1.

(i)	$y-6=-\frac{4}{12}(x+8)$ $(3y+x=10)$	M1 A1	for a correct method allow unsimplified
(ii)	$y-7=3(x+1)$ $(y=3x+10)$	DM1 A1	for attempt at a perpendicular line using $(-1, 7)$ allow unsimplified
(iii)	point of intersection $(-2, 4)$ which is the midpoint of AB	M1 M1 A1	for attempt to find the point of intersection using simultaneous equations for attempt to find midpoint for all correct
	Alternative method: Midpoint $(-2, 4)$ Verification that this point lies on CP.	M1 M1 A1	for attempt to find midpoint for full verification for all correct
(iv)	$CP=\sqrt{10}$ or 3.16	B1	
(v)	Area $=\frac{1}{2}\times\sqrt{10}\times 4\sqrt{10}$ $=20$	M1 A1	for correct method **using *CP*** for 19.9 – 20.1

2.

5	(i)	(2, 8)	B1, B1	
	(ii)	$\frac{their 8-0}{their 2-p}=-2$ or better $[p=]\ 6$	M1 A1	Condone $\frac{their 8-0}{their 2-p}=\frac{-1}{their \text{ gradient } AB}$ oe

(iii)	$[MB=]\sqrt{(6-their2)^2+(10-their8)^2}$ soi or $\left[\frac{1}{2}AB=\right]\frac{1}{2}\sqrt{(6--2)^2+(10-6)^2}$ soi or $[MC=]\sqrt{(their2-their\ p)^2+(their8-0)^2}$ soi or $\tan[...]=\frac{8}{4}$ soi or $4.47^2=8.94^2+10^2-2(8.94)(10)\cos[...]$ or $8.94^2=10^2+10^2-2(10)(10)\cos[...]$	**M1**	implied by $[MB=]\sqrt{20}$ or $\left[\frac{1}{2}AB=\right]\frac{1}{2}\sqrt{80}$ e.g. 4.47, or $[MC=]\sqrt{80}$ or e.g. 8.94 or 63.4° or equivalents
	$\sin^{-1}\left(\frac{\sqrt{20}}{10}\right)$ oe soi	**M1**	or $\cos^{-1}\left(\frac{\sqrt{80}}{10}\right)$ or $\tan^{-1}\left(\frac{\sqrt{20}}{\sqrt{80}}\right)$ or $\tan^{-1}\left(\frac{4}{8}\right)$ or $90-\tan^{-1}\left(\frac{8}{4}\right)$ or equivalent complete correct method; implies first **M1**
	26.56 to 26.6° or 0.4636 to 0.464 rads cao	**A1**	Not from wrong working

3.

8	Eliminates y e.g. $4+\frac{5}{15x+10}+\frac{3}{x}=0$ or eliminates x e.g. $4+\frac{5}{y}+\frac{3}{(y-10)/15}=0$	M1	allow even after incorrect rearrangement of the equation of the curve (dependent on resulting equation still in terms of x and y); condone substitution of e.g. $\frac{y+10}{15}$
	Rearrange to a 3-term quadratic $60x^2+90x+30=0$ oe or $4y^2+10y-50=0$ oe	M1 A1	condone sign slips/arithmetic slips
	Factorise or solve 3-term quadratic	M1	
	$x=-\frac{1}{2}$, $x=-1$ isw	A1	or $y=2\frac{1}{2}$, $y=-5$
	$y=2\frac{1}{2}$, $y=-5$ isw	A1	or $x=-\frac{1}{2}$, $x=-1$ If final A marks not awarded then **A1** for a correct x, y pair

4.

8 (i)	$\lg y = x^2\lg b+\lg A$		
	$\lg b=\pm 0.21$	B1	for $\lg b=\pm 0.21$ may be implied
	$b=0.617$ allow 0.62, $10^{-0.21}$	B1	
	$\lg A=0.94$ allow 0.93 to 0.95	B1	
	$A=8.71$ allow awrt 8.5 to 8.9	B1	
	Alternative method		
	5.37 or $10^{0.73}=Ab$ 1.259 or $10^{0.1}=Ab^4$	B1	for both equations, allow correct to 2 sf
	$b^3=10^{-0.63}$	B1	
	$b=0.617$ allow 0.62, $10^{-0.21}$	B1	
	$A=8.71$ allow awrt 8.5 to 8.9	B1	
(ii)	$x=1.5$, $x^2=2.25$	M1	for correct use of graph $y=theirA\times theirb^{1.5^2}$ or $\lg y=\lg theirA+\left(1.5^2\lg theirb\right)$
	$y=2.93$, allow awrt 2.9 or 3.0	A1	
(iii)	$\lg y=0.301$, or $2='8.71(0.617)^{x^2}'$	M1	for correct use of graph to read off x^2 $2=theirA(theirb)^{x^2}$ or $\lg 2=(\lg theirb)x^2+\lg(theirA)$
	$x=1.74$, allow $\sqrt{3}$ or awrt 1.7, 1.8	A1	

5.

7(i)	$\lg y = \lg A + bx$	**B1**	straight line form, may be implied by correct values of both A and b later
	Gradient = b,	**M1**	equating gradient to b
	$b = 3$	**A1**	
	Use of substitution into one of the following $2.2 = \lg A + 0.5b$ $3.7 = \lg A + b$ $158.489 = A \times 10^{0.5b}$ $5011.872 = A \times 10^{b}$ or equivalent valid method leads to $\lg A = 0.7$	**M1**	
	$A = 5,\ 5.01$ or $10^{0.7}$	**A1**	
	Alternative 1 $\lg y = \lg A + bx$	**B1**	straight line form, may be implied by correct work later
	$2.2 = \lg A + 0.5b$	**M1**	one correct equation
	$3.7 = \lg A + b$	**A1**	both equations correct
	attempt to solve 2 correct equations	**M1**	
	leading to $b = 3$ **and** $A = 5,\ 5.01$ or $10^{0.7}$	**A1**	

7(i)	**Alternative 2** $y = A\left(10^{bx}\right)$ $158.489 = A \times 10^{0.5b}$	M1	one correct equation
	$5011.872 = A \times 10^{b}$	A1	both correct
	$\dfrac{5011.872}{158.489} = 10^{0.5b}$	M1	attempt to solve 2 correct equations
	leading to $b = 3$	A1	correct b
	Use of substitution leads to $A = 5,\ 5.01$ or $10^{0.7}$	A1	correct A
7(ii)	Substitute A and b correctly into either $y = A\left(10^{0.6b}\right)$, $\lg y = \lg A + 0.6b$ or $\lg y = \lg A + 0.6\lg 10^{b}$ or using $\lg y = 1.8 + 0.7$	M1	correct statement using *their A* and b **correctly** in either equation or using $\lg y = 3x + 0.7$
	$y = 316$, 315 or $10^{2.5}$	A1	
7(iii)	Substitute A and b correctly into either $600 = A\left(10^{bx}\right)$, $\lg 600 = \lg A + bx$ or $\lg 600 = \lg A + x\lg 10^{b}$ or using $\lg 600 = 3x + 0.7$	M1	correct statement using *their A* and b **correctly** in either equation or using $\lg y = 3x + 0.7$
	$x = 0.693$	A1	

6.

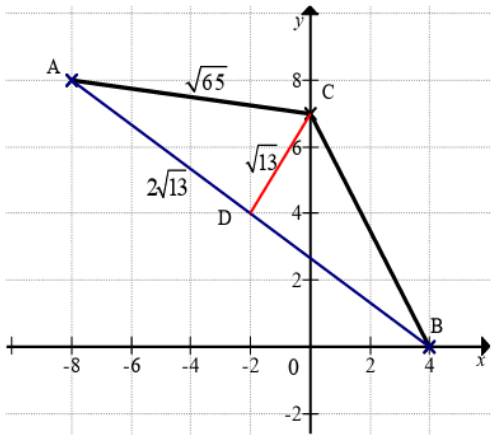
10(i)	0.5	B1	for 0.5 from correct work only
10(ii)	$15^2 = 8^2 + 8^2 - (2 \times 8 \times 8 \times \cos AOB)$ $AOB = 2.43075$ rads	M1	use of cosine rule (or equivalent) to obtain angle AOB.
	$DOC = AOB - 2(\textit{their } AOD)$	M1	use of angle AOD and symmetry
	$DOC = 1.43$ to 2 dp	A1	Answer Given: need to have seen either 2.431 or better, or 1.431 or better in previous calculations
	Alternative 1 $15 = 2 \times 8 \times \sin\left(\dfrac{1 + DOC}{2}\right)$	M1	use of basic trigonometry
	use of $\dfrac{1 + 0.5DOC}{2}$	M1	may be implied
	$DOC = 1.43$ to 2 dp	A1	Answer Given: need to have seen either 2.431 or better, or 1.431 or better or 1.215 or better in previous calculations

7.

10(i)	t: 1, 1.5, 2, 2.5; $\ln P$: 1.48, 2.12, 2.76, 3.4(0)	**M1**	allow $\ln P$ values to 1 dp rounded or truncated (1.5, 2.1, 2.8, 3.4)
	single ruled line drawn within tolerance at least for t between 1 and 2.5	**A1**	All points within 1 square of line / must **not** pass through origin
10(ii)	$e^{their 3}$	**M1**	
	18 to 22.2	**A1**	
10(iii)	$(0, c)$ with $0.1 \leqslant c \leqslant 0.3$ (0.2)	**B1**	allow $y = c$ condone $c = \ldots$
	m in the range $1.25 \leqslant m \leqslant 1.34$ (1.28)	**B1**	
10(iv)	$\ln P = (their 1.28)t + their 0.2$	**M1**	or $\ln P = (\ln b)t + \ln a$
	$P = e^{(their 1.28)t + their 0.2}$	**M1**	or $\ln b = m = their 1.28$ and $\ln a = c = their 0.2$
	$P = e^{their 0.2} e^{(their 1.28)t}$	**A1**	or $1.10 \leqslant a \leqslant 1.35$ $3.49 \leqslant b \leqslant 3.82$
10(v)	$1000 * e^{their 0.2} \times e^{their 1.28t}$ or $1000 * their\ a \times their\ b^t$	**M1**	A correct relationship e.g. $1.3t * \ln(1000) - 0.2$ where * is = or an inequality sign
	5.3	**A1**	5.2 to 5.5 must be to 1dp

8.

8(i)	$y - 8 = -\frac{8}{12}(x - (-8))$ oe isw or $y[-0] = -\frac{8}{12}(x - 4)$ oe isw or $3y = -2x + 8$ oe isw	**B2**	**B1** for $m_{AB} = -\frac{8}{12}$ oe or **M1** for $\frac{8-0}{-8-4}$ oe
8(ii)	$(-8-4)^2 + (8[-0])^2$ oe	**M1**	any valid method
	$\sqrt{208}$ isw or $4\sqrt{13}$ isw or 14.4222051… rot to 3 or more sf	**A1**	implies **M1** provided nfww

8(iii)	[coordinates of D =] (–2, 4) soi	**B1**	If coordinates of D not stated then a calculation for m_{CD} or a relevant length with the coordinates clearly embedded must be shown to imply **B1**
	Gradient methods: $\left[m_{CD} = \frac{7 - their\,4}{0 - their(-2)} = \right]$ $their\left(\frac{3}{2}\right)$ 	**M1**	or **Length of sides methods:** finds or states $AC^2 = 65$ or $AC = \sqrt{65}$ or $AC^2 = (-8-0)^2 + (8-7)^2$ oe or $AC = \sqrt{(-8-0)^2 + (8-7)^2}$ oe **and** $CD^2 = their\,13$ or $CD = their\sqrt{13}$ or $CD^2 = (0 - their(-2))^2 + (7 - their\,4)^2$ oe or $CD = \sqrt{(0 - their(-2))^2 + (7 - their\,4)^2}$ oe **and** $AD^2 = their\,52$ or $AD = their\,2\sqrt{13}$ or $AD^2 = (-8 - their(-2))^2 + (8 - their\,4)^2$ or $AD = \sqrt{(-8 - their(-2))^2 + (8 - their\,4)^2}$ or uses a valid method with *their* coordinates of D to find the exact area of the triangle and equates to $\frac{1}{2}(AD)(CD)\sin(ADC)$
	states $\frac{3}{2} \times \left(-\frac{8}{12}\right) = -1$ oe or $\frac{3}{2}$ is the negative reciprocal of $-\frac{2}{3}$ oe or finds the equation of the perpendicular bisector of AB as $y = \frac{3}{2}x + 7$ independently of C and states that C lies on this line.	**A1**	applies Pythagoras to confirm, using integer values, that 65 = 13 + 52 or finds e.g. $AC = \sqrt{65}$ using $\sqrt{(2\sqrt{13})^2 + (\sqrt{13})^2}$ or solves $\frac{1}{2}(2\sqrt{13})(\sqrt{13})\sin ADC = 13$ or $(\sqrt{65})^2 = (2\sqrt{13})^2 + (\sqrt{13})^2 - 2(2\sqrt{13})(\sqrt{13})\cos ADC$ to show ADC is a right angle

9.

5(i)	**Either** Gradient $= -0.2$	**B1**	
	$\lg y = -0.2x + c$	**B1**	$\lg y = mx + c$ soi
	correct attempt to find c	**M1**	must have previous B1
	$\lg y = 0.42 - 0.2x$ or $\lg y = \frac{21}{50} - \frac{x}{5}$	**A1**	line in either form, allow equivalent fractions
	Or $0.3 = 0.6m + c$	**B1**	
	$0.2 = 1.1m + c$	**B1**	
	attempt to solve for both m and c	**M1**	must have at least one of the previous B marks
	Leading to $\lg y = 0.42 - 0.2x$ or $\lg y = \frac{21}{50} - \frac{x}{5}$	**A1**	line in either form, allow equivalent fractions
5(ii)	**Either** $y = 10^{(0.42 - 0.2x)}$	**M1**	dealing with the index, using their answer to **(i)**
	$y = 10^{0.42}\left(10^{-0.2x}\right)$ $y = 2.63\left(10^{-0.2x}\right)$	**A2**	**A1** for each
	Or $y = A\left(10^{bx}\right)$ leads to $\lg y = \lg A + bx$ Compare this form with their equation from (i)	**M1**	comparing their answer to **(i)** with $\lg y = \lg A + bx$ may be implied by one correct term from correct work
	$\lg A = 0.42$ so $A = 2.63$	**A1**	
	$b = -0.2$	**A1**	A1 for each

10.

6(i)	Gradient $= \frac{2.4-0.9}{0.2-0.8}$ $(=-2.5)$	**B1**	
	$\ln y = -\frac{5}{2}x^2 + c$	**M1**	straight line form and correct substitutions to find c
	$\ln y = -\frac{5}{2}x^2 + 2.9$ oe	**A1**	
	<u>Alternative method</u> $2.4 = p(0.2) + q$ $0.9 = p(0.8) + q$	**B1**	
	Correct method of solution to find p and q from two correct equations	**M1**	**M1dep**
	$\ln y = -\frac{5}{2}x^2 + 2.9$	**A1**	
6(ii)	$y = e^{\left(-\frac{5}{2}x^2+2.9\right)}$	**M1**	dealing with ln
	$y = e^{-\frac{5}{2}x^2} \times e^{2.9}$	**M1**	**M1dep** for dealing with the index
	$y = 18.2z^{-\frac{5}{2}}$	**A1**	

11.

12(i)	$2x^2 + 5x - 12 = 0$ or $y^2 + 3y - 28 = 0$	M1	attempt to get in terms of one variable
	$(2x-3)(x+4) = 0$ or $(y+7)(y-4) = 0$	M1	**M1dep** for solution of a three term quadratic
	leading to $x = -4,\ y = -7$ and $x = \frac{3}{2},\ y = 4$	A2	**A1** for each 'pair'
	Midpoint $M\left(\frac{\frac{3}{2}-4}{2}, \frac{4+(-7)}{2}\right)\left(=\left(-\frac{5}{4}, -\frac{3}{2}\right)\right)$	A1	correctly obtained midpoint
	Gradient of $PQ = 2$	B1	may be implied
	Perp gradient $= -\frac{1}{2}$	M1	$\frac{-1}{\textit{their}\text{ gradient of } PQ}$
	Perp bisector: $y + \frac{3}{2} = -\frac{1}{2}\left(x + \frac{5}{4}\right)$	M1	**M1dep** for equation of perp bisector using *their* perp gradient and *their* midpoint. (unsimplified)
	$y = -\frac{1}{2}(-10) - \frac{17}{8} = \frac{23}{8}$ or $\frac{23}{8} = -\frac{1}{2}x - \frac{17}{8} \rightarrow x = -10$	A1	all correct so far and for verification using a correct equation

12(ii)	Area $= \frac{1}{2}\times\left(\frac{17}{8}+1\right)\times\frac{5}{4}$	**M1**	finding R, S and RS
	correct method for finding area	**M1**	**M1dep**
	$= \frac{125}{64}$ or 1.95 or $1\frac{61}{64}$	**A1**	
	<u>Alternative method 1</u> Area $= \frac{1}{2}\times\frac{\sqrt{125}}{4}\times\frac{\sqrt{125}}{8}$	**M1**	finding R, S, RM and MS
	correct method for finding area	**M1**	**M1dep**
	$= \frac{125}{64}$ or 1.95 or $1\frac{61}{64}$	**A1**	
	<u>Alternative method 2</u> Area $= \frac{1}{2}\begin{vmatrix} 0 & 0 & \frac{-5}{4} & 0 \\ 1 & \frac{-17}{8} & \frac{-3}{2} & 1 \end{vmatrix}$	**M1**	finding R and S to obtain *their* $\frac{1}{2}\begin{vmatrix} 0 & 0 & \frac{-5}{4} & 0 \\ 1 & \frac{-17}{8} & \frac{-3}{2} & 1 \end{vmatrix}$
	$= \frac{1}{2}\left\vert -\frac{5}{4}-\frac{85}{32}\right\vert$ oe	**M1**	**M1dep** for correct method of evaluation
	$= \frac{125}{64}$ or 1.95 or $1\frac{61}{64}$	**A1**	

12.

2	Midpoint $\left(\frac{5}{2},-1\right)$	**B1**	
	Gradient of line $=-\frac{8}{3}$	**B1**	
	Gradient of perp $=\frac{3}{8}$	**M1**	
	Equation of perp bisector: $y+1=\frac{3}{8}\left(x-\frac{5}{2}\right)$	**M1**	**M1 dep** Using *their* perpendicular gradient and *their* midpoint
	$6x-16y-31=0$ or $-6x+16y+31=0$	**A1**	

13.

3	$e^y = ax^2 + b$	**B1**	may be implied, $b \neq 0$
	either $3 = 5a + b$ $1 = 3a + b$ or Gradient = 1, so $a = 1$	**M1**	correct attempt to find a or b by use of simultaneous equations or finding the gradient and equating it to a
	Coefficient of x^2 is 1	**A1**	
	Intercept is –2	**A1**	
	$y = \ln\left(x^2 - 2\right)$	**A1**	For correct form

14.

8(i)	Takes logs of both sides	**M1**	
	$\ln y = \ln a + n \ln x$ or $\lg y = \lg a + n \lg x$	**A1**	
8(ii)	$n =$ –0.2 to –0.3 nfww	**B1**	
	attempts to equate y-intercept to ln a or forms *their* ln equation with *their* gradient and a point on the line or uses two points on the line to form a pair of simultaneous equations	**M1**	
	$a = e^{4.7}$ isw or 110 or 109.9[47…]	**A1**	maximum of 2 marks if no coordinates stated
8(iii)	use of ln(50) and ln$x$ = 3 to 3.2	**M1**	or for $\dfrac{50}{theira} = x^{their\ n}$ or better or for $\ln 50 = \ln(theira) + (their\ n)\ln x$ oe
	awrt 22 or 23 to 2 significant figures	**A1**	implies **M1**

15.

8(i)	$\frac{12.1-5.5}{3.7-1.5}$ [= 3]	**B1**	correct expression for gradient
	$\frac{y^2-5.5}{e^{2x}-1.5}$ = *their* grad or correctly use $y^2 = (\textit{their } m)\, e^{2x} + c$ with one point to find c	**M1**	
	$y = [\pm]\sqrt{3e^{2x}+1}$	**A1**	
8(ii)	[±]34.8	**1**	
8(iii)	$50 = \sqrt{(\textit{their}3)e^{2x} + \textit{their}1}$ or $2500 = (\textit{their}3)e^{2x} + \textit{their}1$	**B1**	*
	$2x = \ln\left(\frac{2499}{3}\right)$	**M1**	**Dep*** obtain $2x$ explicitly
	3.36 cao	**A1**	

16.

10(i)	Method 1 $\lg y = A + Bx^2$	**B1**	statement soi
	$16 = A + 6B$ $4 = A + 2B$	**M1**	one correct equation
	leading to $A = -2$ and $B = 3$	**A2**	**A1** for each
10(i)	Method 2 $\lg y = A + Bx^2$	**B1**	statement soi
	Gradient $= B$ $B = 3$	**B1**	
	$16 = A + 6B$ or $4 = A + 2B$	**M1**	a correct equation
	$A = -2$	**A1**	
10(i)	Method 3 $\lg y - 4 = 3(x^2 - 2)$ or $\lg y - 16 = 3(x^2 - 6)$ OR $4 = 3(2) + c$ or $16 = 3(6) + c$	**M1**	correct equation or for correct method for finding constant.
	$\lg y = A + Bx^2$	**B1**	statement soi by *their* A and B
	Hence $y = 10^{3x^2 - 2}$ $B = 3$	**B1**	
	$A = -2$	**A1**	
10(ii)	$y = 10^{-2+3\left(\frac{1}{\sqrt{3}}\right)^2}$	**M1**	correct use of *their* A and B
	$y = 0.1$ oe	**A1**	
10(iii)	$2 = 10^{3x^2 - 2}$	**M1**	correct use of *their* A and B
	$\lg 2 = 3x^2 - 2$ $x = \sqrt{\dfrac{\lg 2 + 2}{3}}$	**M1**	complete correct method to solve for x
	$x = 0.876$	**A1**	

17.

8(i)	$e^y = \frac{m}{x} + c$	**B1**	May be implied by subsequent work
	Either $20 = 2m + c$ $8 = 4m + c$	**M1**	For at least 1 correct equation
		M1	**Dep** For attempt to solve *their* 2 equations simultaneously to obtain at least one unknown
	leading to $m = -6,\ c = 32$	**A1**	For both
	$y = \ln\left(32 - \frac{6}{x}\right)$	**A1**	Must have correct brackets Mark the final answer given
	Or: Gradient = $m = (-6)$	**M1**	For attempt to find gradient and equate it to m
	$20 = 2m + c$ or $8 = 4m + c$ or $e^y - 8 = m\left(\frac{1}{x} - 4\right)$ or $e^y - 20 = m\left(\frac{1}{x} - 2\right)$	**M1**	For at least 1 correct equation, may be using *their* m
	leading to $c = 32$ and $m = -6$	**A1**	For both $m = -6,\ c = 32$
	$y = \ln\left(32 - \frac{6}{x}\right)$	**A1**	
8(ii)	$x > \frac{3}{16}$ oe	**B1**	
8(iii)	$y = \ln 30$ isw	**B1**	
8(iv)	$2 = \ln\left(32 - \frac{6}{x}\right)$	**M1**	For a correct substitution and attempt to re-arrange using 2, *their* 32 and *their* – 6, keeping exactness to obtain $x =$
	$x = \frac{6}{32 - e^2}$ oe	**A1**	Must be exact

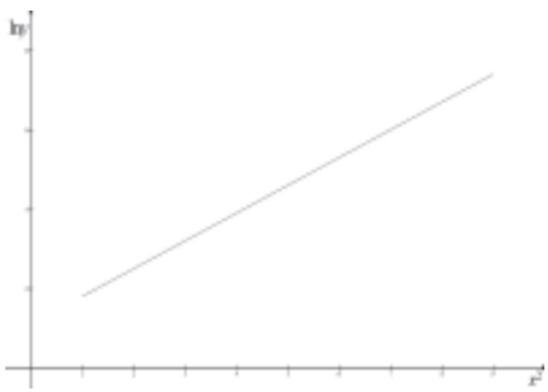
18.

10(i)	$\frac{4-3}{1-p}=\frac{1}{3}$ oe	**M1**	**ALT** uses $y=mx+c$ with A and B as far as an equation in p only
	-2	**A1**	
10(ii)	**Either:** Finds midpoint AB $\left(\frac{their\ p+1}{2}, \frac{3+4}{2}\right)$	**B1**	**FT** *their p*
	Verifies $(-0.5, 3.5)$ is on L	**B1**	
	$y=-3x+2$ therefore $m=-3$ oe **and** $\frac{1}{3}\times -3=-1$ oe	**B1**	
	Or: finds midpoint AB $\left(\frac{their\ p+1}{2}, \frac{3+4}{2}\right)$	**B1**	**FT** *their p*
	$\frac{1}{3}\times -3=-1$ oe	**B1**	
	$y-3.5=-3(x+0.5)$ **and** completion to $y=-3x+2$	**B1**	
10(iii)	$q=4$	**B1**	
10(iv)	22.5 nfww	**B2**	**B1** for correct method to find area using correct values e.g. $\frac{1}{2}\times AB\times MC$ where M is the midpoint of AB

19.

2	$\lg y^2 = mx + c$	**B1**	May be implied by subsequent work
	Gradient $= -4 \quad (= m)$	**B1**	
	$c = 32$	**B1**	
	$y = 10^{their\ \frac{c}{2} + their\ \frac{mx}{2}}$	**M1**	Dep on first B1 Use of $\lg y^2 = 2\lg y$ and $10^{their\ \frac{c}{2} + their\ \frac{mx}{2}}$ Or use of $y^2 = 10^{(their\ c + their\ mx)}$ and $10^{their\ \frac{c}{2} + their\ \frac{mx}{2}}$
	$y = 10^{16-2x}$	**A1**	

20.

6(i)	$\ln y = \ln A + x^2 \ln b$ or $\lg y = \lg A + x^2 \lg b$	**B1**	May be implied by a table of values for x^2 and $\ln y$ or $\lg y$ or axes labelled $\ln y$ or $\lg y$ and x^2
		**M1**	for attempt to plot either $\ln y$ or $\lg y$ against x^2 using an evenly spaced scale on each axis.
		A2	**A2** All points on a correct line (for $1 \leqslant x^2 \leqslant 9$) with axes correctly labelled **A1** One point not on the correct line or a correct line with axes not correctly labelled. **A0** Two or more points not on the correct line or one point not on the line and axes incorrect

6(ii)	Gradient = $\ln b$ or $\lg b$ $\ln b \approx 0.7$ or $\lg b \approx 0.3$ leading to	**M1**	for a complete method using the gradient of *their* straight-line graph of $\lg y$ or $\ln y$ against x^2 to obtain b
	$b = 2$ (allow $1.6 - 2.4$)	**A1**	from correct working
	Intercept = $\ln A$ or $\lg A$ $\ln A \approx 1.1$ $\lg A \approx 0.5$ leading to	**M1**	for a complete method using intercept of *their* straight-line graph of $\lg y$ or $\ln y$ against x^2 to find A
	$A = 3$ (allow $2.5 - 3.6$)	**A1**	from correct working
6(iii)	$100 = 3\left(2^{x^2}\right)$ or $\ln 100 = \textit{their}1.1 + \textit{their}0.7x^2$ or $\lg 100 = \textit{their}0.5 + \textit{their}0.3x^2$ or reading from $\lg y = 2$ to obtain x^2 or from $\ln y = 4.6$ to obtain x^2	**M1**	for a valid method to find x^2 Substitution methods should be using values of A and b in range
	leading to $x = 2.25$ (allow $2.0 - 2.7$)	**A1**	for an answer in range from correct working

21.

9(i)	Midpoint (1, 2)	**B1**	May be seen on diagram
	Gradient of $AB = -\frac{3}{4}$	**B1**	
	Gradient of PM $= \frac{-1}{\textit{their}\text{ gradient of }AB} = \frac{4}{3}$	**M1**	Use $m_1 \times m_2 = -1$
	Equation PM $\frac{y-2}{x-1} = \frac{4}{3}$	**M1**	**dep** Attempt to find equation of line with *their* midpoint and *their* gradient of *PM*. If $y = mx + c$ used c must be found.
	$y = \frac{4}{3}x + \frac{2}{3}$	**A1**	
9(ii)	$s = \frac{4}{3}r + \frac{2}{3}$	**B1**	**FT**

	Eliminate r or s	**M1**	From one linear and one quadratic expression. Unsimplified
	$25r^2 - 50r - 875 = 0$ oe or $25s^2 - 100s - 1500 = 0$ oe	**A1**	
	$(5r + 25)(5r - 35) = 0$ oe or $(5s - 50)(5s + 30) = 0$ oe	**M1**	Solve three term quadratic Can be implied by correct solution.
	$r = 7$, $s = 10$	**A1**	Do not award if negative values of r and s are also given nfww
	OR Equivalent method such as: $\overrightarrow{MP} = \begin{pmatrix} a \\ b \end{pmatrix} \rightarrow a^2 + b^2 = 100$ and $\frac{b}{a} = \frac{4}{3}$	**B1**	Using distance =10 and gradient = $\frac{4}{3}$.
	Eliminate a or b	**M1**	
	$a^2 + \left(\frac{4a}{3}\right)^2 = 100$ or $\left(\frac{3b}{4}\right)^2 + b^2 = 100$	**A1**	
	$\rightarrow a = (\pm)6$ and $b = (\pm)8$	**M1**	Solve
	$r = 7$, $s = 10$	**A1**	

22.

6(a)	$x(5x+6) = 8$ $5x^2 + 6x - 8 = 0$	**M1**	For attempt to equate and obtain a 3-term quadratic in either x or y
	$\left(\frac{4}{5}, 10\right)$	**A1**	Allow A1 if only x-coordinates or only y-coordinates are given
	$(-2, -4)$	**A1**	

6(b)	Midpoint $\left(-\frac{3}{5},\ 3\right)$	**B1**	
	Gradient 5	**B1**	
	$y-3=-\frac{1}{5}\left(x+\frac{3}{5}\right)$	**M1**	Attempt at perp bisector using *their* midpoint and perp gradient
	$x-3=-\frac{1}{5}\left(x+\frac{3}{5}\right)$	**M1**	For use of $y=x$ and attempt to solve
	$\left(\frac{12}{5},\ \frac{12}{5}\right)$	**A1**	

23.

1	Valid method to find m $m=\frac{34-9}{3-0.5}[=10]$ oe	**M1**	
	Valid method to find c, e.g. $34 = \textit{their}\ 10\times 3+c$	**M1**	
	$\sqrt[4]{y}=(\textit{their}10)\frac{1}{x}+\textit{their}4$	**M1**	
	$y=\left(\frac{10}{x}+4\right)^4$ oe, cao	**A1**	

24.

5(a)	Finds coordinates of mid-point (8, –2)	**B1**	
	$m_{AB}=\frac{3+7}{4-12}\left[=-\frac{5}{4}\right]$ oe soi	**B1**	
	$m_L=\frac{-1}{-5/4}$ oe	**M1**	
	$y+2=\frac{4}{5}(x-8)$ oe isw	**A1**	

5(b)	$y-12=-\frac{5}{4}(x-5)$	**B1**	
	Attempts to solve *their* equations	**M1**	
	(13, 2)	**A2**	**A1** for $x=13$ or $y=2$

25.

6(a)	$\lg y=\lg A+bx^2$	**B1**	Stated or may be implied by later work
	If using $\lg y=\lg A+bx^2$ as a starting point $5.25=\lg A+3.63b$ and $6.88=\lg A+4.83b$ or $5.25=\lg A+1.358(3.63)$ or $6.88=\lg A+1.358(4.83)$ OR If finding the equation of the straight line and then finding $\lg A$ and b by inspection $\lg y-6.88=1.358(x^2-4.83)$ or $\lg y-5.25=1.358(x^2-3.63)$ or $\lg y=1.358x^2+0.31..$(or $0.32..$)	**M1**	For correctly finding required equation(s)
	$b=1.36,\ \frac{163}{120}$ or $1\frac{43}{120}$	**B1**	Must be $b=$ and from correct working
	A in range 2.05 to 2.09	**A1**	
6(b)	$\lg y=0.3132+(4\times1.36)$ $y=2.09\times10^{4\times1.36}$	**M1**	For $\lg y=(\textit{their}\ \lg A)+4(\textit{their}\ b)$ or $y=(\textit{their}\ A)\left(10^{4(\textit{their}\ b)}\right)$
	Allow 553 000 to 576 000	**A1**	
6 (c)	$4=2.09\left(10^{1.36x^2}\right)$ or $\lg 4=0.3132+1.36x^2$	**M1**	$4=(\textit{their}\ A)\left(10^{\textit{their}\ bx^2}\right)$ or $\lg 4=(\textit{their}\ \lg A)+(\textit{their}\ b)x^2$
	awrt 0.46	**A1**	

26.

3(a)	Gradient of line $\frac{3-1}{4-12} = \left(-\frac{1}{4}\right)$	**B1**	
	Gradient of perpendicular = 4	**M1**	$\frac{-1}{\textit{their}\text{ grad line}}$
	Mid-point is (8, 2)	**B1**	
	Equation: $\frac{y-2}{x-8} = 4$	**M1**	Using *their* perpendicular gradient and mid-point
	$y = 4x - 30$	**A1**	
3(b)	$x = 0 \rightarrow (y) = -30$	**B1**	**FT** equation must have 3 terms
	$y = 0 \rightarrow (x) = 7.5$	**B1**	**FT** equation must have 3 terms
	$AB = \sqrt{30^2 + 7.5^2} = 30.9$ or better	**B1**	nfww Accept exact answer of $\frac{15\sqrt{17}}{2}$

27.

8(a)	$\lg y = b\lg x + \lg A$	**B1**	May be implied by subsequent work
	$4.37 = 5.36b + \lg A$ $0.57 = 0.61b + \lg A$	**M1**	For at least one correct equation
	$b = 0.8$	**A1**	
	$\lg A = k \quad (0.082)$ $A = 10^k$	**M1**	**Dep** for substitution to obtain $\lg A = k$ and hence A
	$A = 1.21$	**A1**	
	Alternative 1 $\lg y = b\lg x + \lg A$	**(B1)**	 May be implied by subsequent work
	Gradient $= \dfrac{4.37 - 0.57}{5.36 - 0.61}$	**(M1)**	
	$b = 0.8$	**(A1)**	
	$\lg A = k \quad (0.082)$ $A = 10^k$	**(M1)**	**Dep** for substitution into a correct equation to obtain $\lg A = k$ and hence A
	$A = 1.21$	**(A1)**	
	Alternative 2 $10^{4.37} = A \times 10^{5.36b}$ or $10^{0.57} = A \times 10^{0.61b}$	**(B1)**	
	$3.8 = 4.75b$	**(M1)**	For eliminating A correctly Must have B1.
	$b = 0.8$	**(A1)**	
	$A = 10^{4.37-(5.36\times(their b))}$ oe	**(M1)**	For a correct attempt to find A. Must have B1
	$A = 1.21$	**(A1)**	

8(b)	$y = 1.21(3)^{0.8}$ or $\lg y = 0.8\lg 3 + 0.082$	**B1**	**FT** for substitution into *their* equation
	$y =$ awrt 2.9	**B1**	
8(c)	$3 = 1.21x^{0.8}$ or $\lg 3 = 0.8\lg x + 0.082$	**B1**	**FT** for substitution into *their* equation
	$x =$ awrt 3.1	**B1**	

28.

2	$m = \dfrac{9-5}{8-6}$ oe	**M1**	
	$9 =$ *their* $2(8) + c$ oe or $5 =$ *their* $2(6) + c$	**M1**	
	$\ln y = 2\ln x - 7$	**A1**	
	Correct completion to answer: $y = e^{\ln x^2 - 7} = e^{-7}x^2$ nfww	**A1**	
	Alternative $\ln y = p + q\ln x$ soi	**(B1)**	
	$m = \dfrac{9-5}{8-6}$ oe	**(M1)**	
	$9 =$ *their* $2(8) + c$ oe or $5 =$ *their* $2(6) + c$	**(M1)**	
	$y = e^{-7}x^2$	**(A1)**	

29.

5	$27x = (x^2)^2$ or $y = \left(\frac{y^2}{27}\right)^2$ oe	**M1**	if **M0** then, for first 4 marks, **SC4** if (3, 9) only stated and verified in both equations, ignore (0, 0) or **SC2** for (3, 9) only stated with no working, ignore (0, 0) If first **M1** then (3, 9) with no additional working award **M1SC1**
	$x^4 - 27x = 0$ or $y^4 - 729y = 0$ oe nfww	**A1**	
	$x(x^3 - 27) = 0$ or $y(y^3 - 729) = 0$ oe	**M1**	
	$A(3, 9)$ oe only nfww	**A1**	
	Mid-point = $(1.5, 4.5)$	**B1**	
	$m_{OA} = \frac{9}{3}$ oe	**B1**	
	$m_{\perp} = -\frac{3}{9}$ oe	**M1**	
	$y - 4.5 = -\frac{3}{9}(x - 1.5)$ oe isw	**A1**	**FT** *their* mid-point and *their* $-\frac{1}{\frac{9}{3}}$

30.

6(a)	$\sqrt{(11-5)^2 + (6 - -4)^2}$ oe	**M1**	
	11.7 or 11.66[19...] rot to 4 or more figs	**A1**	
6(b)(i)	[y =] 1	**B1**	
6(b)(ii)	$m_{AC} = \frac{6 - -4}{11 - 5}$ or $\frac{10}{6}$ nfww oe	**B1**	
	$m_{BD} = \frac{-1}{their\frac{10}{6}}$ oe	**M1**	
	$y - their\ 1 = -\frac{3}{5}(x - 8)$ oe isw	**A1**	**FT** *their* 1 from (b)(i) and *their* perpendicular gradient
6(b)(iii)	$\begin{pmatrix} -5 \\ 3 \end{pmatrix}$ and $\begin{pmatrix} 5 \\ -3 \end{pmatrix}$	**B2**	**B1** for either If 0 scored, **SC1** for $-5\mathbf{i} + 3\mathbf{j}$ and $5\mathbf{i} - 3\mathbf{j}$

31.

3	gradient $= \dfrac{11--4}{2--1}$ oe or 5 soi	M1	or $-4=-m+c$ and $11=2m+c$ oe and subtracting/substituting to solve for m or c, condone one error
	$Y-11=their\ 5(X-2)$ oe or $Y--4=their\ 5(X--1)$ oe or $11=2\times their\ 5+c$ oe or $-4=-1\times their\ 5+c$ oe	M1	or using *their m* or *their c* to find *their c* or *their m*, without further error
	$\lg y=5\lg x+1$ oe or $\lg y=5(\lg x-2)+11$ oe or $\lg y=5(\lg x--1)-4$ oe	A1	
	$y=10^{5\times\lg x+1}$ oe or $\lg y=\lg x^5+\lg 10$ oe or $\lg\left(\dfrac{y}{x^5}\right)=1$ oe	A1	this first step in manipulating the equation, or the second step, must be seen; only one step may be implied
	$y=10^{\lg x^5}\times 10^{[1]}$ oe or $\lg y=\lg 10x^5$ oe or $\dfrac{y}{x^5}=10^{[1]}$ oe or $\lg\left(\dfrac{y}{x^5}\right)=\lg 10$	A1	this second step in manipulating the equation, or the first step, must be seen; only one step may be implied
	$y=10x^5$	A1	must be seen
3	Alternative $\lg y=\lg a+n\lg x$ soi	(B1)	
	Valid method to find n or $\lg a$ e.g. Solves for n or $\lg a$: $11=\lg a+2n$ and $-4=\lg a-n$	(M1)	May find gradient as above (do not need to identify it as n for this mark)
	$n=5$ or $\lg a=1$ so $a=10^1$ or 10	(A1)	
	Correct method using *their* $\lg a$ or *their* n to find *their* n or *their* $\lg a$	(M1)	**FT** May find intercept as above (do not need to identify it as $\lg a$ for this mark)
	$\lg a=1$ so $a=10^1$ or 10 or $n=5$	(A1)	
	$y=10x^5$	(A1)	must be seen

32.

8(a)	$2x^2+2x-2=x^2+6x-2$ $x^2-4x=0$ $x(x-4)=0$ $x=0,\ \ x=4$	M1	For obtaining an equation in one variable
		M1	**Dep** for a correct attempt to obtain at least one solution
	$(0,\ -1)$	A1	nfww
	$(4,\ 19)$	A1	nfww
	Mid-point $(2,9)$ with sufficient detail	B1	**AG**
8(b)	**Either** Gradient of perpendicular $=-\frac{1}{5}$	M1	
	$y-9=-\frac{1}{5}(x-2)$	M1	**Dep** on previous **M** mark for perpendicular bisector using *their* mid-point and *their* perpendicular gradient
	$7-9=-\frac{1}{5}(12-2)$ oe	A1	For checking by substitution, must see evidence.
	Or Alternative 1 Gradient of perpendicular $=-\frac{1}{5}$	(M1)	
	$y-7=-\frac{1}{5}(x-12)$	(M1)	**Dep** on previous **M** mark for perpendicular bisector using $(12,7)$ and *their* perpendicular gradient
	$9-7=-\frac{1}{5}(2-12)$ oe	(A1)	For checking by substitution, must see evidence
	Or Alternative 2 Gradient of perpendicular $=-\frac{1}{5}$	(M1)	
	Gradient of line joining *their* $(2,9)$ to $(12,7)$ $==-\frac{1}{5}$	(M1)	
	$(2,9)$ is a common point and gradients of perpendicular bisector and l are the same so C lies on l.	(A1)	

8(c)	$(22, 5)$	2	**B1** for 22 **B1** for 5
	$(-18, 13)$	2	**B1** for -18 **B1** for 13

33.

9(a)	$e^{2y} = mx^2 + c$	**B1**	May be implied by later work
	Either $7.96 = 4m + c$ $3.76 = 2m + c$	**M1**	
	$m = 2.1$ oe	**A1**	
	$c = -0.44$ oe	**A1**	
	$y = \frac{1}{2}\ln\left(2.1x^2 - 0.44\right)$ oe	**A1**	Do not isw
	Or gradient = 2.1 oe	**(B1)**	
	Use of either $7.96 = 4m + c$ or $3.76 = 2m + c$	**(M1)**	For use with *their* m
	$c = -0.44$ oe	**(A1)**	
	$y = \frac{1}{2}\ln\left(2.1x^2 - 0.44\right)$ oe	**(A1)**	Must be bracketed correctly
9(b)	$y = \frac{1}{2}\ln\left(\mathit{their}\,2.1x^2 - \mathit{their}\,0.44\right)$ oe	**M1**	Must use the form $y = k\ln\left(px^2 \pm q\right)$ $p \neq 1$ and $q \neq 0$ or $e^{2y} = mx^2 + c$
	0.253	**A1**	
9(c)	$\mathit{their}\,2.1x^2 - \mathit{their}\,0.44 > 0$ or $= 0$ or ≥ 0 soi	**B1**	
	Correct attempt to obtain the critical value using $\mathit{their}\,2.1x^2 - 0.44 = 0$	**M1**	Must be from the form $y = k\ln\left(px^2 - q\right)$, $p \neq 1$ and $q > 0$
	$x > 0.458$ or $x > \sqrt{\frac{22}{105}}$ oe	**A1**	

34.

3(a)	Gradient = 4 soi	**B1**	
	Intercept = -3 soi	**B1**	
	$\lg(2y+1)=4x^2-3$ oe	**M1**	For $\lg(2y+1)=$ *their* $m(x^2)+$ *their* c
	$y=\frac{1}{2}\left(10^{4x^2-3}-1\right)$ or $y=\dfrac{\frac{10^{4x^2}}{1000}-1}{2}$	**A1**	
3(b)	$y=0$	**B1**	Must have at least 3 marks from part **(a)**
3(c)	$2=\frac{1}{2}\left(10^{4x^2-3}-1\right)$ oe and attempt to obtain $x=\ldots$	**M1**	**Dep** on **M** mark in part **(a)** for use of $y=2$ in *their* $y=\frac{1}{2}\left(10^{4x^2-3}-1\right)$, $y=\dfrac{\frac{10^{4x^2}}{1000}-1}{2}$ or $\lg(2y+1)=4x^2-3$ and attempt to obtain $x=\ldots$
	$x=(\pm)\,0.962$ or better	**A1**	

35.

3	Valid method to find m $m=\dfrac{8-1}{9-16}\,[=-1]$	**M1**	
	Valid method to find c e.g. $1=\mathit{their}(-1)\times16+c$	**M1**	**FT** *their m*
	$\sqrt[3]{y}=\mathit{their}(-1)x^2+\mathit{their}17$	**A1**	Equation with correct variables and $\sqrt[3]{y}=$
	$y=(-x^2+17)^3$ oe, isw	**A1**	

36.

3	Uses $b^2 - 4ac$: $6^2 - 4(2k - 1)(k + 1)$	**M1**	
	$-8k^2 - 4k + 40 * 0$ oe	**M1**	**dep** on first **M1** where * is = or any inequality sign condone one sign or arithmetic slip in simplification
	Factorises or solves *their* 3-term quadratic expression or equation for CVs e.g. $(5 + 2k)(8 - 4k)$ oe	**M1**	
	Finds correct CVs: -2.5 oe, 2	**A1**	
	$-2.5 \leqslant k \leqslant 2$	**A1**	mark final answer

37.

13(a)	Midpoint (10, 9)	**B1**	
	Gradient of $l = -\frac{5}{3}$	**B1**	
	Equation of l: $y + 9 = -\frac{5}{3}(x - 10)$ oe	**M1**	Must be using *their* perpendicular gradient and *their* mid-point
	$y = -4$	**A1**	
13(b)	Attempt to use *their* R and displacement vectors or Pythagoras to find S	**M1**	May be implied by one correct coordinate If Pythagoras is used: **M1** for an attempt to reach to a 3-term quadratic with one variable using *their* equation and *their* midpoint from **(a)** e.g. $34x^2 - 680x + 646 = 0$
	(1, 6)	**A1**	
	(19, –24)	**A1**	

38.

11(b)	$m_{AB} = \dfrac{-6-6}{4-(-5)}$ oe or $-\dfrac{12}{9}$ or $-\dfrac{4}{3}$	**B1**	
	$m_{CD} = \dfrac{3}{4}$	**M1**	**FT** $\dfrac{-1}{their\ m_{AB}}$
	$y - 2 = \dfrac{3}{4}(x+2)$ oe or $y = \dfrac{3}{4}x + c$ and $2 = \left(\dfrac{3}{4}\right)(-2)+c$ oe soi	**M1**	**FT** *their* (–2, 2) and $\dfrac{-1}{their\ m_{AB}}$
	$y = \dfrac{3}{4}x + \dfrac{7}{2}$ or equivalent in form $y = mx + c$	**A1**	
11(c)	$(x-4)^2 + (y+6)^2 = 125$ oe, soi	**B1**	
	Uses *their* $y = \dfrac{3}{4}x + \dfrac{7}{2}$ to eliminate one unknown	**M1**	if correct implies **B1**
	Correct equation in one unknown $[BD^2 =](x-4)^2 + \left(\dfrac{3}{4}x + \dfrac{7}{2} + 6\right)^2 = 125$ oe	**A1**	
	Writes in solvable form: $25x^2 + 100x - 300 = 0$ oe	**A1**	
	Factorises or solves a correct 3-term quadratic	**A1**	
	(2, 5) and (–6, –1)	**A1**	If **B1, M0** award: **SC2** for identifying one correct point by inspection from the length equation and testing it in the correct equation of *CD* **and** **SC2** for identifying the second correct point by inspection from the length equation and testing it in the correct equation of *CD*

11(c)	**Alternative**		
	$[BC =]$ $\sqrt{(4-(their-2))^2+(-6-(their 2))^2}$	**(B1)**	**FT** *their C*
	$CD = \sqrt{125 \ - their 100}$	**(M1)**	**FT** *their* BC^2 providing 125 – *their* 100 > 0
	$CD = 5$	**(A1)**	
	$\begin{pmatrix}4\\3\end{pmatrix}+\begin{pmatrix}-2\\2\end{pmatrix}$ or $\begin{pmatrix}-4\\-3\end{pmatrix}+\begin{pmatrix}-2\\2\end{pmatrix}$ OR finds $25x^2 + 100x - 300 = 0$ oe	**(A2)**	**A1** for $\overrightarrow{CD_1}=\begin{pmatrix}4\\3\end{pmatrix}$ or $\overrightarrow{CD_2}=\begin{pmatrix}-4\\-3\end{pmatrix}$ soi OR **A1** for finds $(x+2)^2+\left(\frac{3}{4}x+\frac{7}{2}-2\right)^2=25$
	(2, 5) and (–6, –1)	**(A1)**	

39.

10 (a)	$2 = p - q$ and $14 = 4p - 2q$ oe $p = 5$ $q = 3$	**M1** **A1** **A1**	
(b)	Factorise $10^{2x} \quad 2(10^x) \quad 24\,[-0]$ or factorise $u^2 - 2u - 24\,[=0]$	**M1**	or applies the formula or completes the square
	$10^x = 6$ $x = \lg 6$ cao as final answer	**A1** **A1**	ignore $10^x = -4$ for this mark or exact equivalent