Question Number	Scheme	Marks
1 (a)	$P_0 = 300$	B1 (1)
(b)	$420 = \dfrac{900e^{0.12t}}{2e^{0.12t}+1} \Rightarrow 60e^{0.12t} = 420$	M1 A1
	Correct use of lns $\Rightarrow t = \dfrac{\ln 7}{0.12} = 16.22$	dM1 A1 (4)
(c)	States that maximum number (upper limit) is 450 so cannot reach 500	B1 (1)
		6 marks

(a)

B1 300

(b)

M1 Substitutes $N = 420$ and proceeds to $Ae^{0.12t} = B$ condoning slips

A1 $60e^{0.12t} = 420$ oe

dM1 Uses correct ln work to find *t*. This must be from a solvable equation.

Method 1: $Ae^{0.12t} = B \rightarrow e^{0.12t} = k \rightarrow 0.12t = \ln k \rightarrow t = ...$ ($k > 0$)

Method 2: $Ae^{0.12t} = B \rightarrow \ln A + 0.12t = \ln B \rightarrow t = ...$ (A, $B > 0$)

A1 Awrt 16.22 (years)

Note: **Answers without working** (even to accuracy of 1 dp) can score SC 1100.

Eg. $420 = \dfrac{900e^{0.12t}}{2e^{0.12t}+1} \Rightarrow t = 16.2$

(c)

B1 May be tackled in a variety of ways. **Requires a reason and a conclusion**

E.g.

- States that the **upper** limit (or maximum value) is 450 so cannot reach 500. Note that it is acceptable to state that the number of toads cannot exceed 449. (Allow here $N < 450$ for upper limit is 450)
- The conclusion can be implied by a statement such as "as the maximum value is 450"
- Alternatively substitutes $500 = \dfrac{900e^{0.12t}}{2e^{0.12t}+1} \Rightarrow 100e^{0.12t} = -500$ or similar and states this cannot be found as ln's cannot be taken of negative numbers, hence cannot ever be 500. (Allow the candidate to state maths error, exponentials cannot be negative to form part of their reason)

The calculations here must be correct and the proof complete.

The following 3 examples score B0 as they are incomplete and/or incorrect

1) $500 = \dfrac{900e^{0.12t}}{2e^{0.12t}+1} \Rightarrow e^{0.12t} = -5$ which cannot be found. (Requires a conclusion)

2) The limit is 450 so they cannot reach 500. (Requires upper limit)

3) $500 = \dfrac{900e^{0.12t}}{2e^{0.12t}+1} \Rightarrow e^{0.12t} = -0.01$ which cannot be found and so they cannot reach 500.

(Requires correct calculation)

Question Number	Scheme	Marks
2.(a)	$\mathrm{fg}\left(\mathrm{e}^2\right)=\mathrm{f}\left(\frac{5}{2}\ln \mathrm{e}^2\right)=\frac{12}{\frac{5}{2}\ln \mathrm{e}^2+1},=2$	M1, A1
		(2)
(b)	$\mathrm{f}(x)=\frac{12}{x+1}$	
	$\mathrm{f}^{-1}(x)=\frac{12}{x}-1$	M1 A1
	$0<x<12$	B1
		(3)
(c)	$\frac{12}{x+1}=\frac{12}{x}-1\Rightarrow 12x=12(x+1)-x(x+1)$	M1
	$\Rightarrow x^2+x-12=0\Rightarrow x=...$ Must be 3TQ	dM1
	$x=3$ only	A1
		(3)
		8 marks
(c) Alts	Solves $\mathrm{f}^{-1}(x)=x\Rightarrow\frac{12}{x}-1=x$ leading to quadratic equation,	
	or solves $\mathrm{f}(x)=x\Rightarrow\frac{12}{x+1}=x$ leading to quadratic equation	M1
	$\Rightarrow x^2+x-12=0\Rightarrow x=...$ Must be 3TQ	dM1
	$x=3$ only	A1
		(3)

(a)

M1 Correct order of operations applying g before f on e^2.

Allow an attempt to substitute $x= e^2$ into $\mathrm{fg}(x)=\frac{12}{\frac{5}{2}\ln x+1}$

This must be a complete attempt using all aspects of both functions but allow for slips on the coefficients

A1 cso 2.