1	${}^7C_2\,x^5\left(\frac{2}{x^2}\right)^2$ SOI and leading to final answer	B2	B1 for 2/3 parts correct leading to ans.
	84 or $84x$ as final answer	B1 [3]	If no answer; $84x$ seen scores B2, else ${}^7C_2\,x^5\left(\frac{2}{x^2}\right)^2$ scores SCB1 only
2	$\left(\frac{dv}{dr}=\right)4\pi r^2$	M1	
	$=4\pi\times10^2$	A1	SOI at any point
	$\frac{dr}{dt}=\frac{dv}{dt}\Big/\frac{dv}{dr}$ **OE** used	M1	Correct link between differentials with $\frac{dr}{dt}$ finally as subject
	$\frac{50}{4\pi\times10^2}=\frac{1}{8\pi}$ or 0.0398	A1 [4]	Allow $\frac{50}{400\pi}$. Non-calculus methods $\frac{0}{4}$
3	**(i)** Correct shape – touching positive x-axis	B1 [1]	Ignore intersections with axes
	(ii) $(\pi)\int(x-2)^4\mathrm{d}x$	M1	Use $(\pi)\int y^2\mathrm{d}x$ & attempt integrate but expansion before integn needs 5 terms
	$(\pi)\left[\frac{(x-2)^5}{5}\right]$	A1	
	$(\pi)[0-(-32)/5)]$	M1	Use of limits 0, 2 on *their* $(\pi)\int y^2\mathrm{d}x$
	$\frac{32\pi}{5}$ or 6.4π	A1 [4]	cao Rotation about y-axis max 1/5
4	**(i)** $\overrightarrow{CP}=-6\mathbf{i}+6\mathbf{j}-2\mathbf{k}$	B1	
	$\overrightarrow{CQ}=-6\mathbf{i}+6\mathbf{j}+3\mathbf{k}$	B1 [2]	
	(ii) Scalar product = 36 + 36 − 6	M1	Use of $x_1x_2+y_1y_2+z_1z_2$
	$66=\lvert\overrightarrow{CP}\rvert\lvert\overrightarrow{CQ}\rvert\cos\theta$	M1	Linking everything correctly
	$\lvert\overrightarrow{CP}\rvert=\sqrt{76}$, $\lvert\overrightarrow{CQ}\rvert=\sqrt{81}$	M1	Correct magnitude for either
	Angle PCQ = 32.7° (or 0.571 rad)	A1 [4]	cao 147.3° converted to 32.7° gets A0

5 **(i)** $\dfrac{2\sin^2\theta\sin^2\theta}{1-\sin^2\theta} = 1$	M1	Equation as function of sin θ
$2\sin^4\theta + \sin^2\theta - 1 = 0$ **AG**	A1 [2]	
(ii) $(2\sin^2\theta - 1)(\sin^2\theta + 1) = 0$	M1	Or use formula on quadratic in $\sin^2\theta$
$\sin\theta = \dfrac{(\pm)1}{\sqrt{2}}$	A1	
θ = 45°, 135°	A1	
θ = 225°, 315°	A1 [4]	Provided no excess solutions in range
6 **(i)** $z = 3x + 2\left(\dfrac{600}{x}\right)$ or $x\dfrac{(z-3x)}{2} = 600$ OE $\rightarrow$ **AG**	B1 [1]	
(ii) $\dfrac{dz}{dx} = 3 - \dfrac{1200}{x^2}$ or $\dfrac{dz}{dy} = 2 - \dfrac{1800}{y^2}$	B1	
$= 0 \rightarrow x = 20$ or $= 0 \rightarrow y = 30$	M1A1	Set to 0 & attempt to solve. Allow ±20
$z = 60 + \dfrac{120}{20} = 120$	A1√	Ft from *their* x provided positive Or other valid method
$\dfrac{d^2z}{dx^2} = \dfrac{2400}{x^3}$	B1√	Dep. on $\dfrac{d^2z}{dx^2} = \dfrac{k}{x^3}$ $(k > 0)$ or other valid method.
$> 0 \Rightarrow$ minimum	B1 [6]	
7 **(i)** $\dfrac{3(1+2x)^{-1}}{-1} + (c)$	B1	
$y = \dfrac{3(1+2x)^{-1}}{-2} + (c)$	B1(indep)	Division by 2 $y =$ necessary
Sub (1, (1/2))	M1	Dependent on c present
$\dfrac{1}{2} = \dfrac{3}{-6} + c \Rightarrow c = 1$	A1 [4]	Use of $y = mx + c$ etc. gets 0/4
(ii) $(1 + 2x)^2(>)9$ or $4x^2 + 4x - 8(>)0$ **OE**	M1	
1, −2	A1	
$x > 1, x < -2$ ISW	A1 [3]	
8 **(i)** 1000, 2000, 3000... or 50, 100, 150...	M1	Recognise series, correct a/d (or 3 terms)
$\dfrac{40}{2(1000+40000)}$ or $\dfrac{40}{2(2000+39000)}$	M1	Correct use of formula
× 5% of attempt at valid sum	M1	Can be awarded in either **(i)** or **(ii)**
41000	A1 [4]	cao
(ii) 1000, 1000 × 1.1, 1000 × 1.1^2 + ... or with a = 50	M1	Recognise series, correct a/r (or 3 terms)
$\dfrac{1000(1.1^{40}-1)}{1.1-1}$	M1	Correct use of formula. Allow e.g. r = 0.1
22100	A1 [3]	Or answers rounding to this

9 **(i)**	$AS = r\tan\theta$	M1	Or $(AB) = 2r\tan\theta$ or $(AO) = \dfrac{r}{\cos\theta}$
	Area $OAB = r^2\tan\theta$ or $(OAS) = \frac{1}{2}r^2\tan\theta$	A1	Or $OAB = \dfrac{1}{2}\dfrac{r^2}{\cos 2\theta}\sin 2\theta$
	Area of sector $= \frac{1}{2}r^2 \times 2\theta\ (= r^2\theta)$	B1	Or area sector $(OPS) = \frac{1}{2}r^2\theta$
	Shaded area $= r^2(\tan\theta - \theta)$ **OE**	A1 [4]	Allow e.g. $r^2\tan\theta - \frac{1}{2}r^2 2\theta$
(ii)	$\cos\dfrac{\pi}{3} = \dfrac{6}{OA} \Rightarrow OA = 12$	M1	
	$AP = 6$	A1	
	$AS = 6\tan\dfrac{\pi}{3} (\Rightarrow AB = 12\sqrt{3})$	B1	
	Arc $(PST) = 12\dfrac{\pi}{3}$	B1	Or arc $(PS) = 6\dfrac{\pi}{3}$ or arc $(ST) = 6\dfrac{\pi}{3}$
	Perimeter $= 12 + 12\sqrt{3} + 4\pi$	A1 [5]	Allow unsimplified 4π
10 **(i)**	$2(x-1)^2 - 1$ *OR* $a = 2, b = -1, c = -1$	B1, B1, B1	
	$A = (1, -1)$	B1√ [4]	Allow alt. method for final mark
(ii)	$2x^2 - 5x - 3 = 0 \Rightarrow (2x+1)(x-3) = 0$ **OE** in y	M1, M1	Complete elim & simplify, attempt soln.
	$x = -\frac{1}{2},\ y = 3\frac{1}{2}$	A1 [3]	Additional (3, 7) not penalised
(iii)	Mid-point of $AP = (2, 3)$	B1√	Follow through on *their A*
	Gradient of line $= \dfrac{1}{2} \Big/ \dfrac{-5}{2} = \dfrac{-1}{5}$	B1	
	Equation is $y - 3 = \dfrac{-1}{5}(x-2)$ **OE**	B1 [3]	Or $y - 3\frac{1}{2} = -\dfrac{1}{5(x+\frac{1}{2})}$
11 **(i)**	$fg(x) = 2x^2 - 3$, $gf(x) = 4x^2 + 4x - 1$	B1, B1 [2]	fg & gf clearly transposed gets B0B0
(ii)	$2a^2 - 3 = 4a^2 + 4a - 1 \Rightarrow 2a^2 + 4a + 2 = 0$	M1	Dep. quadratic. Allow x for all 3 marks
	$(a+1)^2 = 0$	M1	Allow marks in **(ii)** if transposed in **(i)**
	$a = -1$	A1 [3]	
(iii)	$b^2 - b - 2 = 0 \to (b+1)(b-2) = 0$	M1	Allow in terms of x for M1 only
	$b = 2$ Allow $b = -1$ in addition	A1 [2]	Correct answer without working B2
(iv)	$f^{-1}(x) = \dfrac{1}{2}(x-1)$	B1	
	$f^{-1}g(x) = \dfrac{1}{2}(x^2 - 3)$	B1√ [2]	Must be simplified. Ft from *their* f^{-1}
(v)	$x = (\pm)\sqrt{y+2}$	M1	
	$h^{-1}(x) = -\sqrt{x+2}$	A1 [2]	