1.

11	**(i)**	$AB = 2r\sin\theta$ or $\sqrt{r^2 + r^2 - 2r^2\cos 2\theta}$ or $\dfrac{r\sin 2\theta}{\sin\left(\dfrac{\pi}{2} - \theta\right)}$ or $\dfrac{r\sin 2\theta}{\cos\theta}$	**B1**	
	(ii)	$2r\sin\theta + 2r\theta = 20$ $r = \dfrac{10}{\theta + \sin\theta}$	**M1** **A1**	for use of (i) + arc length = 20, oe must be convinced

2.

4	**(i)**	$\dfrac{\pi}{3}$ isw	**B1**	
	(ii)	[Area triangle ABC =] $\dfrac{1}{2}\times 10^2 \times \sin\left(their\dfrac{\pi}{3}\right)$ oe	**M1**	seen or implied by $25\sqrt{3}$ or 43.3(0...)
		[Area 1 sector =] $\dfrac{1}{2}\times 5^2 \times their\dfrac{\pi}{3}$ oe or $\pi \times 5^2 \times \dfrac{their 60°}{360}$	**M1**	seen or implied by $\dfrac{25\pi}{6}$ or 13.0(8...) or 13.09
		Complete correct plan	**M1**	e.g. *their* triangle – 3(*their* sector)
		4.03(1...) or $25\sqrt{3} - \dfrac{25\pi}{2}$ isw	**A1**	Units not required

3.

6	**(i)**	Valid explanation	**B1**	e.g. arc length is greater than the radius or 7 is greater than 5
	(ii)	$7 = 5\theta$ $\theta = 1.4$ oe	**M1** **A1**	implies **M1**
	(iii)	$\dfrac{1}{2}\times 5^2 \times their 1.4$ oe 17.5oe	**M1** **A1**	

(iv)	$[\text{triangle area} =]\frac{1}{2}\times 5^2 \times \sin \textit{their}1.4$ or 12.3 to 12.32 or for $[\frac{1}{2}$ × base × height=] $\frac{1}{2}\times 6.4[4...]\times 3.8[2...]$ oe	**M1**	may be embedded in a difference calculation
	5.18 to 5.2 inclusive	**A1**	implies **M1**

4.

8 (i)	$47-24=12\theta$		
	$\theta=\frac{23}{12}$, so $\theta=1.917$ or better	**M1**	for complete correct method to get $\theta =$
	$\theta=1.92$ to 2dp	**A1**	must have evidence of working to more than 2 dp, allow if 1.916 seen (truncated)
(ii)	$\sin\frac{\theta}{2}=\frac{CD/2}{12}$	**M1**	for a complete method, may use cosine rule to get *CD*
	CD = awrt 19.6 or 19.7	**A1**	
(iii)	Area of sector = awrt 138	**B1**	for sector area, allow unsimplified
	Area of triangle *AOB* = awrt 67 or 68	**M1**	for a correct attempt at area
	Area of segment = awrt 70 or 71	**M1**	for segment area (*their* sector area – *their* triangle area)
	$AD \times AB$ + segment area = 425	**M1**	for complete method to find *AD*
	leading to *AD* = awrt 18.1 or 18.0	**A1**	Allow **A1** for 18
	Alternative method:		
	Area of sector = awrt 138	**B1**	for sector area
	Difference in length between *BC* (or *AD*) and *OM* where *M* is the midpoint of *CD* = 6.88, allow awrt 6.9	**M1**	for attempt to find difference between parallel sides
	Remaining area consists of two trapezia each of width 9.85 and each of area 143.4 $\frac{1}{2}(2BC-6.88)\times 9.85=143.4$ oe	**M1**	for area of one trapezium $\frac{1}{2}(2BC-\textit{their}\ 6.88)\times \textit{their}\ 9.85$ oe
	leading to *AD* = awrt 18.1 or 18.0	**M1** **A1**	for attempt to find either *BC* or *AD*

5.

8	**(i)**	$\cos TOA = \frac{6}{10} \rightarrow$ $TOA = 0.927$	**M1** **A1**	any method
	(ii)	area of major sector = $\frac{1}{2}6^2(2\pi - 2\times their 0.927)$ (= 79.7)	**M2**	or **M1** for $\frac{1}{2}6^2(2 \times their\ 0.927)$ **DM1** for $\pi\times6^2 - \frac{1}{2}6^2(2 \times their\ 0.927)$
		area of half kite = $\frac{1}{2}(6)\sqrt{10^2-6^2}$ (=24)	**M1**	
		area of kite × 2 (=48)	**DM1**	any method
		complete correct plan awrt 128	**DM1** **A1**	*their* major sector + *their* kite
	(iii)	arc length = $6\times(2\pi - 2\times their 0.927) + 2\times\sqrt{10^2-6^2}$) awrt 42.6	**M1** **A1**	complete correct method

6.

10(i)	0.5	**B1**	for 0.5 from correct work only
10(ii)	$15^2 = 8^2 + 8^2 - (2\times8\times8\times\cos AOB)$ $AOB = 2.43075$ rads	**M1**	use of cosine rule (or equivalent) to obtain angle AOB.
	$DOC = AOB - 2(their\ AOD)$	**M1**	use of angle AOD and symmetry
	$DOC = 1.43$ to 2 dp	**A1**	Answer Given: need to have seen either 2.431 or better, or 1.431 or better in previous calculations
	Alternative 1 $15 = 2\times8\times\sin\left(\frac{1+DOC}{2}\right)$	**M1**	use of basic trigonometry
	use of $\frac{1+0.5DOC}{2}$	**M1**	may be implied
	$DOC = 1.43$ to 2 dp	**A1**	Answer Given: need to have seen either 2.431 or better, or 1.431 or better or 1.215 or better in previous calculations

	Alternative 2		
	$15^2 = 8^2 + 8^2 - (2 \times 8 \times 8 \times \cos AOB)$ $AOB = 2.43075$ rads $\angle AOB \times 8 =$ arc AB	**M1**	use of cosine rule (or equivalent) to obtain angle AOB.
	$\frac{\text{arc}AB - 8}{8} = \angle DOC$	**M1**	attempt at DOC, must be a complete method with AOB found
	$DOC = 1.43$ to 2 dp	**A1**	Answer Given: need to have seen either 2.431 or better, or 1.431 or better or 1.215 or better in previous calculations
	Alternative 3 Equating 2 different forms for the area of triangle AOB $\frac{15\sqrt{31}}{4} = \frac{1}{2} \times 8^2 \sin AOB$, $AOB = 2.43075$ rads	**M1**	using both different forms of the area of triangle AOB
	$DOC = AOB - 2(\text{their } AOD)$	**M1**	use of angle AOD and symmetry
	$DOC = 1.43$ to 2 dp	**A1**	Answer Given: need to have seen either 2.431 or better, or 1.431 or better in previous calculations

Question	Answer	Marks	Partial Marks
10(iii)	$\sin\left(\frac{1.43}{2}\right) = \frac{\frac{DC}{2}}{8}$ or $DC^2 = 8^2 + 8^2 - (2 \times 8 \times 8 \times \cos 1.43)$	**M1**	use of cosine rule or basic trigomoetry to obtain DC
	$DC = 10.49$	**A1**	awrt 10.5, may be implied
	Perimeter = $10.49 + 4 + 4 + 15$ = 33.5	**A1**	awrt 33.5
10(iv)	$\frac{1}{2} \times 8^2 (2.43 - \sin 2.43) - \frac{1}{2} \times 8^2 (1.431 - \sin 1.431)$	**B1**	area of one appropriate sector; allow unsimplified; may be implied by a correct segment
	area of one appropriate triangle, allow unsimplified	**B1**	
	an appropriate segment, allow unsimplified	**B1**	
	= 42.8 (allow awrt 42.8)	**B1**	final answer

	Alternative 1 Area of a trapezium + 2 small segments	**B1**	one appropriate small sector, allow unsimpified (could be doubled)
	Each small segment = $\frac{1}{2}\times 8^2\left(0.5-\sin 0.5\right)$	**B1**	an appropriate triangle, allow unsimplfied (could be doubled)
	Area of trapezium = $\frac{1}{2}(15+10.5)\times(6.041-2.784)$	**B1**	attempt at trapezium, must have a correct attempt at finding the distance between the parallel sides – allow unsimplified
	Total area = 42.8 (allow awrt 42.8)	**B1**	final answer
	Alternative 2 Area of 2 small sectors + area of triangle ODC – the area of triangle OAB Area of a small sector = $\frac{1}{2}\times 8^2\times\frac{1}{2}$	**B1**	area of small sector, allow unsimplified, (could be doubled)
	Area of triangle ODC = $\frac{1}{2}\times 8^2\times\sin 1.43$	**B1**	area of triangle ODC, allow unsimplified
	Area of triangle OAB = $\frac{1}{2}\times 8^2\times\sin 2.43$	**B1**	area of triangle OAB, allow unsimplified
	Total area = 42.8 (allow awrt 42.8)	**B1**	final answer

Question	Answer	Marks	Partial Marks
10(iv)	**Alternative 3** Area of rectangle + 2 small triangles + 2 small segments Each small segment = $\frac{1}{2}\times 8^2(0.5-\sin 0.5)$	**B1**	area of a small segment, allow unsimplified, could be doubled
	$\frac{1}{2}\times\frac{(15-10.49)}{2}(6.041-2.784)$	**B1**	area of a small triangle, allow unsimplified, could be doubled
	Area of rectangle = $10.49\times(6.041-2.784)$	**B1**	allow unsimplified, could be doubled
	Total area = 42.8 (allow awrt 42.8)	**B1**	final answer
	Alternative 4 Sector AOB – sector AOD – sector COB – triangle DOC	**B1**	area of one appropriate sector; allow unsimplified; may be implied by a correct segment
	$\left(\frac{1}{2}\times 8^2\times 2.43\right)-2\left(\frac{1}{2}\times 8^2\times 0.5\right)-\left(\frac{1}{2}\times 8^2\sin 1.43\right)$ Area = sector AOB – segment DC – triangle AOB	**B1**	area of one appropriate triangle, allow unsimplified
	$\left(\frac{1}{2}\times 8^2\times 2.43\right)-(\text{their segment})-\left(\frac{1}{2}\times 8^2\sin 2.43\right)$	**B1**	an appropriate segment, allow unsimplified
	Total area = 42.8 (allow awrt 42.8)	**B1**	final answer

7.

10(i)	$5\angle BAC = 6.2$, $\angle BAC = 1.24$	**B1**	
10(ii)	$\sin 0.62 = \frac{BD}{5}$, $BD = 2.905$, 2.91	**B1**	valid method to find BD
	Arc BFC: $\pi\times BD$ $(=9.13)$	**M1**	attempt to find arc length BFC, using *their* BD
	Perimeter: $9.13+6.2=15.3$	**A1**	
10(iii)	Area: $\left(\frac{1}{2}\times\pi\times 2.91^2\right)-$ $\left(\left(\frac{1}{2}\times 5^2\times 1.24\right)-\left(\frac{1}{2}\times 5^2\times\sin 1.24\right)\right)$	**B3**	**B1** for area of semi circle (= 13.3) **B1** for area of sector (= 15.5) **B1** for area of triangle (= 11.8)
	$9.58 \leqslant$ Area $\leqslant 9.62$	**B1**	final answer

8.

Question	Answer	Marks	Guidance
11(i)	1.48	**B1**	
11(ii)	$\frac{1}{2}\times 10^2 \times \theta = 21.8$	**M1**	correct use of sector area
	$\theta = 0.436$	**A1**	
11(iii)	$\angle BOC = \frac{2\pi - 1.48 - 0.436}{2} \quad (= 2.18(4))$	**B1**	2.18(4) or unsimplified
	$BC = 20\sin\left(\frac{1}{2}\angle BOC\right)$ or $BC = \frac{10 \times \sin BOC}{\sin\left(\frac{\pi - BOC}{2}\right)}$ or $BC = \sqrt{(200 - 200\cos BOC}$ $BC = 17.7(5)$	**M2**	**M1** for a complete correct method to find *BC* using *their* angle *BOC* **M1** for a correct plan using 14.8, *their BC* and 10 × *their* answer to (ii)
	Perimeter $= 14.8 + (2 \times 17.7(5)) + 4.36$ $= 54.7$ or 54.6	**A1**	awrt 54.7 or awrt 54.6

Question	Answer	Marks	Guidance
11(iv)	Area = $\left(\frac{1}{2}\times10^2\times1.48\right)+21.8+2\left(\frac{1}{2}\times10^2\sin 2.18(4)\right)$	**B2**	**B1** for $\left(\frac{1}{2}\times10^2\times1.48\right)+21.8$ **B1** for $2\left(\frac{1}{2}\times10^2\sin 2.18(4)\right)$
	= 178	**B1**	awrt 178 from correct working
	<u>Alternative method 1</u> Segment area $=\frac{1}{2}\left(10^2\left(2.18-\sin 2.18\right)\right)$	**B1**	**B1** for $2\times\frac{1}{2}\left(10^2\left(2.18(4)-\sin 2.18(4)\right)\right)$
	Area required = $100\pi-2\times\frac{1}{2}\left(10^2\left(2.18(4)-\sin 2.18(4)\right)\right)$	**B1**	
	= 178	**B1**	awrt 178 from correct working
	<u>Alternative method 2</u> Area of trapezium = $\frac{1}{2}\left((13.5+4.33)(17.1)\right)$	**B1**	correct area of trapezium *ABCD* (allow unsimplified)
	Area of segments = $\frac{1}{2}\left(10^2\left(1.48-\sin 1.48\right)\right)$ + $\frac{1}{2}\left(10^2\left(0.436-\sin 0.436\right)\right)$	**B1**	correct area of both segments (allow unsimplified)
	= 178	**B1**	awrt 178 from correct working

9.

6(i)	$16x = 40$ oe	**M1**	
	$x = 2.5$ oe (radians)	**A1**	
6(ii)	$\frac{1}{2}(16)^2(2.5)$ oe	**M1**	
	320	**A1**	
6(iii)	$\frac{1}{2}r^2(their 2.5) = (their 320) - 140$ oe	**M1**	**FT** provided *their* 320 > 140
	correct simplification to $r^2 = \ldots$	**M1**	**dep** on first **M1**
	12	**A1**	

10.

Question	Answer	Marks	Partial Marks
6(i)	(Arc length =) 1.5 × 5 oe soi	**M1**	implied by 7.5
	(DE =) 10sin(0.75) oe soi	**M1**	implied by awrt 6.82
	34.3 or answer in range 34.31 to 34.32	**A1**	
6(ii)	(Area sector =) $\frac{1}{2} \times 5^2 \times 1.5$ oe	**M1**	implied by 18.75
	(Area triangle =) $\frac{1}{2} \times 5^2 \times \sin(1.5)$ oe	**M1**	implied by awrt 12.47
	31.2 or answer in range 31.21 to 31.22	**A1**	

11.

5(i)	$9.6 = 12\theta$	**M1**	For use of arc length
	$\theta = 0.8$	**A1**	

Question	Answer	Marks	Guidance
5(ii)	Either $\tan\theta = \frac{AB}{12}$, $(AB = 12.36)$ Or $OB = \frac{12}{\cos\theta}$ $(OB = 17.22)$	**M1**	For attempt to find AB or OB using *their* θ May be implied by a correct triangle area Allow if using degrees consistently
	Either Area $\Delta OAB = \frac{1}{2} \times 12 \times$ *their* 12.36 Or Area $\Delta OAB = \frac{1}{2} \times 12 \times$ *their* $17.22 \times \sin\theta$ $(= 74.1$ or $74.2)$	**M1**	Allow if using degrees consistently For attempt to find area of triangle using *their* θ
	Area of sector $OAC = \frac{1}{2} \times 12^2 \times 0.8$ $= 57.6$	**B1**	Allow unsimplified
	Area of shaded region = 16.5 or 16.6	**A1**	

12.

8(i)	[angle ECD =] $\frac{5\pi}{18}$ oe or 0.873 soi	**B1**	
	Attempts to find AC and subtract 8	**M1**	e.g. $AC = \frac{8}{\cos\frac{2\pi}{9}}$
	$[DC =]$ 2.44	**A1**	
	$\frac{1}{2}\times 8\times their AC\times\sin\frac{2\pi}{9}$ OR $\frac{1}{2}\times 8\times 8\tan\left(\frac{2\pi}{9}\right)-\frac{1}{2}\times 8^2\times\frac{2\pi}{9}$ $-\frac{1}{2}\times their\,2.44^2\times their\frac{5\pi}{18}$	**M2**	**M1** for $\frac{1}{2}\times 8^2\times\frac{2\pi}{9}$ or for $\frac{1}{2}\times their\,2.44^2\times their\frac{5\pi}{18}$ seen
	awrt 1.91	**A1**	
8(ii)	$their(6.712-2.443)$ $+ their\,2.443\left(\frac{5\pi}{18}\right)+8\left(\frac{2\pi}{9}\right)$	**M2**	**M1** for either arc seen
	awrt 12.0	**A1**	

13.

Question	Answer	Marks	Guidance
10(i)	**Either** $18^2 = 10^2 + 10^2 - 200\cos AOB$	**M1**	Attempt to use cosine rule
	$\cos AOB = -0.62$	**A1**	Allow unsimplified
	$AOB = 2.2395$ or greater accuracy, so 2.24 (to 2 dp) or $AOB = 2.239...$ so 2.24 (to 2 dp) $AOB = 2.240$ so 2.24 (to 2 dp)	**A1**	Must justify 2 dp
10(i)	**Or** $\sin\frac{AOB}{2} = \frac{9}{10}$ or $\tan\frac{AOB}{2} = \frac{9}{\sqrt{19}}$ or $\cos\frac{AOB}{2} = \frac{\sqrt{19}}{10}$	**M1**	Attempt at trig using a right angled triangle
	$\frac{AOB}{2} =$ awrt 1.12	**A1**	
	$AOB = 2.2395$ or greater accuracy, so 2.24 (to 2 dp) or $AOB = 2.239...$ so 2.24 (to 2 dp) $AOB = 2.240$ so 2.24 (to 2 dp)	**A1**	Must justify 2 dp
10(ii)	$AOC = 2\pi - 2(2.2395)$ or $\frac{AOC}{2}$ or $ABC = \pi - (2.2395)$ oe	**M1**	For attempt to find angle AOC or ABC $AOC = 2\pi - 2(their\ AOB)$ $ABC = \pi - (their\ AOB)$ oe
	$AOC = 1.804$ or 1.803	**A1**	Condone 1.8 or 1.80
	Arc length = 18.04 or 18.03	**M1**	For attempt at arc length using $10 \times their\ AOC$
	$AC = 20\sin\frac{AOC}{2}$ or $36\sin\frac{ABC}{2}$ or $\sqrt{10^2 + 10^2 - 200\cos AOC}$ or $\sqrt{18^2 + 18^2 - 648\cos ABC}$ $= 15.69$ or 15.7	**M1**	For attempt at AC using *their* AOC, or ABC but $AOC \neq 2.24$ or $\frac{2\pi}{3}$
	Perimeter = 33.7	**A1**	Allow awrt 33.7

10(iii)	Area of sector $= 50 \times 1.804$ $= 90.2$ or 90.15	**M1**	For attempt at sector area $\frac{1}{2} \times 10^2 \times$ *their AOC* *AOC* must be in radians
	Area of triangle $= 50 \sin 1.804 = 48.6$ or 48.66	**M1**	For attempt at area of triangle $\frac{1}{2} \times 10^2 \times \sin$ *their AOC* *AOC* must be in radians
	Shaded area $= 41.6$ or 41.5	**A1**	Lack of accuracy is penalised here

14.

7(a)	0.8	**B1**	
7(b)	Sector area $= \frac{1}{2} 12^2 (0.8)$ 57.6	**B1**	Allow unsimplified
	$\tan 0.4 = \frac{AM}{12}$ $AM = 12 \tan 0.4$ 5.074	**M1**	Attempt at AM using *their* $\frac{\theta}{2}$ Allow unsimplified
	Area of triangle $= \frac{1}{2}(5.074 \times 2) \times 2 \times 12$ 60.88	**M1**	Area of triangle using *their AM*, allow unsimplified
	Shaded area 3.28	**A1**	
7(c)	$\sin 0.4 = \frac{AM}{OA}$ $OA = \frac{5.074}{\sin 0.4}$ 13.03	**M1**	Attempt to find OA using *their* $\frac{\theta}{2}$ and *their AM*
	Perimeter $= 2(1.03) + 9.6 + 2(5.074)$	**M1**	Allow if using *their* $\frac{\theta}{2}$ and *their CM*
	Perimeter $= 21.8$	**A1**	

15.

11(a)	[perimeter =] $\frac{4}{3}\pi r$ soi	**B2**	**B1** for angle $ACB = \frac{2}{3}\pi$
	$\left(their\ \frac{4}{3}\pi r\right) = 4\pi$ oe	**M1**	
	$r = 3$	**A1**	
11(b)	$\frac{1}{2} \times their 3^2 \times their \frac{2\pi}{3}$ oe	**M1**	
	$\frac{1}{2} \times their 3^2 \times \sin their \frac{2\pi}{3}$ oe	**M1**	
	For subtracting and doubling: $their 3^2 \times their \frac{2\pi}{3} -$ $their 3^2 \times \sin their \frac{2\pi}{3}$	**M1**	
	$6\pi - \frac{9}{2}\sqrt{3}$ or exact equivalent	**A1**	

16.

11(a)	$\angle BOC = 1.5$ rad	**B1**	
	$\sin 0.75 = \frac{BC/2}{r}$	**M1**	For a complete attempt to find BC – must be using a right-angled triangle to get required result – **Given answer**
	$BC = 2r \sin 0.75$	**A1**	
	Perimeter = $2r + 2r\sin 0.75 + 4r + 1.5r$	**M1**	**Dep** on first M mark for attempt at perimeter
	$r(7.5 + 2\sin 0.75)$	**A1**	**Given answer**
11(b)	Area = $(2r + 2r\sin 0.75)r - \frac{1}{2}r^2(1.5 - \sin 1.5)$ Area = $3.36r^2 - 0.75r^2 + 0.4987r^2$	**3**	**M1** for a correct plan **M1** for $(2r + 2r\sin 0.75)r$, using *their* $2r\sin 0.75$ **B1** for segment $\frac{1}{2}r^2(1.5 - \sin 1.5) = 0.251r^2$
	Area = $3.11r^2$	**A1**	

17.

8(a)	$\angle AOB = 1.45$ (radians)	**B1**	
8(b)	Sector area $= \frac{1}{2}(r^2)(1.45)$	**B1**	For correct sector area. Allow unsimplified
	Area of triangle $= \frac{1}{2} \times 0.5r \times r \times \sin(\pi - \textit{their } 1.45)$	**B1**	For correct area of triangle Allow unsimplified
	Total area $= 0.973r^2$	**B1**	

8(c)	$(AC^2) = r^2 + 0.25r^2 - (2 \times r \times 0.5r \cos(\pi - 1.45))$	**M1**	For correct substitution in cosine rule using $(\pi - \textit{their } 1.45)$
	$AC = 1.17r$	**A1**	
	Perimeter $= 2.95r + 1.17r$	**B1**	**FT** on *their AC*
	$r = 2.91$	**A1**	

18.

10(a)	$\sin\frac{AOB}{2} = \frac{7.5}{10}$	**M1**	For a valid method
	$AOB = 1.696$ $= 1.70$ to 2 dp	**A1**	Must see greater accuracy to justify given answer

19.

Question	Answer	Marks	Guidance
10(b)	$AC^2 = 10^2 + 25^2 - \left(2\times10\times25\cos\left(\frac{AOB}{2}\right)\right)$	**M1**	For a complete and valid method to find AC
	AC = awrt 19.9	**A1**	
	Major arc AB = awrt 45.9 or awrt 45.8	**B1**	
	Perimeter = awrt 85.5 or awrt 85.6	**A1**	
10(c)	Area of major sector AOB = $\frac{1}{2}\times10^2\left(2\pi - AOB\right)$	**M1**	
	awrt 229	**A1**	
	Area of kite $OACB$ = $\frac{1}{2}\times15\times25$	**B1**	Allow working with 2 separate triangles
	Area of *their* major sector plus area of *their* kite	**M1**	
	Total area = awrt 417	**A1**	

20.

9(a)	$AOD = 2\times\tan^{-1}\left(\frac{2}{3}\right)$	**M1**	For correct method to find AOD
	$AOD = 1.1760...$ $AOD = 1.176$ [to 3dp]	**A1**	Need to see 4 dp or more to justify 3 dp answer
9(b)	Major arc $MN = (2\pi - 1.176)12$	**B1**	
	ND or $MA = 12 - \sqrt{13}$	**B1**	
	Perimeter = major arc MN + MA + ND + 16 oe	**B1**	For *their* values in a correct plan, may be implied by a correct answer
	Perimeter = 94.1	**B1**	
9(c)	Minor sector area = $\frac{1}{2}\times 1.176\times 12^2$ **or** Major sector area = $\frac{1}{2}\times(2\pi - 1.176)\times 12^2$	**B1**	
	Area = major sector area – remainder of rectangle or Area = area of circle – minor sector area – remainder of rectangle or Area = circle – rectangle – minor sector + triangle AOD	**B1**	For *their* values in a correct plan, may be implied by a correct answer
	Area = 350	**B1**	Allow greater accuracy

21.

Question	Answer	Marks	Guidance
7(a)	$\sin AOQ = \frac{7}{10}$ $POA = \pi - AOQ$ or $14^2 = 10^2 + 10^2 - 200\cos AOB$ oe $POA = \frac{2\pi - AOB}{2}$	**M1**	Allow alternatives, but must be a complete method to find POA
	$POA = 2.366195157 = 2.366$ to 3 dp	**A1**	Must see an angle correct to more than 3dp used in order to justify 3 dp
7(b)	Area of sector $= \frac{1}{2}10^2(2.366)$ (118.3)	**B1**	Allow unsimplified. Also allow use of 2.37
	Area of triangle $= \frac{1}{2}10^2 \sin 2.366$ (35)	**B1**	Allow unsimplified. Also allow use of 2.37
	Total area = awrt 153	**B1**	Allow greater accuracy
7(c)	Major arc $PB = 10\times 2.366$	**B1**	Allow unsimplified. Also allow use of 2.37
	$\sin\frac{POA}{2} = \frac{AP/2}{10}$ or $AP^2 = 10^2 + 10^2 - 200\cos POA$	**M1**	For a valid attempt to find AP – may be seen in **(a)** or **(b)** but AP must be stated in this part.
	$AP = 18.5$	**A1**	Allow awrt 18.5
	Perimeter: major arc PB + 20 + *their* AP	**B1**	For plan, may be implied, but must have an attempt to calculate AP
	Total perimeter = 62.2	**A1**	Allow awrt 62.2

22.

9(a)	[area sector =] $2\times\frac{1}{2}a^2\phi$ or $\frac{1}{2}a^2(2\phi)$ oe	**B1**	or [area kite =] $2a^2\phi$ or [area OPT =] $a^2\phi$ nfww
	[shaded area =] $\left[2\times\frac{1}{2}\times\right]\frac{1}{2}a(a\tan\phi)$ oe or $a(a\tan\phi)-\frac{1}{2}a^2(2\phi)$ oe soi	**B1**	or $[a^2\phi=\frac{1}{2}a\times PT\therefore]$ $PT=2a\phi$ **and** $PT=a\tan\phi$ oe, nfww
	Correct equation using correct areas e.g. $a^2\phi=\frac{1}{2}a(a\tan\phi)$ or $a(a\tan\phi)-a^2\phi=a^2\phi$ soi	**M1**	or equates expressions for PT
	Correct completion to given equation $\tan\phi=2\phi$	**A1**	
	Alternative method [$\frac{1}{2}$ area sector =] $\frac{1}{2}a^2\phi$	**(B1)**	
	[$\frac{1}{2}$ shaded area =] $\frac{1}{2}\times\frac{1}{2}a(a\tan\phi)$ oe or $\frac{1}{2}a(a\tan\phi)-\frac{1}{2}a^2\phi$ oe soi	**(B1)**	
	Correct equation using correct areas e.g. $\frac{1}{2}a^2\phi=\frac{1}{4}a(a\tan\phi)$ or $\frac{1}{2}a^2\tan\phi-\frac{1}{2}a^2\phi=\frac{1}{2}a^2\phi$ soi	**(M1)**	
	Correct completion to given equation $\tan\phi=2\phi$	**(A1)**	
9(b)	$2a+a(2\phi)=\frac{1}{2}(2a\tan\phi+a(2\phi))$ oe or $a\tan\phi=2a+a\phi$	**M2**	**M1** for arc length $=2a\phi$ soi or for $PT=a\tan\phi$ **and** $PT=2a+a\phi$
	$\tan\phi=2+\phi$	**A1**	

23.

7(a)	2.8 oe	**B1**	
7(b)	$(BC = AC =)\ 10\tan 1.4$ or $\dfrac{10\sin 1.4}{\sin 0.1708}$	**M1**	
	Perimeter = $10(their\ 2.8) + 2(their\ AC \text{ or } BC)$	**M1**	
	144	**A1**	
7(c)	Area of triangle AOC or BOC = $\dfrac{1}{2}their(AC \text{ or } BC)\times 10$ or $\dfrac{1}{2}their\ OC \times 10\sin 1.4$ soi	**M1**	Allow premature approximation for OC
	Area of minor sector AOB = 140	**B1**	**FT** on 50 × *their* 2.8
	Shaded area = 439 to 440	**A1**	Must have 579 ⩽ kite area ⩽ 580

24.

8(a)	1.75	**B1**	
8(b)	$\cos BOC = \dfrac{7}{25}$, $\tan BOC = \dfrac{24}{7}$, $\sin BOC = \dfrac{24}{25}$ BOC = 1.287 soi	**B1**	
	Arc length = r × *their* 1.287	**B1**	Follow through on *their BOC*
	Perimeter = 12.25 + *their* 9.009 + 14	**M1**	For a complete method
	35.3	**A1**	
8(c)	$\left(\dfrac{1}{2}\times 7^2 \times 1.75\right) + \left(\dfrac{1}{2}\times 7^2 \times their\ BOC\right)$ oe or $\pi \times 7^2 - \dfrac{1}{2}\times 7^2 \times (2\pi - 1.75 - their 1.287)$	**M1**	For a complete method
	74.4	**A1**	

25.

4(a)	$r\theta = 12$ soi	**B1**	
	$\frac{1}{2}r^2\theta = 57.6$ soi	**B1**	
	$r = 9.6$ oe nfww	**B1**	
	$\theta = 1.25$ oe nfww	**B1**	
4(b)	$AC = 28.89$	**B1**	
	Shaded area $= \left(\frac{1}{2} \times 28.89 \times 9.6\right) - 57.6$ soi	**M1**	Using *their AC*
	81.1	**A1**	
	Alternative $OC = 30.45$	**(B1)**	
	Shaded area $= \left(\frac{1}{2} \times 30.45 \times 9.6 \times \sin 1.25\right) - 57.6$ soi	**(M1)**	Using *their OC*
	81.1	**(A1)**	

26.

Question	Answer	Marks	Partial Marks
9(a)	$\frac{1}{2}\times 24^2\times\theta = 432$	**M1**	
	$\theta = \frac{3}{2}$ rads soi	**A1**	
	$24 \times$ *their* θ	**M1**	
	36 cao	**A1**	
	Alternative method		
	$s = r\theta$ soi and $\frac{1}{2}\times r\times s = 432$	**(B1)**	
	$\frac{1}{2}\times 24\times s = 432$	**(M1)**	
	$s = \frac{432\times 2}{24}$ oe	**(M1)**	
	$[s =]$ 36	**(A1)**	
9(b)(i)	$[OB =]$ $2y\cos\alpha$ oe	**B1**	
9(b)(ii)	$\frac{(their\ 2y\cos\alpha)\times y\sin\alpha}{2}$ $-\frac{1}{2}\times(their\ y\cos\alpha)^2\times\alpha$ oe	**M2**	**M1** for either area
	correct completion to $\frac{y^2}{2}\cos\alpha(2\sin\alpha - \alpha\cos\alpha)$	**A1**	

27.

10(a)	$27 = 12\theta$ $\theta = \frac{9}{4}$ oe	**B1**	$\angle AOB = \theta$
	Either $\tan(\pi - \theta) = \frac{CB}{12}$ soi Or $\frac{CB}{\sin(\pi - \theta)} = \frac{12}{\sin\left(\theta - \frac{\pi}{2}\right)}$	**M1**	Allow with *their* θ.
	Perimeter = $24 + 27 + 2(14.86..)$	**M1**	Allow with *their CB*.
	Perimeter = awrt 80.7	**A1**	From correct working only
10(b)	$\left(\frac{1}{2} \times 12^2 \times \textit{their } \theta\right) + (12 \times \textit{their } CB)$ 340 oe or 341 oe	**3**	**M1** for each area **A1** for awrt 340 or 341

28.

Question	Answer	Marks	Guidance
10	$40+20\theta=65$	*M1	
	$\theta=1.25$	A1	
	$\sin\left(\frac{\text{their } \theta}{2}\right)=\frac{\frac{1}{2}AB}{20}$ $AB=23.4$ or $\frac{1}{2}AB = 11.7$	2	**Dep M1** for an attempt to find AB or $\frac{1}{2}AB$
	Either $\tan\left(\frac{\text{their } \theta}{2}\right)=\frac{\text{height of triangle } ACB}{\text{their } \frac{1}{2}AB}$ Height of triangle = 8.44 Area of triangle = 98.8	3	**DepM1** for a correct attempt to find the height of the triangle **M1** for attempt to find the area of the triangle using *their* height and *their AB* **A1** must be at least 3 significant figures.
	Or $\cos\left(\frac{\text{their } \theta}{2}\right)=\frac{\text{their } \frac{1}{2}AB}{AC}$ $AC=14.4$ Area of triangle $=\frac{1}{2}\times \text{their } AB\times \text{their } AC\times\sin\left(\frac{\theta}{2}\right)$ Area of triangle = 98.8	(3)	**DepM1** for a correct attempt to find CA **M1** for attempt to find the area of the triangle using the sine rule with *their CA*. **A1** must be at least 3 significant figures.
	Area of the segment $=\frac{1}{2}\times 20^2\times(1.25-\sin 1.25)$ Area of the segment = 60.2	B1	
	Area = 38.6	A1	

Question	Answer	Marks	Guidance
10	**Alternative 1**		
	$40+20\theta=65$	**(*M1)**	
	$\theta=1.25$	**(A1)**	
	$\tan\left(\frac{\text{their } \theta}{2}\right)=\frac{AC}{20}$ oe soi $AC=14.43$	**(2)**	**DepM1** for a correct attempt to find the AC
	Area of triangle $ACO=\frac{1}{2}\times 20\times 14.43=144.3$	**(2)**	**M1** for a correct attempt to find the area of the triangle using *their* AC
	Area of the sector = 250	**(B1)**	
	Area of half shaded region = $(144.3-125)\times 2$	**(M1)**	Dependent on a valid method for finding triangle ACO . Allow use of 144
	Area = 38.6	**(A1)**	
	Alternative 2		
	$40+20\theta=65$	**(*M1)**	
	$\theta=1.25$	**(A1)**	
	$\sin\left(\frac{\text{their } \theta}{2}\right)=\frac{\frac{1}{2}AB}{20}$ $AB=23.4$	**(2)**	**Dep M1** for an attempt to find AB or $\frac{1}{2}AB$
	$\tan\left(\frac{\text{their } \theta}{2}\right)=\frac{AC}{20}$ oe soi $AC=14.43$	**(2)**	**DepM1** for a correct attempt to find AC
	Shaded area $=14.4\times 20-\frac{1}{2}\times 20^2\times\frac{5}{4}$ Area = 38.6	**(3)**	**M1** for area of Kite **B1** for area of sector

Question	Answer	Marks	Guidance
10	**Alternative 3**		
	$40+20\theta=65$	**(*M1)**	
	$\theta=1.25$	**(A1)**	
	$\tan\left(\frac{\text{their } \theta}{2}\right)=\frac{AC}{20}$ oe soi $AC=14.43$	**(2)**	**DepM1** for a correct attempt to find AC
	Area of triangle AOB $=\frac{1}{2}\times 20^2\times\sin\ (\text{their } \theta)$ $=189.[7969...]$	**(M1)**	
	Area of triangle ACB $=\frac{1}{2}\times \text{their } AC\times \text{their } AB\times\sin\ \frac{\theta}{2}$ $=98.8$	**(M1)**	for a correct attempt to find the area of the triangle using *their* AC and *their* AB
	Area of the sector = 250	**(B1)**	
	Area of half shaded region = area of triangle ACB + area of triangle AOB − area of sector = 189.8 + 98.8 – 250	**(M1)**	
	Area = 38.6	**(A1)**	

Question	Answer	Marks	Guidance
10	**Alternative 4**		
	$40+20\theta=65$	**(*M1)**	
	$\theta=1.25$	**(A1)**	
	$\sin\left(\frac{their\ \theta}{2}\right)=\frac{\frac{1}{2}AB}{20}$ $AB=23.4$ or $\frac{1}{2}AB=11.7$	**(2)**	**Dep M1** for an attempt to find AB or $\frac{1}{2}AB$
	$\tan\left(\frac{their\ \theta}{2}\right)=\frac{\text{height of triangle } ACB}{their\frac{1}{2}AB}$ Height of triangle = 8.44	**(M1)**	**DepM1** for a correct attempt to find the height of the triangle
	Height of triangle ABO $=\sqrt{20^2-\left(\frac{1}{2}AB\right)^2}$ $=16.22$	**(M1)**	for a correct attempt to find to find the height of the triangle
	Area of the sector = 250	**(B1)**	
	Area of kite $=\frac{1}{2}\times23.4\times(16.22+8.44)$ $=288.5$	**(M1)**	
	Area = 288.5 − 250 =38.5	**(A1)**	