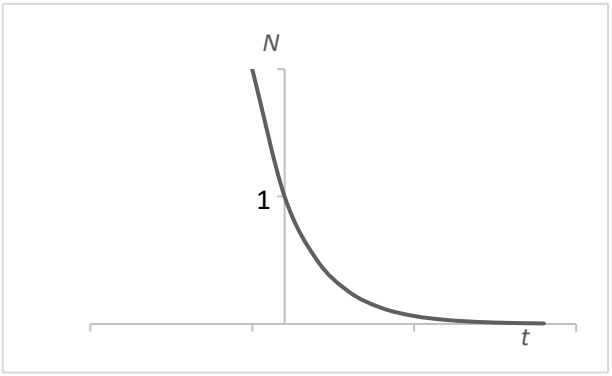
Question	Scheme	Marks
9(a)		
	Correct shape from or passing through a point on positive vertical axis. May extend to the left of the vertical axis and allow to pass into quadrant 4. There must be no (obvious) turning points. Labels not required on axes and ignore any that are given.	**M1**
	Shape and 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 $t = 3250$, $N = 15 \times 0.999878^{3250} = ...$	**M1**
	$= \text{awrt } 10.1 \text{ (grams)}$	**A1**
		(2)
(d)	$18 = 25 \times 0.999878^t$	**B1**
	$\Rightarrow 0.999878^t = \frac{18}{25} \Rightarrow t = \frac{\log \frac{18}{25}}{\log 0.999878} = ...$	**M1**
	$t = 2692.49...$ so item is 2700 years old	**A1**
		(3)
		(9 marks)

Notes:

(a)
M1: See scheme.
A1: See scheme.

(b)

M1: Uses the information to set up a correct equation and rearranges to form $\lambda^a = b$ where *a* and *b* are constants. Allow $\lambda^{5700} = \frac{1}{2}$ to be written down directly.

A1*: Evidence of taking fractional root seen, leading to the given answer. Alternatively, may see logs used, $5700\log\lambda = \log\frac{1}{2} \Rightarrow \log\lambda = \frac{-\log 2}{5700} \Rightarrow \lambda = 10^{\frac{-\log 2}{5700}} = ...$ Look for at least one correct intermediate step (and no incorrect ones). Allow greater accuracy e.g. 0.9998784026…
Note that the use of 5699 instead of 5700 scores M1A0

Alt:

M1: Substitutes values 0.9998775 and 0.9998785 or a tighter range containing the root (e.g. 0.999878 and 0.9998785 will do) to calculate *N* or just λ^t at *t* = 5700.

A1*: Correct values, with suitable conclusion that as half value occurs between these λ =0.999878 to 6 d.p.

(c)

M1: Substitutes given values (or more accurate λ) into the equation and evaluates. Implied by a correct answer, but an incorrect answer with no evidence is M0. Allow 3249 for 3250.
Condone the use of a less accurate λ e.g. 0.9999 if the intention is clear.

A1: Awrt 10.1. Units not required. Answer only can score both marks.

(d)

B1: Sets up the correct equation from the information given. It must be clear they are using the given λ or better accuracy so clear use of e.g. 0.9999 scores B0 but allow the M1 below.
This may be implied if they write e.g. $18 = 25\times\lambda^t$ and then go on to use the given value of λ.
Allow this mark if a different letter is used for *t* as long as the equation is correct.

M1: Solves an equation of the form $a = b\lambda^t$ for *t* to obtain a value

Must be correct log work so look for e.g. $a = b\lambda^t \Rightarrow \frac{a}{b} = \lambda^t \Rightarrow t = \log_\lambda \frac{a}{b}$

Or e.g. $a = b\lambda^t \Rightarrow \frac{a}{b} = \lambda^t \Rightarrow t = \log\frac{a}{b} = \log\lambda^t = t\log\lambda \Rightarrow t = \frac{\log\frac{a}{b}}{\log\lambda}$

Allow a mis-copied λ or a less accurate λ for this mark.

A1: Correct answer of 2700 (not awrt). Accept "27 hundred" or even "2692.49… so 27"

FYI use of $\lambda = 2^{-\frac{1}{5700}}$ gives 2701.4 years.

Question	Scheme	Marks
10(a)	Equation of circle is $(x-3)^2+(y-5)^2=r^2$ and line is $y=2x+k$ So intersect when $(x-3)^2+(2x+k-5)^2=r^2$	**M1**
	$\Rightarrow x^2-6x+9+4x^2+4(k-5)x+(k-5)^2=r^2$ $\Rightarrow 5x^2+(-6+4k-20)x+9+k^2-10k+25-r^2=0$	**dM1**
	$\Rightarrow 5x^2+(4k-26)x+k^2-10k+34-r^2=0$*	**A1***
		(3)
(b)	Tangent to $C \Rightarrow b^2-4ac=0 \Rightarrow (4k-26)^2-4\times5\times(k^2-10k+34-r^2)=0$	**M1**
	$\Rightarrow 16k^2-208k+676-20k^2+200k-680+20r^2=0$ $\Rightarrow 5r^2=\ldots$	**M1**
	$\Rightarrow 5r^2=k^2+2k+1=(k+1)^2$	**A1**
		(3)
(b) **Way 2**	Gradient of BX is $-\frac{1}{2}$ so equation of BX is $y-5=-\frac{1}{2}(x-3)$ $y-5=-\frac{1}{2}(x-3), y=2x+k \Rightarrow x=\ldots, y=\ldots\left(\frac{13-2k}{5},\frac{26+k}{5}\right)$	**M1**
	$\left(\frac{13-2k}{5}-3\right)^2+\left(\frac{26+k}{5}-5\right)^2=r^2$	**dM1**
	$\Rightarrow 5r^2=k^2+2k+1=(k+1)^2$	**A1**
		(3)
(c)	Triangle AXB is right angled so $AB^2+r^2=XA^2=(3-0)^2+(5-k)^2$	**M1**
	$AB^2=4r^2$ so $AB^2+r^2=5r^2$	**M1**
	$\Rightarrow 5r^2=9+(5-k)^2$	**A1**
	$\Rightarrow k^2+2k+1=9+25-10k+k^2$	**M1**
	$\Rightarrow 12k=33 \Rightarrow k=\ldots$	**dM1**
	$k=\frac{11}{4}$	**A1**
		(6)
		(12 marks)

Notes:

(a)

M1: Forms equation of circle and substitutes in equation of line.

The circle equation must be of the form $(x\pm3)^2+(y\pm5)^2=r^2$

dM1: Expands both sets of brackets and collects terms in x^2 and x.