1	$f : x \mapsto 3x + 2,\ g : x \mapsto 4x - 12$ $f^{-1}(x) = \dfrac{x-2}{3}$ $gf(x) = 4(3x + 2) - 12$ Equate $\rightarrow x = \dfrac{2}{7}$	**B1** **B1** **M1** **A1** [4]	 Equates, collects terms, +soln
2	$(x + 2k)^7$ Term in $x^5 = 21 \times 4k^2 = 84k^2$ Term in $x^4 = 35 \times 8k^3 = 280k^3$ Equate and solve $\rightarrow k = 0.3$ or $\dfrac{3}{10}$	 **B1** **B1** **M1 A1** [4]	 Correct method to obtain *k*.
3 (i)	$\tan 60 = \dfrac{x}{h} \rightarrow x = h\tan 60$ $A = h \times x$ $V = 40\sqrt{(3h^2)}$	**B1** **M1** **A1** [3]	Any correct unsimplified length Correct method for area ag
(ii)	$\dfrac{dV}{dh} = 80\sqrt{(3h)}$ If $h = 5$, $\dfrac{dh}{dt} = \dfrac{1}{2\sqrt{(3)}}$ or 0.289	**B1** **M1A1** [3]	 B1 M1 (must be ÷, not ×).
4 (i)	$\left(\dfrac{1}{\sin x} - \dfrac{1}{\tan x}\right)^2 = \left(\dfrac{1}{s} - \dfrac{c}{s}\right)^2$ $\dfrac{(1-c)^2}{s^2} = \dfrac{(1-c)^2}{1-c^2}$ $= \dfrac{(1-c)(1-c)}{(1-c)(1+c)}$ or $\dfrac{(1-c)^2}{(1-c)(1+c)}$ $\equiv \dfrac{1-\cos x}{1+\cos x}$	**M1** **M1** **A1** **A1** [4]	Use of tan = sin/cos Use of $s^2 = 1 - c^2$ ag
(ii)	$\left(\dfrac{1}{\sin x} - \dfrac{1}{\tan x}\right)^2 = \dfrac{2}{5}$ $\dfrac{1-\cos x}{1+\cos x} = \dfrac{2}{5} \rightarrow \cos x \dfrac{3}{7}$ $\rightarrow x = 1.13$ or 5.16	 **M1** **A1 A1**√ [3]	 Making cos*x* the subject $2\pi - 1^{st}$ answer.

5	**(i)**	Length of $OB = \dfrac{6}{\cos 0.6} = 7.270$	**M1** [1]	ag Any valid method
	(ii)	$AB = 6\tan 0.6$ or 4.1 Arc length = 7.27 × (½π – 0.6) = (7.06) Perimeter = 6 + 7.27 + 7.06 + 6tan0.6 = 24.4	**B1** **M1** **A1** [3]	Sight of in **(ii)** Use of $s = r\theta$ with sector angle
	(iii)	Area of AOB = ½ × 6 × 7.27 × sin0.6 Area of OBC = ½ × 7.27² × (½π – 0.6) → area = 12.31 + 25.65 = 38.0	**M1** **M1** **A1** [3]	Use of any correct area method Use of $\frac{1}{2}r^2\theta$.
6		$A(-3, 7)$, $B(5, 1)$ and $C(-1, k)$		
	(i)	$AB = 10$ $6^2 + (k-1)^2 = 10^2$ $k = -7$ and 9	**B1** **M1** **A1** [3]	Use of Pythagoras
	(ii)	m of $AB = -\frac{3}{4}$ m perp $= \dfrac{4}{3}$ $M = (1, 4)$ Eqn $y - 4 = \dfrac{4}{3}(x-1)$ Set y to 0, → $x = -2$	**B1 M1** **B1** **M1 A1** [5]	B1 M1 Use of $m_1 m_2 = -1$ Complete method leading to D.
7		$\overrightarrow{OA} = \begin{pmatrix} 0 \\ 2 \\ -3 \end{pmatrix}$, $\overrightarrow{OB} = \begin{pmatrix} 2 \\ 5 \\ -2 \end{pmatrix}$, $\overrightarrow{OC} = \begin{pmatrix} 3 \\ p \\ q \end{pmatrix}$.		
	(i)	$\overrightarrow{AB} = \begin{pmatrix} 2 \\ 3 \\ 1 \end{pmatrix}$ $\overrightarrow{AC} \begin{pmatrix} 3 \\ p-2 \\ q+3 \end{pmatrix}$ $\overrightarrow{BC} \begin{pmatrix} 1 \\ p-5 \\ q+2 \end{pmatrix}$ → $p = 6\frac{1}{2}$ and $q = -1\frac{1}{2}$	**B1B1** **B1 B1** [4]	Any 2 of 3 relevant vectors
	(ii)	$6 + 3p - 6 + q + 3 = 0$ → $q = -3p - 3$	**M1** **A1** [2]	Use of $x_1x_2 + y_1y_2 + z_1z_2 = 0$
	(iii)	$AB^2 = 4 + 9 + 1$ $AC^2 = 9 + 1 + (q+3)^2$ → $(q+3)^2 = 4$ → $q = -1$ or -5	**M1** **A1 A1** [3]	For attempt at either

8	$f: x \to x^2 + ax + b$,		
(i)	$x^2 + 6x - 8 = (x+3)^2 - 17$ or $2x + 6 = 0 \to x = -3 \to y = -17$ $\to$ Range $f(x) \geqslant -17$	**B1 B1** **B1**√ [3]	B1 for $(x + 3)^2$. B1 for -17 or B1 for $x = -3$, B1 $y = -17$ Following through visible method.
(ii)	$(x - k)(x + 2k) = 0$ $\equiv x^2 + 5x + b = 0$ $\to k = 5$ $\to b = -2k^2 = -50$	**M1** **A1** **A1** [3]	Realises the link between roots and the equation comparing coefficients of x
(iii)	$(x+a)^2 + a(x+a) + b = a$ Uses $b^2 - 4ac \to 9a^2 - 4(2a^2 + b - a)$ $\to a^2 < 4(b - a)$	**M1** **DM1** **A1** [3]	Replaces "x" by "$x + a$" in 2 terms Any use of discriminant
9	$f''(x) = \dfrac{12}{x^3}$		
(i)	$f'(x) = -\dfrac{6}{x^2}$ $(+c)$ $= 0$ when $x = 2 \to c = \dfrac{3}{2}$ $f(x) = \dfrac{6}{x} + \dfrac{3x}{2}$ $(+A)$ $= 10$ when $x = 2 \to A = 4$	**B1** **M1 A1** **B1**√**B1**√ **A1** [6]	Correct integration Uses $x = 2$, $f'(x = 0)$ For each integral
(ii)	$-\dfrac{6}{x^2} + \dfrac{3}{2} = 0 \to x = \pm 2$ Other point is $(-2, -2)$	**M1** **A1** [2]	Sets their 2 term $f'(x)$ to 0.
(iii)	At $x = 2$, $f''(x) = 1.5$ Min At $x = -2$, $f''(x) = -1.5$ Max	**B1** **B1** [2]	

10		$y=\sqrt{(9-2x^2)}$ $P\,(2, 1)$		
	(i)	$\frac{dy}{dx}=\frac{1}{2\sqrt{(9-2x^2)}}\times -4x$	B1 B1	Without " $\times -4x$" Allow even if B0 above.
		At P, $x=2$, $m=-4$ Normal grad = ¼	M1	For $m_1m_2=-1$ calculus needed
		Eqn AP $y-1=\frac{1}{4}(x-2)$	M1	Normal, not tangent
		$\rightarrow A\,(-2, 0)$ or $B\,(0, \frac{1}{2})$	A1	
		Midpoint AP also $(0, \frac{1}{2})$	A1 [6]	Full justification.
	(ii)	$\int x^2 dy=\int\left(\frac{9}{2}-\frac{y^2}{2}\right)dy$	M1	Attempt to integrate x^2
		$=\frac{9y}{2}-\frac{y^3}{6}$	A1	Correct integration
		Upper limit = 3	B1	Evaluates upper limit
		Uses limits 1 to 3	DM1	Uses both limits correctly
		$\rightarrow$ volume = $4\frac{2}{3}\pi$	A1 [5]	