Question Number	Scheme	Marks
7a	$H = t^{\frac{1}{2}} + \frac{3t^{\frac{3}{2}}}{10} - \frac{t^{\frac{5}{2}}}{20} + 17 \Rightarrow \left(\frac{\mathrm{d}H}{\mathrm{d}t} =\right) \frac{1}{2}t^{-\frac{1}{2}} + \frac{9}{20}t^{\frac{1}{2}} - \frac{1}{8}t^{\frac{3}{2}}$	M1A1A1
	e.g. $\frac{1}{2}t^{-\frac{1}{2}} + \frac{9}{20}t^{\frac{1}{2}} - \frac{1}{8}t^{\frac{3}{2}} = 0 \Rightarrow \frac{1}{2} + \frac{9}{20}t - \frac{1}{8}t^{2} = 0 \ldots \Rightarrow 5\alpha^2 - 18\alpha - 20 = 0$ *	dM1A1*
		(5)
b	$\alpha = \frac{9+\sqrt{181}}{5} = \text{awrt } 4.491$	B1
		(1)
c	$\left(\frac{\mathrm{d}^2H}{\mathrm{d}t^2} =\right) -\frac{1}{4}t^{-\frac{3}{2}} + \frac{9}{40}t^{-\frac{1}{2}} - \frac{3}{16}t^{\frac{1}{2}} \Rightarrow -\frac{("4.49")^{-\frac{3}{2}}}{4} + \frac{9("4.49")^{-\frac{1}{2}}}{40} - \frac{3("4.49")^{\frac{1}{2}}}{16}$	M1
	$\frac{\mathrm{d}^2H}{\mathrm{d}t^2} = (-0.3\ldots) < 0 \Rightarrow \max$ *	A1*
		(2)
		(8 marks)

(a) **If they change *t* to α before differentiating then score maximum M1A1A0dM1A0**

M1 Multiplies out and attempts to differentiate. Award for one correct index from correct working (may be implied if they multiply out and differentiate at the same time) $t^{\frac{3}{2}}$ or $t^{\frac{1}{2}}$ or $t^{-\frac{1}{2}}$ (condone if these are $\alpha^{\frac{3}{2}}$ or $\alpha^{\frac{1}{2}}$ or $\alpha^{-\frac{1}{2}}$ or any other variable) The indices do not need to be processed for this mark.
e.g. $t^{\frac{5}{2}-1}$
Alternatively, they may attempt the product rule so look for a correct general expression such as $\left(\frac{\mathrm{d}H}{\mathrm{d}t} =\right) \ldots t^{-\frac{1}{2}}(20+6t-t^2) + \ldots t^{\frac{1}{2}}(A+Bt)$ (condone if in terms of α or another variable instead)

A1 One of $\frac{1}{2}t^{-\frac{1}{2}}$, $\frac{9}{20}t^{\frac{1}{2}}$, $-\frac{1}{8}t^{\frac{3}{2}}$ (simplified or unsimplified) via the main scheme
If they differentiate using the product rule then this mark can only be awarded for one of $\frac{1}{40}t^{-\frac{1}{2}}(20+6t-t^2) + \ldots t^{\frac{1}{2}}(A+Bt)$ or $\ldots t^{-\frac{1}{2}}(20+6t-t^2) + \frac{1}{20}t^{\frac{1}{2}}(6-2t)$ (unsimplified).
In both cases the indices must be processed. Condone if in terms of α

A1 $\left(\frac{\mathrm{d}H}{\mathrm{d}t} =\right) \frac{1}{2}t^{-\frac{1}{2}} + \frac{9}{20}t^{\frac{1}{2}} - \frac{1}{8}t^{\frac{3}{2}}$ or equivalent e.g. $\left(\frac{\mathrm{d}H}{\mathrm{d}t} =\right) \frac{1}{40}t^{-\frac{1}{2}}\left(20+18t-5t^2\right)$ which may be unsimplified. Also allow
e.g. $\left(\frac{\mathrm{d}H}{\mathrm{d}t} =\right) \frac{1}{40}t^{-\frac{1}{2}}(20+6t-t^2) + \frac{1}{20}t^{\frac{1}{2}}(6-2t)$ (via the product rule)

dM1 Sets their derivative of the form $\ldots t^{-\frac{1}{2}} \pm \ldots t^{\frac{1}{2}} \pm \ldots t^{\frac{3}{2}} = 0$ (may be implied) and proceeds via a correct method to a 3TQ in *t* or α (or any other variable) where the powers and the coefficients of the terms are integers. Condone sign slips only. It is dependent on the previous method mark.
Proceeding directly to the given answer is M0, unless they state how they have proceeded from the derivative directly to the given answer e.g. set $t = \alpha$ **and** $\times -40t^{\frac{1}{2}}$

Derivatives which are already factorised before being set = 0 and have the quadratic factor $20+18t-5t^2$ can score this mark for

e.g. $\left(\frac{\mathrm{d}H}{\mathrm{d}t}=\right)\frac{1}{40}t^{-\frac{1}{2}}\left("20+18t-5t^2"\right)=0\Rightarrow "5t^2-18t-20"=0$

A1* Achieves $5\alpha^2-18\alpha-20=0$ with no errors seen and all previous marks scored. Must be in terms of α (do not be concerned if it looks like a) . The $=0$ must have been seen before achieving the given answer.

Do not be concerned with the labelling of the derivative if seen e.g. $\frac{\mathrm{d}y}{\mathrm{d}x}$ instead

Do not penalise invisible brackets as long as they are recovered and the intention is clear through their subsequent lines of working.

Alternative method: They may attempt to multiply by e.g. 20 or take out a factor and then differentiate. This can score full marks, provided for A1* they explain at some point that this does not affect the given answer. You will need to check their terms are correct for the first A mark and withhold the A marks if e.g. they do not multiply all terms including the +17 by 20

(b) Mark (b) and (c) together

B1 $\alpha=$ awrt 4.491 only. Accept the exact answer. If both roots are stated then awrt 4.491 must be the only one used within their $\frac{\mathrm{d}^2H}{\mathrm{d}t^2}$, or if both values are used then the other is rejected. If awrt 4.491 is seen then allow for it to be subsequently rounded to 2 or 3sf when used as evidence of selecting awrt 4.491

(c)

M1 Attempts to differentiate their $\frac{\mathrm{d}H}{\mathrm{d}t}$ to achieve a second derivative of the form $...t^{-\frac{3}{2}}+...t^{-\frac{1}{2}}+...t^{\frac{1}{2}}$ (may be in terms of α or another variable) and either attempts to substitute in their value of α which must be between 0 and 7 or considers the sign of their second derivative. Condone their α to have been subsequently rounded before substituted in

May be seen as $\frac{1}{40}t^{-\frac{1}{2}}\left(20+18t-5t^2\right)\rightarrow-\frac{1}{80}t^{-\frac{3}{2}}\left(20-18t+15t^2\right)$

If differentiation in part (a) is via the product rule then look for an attempt to apply the product rule on their $\left(\frac{\mathrm{d}H}{\mathrm{d}t}=\right)...t^{-\frac{1}{2}}(20+6t-t^2)+...t^{\frac{1}{2}}(A+Bt)$ leading to

$...t^{-\frac{3}{2}}(20+6t-t^2)+...t^{-\frac{1}{2}}(C+Dt)+...t^{\frac{1}{2}}$

Alternatively, attempts to show that the second derivative is always negative. e.g. attempts to complete the square on $20-18t+15t^2$ and considers its sign.

A1* $\frac{\mathrm{d}^2H}{\mathrm{d}t^2}\ (=-0.3)<0\Rightarrow$ max when $\alpha=$ awrt 4.491. If evaluated, it must be -0.3 or better $(-0.3174...)$. The second derivative must be correct but condone in terms of α

In the alternative method look for correct working and valid argument explaining that eg $20-18t+15t^2$ is always greater than zero so $-\frac{1}{80}t^{-\frac{3}{2}}\left(20-18t+15t^2\right)$ is always negative for any value of t

Condone poor phrasing as part of the explanation e.g. "$t=4.491$ is a maximum" instead of "$t=4.491$ is the value at which H is at a maximum"

Condone poor notation for $\frac{\mathrm{d}^2H}{\mathrm{d}t^2}$ and condone e.g. $y"$

Question Number	Scheme	Marks
8(i)	Eg $7^2+11^2=170 \Rightarrow 170$ is a multiple of 10 so the statement is untrue *	M1A1*
		(2)
(ii)	Check first if they have multiplied the inequality e.g. by 4 to give $4<4x^2-xy<60$	M1A1
	Concludes that $1<x^2-\frac{xy}{4}<15$ for all x and y that are positive even integers less than 6 *	A1*
		(3)
		(5 marks)

x	y	$x^2-\frac{xy}{4}$ or $4x^2-xy$	
2	2	3	12
2	4	2	8
4	2	14	56
4	4	12	48

(i)

M1 Attempts to find a^2+b^2 using two consecutive prime numbers a and b. It does not matter whether this combination of prime numbers results in a multiple of 10 to score M1. Condone slips in their evaluation of the sum of the squares of these two numbers. If a candidate has several combinations, you only need to look for one calculation using two consecutive prime numbers.
Note $1^2+2^2=...$ as the only calculation is M0A0

A1* Correctly:

- evaluates the sum of two consecutive prime numbers squared
- either
  - makes a comment that the answer is a multiple of 10
  - makes a comment that 10 is a factor of their answer
  - makes a comment that their answer is divisible by 10 (do not accept can be divided by 10)
  - shows that the answer is a multiple of 10 (such as splitting the number into two factors, one of which is 10, or showing the number is divisible by 10 e.g. $\frac{170}{10}=17$)
- concludes not true o.e. (condone e.g. "not correct", "not always true")

If a candidate has several combinations, you do not need to check all of them. Just look for one which would lead to correct counter example.

Below are a list of common combinations which provide the required counter example but there will be others

- $7^2+11^2=170$
- $11^2+13^2=290$
- $17^2+19^2=650$
- $19^2+23^2=890$
- $23^2+29^2=1370$