1		$BDF = 70°$	4	B1	may be marked on diagram
		Alternate segment theorem		B1	reason, the angle between a tangent and a chord is equal to the angle subtended in the alternate segment
		$EFB = 180 – (70 + 40) = 70$ opposite angles in a cyclic quadrilateral		B1	Angle EFB with reason, opposite angles in a cyclic quadrilateral sum to 180°
		$CBF = EFB$ alternate angles therefore EF is parallel to ABC		B1	conclusion, alternate angles are equal
					Total 4 marks

2	$(AC^2 =)\ 17^2 – 15^2$		5	M1	
	$(AC =)\sqrt{17^2 – 15^2}\ (=\sqrt{64} = 8)$			M1	
	$\frac{\pi \times '8'}{2} (= 4\pi = 12.566...)$			M1	dep on M2 for $\frac{\pi \times '8'}{2}$ oe or 4π 12.5663…
	'12.566…' + 15 + 17			M1	for '12.566' + 15 + 17 and no additional values
		44.6		A1	for awrt 44.6
					Total 5 marks
Alternative mark scheme for 2					
	$\cos^{-1}\left(\frac{15}{17}\right) (= 28.0724)$ or $\sin^{-1}\left(\frac{15}{17}\right) (= 61.9275)$		5	M1	for a correct method to find one of the angles
	15 × tan ('28.0724')(= 8) or 15 ÷ tan ('61.9275')(= 8)			M1	
	$\frac{\pi \times '8'}{2}$ (= 4π = 12.566…)			M1	dep on M2 for $\frac{\pi \times '8'}{2}$ or 12.5663… or 4π
	"12.566" + 15 + 17			M1	for "12.566" + 15 + 17 and no additional values
		44.6		A1	for awrt 44.6
					Total 5 marks

3	$1600 = \frac{1}{3} \times \pi \times r^2 \times 25$ oe		6	M1	for substituting into volume formula for cone correctly and equating to 1600
	eg $r = \sqrt{\frac{1600}{\frac{1}{3} \times \pi \times 25}}$ or $r = \sqrt{\frac{192}{\pi}} (= \sqrt{61.1(154..)} = 7.8176...)$			M1	dep for correct rearrangement of volume formula for r
	$l = \sqrt{"7.817..."^2 + 25^2}\ (= \sqrt{686.1154...} = 26.193...)$			M1	Dep on M2 correct method to find slant height of cone (radius of sector)
	2 × π × "7.817…" (= 49.1196…) **or** π × "7.817..." × "26.193..." (= 643.315...)			M1	for using $C = 2\pi r$ oe using figures from correct method **or** for using $A = \pi rl$ using figures from correct method
	$"49.1196..." = 2 \times \pi \times "26.193..." \times \frac{x}{360}$ **or** $"643.315..." = \pi \times "26.193..."^2 \times \frac{x}{360}$			M1	for using arc length = $2\pi r \times \frac{x}{360}$ **or** for using area of sector = $\pi r^2 \times \frac{x}{360}$
		107°		A1	for 107° - 108°
					Total 6 marks

4	2 × π × 7 (= 43.982… or 14π) **or** (2 × π × 7) ÷ 2 (= 21.991… or 7π) **or** 2 × π × 9 (= 56.548… or 18π) **or** (2 × π × 9) ÷ 2 (= 28.274… or 9π)		3	M1	for finding the circumference of either the full circle or the length of the arc for either semicircle
	e.g. "21.991" + "28.274" (= 50.26…) **or** "7π" + "9π" (=16π) **or** "21.991" + "28.274" + 2 (= 52.26…) **or** "7π" + "9π" + 2 (= 52.26…) **or** "21.991" + "28.274" + 2 + 2 **or** "7π" + "9π" + 2 + 2			M1	for a method to find the length of the two arcs with intention to add
		54.3		A1	accept 54.2 – 54.3
					Total 3 marks

5		$8^2 + 15^2$ (= 289)		5	M1	
		$\sqrt{8^2 + 15^2}$ (=17)			M1	
		$\pi \times \left("\frac{17}{2}"\right)^2$ (= 226.98...) **or** 0.5 × 15 × 8 (= 60)			M1	
		$\pi \times \left("\frac{17}{2}"\right)^2 - 0.5 \times 15 \times 8$ ("226.98" – "60")			M1	
			167		A1	Accept answers which round to 167
						Total 5 marks

6	$\sqrt{36}$ (= 6) **or** 6 **or** 6 × 6		4	M1	for method to find the length of the square – may be seen in later working
	eg $\pi \times \left(\frac{\text{[their 6]}}{2}\right)^2 \div 2$ (=14.1... or 4.5π or $\frac{9}{2}\pi$) **or** $\pi \times \left(\frac{\text{[their 6]}}{2}\right)^2$ (= 28.2... or 9π)			M1	for method to find the area of one semicircle **or** circle or the incorrect number of semicircles or circles provided correct area of circle formula is seen for [their 6] allow any value if there is a clear implication this is their side length of square.
	eg 4 × "14.1" (= 56.5... or 18π) **or** 2 × "28.2" (= 56.5... or 18π)			M1	ft dep on previous M1 for a complete method to find the total area of the semicircles [if the pupil multiplies again and uses the incorrect number of circles or semicircles this mark is not awarded]
		92.5		A1	accept 92.4 – 92.6 (not in terms of π)
					Total 4 marks

7	eg $2 \times \pi \times 5.2$ (= 32.6...or $\frac{52}{5}\pi$) oe $\frac{67}{360} \times 2 \times \pi \times 5.2$ (= 6.08...or $\frac{871}{450}\pi$) oe		3	M1	for finding the whole circumference or the arc length
	$\frac{67}{360} \times 2 \times \pi \times 5.2 + 2 \times 5.2$ oe			M1	for a complete method
		16.5		A1	accept 16.4 - 16.5 (not in terms of π)
					Total 3 marks

8	$\pi\times(r+7)^2\times\frac{45}{360}$ oe or $(2\times)\pi\times(r-2)^2$ oe		5	M1
	$\pi\times(r+7)^2\times\frac{45}{360}=2\times\pi\times(r-2)^2$ oe			M1 for a correct equation
	E.g. $675r^2-3510r+675(=0)$ $15r^2-78r+15(=0)$ oe or $5r^2-26r+5(=0)$ oe Allow $5r^2-26r=-5$ or $[4(r-2)]^2=(r+7)^2$ or $(r-2)^2=\left[\frac{(r+7)}{4}\right]^2$			A1 (dep on M2) writing a correct quadratic expression in form $ax^2+bx+c\ (=0)$ allow $ax^2+bx=c$
	$(5r-1)(r-5)(=0)$ oe or $(r=)\ \frac{--26\pm\sqrt{(-26)^2-4\times5\times5}}{2\times5}$ or $5\left(\left(r-\frac{26}{10}\right)^2-\left(\frac{26}{10}\right)^2\right)+5=0$ oe or $4r-8=r+7$ oe			M1 (dep on M1) for a complete method to solve their 3-term quadratic equation Allow one sign error and some simplification – allow as far as $\frac{26+\sqrt{676-100}}{10}$
		5		A1 dep on M2 (5 and $\frac{1}{5}$ scores M1M1A1M1A0)
				Total 5 marks

9	$\cos30=\frac{24}{(AC)}$ or $\sin'60'=\frac{24}{(AC)}$ **or** $\frac{\sin'60'}{24}=\frac{\sin90}{(AC)}$ oe		5	M1 for correct trig ratio involving AC	M2 for use of tan **and** Pythagoras to obtain AC $(AB=)\ 24\tan30\ (=13.856...)$ **and** $\sqrt{'13.856...'^2+24^2}\ (=27.712...)$ If not M2, then M1 for use of tan and Pythagoras to obtain AC^2 $(AB=)\ 24\tan30\ (=13.856...)$ **and** $'13.856...'^2+24^2\ (=768)$
	$(AC=)\frac{24}{\cos30}\ (=16\sqrt{3}=27.712\ldots)$ or $(AC=)\frac{24}{\sin'60'}\ (=16\sqrt{3}=27.712\ldots)$ **or** $(AC=)\frac{24\times\sin90}{\sin'60'}$			M1 for a correct trig ratio for AC	
	$\frac{1}{2}\times2\times\pi\times3\ (=3\pi=9.424\ldots)$			M1 for using $\pi\times2\times3$ or $2\pi\times3$	
	'27.712…' + '9.424…' – 2×3			M1 for a complete method to find the length $AFEDC$	
		31		A1 accept answers in range from 31 to 31.15	
					Total 5 marks

10	eg $\frac{55}{360}\times\pi\times d=5$ **or** $\frac{55}{360}\times\pi\times2\times r=5$ oe **OR** $\frac{360}{55}\times5(=32.7...)$ oe		4	M1	for a correct equation for the diameter **or** radius **OR** for a method to find the circumference of the circle
	eg $d=\frac{5\times360}{55\pi}(=10.4...)$ **or** $r=\frac{5\times360}{55\times2\times\pi}(=5.2...)$ **OR** $d=\frac{32.7...}{\pi}(=10.4...)$ **or** $r=\frac{32.7...}{2\times\pi}(=5.2...)$			M1	for a method to work out the diameter **or** radius
	(area =) eg $\pi\times\left(\frac{"10.4..."}{2}\right)^2$ **or** $\pi\times$ "5.2..."^{2}			M1	
		85.2		A1	allow 84.9 – 85.4
					Total 4 marks

11	$(\angle AOC =) 132 \times 2 (= 264)$		3	M1	for method to find angle at the centre. Do not award this mark if contradicted on the diagram eg if obtuse AOC is labelled as 264
	eg $\frac{"264"}{360} \times 2 \times \pi \times 8.5$ $(= 39.1...$ or $\frac{187}{15}\pi)$ **or** $2 \times \pi \times 8.5 - \frac{360 - "264"}{360} \times 2 \times \pi \times 8.5$ $(= 39.1...$ or $\frac{187}{15}\pi)$ **or** $\frac{"264"}{360} \times 2 \times \pi \times 8.5 + 2 \times 8.5$ **or** $2 \times \pi \times 8.5 - \frac{360 - "264"}{360} \times 2 \times \pi \times 8.5 + 2 \times 8.5$			M1	for a method to find the length of arc AC or perimeter of the sector – allow use of their AOC as long as clearly labelled
	Correct answer scores full marks (unless from obvious incorrect working)	56.2		A1	accept 56.1 – 56.2
					Total 3 marks

12	$\cos 50 = \frac{18}{(AB)}$ or $\sin 40 = \frac{18}{(AB)}$ or $\frac{(AB)}{\sin 90} = \frac{18}{\sin 40}$		5	M1	M2 for $(AB =) \sqrt{18^2 + (18 \tan 50)^2}$ oe $(= 28.0030\ldots)$ or 28
	$(AB =) \frac{18}{\cos 50} (= 28.0030...)$ oe or 28 or $(AB =) \frac{18}{\sin 40} (= 28.0030...)$ oe or 28			M1	
	$\frac{1}{2} \times \pi \times "28.0030..." (= 43.9...)$ oe or 44 $\pi \times "28.0030..." (= 87.9...)$ oe or 88			M1 for use of πd or $\frac{1}{2}\pi d$ oe Allow any value of $AB > 18$ if M2 not scored	
	"28…" + "43.9…" (= 71.9900…) or "28" + "44"			M1ft from previous M1 Allow *their* d + *their* $\frac{1}{2}\pi d$	
	Correct answer scores full marks (unless from obvious incorrect working)	72		A1 awrt 72	
				Total 5 marks	

13	(radius of large circle =) $\frac{4}{\cos 54}$ **or** $\frac{4}{\sin 36}$ **or** $\frac{8 \sin 54}{\sin 72}$ **or** $\sqrt{\frac{8^2}{2 - 2\cos 72}}$ $(= 6.805...)$ **or** (height of 1 triangle within pentagon =) 4tan54 (=5.505...) oe		6	M1	for a complete method to find the radius of the large circle **or** the perpendicular height of one triangle within the pentagon
	(area of large circle =) $\pi \times ("6.805...")^2$ $(= 145.489...)$ oe **or** (area of sector =) $\frac{72}{360} \times \pi \times ("6.805...")^2$ $(= 29.097...)$ oe			M1	for a complete method to find the area of the large circle **or** the area of a sector of the large circle
	(area of pentagon =) 5 × ½ × 8 × "5.505..." (= 80tan54 = 110.11...) **or** 10 × ½ × 4 × "5.505..." (= 80tan54 = 110.11...) **or** 5 × ½ × "6.805..." × "6.805..." × sin72 (= 110.11...) oe **OR** (area of one triangle =) ½ × 8 × "5.505..." (= 22.022...) **or** ½ × "6.805..." × "6.805..." × sin72 (= 22.022...) **or** ½ × "6.805..." × 8 × sin54 (= 22.022...) oe			M1	for a complete method to find the area of the pentagon **OR** the area of one triangle eg *OED* or equivalent
	$"145.489..." - "110.11..." + \pi r^2 = "110.11..." - \pi r^2$ oe **or** $5 \times ("29.097..." - "22.022...") + \pi r^2 = 5 \times "22.022..." - \pi r^2$ oe			M1	for a correct equation for the radius of the smaller circle
	$2\pi r^2 = 2 \times "110.11..." - "145.489..."$ $(= 74.731...)$ oe			M1	for a correct rearranged equation with the area of the circle the subject or better
	Correct answer scores full marks (unless from obvious incorrect working)	3.45		A1	accept 3.43 – 3.45
				Total 6 marks	