1	Normal with mean 28 Var = $0.12^2 \times 8$ = 0.115 (3 sfs)	B1 M1 A1	[3]	Both square & × by 8 or sd = 0.12 × √8 or sd = 0.339 (3 sfs) clearly stated var / sd
Total			**[3]**	
2 (i)	μ	B1		(as an expression)
	$\frac{\sigma^2}{n}$	B1	[2]	(as an expression) SC If B0B0 scored, N(μ, $\frac{\sigma^2}{n}$) scores B1
(ii)	$\frac{176-177.8}{\frac{6.1}{\sqrt{12}}}$ (= –1.022)	M1		Standardise with √ 12 Accept 'totals' method. No mixed methods. (2112 – 2133.6) / √ ($6.1^2 \times 12$)
	Φ('–1.022') = 1 – Φ ('1.022')	M1		Correct area (consistent with working)
	= 0.153 (3 sfs)	A1	[3]	
(iii)	No; *X* norm distr'd or pop norm distr'd Or hts norm distr'd Or original dist normal	B1	[1]	Need 'No' stated or implied AND correct reason NB 'No, because small sample' scores B0 NB 'it is normally distr`d' scores B0
Total			**[6]**	
3 (i)	$\left(\frac{5}{6}\right)^{25} + 25\left(\frac{5}{6}\right)^{24}\left(\frac{1}{6}\right)$	M1		Allow end errors, but just P(2) implies M0 Accept p/q mix
	= 0.0629 final answer	A1		
	Sig level = 6.29%	B1ft	[3]	ft their P($X \leq 1$) with Binomial used. Allow 6.3% or 6%
(ii)	Var (p) $\approx \frac{0.09 \times 0.91}{100}$ (= 0.000819)	M1		For pq /100 seen (any p/q) (must be probs)
	$z = 1.96$	B1		
	$0.09 \pm z\sqrt{\frac{0.09 \times 0.91}{100}}$	M1		For correct form of C.I. (any p/q) (must be probs)
	= 0.034 to 0.146 (3 dps)	A1	[4]	
Total			**[7]**	

4	Use of $X_1 - 2X_2$ or similar $E(X_1-2X_2) = 180 - 360$ ($= -180$)	B1		Or use of $½ X_1 - X_2$ $E(2X_1-X_2) = 360 - 180$ ($= 180$) Or $E(½ X_1 - X_2) = 90 - 180 = (-90)$
	$Var(X_1-2X_2) = 5\times1550$ or 7750	M1 A1		for $1550 + 4 \times 1550$ or $¼ \times 1550 + 1550$ 7750 or 1937.5
	$\frac{0-(-180)}{\sqrt{'7750'}}$ or $\frac{0-180}{\sqrt{'7750'}}$ $(= \pm 2.045)$	M1		Allow incorrect var (dep > 0 & ≠ 1550), no √ Standardising – no mixed methods Or $\pm (0 - -90)/\sqrt{1937.5}$
	$1 - \Phi('2.045')$ = 0.0205 or 0.0204	M1 A1		For finding correct area (consistent with working)
	Ans 0.041 (2 sf)	B1ft	[7]	Allow double their prob
Total			**[7]**	
5 (i)	$Est(\mu) = 2.3$	B1		
	$Est(\sigma^2) = \frac{200}{199}\left(\frac{1636}{200} - \left(\frac{460}{200}\right)^2\right)$	M1		Allow $\sqrt{\frac{200}{199}\left(\frac{1636}{200} - \left(\frac{460}{200}\right)^2\right)}$ or 1.7043 for M1 Or $1/199\ (1636 - 460^2/200)$
	= 2.90 (3 sf) or 2.91 or 578/199	A1	[3]	
(ii)	H_0: Pop mean wt loss = 2 kg H_1: Pop mean wt loss > 2 kg	B1		Allow 'μ' but not just 'mean'
	$\frac{2.3-2}{\sqrt{\frac{'2.9045'}{200}}}$	M1		$\frac{2.3-2}{\sqrt{\frac{'1.7043'}{200}}}$ Stand'ise with √200. Accept sd/var mixes Or $x_{crit} = 2 + 2.326\sqrt{(2.9045/200)}$
	= 2.489 or ± 2.49 or 0.0064 / 0.9936 for area comparison or $x_{crit} = 2.28(03)$	A1		
	comp $z = 2.326$	M1		For valid comparison (z or area or x_{crit})
	Evidence that mean wt loss > 2 kg	A1ft		No contradictions Reject H_0 / accept H_1 only if H_0 / H_1 correctly defined
			[5]	If $\frac{200}{199}$ not used in **(i)**: var = 2.89, sd = 1.7, cr $z = 2.496$ can score all marks
Total			**[8]**	

6 (i)	f(x) ⩾ 0 for all x defined	B1		
	$\int_0^a \frac{2}{a^2} x\,dx$	M1		Attempt $\int f(x)dx$ with limits 0, a. Must be a.
	$\left(= \left[\frac{2x^2}{2a^2}\right]_0^a\right)$	A1		Or equivalent methods (e.g. by areas)
	= 1		[3]	
(ii)	$\int_0^a \frac{2}{a^2} x^2\,dx$ (= 8)	M1		Attempt $\int xf(x)dx$, ignore limits
	$\frac{2}{a^2}\left[\frac{x^3}{3}\right]_0^a$ (= 8)	A1		Correct integrand and limits
	$\left(\frac{2a}{3} = 8\right)$	A1		
	a = 12		[3]	
(iii)	$1 - \int_0^6 \frac{2}{144} x\,dx$ or $\int_6^{12} \frac{2}{144} x\,dx$	M1		Correct expr'n incl limits; ft their 'a'
	$=1 - 1 - \frac{1}{72}\left[\frac{x^2}{2}\right]_0^6$ or	A1ft		Correct integrand and limits; ft their 'a'
	$\frac{1}{72}\left[\frac{x^2}{2}\right]_6^{12}$			
	$= \frac{3}{4}$	A1ft	[3]	ft their 'a', dep 0 < ans < 1
Total			**[9]**	

7 (i)	$n > 50$	B1		Accept n large
	$np = 0.8$, which is < 5	B1	[2]	Accept p small
(ii)	$\lambda = 9.6$	B1		
	$e^{-9.6}(\frac{9.6^3}{3!}+\frac{9.6^4}{4!}+\frac{9.6^5}{5!})$	M1		Any λ Accept end errors.
	$= 0.0800$ (3 sfs)	A1	[3]	Allow 0.08
(iii)	H_0: Pop mean for 10 days = 8 H_1: Pop mean for 10 days < 8	B1		or Pop mean for 1 day = 0.8 Pop mean for 1 day < 0.8 Allow λ or μ but not just 'mean'
	$e^{-8}(1 + 8 + \frac{8^2}{2!})$	M1		Any λ. Accept end errors. NB P(2) only used scores M0M0 Accept CR method
	$= 0.0138$ or 0.0137	A1		CR = 0, 1, 2 all working must be shown
	Compare 0.02 Evidence that mean number of absentees has decreased	M1 A1ft	[5]	Valid comparison with 0.02 or CR No contradictions Reject H_0 / accept H_1 only if H_0 / H_1 correctly defined
Total			**[10]**	
	Total for paper		**[50]**	