1.	Considers the expression $x^2 + \frac{13}{2}x + 16$ either on its own or as part of an inequality/equation with 0 on the other side.	**M1**
	Makes an attempt to complete the square. For example, stating: $\left(x + \frac{13}{4}\right)^2 - \frac{169}{16} + \frac{256}{16}$ (ignore any (in)equation)	**M1**
	States a fully correct answer: $\left(x + \frac{13}{4}\right)^2 + \frac{87}{16}$ (ignore any (in)equation)	**A1**
	Interprets this solution as proving the inequality for all values of x. Could, for example, state that $\left(x + \frac{13}{4}\right)^2 \geq 0$ as a number squared is always positive or zero, therefore $\left(x + \frac{13}{4}\right)^2 + \frac{87}{16} > 0$. Must be logically connected with the statement to be proved; this could be in the form of an additional statement. So $x^2 + 6x + 18 > 2 - \frac{1}{2}x$ (for all x) or by a string of connectives which must be equivalent to "if and only if"s.	**A1**
		Total: 4 marks

NOTE: Any correct and complete method is acceptable for demonstrating that $x^2 + \frac{13}{2}x + 16 > 0$ for all x.

(e.g. finding the discriminant and single value,
finding the minimum point by differentiation
or completing the square and showing that it is both positive and a minimum, sketching the graph supported with appropriate methodology etc).

2a	$m = \frac{11-(-7)}{-6-4} = \frac{18}{-10} = -\frac{9}{5}$	**B1**
	Correct substitution of (4, −7) or (−6, 11) and their gradient into $y = mx + b$ or $y - y_1 = m(x - x_1)$ o.e. to find the equation of the line. For example, $-7 = \left(-\frac{9}{5}\right)(4) + b$ or $y + 7 = -\frac{9}{5}(x-4)$ or $11 = \left(-\frac{9}{5}\right)(-6) + b$ or $y - 11 = -\frac{9}{5}(x+6)$.	**M1**
	$5y + 9x - 1 = 0$ or $-5y - 9x + 1 = 0$ only	**A1**
		(3 marks)
2b	$y = 0, x = \frac{1}{9}$ so $A\left(\frac{1}{9}, 0\right)$. Award mark for $x = \frac{1}{9}$ seen.	**B1**
	$x = 0, y = \frac{1}{5}$ so $B\left(0, \frac{1}{5}\right)$. Award mark for $y = \frac{1}{5}$ seen.	**B1**
	Area = $\frac{1}{2} \times \frac{1}{5} \times \frac{1}{9} = \frac{1}{90}$	**B1**
		(3 marks)
		Total: 6 marks

3	Makes an attempt to begin solving the equation. For example, states that $\frac{\sin(3\theta + 20^\circ)}{\cos(3\theta + 20^\circ)} = \frac{4}{4\sqrt{3}}$	**M1**
	Uses the identity $\tan\theta = \frac{\sin\theta}{\cos\theta}$ to write, $\tan(3\theta + 20^\circ) = \frac{4}{4\sqrt{3}} = \frac{1}{\sqrt{3}}$	**M1**
	States or implies use of the inverse tangent. For example, $3\theta + 20^\circ = \tan^{-1}\left(\frac{1}{\sqrt{3}}\right)$ or $3\theta + 20^\circ = 30^\circ$	**M1**
	Shows understanding that there will be further solutions in the given range, by adding 180° to 30° at least once. $3\theta + 20^\circ = 30^\circ, 210^\circ, 390^\circ, \ldots$ (ignore any out of range values).	**M1**
	Subtracts 20 and divides each answer by 3. $\theta = \left(\frac{10}{3}\right)^\circ, \left(\frac{190}{3}\right)^\circ, \left(\frac{370}{3}\right)^\circ, \ldots$ (ignore any out of range values).	**M1**
	States the correct final answers to 1 decimal place. $3.3^\circ, 63.3^\circ, 123.3^\circ$ cao	**A1**

4	Uses appropriate law of logarithms to write $\log_{11}(2x-1)(x+4)=1$	**M1**
	Inverse $\log_{11}$ (or 11 to the) both sides. $(2x-1)(x+4)=11$	**M1**
	Derives a 3 term quadratic equation. $2x^2+7x-15=0$	**M1**
	Correctly factorises $(2x-3)(x+5)=0$ or uses appropriate technique to solve their quadratic.	**M1**
	Solves to find $x=\frac{3}{2}$	**A1**
	Understands that $x \neq -5$ stating that this solution would require taking the log of a negative number, which is not possible.	**B1**
		Total: 6 marks
		Total: 6 marks

5a	Equates the **i** components for the equation **a** + **b** = m**c** o.e. $2p+6=4m$	**B1**
	Equates the **j** components for the their equation **a** + **b** = m**c** $-5-3p=-5m$	**B1**
	Makes an attempt to find p by eliminating m in some way. For example, $\begin{matrix}10p+30=20m\\20+12p=20m\end{matrix}$ o.e. or $\frac{2p+6}{-5-3p}=-\frac{4}{5}$ o.e.	**M1**
	$p=5$	**A1**
	NOTES: Alternatively, M1: attempt to eliminate p first. A1: $m=4$ and $p=5$	**(4 marks)**
5b	Using their value for p from above, makes a substitution into the vectors to form **a** + **b** 10**i** – 5**j** + 6**i** – 15**j**	**M1ft**
	Correctly simplifies. 16**i** – 20**j**	**A1ft**
	NOTES: OR M1ft: substitute their $m=4$ into their **a** + **b** = m**c**. A1ft: correct simplification.	**(2 marks)**
		Total: 6 marks

6a	Makes an attempt to subsitute 7 into the equation, for example, $P = 100e^{0.4\times 7}$ seen.	**M1**
	1644 or 1640 only (do not accept non-integeric final answer).	**A1**
		(2 marks)
6b	It is the initial bacteria population.	**B1**
		(1 mark)
6c	States that $100e^{0.4t} > 1000000$ or that $e^{0.4t} > 10000$	**M1**
	Solves to find $t > \frac{\ln(10000)}{0.4}$	**M1**
	24 (hours) cao (do not accept e.g. 24.0).	**A1**
		(3 marks)
		Total: 6 marks

7	$y = mx - 2$ seen or implied.	**M1**
	Substitutes their $y = mx - 2$ into $x^2 + 6x + y^2 - 8y = 4$ $x^2 + 6x + (mx-2)^2 - 8(mx-2) = 4$ o.e.	**M1**
	Rearranges to a 3 term quadratic in x (condone one arithmetic error). $(1+m^2)x^2 + (6-12m)x + 16 = 0$	**M1**
	Uses $b^2 - 4ac = 0$, $(6-12m)^2 - (4)(1+m^2)(16) = 0$	**M1**
	Rearranges to $20m^2 - 36m - 7 = 0$ or any multiple of this.	**A1**
	Attempts solution using valid method. For example, $m = \dfrac{36 \pm \sqrt{(-36)^2 - (4)(20)(-7)}}{2(20)}$	**M1**
	$m = \dfrac{9}{10} \pm \dfrac{\sqrt{29}}{5}$ or $m = \dfrac{9 \pm 2\sqrt{29}}{10}$ o.e. (NB decimals A0).	**A1**
		Total: 7 marks

NOTES: Elimination of x follows the same scheme. $x = \dfrac{y+2}{m}$ leading t $\left(\dfrac{y+2}{m}\right)^2 + 6\left(\dfrac{y+2}{m}\right) + y^2 - 8y = 4$

This leads to $(1+m^2)y^2 + (4+6m-8m^2)y + 4 + 12m - 4m^2 = 0$

Use of $b^2 - 4ac = 0$ gives $(4+6m-8m^2)^2 - (4)(1+m^2)(4+12m-4m^2) = 0$ which reduces to $4m^2(20m^2 - 36m - 7) = 0$. m cannot equal 0, so this must be discarded as a solution for the final A mark.

$b^2 - 4ac = 0$ could be used implicitly within the quadratic equation formula.

8a	Makes an attempt to find the vector $\overrightarrow{AB}$. For example, writing $\overrightarrow{AB} = \overrightarrow{OB} - \overrightarrow{OA}$ or $\overrightarrow{AB} = 10\mathbf{i} + q\mathbf{j} - (4\mathbf{i} + 7\mathbf{j})$	**M1**
	Shows a fully simplified answer: $\overrightarrow{AB} = 6\mathbf{i} + (q-7)\mathbf{j}$	**A1**
		(2 marks)
8b	Correctly interprets the meaning of $\left\|\overrightarrow{AB}\right\| = 2\sqrt{13}$, by writing $(6)^2 + (q-7)^2 = \left(2\sqrt{13}\right)^2$ o.e.	**M1**
	Correct method to solve quadratic equation in q (full working must be shown). For example, $(q-7)^2 = 16$ or $q^2 - 14q + 33 = 0$	**M1**
	$q - 7 = \pm 4$ or $(q-11)(q-3) = 0$ or $q = \dfrac{14 \pm \sqrt{14^2 - 4\times1\times33}}{2\times1}$	**M1**
	$q = 11$	**A1**
	$q = 3$	**A1**
		(5 marks)
		Total: 7 marks

9a	States or implies the expansion of a binomial expression to the 9th power, up to and including the x^3 term. $(a+b)^9 = {}^9C_0a^9 + {}^9C_1a^8b + {}^9C_2a^7b^2 + {}^9C_3a^6b^3 + \dots$ or $(a+b)^9 = a^9 + 9a^8b + 36a^7b^2 + 84a^6b^3 + \dots$	**M1**
	Correctly substitutes 2 and px into the formula. $(2+px)^9 = 2^9 + 9\times 2^8 \times px + 36\times 2^7 \times (px)^2 + 84\times 2^6 \times (px)^3 + \dots$	**M1**
	Makes an attempt to simplify the expression (at least one power of 2 calculated and one bracket expanded correctly). $(2+px)^9 = 512 + 9\times 256\times px + 36\times 128\times p^2x^2 + 84\times 64\times p^3x^3 + \dots$	**M1dep**
	States a fully correct answer: $(2+px)^9 = 512 + 2304px + 4608p^2x^2 + 5376p^3x^3 + \dots$	**A1**
		(4 marks)
9bi	States that $5376p^3 = -84$	**M1ft**
	Correctly solves for p: $p^3 = -\frac{1}{64}$ so $p = -\frac{1}{4}$	**A1ft**
9bi	Correctly find the coefficient of the x term: $2304\left(-\frac{1}{4}\right) = -576$	**B1ft**
	Correctly find the coefficient of the x^2 term: $4608\left(-\frac{1}{4}\right)^2 = 288$	**B1ft**
		(4 marks)
		Total: 8 marks

NOTES: ft marks – pursues a correct method and obtains a correct answer or answers from their 5376 from part **a**.

10a	States or implies that the angle at P is 74°	**B1**
	States or implies the use of the cosine rule. For example, $p^2 = q^2 + r^2 - 2qr\cos P$	**M1**
	Makes substitution into the cosine rule. $p^2 = 7^2 + 15^2 - 2 \times 7 \times 15\cos 74^\circ$	**M1ft**
	Makes attempt to simplify, for example, stating $p^2 = 216.11...$	**M1ft**
	States the correct final answer. QR = 14.7 km.	**A1**
		(5 marks)
10b	States or implies use of the sine rule, for example, writing $\frac{\sin Q}{q} = \frac{\sin P}{p}$	**M1**
	Makes an attempt to substitute into the sine rule. $\frac{\sin Q}{15} = \frac{\sin 74^\circ}{14.7}$	**M1ft**
	Solves to find Q = 78.77…°	**A1ft**
	Makes an attempt to find the bearing, for example, writing bearing = 180° – 78.77…° – 33°	**M1ft**
	States the correct 3 figure bearing as 068°	**A1ft**
		(5 marks)
		Total: **10 marks**

NOTES: **10a:** Award ft marks for correct use of cosine rule using an incorrect initial angle.

10b: Award ft marks for a correct solution using their answer to part (a).

11a	States or implies that area of base is x^2.	**M1**
	States or implies that total surface area of the fish tank is $x^2 + 4xh = 1600$ Use of a letter other than h is acceptable.	**M1**
	$h = \frac{400}{x} - \frac{x}{4}$	**M1**
	Substitutes for h in $V = x^2 h = x^2\left(\frac{400}{x} - \frac{x}{4}\right)$	**M1**
	Simplifies to obtain $V = 400x - \frac{x^3}{4}$ *	**A1***
		(5 marks)
11b	Differentiates f(x) $\quad \frac{dV}{dx} = 400 - \frac{3x^2}{4}$	**B1**
	Attempts to solve $\frac{dV}{dx} = 0$ $\quad 400 - \frac{3x^2}{4} = 0$ or $400 = \frac{3x^2}{4}$	**M1**
	$x = \frac{40\sqrt{3}}{3}$ o.e. (NB must be positive)	**A1**
	Substitutes for x in $V = 400x - \frac{x^3}{4}$ $\quad V_{\text{max/min}} = \frac{32\,000\sqrt{3}}{9}$ o.e. or awrt 6160	**A1**
		(4 marks)
11c	Differentiates f′(x) $\quad \frac{d^2V}{dx^2} = -\frac{3x}{2}$ o.e.	**M1**
	Substitutes $x = \frac{40\sqrt{3}}{3}$ into f″(x) $\quad$ States $\frac{d^2V}{dx^2} < 0$, so V in part **b** is a maximum value.	**A1**
		(2 marks)
		Total: 11 marks

NOTES: (a): A sketch of a rectangular prism with a base of x by x and a height of h is acceptable for the first method mark.

(c): Other complete methods for demonstrating that V is a maximum are acceptable.

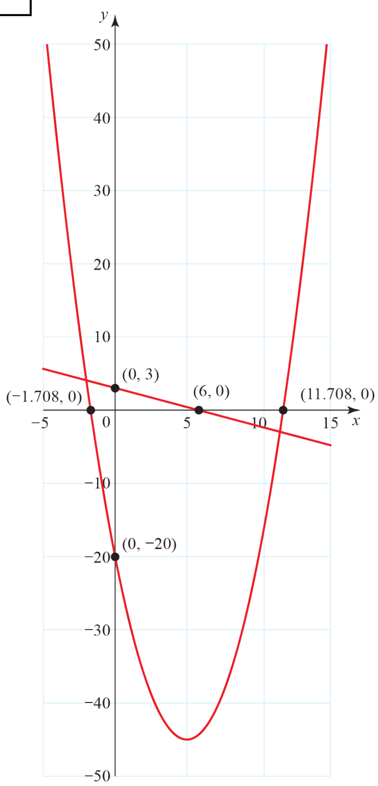
For example a sketch of the graph of V against x or calculation of values of V or $\frac{dV}{dx}$ on either side.

12a Attempts to take out x or $-x$. $y = x\left(-x^2 + 2x + 8\right)$ or $y = -x\left(x^2 - 2x - 8\right)$		**M1**
Fully and correctly factorised cubic. $y = x(4 - x)(2 + x)$ or $y = -x(x - 4)(x + 2)$		**M1**
Correct coordinates written. $A(-2,0)$ and $B(4, 0)$.		**A1**
		(3 marks)
12b Makes an attempt to find $\int (-x^3 + 2x^2 + 8x)\mathrm{d}x$ Raising at least one x power by 1 would constitute an attempt.		**M1**
Fully correct integration seen. $\left[-\frac{x^4}{4} + \frac{2}{3}x^3 + 4x^2\right]_{-2}^{0}$ (ignore limits at this stage)		**A1**
Makes an attempt to substitute limits into integrated function to find the area between $x = -2$ and $x = 0$ $(0) - \left(-4 - \frac{16}{3} + 16\right)$		**M1**
Finds the correct answer. $-\frac{20}{3}$		**A1**
$+\frac{20}{3}$ stated or used as area here or later in solution (could be implied by correct final answer).		**B1**
Makes an attempt to substitute limits into integrated function to find the area between $x = 0$ and $x = 4$ $\left(-64 + \frac{128}{3} + 64\right) - (0)$		**M1**
Finds the correct answer. $\frac{128}{3}$		**A1**
Correctly adds the two areas. $\frac{148}{3}$ o.e.		**A1**
		(8 marks)
		Total: 11 marks

NOTES:

12a: Award method marks for substituting limits even if evaluation at $x = 0$ is not seen.

12b: For the first integral, candidates may integrate $-\mathrm{f}(x)$ between -2 and 0 to obtain a positive answer directly.

13a Attempt to solve $q(x) = 0$ by completing the square or by using the formula. $x^2 - 10x - 20 = 0$ $(x-5)^2 - 45 = 0$ or $x = \dfrac{10 \pm \sqrt{100 - 4(1)(-20)}}{2(1)}$		M1
$x = 5 \pm 3\sqrt{5}$ and/or statement that says $a = 5$ and $b = 5$		A1
		(2 marks)
13b **Figure 1** 	$q(0) = -20$, so $y = q(x)$ intersects y-axis at $(0, -20)$ and x-intercepts labelled (accept incorrect values from part **a**).	B1ft
	$y = p(x)$ intersects y-axis at $(0, 3)$.	B1
	$y = p(x)$ intersects x-axis at $(6, 0)$.	B1
	Graphs drawn as shown with all axes intercepts labelled. The two graphs should clearly intersect at two points, one at a negative value of x and one at a positive value of x. These points of intersection do not need to be labelled.	B1
		(4 marks)

13c	Statement indicating that this is the point where p(x) = q(x) or $x^2 - 10x - 20 = 3 - \frac{1}{2}x$ seen.	**M1**
	Their equation factorised, or attempt to solve their equation by completing the square. $2x^2 - 19x - 46 = 0$ $(2x - 23)(x + 2) = 0$	**M1**
	$\left(\frac{23}{2}, -\frac{11}{4}\right)$	**A1**
	$(-2, 4)$	**A1**
		(4 marks)
13d	$x < -2$ or $x > \frac{23}{2}$ o.e.	**B1**
	$\{x : x \in {}^{\sim}, x < -2\} \cup \{x : x \in {}^{\sim}, x > 11.5\}$ **NB**: Must see "or" or $\cup$ (if missing SC1 for just the correct inequalities).	**B1**
		(2 marks)
		Total: 12 marks

NOTES:

13a: Equation can be solved by completing the square or by using the quadratic formula. Either method is acceptable.

13b: Answers with incorrect coordinates lose accuracy marks as appropriate. However, the graph accuracy marks can be awarded for correctly labelling their coordinates, even if their coordinates are incorrect.

13c: If the student incorrectly writes the initial equation, award 1 method mark for an attempt to solve the incorrect equation. Solving the correct equation by either factorising or completing the square is acceptable.

(TOTAL: 100 MARKS)