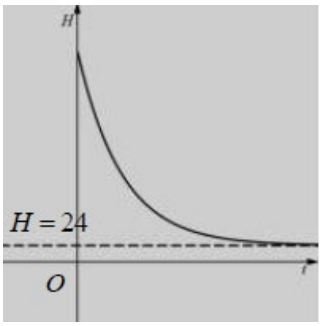
Question Number	Scheme	Marks
5 (a)	$304(°\text{C})$	B1 **(1)**
(b)	 Shape or Asymptote Fully correct Shape and Asymptote	M1 A1 **(2)**
(c)	$144 = 280\,e^{-0.05t} + 24 \Rightarrow 280\,e^{-0.05t} = 120$ Correct use of lns $\Rightarrow -0.05t = \ln\frac{120}{280} \Rightarrow t = 16.95$	M1 dM1 A1 **(3)**
(d)	$\left(\frac{dH}{dt} =\right) -0.05 \times 280\,e^{-0.05t}$ $\frac{dH}{dt} = -0.05 \times (H - 24) \Rightarrow \frac{dH}{dt} = 1.2 - 0.05H$	M1 M1, A1cso **(3)** **(9 marks)**

(a)

B1: 304

(b)

M1: Correct shape or correct asymptote. For the shape the curve must be at least in the upper half plane with negative gradient which levels out to 0, but which may be asymptotic to the *x*-axis. Be tolerant with curves that begin to turn back on themselves for this mark if the intent is clear.
For the asymptote it must be an asymptote for their curve (not just a dashed line with no curve approaching it), and may just be labelled 24 on the *y*-axis for this mark.

A1: Correct shape and asymptote. For the shape the curve must be in quadrant 1 only, starting on the *H* axis with negative gradient which levels to 0 at the asymptote which must be above the *x*-axis. It must not cross the asymptote or clearly turn back on itself, but condone touching the asymptote and slight "pen flicks" at the end.
The asymptote must be an equation, $H = 24$ but condone $y = 24$. Must be an equation, not just 24 labelled as the intercept of the asymptote.

(c)

M1: Substitutes $H = 144$ into the equation and proceeds at least as far as $Ae^{\pm 0.05t} = B$ condoning slips.

dM1 Uses correct ln work to find *t*.

Method 1: $Ae^{-0.05t} = B \to e^{\pm 0.05t} = k \to \pm 0.05t = \ln k \to t = ...$

Method 2: $Ae^{-0.05t} = B \to \ln A - 0.05t = \ln B \to t = ...$

May be implied by a correct f.t. value following reaching an equation $Ae^{\pm 0.05t} = B$

A1 Awrt 16.95. Condone awrt 16.95 minutes.

(d)

M1: Differentiates to a form $k\mathrm{e}^{-0.05t}$ where $k \neq 1$ or 280. May be called $\frac{\mathrm{d}y}{\mathrm{d}x}$ or unlabelled as long as it is clearly an attempt at the derivative.

M1: Rearranges the equation for H to find $\mathrm{e}^{-0.05t}$ or a multiple of $\mathrm{e}^{-0.05t}$ which is then substituted into their $k\mathrm{e}^{-0.05t}$ (not dependent, so their k may be 280 for this mark). May be implied as long as a derivative has been attempted.

A1: cso $\frac{\mathrm{d}H}{\mathrm{d}t} = 1.2 - 0.05H$ or with fractions e.g. $\frac{\mathrm{d}H}{\mathrm{d}t} = \frac{6}{5} - \frac{H}{20}$, which must follow correct work and notation. The $\frac{\mathrm{d}H}{\mathrm{d}t}$ must have been seen to score this mark.

Alt:

M1: Makes t the subject and differentiates: $H = 280\mathrm{e}^{-0.05t} + 24 \Rightarrow t = -20\ln\frac{H-24}{280} \Rightarrow \left(\frac{\mathrm{d}t}{\mathrm{d}H} =\right) \frac{-20}{H-24}$

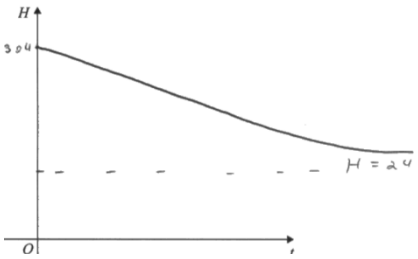
M1: Applies $\frac{\mathrm{d}H}{\mathrm{d}t} = 1 \div \frac{\mathrm{d}t}{\mathrm{d}H}$ with their attempt at $\frac{\mathrm{d}t}{\mathrm{d}H}$

A1: cso per main scheme.

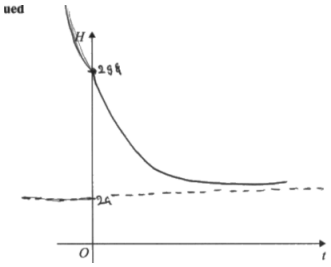
Alt 2: for Second M (first M and A as per scheme, allowing for a and b to be stated as values).

M1: Sets $\frac{\mathrm{d}H}{\mathrm{d}t}$ equal to $a + bH$, substitutes for H and compares coefficients to find values for a and b.

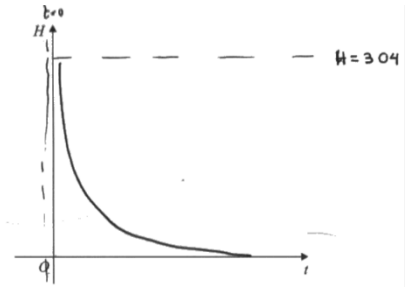
Some examples of scores for graphs:



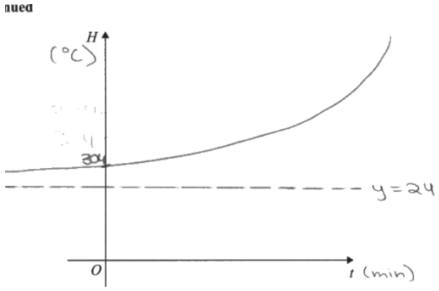
M1A0 Asymptote correct and labelled, shape incorrect



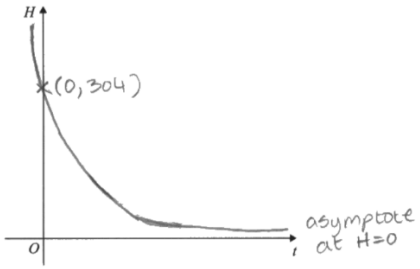
M1A0 Asymptote correct labelled but graph extends into second quadrant, and no equation.



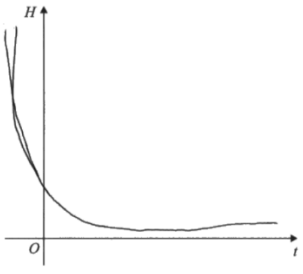
M1A0 Shape acceptable, but asymptote incorrect and does not start on H axis



M1A0 Asymptote correct and labelled (and is an asymptote to their graph), shape incorrect



M1A0 Shape acceptable, asymptote incorrect (and curve extends to Q2)



M0A0 Shape and asymptote both incorrect. Gradient increases above zero.

Question Number	Scheme	Marks
6 (a)	$y=\dfrac{4x+3}{x-2}\Rightarrow yx-2y=4x+3$ $\Rightarrow yx-4x=2y+3$ | $y=4+\dfrac{11}{x-2}\Rightarrow y-4=\dfrac{11}{x-2}$ $x-2=\dfrac{11}{y-4}$	M1
	$\Rightarrow x=\dfrac{2y+3}{y-4}\Rightarrow \mathrm{f}^{-1}(x)=\dfrac{2x+3}{x-4}$ | $\Rightarrow x=2+\dfrac{11}{y-4}\Rightarrow \mathrm{f}^{-1}(x)=2+\dfrac{11}{x-4}$	A1
	$x\neq 4$	B1
		(3)
(b)	$\mathrm{ff}(x)=\dfrac{4\times\dfrac{4x+3}{x-2}+3}{\dfrac{4x+3}{x-2}-2}$ or $\mathrm{ff}(x)=4+\dfrac{11}{4+\dfrac{11}{x-2}-2}$	M1
	$=\dfrac{4\times(4x+3)+3(x-2)}{4x+3-2(x-2)}=\dfrac{19x+6}{2x+7}$	dM1 A1
		(3)
(c)	Either $x=1$ or $y=38$	M1
	$(1, 38)$	A1
		(2)
		(8 marks)

(a)

M1: Attempts to change the subject. May interchange x and y at the start or work towards $x = \ldots$ Must proceed as far as getting the two x terms on one side of the equation and the terms not in x on the other or equivalent if x and y are swapped first. Alternatively may divide through first, gather terms and proceed as far as cross multiplying.

A1: $\mathrm{f}^{-1}(x)=\dfrac{2x+3}{x-4}$ (oe) but accept $y=\dfrac{2x+3}{x-4}$ and even $\mathrm{f}^{-1}=\dfrac{2x+3}{x-4}$ or e.g. $\mathrm{f}(x)^{-1}=\dfrac{-2x-3}{4-x}$ Accept equivalent simplified forms.

B1: States correct domain $x\neq 4$ $(x\in\mathbb{R})$ Ignore reference to $y\neq 2$ but extra x exclusions is B0.

(b)

M1: Attempts to replace both the x's in $\dfrac{4x+3}{x-2}$ by $\dfrac{4x+3}{x-2}$. Condone a slip such as missing the "+3" as long as the attempt to replace both x's is seen. Alternatively if dividing through look for the attempt to replace the x by $4+\dfrac{11}{x-2}$ condoning a slip missing the extra $"-2"$

dM1: Full attempt to form a fraction of the required form by multiplying all terms in the numerator and denominator by $(x-2)$ If dividing through they must combine to a single fraction.
An equally valid alternative is to put both numerator and denominator over common factors of $(x-2)$

A1: $\dfrac{19x+6}{2x+7}$ but allow equivalent fractions of this form.

(c) Mark only the final attempt here as the candidate may "build up" their answer in stages.
Also watch out for the answer stated next to the question, which can be taken as their final answer.

M1: Either $x=1$ or $y=38$

A1: (1, 38) but allow to be written out separately, or with the brackets omitted.