	1 1				
Question	Scheme	Marks	AOs		
2	$\frac{9^{x-1}}{3^{y+2}} = 81 \Longrightarrow \frac{3^{2x-2}}{3^{y+2}} = 3^4 \text{ or } \frac{9^{x-1}}{3^{y+2}} = 81 \Longrightarrow \frac{9^{x-1}}{9^{\frac{1}{2}(y+2)}} = 9^2$	M1	1.1b		
	$\Rightarrow 2x - 2 - y - 2 = 4 \Rightarrow y = \text{ or } \Rightarrow x - 1 - \frac{1}{2}y - 1 = 2 \Rightarrow y =$	dM1	1.1b		
	$\Rightarrow y = 2x - 8$	A1	1.1b		
		(3)			
	Eg. $\log_3\left(\frac{9^{x-1}}{3^{y+2}}\right) = \log_3 81$	M1	1.1b		
Alt	$\Rightarrow (x-1)\log_3(9^{x-1}) - (y+2)\log_3(3^{y+2}) = 4$ $\Rightarrow 2(x-1) - y - 2 = 4 \Rightarrow y =$	dM1	1.1b		
	$\Rightarrow y = 2x - 8$	A1	1.1b		
		(3	6 marks)		
	Notes				
	0^{x-1} and 81 (2. C 1 0^{x-1} 2^{2x-1} 1 0^{x-1}	o 3r=3			
MI: Attem	pts to set 9 and 01 as powers of 3. Condone $9^{x+1} = 3^{2x+1}$ and $9^{x+1} =$	3^{3x-3} .			
Alternatively attempts to write each term as a logarithm of base 3 or 9. You must see the					
base written to award this mark.					
dM1: Attempts to use the addition (or subtraction) index law, or laws or logarithms, correctly and rearranges the equation to reach <i>y</i> in terms of <i>x</i> . Condone slips in their rearrangement.					
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A1: y = 2x - 8

Question	Sch	eme	Marks	AOs	
2(i)	$16a^2 = 2\sqrt{a} \Longrightarrow a^{\frac{3}{2}} = \frac{1}{8}$	$16a^{2} - 2\sqrt{a} = 0$ $\Rightarrow 2a^{\frac{1}{2}} \left(8a^{\frac{3}{2}} - 1 \right) = 0$ $\Rightarrow a^{\frac{3}{2}} = \frac{1}{8}$	M1	1.1b	
	$\Rightarrow a = \left(\frac{1}{8}\right)^{\frac{2}{3}}$	$\Rightarrow a = \left(\frac{1}{8}\right)^{\frac{2}{3}}$	M1	1.1b	
	$\Rightarrow a = \frac{1}{4}$	$\Rightarrow a = \frac{1}{4}$	A1	1.1b	
	Deduces that <i>a</i> =	= 0 is a solution	B1	2.2a	
			(4)		
(11)	$b^4 + 7b^2 - 18 = 0 \Longrightarrow (b^2 + 9)(b^2 - 18) = 0 \Longrightarrow (b^2 - 18) = 0 \Longrightarrow (b^2 + 9)(b^2 - 18) = 0 \Longrightarrow (b^2 - 18) = 0 $	(-2) = 0	M1	1.1b	
	$b^2 = -9, 2$		A1	1.1b	
	$b^2 = k \Longrightarrow b =$	$\sqrt{k}, k > 0$	dM1	2.3	
	$b=\sqrt{2}$, $-\sqrt{2}$	only	A1	1.1b	
			(4)		
		Notos	(8	marks)	
(i)		INULES			
M1: Comb	pines the two algebraic terms to rea	then $a^{\pm \frac{3}{2}} = C$ or equivalent such as	$\left(\sqrt{a}\right)^3 = C$,	
$(C \neq 0)$					
An alternation	ive is via squaring and combining	the algebraic terms to reach $a^{\pm 3} = 1$	k, k > 0		
Ega	$a^4 = \dots a \Rightarrow a^{\pm 3} = k$ or $\dots a^4 =$	$a \Rightarrowa^4a = 0 \Rightarrowa \left(a^3\right)^4$	$= 0 \Longrightarrow a^3$	=	
Allow for s	slips on coefficients.				
M1: Undo You	es the indices correctly for their a^2 may even see logs used.	$\frac{m}{n} = C$ (So M0 M1 A0 is p	ossible)		
A1: $a = \frac{1}{4}$ B1: Deduc	A1: $a = \frac{1}{4}$ and no other solutions apart from 0 Accept exact equivalents Eg 0.25 B1: Deduces that $a = 0$ is a solution.				
(ii) M1: Attempts to solve as a quadratic equation in b^2 Accept $(b^2 + m)(b^2 + n) = 0$ with $mn = \pm 18$ or solutions via the use of the quadratic					
formu A1: Correc	formula Also allow candidates to substitute in another variable, say $u = b^2$ and solve for u A1: Correct solution. Allow for $b^2 = 2$ or $u = 2$ with no incorrect solution given.				
Candio dM1: Find	Candidates can choose to omit the solution $b^2 = -9$ or $u = -9$ and so may not be seen dM1: Finds at least one solution from their $b^2 = k \Rightarrow b = \sqrt{k}, k > 0$. Allow $b = 1.414$				

Question	Scheme	Marks	AOs
3 (i)	$x\sqrt{2} - \sqrt{18} = x \Longrightarrow x\left(\sqrt{2} - 1\right) = \sqrt{18} \Longrightarrow x = \frac{\sqrt{18}}{\sqrt{2} - 1}$	M1	1.1b
	$\Rightarrow x = \frac{\sqrt{18}}{\sqrt{2} - 1} \times \frac{\sqrt{2} + 1}{\sqrt{2} + 1}$	dM1	3.1a
	$x = \frac{\sqrt{18}\left(\sqrt{2} + 1\right)}{1} = 6 + 3\sqrt{2}$	A1	1.1b
		(3)	
(ii)	$4^{3x-2} = \frac{1}{2\sqrt{2}} \Longrightarrow 2^{6x-4} = 2^{-\frac{3}{2}}$	M1	2.5
	$6x - 4 = -\frac{3}{2} \Longrightarrow x = \dots$	dM1	1.1b
	$x = \frac{5}{12}$	A1	1.1b
		(3)	
		(6	marks)

Notes

(i)

M1: Combines the terms in *x*, factorises and divides to find *x*. Condone sign slips and ignore any attempts to simplify $\sqrt{18}$

Alternatively squares both sides $x\sqrt{2} - \sqrt{18} = x \Longrightarrow 2x^2 - 12x + 18 = x^2$

- **dM1:** Scored for a complete method to find x. In the main scheme it is for making x the subject and then multiplying both numerator and denominator by $\sqrt{2} + 1$ In the alternative it is for squaring both sides to produce a 3TQ and then factorising their quadratic equation to find x. (usual rules apply for solving quadratics)
- A1: $x = 6 + 3\sqrt{2}$ only following a correct intermediate line. Allow $\frac{6+3\sqrt{2}}{1}$ as an intermediate line. In the alternative method the $6-3\sqrt{2}$ must be discarded.
- (ii)
- M1: Uses correct mathematical notation and attempts to set both sides as powers of 2 or 4. Eg $2^{ax+b} = 2^c$ or $4^{dx+e} = 4^f$ is sufficient for this mark. Alternatively uses logs (base 2 or 4) to get a linear equation in x. $4^{3x-2} = \frac{1}{2\sqrt{2}} \Rightarrow \log_2 4^{3x-2} = \log_2 \frac{1}{2\sqrt{2}} \Rightarrow 2(3x-2) = \log_2 \frac{1}{2\sqrt{2}}$. Or $4^{3x-2} = \frac{1}{2\sqrt{2}} \Rightarrow 3x - 2 = \log_4 \frac{1}{2\sqrt{2}}$ Or $4^{3x-2} = \frac{1}{2\sqrt{2}} \Rightarrow 4^{3x} = 4\sqrt{2} \Rightarrow 3x = \log_4 4\sqrt{2}$

Quest	ion Scheme	Marks	AOs
12(8) $2^{2x} + 2^4$ is wrong in line 2 - it should be $2^{2x} \times 2^4$	B1	2.3
	In line 4, 2^4 has been replaced by 8 instead of by 16	B1	2.3
		(2)	
(b)	<u>Way 1:</u> <u>Way 2:</u>		
	$2^{2x+4} - 9(2^{x}) = 0$ $2^{2x} \times 2^{4} - 9(2^{x}) = 0$ Let $2^{x} = y$ $16y^{2} - 9y = 0$ $(2x+4)\log 2 - \log 9 - x\log 2 = 0$	M1	2.1
	$y = \frac{9}{16} \text{ or } y = 0$ So $x = \log_2\left(\frac{9}{16}\right)$ or $\frac{\log\left(\frac{9}{16}\right)}{\log 2}$ $x = \frac{\log 9}{\log 2} - 4$ o.e.	A1	1.1b
		(2)	
		(4 n	narks)
Notes			
(a) B1: B1:	Lists error in line 2 (as above) Lists error in line 4 (as above)		
(b) M1: A1:	Correct work with powers reaching this equation Correct answer here – there are many exact equivalents		

Question Number	Scheme	Marks
2 (a)	$\frac{1}{3}x^2$	B1
(b)	$\left(\frac{x}{\sqrt{2}}\right)^{-2} = \frac{2}{x^2}$	(1) B1 (1)
(c)	$\sqrt{3}(x) \div \sqrt{\frac{48}{x^4}} = \frac{\sqrt{3}}{\sqrt{48}} \times x\sqrt{x^4} = \frac{1}{4}x^3$	M1A1 (2) (4 marks)

(a)

B1
$$\frac{1}{3}x^2$$
 Accept exact alternatives like $\frac{x^2}{3}$ and $0.3x^2$ but not expressions such as $0.33x^2$ (b)

B1
$$\frac{2}{x^2}$$
 Accept exact alternatives such as $2 \times x^{-2}$ or $2 \times \frac{1}{x^2}$ (All forms must have a '2')

M1 Either the correct coefficient (accept $\frac{1}{4}$ or 0.25) or the correct power of x (accept x^3 or $\frac{1}{x^{-3}}$) A1 Only accept $\frac{1}{4}x^3$ or simplified equivalents such as $0.25 \times x^3$ Do NOT accept $\frac{1}{4x^{-3}}$ for this mark.

	Scheme	Marks		
3 (i)				
	$\sqrt{45} - \frac{26}{\sqrt{5}} + \sqrt{6}\sqrt{30}$			
	$-\sqrt{9}\sqrt{5} - \frac{20\sqrt{5}}{1+\sqrt{6}} + \sqrt{6}\sqrt{5} = 3\sqrt{5} - 4\sqrt{5} + 6\sqrt{5}$			
	$=\sqrt{5}\sqrt{5} = \frac{1}{\sqrt{5}\sqrt{5}} + \sqrt{5}\sqrt{5}$	M1		
	$=5\sqrt{5}$	Δ1*		
		[2]		
(ii)	$17\sqrt{2}(\sqrt{2}-6)$	M1		
	LHS = $\frac{1}{(\sqrt{2}+6)(\sqrt{2}-6)}$	1011		
	$=\frac{17\times2-17\times6\sqrt{2}}{0}$ or			
	2-36	A1		
	$=\frac{34-102\sqrt{2}}{3\sqrt{2}-1*}$	Δ1*		
	-34	[3]		
		5 marks		
(;)	Notes			
(1)				
M1: Shov	vs at least one term on LHS as multiple of $\sqrt{3}$ with a correct intermediate step			
Look	for $\sqrt{45} = \sqrt{9} \times \sqrt{5}$ or $\sqrt{3} \times 3 \times 5 = 3\sqrt{5}$, or even $45 = 3 \times 3 \times 5$ or 9×5 followed by $\sqrt{3}$	$/45 = 3\sqrt{5}$		
	$\frac{20}{\sqrt{5}} = \frac{20\sqrt{5}}{\sqrt{5}}$ or $\frac{20\sqrt{5}}{5} = 4\sqrt{5}$ or $\frac{4\times5}{\sqrt{5}} = 4\sqrt{5}$			
	$\sqrt{5}$ $\sqrt{5}\sqrt{5}$ $\sqrt{5}$ $\sqrt{5}$ $\sqrt{6}\sqrt{30} = \sqrt{6}\sqrt{6}\sqrt{5}$ or $\sqrt{6}\sqrt{30} = \sqrt{180} = \sqrt{36 \times 5} = 6\sqrt{5}$			
	or even $180 = 2 \times 2 \times 3 \times 5$ followed by $\sqrt{180} = 6\sqrt{5}$			
A1*: All	three terms must have the intermediate step with $3\sqrt{5} - 4\sqrt{5} + 6\sqrt{5}$ followed by $5\sqrt{5}$	5		
Special Ca	ase: Score M1 A0 for $\sqrt{45} - \frac{20}{\sqrt{5}} + \sqrt{6}\sqrt{30} = 3\sqrt{5} - 4\sqrt{5} + 6\sqrt{5} = 5\sqrt{5}$ without the intermed	diate steps		
Alternativ	e method:			
M1: Mult	iplies all terms by $\sqrt{5}$ to achieve $\sqrt{45} \times \sqrt{5} - 20 + \sqrt{5}\sqrt{6}\sqrt{30} = 5\sqrt{5}\sqrt{5}$ and simplify	es any one of		
the above $\mathbf{A} = \mathbf{A} + \mathbf{A}$	ove terms to 15, -20, 30 or 25 showing the intermediate step	allowed by		
AI. AII 0 15 –	20 + 30 = 25, and minimal conclusion eg, hence true	Showed by		
(ii)				
M1: Multiply numerator and denominator by $\sqrt{2} - 6$ or $6 - \sqrt{2}$				
A1: Multiplies out to a correct (unsimplified) answer. For example allow $=\frac{17 \times 2 - 17 \times 6\sqrt{2}}{2 - 36}$				
A1: The denominator must be simplified so $\frac{34-17\times 6\sqrt{2}}{-34}$ or similar such as $\frac{17\times 2-102\sqrt{2}}{-34}$ is seen before				
you see the given answer $3\sqrt{2}-1$. There is no need to 'split' into two separate fractions.				
Alternative method:				
M1: Alternatively multiplies the rhs by $(\sqrt{2}+6)(3\sqrt{2}-1)$				
A1: Correct unsimplified rhs Accept $3 \times 2 - 6 + 18\sqrt{2} - \sqrt{2}$				
A1*: Simplifies rhs to $17\sqrt{2}$ and gives a minimal conclusion e.g. hence true or hence $\frac{17\sqrt{2}}{(\sqrt{2}+6)} = 3\sqrt{2}-1$				

Question Number	Scheme	Marks
3 (i)	Either $4^{2x+1} = 2^{2(2x+1)}$ and $8^{4x} = 2^{3\times 4x}$ or $8^{4x} = 4^{\frac{3}{2}\times 4x}$	M1
	$2(2x+1) = 12x \Longrightarrow x = \frac{1}{4}$	dM1A1
(ii)(a)	$3\sqrt{18} - \sqrt{32} = 9\sqrt{2} - 4\sqrt{2} = 5\sqrt{2}$	(3) M1A1
(b)	$\sqrt{n} = 5\sqrt{2} \Longrightarrow n = (5\sqrt{2})^2 = 25 \times 2 = 50$	(2) M1A1
		(2) (7 marks)
Alt 3 (i)	Taking logs of both sides and proceeding to $(2x+1)\log 4 = 4x\log 8$	M1
	$\Rightarrow x = \frac{\log 4}{4\log 8 - 2\log 4}$	
	$\implies x = \frac{\log 4}{\log 256} = \frac{1}{4}$	dM1A1
		(3)

(i)

Writes both sides as powers of 2 or equivalent Eg $2^{2(2x+1)} = 2^{3\times 4x}$ M1

> Alternatively writes both sides as powers of 4 or 8 or 64. Eg $8^{4x} = 4^{\frac{3}{2} \times 4x}$ Note that expressions such as $2^{2+(2x+1)} = 2^{3+4x}$ would be M0

Condone poor (or missing) brackets $2^{2 \times 2x+1} = 2^3$ but not incorrect index work eg $4^{2x+1} = 8^{\frac{1}{2}(2x+1)}$ It is possible to use logs. most commonly with base 2 or 4. Using logs it is for reaching a linear form of the equation, again condoning poor bracketing. 4^{2}

$$4^{2x+1} = 8^{4x} \Longrightarrow \log 4^{2x+1} = \log 8^{4x} \Longrightarrow (2x+1)\log 4 = 4x\log 8$$

dM1 Dependent upon the previous M. It is for equating the indices and proceeding to x = ...Condone sign/bracketing errors when manipulating the equation but not processing errors If logs are used they must be evaluated without a calculator. Lengthy decimals would be evidence of this and would be dM0

$$(2x+1)\log_2 4 = 4x\log_2 8 \Longrightarrow (2x+1) \times 2 = 4x \times 3 \Longrightarrow x = ..$$
$$4^{2x+1} = 8^{4x} \Longrightarrow 2x+1 = 4x\log_4 8 \Longrightarrow 2x+1 = \frac{3}{2} \times 4x \Longrightarrow x = ..$$
 is fine

 $x = \frac{1}{4}$ or equivalent A1

(ii)(a) Mark part (ii) as one complete question. Marks in (a) can be gained from (b) Writes either $\sqrt{18} = 3\sqrt{2}$ or $3\sqrt{18} = 9\sqrt{2}$ or $\sqrt{32} = 4\sqrt{2}$ M1

If the candidate writes $3\sqrt{18} - \sqrt{32} = k\sqrt{2}$ it can be scored for $\frac{3\sqrt{18}}{\sqrt{2}} = 9$ or $\frac{\sqrt{32}}{\sqrt{2}} = 4$

- $5\sqrt{2}$ or states k = 5A1 The answer without working (the M1) would be 0 marks (ii)(b)
- Moves from $\sqrt{n} = k\sqrt{2}$ to $n = 2k^2$ M1 Also accept for this mark $\sqrt{n} = \sqrt{50}$ or indeed $\sqrt{50}$ on its own

(n =) 50A1

Question Number	Scheme			Marks	
	Way 1:	W	ay 2:	Way 3:	
2(i)	$\frac{49}{\sqrt{7}} = \frac{7^2}{7^{\frac{1}{2}}} = 7^{2-\frac{1}{2}}$	7√7	$=7^{1+\frac{1}{2}}$	$7^{a} = \frac{49}{\sqrt{7}} \Longrightarrow a = \frac{\log \frac{49}{\sqrt{7}}}{\log 7}!$ or $7^{a} = \frac{49}{\sqrt{7}} \Longrightarrow a = \log_{7} \frac{49}{\sqrt{7}}$	M1
	!!(a	$=)1\frac{1}{2}$ (oe) or	see answer = $7^{1\frac{1}{2}}$		A1
		!			[2]
(ii)	Way 1:			Way 2:	1
	$\frac{10(\sqrt{18}+4)}{(\sqrt{18}-4)(\sqrt{18}+4)}$	-!	(15√2	$(\sqrt{18} - 4)$	M1
	$=\frac{\cdots}{2}!$		$=15\sqrt{36}$ -	$-60\sqrt{2}+20\sqrt{18}-80!$	B1
	$\frac{10}{\sqrt{18}-4} = 5\left(3\sqrt{2}+4\right) = 154$	$\sqrt{2} + 20*!$	$= 90 - 0$ $= 10 \text{ so } \frac{1}{\sqrt{2}}$	$\frac{50\sqrt{2} + 60\sqrt{2} - 80}{\frac{10}{18} - 4} = 15\sqrt{2} + 20*$	Alcso
	!				[3]
		Not	P S		5 marks
(i)	Wav 1:	V	Vav 2:	Way 3:	
	M1: Subtracts their powers of 7 M1: Cancels fraction to $7\sqrt{7}$ and adds their powers of 7 M1: Correct use of logs correct expression for <i>a</i>		M1: Correct use of logs to correct expression for <i>a</i>	bgs to obtain a a	
	Do not al	A1: cao (ar low work with	nswer only is 2 ma inexact decimals f	rks) for this mark e.g.	
(ii)	$49 \times 7^{-2} = 12$ Way 1:	$5.52 \Rightarrow \log 18.32$	52 = 1.49999⇒	$\frac{a = 1.5 \text{ scores M1A0}}{\text{Way 2:}}$	
(11)	M1: Multiply numerator and den	ominator by	M1: Attempts to	$(\sqrt{4}) = (\sqrt{4})(\sqrt{18} - 1)(\sqrt{18})$	4) to obtain
	$\sqrt{18}$ + 4 or equivalent. The staten	nent	at least 3 (not ne	cessarily correct) terms	,
	$10(\sqrt{18+4})$ is sufficient	but do not	B1: All 4 terms (A1)	correct (Must follow M1 – i.	e. treat as
	$(\sqrt{18} - 4)(\sqrt{18} + 4)$		A1: Obtains 10	with no errors and $\sqrt{18} = 3\sqrt{18}$	$\overline{2}$ seen or
	allow $\frac{10(\sqrt{18}+4)}{\sqrt{10}}$ unless 1	nissing	implied by e.g.	$20\sqrt{18} = 60\sqrt{2}$ and conclus	ion that
	$\sqrt{18} - 4(\sqrt{18} + 4)$ brackets are implied by subseque	nt work	states the given a	answer i.e. not just $10 = 10$	
	B1: Correctly obtains ±2 in the denominator (Must follow M1 – i.e. treat as A1). May be				
	implied by e.g. $\frac{10(\sqrt{18}+4)}{18-16} = 5(\sqrt{18}+4)$				
	A1: Correct result with no errors seen and $\sqrt{10} = 2\sqrt{2}$ where $r_{10} = r_{10}$				
	$\sqrt{18} = 3\sqrt{2}$ used before their final answer. Note that for Way 1, correct work leading to				
	Note that for Way I , correct work leading to $5\sqrt{18} + 20$ followed by $15\sqrt{2} + 20$ with no				
	intermediate step would lose the f	inal mark			

Scheme	Marks
$\frac{1}{3}x$ as the final answer.	B1
$81x^{-3}$ as the final answer	B1
$x^{\frac{3}{2}}$ as the final answer	B1
	[3]
	Scheme $\frac{1}{3}x$ as the final answer. $81x^{-3}$ as the final answer $x^{\frac{3}{2}}$ as the final answer

In all parts of this question candidates do not have to explicitly state the values of *k* and *n*. Award the mark(s) as above. If they go on to give incorrect values of *k* and *n* you may isw, but do not isw on incorrect index work Eg. $\frac{1}{3}x = x^{-3}$. If candidates make two different attempts and give two (or more) different answers then please put these in review

B1
$$\frac{1}{3}x$$
 but accept equivalent such as $\frac{x}{3}$, $\frac{1}{3} \times x$, $\frac{1}{3}x^1$ or $3^{-1}x$ etc.

(b)

B1 $81x^{-3}$. Accept exact equivalents such as $81 \times x^{-3}$ Do not accept $\frac{81}{x^3}$ as the final answer unless it is preceded by $81x^{-3}$ as it is not in the form required by the question.

(c)

B1 $x^{\frac{3}{2}}$ but accept exact equivalents such as $1 \times x^{1.5}$ Do not accept $x x^{\frac{1}{2}}$ or $x \sqrt{x}$ as the final answer unless preceded by $x^{\frac{3}{2}}$ as they are not in the form required by the question.

January 2015 International A Level WMA01/01 Core Mathematics C12 Mark Scheme

Question Number	Scheme	Marks			
1.	(a) x^2	B1			
	(b) $\frac{1}{4}x^4$ or $\frac{1}{2^2}x^4$ or $0.25x^4$	[1] B1, B1 [2] 3 marks			
	Notes				
(a) B1 : Th	is answer only				
(b) B1: Fo	(b) B1: For $\frac{1}{4}x^k$ as final answer, k can even be 0. Also accept $\frac{1}{2^2}$ for B1 but 2^{-2} is not simplified and is B0				
B1 : for n.b. (Mark	B1 : for x to power 4 (independent mark) so kx^4 with k a constant (could even be 1) as final answer n.b. Can score B0B1 or B1B0 or B0B0 or B1B1 Mark the final answer on this question				
Also note : Candidates who misread question as $\sqrt{2x^3} \div \sqrt{\frac{32}{x^2}}$ should get $\frac{1}{4}x^{\frac{5}{2}}$ This is awarded B1B0					
Special case: The answer $\left(\frac{1}{\sqrt{2}}x\right)^4$ is awarded B0 B1 as x may be in a bracket with power 4 outside.					

Question Number	Scheme	Marks
2	$\sqrt{27} = 3\sqrt{3}, \frac{6}{\sqrt{3}} = 2\sqrt{3}$	
	$x\sqrt{27} + 21 = \frac{6x}{\sqrt{3}} \Longrightarrow 3\sqrt{3}x + 21 = 2\sqrt{3}x$	M1 A1
	$\Rightarrow \sqrt{3}x = -21$	
	$\Rightarrow x = -\frac{21}{\sqrt{3}} \Rightarrow x = -7\sqrt{3}$	M1 A1
		(4 marks)

M1 Simplify either
$$\sqrt{27} = 3\sqrt{3}$$
 or $\frac{6}{\sqrt{3}} = 2\sqrt{3} = \left(\frac{6\sqrt{3}}{3}\right)$

A1 Uses both $\sqrt{27} = 3\sqrt{3}$ and $\frac{6}{\sqrt{3}} = 2\sqrt{3}$ to rewrite equation in a form equivalent to $3\sqrt{3}x + 21 = 2\sqrt{3}x$

- M1 Collects x terms on one side of the equation, simplifies and divides reaching $x = \dots$
- A1 Writes answer in the required form $-7\sqrt{3}$. Accept $-1\sqrt{147}$

Question Number	Scheme	Marks
Alt 2	$x\sqrt{27} + 21 = \frac{6x}{\sqrt{3}} (\times\sqrt{3}) \Rightarrow \sqrt{3}\sqrt{27}x + 21\sqrt{3} = 6x$ $\Rightarrow 9x + 21\sqrt{3} = 6x$ $\Rightarrow 3x = -21\sqrt{3} \Rightarrow x = -7\sqrt{3}$	M1 A1 M1A1
	$\rightarrow 5x - 21y_5 \rightarrow x - 7y_5$	(4 marks)

- M1 Multiply equation by $\sqrt{3}$, seen in at least two terms.
- A1 $9x + 21\sqrt{3} = 6x$ or equivalent but the $\sqrt{81}$ must have been dealt with
- M1 Collects terms in x, and proceeds to x=..
- A1 Writes answer in the required form $-7\sqrt{3}$. Accept $-1\sqrt{147}$

Numer4 (i) $\frac{4(2\sqrt{2} + \sqrt{6})}{(2\sqrt{2} - \sqrt{6})(2\sqrt{2} + \sqrt{6})}$ M14. (i) $\frac{4(2\sqrt{2} + \sqrt{6})}{(2\sqrt{2} - \sqrt{6})(2\sqrt{2} + \sqrt{6})} = 8 - 6 = 2$ M1 $\sqrt{6} - \sqrt{2}\sqrt{3}$ used in numerator - may be implied by a correct factorisation of numeratorB1 $\sqrt{6} - \sqrt{2}\sqrt{3}$ used in numerator - may be implied by a correct factorisation of numeratorB1 1^{ii} two terms $\sqrt{27} = 3\sqrt{3}$ and $\sqrt{21} \times \sqrt{7} = 7\sqrt{3}$ 3^{ii} termSee $2\sqrt{3}$ or $\frac{6\sqrt{3}}{3}$ B1 3^{ii} termSee $2\sqrt{3}$ or $3\sqrt{3} + 7\sqrt{3} - \frac{6\sqrt{3}}{3} = 8\sqrt{3}$ $3\sqrt{3} + 7\sqrt{3} - 2\sqrt{3} = 8\sqrt{3}$ or $3\sqrt{3} + 7\sqrt{3} - \frac{6\sqrt{3}}{3} = 8\sqrt{3}$ B1Alternative for (i)Assume result and multiply both sides by $(2\sqrt{2} - \sqrt{6})$ $(2\sqrt{2} - \sqrt{6})(4\sqrt{2} + 2\sqrt{6}) = 16 - 12 = 4$ B1So LHS = RHS and result is trueA1alternative for (ii) $\frac{\sqrt{81} + \sqrt{21 \times 7 \times 3} - 6}{\sqrt{3}}$ $\frac{\sqrt{81} + \sqrt{21 \times 7 \times 3} - 6}{\sqrt{3}}$ $9 + 21 - 6 =$ $\frac{24}{\sqrt{3}} \times \frac{\sqrt{5}}{\sqrt{3}} = 8\sqrt{3}$ $9 + 21 - 6 =$ B1B1Crarks)B1: correct treatment or decominator by $\pm (2\sqrt{2} + \sqrt{6})$ B1: correct reatment or dominator by $\pm (2\sqrt{2} + \sqrt{5})$ B1: correct freatment or dominator by $\pm (2\sqrt{2} + \sqrt{5})$ B1: correct freatment or dominator by $\pm (2\sqrt{2} + \sqrt{5})$ B1: correct freatment or ad denominator by $\pm (2\sqrt{2} + \sqrt{5})$ B1: expresses both of first two terms as multiple of root 3 correctlyB1: hybits $\sqrt{5} = \sqrt{2}\sqrt{3} = \sqrt{5}$ B1: hybits $\sqrt{5} = 2\sqrt{3} = \sqrt{5}$ B1: hybits $\sqrt{5} = \sqrt{5} = \sqrt{5}$ B1: hybits $\sqrt{5} = \sqrt{5} = \sqrt{5}$ B1: hybits \sqrt	Question	Scheme	Marks		
4. (i) $\frac{4(2\sqrt{2}+\sqrt{6})}{(2\sqrt{2}-\sqrt{6})(2\sqrt{2}+\sqrt{6})} $ M1 M1 (ii) $\frac{4(2\sqrt{2}-\sqrt{6})(2\sqrt{2}+\sqrt{6})}{\sqrt{6}-\sqrt{2}\sqrt{3}}$ used in numerator - may be implied by a correct factorisation of numerator Concludes $\frac{4(2\sqrt{2}+\sqrt{6})}{2}-2\sqrt{2}(2+\sqrt{3}) = $ A1 * (ii) 1^{4} two terms $\sqrt{27}-3\sqrt{3}$ and $\sqrt{21}\times\sqrt{7}-7\sqrt{3}$ B1 3^{4} term $Sec 2\sqrt{3} \text{ or } \frac{6\sqrt{3}}{3}$ B1 3^{3} term $Sec 2\sqrt{3} \text{ or } \frac{6\sqrt{3}}{3}$ B1 3^{3} term $Sec 2\sqrt{3} \text{ or } \frac{6\sqrt{3}}{3}$ B1 4 Alternative for (i) $\frac{\sqrt{81}+\sqrt{21\times7\times3}-6}{\sqrt{3}}$ Corrected and multiply both sides by $(2\sqrt{2}-\sqrt{6})$ Corrected and $\sqrt{1}$ B1 B1 Alternative for (ii) $\frac{\sqrt{81}+\sqrt{21\times7\times3}-6}{\sqrt{3}}$ Corrected and essuit is true (i) M1: Multiplies numerator and denominator by $\pm(2\sqrt{2}-\sqrt{6})$ B1: correct restment of denominator to give 2 (may be implied by answer obtained with no errors should be seen NR. $\frac{4(2\sqrt{2}+\sqrt{3})}{2}-2\sqrt{2}(2+\sqrt{3})$ may be avarded B1 A1 as there is an implication that $\sqrt{6}-\sqrt{2}\sqrt{3}$ (i) M1: Multiplies numerator and denominator by $\pm(2\sqrt{2}-\sqrt{6})$ B1: correct treatment of first two terms as multiple of total 3 correctly B1: splits $\sqrt{6}-\sqrt{2}\sqrt{3} - \sqrt{3} = 8\sqrt{3}$ N. B. $3\sqrt{3}+7\sqrt{3}-\frac{6}{\sqrt{3}}=8\sqrt{3}$ is B1B0B0 B1: has used $3\sqrt{3}+7\sqrt{3}-2\sqrt{3}=8\sqrt{3}$ N. B. $3\sqrt{3}+7\sqrt{3}-\frac{6}{\sqrt{3}}=8\sqrt{3}$ is B1B0B0 Alternative B1: HS numerator correctly simplified or just see 9+21-6 B1: this used $3\sqrt{3}+7\sqrt{3}-2\sqrt{3}=8\sqrt{3}$ N. B. $3\sqrt{3}+7\sqrt{3}-\frac{6}{\sqrt{3}}=8\sqrt{3}$ is B1B0B0 B1: correct restment of denominator to give 2 (may be implied by answer obtained with no errors should be seen N. B. $\frac{4(2\sqrt{2}+\sqrt{6})}{2}-2\sqrt{2}(2+\sqrt{3})$ may be awarded B1 A1 as there is an implication that $\sqrt{6}-\sqrt{2}\sqrt{3}$ (i) B1: expresses both of first two terms as multiple of rotal 3 correctly B1: this used $3\sqrt{3}+7\sqrt{3}-2\sqrt{3}=8\sqrt{3}$ N. B. $3\sqrt{3}+7\sqrt{3}-\frac{6}{\sqrt{3}}=8\sqrt{3}$ is B1B0B0 B1: HS numerator correctly simplified or just see 9+21-6 B1: the first attermative correcty simplified or just see 9+21-6 B1: the first attermative sums term and thighties by first obtains by rot 3 and obtains correct unsimplifie	Number	$(2\sqrt{2},\sqrt{2})$			
$\begin{array}{ c c c c c c c c c c c c c c c c c c c$	4. (i)	$\frac{4(2\sqrt{2}+\sqrt{6})}{(2\sqrt{2}-\sqrt{6})(2\sqrt{2}+\sqrt{6})}$			
(ii) $\sqrt{6} = \sqrt{2}\sqrt{3}$ used in numerator - may be implied by a correct factorisation of numerator Concludes $\frac{4(2\sqrt{2} + \sqrt{6})}{2} = 2\sqrt{2}(2 + \sqrt{3})$ * [4] (iii) 1^{4} two terms $\sqrt{27} - 3\sqrt{3}$ and $\sqrt{21} \times \sqrt{7} - 7\sqrt{3}$ [3] 3^{*4} term $Sec 2\sqrt{3}$ or $\frac{6\sqrt{3}}{3}$ $3\sqrt{3} + 7\sqrt{3} - 2\sqrt{3} = 8\sqrt{3}$ or $3\sqrt{3} + 7\sqrt{3} - \frac{6\sqrt{3}}{3} = 8\sqrt{3}$ * [3] $3\sqrt{3} + 7\sqrt{3} - 2\sqrt{3} = 8\sqrt{3}$ or $3\sqrt{3} + 7\sqrt{3} - \frac{6\sqrt{3}}{3} = 8\sqrt{3}$ * [3] Alternative Assume result and multiply both sides by $(2\sqrt{2} - \sqrt{6})$ [3] $(2\sqrt{2} - \sqrt{6})(4\sqrt{2} + 2\sqrt{6}) = 16 - 12 = 4$ [3] $So LHS = RHS and result is true [4] Alternative \sqrt{31} + \sqrt{21 \times 7 \times 3} - 6 Or \sqrt{81} + \sqrt{21 \times 7 \times 3} - 6 = 8\sqrt{3}\sqrt{3} [3]\frac{9 + 21 - 6}{\sqrt{3}} 9 + 21 - 6 - [3]\frac{24}{\sqrt{3}} \times \frac{\sqrt{3}}{\sqrt{3}} = 8\sqrt{3} 9 + 21 - 6 - [3](0) M1: Multiplies numerator and denominator by \pm (2\sqrt{2} + \sqrt{6}) [3]H1: splits \sqrt{6} - \sqrt{2}\sqrt{3} may be implied by answer obtained with no errors seen)H1: splits \sqrt{6} - \sqrt{2}\sqrt{3} may be implied by a solution that \sqrt{6} = \sqrt{2}\sqrt{3}(i) B1: correct treatment of denominator by \pm (2\sqrt{2} + \sqrt{6}) [3]H1: splits \sqrt{6} - \sqrt{2}\sqrt{3} may be implied by answer obtained with no errors should be seen N, B. \frac{4(2\sqrt{2} + \sqrt{6})}{2} = 2\sqrt{2}(2 + \sqrt{3}) may be avarded B1 A1 as there is an implication that \sqrt{6} = \sqrt{2}\sqrt{3}(ii) B1: expresses both of first two terms as multiple of root 3 correctlyH1: has used 3\sqrt{3} + 7\sqrt{3} - 2\sqrt{3} = 8\sqrt{3} N. B. 3\sqrt{3} + 7\sqrt{5} - \frac{6}{\sqrt{3}} = 8\sqrt{3} is B110B0(iii) Alternative B1: Uses \sqrt{2}\sqrt{3} = \sqrt{6} 1" B1: Multiplies out these two brackets to give 4 A1: conclusion(iii) B1: Uses \sqrt{2}\sqrt{3} = \sqrt{6} 1" B1: Multiplies out these two brackets to give 4 A1: conclusion(iii) B1: H1S Numerator correctly simplified or just see 9 + 21 - 6B1: In the instructure multiplic sout shore brackets to give 3 (at 1 at 2 + 3 \sqrt{3}) In the second 1 + 10 + 10 + 10 + 10 + 10 + 10 + 10 +$		$(2\sqrt{2} - \sqrt{6})(2\sqrt{2} + \sqrt{6}) = 8 - 6 = 2$			
(i) (i) (ii) (ii) (ii) (ii) (iii) (iv)		$\sqrt{6} = \sqrt{2}\sqrt{3}$ used in numerator - may be implied by a correct factorisation of numerator	B1		
$\begin{array}{ c c c c c c } \hline Concludes & (1-2-1)/2 = 2\sqrt{2}(2+\sqrt{3}) & * \\ \hline All & * \\ \hline Concludes & \sqrt{27} = 3\sqrt{3} & and & \sqrt{21} \times \sqrt{7} = 7\sqrt{3} \\ \hline B1 \\$		$4(2\sqrt{2}+\sqrt{6}) \qquad - \qquad - \qquad - \qquad $			
(ii) $ \begin{array}{ c c c c c } 1^{4} \text{ two terms} & \sqrt{27} - 3\sqrt{3} & \text{and} & \sqrt{21} \times \sqrt{7} - 7\sqrt{3} \\ 1^{4} \text{ term} & \text{Sec } 2\sqrt{3} & \text{or } \frac{6\sqrt{3}}{3} \\ 3^{4} \text{ term} & \text{Sec } 2\sqrt{3} & \text{or } \frac{6\sqrt{3}}{3} \\ 3\sqrt{3} + 7\sqrt{3} - 2\sqrt{3} = 8\sqrt{3} & \text{or } 3\sqrt{3} + 7\sqrt{3} - \frac{6\sqrt{3}}{3} = 8\sqrt{3} & * \\ 3\sqrt{3} + 7\sqrt{3} - 2\sqrt{3} = 8\sqrt{3} & \text{or } 3\sqrt{3} + 7\sqrt{3} - \frac{6\sqrt{3}}{3} = 8\sqrt{3} & * \\ 131 \\ \hline & \text{Alternative} \\ \text{for (i)} & \text{Assume result and multiply both sides by } (2\sqrt{2} - \sqrt{6}) \\ (2\sqrt{2} - \sqrt{6})(4\sqrt{2} + 2\sqrt{6}) = 16 - 12 = 4 \\ 80 & \text{LHS = RHS and result is true} \\ 141 \\ \hline & \text{Alternative} \\ \text{for (ii)} & \frac{\sqrt{81} + \sqrt{21 \times 7 \times 3} - 6}{\sqrt{3}} & \text{Or } \sqrt{81} + \sqrt{21 \times 7 \times 3} - 6 = 8\sqrt{3}\sqrt{3} \\ 9 + 21 - 6 \\ \frac{24}{\sqrt{3}} \times \sqrt{\frac{3}{3}} = 8\sqrt{3} & 9 + 21 - 6 = \\ 81 \\ \frac{24}{\sqrt{3}} \times \sqrt{\frac{3}{3}} = 8\sqrt{3} & 9 + 21 - 6 = \\ 81 \\ \frac{24}{\sqrt{3}} \times \sqrt{\frac{3}{3}} = 8\sqrt{3} & 9 + 21 - 6 = \\ 81 \\ 17 \\ \text{marks} \\ \hline & \text{In Wultiplies numerator and denominator by } \pm (2\sqrt{2} + \sqrt{6}) \\ \hline \text{B1: correct treatment of denominator to give 2 (may be implied by answer obtained with no errors seen) \\ \text{B1: softis } \sqrt{6} = \sqrt{2}\sqrt{3} & \text{-nay be implied}, but \text{ B0 for } 2\sqrt{6} = 2\sqrt{2}(2\sqrt{3}) \\ \text{A1 termative for the treatment of ferminator to give 2 (may be implied by answer obtained with no errors seen) \\ \text{B1: softis } \sqrt{6} = \sqrt{2}\sqrt{2} + \sqrt{3} \\ 2 = 2\sqrt{2}(2(2 + \sqrt{3})) \\ \text{may be awarded B1 A1 as there is an implication that } \sqrt{6} = \sqrt{2}\sqrt{3} \\ \text{(i) B1: corrects sess both of first two terms as multiple of root 3 correctly \\ \text{B1: ationalises denominator in second term -may not see working \\ \text{B1: has used } 3\sqrt{3} + 7\sqrt{3} - 2\sqrt{3} = 8\sqrt{3} & \text{N.B. } 3\sqrt{3} + 7\sqrt{3} - \frac{6}{\sqrt{3}} = 8\sqrt{3} \text{ is B1B0B0} \\ \hline \\ \begin{array}{c} (i) \\ (i) \\ \text{Alternative} \\ (ii) \\ \text{Alternative} \\ \text{B1: Uses } \sqrt{2}\sqrt{3} = \sqrt{6} & 1^{4} \text{ B1: Multiplies out these two brackets to give 4 A1: conclusion \\ \text{B1: Lins materiac recorrectly simplified or just sec 9 + 21 - 6 \\ \text{B1: In the first alternative mut see multiplication of numerator and denominator by \sqrt{3} to give 8\sqrt{3} In the second thereas the unintipatior on tr $		Concludes $\frac{(1+1)}{2} = 2\sqrt{2}(2+\sqrt{3})$ *	Al *		
3^{sd} termSee $2\sqrt{3}$ or $\frac{6\sqrt{3}}{3}$ BI $3\sqrt{3} + 7\sqrt{3} - 2\sqrt{3} = 8\sqrt{3}$ or $3\sqrt{3} + 7\sqrt{3} - \frac{6\sqrt{3}}{3} = 8\sqrt{3}$ BIAlternative for (i)Assume result and multiply both sides by $(2\sqrt{2} - \sqrt{6})$ M1 $(2\sqrt{2} - \sqrt{6})(4\sqrt{2} + 2\sqrt{6}) = 16 - 12 = 4$ B1 BISo LHS = RHS and result is trueA1So LHS = RHS and result is true[4]Atternative for (ii) $\frac{\sqrt{81} + \sqrt{21 \times 7 \times 3} - 6}{\sqrt{3}}$ $Or \sqrt{81} + \sqrt{21 \times 7 \times 3} - 6 = 8\sqrt{3}\sqrt{3}$ $9 + 21 - 6$ BI $2\frac{4}{\sqrt{3}} \times \frac{\sqrt{3}}{\sqrt{3}} = 8\sqrt{3}$ $9 + 21 - 6 = 24$ B1B1B1B1: orrect treatment of denominator by $\pm (2\sqrt{2} + \sqrt{6})$ B1B1: correct treatment of denominator to give 2 (may be implied by answer obtained with no errors seen)B1: splits $\sqrt{6} = \sqrt{2}\sqrt{3} - may be implied, but B0 for 2\sqrt{6} = 2\sqrt{2}(2\sqrt{3})A1 cao reaches result and no errors should be seenN.B.\frac{4(2\sqrt{2} + \sqrt{6})}{2} = 2\sqrt{2}(2 + \sqrt{3}) may be awarded B1 A1 as there is an implication that \sqrt{6} = \sqrt{2}\sqrt{3}(i) B1: correct second term may not as correctlyB1: has used 3\sqrt{3} + 7\sqrt{3} - 2\sqrt{3} = 8\sqrt{3}N.B. 3\sqrt{3} + 7\sqrt{3} - \frac{6}{\sqrt{3}} = 8\sqrt{3} is B1B0B0(ii)(iii)(iii)(iii)B1: Uses \sqrt{2}\sqrt{3} = \sqrt{6}1* B1: Multiplies out these two brackets to give 4A1: conclusion(iii)(iii)B1: Uses \sqrt{2}\sqrt{3} = \sqrt{6}1* B1: Multiplies to the set wo brackets to give 4A1: conclusion(iii)B1: Uses common denominator or multiplies both sides by root 3 and obtains correct unsimplified equation<$	(ii)	1 st two terms $\sqrt{27} = 3\sqrt{3}$ and $\sqrt{21} \times \sqrt{7} = 7\sqrt{3}$	[4] B1		
$3\sqrt{3} + 7\sqrt{3} - 2\sqrt{3} = 8\sqrt{3}$ or $3\sqrt{3} + 7\sqrt{3} - \frac{6\sqrt{3}}{3} = 8\sqrt{3}$ *B1 *Alternative for (i)Assume result and multiply both sides by $(2\sqrt{2} - \sqrt{6})$ M1 $(2\sqrt{2} - \sqrt{6})(4\sqrt{2} + 2\sqrt{6}) = 16 - 12 = 4$ B1 B1So LHS = RHS and result is trueA1Gr (ii) $\frac{\sqrt{81} + \sqrt{21 \times 7 \times 3} - 6}{\sqrt{3}}$ Or $\sqrt{81} + \sqrt{21 \times 7 \times 3} - 6 = 8\sqrt{3}\sqrt{3}$ $9 + 21 - 6$ B1 $\frac{24}{\sqrt{3}} \times \frac{\sqrt{3}}{\sqrt{3}} = 8\sqrt{3}$ $9 + 21 - 6 = $ B1B1B1M1(i) M1: Multiplies numerator and denominator by $\pm (2\sqrt{2} + \sqrt{6})$ B1: correct treatment of denominator to give 2 (may be implied by answer obtained with no errors seen)B1: Splits $\sqrt{6} = \sqrt{2}\sqrt{3}$ - may be implied, but B0 for $2\sqrt{6} = 2\sqrt{2}(2\sqrt{3})$ A1 cao reaches result and no errors should be seenN.B. $\frac{4(2\sqrt{2} + \sqrt{6})}{2} = 2\sqrt{2}(2 + \sqrt{3})$ may be awarded B1 A1 as there is an implication that $\sqrt{6} = \sqrt{2}\sqrt{3}$ (ii) B1: expresses both of first two terms as multiple of rot 3 correctlyB1: has used $3\sqrt{3} + 7\sqrt{3} - 2\sqrt{3} = 8\sqrt{3}$ N.B. $3\sqrt{3} + 7\sqrt{3} - \frac{6}{\sqrt{3}} = 8\sqrt{3}$ is B1B0B0AlternativeM1: Assume result and multiply both sides by $(2\sqrt{2} - \sqrt{6})$ 2 ^{vid} B1: Uses $\sqrt{2\sqrt{3}} = \sqrt{6}$ 1 ^{vid} B1: Multiplies out these two brackets to give 4 A1: conclusionAlternativeB1: Uses common denominator or multiplies both sides by root 3 and obtains correct unsimplified equationB1: L1B numerator correctly simplified or just see $9 + 21 - 6$ B1: In the first alternative must see multiplication of numerator and denominator by $\sqrt{3}$ to give $8\sqrt{3}$ In the second		3^{rd} term See $2\sqrt{3}$ or $\frac{6\sqrt{3}}{3}$	B1		
Alternative for (i)Assume result and multiply both sides by $(2\sqrt{2} - \sqrt{6})$ MI B1 B1 B1 B1 A1 B1 B1Alternative for (ii) $(2\sqrt{2} - \sqrt{6})(4\sqrt{2} + 2\sqrt{6}) = 16 - 12 = 4$ B1 B1 B1 A1 A1 A1Alternative for (ii) $\frac{\sqrt{81} + \sqrt{21 \times 7 \times 3} - 6}{\sqrt{3}}$ Or $\sqrt{81} + \sqrt{21 \times 7 \times 3} - 6 = 8\sqrt{3}\sqrt{3}$ B1Alternative for (ii) $\frac{\sqrt{81} + \sqrt{21 \times 7 \times 3} - 6}{\sqrt{3}}$ Or $\sqrt{81} + \sqrt{21 \times 7 \times 3} - 6 = 8\sqrt{3}\sqrt{3}$ B1 $\frac{9 + 21 - 6}{\sqrt{3}}$ $9 + 21 - 6 =$ B1 $\frac{24}{\sqrt{3}} \times \sqrt{3}{\sqrt{3}} = 8\sqrt{3}$ $9 + 21 - 6 = 24$ so equation is true(i) M1: Multiplies numerator and denominator by $\pm (2\sqrt{2} + \sqrt{6})$ B1: correct treatment of denominator to give 2 (may be implied by answer obtained with no errors seen)B1: Splits $\sqrt{6} = \sqrt{2}\sqrt{3}$ - may be implied , but B0 for $2\sqrt{6} = 2\sqrt{2}(2\sqrt{3})$ A1 cao reaches result and no errors should be seenNB. $\frac{4(2\sqrt{2} + \sqrt{6})}{2} = 2\sqrt{2}(2 + \sqrt{3})$ may be awarded B1 A1 as there is an implication that $\sqrt{6} = \sqrt{2}\sqrt{3}$ (ii) B1: expresses both of first two terms as multiple of root 3 correctly B1: rationalises denominator in second term -may not see working B1: has used $3\sqrt{3} + 7\sqrt{3} - 2\sqrt{3} = 8\sqrt{3}$ B1: Uses $\sqrt{2}\sqrt{2} = \sqrt{6}$ 2^{nd} B1: Uses $\sqrt{2}\sqrt{3} = \sqrt{6}$ (iii) AlternativeB1: Uses $\sqrt{2}\sqrt{3} = \sqrt{6}$ B1: Uses common denominator or multiplies both sides by root 3 and obtains correct unsimplified equation B1: LHS numerator correctly simplified or just see $9 + 21 - 6$ B1: In the first alternative must see multiplication of numerator and denominator by $\sqrt{3}$ to give $8\sqrt{3}$ In the second product of two end to first two terms at multiplication of numerator and denominator		$3\sqrt{3} + 7\sqrt{3} - 2\sqrt{3} = 8\sqrt{3}$ or $3\sqrt{3} + 7\sqrt{3} - \frac{6\sqrt{3}}{3} = 8\sqrt{3}$ *	B1 *		
(i) (i) ($2\sqrt{2} - \sqrt{6}$) ($4\sqrt{2} + 2\sqrt{6}$) = 16 - 12 = 4 So LHS = RHS and result is true [4] Alternative for (ii) $\frac{\sqrt{81 + \sqrt{21 \times 7 \times 3} - 6}}{\sqrt{3}}$ Or $\sqrt{81 + \sqrt{21 \times 7 \times 3} - 6} = 8\sqrt{3}\sqrt{3}$ B1 $\frac{9 + 21 - 6}{\sqrt{3}}$ 9 + 21 - 6 = B1 B1 $\frac{24}{\sqrt{3}} \times \frac{\sqrt{3}}{\sqrt{3}} = 8\sqrt{3}$ 9 + 21 - 6 = 24 so equation is true [3] (7 marks) (i) M1: Multiplies numerator and denominator by $\pm (2\sqrt{2} + \sqrt{6})$ B1: correct treatment of denominator to give 2 (may be implied by answer obtained with no errors seen) B1: Splits $\sqrt{6} = \sqrt{2}\sqrt{3}$ - may be implied, but B0 for $2\sqrt{6} = 2\sqrt{2}(2\sqrt{3})$ A1 cao reaches result and no errors should be seen N.B. $\frac{4(2\sqrt{2} + \sqrt{6})}{2} = 2\sqrt{2}(2 + \sqrt{3})$ may be awarded B1 A1 as there is an implication that $\sqrt{6} = \sqrt{2}\sqrt{3}$ (ii) B1: expresses both of first two terms as multiple of root 3 correctly B1: nationalises denominator in second term -may not see working B1: has used $3\sqrt{3} + 7\sqrt{3} - 2\sqrt{3} = 8\sqrt{3}$ N.B. $3\sqrt{3} + 7\sqrt{3} - \frac{6}{\sqrt{3}} = 8\sqrt{3}$ is B1B0B0 (i) Alternative (iii) Alternative B1: Uses $\sqrt{2}\sqrt{3} = \sqrt{6}$ 1 ⁴ B1: Multiplies out these two brackets to give 4 A1: conclusion B1: LHS numerator correctly simplified or just see 9 + 21 - 6 B1: In the first alternative must see multiplication of numerator and denominator by $\sqrt{3}$ to give $8\sqrt{3}$ In the second	Alternative for (i)	Assume result and multiply both sides by $(2\sqrt{2} - \sqrt{6})$			
Alternative for (ii)Al So LHS = RHS and result is trueAl [4]Alternative for (ii) $\frac{\sqrt{81} + \sqrt{21 \times 7 \times 3} - 6}{\sqrt{3}}$ $Or \sqrt{81} + \sqrt{21 \times 7 \times 3} - 6 = 8\sqrt{3}\sqrt{3}$ B1 $\frac{9 + 21 - 6}{\sqrt{3}}$ $9 + 21 - 6 =$ B1 $\frac{24}{\sqrt{3}} \times \sqrt{3}}{\sqrt{3}} = 8\sqrt{3}$ $9 + 21 - 6 = 24$ B1 $\frac{13}{\sqrt{3}}$ $\sqrt{3} + 21 - 6 = 24$ so equation is true[3] (7 marks)(i) M1: Multiplies numerator and denominator by $\pm (2\sqrt{2} + \sqrt{6})$ A1 cao reaches result and no errors should be seenB1: Splits $\sqrt{6} = \sqrt{2}\sqrt{3}$ - may be implied, but B0 for $2\sqrt{6} = 2\sqrt{2}(2\sqrt{3})$ A1 cao reaches result and no errors should be seenN.B. $\frac{4(2\sqrt{2} + \sqrt{6})}{2} = 2\sqrt{2}(2 + \sqrt{3})$ may be awarded B1 A1 as there is an implication that $\sqrt{6} = \sqrt{2}\sqrt{3}$ (ii) B1: expresses both of first two terms as multiple of root 3 correctly B1: rationalises denominator in second term -may not see working B1: has used $3\sqrt{3} + 7\sqrt{3} - 2\sqrt{3} = 8\sqrt{3}$ N.B. $3\sqrt{3} + 7\sqrt{3} - \frac{6}{\sqrt{3}} = 8\sqrt{3}$ is B1B0B0(ii) AlternativeM1: Assume result and multiply both sides by $(2\sqrt{2} - \sqrt{6})$ 2^{nd} B1: Uses $\sqrt{2}\sqrt{3} = \sqrt{6}$ 1^{d} B1: Multiplies out these two brackets to give 4 A1: conclusion B1: L1IS numerator correctly simplified or just see $9 + 21 - 6$ B1: In the first alternative must see multiplication of numerator and denominator by $\sqrt{3}$ to give $8\sqrt{3}$ In the second B1: L1IS numerator correctly simplified or just see $9 + 21 - 6$ B1: In the first alternative must see multiplication of numerator and denominator by $\sqrt{3}$ to give $8\sqrt{3}$ In the second B1: L1IS numerator correctly simplified or just see $9 + 21 - 6$ B1: In the first alternative must see multiplication of numerator and denominator by $\sqrt{3}$ to give $8\sqrt$		$(2\sqrt{2} - \sqrt{6})(4\sqrt{2} + 2\sqrt{6}) = 16 - 12 = 4$			
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Question Number	Scheme	Notes	Marks
3.(a)	$\sqrt{50} - \sqrt{18} = 5\sqrt{2} - 3\sqrt{2}$	$\sqrt{50} = 5\sqrt{2}$ or $\sqrt{18} = 3\sqrt{2}$ and the other term in the form $k\sqrt{2}$. This mark may be implied by the correct answer $2\sqrt{2}$	M1
	$=2\sqrt{2}$	Or $a = 2$	A1
			[2]
(b) WAY 1	$\frac{12\sqrt{3}}{\sqrt{50} - \sqrt{18}} = \frac{12\sqrt{3}}{"2"\sqrt{2}}$	Uses part (a) by replacing denominator by their $a\sqrt{2}$ where <i>a</i> is numeric. This is all that is required for this mark.	M1
	$=\frac{12\sqrt{3}}{"2"\sqrt{2}}\times\frac{\sqrt{2}}{\sqrt{2}}=\frac{12\sqrt{6}}{4}$	Rationalises the denominator by a correct method e.g. multiplies numerator and denominator by $k\sqrt{2}$ to obtain a multiple of $\sqrt{6}$. Note that multiplying numerator and denominator by $2\sqrt{2}$ or $-2\sqrt{2}$ is quite common and is acceptable for this mark. May be implied by a correct answer. This is dependent on the first M1.	dM1
	$= 3\sqrt{6}$ or $b = 3, c = 6$	Cao and cso	A1
			[3]
(b) WAY 2	$\frac{12\sqrt{3}}{\sqrt{50} - \sqrt{18}} \times \frac{\sqrt{50} + \sqrt{18}}{\sqrt{50} + \sqrt{18}}$ or $\frac{12\sqrt{3}}{5\sqrt{2} - 3\sqrt{2}} \times \frac{5\sqrt{2} + 3\sqrt{2}}{5\sqrt{2} + 3\sqrt{2}}$	For rationalising the denominator by a correct method i.e. multiplying numerator and denominator by $k\left(\sqrt{50} + \sqrt{18}\right)$	M1
	$\frac{60\sqrt{6} + 36\sqrt{6}}{50 - 18}$	For replacing numerator by $\alpha \sqrt{6} + \beta \sqrt{6}$. This is dependent on the first M1 and there is no need to consider the denominator for this mark.	dM1
	$= 3\sqrt{6}$ or $b = 3, c = 6$	Cao and cso	A1
			[3]
(b) WAY 3	$\frac{12\sqrt{3}}{\sqrt{50} - \sqrt{18}} = \frac{12\sqrt{3}}{"2"\sqrt{2}}$	Uses part (a) by replacing denominator by their $a\sqrt{2}$ where <i>a</i> is numeric. This is all that is required for this mark.	M1
	$=\frac{12\sqrt{3}}{2\sqrt{2}}=\frac{6\sqrt{3}}{\sqrt{2}}=\frac{\sqrt{108}}{\sqrt{2}}=\sqrt{54}=\sqrt{9}\sqrt{6}$	Cancels to obtain a multiple of $\sqrt{6}$. This is dependent on the first M1.	dM1
	$= 3\sqrt{6}$ Or $b = 3, c = 6$	Cao and cso	A1
			[3]
(b) WAY 4	$\frac{12\sqrt{3}}{\sqrt{50} - \sqrt{18}} = \frac{12\sqrt{3}}{"2"\sqrt{2}}$	Uses part (a) by replacing denominator by their $a\sqrt{2}$ where <i>a</i> is numeric. This is all that is required for this mark.	M1
	$\left(\frac{12\sqrt{3}}{"2"\sqrt{2}}\right)^2 = \frac{432}{8}$		
	$\sqrt{54} = \sqrt{9}\sqrt{6}$	Obtains a multiple of $\sqrt{6}$. This is dependent on the first M1.	dM1
	$= 3\sqrt{6}$ Or $b = 3, c = 6$	Cao and cso (do not allow $\pm 3\sqrt{6}$)	A1
			5 marks

Question Number	Scheme		Marks	
1. (a)	20	Sight of 20. (4×5 is not sufficient)	B1	
			(1)	
(b)	$\frac{\sqrt{2}}{2\sqrt{5} - 3\sqrt{2}} \times \frac{2\sqrt{5} + 3\sqrt{2}}{2\sqrt{5} + 3\sqrt{2}}$	Multiplies top and bottom by a correct expression. This statement is sufficient. NB $2\sqrt{5} + 3\sqrt{2} \equiv \sqrt{20} + \sqrt{18}$	M1	
	(Allow to multiply to	op and bottom by $k(2\sqrt{5}+3\sqrt{2})$		
		Obtains a denominator of 2 or sight of		
		$(2\sqrt{5} - 3\sqrt{2})(2\sqrt{5} + 3\sqrt{2}) = 2$ with no errors		
	$=\frac{\dots}{2}$	seen in this expansion.	A1	
	2	May be implied by $\frac{\dots}{2k}$		
	Note that M0A1 is not possible	. The 2 must come from a correct method.		
	Note that if M1 is scored the	re is no need to consider the numerator.		
	e.g. $\frac{2(MR?)}{2\sqrt{5}-3\sqrt{2}} \times \frac{2\sqrt{5}+3\sqrt{2}}{2\sqrt{5}+3\sqrt{2}} = {2}$ scores M1A1			
		An attempt to multiply the numerator by		
		$+(2\sqrt{5}+3\sqrt{2})$ and obtain an expression of the		
	Numerator =		M1	
	$\sqrt{2}(2\sqrt{5}\pm 3\sqrt{2}) = 2\sqrt{10}\pm 6$	form $p + q\sqrt{10}$ where p and q are integers.	1011	
		This may be implied by e.g. $2\sqrt{10} + 3\sqrt{4}$ or by their final answer.		
	(Allow attempt to multiple)	ply the numerator by $k(2\sqrt{5}\pm 3\sqrt{2})$		
	$\frac{\sqrt{2}}{2\sqrt{5} - 3\sqrt{2}} = \frac{2\sqrt{10} + 6}{2} = 3 + \sqrt{10}$	Cso. For the answer as written or $\sqrt{10} + 3$ or a statement that $a = 3$ and $b = 10$. Score when first seen and ignore any subsequent attempt to 'simplify'. Allow $1\sqrt{10}$ for $\sqrt{10}$	A1	
			(4)	
			(5 marks)	
	Alternative for (b)			
	$\sqrt{2}$ 1 2	M1: Divides or multiplies top and bottom by $\sqrt{2}$		
	$\frac{\sqrt{2}}{2\sqrt{5} - 3\sqrt{2}} = \frac{1}{\sqrt{10} - 3} \text{ or } \frac{2}{2\sqrt{10} - 6}$	A1: $\frac{k}{k\left(\sqrt{10}-3\right)}$	M1A1	
	$=\frac{1}{\sqrt{10}-3} \times \frac{\sqrt{10}+3}{\sqrt{10}+3} $ M1	Multiplies top and bottom by $\sqrt{10} + 3$	M1	
	$=3+\sqrt{10}$		A1	
	·			
2.	$y-2x-4=0, \ 4x^2+y^2+20x=0$			