Question 1

Question	Scheme	Marks
(a)	$\sqrt{32}=4\sqrt{2}$ or $\sqrt{18}=3\sqrt{2}$	B1
	$\left(\sqrt{32}+\sqrt{18}=\right)\ \underline{7\sqrt{2}}$	B1 (2)
(b)	$\times\dfrac{3-\sqrt{2}}{3-\sqrt{2}}$ or $\times\dfrac{-3+\sqrt{2}}{-3+\sqrt{2}}$ seen	M1
	$\left[\dfrac{\sqrt{32}+\sqrt{18}}{3+\sqrt{2}}\times\dfrac{3-\sqrt{2}}{3-\sqrt{2}}=\right]\ \dfrac{a\sqrt{2}\left(3-\sqrt{2}\right)}{[9-2]} \rightarrow \dfrac{3a\sqrt{2}-2a}{[9-2]}$ (or better)	dM1
	$=\underline{3\sqrt{2},-2}$	A1, A1 (4)
ALT	$(b\sqrt{2}+c)(3+\sqrt{2})=7\sqrt{2}$ leading to: $3b+c=7,\quad 3c+2b=0$	M1
	e.g. $3(7-3b)+2b=0$ (o.e.)	dM1
		6 marks
	Notes	
(a)	1st B1 for either surd simplified 2nd B1 for $7\sqrt{2}$ or accept $a=7$. Answer only scores B1B1 NB Common error is $\sqrt{32}+\sqrt{18}=\sqrt{50}=5\sqrt{2}$ this scores B0B0 but can use their "5" in (b) to get M1M1	
(b)	1st M1 for an attempt to multiply by $\dfrac{3-\sqrt{2}}{3-\sqrt{2}}$ (o.e.) Allow poor use of brackets 2nd dM1 for using $a\sqrt{2}$ to correctly obtain a numerator of the form $p+q\sqrt{2}$ where p and q are non-zero integers. Allow arithmetic slips e.g. $21\sqrt{2}-28$ or $3\sqrt{2}\times\sqrt{2}=3$ Follow through their $a=7$ or a new value found in (b). Ignore denominator. Allow use of letter a. Dependent on 1st M1 So $3\sqrt{32}-\sqrt{64}+3\sqrt{8}-\sqrt{36}$ is M0 until they reduce $p+q\sqrt{2}$ 1st A1 for $3\sqrt{2}$ or accept $b=3$ from correct working 2nd A1 for -2 or accept $c=-2$ from correct working	
ALT	**Simultaneous Equations** 1st M1 for $(b\sqrt{2}+c)(3+\sqrt{2})=7\sqrt{2}$ and forming 2 simultaneous equations. Ft their $a=7$ 2nd dM1 for solving their simultaneous equations: reducing to a linear equation in one variable	

Question 2

Question Number	Scheme	Marks
(a)	$\left\{(32)^{\frac{3}{5}}\right\} = \left(\sqrt[5]{32}\right)^3$ or $\sqrt[5]{(32)^3}$ or 2^3 or $\sqrt[5]{32768}$	M1
	$= 8$	A1
		[2]
(b)	$\left\{\left(\dfrac{25x^4}{4}\right)^{-\frac{1}{2}}\right\} = \left(\dfrac{4}{25x^4}\right)^{\frac{1}{2}}$ or $\left(\dfrac{5x^2}{2}\right)^{-1}$ or $\dfrac{1}{\left(\dfrac{25x^4}{4}\right)^{\frac{1}{2}}}$ *See notes below*	M1
	$= \dfrac{2}{5x^2}$ or $\dfrac{2}{5}x^{-2}$ *See notes for other alternatives*	A1
		[2]
		4

	Notes
(a)	**M1**: for a full correct interpretation of the fractional power. **Note:** $5\times(32)^3$ is M0. **A1**: for 8 only. **Note:** Award M1A1 for writing down 8.
(b)	**M1**: For use of $\dfrac{1}{2}$ OR use of -1 Use of $\dfrac{1}{2}$: Candidate needs to demonstrate the they have rooted all three elements in their bracket. Use of -1: Either Candidate has $\dfrac{1}{\text{Bracket}}$ or $\left(\dfrac{Ax^C}{B}\right)$ becomes $\left(\dfrac{B}{Ax^C}\right)$. Allow M1 for... • $\left(\dfrac{4}{25x^4}\right)^{\frac{1}{2}}$ or $\left(\dfrac{5x^2}{2}\right)^{-1}$ or $\dfrac{1}{\left(\dfrac{25x^4}{4}\right)^{\frac{1}{2}}}$ or $\sqrt{\left(\dfrac{4}{25x^4}\right)}$ or $\dfrac{1}{\sqrt{\left(\dfrac{25x^4}{4}\right)}}$ or $\left(\dfrac{\frac{1}{25x^4}}{\frac{1}{4}}\right)^{\frac{1}{2}}$ or $\dfrac{\frac{1}{5x^2}}{\frac{1}{2}}$ or $\dfrac{\frac{1}{5}x^{-2}}{\frac{1}{2}}$ or $-\left(\dfrac{5x^2}{2}\right)$ or $\left(\dfrac{-5x^{-2}}{-2}\right)$ or $-\left(\dfrac{5x^{-2}}{2}\right)$ or $\dfrac{5x^{-2}}{2}$ • $\left(\dfrac{4}{25x^4}\right)^K$ or $\left(\dfrac{5x^2}{2}\right)^C$ where K, C are any powers including 1. **A1**: for either $\dfrac{2}{5x^2}$ or $\dfrac{2}{5}x^{-2}$ or $0.4x^{-2}$ or $\dfrac{0.4}{x^2}$. **Note:** $\left(\sqrt{\left(\dfrac{25x^4}{4}\right)}\right)^{-1}$ is not enough work by itself for the method mark. **Note:** A final answer of $\dfrac{1}{\frac{5}{2}x^2}$ or $\dfrac{1}{2\frac{1}{2}x^2}$ or $\dfrac{1}{2.5x^2}$ is A0. **Note:** Also allow $\pm\dfrac{2}{5x^2}$ or $\pm\dfrac{2}{5}x^{-2}$ or $\pm 0.4x^{-2}$ or $\pm\dfrac{0.4}{x^2}$ for A1.

Question 3

Question Number	Scheme		Marks
	$\left\{\dfrac{2}{\sqrt{12}-\sqrt{8}}\right\} = \dfrac{2}{(\sqrt{12}-\sqrt{8})} \times \dfrac{(\sqrt{12}+\sqrt{8})}{(\sqrt{12}+\sqrt{8})}$	Writing this is sufficient for M1.	M1
	$= \dfrac{\{2(\sqrt{12}+\sqrt{8})\}}{12-8}$	For $12-8$. This mark can be implied.	A1
	$= \dfrac{2(2\sqrt{3}+2\sqrt{2})}{12-8}$		B1 B1
	$= \sqrt{3}+\sqrt{2}$		A1 cso
			5

Notes

M1: for a correct method to rationalise the denominator.

1st A1: $(\sqrt{12}-\sqrt{8})(\sqrt{12}+\sqrt{8}) \rightarrow 12-8$ or $(\sqrt{3}+\sqrt{2})(\sqrt{3}-\sqrt{2}) \rightarrow 3-2$

1st B1: for $\sqrt{12}=2\sqrt{3}$ or $\sqrt{48}=4\sqrt{3}$ seen or implied in candidate's working.

2nd B1: for $\sqrt{8}=2\sqrt{2}$ or $\sqrt{32}=4\sqrt{2}$ seen or implied in candidate's working.

2nd A1: for $\sqrt{3}+\sqrt{2}$. Note: $\dfrac{\sqrt{3}+\sqrt{2}}{1}$ as a final answer is A0.

Note: The first accuracy mark is dependent on the first method mark being awarded.

Note: $\frac{1}{2}\sqrt{12}+\frac{1}{2}\sqrt{8}=\sqrt{3}+\sqrt{2}$ with no intermediate working implies the B1B1 marks.

Note: $\sqrt{12}=\sqrt{4}\sqrt{3}$ or $\sqrt{8}=\sqrt{4}\sqrt{2}$ are not sufficient for the B1 marks.

Note: A candidate who writes down (by misread) $\sqrt{18}$ for $\sqrt{8}$ can potentially obtain M1A0B1B1A0, where the 2nd B1 will be awarded for $\sqrt{18}=3\sqrt{2}$ or $\sqrt{72}=6\sqrt{2}$

Note: The final accuracy mark is for a correct solution only.

Alternative 1 solution

$\left\{\dfrac{2}{\sqrt{12}-\sqrt{8}}\right\} = \dfrac{2}{(2\sqrt{3}-2\sqrt{2})}$ B1 B1

$= \dfrac{1}{(\sqrt{3}-\sqrt{2})} \times \dfrac{(\sqrt{3}+\sqrt{2})}{(\sqrt{3}+\sqrt{2})}$ M1

$= \dfrac{\{(\sqrt{3}+\sqrt{2})\}}{3-2}$ A1 for $3-2$

$= \sqrt{3}+\sqrt{2}$ A1

Please record the marks in the relevant places on the mark grid.

Alternative 2 solution

$\left\{\dfrac{2}{\sqrt{12}-\sqrt{8}}\right\} = \dfrac{2}{(2\sqrt{3}-2\sqrt{2})} = \dfrac{1}{(\sqrt{3}-\sqrt{2})} = \sqrt{3}+\sqrt{2}$, or $\dfrac{2}{(2\sqrt{3}-2\sqrt{2})} = \sqrt{3}+\sqrt{2}$

with no incorrect working seen is awarded M1A1B1B1A1.

Question 4

Question Number	Scheme	Marks
	$x(1-4x^2)$ Accept $x(-4x^2+1)$ or $-x(4x^2-1)$ or $-x(-1+4x^2)$ or even $4x(\frac{1}{4}-x^2)$ or equivalent quadratic (or initial cubic) into two brackets $x(1-2x)(1+2x)$ or $-x(2x-1)(2x+1)$ or $x(2x-1)(-2x-1)$	B1 M1 A1 [3]
		3 marks
	Notes	
	B1: Takes out a factor of x or $-x$ or even $4x$. This line may be implied by correct final answer, but if this stage is shown it **must be correct**. So **B0** for $x(1+4x^2)$ **M1:** Factorises the quadratic resulting from their first factorisation using usual rules (see note 1 in General Principles). e.g. $x(1-4x)(x-1)$. Also allow attempts to factorise cubic such as $(x-2x^2)(1+2x)$ etc N.B. Should not be completing the square here. **A1:** Accept either $x(1-2x)(1+2x)$ or $-x(2x-1)(2x+1)$ or $x(2x-1)(-2x-1)$. (No fractions for this final answer)	
	Specific situations	
	Note: $x(1-4x^2)$ followed by $x(1-2x)^2$ scores B1M1A0 as factors follow quadratic factorisation criteria **And** $x(1-4x^2)$ followed by $x(1-4x)(1+4x)$ **B1M0A0.**	
	Answers with no working: Correct answer gets all three marks B1M1A1	
	: $x(2x-1)(2x+1)$ gets B0M1A0 if **no working** as $x(4x^2-1)$ would earn B0	
	Poor bracketing: e.g. $(-1+4x^2)-x$ gets B0 unless subsequent work implies bracket round the $-x$ in which case candidate may recover the mark by the following correct work.	

Question 5

Question Number	Scheme	Marks
	$(8^{2x+3}=\left(2^3\right)^{2x+3})=2^{3(2x+3)}$ or 2^{ax+b} with $a=6$ or $b=9$ $=2^{6x+9}$ *or* $=2^{3(2x+3)}$ as **final** answer with no errors or $(y=)6x+9$ or $3(2x+3)$	M1 A1 [2]
		2 marks
	Notes	
	M1: Uses $8=2^3$, and **multiplies** powers $3(2x+3)$. Does **not** add powers. (Just $8=2^3$ or $8^{\frac{1}{3}}=2$ is M0) **A1:** Either 2^{6x+9} *or* $=2^{3(2x+3)}$ or $(y=)6x+9$ or $3(2x+3)$	
	Note: Examples: 2^{6x+3} scores M1A0 : $8^{2x+3}=\left(2^3\right)^{2x+3}=2^{3+2x+3}$ gets M0A0 **Special case:** : $=2^{6x}\,2^9$ without seeing as single power M1A0 **Alternative method using logs:** $8^{2x+3}=2^y\Rightarrow(2x+3)\log 8=y\log 2\Rightarrow y=\dfrac{(2x+3)\log 8}{\log 2}$ — **M1** So $(y=)6x+9$ or $3(2x+3)$ — **A1 [2]**	

Question 6

Question Number	Scheme	Marks
(i)	$\left(5-\sqrt{8}\right)\left(1+\sqrt{2}\right)$ $=5+5\sqrt{2}-\sqrt{8}-4$ $=5+5\sqrt{2}-2\sqrt{2}-4$ $\quad$ $\sqrt{8}=2\sqrt{2}$, seen or implied at any point. $=1+3\sqrt{2}$ $\quad$ $1+3\sqrt{2}$ or $a=1$ and $b=3$.	 M1 B1 A1 [3]
(ii)	**Method 1** **Either** $\sqrt{80}+\frac{30}{\sqrt{5}}\left(\frac{\sqrt{5}}{\sqrt{5}}\right)$ $=4\sqrt{5}+\ldots$ $=4\sqrt{5}+6\sqrt{5}$ **Method 2** **Or** $\left(\frac{\sqrt{400}+30}{\sqrt{5}}\right)\frac{\sqrt{5}}{\sqrt{5}}$ $=\left(\frac{20+..}{..}\right)\frac{..}{..}$ $=\left(\frac{50\sqrt{5}}{5}\right)$ **Method 3** $\sqrt{80}+\frac{\sqrt{900}}{\sqrt{5}}=\sqrt{80}+\sqrt{180}$ $=4\sqrt{5}+\ldots$ $=4\sqrt{5}+6\sqrt{5}$ $=10\sqrt{5}$	M1 B1 A1 [3]
Alternative for (i)	$\left(5-2\sqrt{2}\right)\left(1+\sqrt{2}\right)$ $\quad$ This earns the B1 mark. $=5+5\sqrt{2}-2\sqrt{2}-2\sqrt{2}\sqrt{2}$ $\quad$ Multiplies out correctly with $2\sqrt{2}$. This may be seen or implied and may be simplified e.g. $=5+3\sqrt{2}\ -2\sqrt{4}$ o.e For earlier use of $2\sqrt{2}$ $=1+3\sqrt{2}$ $\quad$ $1+3\sqrt{2}$ or $a=1$ and $b=3$.	 M1 B1 A1 [3] **6 marks**
	Notes	
(i)	**M1:** Multiplies out brackets correctly giving four correct terms or simplifying to correct expansion. (This may be implied by correct answer) – can appear as table **B1:** $\sqrt{8}=2\sqrt{2}$, seen or implied at any point **A1:** Fully and correctly simplified to $1+3\sqrt{2}$ or $a=1$ and $b=3$.	
(ii)	**M1:** Rationalises denominator i.e. Multiplies $\left(\frac{k}{\sqrt{5}}\right)$ by $\left(\frac{\sqrt{5}}{\sqrt{5}}\right)$ or $\left(\frac{-\sqrt{5}}{-\sqrt{5}}\right)$, seen or implied or uses Method 3 or similar e.g. $\left(\frac{30}{\sqrt{5}}\right)=\frac{6\times 5}{\sqrt{5}}=6\sqrt{5}$ **B1**: (Independent mark) States $\sqrt{80}=4\sqrt{5}$ Or either $\sqrt{400}=20$ *or* $\sqrt{80}\sqrt{5}=20$ at any point if they use Method 2. **A1:** $10\sqrt{5}$ or $c=10$.	
	N.B There are other methods e.g. $\sqrt{80}=\frac{20}{\sqrt{5}}$ (B1) then add $\frac{20}{\sqrt{5}}+\frac{30}{\sqrt{5}}=\frac{50}{\sqrt{5}}$ then M1 A1as before Those who multiply initial expression by $\sqrt{5}$ to obtain $\sqrt{400}+30=20+30=50$ earn M0 B1 A0	

Question 7

Question Number	Scheme	Notes	Marks
	$\frac{15}{\sqrt{3}} = \frac{15}{\sqrt{3}} \times \frac{\sqrt{3}}{\sqrt{3}} = 5\sqrt{3}$	M1: Attempts to multiply numerator and denominator by $\sqrt{3}$. This may be implied by a correct answer. A1: $5\sqrt{3}$	M1A1
	$\sqrt{27} = 3\sqrt{3}$		B1
	$\frac{15}{\sqrt{3}} - \sqrt{27} = 2\sqrt{3}$		A1
	Correct answer only scores full marks		
			[4]
Way 2	$\frac{15}{\sqrt{3}} - \sqrt{27} = \frac{15-\sqrt{81}}{\sqrt{3}}\left(=\frac{6}{\sqrt{3}}\right)$	Terms combined correctly with a common denominator (Need not be simplified)	B1
	$\frac{6}{\sqrt{3}} \times \frac{\sqrt{3}}{\sqrt{3}} = \frac{6\sqrt{3}}{3}$	M1: Attempts to multiply numerator and denominator by $\sqrt{3}$. This may be implied by a correct answer. A1: $\frac{6\sqrt{3}}{3}$	M1A1
	$\frac{15}{\sqrt{3}} - \sqrt{27} = 2\sqrt{3}$		A1
			[4]
	Note that $\frac{15}{\sqrt{3}} - \sqrt{27} = \frac{15\sqrt{3}}{3} - 3\sqrt{3} = 15\sqrt{3} - 9\sqrt{3} = 6\sqrt{3}$ is quite common and scores M1A0B1A0 (i.e. $5\sqrt{3}$ is never seen)		

Question 8

Question Number	Scheme	Notes	Marks
(a)	$2^y = 8 \Rightarrow y = 3$	Cao (Can be implied i.e. by 2^3)	B1
	(Alternative: Takes logs base 2: $\log_2 2^y = \log_2 8 \Rightarrow y\log_2 2 = 3\log_2 2 \Rightarrow y = 3$)		
			(1)
(b)	$8 = 2^3$	Replaces 8 by 2^3 (May be implied)	M1
	$4^{x+1} = (2^2)^{x+1}$ or $(2^{x+1})^2$	Replaces 4 by 2^2 **correctly.**	M1
	$2^{3x+2} = 2^3 \Rightarrow 3x + 2 = 3 \Rightarrow x = \frac{1}{3}$	M1: Adds their powers of 2 on the lhs and puts this equal to 3 leading to a solution for x.	M1A1
		A1: $x = \frac{1}{3}$ or $x = 0.\dot{3}$ or awrt 0.333	
			(4)
(b) Way 2	$4^{x+1} = 4 \times 4^x$	Obtains 4^{x+1} in terms of 4^x **correctly**	M1
	$2^x \times 4^x = 8^x$	Combines their 2^x and 4^x **correctly**	M1
	$4 \times 8^x = 8 \Rightarrow 8^x = 2 \Rightarrow x = \frac{1}{3}$	M1: Solves $8^x = k$ leading to a solution for x.	M1A1
		A1: $x = \frac{1}{3}$ or $x = 0.\dot{3}$ or awrt 0.333	
			[5]

Question 9

Question Number	Scheme		Marks
	$\frac{7+\sqrt{5}}{\sqrt{5}-1} \times \frac{(\sqrt{5}+1)}{(\sqrt{5}+1)}$	Multiplies top and bottom by a correct expression. This statement is sufficient.	M1
	(Allow to multiply top and bottom by $k(\sqrt{5}+1)$)		
	$=\frac{\cdots}{4}$	Obtains a denominator of 4 or sight of $(\sqrt{5}-1)(\sqrt{5}+1)=4$	A1cso
	Note that M0A1 is not possible. The 4 must come from a correct method.		
	$(7+\sqrt{5})(\sqrt{5}+1)=7\sqrt{5}+5+7+\sqrt{5}$	An attempt to multiply the numerator by $(\pm\sqrt{5}\pm1)$ and get 4 terms with at least 2 correct for their $(\pm\sqrt{5}\pm1)$. (May be implied)	M1
	$3+2\sqrt{5}$	Answer as written or a = 3 and $b=2$. (Allow $2\sqrt{5}+3$)	A1cso
	Correct answer with no working scores full marks		
			[4]
Way 2	$\frac{7+\sqrt{5}}{\sqrt{5}-1} \times \frac{(-\sqrt{5}-1)}{(-\sqrt{5}-1)}$	Multiplies top and bottom by a correct expression. This statement is sufficient.	M1
	(Allow to multiply top and bottom by $k(-\sqrt{5}-1)$)		
	$=\frac{\cdots}{-4}$	Obtains a denominator of -4	A1cso
	$(7+\sqrt{5})(-\sqrt{5}-1)=-7\sqrt{5}-5-7-\sqrt{5}$	An attempt to multiply the numerator by $(\pm\sqrt{5}\pm1)$ and get 4 terms with at least 2 correct for their $(\pm\sqrt{5}\pm1)$. (May be implied)	M1
	$3+2\sqrt{5}$	Answer as written or a = 3 and $b=2$	A1cso
	Correct answer with no working scores full marks		
			[4]
	Alternative using Simultaneous Equations: $\frac{(7+\sqrt{5})}{\sqrt{5}-1}=a+b\sqrt{5} \Rightarrow 7+\sqrt{5}=(a-b)\sqrt{5}+5b-a$ M1 Multiplies and collects rational and irrational parts $a-b=1,\ \ 5b-a=7$ A1 Correct equations $a=3,\ b=2$ M1 for attempt to solve simultaneous equations A1 both answers correct		

Question 10

Question Number	Scheme		Marks
(a)	$8^{\frac{1}{3}} = 2$ or $8^5 = 32768$	A correct attempt to deal with the $\frac{1}{3}$ or the 5. $8^{\frac{1}{3}} = \sqrt[3]{8}$ or $8^5 = 8\times8\times8\times8\times8$	M1
	$\left(8^{\frac{5}{3}} =\right)$ 32	Cao	A1
	A correct answer with no working scores full marks		
	Alternative $8^{\frac{5}{3}} = 8\times 8^{\frac{2}{3}} = 8\times 2^2 =$ M1 (Deals with the 1/3) $= 32$ A1		
			(2)
(b)	$\left(2x^{\frac{1}{2}}\right)^3 = 2^3x^{\frac{3}{2}}$	One correct power either 2^3 or $x^{\frac{3}{2}}$. $\left(2x^{\frac{1}{2}}\right)\times\left(2x^{\frac{1}{2}}\right)\times\left(2x^{\frac{1}{2}}\right)$ on its own is not sufficient for this mark.	M1
	$\dfrac{8x^{\frac{3}{2}}}{4x^2} = 2x^{-\frac{1}{2}}$ or $\dfrac{2}{\sqrt{x}}$	M1: Divides coefficients of x **and** subtracts their powers of x. **Dependent on the previous M1** A1: Correct answer	dM1A1
	Note that unless the power of x implies that they have subtracted their powers you would need to see evidence of subtraction. E.g. $\dfrac{8x^{\frac{3}{2}}}{4x^2} = 2x^{\frac{1}{2}}$ would score dM0 unless you see some evidence that $3/2 - 2$ was intended for the power of x.		
	Note that there is a misconception that $\dfrac{\left(2x^{\frac{1}{2}}\right)^3}{4x^2} = \left(\dfrac{2x^{\frac{1}{2}}}{4x^2}\right)^3$ - this scores 0/3		
			(3)
			[5]

Question 11

Question Number	Scheme	Marks
	(a) $32^{\frac{1}{5}} = 2$	B1 (1)
	(b) For 2^{-2} or $\frac{1}{4}$ or $\left(\frac{1}{2}\right)^2$ or 0.25 as coefficient of x^k, for any value of k including $k = 0$	M1
	Correct index for x so Ax^{-2} or $\frac{A}{x^2}$ o.e. for any value of A	B1
	$= \frac{1}{4x^2}$ or $0.25x^{-2}$	A1 cao (3)
		4 Marks

Notes

(a) B1 Answer 2 must be in part (a) for this mark

(b) Look at their final answer

M1 For 2^{-2} or $\frac{1}{4}$ or $\left(\frac{1}{2}\right)^2$ or 0.25 in their answer as coefficient of x^k for numerical value of k (including $k = 0$) so final answer $\frac{1}{4}$ is M1 B0 A0

B1 Ax^{-2} or $\frac{A}{x^2}$ or equivalent e.g. $Ax^{-\frac{10}{5}}$ or $Ax^{-\frac{50}{25}}$ i.e. correct power of x seen in final answer

May have a bracket provided it is $(Ax)^{-2}$ or $\left(\frac{A}{x}\right)^2$

A1 $\frac{1}{4x^2}$ or $\frac{1}{4}x^{-2}$ or $0.25x^{-2}$ oe but must be correct power **and** coefficient combined correctly and must not be followed by a different wrong answer.

Poor bracketing: $2x^{-2}$ earns M0 B1 A0 as correct power of x is seen in this solution (They can recover if they follow this with $\frac{1}{4x^2}$ etc)

Special case $(2x)^{-2}$ as a **final** answer and $\left(\frac{1}{2x}\right)^2$ can have M0 B1 A0 if the correct expanded answer is not seen

The correct answer $\frac{1}{4x^2}$ etc. followed by $\left(\frac{1}{2x}\right)^2$ or $(2x)^{-2}$, treat $\frac{1}{4x^2}$ as final answer so M1 B1 A1 isw

But the correct answer $\frac{1}{4x^2}$ etc clearly followed by the wrong $2x^{-2}$ or $4x^{-2}$, gets M1 B1 A0 do not ignore subsequent wrong work here

Question 12

Question Number	Scheme	Marks
	(a) $80 = 5\times16$ $\sqrt{80} = 4\sqrt{5}$	B1 (1)
	Method 1 (b) $\dfrac{\sqrt{80}}{\sqrt{5}+1}$ or $\dfrac{c\sqrt{5}}{\sqrt{5}+1}$ $=\dfrac{\sqrt{80}}{\sqrt{5}+1}\times\dfrac{\sqrt{5}-1}{\sqrt{5}-1}$ or $\dfrac{\sqrt{80}}{1+\sqrt{5}}\times\dfrac{1-\sqrt{5}}{1-\sqrt{5}}$ $=\dfrac{20-4\sqrt{5}}{4}$ or $\dfrac{4\sqrt{5}-20}{-4}$ $=5-\sqrt{5}$ **Method 2** $(p+q\sqrt{5})(\sqrt{5}+1)=\sqrt{80}$ $p\sqrt{5}+q\sqrt{5}+p+5q = 4\sqrt{5}$ $p+5q=0$ $p+q=4$ $p=5,\ q=-1$	B1ft M1 A1 A1cao (4) **(5 marks)**

Notes

(a) B1 Accept $4\sqrt{5}$ or $c=4$ – no working necessary

(b)

(Method 1)

B1ft Only ft on c See $\dfrac{\sqrt{80}}{\sqrt{5}+1}$ or $\dfrac{c\sqrt{5}}{\sqrt{5}+1}$

M1 State intention to multiply by $\sqrt{5}-1$ or $1-\sqrt{5}$ in the numerator **and** the denominator

A1 Obtain denominator of 4 (for $\sqrt{5}-1$) **or** -4 (for $1-\sqrt{5}$) **or** correct simplified numerator of $20-4\sqrt{5}$ or $4(5-\sqrt{5})$ **or** $4\sqrt{5}-20$ or $4(\sqrt{5}-5)$ **So either numerator or denominator must be correct**

A1 Correct answer only. Both **numerator and denominator must have been correct and division of** numerator and denominator by 4 has been performed.

Accept $p=5,\ q=-1$ or accept $5-\sqrt{5}$ or $-\sqrt{5}+5$ Also accept $5-1\sqrt{5}$

(Method 2)

B1ft Only ft on c $(p+q\sqrt{5})(\sqrt{5}+1)=\sqrt{80}$ or $c\sqrt{5}$

M1 Multiply out the lhs and replace $\sqrt{80}$ by $c\sqrt{5}$

A1 Compare rational and irrational parts to give $p+q=4$, **and** $p+5q=0$

A1 Solve equations to give $p=5,\ q=-1$

Common error:

$\dfrac{\sqrt{80}}{1+\sqrt{5}}\times\dfrac{1-\sqrt{5}}{1-\sqrt{5}} = \dfrac{4\sqrt{5}-20}{4} = \sqrt{5}-5$ gets B1 M1 A1 (for correct numerator – denominator is wrong for their product) then A0

Correct answer with no working – send to review – have they used a calculator?
Correct answer after trial and improvement with evidence that $(5-\sqrt{5})(\sqrt{5}+1)=\sqrt{80}$ could earn all four marks

Question 13

Question Number	Scheme	Marks
	$25x-9x^3=x(25-9x^2)$	B1
	$(25-9x^2)=(5+3x)(5-3x)$	M1
	$25x-9x^3=x(5+3x)(5-3x)$	A1
		(3)

B1 Take out a common factor, usually x, to produce $x(25-9x^2)$. Accept $(x\pm 0)(25-9x^2)$ or $-x(9x^2-25)$ Must be correct.
Other possible options are $(5+3x)(5x-3x^2)$ or $(5-3x)(5x+3x^2)$

M1 For factorising their quadratic term, usually $(25-9x^2)=(5+3x)(5-3x)$ Accept sign errors
If $(5\pm 3x)$ has been taken out as a factor first, this is for an attempt to factorise $(5x\mp 3x^2)$

A1 cao $x(5+3x)(5-3x)$ or any equivalent with three factors
e.g. $x(5+3x)(-3x+5)$ or $x(3x-5)(-3x-5)$ etc including $-x(3x+5)(3x-5)$
isw if they go on to show that $x=0,\ \pm\frac{5}{3}$

Question 14

Question Number	Scheme	Marks
(a)	$81^{\frac{3}{2}}=(81^{\frac{1}{2}})^3=9^3$ or $81^{\frac{3}{2}}=(81^3)^{\frac{1}{2}}=(531441)^{\frac{1}{2}}$	M1
	$=729$	A1
		(2)
(b)	$(4x^{-\frac{1}{2}})^2=16x^{-\frac{2}{2}}$ or $\frac{16}{x}$ or equivalent	M1
	$x^2(4x^{-\frac{1}{2}})^2 \quad =16x$	A1
		(2)
		(4 marks)

(a) M1 Dealing with either the 'cube' or the 'square root' first. A correct answer will imply this mark.
Also accept a law of indices approach $81^{\frac{3}{2}}=81^1\times 81^{\frac{1}{2}}=81\times 9$

A1 Cao 729. Accept $(\pm)729$

(b) M1 For correct use of power 2 on both 4 and the $x^{-\frac{1}{2}}$ term.

A1 Cao $=16x$

Question 15

Question Number	Scheme	Marks
Method 1	$x\sqrt{8}+10=\dfrac{6x}{\sqrt{2}}$ $\times\sqrt{2}\Rightarrow x\sqrt{16}+10\sqrt{2}=6x$ $4x+10\sqrt{2}=6x\Rightarrow 2x=10\sqrt{2}$ $x=5\sqrt{2}$ or $a=5$ and $b=2$	M1,A1 M1A1 (4)
Method 2	$x\sqrt{8}+10=\dfrac{6x}{\sqrt{2}}$ $2\sqrt{2}x+10=3\sqrt{2}x$ $\sqrt{2}x=10\Rightarrow x=\dfrac{10}{\sqrt{2}}=\dfrac{10\sqrt{2}}{2},=5\sqrt{2}$ oe	M1A1 M1,A1 (4)

Method 1

M1 For multiplying both sides by $\sqrt{2}$ – allow a slip e.g. $\sqrt{2}x\sqrt{8}+10=\dfrac{6x}{\sqrt{2}}\times\sqrt{2}$ or

$\sqrt{2}\times 10+x\sqrt{8}=\dfrac{6x}{\sqrt{2}}\times\sqrt{2}$, where one term has an error or the correct $\sqrt{2}(10+x\sqrt{8})=\dfrac{6x}{\sqrt{2}}\times\sqrt{2}$

NB $x\sqrt{8}+10=6x\sqrt{2}$ is M0

A1 A correct equation in x with no fractional terms. Eg $x\sqrt{16}+10\sqrt{2}=6x$ oe.

M1 An attempt to solve their linear equation in x to produce an answer of the form $a\sqrt{2}$ or $a\sqrt{50}$

A1 $5\sqrt{2}$ oe (accept $1\sqrt{50}$)

Method 2

M1 For writing $\sqrt{8}$ as $2\sqrt{2}$ or $\dfrac{6}{\sqrt{2}}$ as $3\sqrt{2}$

A1 A correct equation in x with no fractional terms. Eg $2\sqrt{2}x+10=3\sqrt{2}x$ *or* $x\sqrt{8}+10=3\sqrt{2}x$ oe.

M1 An attempt to solve their linear equation in x to produce an answer of the form $a\sqrt{2}$ or $a\sqrt{50}$

$\sqrt{2}x=10\Rightarrow x=\dfrac{10}{\sqrt{2}}=\dfrac{10\sqrt{2}}{2},=5\sqrt{2}$

or $\sqrt{2}x=10\Rightarrow 2x^2=100\Rightarrow x^2=50\Rightarrow x=\sqrt{50}$ or $5\sqrt{2}$

A1 $5\sqrt{2}$ oe Accept $1\sqrt{50}$

Question 16

Question Number	Scheme		Marks
(a)	20	Sight of 20. (4×5 is not sufficient)	B1
			(1)
(b)	$\dfrac{\sqrt{2}}{2\sqrt{5}-3\sqrt{2}}\times\dfrac{2\sqrt{5}+3\sqrt{2}}{2\sqrt{5}+3\sqrt{2}}$	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 top and bottom by $k(2\sqrt{5}+3\sqrt{2})$)		
	$=\dfrac{\cdots}{2}$	Obtains a denominator of 2 or sight of $\left(2\sqrt{5}-3\sqrt{2}\right)\left(2\sqrt{5}+3\sqrt{2}\right)=2$ with no errors seen in this expansion. May be implied by $\dfrac{\cdots}{2k}$	A1
	Note that M0A1 is not possible. The 2 must come from a correct method.		
	Note that if M1 is scored there is no need to consider the numerator. **e.g.** $\dfrac{2\,(MR?)}{2\sqrt{5}-3\sqrt{2}}\times\dfrac{2\sqrt{5}+3\sqrt{2}}{2\sqrt{5}+3\sqrt{2}}=\dfrac{\cdots}{2}$ scores M1A1		
	Numerator $=$ $\sqrt{2}(2\sqrt{5}\pm3\sqrt{2})=2\sqrt{10}\pm6$	An attempt to multiply the numerator by $\pm\left(2\sqrt{5}\pm3\sqrt{2}\right)$ and obtain an expression of the form $p+q\sqrt{10}$ where p and q are integers. This may be implied by e.g. $2\sqrt{10}+3\sqrt{4}$ or by their final answer.	M1
	(Allow attempt to multiply the numerator by $k(2\sqrt{5}\pm3\sqrt{2})$)		
	$\dfrac{\sqrt{2}}{2\sqrt{5}-3\sqrt{2}}=\dfrac{2\sqrt{10}+6}{2}=3+\sqrt{10}$	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)		
	$\dfrac{\sqrt{2}}{2\sqrt{5}-3\sqrt{2}}=\dfrac{1}{\sqrt{10}-3}$ or $\dfrac{2}{2\sqrt{10}-6}$	M1: Divides or multiplies top and bottom by $\sqrt{2}$ A1: $\dfrac{k}{k\left(\sqrt{10}-3\right)}$	M1A1
	$=\dfrac{1}{\sqrt{10}-3}\times\dfrac{\sqrt{10}+3}{\sqrt{10}+3}$	M1: Multiplies top and bottom by $\sqrt{10}+3$	M1
	$=3+\sqrt{10}$		A1

Question 17

Question Number	Scheme	Notes	Marks
	9^{3x+1} = for example $3^{2(3x+1)}$ or $\left(3^2\right)^{3x+1}$ or $\left(3^{(3x+1)}\right)^2$ or $3^{3x+1}\times 3^{3x+1}$ or $(3\times 3)^{3x+1}$ or $3^2\times\left(3^2\right)^{3x}$ or $\left(9^{\frac{1}{2}}\right)^y$ or $9^{\frac{1}{2}y}$ or $y=2(3x+1)$	Expresses 9^{3x+1} correctly as a power of 3 or expresses 3^y correctly as a power of 9 or expresses y correctly in terms of x **(This mark is <u>not</u> for just** $3^2=9$ **)**	M1
	$= 3^{6x+2}$ or $y = 6x + 2$ or $a = 6$, $b = 2$	Cao (isw if necessary)	A1
	Providing there is no incorrect work, allow sight of $6x + 2$ to score both marks Correct answer only implies both marks **Special case:** 3^{6x+1} **only** scores M1A0		
			[2]
	Alternative using logs		
	$9^{3x+1}=3^y \Rightarrow \log 9^{3x+1}=\log 3^y$		
	$(3x+1)\log 9 = y\log 3$	Use power law correctly on both sides	M1
	$y=\dfrac{\log 9}{\log 3}(3x+1)$		
	$y=6x+2$	cao	A1
			2 marks

Question 18

Question Number	Scheme	Notes	Marks
(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**	$\dfrac{12\sqrt{3}}{\sqrt{50}-\sqrt{18}} = \dfrac{12\sqrt{3}}{"2"\sqrt{2}}$	Uses part (a) by replacing denominator by their $a\sqrt{2}$ where a is numeric. This is all that is required for this mark.	M1
	$= \dfrac{12\sqrt{3}}{"2"\sqrt{2}} \times \dfrac{\sqrt{2}}{\sqrt{2}} = \dfrac{12\sqrt{6}}{4}$	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**	$\dfrac{12\sqrt{3}}{\sqrt{50}-\sqrt{18}} \times \dfrac{\sqrt{50}+\sqrt{18}}{\sqrt{50}+\sqrt{18}}$ **or** $\dfrac{12\sqrt{3}}{5\sqrt{2}-3\sqrt{2}} \times \dfrac{5\sqrt{2}+3\sqrt{2}}{5\sqrt{2}+3\sqrt{2}}$	For rationalising the denominator by a correct method i.e. multiplying numerator and denominator by $k\left(\sqrt{50}+\sqrt{18}\right)$	M1
	$\dfrac{60\sqrt{6}+36\sqrt{6}}{50-18}$	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**	$\dfrac{12\sqrt{3}}{\sqrt{50}-\sqrt{18}} = \dfrac{12\sqrt{3}}{"2"\sqrt{2}}$	Uses part (a) by replacing denominator by their $a\sqrt{2}$ where a is numeric. This is all that is required for this mark.	M1
	$= \dfrac{12\sqrt{3}}{2\sqrt{2}} = \dfrac{6\sqrt{3}}{\sqrt{2}} = \dfrac{\sqrt{108}}{\sqrt{2}} = \sqrt{54} = \sqrt{9}\sqrt{6}$	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**	$\dfrac{12\sqrt{3}}{\sqrt{50}-\sqrt{18}} = \dfrac{12\sqrt{3}}{"2"\sqrt{2}}$	Uses part (a) by replacing denominator by their $a\sqrt{2}$ where a is numeric. This is all that is required for this mark.	M1
	$\left(\dfrac{12\sqrt{3}}{"2"\sqrt{2}}\right)^2 = \dfrac{432}{8}$		
	$\sqrt{54} = \sqrt{9}\sqrt{6}$	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 19

Question Number	Scheme		Marks
(a)	Replaces 2^{2x+1} with $2^{2x}\times 2$ or states $2^{2x+1}=2^{2x}\times 2$ or states $\left(2^{x}\right)^{2}=2^{2x}$	Uses the addition **or** power law of indices on 2^{2x} or 2^{2x+1}. E.g. $2^{x}\times 2^{x}=2^{2x}$ or $\left(2^{x}\right)^{2}=2^{2x}$ or $2^{2x+1}=2\times 2^{2x}$ or $2^{x+0.5}=2^{x}\times\sqrt{2}$ or $2^{2x+1}=\left(2^{x+0.5}\right)^{2}$.	M1
	$2^{2x+1}-17\times 2^{x}+8=0$ $\Rightarrow 2y^{2}-17y+8=0$*	Cso. Complete proof that includes explicit statements for the addition **and** power law of indices on 2^{2x+1} with no errors. The equation needs to be as printed including the "= 0". If they work backwards, they do not need to write down the printed answer first but must end with the version in 2^{x} including '= 0'.	A1*

	The following are examples of acceptable proofs.	
	$2^{2x+1}=\left(2^{x+0.5}\right)^{2}=\left(2^{x}\sqrt{2}\right)^{2}=\left(y\sqrt{2}\right)^{2}=2y^{2}$ $\Rightarrow 2^{2x+1}-17\left(2^{x}\right)+8=2y^{2}-17y+8=0$	
	$2y^{2}=2\times 2^{x}\times 2^{x}=2^{2x+1}$ $\Rightarrow 2^{2x+1}-17\left(2^{x}\right)+8=2y^{2}-17y+8=0$	
	$2y^{2}-17y+8=0\Rightarrow 2\left(2^{x}\right)^{2}-17\left(2^{x}\right)+8=0$ $\Rightarrow 2\times 2^{2x}-17\left(2^{x}\right)+8=0\Rightarrow 2^{2x+1}-17\left(2^{x}\right)+8=0$	
	$2^{2x+1}=2\times 2^{2x}\Rightarrow 2\times 2^{2x}-17\left(2^{x}\right)+8=0$ $\Rightarrow 2y^{2}-17y+8=0$ Scores **M1A0** as $2^{2x}=\left(2^{x}\right)^{2}$ has not been shown explicitly	
	Special Case: $2^{2x+1}=2^{1}\times\left(2^{x}\right)^{2}$ or $2^{2x+1}=\left(2^{x}\right)^{2}\times 2^{1}$ **With or without the multiplication signs and with no subsequent explicit evidence of the power law scores M1A0**	
	Example of insufficient working: $2^{2x+1}=2\left(2^{x}\right)^{2}=2y^{2}$ **scores no marks as neither rule has been shown explicitly.**	
		(2)

<table>
<tr><td rowspan="5">(b)</td><td colspan="2">$2y^2-17y+8=0\Rightarrow(2y-1)(y-8)(=0)\Rightarrow y=...$
or
$2(2^x)^2-17(2^x)+8=0\Rightarrow(2(2^x)-1)((2^x)-8)(=0)\Rightarrow 2^x=...$
Solves the given quadratic either in terms of y or in terms of 2^x
See General Principles for solving a 3 term quadratic
Note that completing the square on e.g. $y^2-\frac{17}{2}y+4=0$ requires
$\left(y\pm\frac{17}{4}\right)^2\pm q\pm 4=0\Rightarrow y=...$</td><td>M1</td></tr>
<tr><td>$(y=)\frac{1}{2},8$ or $(2^x=)\frac{1}{2},8$</td><td>Correct values</td><td>A1</td></tr>
<tr><td rowspan="2">$\Rightarrow 2^x=\frac{1}{2},8\Rightarrow x=-1,3$</td><td>M1: Either finds one correct value of x for their 2^x or obtains a correct numerical expression in terms of logs e.g. for $k>0$
$2^x=k\Rightarrow x=\log_2 k$ or $\frac{\log k}{\log 2}$</td><td rowspan="2">M1 A1</td></tr>
<tr><td>A1: $x=-1,3$ only. Must be values of x.</td></tr>
<tr><td colspan="2"></td><td>(4)</td></tr>
<tr><td></td><td colspan="2"></td><td>(6 marks)</td></tr>
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