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Mark Scheme (Results)

Summer 2014

Pearson Edexcel GCE in Core Mathematics 2R (6664_01R)

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General Marking Guidance

- All candidates must receive the same treatment. Examiners must mark the first candidate in exactly the same way as they mark the last.
- Mark schemes should be applied positively. Candidates must be rewarded for what they have shown they can do rather than penalised for omissions.
- Examiners should mark according to the mark scheme not according to their perception of where the grade boundaries may lie.
- There is no ceiling on achievement. All marks on the mark scheme should be used appropriately.
- All the marks on the mark scheme are designed to be awarded. Examiners should always award full marks if deserved, i.e. if the answer matches the mark scheme. Examiners should also be prepared to award zero marks if the candidate's response is not worthy of credit according to the mark scheme.
- Where some judgement is required, mark schemes will provide the principles by which marks will be awarded and exemplification may be limited.
- Crossed out work should be marked UNLESS the candidate has replaced it with an alternative response.

PEARSON EDEXCEL GCE MATHEMATICS

General Instructions for Marking

1. The total number of marks for the paper is 75

2. The Edexcel Mathematics mark schemes use the following types of marks:

- **M** marks: Method marks are awarded for 'knowing a method and attempting to apply it', unless otherwise indicated.
- **A** marks: Accuracy marks can only be awarded if the relevant method (M) marks have been earned.
- **B** marks are unconditional accuracy marks (independent of M marks)
- Marks should not be subdivided.

3. Abbreviations

   These are some of the traditional marking abbreviations that will appear in the mark schemes.

   - bod – benefit of doubt
   - ft – follow through
   - the symbol $\sqrt{}$ will be used for correct ft
   - cao – correct answer only
   - cso - correct solution only. There must be no errors in this part of the question to obtain this mark
   - isw – ignore subsequent working
   - awrt – answers which round to
   - SC: special case
   - oe – or equivalent (and appropriate)
   - d… or dep – dependent
   - indep – independent
   - dp decimal places
   - sf significant figures
   - ∗ The answer is printed on the paper or AG - answer given
   - ⎿ or d… The second mark is dependent on gaining the first mark
   - aliter – alternative method
   - aef – any equivalent form

4. All A marks are 'correct answer only' (cao.), unless shown, for example, as A1 ft to indicate that previous wrong working is to be followed through. After a misread however, the subsequent A marks affected are treated as A ft, but manifestly absurd answers should never be awarded A marks.

5. For misreading which does not alter the character of a question or materially simplify it, deduct two from any A or B marks gained, in that part of the question affected.
6.
7. If a candidate makes more than one attempt at any question:
    - If all but one attempt is crossed out, mark the attempt which is NOT crossed out.
    - If either all attempts are crossed out or none are crossed out, mark all the attempts and score the highest single attempt.

8. Ignore wrong working or incorrect statements following a correct answer.

General Principles for Core Mathematics Marking

(But note that specific mark schemes may sometimes override these general principles).

Method mark for solving 3 term quadratic:

1. Factorisation

$(x^2 + bx + c) = (x + p)(x + q)$, where $|pq| = |c|$, leading to x = ...

$(ax^2 + bx + c) = (mx + p)(nx + q)$, where $|pq| = |c|$ and $|mn| = |a|$, leading to x = ...

2. Formula

Attempt to use the correct formula (with values for a, b and c).

3. Completing the square

Solving $x^2 + bx + c = 0$: $\left(x \pm \frac{b}{2}\right)^2 \pm q \pm c = 0, \quad q \neq 0$, leading to x = ...

Method marks for differentiation and integration:

1. Differentiation

Power of at least one term decreased by 1. ($x^n \to x^{n-1}$)

2. Integration

Power of at least one term increased by 1. ($x^n \to x^{n+1}$)

Use of a formula

Where a method involves using a formula that has been learnt, the advice given in recent examiners' reports is that the formula should be quoted first.

Normal marking procedure is as follows:

Method mark for quoting a correct formula and attempting to use it, even if there are small errors in the substitution of values.

Where the formula is not quoted, the method mark can be gained by implication from correct working with values, but may be lost if there is any mistake in the working.

Exact answers

Examiners' reports have emphasised that where, for example, an exact answer is asked for, or working with surds is clearly required, marks will normally be lost if the candidate resorts to using rounded decimals.

<table>
<tr><th>Question Number</th><th colspan="2">Scheme</th><th>Marks</th></tr>
<tr><td rowspan="7">1.</td><td colspan="2">$\left(1+\frac{3x}{2}\right)^8$</td><td></td></tr>
<tr><td>$1+12x$</td><td>Both terms correct as printed (allow $12x^1$ but not 1^8)</td><td>B1</td></tr>
<tr><td>$\ldots+\frac{8(7)}{2!}\left(\frac{3x}{2}\right)^2+\frac{8(7)(6)}{3!}\left(\frac{3x}{2}\right)^3+\ldots$
$\ldots+{}^8C_2\left(\frac{3x}{2}\right)^2+{}^8C_3\left(\frac{3x}{2}\right)^3+\ldots$</td><td>$\left(\frac{8(7)}{2!}\times\ldots\times x^2\right)$ or $\left(\frac{8(7)(6)}{3!}\times\ldots\times x^3\right)$ or
$\left({}^8C_2\times\ldots\times x^2\right)$ or $\left({}^8C_3\times\ldots\times x^3\right)$
M1: For <u>either</u> the x^2 term <u>or</u> the x^3 term. Requires <u>correct</u> binomial coefficient in any form <u>with the correct power of x</u>, but the other part of the coefficient (perhaps including powers of 2 and/or 3 or signs) may be wrong or missing.</td><td>M1</td></tr>
<tr><td colspan="2"><u>Special Case:</u> Allow this M1 <u>only</u> for an attempt at a descending expansion provided the equivalent conditions are met for any term <u>other than the first</u>
e.g. $\ldots+8\left(\frac{3x}{2}\right)^7(1)+\frac{8(7)}{2!}\left(\frac{3x}{2}\right)^6(1)^2+\ldots$
$\ldots+{}^8C_1\left(\frac{3x}{2}\right)^7+{}^8C_2\left(\frac{3x}{2}\right)^6+\ldots$</td><td></td></tr>
<tr><td>$\ldots+63x^2+189x^3+\ldots$</td><td>A1: Either $63x^2$ or $189x^3$
A1: Both $63x^2$ and $189x^3$</td><td>A1A1</td></tr>
<tr><td colspan="2">Terms may be listed but must be positive</td><td></td></tr>
<tr><td colspan="2"></td><td>[4]</td></tr>
<tr><td></td><td colspan="2"></td><td>Total 4</td></tr>
<tr><td></td><td colspan="2">Note it is common not to square the 2 in the denominator of $\left(\frac{3x}{2}\right)$ and this gives $1+12x+126x^2+756x^3$. This could score B1M1A0A0.</td><td></td></tr>
<tr><td></td><td colspan="2">Note $\ldots+{}^8C_2\left(1^4+\frac{3x}{2}\right)^2+{}^8C_3\left(1^3+\frac{3x}{2}\right)^3+\ldots$ would score M0 unless a correct method was implied by later work</td><td></td></tr>
</table>

Question Number	Scheme		Marks
2. (a)	$S_\infty = 6a$		
	$\dfrac{a}{1-r} = 6a$	Either $\dfrac{a}{1-r} = 6a$ or $\dfrac{6a}{1-r} = a$ or $\dfrac{6}{1-r} = 1$	M1
	$\{\Rightarrow 1 = 6(1-r) \Rightarrow\}\ r = \dfrac{5}{6}$ *	cso	A1*
	Allow verification e.g. $\dfrac{a}{1-r} = 6a \Rightarrow \dfrac{a}{1-\frac{5}{6}} = 6a \Rightarrow \dfrac{a}{\frac{1}{6}} = 6a \Rightarrow 6a = 6a$		
			[2]
(b)	$\{T_4 = ar^3 = 62.5 \Rightarrow\}\ a\left(\dfrac{5}{6}\right)^3 = 62.5$	$a\left(\dfrac{5}{6}\right)^3 = 62.5$ (Correct statement using the 4th term. Do not accept $a\left(\dfrac{5}{6}\right)^4 = 62.5$)	M1
	$\Rightarrow a = 108$	108	A1
			[2]
(c)	$S_\infty = 6(\text{their } a)$ or $\dfrac{\text{their } a}{1-\dfrac{5}{6}}\{= 648\}$	Correct method to find S_∞	M1
	$\{S_{30} =\}\ \dfrac{108\left(1-(\frac{5}{6})^{30}\right)}{1-\frac{5}{6}}\ \{= 645.2701573...\}$	M1: $S_{30} = \dfrac{(\text{their } a)\left(1-\left(\dfrac{5}{6}\right)^{30}\right)}{1-\left(\dfrac{5}{6}\right)}$ **(Condone invisible brackets around 5/6)**	M1 A1ft
		A1ft: Correct follow through expression (follow through their a). **Do not condone invisible brackets around 5/6 unless <u>their</u> evaluation or final answer implies they were intended.**	
	$\{S_\infty - S_{30}\} = 2.72984...$	**awrt** 2.73	A1
			[4]
			Total 8
(c)	**<u>Alternative:</u>** Difference = $\dfrac{ar^{30}}{1-r} = \dfrac{108\left(\dfrac{5}{6}\right)^{30}}{1-\dfrac{5}{6}} = 2.72984...$ M1M1: For an attempt to apply $\dfrac{ar^{30}}{1-r}$. A1ft: $\dfrac{(\textit{their } a)\times r^{30}}{1-r}$ with their ft a. A1: awrt 2.73		

Question Number	Scheme		Marks
3. (a)	$\sqrt{7}$ and $\sqrt{15}$	Both $\sqrt{7}$ and $\sqrt{15}$. Allow awrt 2.65 and 3.87	B1
			[1]
(b)	$\text{Area}\,(R) \approx \frac{1}{2} \times 2 ; \times \underline{\left\{ \sqrt{3} + 2\left(\sqrt{7} + \sqrt{11} + \sqrt{15}\right) + \sqrt{19} \right\}}$	Outside brackets $\frac{1}{2} \times 2$ or 1 (may be implied)	B1;
		<u>For structure of</u> $\underline{\{............\}}$	<u>M1</u>
	Note decimal values are $\frac{1}{2} \times 2 ; \times \underline{\left\{ \sqrt{3} + \sqrt{19} + 2\left(\sqrt{7} + \sqrt{11} + \sqrt{15}\right) \right\}} = \frac{1}{2} \times 2 ; \times \underline{\{ 6.0909.. + 19.6707... \}}$		
	M1 requires the correct structure for the *y* values. It needs to contain first *y* value **plus** last *y* value and the second bracket to be multiplied by 2 and to be the summation of the remaining *y* values in the table with no additional values. If the only mistake is a copying error or is to omit one value from 2(…..) bracket this may be regarded as a slip and the M mark can be allowed (nb: an extra repeated term, however, forfeits the M mark). M0 if any values used are *x* values instead of *y* values. Bracketing mistakes: e.g. $\left(\frac{1}{2} \times 2\right) \times \left(\sqrt{3} + \sqrt{19}\right) + 2\left(\sqrt{7} + \sqrt{11} + \sqrt{15}\right)$ $\left(\frac{1}{2} \times 2\right) \times \sqrt{3} + \sqrt{19} + 2\left(\sqrt{7} + \sqrt{11} + \sqrt{15}\right)$ Both score B1 M1 **Alternative:** Separate trapezia may be used, and this can be marked equivalently. $\left[\frac{1}{2} \times 2(\sqrt{3} + \sqrt{7}) + \frac{1}{2} \times 2(\sqrt{7} + \sqrt{11}) + \frac{1}{2} \times 2(\sqrt{11} + \sqrt{15}) + \frac{1}{2} \times 2(\sqrt{15} + \sqrt{19}) \right]$ B1 for $\frac{1}{2} \times 2$, M1 for correct structure		
	$= 1 \times 25.76166865... = 25.76166... = \underline{25.76}$ (2dp)	<u>25.76</u>	A1 **cao**
			[3]
(c)	underestimate	Accept ‘under’, ‘less than’ etc.	B1
			[1]
			Total 5

Question Number	Scheme		Marks
4. (a)	$\mathrm{f}(x) = -4x^3 + ax^2 + 9x - 18$		
	$\mathrm{f}(2) = -32 + 4a + 18 - 18 = 0$	Attempts $\mathrm{f}(2)$ or $\mathrm{f}(-2)$	M1
	$\Rightarrow\ 4a = 32 \Rightarrow\ a = 8$	cso	A1
			[2]
(a) Way 2	$\mathrm{f}(x) = (x-2)(px^2 + qx + r)$		
	$= px^3 + (q-2p)x^2 + (r-2q)x - 2r$		
	$r = 9 \Rightarrow q = 0$ also $p = -4 \therefore a = -2p = 8$	Compares coefficients leading to $-2p = a$	M1
	$a = 8$	cso	A1
(a) Way 3	$(-4x^3 + ax^2 + 9x - 18) \div (x-2)$		
	$Q = -4x^2 + (a-8)x + 2a - 7$ $R = 4a - 32$	Attempt to divide ±f(x) by (x – 2) to give a quotient at least of the form $\pm 4x^2 + \mathrm{g}(a)x$ and a remainder that is a function of a	M1
	$4a - 32 = 0 \Rightarrow a = 8$	cso	A1
(b)	$\mathrm{f}(x) = (x-2)(-4x^2 + 9)$	Attempts long division or other method, to obtain $(-4x^2 \pm ax \pm b)$, $b \neq 0$, even with a remainder. Working need not be seen as this could be done "by inspection."	M1
	$= (x-2)(3-2x)(3+2x)$ or equivalent e.g. $= -(x-2)(2x-3)(2x+3)$ or $= (x-2)(2x-3)(-2x-3)$	dM1: A ***valid*** attempt to factorise their quadratic – see General Principles. **This is dependent** on the previous method mark being awarded, but there must have been no remainder. A1: cao – must have all 3 factors on the same line. Ignore subsequent work (such as a solution to a quadratic equation.)	**d**M1A1
			[3]
(c)	$\mathrm{f}\left(\frac{1}{2}\right) = -4\left(\frac{1}{8}\right) + 8\left(\frac{1}{4}\right) + 9\left(\frac{1}{2}\right) - 18 = -12$	Attempts $\mathrm{f}\left(\frac{1}{2}\right)$ or $\mathrm{f}\left(-\frac{1}{2}\right)$ Allow A1ft for the correct numerical value of $\frac{\text{their } a}{4} - 14$	M1A1ft
			[2]
(c) Way 2	$\pm(-4x^3 + 8x^2 + 9x - 18) \div (2x-1)$		
	$Q = -2x^2 + 3x + 6$ $R = -12$	M1: Attempt long division to give a remainder that is independent of x A1: Allow A1ft for the correct numerical value of $\frac{\text{their } a}{4} - 14$.	M1A1ft
			Total 7

Question Number	Scheme		Marks
5(a)	Length *DEA* $= 7(2.1) = 14.7$	M1: 7×2.1 only A1: 14.7	M1A1
			[2]
(b)	Angle *CBD* $= \pi - 2.1$	**May be seen on the diagram** (allow awrt 1.0 and allow 180 – 120). Could score for sight of **Angle *CBD* = awrt 60 degrees.**	M1
	Both $7\cos(\pi - 2.1)$ **and** $7\sin(\pi - 2.1)$ or **Both** $7\cos(\pi - 2.1)$ **and** $\sqrt{7^2 - (7\cos(\pi - 2.1))^2}$ or **Both** $7\sin(\pi - 2.1)$ **and** $\sqrt{7^2 - (7\sin(\pi - 2.1))^2}$ **Or equivalents to these**	A correct attempt to find BC and BD. You can ignore how the candidate assigns *BC* and *CD*. $7\cos(\pi - 2.1)$ can be implied by awrt 3.5 and $7\sin(\pi - 2.1)$ can be implied by awrt 6. Note if the sin rule is used, do not allow mixing of degrees and radians unless their answer implies a correct interpretation. **Dependent on the previous method mark**.	dM1
	Note that 2.1 radians is 120 degrees (to 3sf) which if used gives angle CBD as 60 degrees. If used this gives a correct perimeter of 31.3 and could score full marks.		
	$P = 7\cos(\pi - 2.1) + 7\sin(\pi - 2.1) + 7 + 14.7$	their BC + their CD + 7 + their DEA **Dependent on <u>both</u> previous method marks**	ddM1
	$= 31.2764...$	Awrt 31.3	A1
			[4]
			Total 6

Question Number	Scheme		Marks
6.	$\int\left(\frac{1}{8}x^3+\frac{3}{4}x^2\right)\,dx = \frac{x^4}{32}+\frac{x^3}{4}\{+c\}$	M1: $x^n \to x^{n+1}$ on either term A1: $\frac{x^4}{32}+\frac{x^3}{4}$. Any correct simplified or un-simplified form. (+ c not required)	M1A1
	$\left[\frac{x^4}{32}+\frac{x^3}{4}\right]_{-4}^{2} = \left(\frac{16}{32}+\frac{8}{4}\right)-\left(\frac{256}{32}+\frac{(-64)}{4}\right)$ or $\left[\frac{x^4}{32}+\frac{x^3}{4}\right]_{-4}^{0} = (0)-\left(\frac{(-4)^4}{32}+\frac{(-4)^3}{4}\right)$ added to $\left[\frac{x^4}{32}+\frac{x^3}{4}\right]_{0}^{2} = \left(\frac{(2)^4}{32}+\frac{(2)^3}{4}\right)-(0)$		dM1
	Substitutes limits of 2 and -4 into an "integrated function" and subtracts either way round. Or substitutes limits of 0 and -4 **and** 2 and 0 into an "integrated function" and subtracts either way round and adds the two results.		
	$= \frac{21}{2}$	$\frac{21}{2}$ or 10.5	A1
	$\{$At $x=-4,\ y=-8+12=4$ or at $x=2,\ y=1+3=4\}$		
	Area of Rectangle $= 6\times 4 = 24$ or Area of Rectangle**s** $= 4\times 4 = 16$ and $2\times 4 = 8$		M1
	Evidence of $(4--2)\times$ their y_{-4} **or** $(4--2)\times$ their y_2 or Evidence of $4\times$ their y_{-4} **and** $2\times$ their y_2		
	So, $\text{area}(R) = 24-\frac{21}{2}=\frac{27}{2}$	dddM1: Area rectangle – integrated answer. Dependent on all previous method marks **and requires:** **Rectangle > integration > 0** A1: $\frac{27}{2}$ or 13.5	dddM1A1
			[7]
			Total 7

	Alternative:		
	$\pm\int \text{"their4"} - \left(\frac{1}{8}x^3 + \frac{3}{4}x^2\right)\,\mathrm{d}x$	Line – curve. **Condone missing brackets and allow either way round.**	4th M1
	$= 4x - \frac{x^4}{32} - \frac{x^3}{4}\,\{+c\}$	M1: $x^n \to x^{n+1}$ on either curve term A1ft: $\text{"}-\frac{x^4}{32} - \frac{x^3}{4}.\text{"}$ Any correct simplified or un-simplified form of their curve terms, **follow through sign errors.** (+ c not required)	1st M1,1st A1ft
	$[\ ]_{-4}^{2} = \underline{\underline{\left(8 - \frac{16}{32} - \frac{8}{4}\right) - \left(-16 - \frac{256}{32} - \frac{(-64)}{4}\right)}}$	2nd M1 Substitutes limits of 2 and -4 into an "integrated curve" and subtracts either way round. 3rd M1 for $\pm(\text{"8"} - \text{"}-16\text{"})$ **Substitutes limits into the 'line part' and subtracts either way round.** 2nd A1 for correct ± (underlined expression). **Now needs to be correct but allow ± the correct expression.**	2nd M1, 3rd M1 2nd A1
	$= \frac{27}{2}$	A1: $\frac{27}{2}$ or 13.5	3rd A1
	If the final answer is -13.5 you can withhold the final A1 **If -13.5 then "becomes" +13.5 allow the A1**		

Question Number	Scheme		Marks
7.(i)	$\dfrac{\sin 2\theta}{(4\sin 2\theta - 1)} = 1;\quad 0 \leqslant \theta < 180^{\circ}$		
	$\sin 2\theta = \dfrac{1}{3}$	$\sin 2\theta = k$ where $-1 < k < 1$ **Must be 2θ and not θ.**	M1
	$\{2\theta = \{19.4712..., 160.5288...\}\}$		
	$\theta = \{9.7356..., 80.2644...\}$	A1: Either awrt 9.7 or awrt 80.3 A1: Both awrt 9.7 and awrt 80.3	A1 A1
	Do not penalise poor accuracy more than once e.g. 9.8 and 80.2 from correct work could score M1A1A0		
	If <u>both</u> answers are correct in radians award A1A0 otherwise A0A0 Correct answers are 0.2 and 1.4		
	Extra solutions in range in an otherwise fully correct solution deduct the last A1		
			[3]
(ii)	$5\sin^2 x - 2\cos x - 5 = 0,\quad 0 \le x < 2\pi.$		
	$5(1-\cos^2 x) - 2\cos x - 5 = 0$	Applies $\sin^2 x = 1 - \cos^2 x$	M1
	$5\cos^2 x + 2\cos x = 0$ $\cos x(5\cos x + 2) = 0$ $\Rightarrow \cos x = ...$	Cancelling out $\cos x$ or a valid attempt at solving the quadratic in cos$x$ **and** giving cos$x$ = … **Dependent on the previous method mark.**	dM1
	awrt 1.98 or awrt 4.3(0)	Degrees: 113.58, 246.42	A1
	Both 1.98 and 4.3(0)	or their α and their $2\pi - \alpha$, where $\alpha \neq \dfrac{\pi}{2}$. If working in degrees allow 360 – their α	A1ft
	awrt 1.57 or $\dfrac{\pi}{2}$ **and** 4.71 or $\dfrac{3\pi}{2}$ **or** 90^{o} and 270^{o}	**These answers only but ignore other answers <u>outside</u> the range**	B1
			[5]
	NB: $x = \text{awrt}\left\{1.98,\ 4.3(0),\ 1.57 \text{ or } \dfrac{\pi}{2},\ 4.71 \text{ or } \dfrac{3\pi}{2}\right\}$		**8**
	Answers in degrees: 113.58, 246.42, 90, 270 **Could score M1M1A0A1ftB1 (4/5)**		

Question Number	Scheme		Marks
8. (i)	$5^y = 8$		
	$y\log 5 = \log 8$	$y\log 5 = \log 8$ or $y = \log_5 8$	M1
	$\left\{y = \dfrac{\log 8}{\log 5}\right\} = 1.2920...$	awrt 1.29	A1
	Allow correct answer only		
			[2]
	$\log_2(x+15) - 4 = \frac{1}{2}\log_2 x$		
(ii)	$\log_2(x+15) - 4 = \log_2 x^{\frac{1}{2}}$	Applies the power law of logarithms seen **at any point in their working**	M1
	$\log_2\left(\dfrac{x+15}{x^{\frac{1}{2}}}\right) = 4$	Applies the subtraction or addition law of logarithms **at any point in their working**	M1
	$\left(\dfrac{x+15}{x^{\frac{1}{2}}}\right) = 2^4$	Obtains a correct expression with logs removed and no errors	M1
	$x - 16x^{\frac{1}{2}} + 15 = 0$ or e.g. $x^2 + 225 = 226x$	Correct **three** term quadratic in any form	A1
	$(\sqrt{x}-1)(\sqrt{x}-15) = 0 \Rightarrow \sqrt{x} = ...$	A **valid** attempt to factorise or solve their **three term quadratic** to obtain $\sqrt{x} = ...$ or $x = ...$ Dependent on all previous method marks.	**ddd**M1
	$\{\sqrt{x} = 1, 15\}$		
	$x = 1,\ 225$	**Both x = 1 and x = 225 (If both are seen, ignore any other values of $x \le 0$ from an otherwise correct solution)**	A1
			[6]
			Total 8
	<u>Alternative:</u>		
	$2\log_2(x+15) - 8 = \log_2 x$		
	$\log_2(x+15)^2 - 8 = \log_2 x$	Applies the power law of logarithms	M1
	$\log_2\left(\dfrac{(x+15)^2}{x}\right) = 8$	Applies the subtraction law of logarithms	M1
	$\dfrac{(x+15)^2}{x} = 2^8$	Obtains a correct expression with logs removed	M1
	$x^2 + 30x + 225 = 256x$		
	$x^2 - 226x + 225 = 0$	Correct three term quadratic in any form	A1
	$(x-1)(x-225) = 0 \Rightarrow x = ...$	A valid attempt to factorise or solve their 3TQ to obtain $x = ...$ Dependent on all previous method marks.	dddM1
	$x = 1,\ 225$	**Both x = 1 and x = 225 (If both are seen, ignore any other values of $x \le 0$ from an otherwise correct solution)**	A1

Question Number	Scheme		Marks
9. (a)	$\{A=\}\ xy+\frac{\pi}{2}\left(\frac{x}{2}\right)^2+\frac{1}{2}x^2\sin 60^\circ$	M1: An attempt to find 3 areas of the form: $xy,\quad p\pi x^2$ and qx^2 A1: Correct expression for A (terms must be added)	M1A1
	$50=\ xy+\frac{\pi x^2}{8}+\frac{\sqrt{3}x^2}{4}\ \Rightarrow\ y=\frac{50}{x}-\frac{\pi x}{8}-\frac{\sqrt{3}x}{4}\ \Rightarrow y=\frac{50}{x}-\frac{x}{8}\left(\pi+2\sqrt{3}\right)$ * Correct proof with no errors seen		A1 *
			[3]
(b)	$\{P=\}\ \frac{\pi x}{2}+2x+2y$	Correct expression for P in terms of x and y	B1
	$P=\ \frac{\pi x}{2}+2x+2\left(\frac{50}{x}-\frac{x}{8}\left(\pi+2\sqrt{3}\right)\right)$	Substitutes the given expression for y into an expression for P where P is at least of the form $\alpha x+\beta y$	M1
	$P=\ \frac{\pi x}{2}+2x+\frac{100}{x}-\frac{\pi x}{4}-\frac{\sqrt{3}}{2}x\ \Rightarrow\ P=\frac{100}{x}+\frac{\pi x}{4}+2x-\frac{\sqrt{3}}{2}x$		
	$\Rightarrow\ P=\frac{100}{x}+\ \frac{x}{4}\left(\pi+8-2\sqrt{3}\right)$	Correct proof with no errors seen	A1 *
			[3]
	(Note $\frac{\pi+8-2\sqrt{3}}{4}=1.919\ldots\ldots$)		
(c) and (d) can be marked together	$\frac{\mathrm{d}P}{\mathrm{d}x}=-100x^{-2}+\frac{\pi+8-2\sqrt{3}}{4}$	M1: Either $\mu x\rightarrow\mu$ or $\frac{100}{x}\rightarrow\frac{\pm\lambda}{x^2}$ A1: Correct differentiation (need not be simplified). Allow $-100x^{-2}+(\text{awrt}1\cdot 92)$	M1A1
	$-100x^{-2}+\frac{\pi+8-2\sqrt{3}}{4}=0\Rightarrow x=\ldots$	Their $P'=0$ and attempt to solve as far as $x=\ldots.$ (ignore poor manipulation)	M1
	$\Rightarrow\ x=\sqrt{\frac{400}{\pi+8-2\sqrt{3}}}\ =\ 7.2180574\ldots$	$\sqrt{\frac{400}{\pi+8-2\sqrt{3}}}$ or awrt 7.2 **and no other values**	A1
	$\{x=7.218\ldots,\}\ \Rightarrow P=27.708\ldots$ (m)	awrt 27.7	A1
			[5]
	$\frac{\mathrm{d}^2P}{\mathrm{d}x^2}=\frac{200}{x^3}>0\ \Rightarrow$ Minimum	M1: Finds P'' ($x^n\rightarrow x^{n-1}$ allow for constant $\rightarrow 0$) **and** considers sign A1ft: $\frac{200}{x^3}$ (need not be simplified) and >0 and conclusion. Only follow through on a correct P'' and a single positive value of x found earlier.	M1A1ft
			[2]
			Total 13

Question Number	Scheme		Marks
10(a)	$A\left(\frac{-9+15}{2}, \frac{8-10}{2}\right) = A(3, -1)$	M1: A correct attempt to find the midpoint between *P* and *Q*. Can be implied by one of x or y-coordinates correctly evaluated.	M1A1
		A1: $(3, -1)$	
			[2]
(b)	$(-9-3)^2 + (8+1)^2$ or $\sqrt{(-9-3)^2 + (8+1)^2}$ or $(15-3)^2 + (-10+1)^2$ or $\sqrt{(15-3)^2 + (-10+1)^2}$ Uses Pythagoras correctly in order to find the **radius**. Must clearly be identified as the **radius** and may be implied by their circle equation. Or $(15+9)^2 + (-10-8)^2$ or $\sqrt{(15+9)^2 + (-10-8)^2}$ Uses Pythagoras correctly in order to find the **diameter**. Must clearly be identified as the **diameter** and may be implied by their circle equation. This mark can be implied by just 30 clearly seen as the **diameter** or 15 clearly seen as the **radius** (may be seen or implied in their circle equation) **Allow this mark if there is a correct statement involving the radius or the diameter but <u>must be seen in (b)</u>**		M1
	$(x-3)^2 + (y+1)^2 = 225$ $\left(\text{or } (15)^2\right)$	$(x \pm \alpha)^2 + (y \pm \beta)^2 = k^2$ where $A(\alpha, \beta)$ and k is their radius.	M1
	$(x-3)^2 + (y+1)^2 = 225$	Allow $(x-3)^2 + (y+1)^2 = 15^2$	A1
	Accept correct answer only		
			[3]
	Alternative using $x^2 + 2ax + y^2 + 2by + c = 0$		
	Uses $A(\pm\alpha, \pm\beta)$ and $x^2 + 2ax + y^2 + 2by + c = 0$ e.g. $x^2 + 2(-3)x + y^2 + 2(1)y + c = 0$		M1
	Uses P or Q and $x^2 + 2ax + y^2 + 2by + c = 0$ e.g. $(-9)^2 + 2(-3)(-9) + (8)^2 + 2(1)(8) + c = 0 \Rightarrow c = -215$		M1
	$x^2 - 6x + y^2 + 2y - 215 = 0$		A1
(c)	Distance $= \sqrt{15^2 - 10^2}$	$= \sqrt{(\text{their } r)^2 - 10^2}$ or a correct method for the distance e.g. their $r \times \cos\left[\sin^{-1}\left(\frac{10}{\text{their } r}\right)\right]$	M1
	$\left\{= \sqrt{125}\right\} = 5\sqrt{5}$	$5\sqrt{5}$	A1
			[2]

Question Number	Scheme		Marks
(d)	$\sin\left(A\hat{R}Q\right) = \dfrac{20}{30}$ or $A\hat{R}Q = 90 - \cos^{-1}\left(\dfrac{10}{15}\right)$	$\sin\left(A\hat{R}Q\right) = \dfrac{20}{\left(2 \times \text{their } r\right)}$ or $\dfrac{10}{\text{their } r}$ or $A\hat{R}Q = 90 - \cos^{-1}\left(\dfrac{10}{\text{their } r}\right)$ or $A\hat{R}Q = \cos^{-1}\left(\dfrac{\text{Part}(c)}{\text{their } r}\right)$ or $A\hat{R}Q = 90 - \sin^{-1}\left(\dfrac{\text{Part}(c)}{\text{their } r}\right)$ or $20^2 = 15^2 + 15^2 - 2\times15\times15\cos\left(\mathbf{2}ARQ\right)$ or $15^2 = 15^2 + \left(10\sqrt{5}\right)^2 - 2\times15\times10\sqrt{5}\cos\left(ARQ\right)$ A fully correct method to find $A\hat{R}Q$, where their $r > 10$. Must be a **correct** statement involving angle *ARQ*	M1
	$A\hat{R}Q = 41.8103...$	awrt 41.8	A1
			[2]
			Total 9

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