1	**(i)**		both curves with positive gradients in 1st and 2nd quadrants; ignore labels for this mark	**M1**	do not award if clearly not exponential shape; condone touching negative x-axis but not crossing it	consider each curve independently; ignore scales and points apart from $(0, 1)$
			both through $(0, 1)$	**A1**		allow if indicated in table of values or commentary if not marked on graph
			$y = 3^{2x}$ above $y = 3^x$ in first quadrant and below it in second	**A1**	must be clearly labelled, **A0** if wrongly attributed or if coincide for negative x from $(0, 1)$	if **M0** allow **SC1** for one graph fully correct
				[3]		
1	**(ii)**		$x = 3$	**B1**	**B0** if wrongly attributed	
			$3^x = 27$	**B1**	**B0** if wrongly attributed	allow $3^3 = 27$ with $x = 3$ stated
				[2]		
2			$m = 3$ seen	**B1**		
			$\log y = m\log x + 2$ or $\log y = m\log x + \log 100$	**M1**	or $\log y - 8 = m(\log x - 2)$	condone lack of base; "$c = 2$" is insufficient
			$\log y = \log x^3 + 2$ or $\log y = \log x^3 + \log 100$ or better	**M1**	or $10^{\log y} = 10^{3\log x + 2}$ or $10^{3\log x + \log 100}$ or better	condone lack of base, but not bases other than 10 unless fully recovered
			$y = 100x^3$ or $y = 10^{3\log x + 2}$ or $y = 10^{\log x^3 + 2}$ www isw	**A1**	$y = 10^{3\log x + \log 100}$ or $y = 10^{\log x^3 + \log 100}$	
				[4]		

3			$(x + 1) \log 3 = 2x \log 5$ oe $\log 3 = x(2 \log 5 - \log 3)$ oe $\frac{\log 3}{2\log 5 - \log 3}$ oe 0.518 cao	M1 A1 A1 A1 **[4]**	or $x + 1 = 2x \log_3 5$ or $(x + 1)\log_5 3 = 2x$ $x(1 - 2\log_3 5) = -1$ oe or $x(2 - \log_5 3) = \log_5 3$ oe $\frac{1}{2\log_3 5 - 1}$ oe or $\frac{\log_5 3}{2 - \log_5 3}$ oe	allow recovery from omission of brackets in later working NB $0.477121254 = 0.920818754x$ $-1.929947041x = -1$ $1.317393806x = 0.682606194..$ answer only does not score

4	**(i)**		$\log_{10} h = \log_{10} a + bt$ www $m = b$, $c = \log_{10} a$	B1 B1 **[2]**		condone omission of base must be clearly **stated**: linking equations is insufficient
4	**(ii)**		–0.15, 0[.00], 0.23, 0.36, 0.56, 0.67, 0.78, 0.91, 1.08, 1.2[0] plots correct (tolerance half square) single ruled line of best fit for values of x from 5 to 50 inclusive	B2 B1 B1 **[4]**	B1 if 1 error condone 1 error – see overlay line must not go outside overlay between $x = 5$ and $x = 50$	 no ft available for plots

Question			Answer	Marks	Guidance	
4	(iii)		$-0.3 \leq y$-intercept ≤ -0.22	B1	may be implied by $0.5 \leq a \leq 0.603$	
			valid method to find gradient of line	M1	may be embedded in equation; may be implied by eg m between 0.025 and 0.035	condone values from table; condone slips eg in reading from graph
			$h = \text{their}a \times 10^{\text{their}bt}$ or $h = 10^{\text{their log } a + \text{their}bt}$	M1		if B1M1M0, then SC1 for logh = loga + theirbt isw
			$0.028 \leq b \leq 0.032$ and $0.5 \leq a \leq 0.603$ or $-0.3 \leq \log a \leq -0.22$	A1		if both values in the acceptable range for A1
				[4]		
4	(iv)		$a10^{60b} - a10^{50b}$ their values for a and b	M1	or $10^{\log a + b \times 60} - 10^{\log a + b \times 50}$ or their values for log$a$ and b	condone 15.9 as second term may follow starting with log$h$ = log$a$ + theirbt
			8.0 to 26.1 inclusive	A1		NB A0 for estimate without clear valid method using model; both marks available even if a or b or both are outside range in (iii)
				[2]		
4	(v)		comment on the **continuing reduction** in thickness **and** its consequences	B1	eg in long term, it predicts that reduction in thickness will continue to increase, even when the glacier has completely melted	
				[1]		

5	**(i)**		$65 \times (1 - 0.017)^3$ oe 61.7410... showing more than 3 sf	**M1** **A1** **[2]**	may be longer method finding decrease year by year etc answer 61.7 given	NB use of 3×0.017 leads to 61.685, which doesn't score
5	**(ii)**		$[d =] 65 \times 0.983^n$ oe	**B1** **[1]**	eg $63.895 \times 0.983^{n-1}$ or $61.7 \times 0.983^{n-3}$	

Question			Answer	Marks	Guidance	
5	(iii)		$65 \times 0.983^n < 3$ or $\log_{10}(65 \times 0.983^n) < \log_{10}3$ oe	**M1***		condone omission of base 10 throughout
			$\log_{10}65 + \log_{10}0.983^n < \log_{10}3$ www	**M1dep**	may be implied by eg $\log_{10}65 + n\log_{10}0.983 < \log_{10}3$	if **M0M0**, **SC1** for $\log_{10}65 + n\log_{10}0.983 < \log_{10}3$ even if < is replaced by eg = or > with no prior incorrect log moves
			$[\log_{10}65 + n\log_{10}0.983 < \log_{10}3]$ $n\log_{10}0.983 < \log_{10}3 - \log_{10}65$ and		or $[\log_{10}0.983^n < \log_{10}3 - \log_{10}65]$	NB watch for correct inequality sign at each step
			completion to $n > \dfrac{\log_{10}3 - \log_{10}65}{\log_{10}0.983}$ **AG** www	**A1**	inequality signs must be correct throughout	reason for change of inequality sign not required
			$n = 180$ cao	**B1** **[4]**	**B0** for $n > 180$	$n > 179.38...$
5	(iv)		$63.895 = 65 \times 10^{-k}$ soi	**B1**	or $65 \times 0.983 = 65 \times 10^{-k}$	accept 63.895 rot to 3 or 4 sf; **B1** may be awarded for substitution of $t = 1$ after manipulation
			$\log_{10}$(their 63.895) = $\log_{10}65 - k$ or $-k = \log_{10}$(their 0.983)	**M1**	their 63.895 must be from attempt to reduce 65 by 1.7% at least once	**M1A1A1** may be awarded if other value of t with correct d is used
			[k =] 7.4×10^{-3} to 7.45×10^{-3}	**A1**	[k =] $-\log_{10}0.983$ isw	
			[d =] 42.1... to 42.123 [°C] isw	**A1** **[4]**		NB **B1M1A0A1** is possible; unsupported answers for k and/or d do not score

6			gradient = 3 seen $\log_{10} y - 5 =$ (their 3)($\log_{10} x -$ 1) or using (5, 17) $\log_{10} y = 3 \log_{10} x + 2$ oe $y = 10^{3\log_{10} x+2}$ oe $y = 100x^3$	B1 M1 A1 M1 A1 **[5]**	may be embedded or $\log_{10} y = 3 \log_{10} x + c$ and substitution of (1, 5) or (5, 17) for $\log_{10} x$ and $\log_{10} y$ or $\log_{10} y = \log_{10} x^3 + \log_{10} 100$	condone omission of base throughout NB may recover from eg $Y = 3X + 2$ or $\log_{10} \frac{y}{x^3} = 2$ or $\log_{10} y = \log_{10} 100x^3$

7	$6 = ab$ and $3.6 = ab^2$ $a = 10$, $b = 0.6$ c.a.o.	**M1** **A2**	$\log 6 = \log a + \log b$ *and* $\log 3.6 = \log a + \log b^2$ **A1** each; if **M0** then **B3** for both, **B1** for one	

8	$\log p = \log s + \log t^n$ $\log p = \log s + n\log t$ $[n =]\dfrac{\log p - \log s}{\log t}$ or $\dfrac{\log\left(\dfrac{p}{s}\right)}{\log t}$ [base not required]	**M1** **M1** **A1**	or $\dfrac{p}{s} = t^n$ $n\log t = \log\left(\dfrac{p}{s}\right)$ as final answer (i.e. penalise further incorrect simplification)	 or **A2** for $[n =]\log_t\left(\dfrac{p}{s}\right)$ [base t needed] following first M1
9	$\log 16^{½}$ or [–] $\log 5^2$ s.o.i. $\log(4\times75)$ or $\log\dfrac{75}{25}$ s.o. x = 12 www	**M1** **M1** **A1**	 $x = \dfrac{4\times75}{25}$ implies **M1M1**	if a = 10 assumed, x = 12 c.a.o. scores **B3** www no follow through