_4^{25} kx^{-\frac{1}{2}}dx = 1$	M1	Attempt integrate & = 1. Ignore limits
	$\left[\frac{kx^{\frac{1}{2}}}{\frac{1}{2}}\right]_4^{25} = 1$		
	$2k(5 - 2) = 1$ ($k = \frac{1}{6}$ **AG**)	A1 [2]	or equiv correct subst of correct limits
(ii)	$\frac{1}{6}\int_4^{25} x^{\frac{1}{2}}dx$	M1	Attempt integ $xf(x)$. Ignore limits
	$= \frac{1}{6}\left[\frac{x^{\frac{3}{2}}}{\frac{3}{2}}\right]_4^{25}$ (= $\frac{1}{9}$(125 – 8)	A1	Correct integrand and limits
	= 13	A1 [3]	Or 117/9
(iii)	$\frac{1}{6}\int_{20}^{25} x^{-\frac{1}{2}}dx$	M1	Attempt integ $f(x)$ from 20 to 25 Or $1 - \int_4^{20}$
	(= $\frac{1}{6}\left[\frac{x^{\frac{1}{2}}}{\frac{1}{2}}\right]_{20}^{25}$ = $\frac{1}{3}(5 - \sqrt{20})$)		
	= 0.176 (3 sfs)	A1 [2]	Accept surd form
(iv)	Wkly demand may be > 25 (or < 4)	B1 [1]	or other sensible
	[Total: 8]		
7 (i)	$H_0: \mu = 2.0 \quad H_1: \mu \neq 2.0$	B1	
	$\bar{x} = \frac{430}{200} = 2.15$	B1	For $\bar{x}$
	$s^2 = \frac{200}{199}\left(\frac{1290}{200} - \left(\frac{430}{200}\right)^2\right)$ = 1.8366834	B1	Correct subst in s^2 formula For s^2 correct (or s = 1.35524)
	$\frac{2.15-2.0}{\sqrt{\frac{'1.8366834'}{200}}}$ (= 1.565)	M1	For standardising (need 200) accept sd/var mixes
	z = 1.645	M1	For correct comparison of z values or areas
	No evidence that $\mu \neq 2.0$	A1 [6]	Cwo (condone biased variance for last 3 marks)

(ii) (a)	Concluding $\mu = 2.0$ although not true	B1 [1]	Not concluding $\mu \neq 2.0$ although this is true
(b)	$\dfrac{\bar{x}-2.0}{\sqrt{\dfrac{1.85}{200}}} = 1.645$ $\bar{x} = 2 + 0.1582$ Rejection region is $\bar{x} < 1.8418$ and $\bar{x} > 2.1582$	M1 A1	Attempt at finding rejection region
	$\dfrac{2.1582-2.12}{\sqrt{\dfrac{1.85}{200}}}$ $(= 0.397)$ $P(\bar{x} < 2.1582 \mid \mu = 2.12) = \Phi(\text{'}0.397\text{'})$ $= 0.6543$	M1 M1	
	$\dfrac{1.8418-2.12}{\sqrt{\dfrac{1.85}{200}}}$ $(= -2.893)$ $P(\bar{x} < -2.893 \mid \mu = 2.12) = 1 - \Phi(\text{'}2.893\text{'})$ $(= 0.0019)$	M1 M1	
	$\Rightarrow P(1.8418 < \bar{x} < 2.1582 \mid \mu = 2.12)$ $= 0.6543 - 0.0019$ $= 0.6524$ P(Type II error) = 0.652 (3 sfs)	 A1 [7]	Using only RH tail (ans 0.654) scores max M1A0M1M1M0M0A0 SR If zero scored allow SC M1 for one standardisation attempt with den √(1.85 / 200)
		[Total: 14]	