1	$(15 \text{ or } {}^{16}C_2)\times 2^4 \times (ax)^2$, $(20 \text{ or } {}^{6}C_3)\times 2^3 \times (ax)^3$ $a = \dfrac{15\times 2^4}{20\times 2^3} = \dfrac{3}{2}$	**B1B1** **M1A1** **[4]**	 $240a = 160a$ is M0
2	**(i)** CB or $AB = \dfrac{3}{\tan\frac{\pi}{6}}$ or $3\tan\dfrac{\pi}{3}$ Arc or $AC = 3\times\left[\dfrac{2\pi}{3} \text{ or } \dfrac{\pi}{3}\right]$ $\quad (=2\pi \text{ or } \pi)$ Perimeter $= 6\sqrt{3} + 2\pi$ oe **(ii)** Area $OABC$ $(2)\times\dfrac{1}{2}\times 3\times$ *their AB* $(=9\sqrt{3} \text{ or } \dfrac{9\sqrt{3}}{2})$ Area $OADC$ $\dfrac{1}{2}\times 3^2\times\left(\dfrac{2\pi}{2} \text{ or } \dfrac{\pi}{3}\right)$ $\quad \left(=3\pi \text{ or } \dfrac{3\pi}{2}\right)$ Shaded area $9\sqrt{3} - 3\pi$ oe	**B1** **B1** **B1** **[3]** **B1**√ **B1** **B1** **[3]**	Allow throughout for e.g. $3\sqrt{3}$, $\sqrt{27}, \sqrt{3^3}, \left(\sqrt{3}\right)^3$, $\dfrac{9}{\sqrt{3}}$ After B0B0 SCB1 for 16.7 *Their AB* in form $k\sqrt{3}$ After B0B0 SCB1 for 6.16 or 6.17. Allow $\left(\sqrt{3}\right)^5 - 3\pi$
3	**(i)** $(3x-2)^2 + 1$ **(ii)** $f'(x) = 9x^2 - 12x + 5$ $=$ their $(3x-2)^2 + 1$ > 0 (or $\geqslant 1$) hence an increasing function	**B1B1B1** **[3]** **B1** **M1** **A1** **[3]**	For either of 1st 2 marks bracket must be in the form $(ax+b)^2$ except for SCB2 for $9\left(x-\dfrac{2}{3}\right)^2 + 1$ Ft from (i). Some reference/recognition Allow > 1. Allow *their* 1 provided positive. Allow a complete alt method (2/2 or 0/2)
4	**(i)** $S_P = \dfrac{2}{1-\frac{1}{2}}, S_P = \dfrac{3}{1-\frac{1}{3}}$ $S_P = 4, S_Q = \dfrac{9}{2}$ $S_R = 5$ cao **(ii)** $\dfrac{4}{1-r} =$ *their* S_R $r = \dfrac{1}{5}$	**M1** **A1** **A1** **[3]** **M1** **A1**	At least one correct At least one correct

	$R = 4 + \frac{4}{5} + \frac{4}{25} = 4\frac{24}{25}$ or 4.96 cao	**A1** **[3]**	
5 **(i)**	$(s^2 - c^2)(s^2 + c^2)$ OR $s^2(1-c^2) - c^2(1-s^2)$ $\sin^2\theta - \cos^2\theta$ $2\sin^2\theta - 1$ www **AG**	**M1** **A1** **A1** **[3]**	**OR** $\sin^4\theta - (1 - \sin^2\theta)^2$ $\sin^4\theta - (1 - 2\sin^2\theta + \sin^4\theta)$ $= 2\sin^2\theta - 1$ **AG**
(ii)	$2\sin^2\theta - 1 = \frac{1}{2} \Rightarrow \sin\theta = (\pm)\frac{\sqrt{3}}{2}$ or $(\pm)0.866$	**B1**	**OR** $\cos 2\theta = -\frac{1}{2} \rightarrow 2\theta = 120, 240$ etc.
	$\theta = 60°$ $\theta = 120°$	**B1** **B1√**	Ft for 180 – *their* 60 Ft for 180 + *their* 60, 360 – *their* 60
	$\theta = 240°, 300°$	**B1√** **[4]**	Allow $\frac{\pi}{3}$, $\frac{2\pi}{3}$ etc. Extra sols in range −1
6 **(i)**	$m = \frac{3a + 9 - (2a - 1)}{2a + 4 - a} = \frac{a + 10}{a + 4}$ oe e.g. $\frac{-a - 10}{-a - 4}$ Gradient of perpendicular $= \frac{-(a+4)}{a+10}$ oe but not $\frac{-1}{\left(\frac{a+10}{a+4}\right)}$	**M1A1** **A1√** **[3]**	cao Allow omission of brackets for M1 Do not ISW. Max penalty for erroneous cancellation 1 mark
(ii)	$(\surd)[(a+4)^2 + (a+10)^2] = (\surd)260$ $(\surd)[(a+4)^2 + (a+10)^2]$ cao $(2)(a^2 + 14a - 72)\ (= 0)$ $a = 4$ or -18 cao	**M1** **A1** **A1** **A1** **[4]**	Allow *their* $(a + 4)$, $(a + 10)$ from (i). Allow $(-a - 4)^2$ etc. Allow omission of brackets

7	**(i)** $\boldsymbol{OA}.\boldsymbol{OB} = -7+3-3p+p^2$ $(p+1)(p-4)=0$ $p=-1$ or 4	**M1** **DM1** **A1** **[3]**	Correct method for scalar product Equate to zero & attempt to factorise/solve '= 0' implied by answers
	(ii) $49+(1-p^2)+p^2=2(1+9+p^2)$ $p=15$	**M1** **A1** **[2]**	Scalar result required
	(iii) $\boldsymbol{AB} = -8\mathbf{i}+6\mathbf{j}$ Divide $\boldsymbol{AB}$ by $\lvert\boldsymbol{AB}\rvert = \sqrt{(-8)^2+6^2}=10$ soi Unit vector $=\frac{1}{10}(-8\mathbf{i}+6\mathbf{j})$ oe cao	**B1** **M1** **A1** **[3]**	p = 15 used – treat as MR $\rightarrow \frac{1}{\sqrt{353}}\begin{pmatrix}-8\\-17\\0\end{pmatrix}$
8	**(i)** Minimum since f″(3) (= 4/3) > 0 www	**B1** **[1]**	
	(ii) $f'(x)=-18x^{-2}(+c)$ $0=-2+c$ $c=2 \left(\rightarrow f'(x)=-18x^{-2}+2\right)$ $f(x)=18x^{-1}+2x(+k)$ $7=6+6+k$ $k=-5 \rightarrow \left(f(x)=18x^{-1}+2x-5\right)$ cao	**B1** **M1** **A1** **B1√B1√** **M1** **A1** **[7]**	Sub f′(3) = 0. (dep c present) c = 2 sufficient at this stage Allow cx at this stage Sub f(3) = 3 (k present & numeric (or no) c)
9	**(i)** $x-3\sqrt{x}+2$ or k^2-3k+2 or $\left(3\sqrt{x}\right)^2=(x+2)^2$ $\sqrt{x}=1$ or 2 or $k=1$ or 2 or $x^2-5x+4(=0)$ $x=1$ or 4 $y=3$ or 6	**M1** **A1** **A1** **A1** **[4]**	**OR** attempt to eliminate x eg sub $x=\frac{y^2}{9}$ $y^2-9y+18=0$ $y=3$ or 6 $x=1$ or 4

(ii) $\int 3x\frac{1}{2}\,dx - \left[\int(x+2)\,dx \text{ or attempt at trapezium}\right]$ $2x\frac{3}{2} - \left[\left(\frac{1}{2}x^2+2x\right) \text{or} \frac{1}{2}(y_2+y_1)(x_2-x_1)\right]$ $(16-2) - \left[\left[(8+8)-\left(\frac{1}{2}+2\right)\right] \text{or } \textit{their } \frac{1}{2}\times 9\times 3\right]$ $\frac{1}{2}$ OR $\left[\int(y-2)\,dy \text{ or attempt at trap}\right] - \int\frac{y^2}{9}dy$ $\left[\frac{1}{2}y^2-2y \text{ or } \frac{1}{2}(x_1+x_2)(y_2-y_1)\right] - \frac{y^3}{27}$ $\left[(18-12)-\left(4\frac{1}{2}-6\right) \text{or} \frac{1}{2}\times 5\times 3\right] - [8-1]$ $\frac{1}{2}$	**M1DM1** **A1A1** **DM1** **A1** **[6]** **M1DM1** **A1A1** **DM1** **A1**	Attempt to integrate. Subtract at some stage Where $(x_1, y_1), (x_2, y_2)$ is *their* (1, 3), (4, 6) Apply *their* 1→4 limits correctly to curve For A mark allow reverse subtn→ $-\frac{1}{2} \rightarrow \frac{1}{2}$ but not reversed limits Apply *their* 3→6 limits correctly to curve
10 (a) (i) $(a+b)^{\frac{1}{3}}=2,\ (9a+b)^{\frac{2}{3}}=16$ $a+b=8,\ 9a+b=64$ $a=7,\ b=1$	**B1B1** **M1** **A1** **[4]**	Ignore 2nd soln (–9, 17) throughout Cube etc. & attempt to solve Correct answers without any working 0/4
(ii) $x=(7y+1)^{\frac{1}{3}}$ (x/y interchange as first or last step) $x^3=7y+1$ or $y^3=7x+1$ $f^{-1}(x)=\frac{1}{7}(x^3-1)$ cao Domain of f^{-1} is $x\geqslant 1$ cao	**B1√** **B1√** **B1** **B1** **[4]**	ft on from *their a, b* or in terms of *a, b* ft on from *their a*, *b* or in terms of *a*, *b* A function of *x* required Accept >. Must be *x*
(b) $\frac{dy}{dx}=\left[\frac{1}{3}(7x^2+1)^{-\frac{2}{3}}\right]\times[14x]$ When $x=3$, $\frac{dy}{dx}=\frac{1}{3}\times(64)^{-\frac{2}{3}}\times 42 \quad \left(=\frac{7}{8}\right)$ $\frac{dy}{dt}=\frac{dy}{dx}\times\frac{dx}{dt}=\frac{7}{8}\times 8$ 7	**B1B1** **M1** **DM1** **A1** **[5]**	Use chain rule