1	**(i)**	$80(x^4)$, $-32(x^5)$	**B1B1** **[2]**	Fully simplified
	(ii)	$(-32+80p)(x^5)=0$ $p=2/5$ or 32/80 oe	**M1** **A1** **[2]**	Attempt to mult. relevant terms & put $=0$
2		$y=\frac{3x^3}{3}-\frac{2x^{-2}}{-2}$ $(+c)$ $3=-1+1+c$ $y=x^3+x^{-2}+3$	**B1B1** **M1** **A1** **[4]**	Sub $x=-1, y=3$. c must be present Accept $c=3$ www
3		$a+11d=17$ $\frac{31}{2}(2a+30d)=1023$ Solve simultaneous equations $d=4,\ a=-27$ 31st term = 93	**B1** **B1** **M1** **A1** **A1** **[5]**	At least one correct
4	**(a)**	$3x=-\sqrt{3}/2$ $x=\frac{-\sqrt{3}}{6}$ oe	**M1** **A1** **[2]**	Accept −0.866 at this stage Or $\frac{-3}{6\sqrt{3}}$ or $\frac{-1}{2\sqrt{3}}$
	(b)	$(2\cos\theta-1)(\sin\theta-1)=0$ $\cos\theta=1/2$ or $\sin\theta=1$ $\theta=\pi/3$ *or* $\pi/2$	**M1** **A1** **A1A1** **[4]**	Reasonable attempt to factorise and solve Award B1B1 www Allow 1.05, 1.57. SCA1for both 60°, 90°
5	**(i)**	Mid-point of AB = (7, 3) soi Grad. of $AB=-2\rightarrow$grad of perp. bisector = 1/2 soi Eqn of perp. bisector is $y-3=\frac{1}{2}(x-7)$	**B1** **M1** **A1** **[3]**	Use of $m_1m_2=-1$
	(ii)	Eqn of CX is $y-2=-2(x-1)$ $\frac{1}{2}x-\frac{1}{2}=-2x+4$ $x=9/5,\ y=2/5$ $BX^2=7.2^2+1.4^2$ soi $BX=7.33$	**M1** **DM1** **A1** **M1** **A1** **[5]**	Using their original gradient and (1,2) Solve simultaneously dependent on both previous M's

6 (i)	$A = 2\pi r^2 + 2\pi rh$ $\pi r^2 h = 1000 \rightarrow h = \dfrac{1000}{\pi r^2}$ Sub for h into $A \rightarrow A = 2\pi r^2 + \dfrac{2000}{r}$ **AG**	**B1** **M1** **A1** **[3]**	
(ii)	$\dfrac{\mathrm{d}A}{\mathrm{d}r} = 0 \Rightarrow 4\pi r - \dfrac{2000}{r^2} = 0$ $r = = 5.4$ $\dfrac{\mathrm{d}^2 A}{\mathrm{d}r^2} = 4\pi + \dfrac{4000}{r^3}$ > 0 hence MIN hence MOST EFFICIENT **AG**	**M1A1** **DM1 A1** **B1** **[5]**	Attempt differentiation & set = 0 Reasonable attempt to solve to $r^3 =$ Or convincing alternative method
7 (i)	$CP = \dfrac{3}{5}CA$ soi $CP = \dfrac{3}{5}(4\mathbf{i} - 3\mathbf{k}) = 2.4\mathbf{i} - 1.8\mathbf{k}$ **AG**	**M1** **A1** **[2]**	
(ii)	$OP = 2.4\mathbf{i} + 1.2\mathbf{k}$ $BP = 2.4\mathbf{i} - 2.4\mathbf{j} + 1.2\mathbf{k}$	**B1** **B1** **[2]**	
(iii)	$BP.CP = 5.76 - 2.16 = 3.6$ $\lvert BP \rvert \lvert CP \rvert = \sqrt{2.4^2 + 2.4^2 + 1.2^2}\sqrt{2.4^2 + 1.8^2}$ $\cos BPC = \dfrac{3.6}{\sqrt{12.96}\sqrt{9}} \quad \left(= \dfrac{1}{3}\right)$ Angle $BPC = 70.5°$ (or 1.23 rads) cao	**M1** **M1** **M1** **A1** **[4]**	Use of $x_1x_2 + y_1y_2 + z_1z_2$ Product of moduli All linked correctly
8 (i)	$2a + 4b = 8$ $2a^2 + 3a + 4b = 14$ $2a^2 + 3a + (8 - 2a) = 14 \rightarrow (a + 2)(2a - 3) = 0$ $a = -2$ or $3/2$ $b = 3$ or $5/4$	**M1** **A1** **M1** **A1** **A1** **[5]**	Substitute in –2 and –3 Sub linear into quadratic & attempt solution If A0A0 scored allow SCA1 for either $(-2,3)$ or (3/2, 5/4)
(ii)	$y = \left(x - \dfrac{1}{2}\right)^2 - \dfrac{13}{4}$ Attempt completing of square $x - \dfrac{1}{2} = (\pm)\sqrt{y + \dfrac{13}{4}}$ oe $\mathrm{f}^{-1}(x) = \dfrac{1}{2} - \sqrt{x + \dfrac{13}{4}}$ oe Domain of f^{-1} is $(x) \geqslant -13/4$	**M1A1** **DM1** **A1** **B1** **[5]**	Allow with x/y transposed Allow with x/y transposed Allow $y =$..... Must be a function of x Allow $>$, $-13/4 \leqslant x \leqslant \infty$, $\left[-\dfrac{13}{4}, \infty\right]$ etc

9 (a) (i)	$BAO = OBA = \frac{\pi}{2} - \alpha$ $AOB = \pi - \left(\frac{\pi}{2} - \alpha\right) - \left(\frac{\pi}{2} - \alpha\right) = 2\alpha$ ***AG***	**M1A1** **[2]**	Allow use of 90º or 180º Or other valid reasoning
(ii)	$\frac{1}{2}r^2(2\alpha) - \frac{1}{2}r^2 \sin 2\alpha$ oe	**B2,1,0** **[2]**	SCB1 for reversed subtraction
(b)	Use of $\alpha = \frac{\pi}{6}$, $r = 4$ 1 segment $S = \left(\frac{1}{2}\right)4^2\left(\frac{\pi}{3}\right) - \left(\frac{1}{2}\right)4^2 \sin\frac{\pi}{3}$ $= \left(\frac{8\pi}{3} - 4\sqrt{3}\right)$ Area ABC $T = \left(\frac{1}{2}\right)4^2 \sin\frac{\pi}{3}$ $\left(= 4\sqrt{3}\right)$ $T - 3S = \left(\frac{1}{2}\right)4^2 \sin\frac{\pi}{3} - 3\left[\left(\frac{1}{2}\right)4^2\left(\frac{\pi}{3}\right) - \left(\frac{1}{2}\right)4^2 \sin\frac{\pi}{3}\right]$ $16\sqrt{3} - 8\pi$ cao	**B1B1** **M1** **B1** **M1** **A1** **[6]**	Ft *their* **(ii)**, α, r OR $AXB = \frac{T}{3} = 4\tan\frac{\pi}{6}$ or $\frac{1}{2}\left(\frac{4}{\sqrt{3}}\right)^2 \sin\frac{2\pi}{3}$ $\left(= \frac{4\sqrt{3}}{3}\right)$ OR $3\left[\frac{T}{3} - S\right] = 3\left[\frac{4\sqrt{3}}{3} - \left(\frac{8\pi}{3} - 4\sqrt{3}\right)\right]$
10 (i)	$x = 1/3$	**B1** **[1]**	
(ii)	$\frac{dy}{dx} = \left[\frac{2}{16}(3x-1)\right][3]$ When $x = 3$ $\frac{dy}{dx} = 3$ soi Equation of QR is $y - 4 = 3(x-3)$ When $y = 0$ $x = 5/3$	**B1B1** **M1** **M1** **A1** **[5]**	
(iii)	Area under curve $= \left[\frac{1}{16\times 3}(3x-1)^3\right]\left[\times\frac{1}{3}\right]$ $\frac{1}{16\times 9}\left[8^3 - 0\right] = \frac{32}{9}$ Area of $\Delta = 8/3$ Shaded area $= \frac{32}{9} - \frac{8}{3} = \frac{8}{9}$ (or 0.889)	**B1B1** **M1A1** **B1** **A1** **[6]**	Apply limits: *their* $\frac{1}{3}$ and 3