Question Number	Scheme	Marks
6(a)	$\text{fg}(1) = \text{f}(2) = 7$	M1A1
		(2)
(b)	Either $\text{g}(0) = 3$ or $\text{g}(x \to \infty) \to 0.5$	M1
	$0.5 < \text{g}(x)$,, 3	A1
		(2)
(c)	$y = \dfrac{x+9}{2x+3} \Rightarrow y(2x+3) = x+9$ $\Rightarrow x(2y-1) = 9-3y \Rightarrow x = \dfrac{9-3y}{2y-1}$	M1
	$\text{g}^{-1}(x) = \dfrac{9-3x}{2x-1}, \quad 0.5 < x \leq 3$	A1, B1ft
		(3)
(d)	Attempts to find $\text{f}(0) = 2\times3+5=11$ OR $\text{f}(3) = 5$	M1
	$5 < k \leq 11$	A1 A1
		(3)
		(10 marks)

Notes

(a)

M1: Full method for substituting their g(1) into f.

Can also be scored for seeing $x = 1$ substituted into $2\left|3-\dfrac{x+9}{2x+3}\right|+5$

A1: 7. Sight of 7 can achieve both marks if no incorrect work is seen.
Do not accept multiple answers.

(b)

M1: Achieves the correct value for either end of the range. Sight of 0.5 or 3 or e.g. $\dfrac{9}{3}$ is sufficient.

A1: Correct range and correct notation. Accept $0.5 < y \leq 3$ or e.g. $0.5 < \text{g} \leq 3$ or e.g. $(0.5, 3]$

(c)

M1: Full attempt to change the subject for $y = \dfrac{x+9}{2x+3}$ or $x = \dfrac{y+9}{2y+3}$

They must cross multiply and collect terms to get $x = \dfrac{ay+b}{cy+d}$ or $y = \dfrac{ax+b}{cx+d}$ oe where

a, b, c and d are non-zero.

A1: $\text{g}^{-1}(x) = \dfrac{9-3x}{2x-1}$. Accept y or g^{-1} for $\text{g}^{-1}(x)$

B1ft: Correct domain or follow through on their answer for (b) but it must be appropriate notation in terms of x.

E.g. $0.5 < x$,, 3 or $(0.5, 3]$

Do not follow through on $y \in \mathbb{R} \to x \in \mathbb{R}$

(d)

M1: Attempts f(0) or f(3).

Evidence could be seeing $2|3-0|+5$ or $2|3-3|+5$ or the sight of 5 or 11

It may be seen as one of the limits on k.

A1: Achieves correct limits of 5 and 11 which may be seen embedded e.g. $5 < k \leqslant 11$

A1: Fully correct $5 < k \leq 11$ oe e.g. $(5, 11]$

Question Number	Scheme	Marks
7(a)	$t=0 \Rightarrow (P=) 200-\dfrac{160}{15+1}=190 \Rightarrow 190\ 000$	M1A1
		(2)
(b)	$e^{kt} \rightarrow ae^{kt}$	M1
	$\left(\dfrac{dP}{dt}=\right)-\dfrac{(15+e^{0.8t})\times 96e^{0.6t}-160e^{0.6t}\times 0.8e^{0.8t}}{(15+e^{0.8t})^2}$	M1A1
		(3)

Notes

(a)

M1: Sets $t = 0$ and uses $e^0 = 1$. It is for attempting $200-\dfrac{160}{15+1}$ but not $\dfrac{200-160}{15+1}$

This can be awarded for a correct answer.

A1: Correct answer only. Accept 190 000 or 190 thousand or (P =) 190 (bees).
The answer is an integer so do not allow awrt 190 or 190 000 i.e. no decimals.

(b)

M1: For evidence of $e^{kt} \rightarrow ae^{kt}$ where a is a constant.
This may be embedded within the quotient (or product) rule or their attempt to differentiate.

M1: For applying the quotient rule to obtain $\left(\dfrac{dP}{dt}=\right)\pm\dfrac{(15+e^{0.8t})\times pe^{0.6t}-qe^{0.8t}\times e^{0.6t}}{(15+e^{0.8t})^2}$ or the product rule to obtain $\left(\dfrac{dP}{dt}=\right)\pm\left[Ae^{0.6t}(15+e^{0.8t})^{-1}+Be^{0.6t}(15+e^{0.8t})^{-2}\times Ce^{0.8t}\right]$

Condone invisible brackets for this mark but not for the A mark below.

A1: A correct unsimplified or simplified derivative.

e.g. $\left(\dfrac{dP}{dt}=\right)-\dfrac{(15+e^{0.8t})\times 96e^{0.6t}-160e^{0.6t}\times 0.8e^{0.8t}}{(15+e^{0.8t})^2}$ oe

or e.g.

$\left(\dfrac{dP}{dt}=\right)-160\times 0.6e^{0.6t}(15+e^{0.8t})^{-1}+160\times 0.8e^{1.4t}(15+e^{0.8t})^{-2}$ oe

"$\dfrac{dP}{dt}=$" is **not** required so just look for a correct expression.

Apply isw once a correct derivative is seen.

(c)	Sets $\dfrac{(15+\mathrm{e}^{0.8t})\times 96\mathrm{e}^{0.6t}-160\mathrm{e}^{0.6t}\times 0.8\mathrm{e}^{0.8t}}{(15+\mathrm{e}^{0.8t})^2}=0$ $\Rightarrow (15+\mathrm{e}^{0.8t})\times 96\mathrm{e}^{0.6t}-160\mathrm{e}^{0.6t}\times 0.8\mathrm{e}^{0.8t}=0$ $\Rightarrow 1440\mathrm{e}^{0.6t}=32\mathrm{e}^{1.4t}$ or e.g. $\mathrm{e}^{0.8t}=45$ oe **or** $-160\mathrm{e}^{0.6t}(15+\mathrm{e}^{0.8t})^{-2}\times 0.8\mathrm{e}^{0.8t}+(15+\mathrm{e}^{0.8t})^{-1}\times 128\mathrm{e}^{0.6t}=0$ $\Rightarrow 1440\mathrm{e}^{0.6t}=32\mathrm{e}^{1.4t}$ or e.g. $\mathrm{e}^{0.8t}=45$ oe	M1A1
	$\Rightarrow T=\dfrac{\ln 45}{0.8}=4.76$	**d**M1A1
		(4)
		(9 marks)

Notes

Allow recovery here if signs are reversed in their derivative.

May work in *T* and/or *t*.

M1: Sets the numerator of their quotient rule attempt = 0 or sets their product rule attempt = 0 and obtains $p\mathrm{e}^{0.8t}=q$ or $A\mathrm{e}^{0.6t}=B\mathrm{e}^{1.4t}$ or equivalent.
The denominator of their quotient rule (correct or incorrect) can be ignored in part (c).

A1: $1440\mathrm{e}^{0.6t}=32\mathrm{e}^{1.4t}$ or $\mathrm{e}^{0.8t}=45$ or an equivalent correct equation.
Must follow correct work but allow this mark if the only error is reversed signs in their derivative.

dM1: Having set $\dfrac{\mathrm{d}P}{\mathrm{d}t}=0$ and obtained either $A\mathrm{e}^{\pm kt}=B$ (k may be incorrect) or $C\mathrm{e}^{\pm\alpha t}=D\mathrm{e}^{\pm\beta t}$ where $k,\alpha,\beta\neq 0$ it is for the correct order of operations including taking ln's leading to $t=\ldots$
May be implied by their value of t.
It cannot be awarded for impossible equations e.g. $\mathrm{e}^{0.8t}=-45$
Depends on the first method mark.

A1: $T=\dfrac{\ln 45}{0.8}$ or equivalent or awrt 4.76
Must follow correct work but allow this mark if the only error is reversed signs in their derivative.