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INTERNATIONAL A LEVEL MATHEMATICS • PURE 2

Pure Mathematics 2

Exam Questions by Topic: Mark Scheme

Pearson Edexcel International Advanced Level (WMA12/01) • 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, the factor and remainder theorems, proof	10	66	own PDF	
2 Coordinate Geometry in the (x, y) Plane Equations of circles, tangents, chords and intersections	10	68	own PDF	
3 Exponentials and Logarithms Laws of logarithms, exponential equations, modelling	10	68	own PDF	
4 The Binomial Expansion Expanding $(a + bx)^n$, coefficients and approximations	10	65	own PDF	
5 Sequences and Series Arithmetic and geometric series, sigma notation, recurrence	10	69	own PDF	
6 Trigonometric Identities and Equations $\tan \theta = \frac{\sin \theta}{\cos \theta}$, $\sin^2 \theta + \cos^2 \theta = 1$, solving equations	10	66	own PDF	
7 Differentiation Increasing and decreasing functions, stationary points, optimisation	10	67	3	
8 Integration Definite integrals, areas under curves, the trapezium rule	10	67	own PDF	

Question booklet

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Page 1 of 7

How to use this mark scheme

The same marking rules Pearson examiners use for WMA12.

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.



7

Chapter 7: Differentiation

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

Question 1

6 marks

Part	Scheme	Marks
(a)	$\frac{dy}{dx} = 6x^2 - 18x + 12$	M1
	$6(x-1)(x-2) = 0$, so $x = 1, 2$	A1
	Substitutes into y	M1
	$(1, 6)$ and $(2, 5)$	A1
		(4)
(b)	$\frac{d^2y}{dx^2} = 12x - 18$: at $x = 1$ it is -6 and at $x = 2$ it is 6	M1
	$(1, 6)$ is a maximum and $(2, 5)$ is a minimum	A1
		(2)
Total for Question 1: 6 marks		

Question 2

4 marks

Part	Scheme	Marks
	$f'(x) = 3x^2 - 12x - 15$	M1
	$3(x-5)(x+1)$: critical values -1 and 5	A1
	Decreasing where $f'(x) < 0$: chooses the inside region	M1
	$-1 < x < 5$	A1
	Accept $-1 \leq x \leq 5$.	
		(4)
Total for Question 2: 4 marks		



Question 3

5 marks

Part	Scheme	Marks
(a)	$\frac{dy}{dx} = 3x^{\frac{1}{2}} - 12$	M1
	$x^{\frac{1}{2}} = 4$, so $x = 16$	A1
	$(16, -57)$	A1
		(3)
(b)	$\frac{d^2y}{dx^2} = \frac{3}{2}x^{-\frac{1}{2}} = \frac{3}{8}$ at $x = 16$	M1
	$\frac{3}{8} > 0$, so minimum	A1
		(2)
Total for Question 3: 5 marks		

Question 4

4 marks

Part	Scheme	Marks
	$f'(x) = 3x^2 + 6x + 5$	B1
	Completes the square: $3(x+1)^2 + 2$	M1
	$3(x+1)^2 \geq 0$, so $f'(x) \geq 2 > 0$ for all x	A1
	Hence $f(x)$ is increasing for all x	A1
	Alternative: the discriminant of $3x^2 + 6x + 5$ is $36 - 60 < 0$ and the coefficient of x^2 is positive, so $f'(x) > 0$.	(4)
Total for Question 4: 4 marks		

Question 5

5 marks

Part	Scheme	Marks
(a)	$f'(x) = 3x^2 - 6x - 9 = 3(x-3)(x+1) = 0$	M1
	$x = -1, x = 3$	A1
	$(-1, 5)$ and $(3, -27)$	A1
		(3)
(b)	Positive cubic with a maximum at $(-1, 5)$ and a minimum at $(3, -27)$	B1
	Passes through the origin, $(0, 0)$	B1
		(2)
Total for Question 5: 5 marks		



Question 6

8 marks

Part	Scheme	Marks
(a)	Base $(30 - 2x)$ by $(30 - 2x)$ and height x : $V = x(30 - 2x)^2$ $= 4x^3 - 120x^2 + 900x$ *	M1 A1* (2)
(b)	$\frac{dV}{dx} = 12x^2 - 240x + 900$ $12(x - 5)(x - 15) = 0$ $x = 5$ $x = 15$ is rejected: the base would have side $30 - 30 = 0$ cm (no box)	M1 M1 A1 B1 (4)
(c)	$V = 5 \times 20^2 = 2000 \text{ cm}^3$ $\frac{d^2V}{dx^2} = 24x - 240 = -120 < 0$ at $x = 5$, so a maximum	B1 B1 (2)
Total for Question 6: 8 marks		

Question 7

8 marks

Part	Scheme	Marks
(a)	$2x \times x \times h = 72$, so $h = \frac{36}{x^2}$ $S = 2(2x^2) + 2(2xh) + 2(xh) = 4x^2 + 6xh$ $S = 4x^2 + 6x \times \frac{36}{x^2} = 4x^2 + \frac{216}{x}$ *	B1 M1 A1* (3)
(b)	$\frac{dS}{dx} = 8x - 216x^{-2}$ $8x^3 = 216$, so $x = 3$ $S = 36 + 72 = 108 \text{ cm}^2$	M1 A1 A1 (3)
(c)	$\frac{d^2S}{dx^2} = 8 + 432x^{-3}$ $= 24 > 0$ at $x = 3$, so a minimum	M1 A1 (2)
Total for Question 7: 8 marks		



Question 8

8 marks

Part	Scheme	Marks
(a)	Perimeter: $2r + 2h + \pi r = 10$, so $h = \frac{10 - 2r - \pi r}{2}$ $A = 2rh + \frac{1}{2}\pi r^2$ $= r(10 - 2r - \pi r) + \frac{1}{2}\pi r^2 = 10r - \left(2 + \frac{\pi}{2}\right)r^2$ *	B1 M1 A1* (3)
(b)	$\frac{dA}{dr} = 10 - (4 + \pi)r$ $= 0$ gives $r = \frac{10}{4 + \pi}$ Substitutes: $A = \frac{100}{4 + \pi} - \frac{4 + \pi}{2} \times \frac{100}{(4 + \pi)^2}$ $= \frac{100}{4 + \pi} - \frac{50}{4 + \pi} = \frac{50}{4 + \pi}$ *	M1 A1 M1 A1* (4)
(c)	$\frac{d^2A}{dr^2} = -(4 + \pi) < 0$, so a maximum	B1 (1)
Total for Question 8: 8 marks		

Question 9

9 marks

Part	Scheme	Marks
(a)	$f(1) = -2$: $a + b - 12 + 5 = -2$, so $a + b = 5$ $f'(x) = 3ax^2 + 2bx - 12$ and $f'(1) = 0$: $3a + 2b = 12$ Solves simultaneously $a = 2, b = 3$	M1 M1 M1 A1 (4)
(b)	$f'(x) = 6x^2 + 6x - 12 = 6(x + 2)(x - 1)$, so the other point is at $x = -2$: $(-2, 25)$ $f''(x) = 12x + 6$: $f''(1) = 18$ and $f''(-2) = -18$ $(1, -2)$ minimum, $(-2, 25)$ maximum	B1 M1 A1 (3)
(c)	$f'(x) > 0$: outside the roots $x < -2$ or $x > 1$	M1 A1 (2)
Total for Question 9: 9 marks		



Question 10

10 marks

Part	Scheme	Marks
(a)	$\frac{dy}{dx} = 3x^2 - 12x + 9 = 3(x-1)(x-3) = 0$ $x = 1, x = 3$ $(1, 5)$ and $(3, 1)$ $\frac{d^2y}{dx^2} = 6x - 12$: -6 at $x = 1$ and 6 at $x = 3$ $(1, 5)$ maximum, $(3, 1)$ minimum	M1 A1 A1 M1 A1 (5)
(b)	Tangent at the maximum is $y = 5$: $x^3 - 6x^2 + 9x - 4 = 0$ $(x-1)$ is a repeated factor: $(x-1)^2(x-4) = 0$ $P(4, 5)$ <i>Using the factor theorem with $x = 1$ twice, or dividing by $(x-1)^2$, is expected. A calculator solution scores M1 M0 A0.</i>	M1 M1 A1 (3)
(c)	The line $y = k$ must lie strictly between the minimum and the maximum $1 < k < 5$	M1 A1 (2)
Total for Question 10: 10 marks		

