FSMQ

Additional Mathematics

6993/01: Additional Mathematics: Paper 1

Free Standing Mathematics Qualification

Mark Scheme for June 2024

OCR (Oxford Cambridge and RSA) is a leading UK awarding body, providing a wide range of qualifications to meet the needs of candidates of all ages and abilities. OCR qualifications include AS/A Levels, Diplomas, GCSEs, Cambridge Nationals, Cambridge Technicals, Functional Skills, Key Skills, Entry Level qualifications, NVQs and vocational qualifications in areas such as IT, business, languages, teaching/training, administration and secretarial skills.

It is also responsible for developing new specifications to meet national requirements and the needs of students and teachers. OCR is a not-for-profit organisation; any surplus made is invested back into the establishment to help towards the development of qualifications and support, which keep pace with the changing needs of today's society.

This mark scheme is published as an aid to teachers and students, to indicate the requirements of the examination. It shows the basis on which marks were awarded by examiners. It does not indicate the details of the discussions which took place at an examiners' meeting before marking commenced.

All examiners are instructed that alternative correct answers and unexpected approaches in candidates' scripts must be given marks that fairly reflect the relevant knowledge and skills demonstrated.

Mark schemes should be read in conjunction with the published question papers and the report on the examination.

MARKING INSTRUCTIONS

PREPARATION FOR MARKING
RM ASSESSOR

1. Make sure that you have accessed and completed the relevant training packages for on-screen marking: *RM Assessor Assessor Online Training*; *OCR Essential Guide to Marking*.

2. Make sure that you have read and understood the mark scheme and the question paper for this unit. These are posted on the RM Cambridge Assessment Support Portal http://www.rm.com/support/ca

3. Log-in to RM Assessor and mark the **required number** of practice responses ("scripts") and the **number of required** standardisation responses.

   YOU MUST MARK 5 PRACTICE AND 10 STANDARDISATION RESPONSES BEFORE YOU CAN BE APPROVED TO MARK LIVE SCRIPTS.

MARKING

1. Mark strictly to the mark scheme.

2. Marks awarded must relate directly to the marking criteria.

3. The schedule of dates is very important. It is essential that you meet the RM Assessor 50% and 100% (traditional 40% Batch 1 and 100% Batch 2) deadlines. If you experience problems, you must contact your Team Leader (Supervisor) without delay.

4. If you are in any doubt about applying the mark scheme, consult your Team Leader by telephone or the RM Assessor messaging system, or by email.

5. Always check the pages (and additional objects if present) at the end of the response in case any answers have been continued there. If the candidate has continued an answer there, then add the annotation SEEN to confirm that the work has been seen.

6. Award No Response (NR) if:
   - there is nothing written in the answer space

   Award Zero '0' if:
   - anything is written in the answer space and is not worthy of credit (this includes text and symbols).

Team Leaders must confirm the correct use of the NR button with their markers before live marking commences and should check this when reviewing scripts.

7. The RM Assessor **comments box** is used by your team leader to explain the marking of the practice responses. Please refer to these comments when checking your practice responses. **Do not use the comments box for any other reason.**
If you have any questions or comments for your team leader, use the phone, the RM Assessor messaging system, or e-mail.

8. *Assistant Examiners are asked to send a brief report on the performance of candidates to their Team Leader via email by the date specified by your Team Leader. The report should contain notes on particular strengths displayed as well as common errors or weaknesses. Constructive criticism of the question paper/mark scheme is also appreciated.*

11. **Annotations and abbreviations**

Annotation in RM Assessor	**Meaning**
BP	Blank Page – this annotation **must** be used on all blank pages within an answer booklet (structured or unstructured) and on each page of an additional object where there is no candidate response.
✓and ✗	
BOD	Benefit of doubt
FT	Follow through
ISW	Ignore subsequent working
M0, M1	Method mark awarded 0, 1
A0, A1	Accuracy mark awarded 0, 1
B0, B1	Independent mark awarded 0, 1
SC	Special case
^	Omission sign
Other abbreviations in mark scheme	**Meaning**
AG	Answer given

DM1	M mark dependent on previous M mark
cao	Correct answer only
oe	Or equivalent
soi	Seen or implied
www	Without wrong working
ft	Follow through. The mark is awarded if it is as a result of starting with an incorrect value and there is no further error in working
awrt	Answer which rounds to
DR	This is to remind you that the question has the instruction “In this question you must show detailed reasoning”.

12. **Marking Instructions**

a Annotations should be used whenever appropriate during your marking.

The A, M and B annotations must be used for responses that are not awarded either 0 or full marks. It is vital that you annotate standardisation scripts fully to show how the marks have been awarded.

b An element of professional judgement is required in the marking of any written paper. Remember that the mark scheme is designed to assist in marking incorrect solutions. Correct *solutions* leading to correct answers are awarded full marks but work must not be judged on the answer alone, and answers that are given in the question, especially, must be validly obtained; key steps in the working must always be looked at and anything unfamiliar must be investigated thoroughly.

Correct but unfamiliar or unexpected methods are often signalled by a correct result following an *apparently* incorrect method. Such work must be carefully assessed. When a candidate adopts a method which does not correspond to the mark scheme, award marks according to the spirit of the basic scheme; if you are in any doubt whatsoever (especially if several marks or candidates are involved) you should contact your Team Leader.

c The following types of marks are available.

M
A suitable method has been selected and *applied* in a manner which shows that the method is essentially understood. Method marks are not usually lost for numerical errors, algebraic slips or errors in units. However, it is not usually sufficient for a candidate just to indicate an intention of using some method or just to quote a formula; the formula or idea must be applied to the specific problem in hand, eg by substituting the relevant quantities into the formula. In some cases the nature of the errors allowed for the award of an M mark may be specified.

A
Accuracy mark, awarded for a correct answer or intermediate step correctly obtained. Accuracy marks cannot be given unless the associated Method mark is earned (or implied). Therefore M0 A1 cannot ever be awarded.

B
Mark for a correct result or statement independent of Method marks.

d When a part of a question has two or more 'method' steps, the M marks are in principle independent unless the scheme specifically says otherwise; and similarly where there are several B marks allocated. (The notation 'dep *' is used to indicate

that a particular mark is dependent on an earlier, asterisked, mark in the scheme.) Of course, in practice it may happen that when a candidate has once gone wrong in a part of a question, the work from there on is worthless so that no more marks can sensibly be given. On the other hand, when two or more steps are successfully run together by the candidate, the earlier marks are implied and full credit must be given.

e The abbreviation ft implies that the A or B mark indicated is allowed for work correctly following on from previously incorrect results. Otherwise, A and B marks are given for correct work only — differences in notation are of course permitted. A (accuracy) marks are not given for answers obtained from incorrect working. When A or B marks are awarded for work at an intermediate stage of a solution, there may be various alternatives that are equally acceptable. In such cases, exactly what is acceptable will be detailed in the mark scheme rationale. If this is not the case please consult your Team Leader.

Sometimes the answer to one part of a question is used in a later part of the same question. In this case, A marks will often be 'follow through'. In such cases you must ensure that you refer back to the answer of the previous part question even if this is not shown within the image zone. You may find it easier to mark follow through questions candidate-by-candidate rather than question-by-question.

f Wrong or missing units in an answer should not lead to the loss of a mark unless the scheme specifically indicates otherwise. Candidates are expected to give numerical answers to an appropriate degree of accuracy, with 3 significant figures often being the norm. Small variations in the degree of accuracy to which an answer is given (e.g. 2 or 4 significant figures where 3 is expected) should not normally be penalised, while answers which are grossly over- or under-specified should normally result in the loss of a mark. The situation regarding any particular cases where the accuracy of the answer may be a marking issue should be detailed in the mark scheme rationale. If in doubt, contact your Team Leader.

g **Rules for replaced work**

If a candidate attempts a question more than once, and indicates which attempt he/she wishes to be marked, then examiners should do as the candidate requests.

If there are two or more attempts at a question which have not been crossed out, examiners should mark the better attempt and ignore the others.

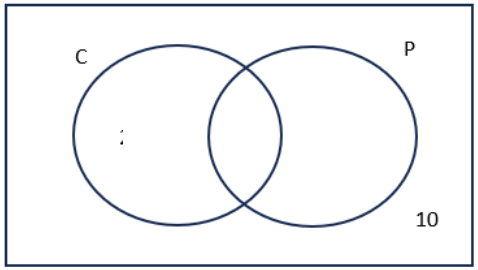
h For a *genuine* misreading (of numbers or symbols) which is such that the object and the difficulty of the question remain unaltered, mark according to the scheme but following through from the candidate's data. A penalty is then applied; 1 mark is generally appropriate, though this may differ for some units. This is achieved by withholding one A mark in the question.

Note that a miscopy of the candidate's own working is not a misread but an accuracy error.

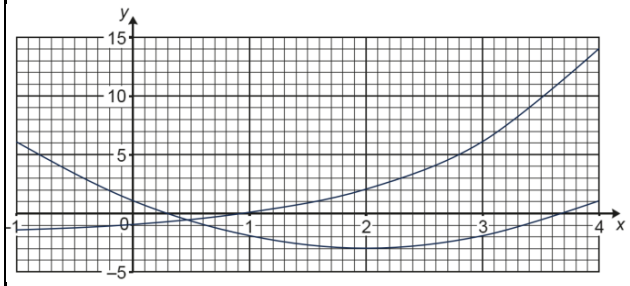
Question			Answer	Marks	Guidance
1			$2-(x+1)>7$ e.g. $2-x-1>7$ or $-(x+1)>5$ $\Rightarrow x<-6$	**M1** **A1**	Correct 1st step. e.g. removal of brackets or collecting like terms or subtract 2 from both sides Accept -6 > *x*
				[2]	

Question			Answer	Marks	Guidance
2			$\log_{10} 2a+2\log_{10} b$ $=\log_{10} 2a+\log_{10} b^2$ $=\log_{10} 2ab^2$	**M1** **A1**	Correct use of at least one log law *Allow answer without any base specified.* N.B. $2\log_{10} 2ab$ or $\log_{10}(2ab)^2$ or $3\log_{10}$ 2ab is M0
				[2]	

Question			Answer	Marks	Guidance
3	(a)		$f(x) = x^2 + 6x - 11$ $= (x+3)^2 - 11 - 9$ $= (x+3)^2 - 20$	**B1** **M1** **A1**	Sight of $(x + 3)^2$ Attempt to find *b* using *their* $(x + 3)^2$
				[3]	
	(b)		$f(x) = 0 \Rightarrow (x+3)^2 = 20$ $\Rightarrow x + 3 = \pm\sqrt{20}$ $\Rightarrow x = -3 \pm \sqrt{20} \left(= -3 \pm 2\sqrt{5}\right)$	**M1** **A1**	Equality and take square root using *their* expression in (a) **cao**. Allow other exact surd forms (isw) N.B. one correct root is M1 A0 Correct roots www B2
				[2]	

Question			Answer	Marks	Guidance
4	(a)			**B1** **B1**	Understanding of a Venn diagram with two rings (not necessarily overlapping, and one could be inside the other) inside a universal set represented by a rectangle Labelled rings overlapping with 10 given outside both (ignore other numbers)
				[2]	
	(b)		Adding 4 sets to make 68 Giving 12 in overlap	**M1** **A1**	**soi** or 3 sets to make 58 Allow 2 marks for 12 clearly seen in diagram for 4(a)
				[2]	

Question			Answer	Marks	Guidance
5			$x_1 = 1, x_2 = 1 \Rightarrow x_3 = 3$ $\Rightarrow x_4 = 3 + 2 = 5$ $\Rightarrow x_5 = 5 + 6 = 11$	**B1** **B1** **B1**	x_3 www x_4 www x_5 www **SC** B2 for answer www
				[3]	

<table>
<tr><th colspan="3">Question</th><th>Answer</th><th>Marks</th><th>Guidance</th></tr>
<tr><td>6</td><td>(a)</td><td></td><td> 

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<tr><td>-1</td><td>0</td><td>1</td><td>2</td><td>3</td><td>4</td></tr>
<tr><td>6</td><td>1</td><td>-2</td><td>-3</td><td>-2</td><td>1</td></tr>
</table>
<table>
<tr><td>-1</td><td>0</td><td>1</td><td>2</td><td>3</td><td>4</td></tr>
<tr><td>-1.5</td><td>-1</td><td>0</td><td>2</td><td>6</td><td>14</td></tr>
</table></td><td>B1
B1

B1
B1</td><td>For quadratic:
Correct points plotted. Allow one error
Smooth curve no more than ½ square from correct points

For exponential:
Correct points plotted. Allow one error
Smooth curve no more than ½ square from correct points

Reminder: the spare copy needs to be annotated as “seen” oe if not used. If used and marked the first grid needs to be annotated.</td></tr>
<tr><td></td><td></td><td></td><td></td><td>[4]</td><td></td></tr>
<tr><td></td><td>(b)</td><td></td><td>0.4 or 0.5</td><td>B1</td><td>Must be to 1 dp
Allow x within a coordinate pair; ignore value for y</td></tr>
<tr><td></td><td></td><td></td><td></td><td>[1]</td><td></td></tr>
</table>

Question			Answer	Marks	Guidance
7	(a)		$\tan^{-1}\frac{20}{80}$ **oe** $=14.0^{o}$	**M1** **A1**	 Accept 14
				[2]	
	(b)		$MC=\sqrt{80^2+60^2}$ $=100$ $\Rightarrow EMC=\tan^{-1}\frac{20}{100}$ $=11.3^{o}$	**M1** **A1** **M1** **A1**	Using Pythagoras' theorem or Pythagorean triple Must be 1dp
			Alternative method $BE=\sqrt{80^2+20^2}=\sqrt{6800}=82.46\left(=20\sqrt{17}\right)$ $ME=\sqrt{their\ BE^2+60^2}=\sqrt{10400}\quad\left(=20\sqrt{26}\right)$ $=101.98$ $\Rightarrow\theta=\sin^{-1}\left(\frac{20}{their\ ME}\right)$ $=11.3$	 **M1** **A1** **M1** **A1**	 Correct use of Pythagoras' theorem twice Awrt 102
				[4]	

Question			Answer	Marks	Guidance
8	(a)		$f(x) = x^3 - 5x^2 + 2x + 8$ e.g. $f(2) = 0$ $\Rightarrow f(x) = (x-2)(x^2 - 3x - 4)$ $\Rightarrow f(x) = (x-2)(x-4)(x+1)$	**M1** **A1** **M1** **A1**	Attempt to find a factor (by any means) Showing that $f(a) = 0$ where $a = -1$, 2, or 4 must be seen Obtain a quadratic and attempt to factorise
			Alternative Method for last two marks e.g. $f(4) = 0$ Complete with third factor and final expression	**M1** **A1**	Try factor theorem with another value
				[4]	
	(b)		$x = -1, 2, 4$	**B1**	**ft** their factors in (a)
				[1]	

<table>
<tr><th colspan="3">Question</th><th>Answer</th><th>Marks</th><th>Guidance</th></tr>
<tr><td>9</td><td>(a)</td><td></td><td>
<table>
<tr><th>2nd dice / 1st dice</th><th>1</th><th>2</th><th>3</th><th>4</th><th>5</th><th>6</th></tr>
<tr><td>1</td><td>1</td><td>2</td><td>3</td><td>4</td><td>5</td><td>6</td></tr>
<tr><td>2</td><td>2</td><td>2</td><td>3</td><td>4</td><td>5</td><td>6</td></tr>
<tr><td>3</td><td>3</td><td>3</td><td>3</td><td>4</td><td>5</td><td>6</td></tr>
<tr><td>4</td><td>4</td><td>4</td><td>4</td><td>4</td><td>5</td><td>6</td></tr>
<tr><td>5</td><td>5</td><td>5</td><td>5</td><td>5</td><td>5</td><td>6</td></tr>
<tr><td>6</td><td>6</td><td>6</td><td>6</td><td>6</td><td>6</td><td>6</td></tr>
</table>
</td><td>B2,1</td><td>All correct – 1 for one error, B0 for more than one error</td></tr>
<tr><td></td><td></td><td></td><td></td><td>[2]</td><td></td></tr>
<tr><td></td><td>(b)
(i)</td><td></td><td>$\frac{1}{36}$</td><td>B1</td><td>ft from their table</td></tr>
<tr><td></td><td></td><td></td><td></td><td>[1]</td><td></td></tr>
<tr><td></td><td>(b)
(ii)</td><td></td><td>$\frac{11}{36}$</td><td>B1</td><td>ft from their table</td></tr>
<tr><td></td><td></td><td></td><td></td><td>[1]</td><td></td></tr>
</table>

Question			Answer	Marks	Guidance
10			$y = x^3 - 6x^2 + 9x + 4$ $\Rightarrow \frac{dy}{dx} = 3x^2 - 12x + 9$	**M1** **A1**	Diffn: powers reduced by 1 in at least one term and coefficients adjusted
			$= 0$ when $x^2 - 4x + 3 = 0$ $\Rightarrow x = 1, 3$ $\Rightarrow y = 8, 4$	**M1** **A1**	Set = 0 and attempt to solve quadratic (soi) For values of x
			i.e.(1, 8) and (3, 4)	**A1**	Must be as coordinate pairs
				[5]	

Question			Answer	Marks	Guidance
11			$\frac{dy}{dx} = 4 + 6x - 3x^2$ $\Rightarrow (y =) 4x + 3x^2 - x^3 + c$	**M1** **A1**	Integrate: powers in at least one term increased by 1 and coefficients adjusted Ignore c
			Substitute (1, 5) $\Rightarrow 5 = 4 + 3 - 1 + c$ $\Rightarrow c = -1$	**M1**	Substitute into *their* function, c must be included
			$\Rightarrow y = 4x + 3x^2 - x^3 - 1$	**A1**	Must be seen and must include $y =$
				[4]	

Question			Answer	Marks	Guidance
12	(a)		$A=\frac{1}{2}\times 1\times\left(y_0+2\left(y_1+y_2+y_3+y_4\right)+y_5\right)$ $=\frac{1}{2}\left(1+2\times\left(1.13+1.43+2.11+3.69\right)+7.30\right)$ $=12.5$	**M1** **A1** **A1**	Use of correct formula (with $h = 1$) or add 5 separate trapezia Correct substitutions **soi** Must be to 1 dp N.B. Use of Simpson's rule is M0 Answer with no working is M0
				[3]	
	(b)	**(i)**	$\frac{\left(y_4-y_2\right)}{2}$ $=1.1$	**M1** **A1**	Use of central difference method with $h = 1$ Accept 1.13 isw
			Alternative methods Central difference with $h = 2$ Or Forward difference with $h = 1$ or 2 Or Backwards difference with $h = 1,2,3$	**M1** **A0**	
				[2]	
		(ii)	Collect data for smaller intervals	**B1**	If M1 A0 in part (b)(i) then accept an answer suggesting an improvement on what they have (e.g. use central difference method)
				[1]	

Backwards difference

$\frac{2.11-1.43}{1}$ or $\frac{2.11-1.13}{2}$ or $\frac{2.11-1}{3}$

$=0.68$ $=0.49$ $=0.37$

Forward difference

$\frac{3.69-2.11}{1}$ or $\frac{7.30-2.11}{2}$

$=1.58$ $=2.595$

Central difference with $h = 2$

$\frac{7.30-1.13}{4}$

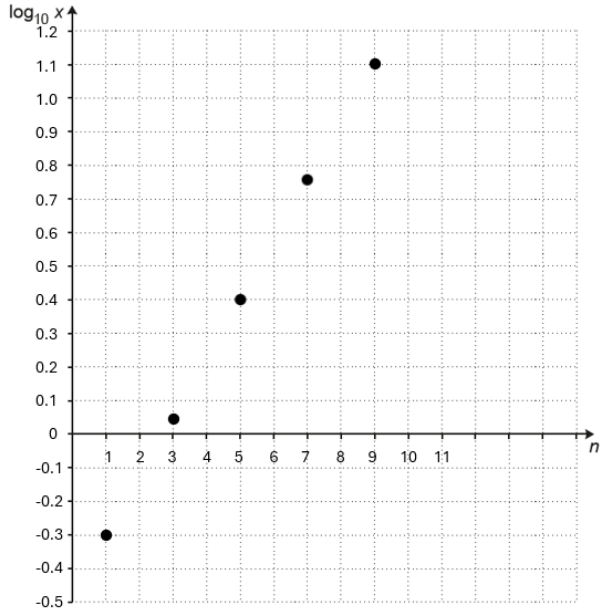
$=1.54$

Question			Answer	Marks	Guidance
13	(a)		f(2) = –1 f(3) = 17 Change of sign means that the root lies in between **oe**	**M1** **A1**	Correct substitutions seen Values correct and conclusion must be seen
				[2]	
	(b)	(i)	$x^3 - x - 7 = 0$ $\Rightarrow x^3 = x + 7$ $\Rightarrow x = \sqrt[3]{x+7}$ $\left(\text{So use } x_{r+1} = \sqrt[3]{x_r + 7}\right)$	**M1** **A1**	Correct rearrangement Or alternatively do it in reverse Convincing algebra (AG)
				[2]	
		(ii)	$x_1 = \sqrt[3]{x_0 + 7} = 2.08....$ $\Rightarrow x_2 = \sqrt[3]{x_1 + 7} = 2.086...$ $\Rightarrow x_3 = \sqrt[3]{x_2 + 7} = 2.086...$ $\Rightarrow (\alpha =) 2.09$	**M1** **A1**	Sight of correct use of formula Conclusion plus sight of x_3 (or other justification for 3sf) e.g. x =2.085 gives f(x)< 0 and x = 2.095 gives f(x)> 0 Accept "x = " in final answer
				[2]	

<table>
<tr><th colspan="3">Question</th><th>Answer</th><th>Marks</th><th>Guidance</th></tr>
<tr><td>14</td><td>(a)</td><td></td><td>$x = ka^n$
$\Rightarrow \log x = \log k + n \log a$

Interpretation of the equation as a straight line</td><td>M1
A1

A1</td><td>Correct use of at least one of the log laws

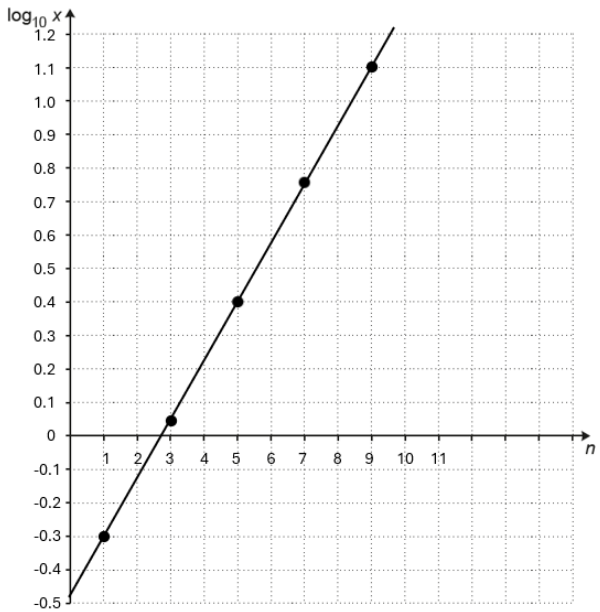
i.e. is of the form $Y = MX + C$</td></tr>
<tr><td></td><td></td><td></td><td></td><td>[3]</td><td></td></tr>
<tr><td></td><td>(b)</td><td></td><td>
<table>
<tr><td>n</td><td>1</td><td>3</td><td>5</td><td>7</td><td>9</td></tr>
<tr><td>x</td><td>0.5</td><td>1.1</td><td>2.5</td><td>5.7</td><td>12.8</td></tr>
<tr><td>$\log_{10} x$</td><td>-0.30</td><td>0.04</td><td>0.40</td><td>0.76</td><td>1.1</td></tr>
</table>


</td><td>M1

A2,1</td><td>Evidence of taking logs

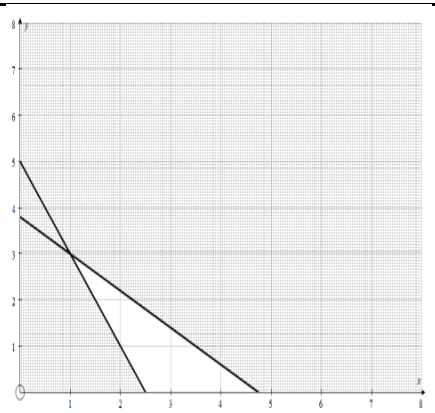
Correct points plotted –A1 for one error A0 for more than one error
A0 if either scale is not linear

A reminder that the spare grid must be annotated.</td></tr>
<tr><td></td><td></td><td></td><td></td><td>[3]</td><td></td></tr>
</table>

	(c)	**(i)**		**B1**	Straight line with positive gradient and (which would have) a negative intercept that best fits *their* log values *A reminder that the spare grid must be annotated.*
				[1]	
		(ii)	Points appear to lie on a (straight) line **oe**	**B1**	e.g. Linear relationship
				[1]	
	(d)			**M1**	Read off intercept and, with two pairs, calculate gradient (One of the pairs could be (0, *their* intercept)) Then anti-log both soi by answers **Or:** Choose two pairs to form 2 equations and attempt to solve
			Intercept = $\log_{10}k$ = -0.49 giving $k \approx 0.3$	**A1**	One correct. For k awrt .3. Allow 0.35
			Gradient = 0.17 = $\log_{10}a$ giving $a \approx 1.5$	**A1**	Other correct. For a awrt 1.5 SC. Correct answers from original figures B3 cao
				[3]	

Question			Answer	Marks	Guidance
15	(a)		**DR** A (–6, 0) B (6, 0) C(0, 2)	 **B1** **B1** **B1**	 Must be a coordinate pair Must be a coordinate pair Must be a coordinate pair Accept coordinate pairs given on figure
				[3]	
	(b)		$y = 2 - \frac{1}{18}x^2 \Rightarrow \frac{dy}{dx} = -\frac{1}{9}x$ At $(-6, 0), \frac{dy}{dx} = \frac{2}{3}$ $\Rightarrow$ Equation of tangent: $3y = 2x + 12$ **oe**	**M1** **A1** **A1** **A1**	Attempt to differentiate 3 term equation
				[4]	
	(c)		(0,4)	**B1**	
				[1]	
	(d)		Using symmetry: Area = 2(ODB – OCD) Area under curve = $\int_0^6 \left(2 - \frac{1}{18}x^2\right) dx$ $= \left[2x - \frac{1}{54}x^3\right]_0^6 = 12 - 4$ $= 8$ Area of triangle ODB = 12 $\Rightarrow$ Area between $= 12 - 8 = 4$ $\Rightarrow$ Total area = 8	 **M1** **A1** **A1** **B1** **A1**	 Attempt to integrate correct equation – ignore limits N.B. DR means that the integrated function must be seen Correct integration Apply appropriate limits to obtain answer Area of triangle In this method requires multiplication by 2 which can be seen anywhere

			Alternative method (1) $\text{Area} = \int_{-6}^{0}\left(\left(\frac{2}{3}x+4\right)-\left(2-\frac{1}{18}x^2\right)\right)\mathrm{d}x$ $= \int_{-6}^{0}\left(\left(2+\frac{2}{3}x+\frac{1}{18}x^2\right)\right)\mathrm{d}x$ $= \left[2x+\frac{1}{3}x^2+\frac{1}{54}x^3\right]_{-6}^{0}$ $= 0-\left(-12+12-4\right) = 4$ Total area = 4 ×2=8	**B1** **M1** **A1** **A1** **A1**	N.B. DR Subtracting equations before integration Correct expression Attempt to integrate – ignore limits Apply appropriate limits to obtain answer
			Alternative method (2) Use of equation of line BD, $y-0 = -\frac{2}{3}(x-6) \Rightarrow y = -\frac{2}{3}x+4$ $\text{Area} = \int_{0}^{6}\left(\left(-\frac{2}{3}x+4\right)-\left(2-\frac{1}{18}x^2\right)\right)\mathrm{d}x$ $= \int_{0}^{6}\left(\left(2-\frac{2}{3}x+\frac{1}{18}x^2\right)\right)\mathrm{d}x = \left[2x-\frac{1}{3}x^2+\frac{1}{54}x^3\right]_{0}^{6}$ $= \left(12-12+4\right)-0 = 4$	**B1** **M1** **A1** **A1** **A1**	N.B. DR Correct expression Attempt to integrate – ignore limits Apply appropriate limits to obtain answer
			Alternative method (3) Limits from -6 to +6 requires areas to be done separately. Same marking allocation		
			For numerical methods used to find area under curve. Use of Simpson's rule to obtain correct answer B3 then subtract from triangle B2 For any other numerical method M0		
				[5]	

Question			Answer	Marks	Guidance
16	(a)	(i)	$2000x + 1000y \geq 5000$ **oe**	**B1**	"Greater than or equal to" symbol must be seen
				[1]	
		(ii)	$40x + 50y \leq 190$ **oe**	**B1**	"Less than or equal to" symbol must be seen
				[1]	
		(iii)	$2x + y \geq 5$ **and** $4x + 5y \leq 19$	**B1**	**Ft** for their symbols
				[1]	
	(b)			**B1** **B1** **B1** **B1**	One line Second line Shading above one line with negative gradient **ft** Shading below other line with negative gradient **ft** 1st line from (0, 5) to (2.5, 0) 2nd line from (0, 3.8) to (4.75, 0) Accept solid lines or dotted lines
				[4]	
	(c)	(i)	2.5 mg of X and 0 mg of Y	**M1** **A1**	Sight of $x + y =$ ....**soi** by answer Accept (2.5,0) N.B. On the assumption that 0 is not an acceptable answer then accept (x, y) where x is in range [2,2.5] and $y = 5 - 2x$. e.g.(2, 1)
				[2]	
		(ii)	Set $x = y$ $x = y = \frac{5}{3}$	**M1** **A1**	**Soi** by equal quantities of x and y Accept awrt 1.6 or 1.7 (but not 2)
				[2]	

Question			Answer	Marks	Guidance
17	(a)		For all $n>1$, $\frac{n+1}{n-1}>1 \Rightarrow \tan\theta>1$ $\Rightarrow 45<\theta<90$ and $225<\theta<270$	**M1** **A1** **M1** **A1**	$\tan\theta>1$ **soi** 1st range SC Either < given as ≤ then M1 A0 Range in 3rd quadrant only 2nd range ft 1st range N.B Assuming *n* is an integer can earn M1 A0 M1 A1ft
				[4]	
	(b)		$\tan\theta=\frac{n+1}{n-1}\Rightarrow \sin\theta=\left(\frac{n+1}{\sqrt{\left((n+1)^2+(n-1)^2\right)}}\right)$ $\Rightarrow \sin\theta=\left(\frac{n+1}{\sqrt{\left(2n^2+2\right)}}\right)$	**M1** **A1** **M1** **A1**	Ignore ± throughout Formula for sin from Pythagoras or use of right angled triangle Attempt to simplify **cao**
			Alternative method $\tan\theta=\frac{\sin\theta}{\cos\theta}=\frac{n+1}{n-1}\Rightarrow\frac{\sin^2\theta}{\cos^2\theta}=\frac{(n+1)^2}{(n-1)^2}$ $\Rightarrow\frac{\sin^2\theta}{(1-\sin^2\theta)}=\frac{(n+1)^2}{(n-1)^2}$ $\Rightarrow(n-1)^2\sin^2\theta=(1-\sin^2\theta)(n+1)^2$ $\Rightarrow\sin^2\theta\left((n-1)^2+(n+1)^2\right)=(n+1)^2$ $\Rightarrow\sin^2\theta=\frac{(n+1)^2}{n^2-2n+1+n^2+2n+1}$ $\Rightarrow\sin\theta=\frac{(n+1}{\sqrt{2n^2+2}}$	**M1** **A1** **M1** **A1**	Pythagoras for sin and cos Attempt to simplify
				[4]	

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