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INTERNATIONAL A LEVEL MATHEMATICS • PURE 3

Pure Mathematics 3

Exam Questions by Topic: Mark Scheme

Pearson Edexcel International Advanced Level (WMA13/01) • Calculator allowed

Every question in the booklet, marked line by line the way an examiner marks it

Chapters (tap a chapter to jump to it)	Qs	Marks	Page	My score
1 Algebraic Methods Algebraic fractions, improper fractions and algebraic division	10	69	own PDF	
2 Functions and Graphs Modulus, composite and inverse functions, transformations	10	76	own PDF	
3 Trigonometric Functions sec, cosec, cot, identities, inverse trigonometric functions	10	72	own PDF	
4 Trigonometric Addition Formulae Addition and double-angle formulae, $R\cos(\theta \pm \alpha)$	10	75	own PDF	
5 Exponentials and Logarithms e^x , $\ln x$, modelling, logarithmic graphs	10	78	3	
6 Differentiation Chain, product and quotient rules, trigonometric and exponential functions	10	76	own PDF	
7 Integration Standard integrals, $f(ax+b)$, trigonometric identities, reverse chain rule	10	77	own PDF	
8 Numerical Methods Locating roots, iteration	10	77	own PDF	

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How to use this mark scheme

The same marking rules Pearson examiners use for WMA13.

Mark every line, not just the answer. Method marks are given for a correct method even when the final answer is wrong. If you lost marks, find the *first* line where your working differs from the scheme. That is the thing to fix.

Code	Meaning
M1	Method mark: for knowing a correct method and attempting to apply it. Small slips in the working do not lose this mark.
dM1	Dependent method mark: can only be given if the method mark before it has been given.
A1	Accuracy mark: for a correct answer or line of working. It can only be given if the method mark it depends on has been given.
B1	Independent mark: for a correct result or statement, whatever method was used.
*	The answer is given in the question. Every step must be shown, and the answer must follow from correct working (cso).
cao	Correct answer only.
cso	Correct solution only: no errors anywhere in the working.
ft	Follow through: the mark can be given for correct work using your own earlier (wrong) answer.
oe	Or equivalent: any correct equivalent form is accepted.

“Solutions relying on calculator technology are not acceptable.” When a question says this, a correct final answer with no algebraic working scores **no marks**. The notes under each scheme line say when this applies.



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Chapter 5: Exponentials and Logarithms

Mark scheme. Marks are shown on the right of each line.

Question 1

5 marks

Part	Scheme	Marks
(a)	$e^{2x-1} = 4 \Rightarrow 2x - 1 = \ln 4$	M1
	$x = \frac{1}{2} + \ln 2$	A1
		(2)
(b)	$\ln \frac{2x+3}{x} = 1$	M1
	$2x+3 = ex$	M1
	$x = \frac{3}{e-2}$	A1
		(3)
Total for Question 1: 5 marks		

Question 2

5 marks

Part	Scheme	Marks
	Multiplies by e^x : $2e^{2x} - 7e^x + 3 = 0$	M1
	Correct quadratic in e^x	A1
	$(2e^x - 1)(e^x - 3) = 0$	M1
	$e^x = \frac{1}{2}$ or $e^x = 3$	A1
	$x = -\ln 2, x = \ln 3$	A1
		(5)
Total for Question 2: 5 marks		



Question 3

5 marks

Part	Scheme	Marks
(a)	Increasing curve approaching $y = 3$ from below	B1
	Asymptote $y = 3$ and y intercept $(0, 1)$	B1
	x intercept $(\ln \frac{2}{3}, 0)$	B1
		(3)
(b)	$f(0) = 1$ and $f(x) \rightarrow 3$	M1
	$1 \leq f(x) < 3$	A1
		(2)
Total for Question 3: 5 marks		

Question 4

5 marks

Part	Scheme	Marks
(a)	Gradient $\frac{1.8 - 0.6}{2} = 0.6$	M1
	$\log_{10} y = 0.6 \log_{10} x + 0.6$	A1
		(2)
(b)	$y = 10^{0.6} x^{0.6}$	M1
	$n = 0.6$	A1
	$y = 3.98x^{0.6}$	A1
	The answer must be written as an equation in the form $y = ax^n$ for the final mark.	
		(3)
Total for Question 4: 5 marks		



Question 5

6 marks

Part	Scheme	Marks
(a)	$\log_{10} y = \log_{10} 10^4 - 2 \log_{10} x = 4 - 2 \log_{10} x$ Straight line with negative gradient Meets the axes at $(0, 4)$ and $(2, 0)$	M1 B1 A1 (3)
(b)	Gradient $\frac{1}{2}$: $\log_3 N = \frac{1}{2}t + 2$ $N = 3^{\frac{1}{2}t+2} = 3^2 \left(3^{\frac{1}{2}}\right)^t$ $N = 9(\sqrt{3})^t$, so $a = 9$, $b = \sqrt{3}$ <i>Treating the base as 10 (e.g. $a = 100$) is a misread: maximum M1 M1 A0.</i>	M1 M1 A1 (3)
Total for Question 5: 6 marks		

Question 6

10 marks

Part	Scheme	Marks
(a)	$20 + A = 90$: $A = 70$	B1 (1)
(b)	$55 = 20 + 70e^{-5k}$ $e^{-5k} = \frac{1}{2}$ $-5k = \ln \frac{1}{2}$, so $k = \frac{1}{5} \ln 2$ *	M1 A1 A1* (3)
(c)	$70e^{-kt} = 10$, so $e^{-kt} = \frac{1}{7}$ $t = \frac{\ln 7}{k} = \frac{5 \ln 7}{\ln 2}$ 14.0 minutes	M1 M1 A1 (3)
(d)	$\frac{d\theta}{dt} = -70ke^{-kt}$ At $t = 5$: $-70 \times \frac{\ln 2}{5} \times \frac{1}{2}$ Decreasing at $4.85^\circ\text{C per minute}$ <i>Finding an average rate, e.g. $\frac{55-90}{5}$, scores M0.</i>	M1 M1 A1 (3)
Total for Question 6: 10 marks		



Question 7

10 marks

Part	Scheme	Marks
(a)	$\frac{500}{5} = \boxed{100}$	B1 (1)
(b)	$250 = \frac{500e^{10k}}{4 + e^{10k}} \Rightarrow 1000 + 250e^{10k} = 500e^{10k}$ $e^{10k} = 4$ $k = \frac{1}{10} \ln 4 = \frac{1}{5} \ln 2$ *	M1 A1 A1* (3)
(c)	$P = \frac{500}{4e^{-kt} + 1}$ and $4e^{-kt} \rightarrow 0$ $\boxed{500 \text{ birds}}$	M1 A1 (2)
(d)	$400(4 + e^{kt}) = 500e^{kt} \Rightarrow e^{kt} = 16$ $t = \frac{\ln 16}{\frac{1}{5} \ln 2} = \frac{5 \times 4 \ln 2}{\ln 2}$ $\boxed{20 \text{ years}}$	M1 M1 A1 (3)
(e)	e.g. food or space on the island, disease or predators may change the limit	B1 (1)
Total for Question 7: 10 marks		



Question 8

10 marks

Part	Scheme	Marks
(a)	Gradient $\frac{4.1 - 3.5}{8 - 2} = 0.1$ $\log_{10} N = 0.1t + 3.3$	M1 A1 (2)
(b)	$\log_{10} N = \log_{10} a + t \log_{10} b$ $a = 10^{3.3} = 1995$ $b = 10^{0.1} = 1.26$ <i>The intercept 3.3 is not given on the figure: it must be found from the equation of the line.</i>	M1 A1 A1 (3)
(c)	The number of subscribers is multiplied by about 1.26 each year (an increase of about 26% per year)	B1 (1)
(d)	$10^{0.1 \times 10 + 3.3} = 10^{4.3}$: 20 000	B1 (1)
(e)	$0.1t + 3.3 > \log_{10} 50\,000$ $t = 14.0$ (13.99..., i.e. during the 14th year)	M1 A1 (2)
(f)	e.g. the number would grow without limit, but the number of possible customers is limited	B1 (1)
Total for Question 8: 10 marks		



Question 9

10 marks

Part	Scheme	Marks
(a)	Increasing curve with vertical asymptote $x = 2$ $\ln(2x - 4) = -1 \Rightarrow 2x - 4 = e^{-1}$ $\left(2 + \frac{1}{2e}, 0\right)$	B1 M1 A1 (3)
(b)	$x = \ln(2y - 4) + 1 \Rightarrow 2y - 4 = e^{x-1}$ $f^{-1}(x) = \frac{1}{2}e^{x-1} + 2$ Domain $x \in \mathbb{R}$, range $f^{-1}(x) > 2$	M1 A1 B1 (3)
(c)	$fg(x) = \ln(2e^{2x} - 4) + 1$ $\ln(2e^{2x} - 4) = \ln 4 \Rightarrow 2e^{2x} - 4 = 4$ $e^{2x} = 4$ $x = \ln 2$	B1 M1 M1 A1 (4)
Total for Question 9: 10 marks		



Question 10

12 marks

Part	Scheme	Marks
(a)	$A = 40$ and $B = 120$	B1 (1)
(b)	$40u = 200 - \frac{80}{u}$ $40u^2 - 200u + 80 = 0$ $u^2 - 5u + 2 = 0$ *	M1 A1 A1* (3)
(c)	$u = \frac{5 \pm \sqrt{17}}{2}$ $t \geq 0$ gives $u = e^{0.1t} \geq 1$, so $u = \frac{5 - \sqrt{17}}{2} = 0.438$ is rejected $0.1t = \ln \frac{5 + \sqrt{17}}{2}$ $t = 10 \ln \left(\frac{5 + \sqrt{17}}{2} \right)$	M1 B1 M1 A1 (4)
(d)	$\frac{dA}{dt} = 4e^{0.1t} = 4u$ 18.2 per day	M1 A1 (2)
(e)	$\ln A = \ln 40 + 0.1t$: a straight line of the form $y = mx + c$ in $\ln A$ and t Gradient 0.1, intercept $\ln 40$	M1 A1 (2)
Total for Question 10: 12 marks		

