Thursday 22 May 2014 – Morning

AS GCE MATHEMATICS

4722/01 Core Mathematics 2

QUESTION PAPER

Candidates answer on the Printed Answer Book.

OCR supplied materials:
- Printed Answer Book 4722/01
- List of Formulae (MF1)

Other materials required:
- Scientific or graphical calculator

Duration: 1 hour 30 minutes

INSTRUCTIONS TO CANDIDATES

These instructions are the same on the Printed Answer Book and the Question Paper.
- The Question Paper will be found inside the Printed Answer Book.
- Write your name, centre number and candidate number in the spaces provided on the Printed Answer Book. Please write clearly and in capital letters.
- **Write your answer to each question in the space provided in the Printed Answer Book.** Additional paper may be used if necessary but you must clearly show your candidate number, centre number and question number(s).
- Use black ink. HB pencil may be used for graphs and diagrams only.
- Answer **all** the questions.
- Read each question carefully. Make sure you know what you have to do before starting your answer.
- Do **not** write in the bar codes.
- You are permitted to use a scientific or graphical calculator in this paper.
- Give non-exact numerical answers correct to 3 significant figures unless a different degree of accuracy is specified in the question or is clearly appropriate.

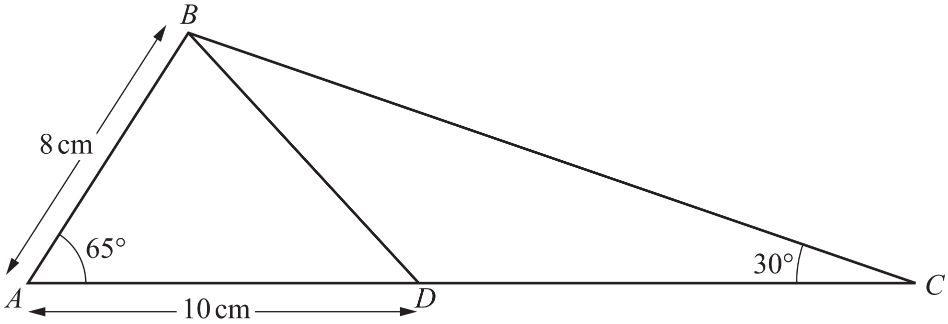
INFORMATION FOR CANDIDATES

This information is the same on the Printed Answer Book and the Question Paper.
- The number of marks is given in brackets **[ ]** at the end of each question or part question on the Question Paper.
- **You are reminded of the need for clear presentation in your answers.**
- The total number of marks for this paper is **72**.
- The Printed Answer Book consists of **12** pages. The Question Paper consists of **4** pages. Any blank pages are indicated.

INSTRUCTION TO EXAMS OFFICER / INVIGILATOR

- Do not send this Question Paper for marking; it should be retained in the centre or recycled. Please contact OCR Copyright should you wish to re-use this document.

1



The diagram shows triangle ABC, with $AB = 8$ cm, angle $BAC = 65°$ and angle $BCA = 30°$. The point D is on AC such that $AD = 10$ cm.

(i) Find the area of triangle ABD. **[2]**

(ii) Find the length of BD. **[2]**

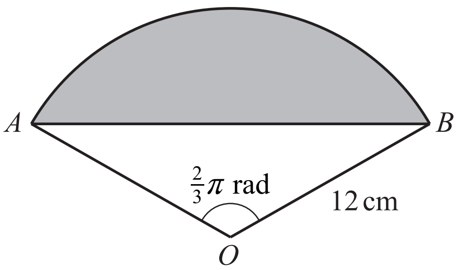
(iii) Find the length of BC. **[2]**

2 A sequence $u_1, u_2, u_3, \ldots$ is defined by $u_n = 3n - 1$, for $n \geqslant 1$.

(i) Find the values of u_1, u_2 and u_3. **[2]**

(ii) Find $\sum_{n=1}^{40} u_n$. **[3]**

3



The diagram shows a sector OAB of a circle, centre O and radius 12 cm. The angle AOB is $\frac{2}{3}\pi$ radians.

(i) Find the exact length of the arc AB. **[2]**

(ii) Find the exact area of the shaded segment enclosed by the arc AB and the chord AB. **[5]**

4 **(i)** Show that the equation

$$\sin x - \cos x = \frac{6\cos x}{\tan x}$$

can be expressed in the form

$$\tan^2 x - \tan x - 6 = 0.$$ **[2]**

(ii) Hence solve the equation $\sin x - \cos x = \dfrac{6\cos x}{\tan x}$ for $0° \leqslant x \leqslant 360°$. **[4]**

5 Solve the equation $2^{4x-1} = 3^{5-2x}$, giving your answer in the form $x = \dfrac{\log_{10} a}{\log_{10} b}$. **[6]**

6 **(i)** Find the binomial expansion of $\left(x^3 + \dfrac{2}{x^2}\right)^4$, simplifying the terms. **[5]**

(ii) Hence find $\displaystyle\int \left(x^3 + \frac{2}{x^2}\right)^4 \mathrm{d}x$. **[4]**

7 The cubic polynomial $f(x)$ is defined by $f(x) = 12 - 22x + 9x^2 - x^3$.

(i) Find the remainder when $f(x)$ is divided by $(x + 2)$. **[2]**

(ii) Show that $(3 - x)$ is a factor of $f(x)$. **[1]**

(iii) Express $f(x)$ as the product of a linear factor and a quadratic factor. **[3]**

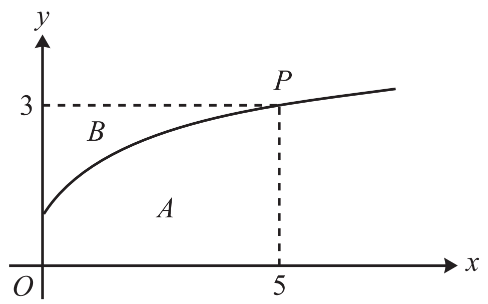
(iv) Hence solve the equation $f(x) = 0$, giving each root in simplified surd form where appropriate. **[3]**

8 **(a)** The first term of a geometric progression is 50 and the common ratio is 0.8. Use logarithms to find the smallest value of k such that the value of the kth term is less than 0.15. **[4]**

(b) In a different geometric progression, the second term is –3 and the sum to infinity is 4. Show that there is only one possible value of the common ratio and hence find the first term. **[8]**

Question 9 begins on page 4.

9



The diagram shows part of the curve $y = -3 + 2\sqrt{x+4}$. The point $P(5, 3)$ lies on the curve. Region A is bounded by the curve, the x-axis, the y-axis and the line $x = 5$. Region B is bounded by the curve, the y-axis and the line $y = 3$.

(i) Use the trapezium rule, with 2 strips each of width 2.5, to find an approximate value for the area of region A, giving your answer correct to 3 significant figures. **[3]**

(ii) Use your answer to part **(i)** to deduce an approximate value for the area of region B. **[2]**

(iii) By first writing the equation of the curve in the form $x = \mathrm{f}(y)$, use integration to show that the exact area of region B is $\frac{14}{3}$. **[7]**

END OF QUESTION PAPER

Question			Answer	Marks	Guidance	
1	(i)		area = $^1/_2 \times 8 \times 10 \times \sin 65°$	M1	Attempt area of triangle using $\frac{1}{2}ab\sin\theta$	Must be correct formula, including $\frac{1}{2}$ Allow if evaluated in radian mode (gives 33.1) If using $\frac{1}{2} \times b \times h$, then must be valid use of trig to find h
			= 36.3	A1 **[2]**	Obtain 36.3, or better	If > 3sf, allow answer rounding to 36.25 with no errors seen
	(ii)		$BD^2 = 8^2 + 10^2 - 2 \times 8 \times 10 \times \cos 65°$	M1	Attempt use of correct cosine rule	Must be correct cosine rule Allow M1 if not square rooted, as long as BD^2 seen Allow if evaluated in radian mode (gives 15.9) Allow if correct formula is seen but is then evaluated incorrectly - using $(8^2 + 10^2 - 2 \times 8 \times 10) \times \cos 65°$ gives 1.30 Allow any equiv method, as long as valid use of trig
			$BD = 9.82$	A1 **[2]**	Obtain 9.82, or better	If > 3sf, allow answer rounding to 9.817 with no errors seen
	(iii)		$\frac{BC}{\sin 65} = \frac{8}{\sin 30}$	M1	Attempt use of correct sine rule (or equiv)	Must get as far as attempting BC, not just quoting correct sine rule Allow any equiv method, as long as valid use of trig including attempt at any angles used If using their BD from part **(ii)** it must have been a valid attempt (eg M0 for $BD = 8\sin 65$, $BC = {}^{BD}/_{\sin 30} = 14.5$)
			$BC = 14.5$	A1 **[2]**	Obtain 14.5, or better	If >3sf, allow answer rounding to 14.5 with no errors in method seen In multi-step solutions (eg using 9.82) interim values may be slightly inaccurate – allow A1 if answer rounds to 14.5

Question			Answer	Marks	Guidance	
2	(i)		2, 5, 8	B1	Obtain at least one correct value	Either stated explicitly or as part of a longer list, but must be in correct position eg -1, 2, 5 is B0
				B1	Obtain all three correct values	Ignore any subsequent values, if given
				[2]		
	(ii)		$S_{40} = \frac{40}{2}(2 \times 2 + 39 \times 3)$	B1*	Identify AP with $a = 2$, $d = 3$	Could be stated, listing of further terms linked by '+' sign or by recognisable attempt at any formula for AP including attempt at u_{40}
			$= 2420$	M1d*	Attempt to sum first 40 terms of the AP	Must use correct formula, with $a = 2$ and $d = 3$ If using ½n ($a + l$) then must be valid attempt at l Could use $3\sum n - \sum 1$, but M0 for $3\sum n - 1$ If summing manually then no need to see all middle terms explicitly as long as intention is clear
				A1	Obtain 2420	Either from formula or from manual summing of 40 terms
				[3]		

Question			Answer	Marks	Guidance	
3	(i)		arc = $12 \times \frac{2\pi}{3}$	M1	Attempt use of $r\theta$	Allow M1 if using θ as $^2/_3$ M1 implied by sight of 25.1, or better M0 if $r\theta$ used with θ in degrees M1 for equiv method using fractions of a circle, with θ as 120^o
			$= 8\pi$	A1 **[2]**	Obtain 8π only	Given as final answer - A0 if followed by 25.1
	(ii)		sector = $\frac{1}{2} \times 12^2 \times \frac{2\pi}{3} = 48\pi$	M1*	Obtain area of sector using $\frac{1}{2}r^2\theta$	Must be correct formula, including $\frac{1}{2}$ Must have $r = 12$ Allow M1 if using θ as $^2/_3$ M0 if $\frac{1}{2}r^2\theta$ used with θ in degrees M1 for equiv method using fractions of a circle, with θ as 120^o M1 implied by sight of 151 or better
			triangle = $\frac{1}{2} \times 12^2 \times \sin\frac{2\pi}{3} = 36\sqrt{3}$	M1*	Attempt area of triangle using $\frac{1}{2}r^2\sin\theta$	Must be correct formula, including $\frac{1}{2}$ Must have $r = 12$ Allow M1 if using θ as $^2/_3$ Allow even if evaluated in incorrect mode (2.63 or 41.8) If using $\frac{1}{2} \times b \times h$, then must be valid use of trig to find b and h M1 implied by sight of 62.4, or better
			segment = $48\pi - 36\sqrt{3}$	M1d*	Correct method to find segment area	Area of sector – area of triangle M0 if using θ as $^2/_3$ Could be exact or decimal values
				A1	Obtain either $48\pi - 36\sqrt{3}$ or 88.4	Allow decimal answer in range [88.44, 88.45] if >3sf
				A1 **[5]**	Obtain $48\pi - 36\sqrt{3}$ only	Given as final answer - A0 if followed by 88.4

Question			Answer	Marks	Guidance	
4	(i)		$\tan x\,(\sin x - \cos x) = 6\cos x$ $\tan x\,(\sin x/\cos x - 1) = 6$ $\tan x\,(\tan x - 1) = 6$	M1	Use $\tan x = \frac{\sin x}{\cos x}$ correctly once	Must be used clearly at least once - either explicitly or by writing eg 'divide by $\cos x$' at side of solution Allow M1 for any equiv eg $\sin x = \cos x \tan x$ Allow poor notation eg writing just tan rather than $\tan x$
			$\tan^2 x - \tan x = 6$ $\tan^2 x - \tan x - 6 = 0$ **AG**	A1	Obtain $\tan^2 x - \tan x - 6 = 0$	Correct equation in given form, including $= 0$ Correct notation throughout so A0 if eg tan rather than $\tan x$ seen in solution
				[2]		
	(ii)		$(\tan x - 3)(\tan x + 2) = 0$ $\tan x = 3$, $\tan x = -2$	M1	Attempt to solve quadratic in $\tan x$	This M mark is just for solving a 3 term quadratic (see guidance sheet for acceptable methods) Condone any substitution used, inc $x = \tan x$
			$x = \tan^{-1}(3)$, $x = \tan^{-1}(-2)$	M1	Attempt to solve $\tan x = k$ at least once	Attempt $\tan^{-1} k$ at least once Not dependent on previous mark so M0M1 possible If going straight from $\tan x = k$ to $x = \ldots$, then award M1 only if their angle is consistent with their k
			$x = 71.6°, 252°, 117°, 297°$	A1	Obtain two correct solutions	Allow 3sf or better Must come from a correct method to solve the quadratic (as far as correct factorisation or substitution into formula) Allow radian equivs ie 1.25 / 4.39 / 2.03 / 5.18
				A1	Obtain all 4 correct solutions, and no others in range	Must now all be in degrees Allow 3sf or better A0 if other incorrect solutions in range $0^\circ - 360^\circ$ (but ignore any outside this range) **SR** If no working shown then allow **B1** for each correct solution (max of **B3** if in radians, or if extra solns in range).
				[4]		

Question			Answer	Marks	Guidance	
5			$(4x-1)\log_{10}2 = (5-2x)\log_{10}3$	M1*	Introduce logs throughout and drop power(s)	Allow no base or base other than 10 as long as consistent, including $\log_3$ on LHS or $\log_2$ on RHS Drop single power if $\log_3$ or $\log_2$ or both powers if any other base
				A1	Obtain $(4x-1)\log_{10}2 =$ $(5-2x)\log_{10}3$	Brackets must be seen, or implied by later working Allow no base, or base other than 10 if consistent Any correct linear equation ie $4x - 1 = (5-2x)\log_2 3$ or $(4x-1)\log_3 2 = 5-2x$
			$x(4\log_{10}2 + 2\log_{10}3) =$ $\log_{10}2 + 5\log_{10}3$	M1*	Attempt to make x the subject	Expand bracket(s) and collect like terms - as far as their $4x\log_{10}2 + 2x\log_{10}3 = \log_{10}2 + 5\log_{10}3$ Expressions could include $\log_2 3$ or $\log_3 2$ Must be working exactly, so M0 if log(s) now decimal equivs
				A1	Obtain a correct equation in which x only appears once	LHS could be $x(4\log_{10}2 + 2\log_{10}3)$, $x\log_{10}144$ or even $\log_{10}144^x$ Expressions could include $\log_2 3$ or $\log_3 2$ RHS may be two terms or single term
			$x\log_{10}144 = \log_{10}486$	M1d*	Attempt correct processes to combine logs	Use $b\log a = \log a^b$, then $\log a + \log b = \log ab$ correctly on at least one side of equation (or $\log a - \log b$) Dependent on previous M1 but not the A1 so $\log_{10}486$ will get this M1 irrespective of the LHS
			$x = \dfrac{\log_{10}486}{\log_{10}144}$	A1 **[6]**	Obtain correct final expression	Base 10 required in final answer - allow A1 if no base earlier, or if base 10 omitted at times, but A0 if different base seen previously (unless legitimate working to change base seen) Do not isw subsequent incorrect log work eg $x = {}^{\log 27}/_{\log 8}$

Question			Answer	Marks	Guidance	
			Alternative solution $2^{4x} \div 2 = 3^5 \div 3^{2x}$ $2^{4x} \times 3^{2x} = 3^5 \times 2$ $16^x \times 9^x = 243 \times 2$ $144^x = 486$ $\log_{10} 144^x = \log_{10} 486$ $x \log_{10} 144 = \log_{10} 486$ $x = \frac{\log_{10} 486}{\log_{10} 144}$	M1 A1 M1 A1 M1 A1	Use index laws to split both terms Obtain $2^{4x} \times 3^{2x} = 3^5 \times 2$ oe Use $a^{bx} = (a^b)^x$ Obtain $144^x = 486$ Introduce logs on both sides and drop power Obtain correct final answer	Either into fractions, or into products involving negative indices ie $2^{4x} \times 2^{-1}$ Combine like terms on each side Use at least once correctly Any correct equation in which x appears only once – logs may have been introduced prior to this Allow no base, or base other than 10 if consistent Do not isw subsequent incorrect log work

Question			Answer	Marks	Guidance	
6	(i)		$(x^3)^4 + 4(x^3)^3(2x^{-2}) + 6(x^3)^2(2x^{-2})^2 + 4(x^3)(2x^{-2})^3 + (2x^{-2})^4$ $= x^{12} + 8x^7 + 24x^2 + 32x^{-3} + 16x^{-8}$	M1*	Attempt expansion – products of powers of x^3 and $2x^{-2}$	Must attempt at least 4 terms Each term must be an attempt at a product, including binomial coeffs if used Allow M1 if no longer $2x^{-2}$ due to index errors Allow M1 for no, or incorrect, binomial coeffs Powers of x^3 and $2x^{-2}$ must be intended to sum to 4 within each term (allow slips if intention correct) Allow M1 even if powers used incorrectly with $2x^{-2}$ ie only applied to x^{-2} and not to 2 as well Allow M1 for expansion of bracket in $x^k(1 + 2x^{-5})^4$ with $k = 3$ or 12 only, or $x^k(x^5 + 2)^4$ with $k = -2$ or -8 only, oe
				M1d*	Attempt to use correct binomial coeffs	At least 4 correct from 1, 4, 6, 4, 1 - allow missing or incorrect (but not if raised to a power) May be implied rather than explicit Must be numerical eg ${}^4C_1$ is not enough They must be part of a product within each term The coefficient must be used in an attempt at the relevant term ie $6(x^3)^3(2x^{-2})$ is M0 Allow M1 for correct coefficients when expanding the bracket in $x^k(1 + 2x^{-5})^4$ or $x^k(x^5 + 2)^4$ $x^{12} + 8x^7 + 12x^2 + 8x^{-3} + 2x^{-8}$ gets M1 M1 implied (even if no method seen) – will also get the first A1 as well
				A1	Obtain two correct simplified terms	Either linked by '+' or as part of a list Powers and coefficients must be simplified
				A1	Obtain a further two correct terms	Either linked by '+' or as part of a list Powers and coefficients must be simplified
				A1 **[5]**	Obtain a fully correct expansion	Terms must be linked by '+' and not just commas Powers and coefficients must be simplified A0 if subsequent attempt to simplify indices (eg x by x^8)

Question			Answer	Marks	Guidance	
						SR for reasonable expansion attempt: M2 for attempt involving all 4 brackets resulting in a quartic with at most one term missing A1 for two correct, simplified, terms A1 for a further two correct, simplified, terms A1 for fully correct, simplified, expansion
	(ii)		$\frac{1}{13}x^{13} + x^8 + 8x^3 - 16x^{-2} - \frac{16}{7}x^{-7} + c$	M1*	Attempt integration	Increase in power by 1 for at least three terms (other terms could be incorrect) Can still gain M1 if their expansion does not have 5 terms Allow if the three terms include x^{-1} becoming $k\ \ln x$ (but not x^0)
				A1FT	Obtain at least 3 correct terms, following their **(i)**	Allow unsimplified coefficients
				A1	Obtain fully correct expression	Coefficients must be fully simplified, inc x^8 not $1x^8$ isw subsequent errors eg $16x^{-2}$ then being written with 16 as well as x^2 in the denominator of a fraction
				B1d* **[4]**	$+ c$, and no dx or integral sign in answer	Ignore notation on LHS such as $\int = \ldots$, $y = \ldots$, $\frac{dy}{dx} = \ldots$

Question			Answer	Marks	Guidance	
7	(i)		$f(-2) = 12 - 22(-2) + 9(-2)^2 - (-2)^3$ $= 12 + 44 + 36 + 8$	M1	Attempt f(–2) or equiv	M0 for using $x = 2$ (even if stated to be f(-2)) Allow slips in evaluation as long as intention is clear At least one of the second or fourth terms must be of the correct sign Allow any other valid method to divide by $(x + 2)$ as long as remainder is attempted (see guidance in part **(iii)** for acceptable methods)
			$= 100$	A1 **[2]**	Obtain 100	Do not ISW if subsequently given as -100 If using division, just seeing 100 on bottom line is fine unless subsequently contradicted by eg -100 or $^{100}/_{x+2}$
	(ii)		$f(3) = 12 - 66 + 81 - 27 = 0$	B1 **[1]**	Attempt f(3), and show = 0	$12 - 22(3) + 9(3)^2 - (3)^3 = 0$ is enough B0 for just stating f(3) = 0 If using division must show '0' on last line or make equiv comment such as ‘no remainder’ If using coefficient matching must show 'R = 0' Just writing f(x) as the product of the linear factor and the correct quadratic factor is not enough evidence - need to show that the expansion would give f(x) Ignore incorrect terminology eg '$x = 3$ is a factor' or '$(3 - x)$ is a root'

Question		Answer	Marks	Guidance	
	(iii)	$f(x) = (3 - x)(x^2 - 6x + 4)$	M1	Attempt complete division by $(3 - x)$ or $(x - 3)$, or equiv	Must be complete method - ie all 3 terms attempted Allow M1 if dividing $x^3 - 9x^2 + 22x - 12$ by $(3 - x)$ oe Long division - must subtract lower line (allow one slip) Inspection - expansion must give at least three correct terms of the cubic Coefficient matching - must be valid attempt at all coeffs of quadratic, considering all relevant terms each time Synthetic division - must be using 3 (not -3) and adding within each column (allow one slip); expect to see $\begin{array}{c\|cccc} 3 & 1 & -9 & 22 & -12 \\ & & 3 & -18 & \\ \hline & 1 & -6 & 4 & \end{array}$ Allow A1 even if division is inconsistent eg dividing $f(x)$ by $(x - 3)$ or $-f(x)$ by $(3 - x)$
			A1	Obtain $x^2 - 6x + 4$ or $-x^2 + 6x - 4$	Must be explicit and not implied ie $A = 1$ etc in coeff matching method or just the bottom line in the synthetic division method is not enough
			A1	Obtain $(3 - x)(x^2 - 6x + 4)$ or $(x - 3)(-x^2 + 6x - 4)$	Must be written as a product, just stating the quadratic quotient by itself is not enough Must come from a method with consistent signs in the divisor and dividend
			[3]		
	(iv)	$x = 3$	B1	State $x = 3$	At any point
		$x = 3 \pm \sqrt{5}$	M1	Attempt to find roots of quadratic quotient	Can gain M1 if using an incorrect quotient from **(iii)**, as long as it is a three term quadratic and comes from a division attempt by $(3 - x)$ or $(x - 3)$ See Appendix 1 for acceptable methods
			A1	Obtain $x = 3 \pm \sqrt{5}$	Must be in simplified surd form Allow A1 if from $-f(x) = 0$ eg $(x - 3)(x^2 - 6x + 4) = 0$
			[3]		

Question			Answer	Marks	Guidance	
8	(a)		$u_k = 50 \times 0.8^{k-1}$	B1	State correct $50 \times 0.8^{k-1}$	Allow B1 even if it subsequently becomes 40^{k-1} Could be implied by a later (in)equation eg $0.8^{k-1} < 0.003$ Must be seen correct numerically so stating $a = 50$, $r = 0.8$, $u_k = ar^{k-1}$ is not enough
			$50 \times 0.8^{k-1} < 0.15$ $0.8^{k-1} < 0.003$ $\log 0.8^{k-1} < \log 0.003$	M1	Link to 0.15, rearrange and introduce logs or equiv	Allow any sign, equality or inequality Allow no, or consistent, log base on both sides or $\log_{0.8}$ on RHS If starting with $\log (50 \times 0.8^{k-1}) < \log 0.15$ then the LHS must be correctly split to $\log 50 + \log 0.8^{k-1}$ for M1 M0 if solving $40^{k-1} < 0.15$ Allow M1 if using 50×0.8^{k} M0 if using S_k
			$(k - 1) \log 0.8 < \log 0.003$	A1	Obtain correct linear (in)equation	Could be $(k - 1) \log 0.8 < \log 0.003$, $(k - 1) < \log_{0.8} 0.003$ or $\log 50 + (k - 1)\log 0.8 < \log 0.15$ Allow no brackets if implied by later work Allow any linking sign, including >
			$k > 27.03$ $k = 28$	A1 **[4]**	Obtain $k = 28$ (equality only)	Must be equality in words or symbols ie $k = 28$ or k is 28, but A0 for $k \geq 28$ or k is at least 28 Allow BOD if inequality sign not correct throughout as long correct final conclusion Answer only, or trial and improvement, is eligible for the first B1 only Allow n not k throughout

Question			Answer	Marks	Guidance	
	(b)		$ar = -3$, $\frac{a}{1-r} = 4$	B1	State $ar = -3$	Any correct statement, including $a \times r^{(2-1)} = -3$ etc soi
				B1	State $\frac{a}{1-r} = 4$	Any correct statement, not involving r^{∞} (unless it becomes 0) soi
			$-\frac{3}{r} = 4(1-r)$	M1*	Attempt to eliminate either a or r	Using valid algebra so M0 for eg $a = -3 - r$ Must be using ar^k and $^{\pm a}/_{(\pm 1 \pm r)}$ Award as soon as equation in one variable is seen
			$4r^2 - 4r - 3$ (= 0) / $a^2 - 4a - 12$ (= 0)	A1	Obtain correct simplified quadratic	Any correct quadratic not involving fractions or brackets ie $4r^2 = 4r + 3$ gets A1
			$(2r - 3)(2r + 1)=0$ / $(a - 6)(a + 2)=0$	M1d*	Attempt to solve 3 term quadratic	See Appendix 1 for acceptable methods
			$r = -\frac{1}{2}$	M1**	Identify $r = -\frac{1}{2}$ as only ratio with a minimally acceptable reason	M0 if no, or incorrect, reason given Must have correct quadratic, correct factorisation and correct roots (if stated) If $r = -\frac{1}{2}$ is not explicitly identified then allow M1 when they use only this value to find a (or later eliminate the other value) Could accept $r = -\frac{1}{2}$ as $r < 1$or reject $r = \frac{3}{2}$ as > 1 Could reject $a = -2$ as S_∞ is positive Could refer to convergent / divergent series
			$a = 6$	A1	Obtain $a = 6$ only	If solving quadratic in a, then both values of a may be seen initially - A1 can only be awarded when $a = 6$ is given as only solution
			for sum to infinity $-1 < r < 1$	A1d**	Convincing reason for $r = -\frac{1}{2}$ as the only possible ratio	Must refer to $\lvert r \rvert < 1$ or $-1 < r < 1$ oe in words A0 if additional incorrect statement
				[8]		No credit for answer only unless both r first found

Question			Answer	Marks	Guidance	
9	(i)		$0.5 \times 2.5 \times (1 + 2(-3 + 2\sqrt{6.5}) + 3)$	M1*	Attempt y-values at $x = 0, 2.5, 5$ only	M0 if additional y-values found, unless not used y_1 can be exact or decimal (2.1 or better) Allow M1 for using incorrect function as long as still clearly y-values that are intended to be the original function eg $-3 + 2\sqrt{x} + 4$ (from $\sqrt{(x+4)} = \sqrt{x} + \sqrt{4}$)
			$= 10.2$	M1d*	Attempt correct trapezium rule, inc $h = 2.5$	Fully correct structure reqd, including placing of y-values The 'big brackets' must be seen, or implied by later working Could be implied by stating general rule in terms of y_0 etc, as long as these have been attempted elsewhere and clearly labelled Using x-values is M0 Can give M1, even if error in evaluating y-values as long correct intention is clear
				A1	Obtain 10.2, or better	Allow answers in the range [10.24, 10.25] if >3sf A0 if exact surd value given as final answer Answer only is 0/3 Using 2 separate trapezia can get full marks Using anything other than 2 strips of width 2.5 is M0 Using the trapezium rule on result of an integration attempt is 0/3
				[3]		
	(ii)		$(5 \times 3) - 10.2 = 4.8$	M1	Attempt area of rectangle – their **(i)**	As long as $0 <$ their **(i)** < 15
				A1FT	Obtain 4.8, or better	Allow for exact surd value as well Allow answers in range [4.75, 4.80] if > 2sf
				[2]		

Question		Answer	Marks	Guidance	
	(iii)	$x = \frac{1}{4}(y^2 + 6y - 7)$	M1	Attempt to write as $x = \mathrm{f}(y)$	Must be correct order of operations, but allow slip with inverse operations eg + / – , and omitting to square the $\frac{1}{2}$ Allow $y^2 + 9$ from an attempt to square $y + 3$, even if $(y + 3)^2$ is not seen explicitly first Allow maximum of 1 error
			A1	Obtain $x = \frac{1}{4}(y^2 + 6y - 7)$ aef	Allow A1 as soon as any correct equation seen in format $x = \mathrm{f}(y)$, eg $x = \frac{1}{4}(y + 3)^2 - 4$ or $x = \frac{1}{4}(y^2 + 6y + 9) - 4$, and isw subsequent error
		area = $\left[\frac{1}{12}y^3 + \frac{3}{4}y^2 - \frac{7}{4}y\right]_1^3$	M1*	Attempt integration of f(y)	Expand bracket and increase in power by 1 for at least two terms (allow if constant term disappears) Independent of rearrangement attempt so M0M1 is possible Can gain M1 if their f(y) has only two terms, as long as both increase in power by 1 Allow M1 for $k(y+3)^3$, any numerical k, as the integral of $(y + 3)^2$ or M1 for $k(\frac{1}{2}(y+3))^3$ from $(\frac{1}{2}(y + 3))^2$ oe if their power is other than 2
			A1	Obtain $\frac{1}{12}y^3 + \frac{3}{4}y^2 - \frac{7}{4}y$ aef	Or $\frac{1}{12}(y + 3)^3 - 4y$ A0 if constant term becomes $-\frac{7}{4}x$ not $-\frac{7}{4}y$
			B1	State or imply limits are $y = 1, 3$	Stated, or just used as limits in definite integral Allow B1 even if limits used incorrectly (eg wrong order, or addition) Allow B1 even if constant term is $-\frac{7}{4}x$ (or their cx)

Question			Answer	Marks	Guidance	
			$= \frac{15}{4} - (-\frac{11}{12})$	M1d*	Attempt correct use of limits	Correct order and subtraction Allow M1 (BOD) if y limits used in $-\frac{7}{4}x$ (or their cx), but M0 if $x = 0, 5$ used Minimum of two terms in y Only term allowed in x is their c becoming cx Allow processing errors eg $(\frac{1}{12} \text{ x } 3)^3$ for $\frac{1}{12} \text{ x } 3^3$ Answer is given so M0 if $\frac{14}{3}$ appears with no evidence of use of limits Minimum working required is $\frac{15}{4} + \frac{11}{12}$ Allow M1 if using decimals (0.92 or better for $\frac{11}{12}$) M0 if using lower limit as $y = 0$, even if $y = 3$ is also used Limits must be from attempt at y-values, so M0 if using 0 and 5
			$= \frac{14}{3}$ **AG**	A1 **[7]**	Obtain $\frac{14}{3}$	Must come from exact working ie fractions or recurring decimals - correct notation required so A0 for 0.9166... A0 if $-\frac{7}{4}x$ seen in solution **SR** for candidates who find the exact area by first integrating onto the x-axis: **B4** obtain area between curve and x-axis as $10\ ^1/_3$ **B1** subtract from 15 to obtain $^{14}/_3$ And, if seen in the solution, **M1A1** for $x = \text{f}(y)$ as above