1	Solve for 3^x and obtain $3^x = \frac{18}{7}$	**B1**	
	Use correct method for solving an equation of the form $3^x = a$, where $a > 0$	**M1**	
	Obtain answer $x = 0.860$ 3 d.p. only	**A1**	[3]
2	State correct unsimplified first two terms of the expansion of $(1+2x)^{-\frac{3}{2}}$, e.g. $1+(-\frac{3}{2})(2x)$	**B1**	
	State correct unsimplified term in x^2, e.g. $(-\frac{3}{2})(-\frac{3}{2}-1)(2x)^2 / 2!$	**B1**	
	Obtain sufficient terms of the product of $(2 - x)$ and the expansion up to the term in x^2	**M1**	
	Obtain **final** answer $2-7x+18x^2$ Do not ISW	**A1**	[4]
3	*EITHER*: Correctly restate the equation in terms of $\sin\theta$ and $\cos\theta$	**B1**	
	Correct method to obtain a horizontal equation in $\sin\theta$	**M1**	
	Reduce the equation to a correct quadratic in any form, e.g. $3\sin^2\theta - \sin\theta - 2 = 0$	**A1**	
	Solve a three-term quadratic for $\sin\theta$	**M1**	
	Obtain final answer $\theta = -41.8°$ only	**A1**	
	[Ignore answers outside the given interval.]		
	OR 1: Square both sides of the equation and use $1+\tan^2\theta = \sec^2\theta$	**B1**	
	Correct method to obtain a horizontal equation in $\sin\theta$	**M1**	
	Reduce the equation to a correct quadratic in any form, e.g. $9\sin^2\theta - 6\sin\theta - 8 = 0$	**A1**	
	Solve a three-term quadratic for $\sin\theta$	**M1**	
	Obtain final answer $\theta = -41.8°$ only	**A1**	
	OR 2: Multiply through by $(\sec\theta + \tan\theta)$	**M1**	
	Use $\sec^2\theta - \tan^2\theta = 1$	**B1**	
	Obtain $1 = 3 + 3\sin\theta$	**A1**	
	Solve for $\sin\theta$	**M1**	
	Obtain final answer $\theta = -41.8°$ only	**A1**	[5]

4	*EITHER*: *EITHER*: State $2xy + x^2\dfrac{dy}{dx}$, or equivalent, as derivative of x^2y	B1	
	State $6y^2 + 12xy\dfrac{dy}{dx}$, or equivalent, as derivative of $6xy^2$	B1	
	OR: Differentiating LHS using correct product rule, state term $xy(1-6\dfrac{dy}{dx})$, or equivalent	B1	
	State term $(y + x\dfrac{dy}{dx})(x-6y)$, or equivalent	B1	
	Equate attempted derivative of LHS to zero and set $\dfrac{dy}{dx}$ equal to zero	M1*	
	Obtain a horizontal equation, e.g. $6y^2 - 2xy = 0$ (from correct work only)	A1	
	Explicitly reject $y = 0$ as a possibility $py^2 - qxy = 0$	A1	
	Obtain an equation in x or y	DM1	
	Obtain answer $(-3a, -a)$	A1	
	OR: Rearrange to $y = \dfrac{9a^3}{x(x-6y)}$ and use correct quotient rule to obtain $-\dfrac{9a^3}{x^2(x-6y)^2}\times .....$	B1	
	State term $(x-6y) + x(1-6y')$, or equivalent	B1	
	Justify division by $x(x-6y)$	B1	
	Set $\dfrac{dy}{dx}$ equal to zero	M1*	
	Obtain a horizontal equation, e.g. $6y^2 - 2xy = 0$ (from correct work only)	A1	
	Obtain an equation in x or y	DM1	
	Obtain answer $(-3a, -a)$	A1	[7]
5 (i)	*EITHER*: Use tan 2A formula to express LHS in terms of $\tan\theta$	M1	
	Express as a single fraction in any correct form	A1	
	Use Pythagoras or cos 2A formula	M1	
	Obtain the given result correctly	A1	
	OR: Express LHS in terms of sin 2θ, cos 2θ, sin θ and cos θ	M1	
	Express as a single fraction in any correct form	A1	
	Use Pythagoras or cos 2A formula or sin($A - B$) formula	M1	
	Obtain the given result correctly	A1	[4]
(ii)	Integrate and obtain a term of the form $a\ln(\cos 2\theta)$ or $b\ln(\cos\theta)$ (or secant equivalents)	M1*	
	Obtain integral $-\frac{1}{2}\ln(\cos 2\theta) + \ln(\cos\theta)$, or equivalent	A1	
	Substitute limits correctly (expect to see use of <u>both</u> limits)	DM1	
	Obtain the given answer following full and correct working	A1	[4]

6	(i)	Make recognizable sketch of a relevant graph Sketch the other relevant graph and justify the given statement	B1 B1	[2]
	(ii)	Use calculations to consider the value of a relevant expression at $x = 1.4$ and $x = 1.6$, or the values of relevant expressions at $x = 1.4$ and $x = 1.6$ Complete the argument correctly with correct calculated values	M1 A1	[2]
	(iii)	State $x = 2\sin^{-1}\left(\dfrac{3}{x+3}\right)$ Rearrange this in the form $\operatorname{cosec}\frac{1}{2}x = \frac{1}{3}x + 1$ If working in reverse, need $\sin\dfrac{x}{2} = \left(\dfrac{3}{x+3}\right)$ for first B1	B1 B1	[2]
	(iv)	Use the iterative formula correctly at least once Obtain final answer 1.471 Show sufficient iterations to 5 d.p. to justify 1.471 to 3 d.p., or show there is a sign change in the interval (1.4705, 1.4715)	M1 A1 A1	[3]
7	(i)	Use the correct product rule Obtain correct derivative in any form, e.g. $(2-2x)e^{\frac{1}{2}x} + \frac{1}{2}(2x - x^2)e^{\frac{1}{2}x}$ Equate derivative to zero and solve for x Obtain $x = \sqrt{5} - 1$ only	M1 A1 M1 A1	[4]
	(ii)	Integrate by parts and reach $a(2x - x^2)e^{\frac{1}{2}x} + b\int(2-2x)e^{\frac{1}{2}x}\,dx$ Obtain $2e^{\frac{1}{2}x}(2x - x^2) - 2\int(2-2x)e^{\frac{1}{2}x}dx$, or equivalent Complete the integration correctly, obtaining $(12x - 2x^2 - 24)e^{\frac{1}{2}x}$, or equivalent Use limits $x = 0$, $x = 2$ correctly having integrated by parts twice Obtain answer 24 – 8e, or <u>exact</u> simplified equivalent	M1* A1 A1 DM1 A1	[5]

8	(i)	State or imply a correct normal vector to either plane, e.g. $3\mathbf{i}+\mathbf{j}-\mathbf{k}$ or $\mathbf{i}-\mathbf{j}+2\mathbf{k}$ Use correct method to calculate their scalar product Show value is zero and planes are perpendicular	B1 M1 A1	[3]
	(ii)	*EITHER*: Carry out a complete strategy for finding a point on l the line of intersection Obtain such a point, e.g. (0, 7, 5) , (1, 0, 1), (5/4, –7/4, 0) *EITHER*: State two equations for a direction vector $a\mathbf{i}+b\mathbf{j}+c\mathbf{k}$ for l, e.g. $3a+b-c=0$ and $a-b+2c=0$ Solve for one ratio, e.g. $a : b$ Obtain $a : b : c = 1 : -7 : -4$, or equivalent State a correct answer, e.g. $\mathbf{r}=7\mathbf{j}+5\mathbf{k}+\lambda(\mathbf{i}-7\mathbf{j}-4\mathbf{k})$	M1 A1 B1 M1 A1 A1√	
		*OR*1: Obtain a second point on l, e.g. (1, 0, 1) Subtract vectors and obtain a direction vector for l Obtain $-\mathbf{i}+7\mathbf{j}+4\mathbf{k}$, or equivalent State a correct answer, e.g. $\mathbf{r}=\mathbf{i}+\mathbf{k}+\lambda(-\mathbf{i}+7\mathbf{j}+4\mathbf{k})$	B1 M1 A1 A1√	
		*OR*2: Attempt to find the vector product of the two normal vectors Obtain two correct components of the product Obtain $\mathbf{i}-7\mathbf{j}-4\mathbf{k}$, or equivalent State a correct answer, e.g. $\mathbf{r}=7\mathbf{j}+5\mathbf{k}+\lambda(\mathbf{i}-7\mathbf{j}-4\mathbf{k})$	M1 A1 A1 A1√	
		*OR*1: Express one variable in terms of a second variable Obtain a correct simplified expression, e.g. $y = 7 - 7x$ Express the third variable in terms of the second Obtain a correct simplified expression, e.g. $z = 5 - 4x$ Form a vector equation for the line Obtain a correct equation, e.g. $\mathbf{r}=7\mathbf{j}+5\mathbf{k}+\lambda(\mathbf{i}-7\mathbf{j}-4\mathbf{k})$	M1 A1 M1 A1 M1 A1√	
		*OR*2: Express one variable in terms of a second variable Obtain a correct simplified expression, e.g. $z=5-4x$ Express the same variable in terms of the third Obtain a correct simplified expression e.g. $z=(7+4y)/7$ Form a vector equation for the line Obtain a correct equation, e.g. $\mathbf{r}=\frac{5}{4}\mathbf{i}-\frac{7}{4}\mathbf{j}+\lambda(-\frac{1}{4}\mathbf{i}+\frac{7}{4}\mathbf{j}+\mathbf{k})$	M1 A1 M1 A1 M1 A1√	[6]

9	(a)	EITHER: Use quadratic formula to solve for w	M1	
		Use $i^2 = -1$	M1	
		Obtain one of the answers $w = \dfrac{1}{2i+1}$ and $w = -\dfrac{5}{2i+1}$	A1	
		Multiply numerator and denominator of an answer by –2i + 1, or equivalent	M1	
		Obtain final answers $\frac{1}{5} - \frac{2}{5}i$ and $-1 + 2i$	A1	
		OR1: Multiply the equation by 1 – 2i	M1	
		Use $i^2 = -1$	M1	
		Obtain $5w^2 + 4w(1-2i) - (1-2i)^2 = 0$, or equivalent	A1	
		Use quadratic formula or factorise to solve for w	M1	
		Obtain final answers $\frac{1}{5} - \frac{2}{5}i$ and $-1 + 2i$	A1	
		OR2: Substitute $w = x + iy$ and form equations for real and imaginary parts	M1	
		Use $i^2 = -1$	M1	
		Obtain $(x^2 - y^2) - 4xy + 4x - 1 = 0$ and $2(x^2 - y^2) + 2xy + 4y + 2 = 0$ o.e.	A1	
		Form equation in x only or y only and solve	M1	
		Obtain final answers $\frac{1}{5} - \frac{2}{5}i$ and $-1 + 2i$	A1	[5]
	(b)	Show a circle with centre 1 + i	B1	
		Show a circle with radius 2	B1	
		Show half-line $\arg z = \frac{1}{4}\pi$	B1	
		Show half-line $\arg z = -\frac{1}{4}\pi$	B1	
		Shade the correct region	B1	[5]

10 **(i)**	Separate variables correctly and integrate at least one side Integrate and obtain term kt, or equivalent	**M1** **A1**	
	Carry out a relevant method to obtain A and B such that $\frac{1}{x(4-x)} \equiv \frac{A}{x} + \frac{B}{4-x}$, or equivalent	**M1***	
	Obtain $A = B = \frac{1}{4}$, or equivalent	**A1**	
	Integrate and obtain terms $\frac{1}{4}\ln x - \frac{1}{4}\ln(4-x)$, or equivalent	**A1**√	
	EITHER: Use a pair of limits in an expression containing $p\ln x$, $q\ln(4-x)$ and rt and evaluate a constant	**DM1**	
	Obtain correct answer in any form, e.g. $\ln x - \ln(4-x) = 4kt - \ln 9$, or $\ln\left(\frac{x}{4-x}\right) = 4kt - 8k$	**A1**	
	Use a second pair of limits and determine k Obtain the given exact answer correctly	**DM1** **A1**	
	OR: Use both pairs of limits in a definite integral Obtain the given exact answer correctly	**M1*** **A1**	
	Substitute k and either pair of limits in an expression containing $p\ln x$, $q\ln(4-x)$ and rt and evaluate a constant	**DM1**	
	Obtain $\ln\frac{x}{4-x} = t\ln 3 - \ln 9$ or equivalent	**A1**	[9]
(ii)	Substitute $x = 3.6$ and solve for t Obtain answer $t = 4$	**M1** **A1**	[2]