

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. $3\theta + 20^\circ = 30^\circ, 210^\circ, 390^\circ, \dots$ (ignore any out of range values).	M1
	Subtracts 20 and divides each answer by 3. $\theta = \left(\frac{10}{3}\right)^\circ, \left(\frac{190}{3}\right)^\circ, \left(\frac{370}{3}\right)^\circ, \dots$ (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
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5a	Equates the i components for the equation $\mathbf{a} + \mathbf{b} = m\mathbf{c}$ o.e. $2p + 6 = 4m$	B1
	Equates the j components for the their equation $\mathbf{a} + \mathbf{b} = m\mathbf{c}$ $-5 - 3p = -5m$	B1
	Makes an attempt to find p by eliminating m in some way. For example, $\frac{10p+30=20m}{20+12p=20m}$ 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 $\mathbf{a} + \mathbf{b}$ $10\mathbf{i} - 5\mathbf{j} + 6\mathbf{i} - 15\mathbf{j}$	M1ft
	Correctly simplifies. $16\mathbf{i} - 20\mathbf{j}$	A1ft
	NOTES: OR M1ft: substitute their $m = 4$ into their $\mathbf{a} + \mathbf{b} = m\mathbf{c}$. A1ft: correct simplification.	(2 marks)
		Total: 6 marks

6a	Makes an attempt to substitute 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, $m = \frac{36 \pm \sqrt{(-36)^2 - (4)(20)(-7)}}{2(20)}$	M1
	$m = \frac{9}{10} \pm \frac{\sqrt{29}}{5}$ or $m = \frac{9 \pm 2\sqrt{29}}{10}$ o.e. (NB decimals A0).	A1
		Total: 7 marks

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

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 $ \overrightarrow{AB} = 2\sqrt{13}$, by writing $(6)^2 + (q - 7)^2 = (2\sqrt{13})^2$ 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 $q = \frac{14 \pm \sqrt{14^2 - 4 \times 1 \times 33}}{2 \times 1}$	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 $Q = 78.77...^\circ$	A1ft
	Makes an attempt to find the bearing, for example, writing bearing $= 180^\circ - 78.77...^\circ - 33^\circ$	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 $V = x^2h = x^2\left(\frac{400}{x} - \frac{x}{4}\right)$	M1
	Simplifies to obtain $V = 400x - \frac{x^3}{4}$ *	A1*
		(5 marks)
11b	Differentiates $f(x)$ $\frac{dV}{dx} = 400 - \frac{3x^2}{4}$	B1
	Attempts to solve $\frac{dV}{dx} = 0$ $400 - \frac{3x^2}{4} = 0$ or $400 = \frac{3x^2}{4}$	M1
	$x = \frac{40\sqrt{3}}{3}$ o.e. (NB must be positive)	A1
	Substitutes for x in $V = 400x - \frac{x^3}{4}$ $V_{\max/\min} = \frac{32\,000\sqrt{3}}{9}$ o.e. or awrt 6160	A1
		(4 marks)
11c	Differentiates $f'(x)$ $\frac{d^2V}{dx^2} = -\frac{3x}{2}$ o.e.	M1
	Substitutes $x = \frac{40\sqrt{3}}{3}$ into $f''(x)$ 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.

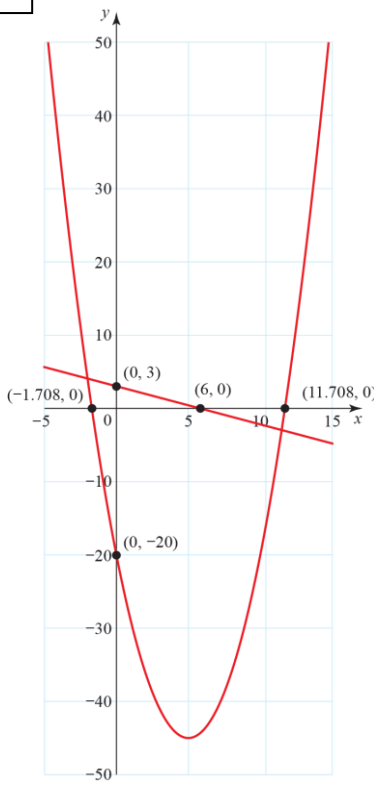
For example a sketch of the graph of V against x or calculation of values of V or $\frac{dV}{dx}$ on either side.

12a	Attempts to take out x or $-x$.	$y = x(-x^2 + 2x + 8)$ or $y = -x(x^2 - 2x - 8)$	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 $\int (-x^3 + 2x^2 + 8x)dx$		M1
	Raising at least one x power by 1 would constitute an attempt.		
	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 $x = 0$		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 $-f(x)$ 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 $x = \frac{10 \pm \sqrt{100 - 4(1)(-20)}}{2(1)}$	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). $y = p(x)$ intersects y-axis at $(0, 3)$. $y = p(x)$ intersects x-axis at $(6, 0)$. 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.
		(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
	$\{x : x \in \mathbb{R}, x < -2\} \cup \{x : x \in \mathbb{R}, x > 11.5\}$ 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)