Question	Scheme	Marks	AOs
10 (a)	$\frac{\mathrm{d}A}{\mathrm{d}t} \propto \sqrt{A} \Rightarrow \frac{\mathrm{d}A}{\mathrm{d}t} = k\sqrt{A}$ or $\frac{\mathrm{d}A}{\mathrm{d}t} = kA^{\frac{1}{2}}$	B1	3.1b
	$\int \frac{1}{A^{\frac{1}{2}}}\,\mathrm{d}A = \int k\,\mathrm{d}t$	M1	1.1b
	$\left\{\int A^{-\frac{1}{2}}\,\mathrm{d}A = \int k\,\mathrm{d}t \Rightarrow\right\}$ $\frac{A^{\frac{1}{2}}}{\left(\frac{1}{2}\right)} = kt\ \{+c\}$ or $2A^{\frac{1}{2}} = kt\ \{+c\}$	A1	1.1b
	$\{t=0,\ A=9 \Rightarrow\}\ 2\sqrt{9} = k(0) + c$	M1	3.4
	$\Rightarrow c = 6 \Rightarrow 2A^{\frac{1}{2}} = kt + 6$ $\{t=6,\ A=56.25 \Rightarrow\}\ 2\sqrt{56.25} = k(6) + 6$	dM1	1.1b
	$\Rightarrow 15 = 6k + 6 \Rightarrow k = \frac{9}{6} \Rightarrow k = \frac{3}{2}$ $\Rightarrow 2A^{\frac{1}{2}} = \frac{3}{2}t + 6 \Rightarrow A^{\frac{1}{2}} = \frac{3}{4}t + 3 \Rightarrow A = \left(\frac{3}{4}t + 3\right)^2$ *	A1*	2.1
		(6)	
(b) **(i), (ii)**	**Either** • $t = 12,\ A = \left(\frac{3}{4}(12) + 3\right)^2 = 144\ \{\approx 143.78\}$ $t = 18,\ A = 272.25\ \{\approx\ 271.19\}$ $t = 24,\ A = 441\ \{> 334.81\}$ $\{\ t = 30,\ A = 650.25\ \{> 337.33\}\ \}$ **or** • $A = 143.78 \Rightarrow 143.78 = \left(\frac{3}{4}t + 3\right)^2 \Rightarrow t = 11.98777...\ \{\approx 12\}$ $A = 271.19 \Rightarrow t = 17.95713...\ \{\approx 18\}$ $A = 334.81 \Rightarrow t = 20.39709...\ \{< 24\}$ $\{A = 337.33 \Rightarrow t = 20.48873...\ \{< 30\}\}$	M1	3.4
	Biologist's model works well for $t = 12$ and $t = 18$ but appears to give an overestimate for A (or does not work well) when $t = 24$ and $t = 30$	A1	3.5a
	E.g. • The biologist's model appears to break down for large values of t. This may be because the biologist's model predicts values for A which are greater than the total surface area of the piece of bread used in the experiment. • The biologist's results indicate an upper limit for A, but the biologist's model does not give an upper limit for A.	B1	3.2a
		(3)	
			(9 marks)

Question 10 Notes:	
(a)	
B1:	Translates the biologist's model regarding proportionality into a differential equation, which involves a constant of proportionality. E.g. $\frac{\mathrm{d}A}{\mathrm{d}t} \propto \sqrt{A} \Rightarrow \frac{\mathrm{d}A}{\mathrm{d}t} = k\sqrt{A}$
M1:	Correct method of separating the variables A and t in their differential equation
A1:	$\frac{A^{\frac{1}{2}}}{\left(\frac{1}{2}\right)} = kt$ or $2A^{\frac{1}{2}} = kt$, with or without a constant of integration
M1:	Some evidence of applying the measurements $t = 0$, $A = 9$ or $A = 9.00$ to a changed equation containing a constant of integration. e.g. c
dM1:	**dependent on the previous M mark** Applies $t = 6$, $A = 56.25$ and their value of c to their changed equation which contains their constant of proportionality
A1*:	Shows that $A = \left(\frac{3}{4}t + 3\right)^2$, with no errors in their working
(b)	
(i), (ii)	
M1:	Uses the model found in part (a) to find • **either** values for A when $t = 12$, $t = 18$ and $t = 24$ • **or** values for t when $A = 143.78$, $A = 271.19$ and $A = 334.81$
A1:	• **Either** $t = 12 \Rightarrow A = 144$, $t = 18 \Rightarrow A =$ awrt 272 **and** $t = 24 \Rightarrow A = 441$ • **or** $A = 143.78 \Rightarrow t =$ awrt 12, $A = 271.19 \Rightarrow t =$ awrt 18 **and** $A = 334.81 \Rightarrow t =$ awrt 20 **and** evaluates (see scheme) the outcomes of the model
B1:	See scheme