1	i	C, mid pt of AB $= \left(\frac{11+(-1)}{2}, \frac{4}{2}\right)$ $= (5, 2)$	B1	evidence of method required – may be on diagram, showing equal steps, or start at A or B and go half the difference towards the other	
		$[AB^2 =]\ 12^2 + 4^2\ [= 160]$ oe or $[CB^2 =]\ 6^2 + 2^2\ [=40]$ oe with AC	B1	or square root of these; accept unsimplified	
		quote of $(x-a)^2 + (y-b)^2 = r^2$ o.e with different letters	B1	or (5, 2) clearly identified as centre and $\sqrt{40}$ as r (or 40 as r^2) www or quote of *gfc* formula and finding c = −11	
		completion (ans given)	B1	dependent on centre (or midpt) and radius (or radius^2) found independently and correctly	4
	ii	correct subst of $x = 0$ in circle eqn soi	M1		
		$(y-2)^2 = 15$ or $y^2 - 4y - 11\ [= 0]$	M1	condone one error	
		$y - 2 = \pm\sqrt{15}$ or ft	M1	or use of quad formula (condone one error in formula); ft only for 3 term quadratic in y	
		$[y =]\ 2 \pm \sqrt{15}$ cao	A1	if $y = 0$ subst, allow SC1 for (11, 0) found alt method: M1 for y values are $2 \pm a$ M1 for $a^2 + 5^2 = 40$ soi M1 for $a^2 = 40 - 5^2$ soi A1 for $[y =]\ 2 \pm \sqrt{15}$ cao	4

	iii	grad AB $= \frac{4}{11-(-1)}$ or 1/3 o.e. so grad tgt $= -3$ eqn of tgt is $y - 4 = -3\,(x - 11)$ $y = -3x + 37$ or $3x + y = 37$ (0, 37) and (37/3, 0) o.e. ft isw	M1 M1 M1 A1 B2	or grad AC (or BC) or ft −1/their gradient of AB or subst (11, 4) in $y = -3x + c$ or ft (no ft for their grad AB used) accept other simplified versions B1 each, ft their tgt for grad $\neq 1$ or 1/3; accept $x = 0$, $y = 37$ etc NB alt method: intercepts may be found first by proportion then used to find eqn	6	14

2		$(x-4)^2 - 16 + (y-2)^2 - 4 = 9$ o. rad = $\sqrt{29}$	M2 B1	M1 for one completing square or for $(x-4)^2$ or $(y-2)^2$ expanded correctly or starting with $(x-4)^2 + (y-2)^2 = r^2$: M1 for correct expn of at least one bracket and M1 for $9 + 20 = r^2$ o.e. or using $x^2 - 2gx + y^2 - 2fy + c = 0$ M1 for using centre is (g, f) [must be quoted] and M1 for $r^2 = g^2 + f^2 - c$	3
	ii	$4^2 + 2^2$ o.e = 20 which is less than 29	M1 A1	allow 2 for showing circle crosses x axis at −1 and 9 or equiv for y (or showing one positive; one negative); 0 for graphical solutions (often using A and B from (iii) to draw circle)	2
	iii	showing midpt of AB = (4, 2) and showing AB = $2\sqrt{29}$ or showing AC or BC = $\sqrt{29}$ or that A or B lie on circle or showing both A and B lie on circle (or AC = BC = $\sqrt{29}$), and showing AB = $2\sqrt{29}$ or that C is midpt of AB or that C is on AB or that gradients of AB and AC are the same or equiv. or showing C is on AB and showing both A and B are on circle or AC = BC = $\sqrt{29}$	2 2 2 2 2 2	in each method, two things need to be established. Allow M1 for the concept of what should be shown and A1 for correct completion with method shown allow M1A0 for AB just shown as $\sqrt{116}$ not $2\sqrt{29}$ allow M1A0 for stating mid point of AB = (4,2) without working/method shown NB showing AB = $2\sqrt{29}$ and C lies on AB is not sufficient – earns 2 marks only if M0, allow SC2 for accurate graph of circle drawn with compasses and AB joined with ruled line through C.	4
	iv	grad AC or AB or BC = −5/2 o.e. grad tgt = −1/their grad AC tgt is $y - 7 =$ their $m(x-2)$ o.e. $y = 2/5\,x + 31/5$ o.e.	M1 M1 M1 A1	may be seen in (iii) but only allow this M1 if they go on to use in this part allow for $m_1m_2 = -1$ used eg $y =$ their $mx + c$ then (2, 7) subst; M0 if grad AC used condone $y = 2/5x + c$ and $c = 31/5$ o.	4

3	**i**	grad AC = $\frac{7-3}{3-1}$ or 4/2 o.e.[= 2]	M1	not from using − ½	
		so grad AT = – ½	M1	or ft their grad AC [for use of $m_1m_2 = -1$]	
		eqn of AT is $y - 7 = -\frac{1}{2}(x - 3)$	M1	or subst (3, 7) in $y = -\frac{1}{2}x + c$ or in $2y + x = 17$; allow ft from their grad of AT, except 2 (may be AC not AT)	
		one correct constructive step towards $x + 2y = 17$ [ans given]	M1	or working back from given line to $y = -\frac{1}{2}x + 8.5$ o.e.	4
	ii	$x + 2(2x - 9) = 17$	M1	attempt at subst for x or y or elimination	
		$5x - 18 = 17$ or $5x = 35$ o.e.	A1	allow $2.5x = 17.5$ etc	
		$x = 7$ and $y = 5$ [so (7, 5)]	B1	graphically: allow M2 for both lines correct or showing (7, 5) fits both lines	3
	iii	$(x - 1)^2 + (2x - 12)^2 = 20$	M1	subst $2x - 9$ for y [oe for x]	
		$5x^2 - 50x + 125$[= 0]	M1	rearranging to 0; condone one error	
		$(x - 5)^2 = 0$	A1	showing 5 is root and only root	
		equal roots so tangent	B1	explicit statement of condition needed (may be obtained earlier in part) or showing line is perp. to radius at point of contact	
		(5, 1)	B1	condone $x = 5$, $y = 1$	
		<u>or</u>			
		$y - 3 = -\frac{1}{2}(x - 1)$ o.e. seen	M1	or if $y = 2x - 9$ is tgt then line through C with gradient $-\frac{1}{2}$ is radius	
		subst or elim. with $y = 2x - 9$	M1		
		$x = 5$	A1		
		(5,1)	B1		
		showing (5, 1) on circle	B1	or showing distance between (1, 3) and (5, 1) = $\sqrt{20}$	5

4	**i**	0.2 to 0.3 and 3.7 to 3.8	1+1	[tol. 1mm or 0.05 throughout qn]; if 0, allow M1 for drawing down lines at both values	2
	iB	$x + \frac{1}{x} = 4 - x$	M1	condone one error	
		their $y = 4 - x$ drawn	M1	allow M2 for plotting positive branch of $y = 2x + 1/x$ [plots at (1,3) and (2,4.5) and above other graph] or for plot of $y = 2x^2 - 4x + 1$	
		0.2 to 0.35 and 1.65 to 1.8	B2	1 each	4
	ii	(0, ±√3)		condone $y = \pm\sqrt{3}$ isw; 1 each or M1 for $1 + y^2 = 4$ or $y^2 = 3$ o.e.	2
	iii	centre (1, 0) radius 2	1+1	allow seen in (ii)	
		touches at (1, 2) [which is distance 2 from centre]	1	allow ft for both these marks for centre at (−1, 0), rad 2;	
		all points on other branch > 2 from centre	1	allow 2 for good sketch or compass-drawn circle of rad 2 centre (±1, 0)	4