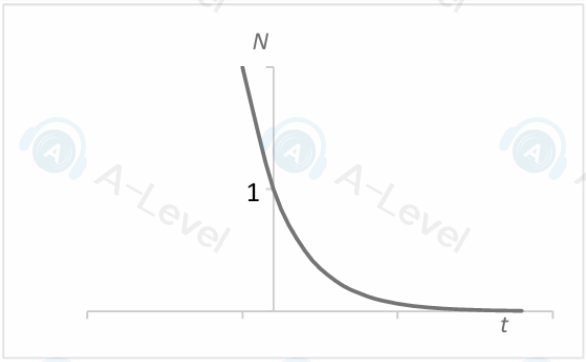
Question Number	Scheme	Marks
10(a)	$x^2+y^2+4x-30y+209=0$ $\Rightarrow (x\pm 2)^2+(y\pm 15)^2\ldots=0$	M1
(i)	Centre (–2, 15)	A1
(ii)	Radius $\sqrt{20}$	A1
		(3)
(b)	$y=mx+1\Rightarrow (x+2)^2+(mx+1-15)^2=20$ or $y=mx+1\Rightarrow x^2+(mx+1)^2+4x-30(mx+1)+209=0$	M1
	$x^2+m^2x^2+4x-28mx+180=0$ $b^2-4ac=0\Rightarrow (4-28m)^2-4(1+m^2)\times 180=0$	**d**M1
	$(4-28m)^2-4(1+m^2)180=0\Rightarrow 16-224m+784m^2-720-720m^2=0$ $\Rightarrow 2m^2-7m-22=0$*	A1*
		(3)
(c)	$2m^2-7m-22=0\Rightarrow m=\frac{11}{2},-2$	M1
	$m=\frac{11}{2}\Rightarrow \frac{125}{4}x^2-150x+180=0\Rightarrow x=\frac{12}{5}\Rightarrow y=\frac{71}{5}$ or $m=-2\Rightarrow 5x^2+60x+180=0\Rightarrow x=-6\Rightarrow y=13$	M1
	$\left(\frac{12}{5},\frac{71}{5}\right)$ **or** $(-6,13)$ oe	A1
	$\left(\frac{12}{5},\frac{71}{5}\right)$ **and** $(-6,13)$ oe	A1
		(4)
		Total 10

Question Number	Scheme	Marks
5. (i)	$\log_a x+\log_a 3=\log_a 27-1\ \Rightarrow\ \log_a\frac{3x}{27}=-1$	M1A1
	$\Rightarrow\ \frac{3x}{27}=a^{-1}$	dM1
	$\Rightarrow\ x=9a^{-1}$ or $x=\frac{9}{a}$	A1 **(4)**
(ii)	$p^2-7p+12=0$ and attempt to solve to give $p=$ or $\log_5 y=$	M1
	p (or $\log_5 y$) = 3 or 4	B1
	$y=5^3$ or 5^4	M1
	y = 125 and 625	A1 **(4)**
		8 marks

Question Number	Scheme	Marks
6. (i)	$2\log_2(4-x) = 3+\log_2\left(\frac{x+11}{2}\right)$	
	One correct law applied – examples (not exhaustive):	
	$2\log_2(4-x) = \log_2(4-x)^2$, $\log_2\left(\frac{x+11}{2}\right) = \log_2(x+11) - \log_2 2$	B1
	$3 = \log_2 8$	
	Correctly combines two original terms e.g. $2\log_2(4-x) = \log_2(4x+44)$	M1
	Correct equation not involving logs $(4-x)^2 = 4x+44$	A1
	$x^2 - 12x - 28 = 0 \Rightarrow (x-14)(x+2) = 0 \Rightarrow x = \ldots$	dM1
	$\Rightarrow x = -2$ only	A1
		(5)
(ii)	Combines $y = 6\times 3^x$ and $y = 3^{2x+1} \Rightarrow 3^{2x+1} = 6\times 3^x$	M1
	$\Rightarrow 3^x \times 3 = 6$	
	$\Rightarrow 3^x = 2 \Rightarrow x = \log_3 2$	dM1, A1
	$y = 6\times 3^{\log_3 "2"} = 6\times "2"$	ddM1
	coordinates of P are: $(\log_3 2,\ 12)$	A1
		(5)
		(10 marks)

Question Number	Scheme	Marks
6 (a)	$2\log_4(x+3) = \log_4(x+3)^2$ or $\frac{1}{2} = \log_4 2$ o.e	B1
	Combines two terms e.g. $2\log_4(x+3) + \log_4 x = \log_4 x(x+3)^2$	M1
	e.g. $x(x+3)^2 = 2(4x+2)$	A1
	e.g. $x(x^2+6x+9) = 8x+4 \Rightarrow x^3+6x^2+x-4=0$ *	A1*
		(4)
(b) (i)	$x^3+6x^2+x-4 = (x+1)(x^2+5x-4)$	M1
	$x = \frac{-5\pm\sqrt{25+16}}{2} \Rightarrow x = \frac{-5\pm\sqrt{41}}{2}$	dM1 A1
		(3)
(ii)	$x = \frac{-5+\sqrt{41}}{2}$	B1
		(1)
		(8 marks)

Question	Scheme	Marks
9(a)		
	Correct shape from or passing through a point on positive vertical axis. May extend to the left of the vertical axis and allow to pass into quadrant 4. There must be no (obvious) turning points. Labels not required on axes and ignore any that are given.	M1
	Shape and position correct, accept 1 or k as intercept on the positive vertical axis and allow to extend to the left of the vertical axis as shown. Condone (1, 0) or (k, 0) as long as it is in the correct position. The curve should approach a horizontal asymptote that is half-way between the horizontal axis and the intercept or below. Be tolerant with "wobbles" as it approaches the asymptote. May just "touch" the horizontal axis but not go below it. Labels not required on axes and ignore any that are given.	A1
		(2)
(b)	$\frac{1}{2}k = k\lambda^{5700} \Rightarrow \lambda^{5700} = \frac{1}{2}$ (see notes for method via substitution)	M1
	$\Rightarrow \lambda = \left(\frac{1}{2}\right)^{\frac{1}{5700}} = 0.999878$ to 6 d.p.*	A1*
		(2)
(c)	When $t = 3250$, $N = 15 \times 0.999878^{3250} = \ldots$	M1
	$= \text{awrt } 10.1 \ (\text{grams})$	A1
		(2)
(d)	$18 = 25 \times 0.999878^{t}$	B1
	$\Rightarrow 0.999878^{t} = \frac{18}{25} \Rightarrow t = \frac{\log \frac{18}{25}}{\log 0.999878} = \ldots$	M1
	$t = 2692.49\ldots$ so item is 2700 years old	A1
		(3)
		(9 marks)

Question Number	Scheme	Marks
4(i)	E.g. $2=\log_3 9$ Eg $\log_3(4x)-\log_3(5x+7)=\log_3\dfrac{4x}{5x+7}$	M1
	E.g. $36x=5x+7$ $\dfrac{4x}{5x+7}=\dfrac{1}{9}$	A1
	$x=\dfrac{7}{31}$	A1
		(3)
(ii)	$\left(\sum_{r=1}^{2}\log_a y^r=\right)\log_a y+\log_a y^2$ or $\left(\sum_{r=1}^{2}(\log_a y)^r=\right)\log_a y+(\log_a y)^2$	B1
	$\log_a y+\log_a y^2=\log_a y+(\log_a y)^2\Rightarrow 2\log_a y-(\log_a y)^2=0$ $\Rightarrow \log_a y(2-\log_a y)=0\Rightarrow \log_a y=2$	M1
	$y=a^2$	A1
		(3)
		Total 6

Question Number	Scheme	Marks
7. (i)	$\log_a\left(\dfrac{\sqrt{a}}{b}\right)=\dfrac{1}{2}\log_a a-\log_a b=\dfrac{1}{2}-k$	M1 A1 **(2)**
(ii)	$\dfrac{\log_a a^2b}{\log_a b^3}=\dfrac{2\log_a a+\log_a b}{3\log_a b}=\dfrac{2+k}{3k}$	M1 A1 **(2)**
(iii)	$\sum_{n=1}^{50}(k+\log_a b^n)=50k+(1k+2k+3k+\ldots+50k)$ or $(2k+3k+4k+\ldots+51k)$	
	Uses the sum formula an AP with $n=50, d=k$	M1
	$S=50k+\dfrac{50}{2}(2k+49k)$ $\quad$ $S=\dfrac{50}{2}(2k+51k)$ $=1325k$	A1 A1 **(3)** **(7 marks)**

Question Number	Scheme	Marks
6 (a)	Centre of circle is midpoint of $(-2,18)$ and $(14,6) = (6,12)$	B1
	Attempts radius^2 or diameter^2. E.g. $D^2 = (14--2)^2 + (6-18)^2 = 400$	M1
	Radius^2 = 100	A1
	$(x-6)^2 + (y-12)^2 = 100$	M1, A1
		(5)
(b)	Recognises equation of C_2 is $x^2 + y^2 = k^2$	B1
	Attempts to find one value of k or k^2 Look for $\sqrt{"6"^2 + "12"^2} \pm \sqrt{"100"}$	M1
	$x^2 + y^2 = \left(6\sqrt{5}+10\right)^2$ or $x^2 + y^2 = \left(6\sqrt{5}-10\right)^2$ o.e.	A1
	$x^2 + y^2 = \left(6\sqrt{5}+10\right)^2$ and $x^2 + y^2 = \left(6\sqrt{5}-10\right)^2$ o.e.	A1
		(4)
		(9 marks)

Question Number	Scheme	Marks
9 (i)	$2\log_3(4x+5) - \log_3(x+3) = 2 \Rightarrow \log_3 \dfrac{(4x+5)^2}{(x+3)} = 2$	M1, M1
	$\Rightarrow \dfrac{(4x+5)^2}{(x+3)} = 9$	A1
	$\Rightarrow 16x^2 + 31x - 2 = 0$	
	$(16x-1)(x+2) = 0 \Rightarrow x = \dfrac{1}{16}$ only	dM1, A1
		(5)
(ii) (a)	States that $\log a + \log b = \log(ab)$ or else uses rule and proceeds from given equation $\log a + \log b = \log(a+b)$ to $\log ab = \log(a+b)$	B1
	Deduces $ab = a+b \Rightarrow ab - a = b \Rightarrow a(b-1) = b \Rightarrow a = \dfrac{b}{b-1}$ *	M1, A1*
(b)	States either $b > 1$ or $b \neq 1$ as a would not be defined	B1
	$b > 1$ as logs only exist for positive numbers	B1
		(5)
		(10 marks)

Question Number	Scheme	Marks
9 (a)	Substitute $t=4$ in $3\log_2(t+4)-2\log_2(t-2) \Rightarrow 3\log_2 8-2\log_2 2$	M1
	$=3\times3-2\times1=7$ ✓	A1
		(2)
(b)	One correct log law applied. E.g $3\log_2(t+4)=\log_2(t+4)^3$	M1
	Correctly removes logs $\dfrac{(t+4)^3}{(t-2)^2}=2^7$	A1
	$t^3+12t^2+48t+64=128\left(t^2-4t+4\right) \Rightarrow t^3-116t^2+560t-448=0$	A1*
		(3)
(c)	$t^3-116t^2+560t-448=(t-4)\left(t^2+.....\pm112\right)$	M1
	$t^3-116t^2+560t-448=(t-4)\left(t^2-112t+112\right)$	A1
	Solves their $t^2-112t+112$ and finds at least the value of t greater than 2	dM1
	$t=4,\ 56+12\sqrt{21}$	A1
		(4)
		Total 9

Question Number	Scheme	Marks
2(a)	Midpoint of $(-2,5)$ and $(4,15)$ is $\left(\dfrac{-2+4}{2},\dfrac{5+15}{2}\right)=(1,10)$	B1
	Attempts radius ^{2} or diameter ^{2}: e.g. $D^2=(4--2)^2+(15-5)^2=136$	M1
	$\text{Radius}^2=34$	A1
	$(x-1)^2+(y-10)^2=34$	M1, A1
		(5)
(b)	$\left(1,10-\sqrt{34}\right)$	B1 , dB1
		(2)
		(7 marks)

2(a)	$u_1=7 \Rightarrow u_2=k-7$	B1
	$u_2=k-7 \Rightarrow u_3=k+k-7 \Rightarrow u_4=k-(2k-7)$ $u_5=k+(-k+7)=7*$	M1A1*
		(3)
(b)	$\sum_{r=1}^{4} u_r=30 \Rightarrow 7+k-7+2k-7-k+7=30 \Rightarrow k=...$	M1
	$k=15$	A1cso
		(2)
(c)	$\sum_{r=1}^{150} u_r=37\times30+7+"15"-7$	M1
	$=1125$	A1cso
		(2)
		Total 7