3(a)	$\log_{10} y = \pm\frac{2}{3.5}\log_{10} x - 2$	M1
	$\log_{10} y = -\frac{4}{7}\log_{10} x - 2$	A1
		(2)

Question	Answer	Marks	Guidance
7(a)	$\frac{du}{dx} = -\sin x$	**B1**	SOI
	Use double angle formula and substitute for x and dx throughout the integral	**M1**	All x's must be removed, can be coefficient errors provided 2 seen in working.
	Obtain $\pm\int 2ue^{2u}du$	**A1**	Limits may be omitted, or left as 0 and π, during the change of variable stage.
	Justify new limits and obtain $\int_{-1}^{1} 2ue^{2u}du$ from correct working	**A1**	AG Must see $x = 0$, $u = 1$ and $x = \pi$, $u = -1$. Inequalities alone e.g. $0 \leqslant x \leqslant \pi$ and $1 \leqslant u \leqslant -1$ or $-1 \leqslant u \leqslant 1$ for limits are insufficient A0 If sign in expression and order of limits incorrect then A0. If negative sign is present in the integrand then this can be removed and limits introduced in correct order in a single step.
		4	

Question	Answer	Marks	Guidance
7(b)	Commence integration and reach $aue^{2u} + b\int e^{2u}du$, where $ab \neq 0$, $b < 0$	**M1***	Condone dx.
	Complete integration and obtain $ue^{2u} - \frac{1}{2}e^{2u}$	**A1**	OE Allow $(2u\frac{1}{2}e^{2u}) - \frac{1}{2}e^{2u}$.
	Use correct limits correctly in $cue^{2u} + de^{2u}$ having integrated twice or in $c\cos x e^{2\cos x} + de^{2\cos x}$	**DM1**	1 and −1 for u, 0 and π for x e.g. $ce^2 + de^2 - (-ce^{-2} + de^{-2})$. Not decimals. Allow one sign error at most in going from $cue^{2u} + de^{2u}$ or $c\cos x\, e^{2\cos x} + de^{2\cos x}$ to $ce^2 + de^2 - (-ce^{-2} + de^{-2})$. $[e^2 - ½e^2 - (-e^{-2} - ½e^{-2})]$ Complete reversal of sign by converting back to cos x and not making $x = 0$ upper limit is DM0 A0.
	Obtain $\frac{1}{2}e^2 + \frac{3}{2}e^{-2}$	**A1**	ISW Or equivalent 2-term expression e.g. $\frac{e^4+3}{2e^2}$ or $\frac{1}{2}\left(e^2 + \frac{3}{e^2}\right)$.
		4	

Question	Answer	Marks	Guidance
8(a)	Separate variables correctly	**B1**	$\frac{dN}{N^{\frac{3}{2}}} = (k\cos 0.02t)\,dt$ Allow without integral signs.
	Obtain term $-\frac{2}{\sqrt{N}}$	**B1**	OE Ignore position of k.
	Obtain term $50\sin 0.02t$	**B1**	OE Ignore position of k.
	Use $t = 0$, $N = 100$ to evaluate a constant, or as limits, in a solution containing terms $\frac{a}{\sqrt{N}}$ and $b\sin 0.02t$, where $ab \neq 0$	**M1**	$\left[\text{e.g. } c = -0.2 \quad \text{or} \quad c = \frac{-0.2}{k}\right]$
	Obtain correct solution in any form, e.g. $-\frac{2}{\sqrt{N}} = 50k\sin 0.02t - 0.2$	**A1**	OE ISW e.g. $N = \frac{1}{(25k\sin 0.02t - 0.1)^2}$ $-2N^{-\frac{1}{2}} = \frac{k}{0.02}\sin 0.02t - \frac{1}{5}$ $50k\sin 0.02t = -\frac{2}{\sqrt{N}} + \frac{1}{5}$ $\frac{1}{\sqrt{N}} = -\frac{1}{2}k(50\sin 0.02t) + \frac{1}{10}$ $50\sin\left(\frac{1}{50}t\right) = -\frac{2\sqrt{N}}{kN} + \frac{20}{100k}$
8(b)	Use the substitution $N = 625$ and $t = 50$ in expression of appropriate form to evaluate k	**M1**	Expression must contain $a + bk\sin 0.02t$, $(\sqrt{N})^{\pm n}$, where $n = -1, 1, 3$ or 5 and a and b are constants $ab \neq 0$ or $(a + bk\sin 0.02t)^{\pm 2}$ and $(N)^{\pm n}$. Allow with k replaced by $\frac{1}{k}$, error due to $k(N^{-3/2})$ when separating variables in **8(a)**. If invert term by term when 3 terms shown then M0.
	Obtain $k = 0.00285[2148]$	**A1**	Must evaluate sin1. Degrees $k = 0.138$ M1 A0.
		2	
8(c)	Rearrange and obtain $N = 4(0.2 - 0.142(607)\sin 0.02t)^{-2}$ Substitution for k required	**M1**	Anything of the form $N = c(d - ek\sin 0.02t)^{-2}$, where c, d and e are constants $cde \neq 0$ and value of k substituted. Allow with k replaced by $1/k$, error due to $k(N^{-3/2})$ when separating variables in **8(a)**. OE ISW e.g. $N = \left(-\frac{10}{0.7125\sin 0.02t - 1}\right)^2$ $N = \frac{1}{(-0.0713\sin 0.02t + 0.1)^2}$ $N = \frac{100}{\left(\left(\frac{0.6}{\sin 1}\right)\sin 0.02t - 1\right)^2}$ $N = \frac{1}{\left(\frac{3}{-50\sin 1} \times \sin 0.02t + \frac{1}{10}\right)^2}$ $N = \left(-\frac{0.06}{\sin 1}\sin 0.02t + 0.1\right)^{-2}$ $N = \left(\frac{800}{80 - 57\sin 0.02t}\right)^2$ Do not need to substitute for $\sin(0.02t) = 1$, but must substitute for k.
	Accept answers between 1209 and 1215	**A1**	ISW Substitute $\sin 0.02t = 1$ or $t = 50\sin^{-1} 1$ or 78.5 or 25π. Answer with no working (rubric) 0/2. **SC** $N = \ldots$ not seen but correct numerical answer **B1** 1/2.

9(a)	Use quotient or product rule	**M1**	
	Obtain correct derivative in any form	**A1**	
	Equate derivative to zero and solve for x	**M1**	
	Obtain answer $x = 3$	**A1**	
		4	
9(b)	State $\frac{du}{dx} = \frac{1}{2\sqrt{x}}$, or $dx = 2\sqrt{x}du$, or $2u\,du = dx$	**B1**	
	Substitute and obtain integrand $\frac{2}{9-u^2}$	**B1**	
	Use given formula for the integral or integrate relevant partial fractions	**M1**	
	Obtain integral $\frac{1}{3}\ln\left(\frac{3+u}{3-u}\right)$	**A1**	OE
	Use limits $u = 0$ and $u = 2$ correctly	**M1**	
	Obtain the given answer correctly	**A1**	

Question	Answer	Marks	Guidance
11(a)	State or imply the form $\frac{A}{3-x} + \frac{Bx+C}{1+3x^2}$	**B1**	
	Use a correct method to find a constant	**M1**	
	Obtain one of $A = 2$, $B = 0$ and $C = 1$	**A1**	
	Obtain a second value	**A1**	
	Obtain the third value	**A1**	
		5	

11(b)	Integrate and obtain term $-2\ln(3-x)$	**B1 FT**	
	Obtain term of the form $b\tan^{-1}(\sqrt{3}x)$	**M1**	
	Obtain term $\frac{1}{\sqrt{3}}\tan^{-1}(\sqrt{3}x)$	**A1 FT**	
	Substitute limits correctly in an integral with terms $a\ln(3-x)$ and $b\tan^{-1}(\sqrt{3}x)$, where $ab \neq 0$	**M1**	
	Obtain answer $2\ln\frac{3}{2} + \frac{1}{3\sqrt{3}}\pi$, or equivalent	**A1**	
		5	

Question	Answer	Marks
10(a)	State or imply $\frac{dV}{dt} = -k\sqrt{h}$	**B1**
	State or imply $\frac{dV}{dh} = 2\pi rh - \pi h^2$, or equivalent	**B1**
	Use $\frac{dV}{dt} = \frac{dV}{dh}.\frac{dh}{dt}$	**M1**
	Obtain the **given answer** correctly	**A1**
		4

10(b)	Separate variables and attempt integration of at least one side	**M1**
	Obtain terms $\frac{4}{3}rh^{\frac{3}{2}} - \frac{2}{5}h^{\frac{5}{2}}$ and $-Bt$	**A3, 2, 1, 0**
	Use $t = 0$, $h = r$ to find a constant of integration c	**M1**
	Use $t = 14$, $h = 0$ to find B	**M1**
	Obtain correct c and B, e.g. $c = \frac{14}{15}r^{\frac{5}{2}}$, $B = \frac{1}{15}r^{\frac{5}{2}}$	**A1**
	Obtain final answer $t = 14 - 20\left(\frac{h}{r}\right)^{\frac{3}{2}} + 6\left(\frac{h}{r}\right)^{\frac{5}{2}}$, or equivalent	**A1**
		8