Q1.

(a) $\sqrt{8\times2}$ or $\sqrt{16}$ or $2\sqrt{2}$ (× $\sqrt{2}$)

or $\sqrt{2\times2\times2\times2}$ or $\sqrt{4\times4}$

M1

4

Accept – 4

A1

(b) $\frac{12}{\sqrt{3}}\times\frac{\sqrt{3}}{\sqrt{3}}$

$\frac{12\sqrt{3}}{3}$

M1

$4\sqrt{3}$

A1

[4]

Q2.

(a) (√175 =) √(25 × 7) or √25 × √7
√(5 × 5 × 7) or √5 × √5 × √7

M1

5√7

Accept a = 5 and b = 7 or 5 × √7

A1

(b) $\frac{24\sqrt{3}}{\sqrt{3}\sqrt{3}}\left(=\frac{24\sqrt{3}}{3}\right)$

M1

8√3

Accept 8 × √3

A1

[4]

Q3.

Use of $\frac{\sqrt{2}}{\sqrt{2}}$ or $\frac{\sqrt{18}}{\sqrt{18}}$

or $\sqrt{50}$ = $\sqrt{25\times2}$ or $\sqrt{18}$ = $\sqrt{9\times2}$

eg $\frac{26\sqrt{2}}{2}$ *or* $\frac{12\sqrt{18}}{18}$

eg $\frac{12}{3\sqrt{2}}$ *or* $\frac{4}{\sqrt{2}}$ *or* $\frac{4\sqrt{2}}{2}$

M1

One term simplified

ie $13\sqrt{2}$

$2\sqrt{2}$

$10\sqrt{2}$ *or* $5\sqrt{2}$

A1

Two terms simplified

ie $13\sqrt{2}$

$2\sqrt{2}$

$10\sqrt{2}$ *or* $5\sqrt{2}$

A1

$21\sqrt{2}$ or $a = 21$

A1

[4]

Q4.

1 : 2 : 5

B2 For any ratio that is one step away from the answer
e.g. $\sqrt{12} : 2\sqrt{12} : 5\sqrt{12}$
$\sqrt{1} : \sqrt{4} : \sqrt{25}$
2 : 4 : 10

B1 For at least two of the three terms in their simplest form
i.e. two of $2\sqrt{3} : 4\sqrt{3} : 10\sqrt{3}$

B1 For any correct equivalent ratio
e.g. $\sqrt{2} : \sqrt{8} : \sqrt{50}$
$\sqrt{3} : \sqrt{12} : \sqrt{75}$

B3

[3]

Q5.

(w^2 =) 162 or (h^2 =) 150

Allow M1 for 81 × 2 − 25 × 6

M1

$\sqrt{12}$

A1

$2\sqrt{3}$

ft their $\sqrt{12}$ *if possible*

B1 ft

[3]

Q6.

$\sqrt{10}\sqrt{15} - \sqrt{10}\sqrt{3} (+) \sqrt{2}\sqrt{15} - \sqrt{2}\sqrt{3}$

or better …

Allow one error (sign or term) in the expansion

M1

Eliminating the two 'middle' terms

These must be the correct two middle terms

M1

$\sqrt{10}\sqrt{15}$ simplified to $5\sqrt{6}$

M1

$4\sqrt{6}$

A1

Alternative method 1

$(\sqrt{5}\sqrt{2} + \sqrt{2})(\sqrt{5}\sqrt{3} - \sqrt{3})$

or

$\sqrt{5}\sqrt{5}\sqrt{2}\sqrt{3} + \sqrt{5}\sqrt{2}\sqrt{3} - \sqrt{2}\sqrt{5}\sqrt{3} - \sqrt{2}\sqrt{3}$

or better …

Allow one error (sign or term) in the expansion

M1

Eliminating the two 'middle' terms

These must be the correct two middle terms

M1

$\sqrt{5}\sqrt{5}\sqrt{2}\sqrt{3}$ simplified to $5\sqrt{6}$

M1

$4\sqrt{6}$

A1

Alternative method 2

$(\sqrt{5}\sqrt{2} + \sqrt{2})(\sqrt{5}\sqrt{3} - \sqrt{3})$

M1

$\sqrt{2}\sqrt{3}(\sqrt{5} + 1)(\sqrt{5} - 1)$

M1

$\sqrt{2}\sqrt{3} \times (5-1)$

M1

$4\sqrt{6}$

A1

[4]

Q7.

(a) $\sqrt{4}$

$\frac{2\sqrt{2}}{\sqrt{2}}$ *or* $\frac{\sqrt{8}}{\sqrt{2}} \times \frac{\sqrt{2}}{\sqrt{2}}$ *or* $\sqrt{\frac{8}{2}}$ *or* $\sqrt{\frac{4}{1}}$ *or* $\frac{\sqrt{16}}{2}$

or $\frac{\sqrt{8}\ \sqrt{2}}{2}$ *or* $\frac{2}{1}$

M1

2

A1

(b) two correct steps

eg two of:

$\sqrt{4}$ *= 2 or* $\sqrt{1}$ *= 1 or cancels* $\sqrt{5}$ *or combines any two surds*

M1

$\sqrt{144}$

M1

oe eg $\sqrt{12}\ \sqrt{12}$ *or* $\sqrt{4}\ \sqrt{36}$

k= 12

A1

[5]

Q8.

(a) 4

B1

(b) $2 + 3\sqrt{2} + 3\sqrt{2} + 9$

Allow one error

M1

$11 + 6\sqrt{2}$

A1

[3]

Q9.

(a) $\sqrt{2 \times 32}$ or $\sqrt{64}$ or

$(\sqrt{2} \times)\ 4\sqrt{2}$ or $2\sqrt{16}$ or $(\sqrt{2} \times)\ \sqrt{2}\sqrt{16}$

M1

8

A1

(b) $\frac{21\sqrt{7}}{\sqrt{7}\sqrt{7}}$ or $\frac{21\sqrt{7}}{7}$ or $\frac{21\sqrt{7}}{\sqrt{49}}$

M1

$3\sqrt{7}$

A1

[4]

Q10.

(a) $\frac{16}{\sqrt{2}} \times \frac{\sqrt{2}}{\sqrt{2}}$ or $\frac{16\sqrt{2}}{\sqrt{4}}$ or $\frac{16\sqrt{2}}{2}$ or $\sqrt{\frac{256}{2}}$ or $\sqrt{128}$ or $\sqrt{64} \times \sqrt{2}$

oe

M1

$8\sqrt{2}$

do not ignore further work

A1

(b) $25 - 5\sqrt{3} - 5\sqrt{3} + 3$ or $25 - 10\sqrt{3} + 3$

allow one error in four terms

M1

$28 - 10\sqrt{3}$ or $a = 28$ and $b = 10$

A1

[4]

Q11.

$15 - 3\sqrt{3} - 5\sqrt{3} + \sqrt{3} \times \sqrt{3}$

oe

Must have 4 terms with at least 3 correct for M1

Terms may be in box method but must have correct signs

M1

$18 - 8\sqrt{3}$

A1

$9 - 4\sqrt{3}$

oe Final answer must be in form $a \pm b\sqrt{3}$

Do not award A1 if further incorrect work, eg $9 - 4\sqrt{3} = 5\sqrt{3}$

ft if M awarded and at most one error, ie 3 correct terms with no further errors in collecting or 4 correct terms and one error in collecting

A1ft

Additional Guidance

$15 - 3\sqrt{3} - 5\sqrt{3} - \sqrt{9}$

M1

$12 - 8\sqrt{3}$

A0

$6 - 4\sqrt{3}$

A1ft

$15 + 3\sqrt{3} - 5\sqrt{3} + \sqrt{9}$

M1

$18 - 2\sqrt{3}$

A0

$9 - \sqrt{3}$

A1ft

$15 - 3\sqrt{3} - 5\sqrt{3} + \sqrt{3}$

M1

$15 - 7\sqrt{3}$

A0

$7\frac{1}{2} - \frac{7}{2}\sqrt{3}$

A1ft

$15 - 3\sqrt{3} - 5\sqrt{3} + \sqrt{9}$

M1

$18 + 8\sqrt{3}$

A0

$9 + 4\sqrt{3}$

A1ft

$\frac{15 - 3\sqrt{3} - 5\sqrt{3} + 3}{2}$

M1

$2(15 - 3\sqrt{3} - 5\sqrt{3} + 3)$

First A1 for $18 - 8\sqrt{3}$ by implication

A1

$30 - 6\sqrt{3} - 10\sqrt{3} + 6$

$36 - 16\sqrt{3}$

A0

$15 + 3\sqrt{3} - 5\sqrt{3} - \sqrt{9}$

M0

	5	$-\sqrt{3}$
3	15	$-3\sqrt{3}$
$-\sqrt{3}$	$-5\sqrt{3}$	-3

M1

	5	$-\sqrt{3}$
3	15	$3\sqrt{3}$
$-\sqrt{3}$	$5\sqrt{3}$	3

M0
(but can be recovered)

[3]

Q12.

Alternative method 1

Correct order **and** all three correct values $\sqrt{20}$, $\sqrt{24}$ and $\sqrt{28}$

B2 three correct values $\sqrt{24}$, $\sqrt{28}$ and $\sqrt{20}$
or $\sqrt{20}$ and $\sqrt{24}$
or $\sqrt{20}$ and $\sqrt{28}$
or $\sqrt{24}$ and $\sqrt{28}$
B1 $\sqrt{20}$ or $\sqrt{24}$ or $\sqrt{28}$

B3

Alternative method 2

Correct order **and** all three correct values $2\sqrt{5}$, $2\sqrt{6}$ and $2\sqrt{7}$

B2 three correct values $2\sqrt{6}$, $2\sqrt{7}$ and $2\sqrt{5}$
or $2\sqrt{5}$ and $2\sqrt{6}$

or $2\sqrt{5}$ *and* $2\sqrt{7}$

or $2\sqrt{6}$ *and* $2\sqrt{7}$

B1 $2\sqrt{5}$ *or* $\frac{10\sqrt{5}}{5}$ *or* $2\sqrt{6}$ *or* $2\sqrt{7}$

B3

Alternative method 3

Correct order **and** all three correct values 20, 24 and 28

B2 three correct values 24, 28 and 20

or 20 and 24

or 20 and 28

or 24 and 28

B1 20 or $\frac{100}{5}$ *or 24 or* $4 \times 3 \times 2$

or 12×2 *or* 8×3 *or* 4×6 *or 28*

B3

Additional Guidance

Correct order is $\frac{10}{\sqrt{5}}$, $2\sqrt{3} \times \sqrt{2}$, $\sqrt{\frac{56}{2}}$

20, 24, 28 using Alt 3

B2

B1 values using Alt 3 can be seen inside square root

$\sqrt{\frac{100}{5}}$ or $\sqrt{4 \times 3 \times 2}$ or $\sqrt{12 \times 2}$ or $\sqrt{8 \times 3}$ or $\sqrt{4 \times 6}$

B1

[3]

Q13.

Alternative method 1

$\frac{5}{\sqrt{3}} \times \frac{\sqrt{3}}{\sqrt{3}}$ or $\frac{5\sqrt{3}}{3}$

oe

$5 - \sqrt{3}\sqrt{6\frac{3}{4}} = 3k$

M1

$(\sqrt{6\frac{3}{4}} = \sqrt{\frac{27}{4}} =)$

$\frac{\sqrt{27}}{2}$ or $\frac{3\sqrt{3}}{\sqrt{4}}$ or $\frac{3\sqrt{3}}{2}$

M1

$(\frac{5\sqrt{3}}{3} - \frac{3\sqrt{3}}{2} =)$

$\frac{10\sqrt{3}}{6} - \frac{9\sqrt{3}}{6}$

oe

Dep on M1 M1

Any correct common denominator with at least one numerator correct

$\frac{10\sqrt{3}}{2} - \frac{9\sqrt{3}}{2} = 3k$

M1dep

$\frac{1\sqrt{3}}{6}$ or $\frac{\sqrt{3}}{6}$ or $\frac{1}{6}\sqrt{3}$

oe but must be $k\sqrt{3}$

A1

Alternative method 2

$(\sqrt{6\frac{3}{4}} = \sqrt{\frac{27}{4}} =)$

$\frac{\sqrt{27}}{2}$ or $\frac{3\sqrt{3}}{\sqrt{4}}$ or $\frac{3\sqrt{3}}{2}$

M1

$(\frac{5\sqrt{3}}{3} - \frac{3\sqrt{3}}{2} =)$

$\frac{10}{2\sqrt{3}} - \frac{9}{2\sqrt{3}}$ or $\frac{1}{2\sqrt{3}}$

oe

Any correct common denominator with at least one numerator correct

ft their $\frac{3\sqrt{3}}{2}$

M1dep

$\frac{1}{2\sqrt{3}} \times \frac{\sqrt{3}}{\sqrt{3}}$

oe

M1dep

$\frac{1\sqrt{3}}{6}$ or $\frac{\sqrt{3}}{6}$ or $\frac{1}{6}\sqrt{3}$

oe but must be $k\sqrt{3}$

A1

Additional Guidance

Alt 1 first M1 and alt 2 third M1

oe Multiplying by eg $\frac{2\sqrt{3}}{2\sqrt{3}}$

[4]

Q14.

$\frac{10}{3\sqrt{5}} \times \frac{\sqrt{5}}{\sqrt{5}}$ or $\frac{10\sqrt{5}}{15}$

$\frac{10}{3\sqrt{5}} \times \frac{3\sqrt{5}}{3\sqrt{5}}$ or $\frac{30\sqrt{5}}{45}$

or $\frac{\sqrt{20}}{3}$

oe

Must multiply numerator and denominator

eg $\frac{10}{\sqrt{45}}$ *is M0*

$\frac{10}{\sqrt{45}} \times \frac{\sqrt{45}}{\sqrt{45}}$ *is M1*

M1

$\frac{2\sqrt{5}}{3}$

A1

[2]

Q15.

Alternative method 1

$\left(\sqrt{12} =\right)\ 2\sqrt{3}$

M1

$\left(\frac{15}{\sqrt{3}} =\right)\ \frac{15\sqrt{3}}{\sqrt{3}\sqrt{3}}$ or $\frac{15\sqrt{3}}{3}$ or $5\sqrt{3}$

M1

$7\sqrt{3}$ or $a = 7$, $b = 3$

A1

Alternative method 2

$\frac{\sqrt{36} + 15}{\sqrt{3}}\ \left(= \frac{21}{\sqrt{3}}\right)$

M1

$\frac{21}{\sqrt{3}} \times \frac{\sqrt{3}}{\sqrt{3}}$ or $\frac{21\sqrt{3}}{3}$

M1

$7\sqrt{3}$ or $a = 7$, $b = 3$

A1

[3]

Q16.

7 $\sqrt{7}$

B1

[1]