Question	Answer	Marks	Guidance
1	Attempt to solve quadratic equation in e^x	M1	Either directly or using substitution $u = e^x$
	Obtain $e^x = \frac{1}{3}$, $e^x = 27$	A1	$e^x = \frac{1}{3}$, $e^x = 27$ may be implied if $u = e^x$ is stated
	Use correct process at least once for solving $e^x = c$ where $c > 0$	M1	
	Obtain $-\ln 3$ from a correct solution	A1	Condone use of $x = e^x$
	Obtain $3\ln 3$ from a correct solution	A1	
		5	

Question	Answer	Marks	Guidance
2	Either		
	State or imply equation $\ln y = \ln A + \ln B \ln x$	B1	
	Equate gradient of line to $\ln B$	M1	
	Obtain $\ln B = 1.6486...$ and hence $B = 5.2$	A1	
	Substitute appropriate values to find $\ln A$	M1	
	Obtain $\ln A = 1.2809...$ and hence $A = 3.6$	A1	
	Or		
	State or imply equation $\ln y = \ln A + \ln B \ln x$	B1	
	Use given coordinates to obtain a correct equation	B1	Equations are $4.908 = \ln A + 2.2 \ln B$ and $11.008 = \ln A + 5.9 \ln B$
	Use given coordinates to obtain a second correct equation and attempt to solve both equations simultaneously to obtain at least one of the unknowns $\ln A$ or $\ln B$	M1	
	Obtain $\ln B = 1.6486...$ and hence $B = 5.2$	A1	
	Obtain $\ln A = 1.2809...$ and hence $A = 3.6$	A1	

Question	Answer	Marks	Guidance
2	Or		
	Use given coordinates to obtain a correct equation	**B1**	Equations are $e^{4.908} = AB^{2.2}$ and $e^{11.008} = AB^{5.9}$
	Use given coordinates to obtain a second correct equation	**B1**	
	Solve to obtain B	**M1**	M mark dependent on both previous B marks
	$B = 5.2$	**A1**	
	$A = 3.6$	**A1**	
		5	

Question	Answer	Marks	Guidance
3	Rewrite integrand as $4e^{2x} + 4e^{-x}$	**B1**	
	Integrate to obtain form $k_1 e^{2x} + k_2 e^{-x}$ where $k_1 \neq 4, k_2 \neq 4$	**M1**	
	Obtain correct $2e^{2x} - 4e^{-x}$	**A1**	
	Apply limits correctly, retaining exactness	**M1**	Dependent on previous M1
	Obtain $2e^4 - 4e^{-2} + 2$ or exact similarly simplified equivalent	**A1**	
		5	

Question	Answer	Marks	Guidance
4(i)	Use quotient rule or equivalent	**M1**	Obtaining two terms in numerator and $(2x+1)^2$ in denominator for a quotient
	Obtain correct $\dfrac{\frac{5}{x}(2x+1)-10\ln x}{(2x+1)^2}$ or equivalent, or $\dfrac{5}{x}(2x+1)^{-1}-10\ln x(2x+1)^{-2}$ or equivalent	**A1**	Obtaining one term with $(2x+1)^{-1}$ oe and a second term with $(2x+1)^{-2}$ oe for a product Condone poor use of brackets if recovered later
	Substitute $x=1$ to obtain $\frac{15}{9}$ or $\frac{5}{3}$ or equivalent, www	**A1**	
		3	
4(ii)	Equate numerator to zero and attempt relevant arrangement	**M1**	For M1, need to see at least one line of working after either $10+\dfrac{5}{x}-10\ln x=0$ or their numerator (which must have at least 2 terms, one involving $\ln x$) = 0
	Confirm $x=\dfrac{x+0.5}{\ln x}$	**A1**	AG; necessary detail needed
		2	
4(iii)	Use iteration process correctly at least once	**M1**	
	Obtain final answer 3.181	**A1**	
	Show sufficient iterations to 6 sf to justify answer or show sign change in interval $(3.1805, 3.1815)$	**A1**	
		3	

Question	Answer	Marks	Guidance
5(i)	Obtain $\frac{dx}{d\theta} = -4\sin 2\theta + 3\cos\theta$	B1	B1 may be implied
	Use $\frac{dy}{dx} = \frac{dy}{d\theta} / \frac{dx}{d\theta}$ in terms of θ or with 1 already substituted	M1	
	Obtain or imply $\frac{dy}{dx} = \frac{-3\sin\theta}{-4\sin 2\theta + 3\cos\theta}$	A1	
	Substitute 1 to obtain 1.25	A1	Or greater accuracy 1.252013…
		4	
5(ii)	Equate denominator of first derivative to zero	M1	
	Use $\sin 2\theta = 2\sin\theta\cos\theta$	A1	
	Obtain $\sin\theta = \frac{3}{8}$	A1	
		3	

Question	Answer	Marks	Guidance
6(i)	Substitute $x = -2$ and equate to zero	**M1**	
	Obtain $-8 + 4a - 28 + a + 1 = 0$ or equivalent and hence $a = 7$	**A1**	
	Attempt <u>either</u> division by $x + 2$ and reach partial quotient $x^2 + kx$, where k is numeric <u>or</u> use of identity <u>or</u> inspection <u>or</u> synthetic division	**M1**	Synthetic division: | –2 | 1 | 7 | 14 | 8 | | | | –2 | –10 | –8 | | | 1 | 5 | 4 | 0 |
	Obtain quotient $x^2 + 5x + 4$ soi	**A1**	
	Conclude with $(x+1)(x+2)(x+4)$	**A1**	
		5	

<table>
<tr><th>Question</th><th>Answer</th><th>Marks</th><th>Guidance</th></tr>
<tr><td>6(ii)</td><td><u>Either</u></td><td></td><td></td></tr>
<tr><td></td><td>State $(2x+1)(2x+2)(2x+4)=3(x+1)(x+2)(x+4)$</td><td>M1</td><td>Following their complete factorised form</td></tr>
<tr><td></td><td>Obtain $x=-1$ and $x=-2$</td><td>A1</td><td>Calculator not permitted so necessary detail needed</td></tr>
<tr><td></td><td>Cancel common factors to obtain linear equation or factorise to find corresponding factor</td><td>M1</td><td></td></tr>
<tr><td></td><td>Obtain $x=\frac{8}{5}$ or equivalent</td><td>A1</td><td></td></tr>
<tr><td></td><td><u>Or</u></td><td></td><td></td></tr>
<tr><td></td><td>State $(2x+1)(2x+2)(2x+4)=3(x+1)(x+2)(x+4)$ or
$(2x)^3+7(2x)^2+14(2x)+8=3(x^3+7x^2+14x+8)$</td><td>M1</td><td>Following their completed factorised form,
Must see $8x^3$ and $28x^2$ if using second statement without bracketed terms in $2x$</td></tr>
<tr><td></td><td>Expand and simplify to obtain $5x^3+7x^2-14x-16=0$</td><td>A1</td><td>Must be equated to 0 for A1</td></tr>
<tr><td></td><td>Attempt complete factorisation of cubic with leading term $5x^3$ (may make use of synthetic division)</td><td>M1</td><td>Synthetic division:
<table>
<tr><td>–2</td><td>5</td><td>7</td><td>–14</td><td>–16</td></tr>
<tr><td></td><td></td><td>–10</td><td>6</td><td>16</td></tr>
<tr><td></td><td>5</td><td>–3</td><td>–8</td><td>0</td></tr>
</table></td></tr>
<tr><td></td><td>Obtain $(x+1)(x+2)(5x-8)=0$ and conclude $x=-1$, $x=-2$, $x=\frac{8}{5}$</td><td>A1</td><td>Calculator not permitted so necessary detail needed</td></tr>
<tr><td></td><td></td><td>4</td><td></td></tr>
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Question	Answer	Marks	Guidance
7(i)	State $R=\sqrt{29}$ or 5.385…	B1	
	Use appropriate trigonometry to find α	M1	Allow M1 for $\tan\alpha=\pm\frac{2}{5}$ or $\pm\frac{5}{2}$ oe
	Obtain 0.3805 with no errors seen	A1	Or greater accuracy 0.3805063…
		3	
7(ii)	State that equation is $5\cos\theta-2\sin\theta=4$	B1	
	Evaluate $\cos^{-1}(k/R)-\alpha$ to find one value of θ	M1	Allow M1 from their $\sqrt{29}\cos(\theta\pm\alpha)$
	Obtain 0.353	A1	Or greater accuracy 0.35307…
	Carry out correct method to find second value	M1	
	Obtain 5.17 and no extra solutions in the range	A1	Or greater accuracy 5.16909… If working consistently in degrees, then no A marks are available, B1, M1, M1 max
		5	
7(iii)	State integrand as $\frac{1}{29}\sec^2(\frac{1}{2}x+0.3805)$	B1 FT	Following their answer from part (i), must be in the form $R\cos(\theta\pm\alpha)$
	Integrate to obtain form $k\tan(\frac{1}{2}x+\text{their }\alpha)$	M1	
	Obtain $\frac{2}{29}\tan(\frac{1}{2}x+0.3805)+c$	A1	
		3	