1	**(i)**	$z = 2.574$ to 2.576 $12.5 \pm z\frac{3.2}{\sqrt{250}}$ 12.0 to 13.0 (3 sfs)	B1 M1 A1 3	Any z *Correct form* Allow 12 to 13	
	(ii)	0.005 or 0.5%	B1 1	Not just 0.5	
			[Total 4]		
2	**(i)**	$E(3X - Y) = 12.1$ $\text{Var}(3X - Y) = 9 \times 14 + 15 = (141)$ $\frac{20-12.1}{\sqrt{'141'}}$ (= 0.665) Φ('0.665') = 0.747 (3 sfs)	B1 B1 M1 M1 A1 5	Allow without √ (No Continuity Correction) Correct area consistent with their working	
			[Total 5]		
3	**(i)**	$\bar{x} = \frac{7520}{150} = (50.1)$ (3 sfs) $s^2 = \frac{150}{149}(\frac{413540}{150} - (\frac{7520}{150})^2)$ = 245 or 246 (3 sfs)	B1 M1 A1 3	Attempt at unbiased variance (either formula) Allow $s^2 = 15.7^2$ (3 sfs)	
	(ii)	$\frac{53-\frac{7520}{150}}{\sqrt{\frac{'245.217'}{80}}}$ (= 1.637 to 1.638) $1 - \Phi$('1.637') = 0.0488 to 0.0509	M1 M1 A1 3	For Standardising (±) with their mean and their variance must have √80 (ignore cc) Correct area consistent with their working Correct working only	
			[Total 6]		
4	**(i)**	$1 - e^{-0.8}(1 + 0.8)$ = 0.191 (3 sfs)	M1 A1 2	Allow one end error	
	(ii)	$\lambda = 3 \times 0.8 + 2 \times 2.7$ (= 7.8) $e^{-'7.8'}(1 + 7.8 + \frac{7.8^2}{2} + \frac{7.8^3}{3!} + \frac{7.8^4}{4!})$ = 0.112 (3 sfs)	M1 M1 A1 3	Attempt find λ P(0, 1, 2, 3, 4) Using their λ. Allow one end error	
	(iii)	$e^{-0.8n} < 0.1$ Allow '=' $-0.8n < \ln 0.1$ Allow '=' min $n = 3$	M1* M1* dep A1 3	or $e^{-x} <$ 0.1 $-x < \ln 0.1$ Correctly obtained	$e^{-1.6} = 0.20$ } M1 for trial and improvement to find P(0) try $n = 2$ $e^{-2.4} = 0.09$ } M1*dep try $n = 3$ both correct $n = 3$ A1
			[Total 8]		

5	**(i)**	P(> 9 Heads | unbiased) = $^{12}C_{10} \times 0.5^{10} \times 0.5^2 + 12 \times 0.5^{11} \times 0.5 + 0.5^{12}$ = 0.0193 Level is 1.93% or 1.9%	M1 M1 A1 3	Allow Bin P(X = 9, 10, 11, 12) correct or 1 – P(X = (9),10,11,12)) any p/q Allow Bin P (X = 9, 10, 11, 12) correct p/q Allow 2% if correct working seen
	(ii)	B(100, 0.5) ≈ N(50, 25) $\frac{x-0.5-'50'}{\sqrt{'25'}} = z$ z = 1.645 x = 58.7 Rejection region is › 59	B1 M1 B1 A1 A1ft 5	Or proportion method N(0.5,0.0025) Allow with wrong or no cc or no √ (cc for proportion method 0.5/100) + only (consistent with their standardisation) or > 58 (region and integer required)
			[Total 8]	
6	**(i)**	Test is for bias in one direction One-tail	B1 B1 2	'Increased' rather than 'changed' or statement that μ >45.7 dep 1st B1
	(ii)	H_0: pop mean = 45.7 H_1: pop mean > 45.7 $\bar{x}$ = 47.375 or 47.4 or 379/8 $\frac{'47.375'-45.7}{\frac{3.2}{\sqrt{8}}}$ (= 1.481 to 1.503)) z = 1.645 '1.481' < 1.645 hence no evidence mean time increased (**AG**)	 B1 B1 M1 M1 A1 5	 Allow μ, but not 'mean' (follow through their (i)) Allow without √ Explicit comparison with their z from table Comparison with 1.645 or probability (0.0664 to 0.0693) with 0.05 Correct conclusion – accept H0 No errors seen
		Not rejected H_0 Type II possible	B1 B1 2	 dep 1st B1 No contradictions for either mark
			[Total 9]	

7 **(i)**	$k\int_0^{\frac{2\pi}{3}} \sin x\,dx = 1$ $k[-\cos x]_0^{\frac{2\pi}{3}}$ $k[-\cos\frac{2\pi}{3} + \cos 0] = 1$ $k[0.5 + 1] = 1$ $(k = \frac{2}{3}$ **AG)**	M1 A1 2	Integ & = 1. Ignore limits Must see this line or next
(ii)	$\frac{2}{3}\int_0^m \sin x\,dx = 0.5$ $\frac{2}{3}[-\cos x]_0^m = 0.5$ $\frac{2}{3}(-\cos m + 1) = 0.5$ $\cos m = 0.25$ $m = 1.32$ (3 sfs) **AG**	M1* M1* dep A1 A1 4	Integ & = 0.5. Ignore limits Correct integrand & limits 0 to unknown & = 0.5 But allow a cos m = b where b/a = 0.25 dep cos$m$ = 0.25 seen NB accept full verification
(iii)	$\frac{2}{3}\int_0^{\frac{2\pi}{3}} x\sin x\,dx$ $= \frac{2}{3}\{[x(-\cos x)]_0^{\frac{2\pi}{3}} - \int_0^{\frac{2\pi}{3}}(-\cos x)dx\}$ $= \frac{2}{3}\{\frac{\pi}{3} - 0 - [-\sin x]_0^{\frac{2\pi}{3}}$ $= \frac{2}{3}(\frac{\pi}{3} + \sin\frac{2\pi}{3})$ $= \frac{2\pi+3\sqrt{3}}{9}$ or 1.28 (3 sf)	M1 M1* dep M1* dep A1 4	Integ $xf(x)$. Ignore limits 1st step attempted ie $x(-\cos x)$ oe. Ignore limits 2nd step attempted including correct limits applied oe
		[Total 10]	