Topic 6 Part 1 *[251 marks]*

1a. *[1 mark]*

Markscheme

5 ***(A1)*** ***(C1)***

Examiners report

Many candidates did not see the connection between the x-intercepts and the factored form of a quadratic function. The syllabus explicitly sates that the graphs of quadratics should be linked to solutions of quadratic equations by factorizing and vice versa. This was one of the most challenging questions for candidates.

1b. *[2 marks]*

Markscheme

$\frac{-b}{2(-1)} = 2$ ***(M1)***

Note: Award ***(M1)*** for correct substitution in axis of symmetry formula.

OR

$y = 5 + bx - x^2$

$9 = 5 + b(2) - (2)^2$ ***(M1)***

Note: Award ***(M1)*** for correct substitution of 9 and 2 into their quadratic equation.

$(b =)4$ ***(A1)*(ft)*** ***(C2)***

Note: Follow through from part (a).

Examiners report

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1c. *[2 marks]*

Markscheme

5, −1 ***(A1)*(ft)*(A1)*(ft)*** ***(C2)***

Notes: Follow through from parts (a) and (b), irrespective of working shown.

Examiners report

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1d. *[1 mark]*

Markscheme

$f(x) = -(x-5)(x+1)$ ***(A1)*(ft)** ***(C1)***

Notes: Follow through from part (c).

Examiners report

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2a. *[1 mark]*

Markscheme

$1.2\ (\mathrm{mg\,l^{-1}})$ ***(A1)*** ***(C1)***

[1 mark]

Examiners report

[N/A]

2b. *[2 marks]*

Markscheme

$1.2 \times (0.87)^3$ ***(M1)***

Note: Award ***(M1)*** for correct substitution into given formula.

$= 0.790\ (\mathrm{mg\,l^{-1}})\ (0.790203\ldots)$ ***(A1)*** ***(C2)***

[2 marks]

Examiners report

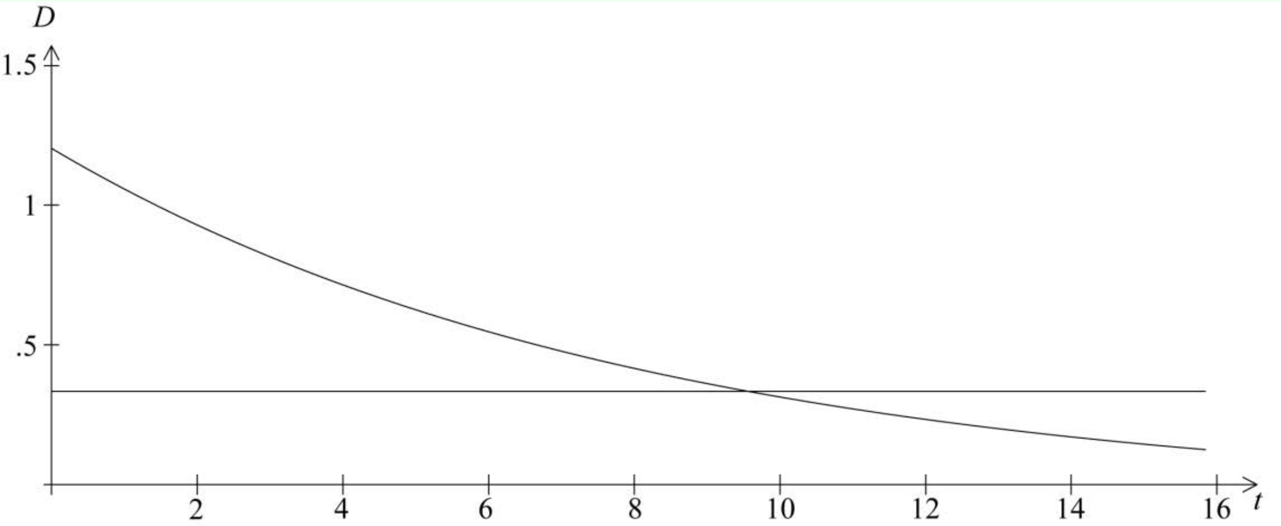
[N/A]

2c. *[3 marks]*

Markscheme

$1.2 \times 0.87^t = 0.333$ ***(M1)***

Note: Award ***(M1)*** for setting up the equation.



(M1)

Notes: Some indication of scale is to be shown, for example the window used on the calculator.
Accept alternative methods.

9.21 (hours) (
$9.20519\ldots$, 9 hours 12 minutes, 9:12) ***(A1)*** ***(C3)***
[3 marks]

Examiners report

[N/A]

3a. *[1 mark]*

Markscheme

$20lw$ **OR**
$V = 20lw$ ***(A1)***
[1 mark]

Examiners report

[N/A]

3b. *[2 marks]*

Markscheme

$3000 = 20lw$ ***(M1)***

Note: Award ***(M1)*** for equating their answer to part (a) to 3000.

$l = \frac{3000}{20w}$ ***(M1)***

Note: Award ***(M1)*** for rearranging equation to make l subject of the formula. The above equation must be seen to award ***(M1)***.

OR

$150 = lw$ ***(M1)***

Note: Award ***(M1)*** for division by 20 on both sides. The above equation must be seen to award ***(M1)***.

$l = \frac{150}{w}$ ***(AG)***

[2 marks]

Examiners report

[N/A]

3c. *[2 marks]*

Markscheme

$S = 2l + 4w + 2(20)$ ***(M1)***

Note: Award ***(M1)*** for setting up a correct expression for S.

$2\left(\frac{150}{w}\right) + 4w + 2(20)$ ***(M1)***

Notes: Award ***(M1)*** for correct substitution into the expression for S. The above expression must be seen to award ***(M1)***.

$= 40 + 4w + \frac{300}{w}$ ***(AG)***

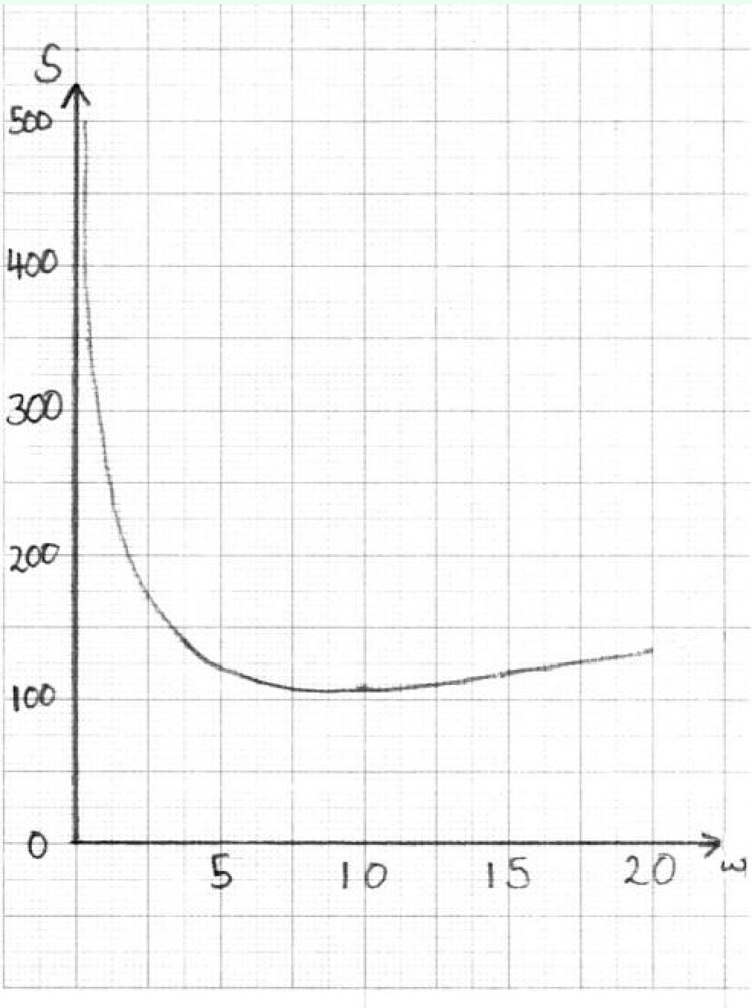
[2 marks]

Examiners report

[N/A]

3d. [2 marks]

Markscheme



(A1)(A1)(A1)(A1)

Note: Award *(A1)* for correct scales, window and labels on axes, *(A1)* for approximately correct shape, *(A1)* for minimum point in approximately correct position, *(A1)* for asymptotic behaviour at $w = 0$.

Axes must be drawn with a ruler and labeled w and S.

For a smooth curve (with approximately correct shape) there should be **one** continuous thin line, no part of which is straight and no (one-to-many) mappings of w.

The S-axis must be an asymptote. The curve must not touch the S-axis nor must the curve approach the asymptote then deviate away later.

[4 marks]

Examiners report

[N/A]

3e.

[3 marks]

Markscheme

$4 - \frac{300}{w^2}$ ***(A1)(A1)(A1)***

Notes: Award ***(A1)*** for
4, ***(A1)*** for
-300, ***(A1)*** for
$\frac{1}{w^2}$ or
w^{-2}. If extra terms present, award at most ***(A1)(A1)(A0)***.

[3 marks]

Examiners report

[N/A]

3f.

[2 marks]

Markscheme

$4 - \frac{300}{w^2} = 0$ **OR**
$\frac{300}{w^2} = 4$ **OR**
$\frac{\mathrm{d}S}{\mathrm{d}w} = 0$ ***(M1)***

Note: Award ***(M1)*** for equating their derivative to zero.

$w = 8.66 \ \left(\sqrt{75},\ 8.66025\ldots\right)$ ***(A1)*(ft)*(G2)***

Note: Follow through from their answer to part (e).

[2 marks]

Examiners report

[N/A]

3g.

[1 mark]

Markscheme

$17.3 \left(\frac{150}{\sqrt{75}},\ 17.3205\ldots\right)$ ***(A1)*(ft)**

Note: Follow through from their answer to part (f).

[1 mark]

Examiners report

[N/A]

3h. *[2 marks]*

Markscheme

$40 + 4\sqrt{75} + \frac{300}{\sqrt{75}}$ ***(M1)***

Note: Award ***(M1)*** for substitution of their answer to part (f) into the expression for S.

$= 110 \text{ (cm)} \ \left(40 + 40\sqrt{3},\ 109.282\ldots\right)$ ***(A1)*(ft)*(G2)***

Note: Do not accept 109.
Follow through from their answers to parts (f) and (g).

[2 marks]

Examiners report

[N/A]

4a. *[1 mark]*

Markscheme

0 ***(A1)(G1)***

[1 mark]

Examiners report

[N/A]

4b. *[2 marks]*

Markscheme

$1.8 = a(3)^2 + 0$ ***(M1)***

OR

$1.8 = a(-3)^2 + 0$ ***(M1)***

Note: Award ***(M1)*** for substitution of $y = 1.8$ or $x = 3$ and their value of c into equation.
0 may be implied.

$a = 0.2$
$\left(\frac{1}{5}\right)$ ***(A1)*(ft)*(G1)***

Note: Follow through from their answer to part (a).
Award ***(G1)*** for a correct answer only.

[2 marks]

Examiners report

[N/A]

4c. *[1 mark]*

Markscheme

$y = 0.2x^2$ ***(A1)*(ft)**

Note: Follow through from their answers to parts (a) and (b).
Answer must be an equation.

[1 mark]

Examiners report

[N/A]

4d. *[2 marks]*

Markscheme

$0.2 \times (2.4)^2$ ***(M1)***
$= 1.15$ (m)
(1.152) ***(A1)*(ft)*(G1)***

Notes: Award ***(M1)*** for correctly substituted formula, ***(A1)*** for correct answer. Follow through from their answer to part (c).
Award ***(G1)*** for a correct answer only.

[2 marks]

Examiners report

[N/A]

4e. *[2 marks]*

Markscheme

y is the height ***(A1)***
positive value of
x is half the width (*or equivalent*) ***(A1)***
[2 marks]

Examiners report

[N/A]

4f. *[2 marks]*

Markscheme

$0.9 = 0.2x^2$ ***(M1)***

Note: Award ***(M1)*** for setting their equation equal to 0.9.

$x = \pm 2.12\ (\text{m})$
$\left(\pm\frac{3}{2}\sqrt{2},\ \pm\sqrt{4.5},\ \pm 2.12132\ldots\right)$ ***(A1)*(ft)*(G1)***

Note: Accept 2.12. Award ***(G1)*** for a correct answer only.

[2 marks]

Examiners report

[N/A]

4g. *[2 marks]*

Markscheme

(i)
2.55×5 ***(M1)***

Note: Award ***(M1)*** for correct substitution in formula.

$= 12.8\ (\text{m}^3)$
$\left(12.75\ (\text{m}^3)\right)$ ***(A1)(G2)***
[2 marks]

(ii)
$\frac{12.75}{36} \times 100$ ***(M1)***

Note: Award ***(M1)*** for correct quotient multiplied by 100.

$= 35.4(\%)$
$(35.4166\ldots)$ ***(A1)*(ft)*(G2)***

Note: Award ***(G2)*** for $35.6(\%)(35.5555\ldots(\%))$.
Follow through from their answer to part (g)(i).

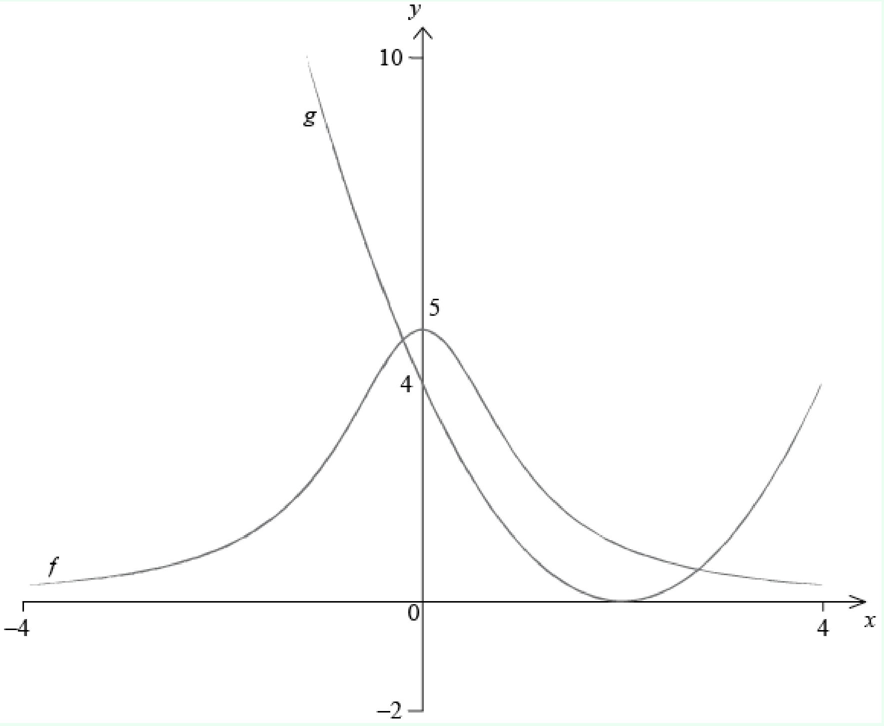
[2 marks]

Examiners report

[N/A]

5a. [4 marks]

Markscheme



$f(x)$: a smooth curve symmetrical about y-axis,
$f(x) > 0$ ***(A1)***

Note: If the graph crosses the x-axis award ***(A0)***.

Intercept at their numbered
$y = 5$ ***(A1)***

Note: Accept clear scale marks instead of a number.

$g(x)$: a smooth parabola with axis of symmetry at about
$x = 2$ (the 2 does not need to be numbered) and
$g(x) \geqslant 0$ ***(A1)***

Note: Right hand side must not be higher than the maximum of
$f(x)$ at
$x = 4$.
Accept the quadratic correctly drawn beyond
$x = 4$.

Intercept at their numbered
$y = 4$ ***(A1)*** ***(C4)***

Note: Accept clear scale marks instead of a number.

[4 marks]

Examiners report

Many candidates attempted this question but relatively few were awarded the full six marks. Although they were asked to indicate clearly where the graph met the axes, many did not do this. Some entered the functions incorrectly into their calculator. A common error in part (b) was to give ordered pairs and therefore were not awarded the final mark.

5b.

[2 marks]

Markscheme

$-0.195, 2.76$

$(-0.194808\ldots, 2.761377\ldots)$ ***(A1)*(ft)*(A1)*(ft)** ***(C2)***

Note: Award ***(A0)(A1)*(ft)** if both coordinates are given.

Follow through only if

$f(x) = \frac{5}{x^2} + 1$ is sketched; the solutions are

$-0.841, 3.22$

$(-0.840913\ldots, 3.217747...)$

[2 marks]

Examiners report

Many candidates attempted this question but relatively few were awarded the full six marks. Although they were asked to indicate clearly where the graph met the axes, many did not do this. Some entered the functions incorrectly into their calculator. A common error in part (b) was to give ordered pairs and therefore were not awarded the final mark.

6a.

[2 marks]

Markscheme

$a(1)^2 + b = -9$ ***(A1)***

$a(3)^2 + b = 119$ ***(A1)*** ***(C2)***

Note: Accept equivalent forms of the equations.

[2 marks]

Examiners report

This question was answered reasonably well with many candidates able to write down the two equations and solve them for a and b. Errors such as mistaking the equation given for

$3a^2 + b = 119$ meant that marks were lost even though the candidates appeared to know what they needed to do. Most candidates who were able to set up the equation in part (c) solved it correctly. Follow through marks were awarded to many candidates for correct working with their substituted values from part (b).

6b.

[2 marks]

$a = 16$

$b = -25$

Examiners report

This question was answered reasonably well with many candidates able to write down the two equations and solve them for a and b. Errors such as mistaking the equation given for
$3a^2 + b = 119$ meant that marks were lost even though the candidates appeared to know what they needed to do. Most candidates who were able to set up the equation in part (c) solved it correctly. Follow through marks were awarded to many candidates for correct working with their substituted values from part (b).

6c.

[2 marks]

Markscheme

$16c^2 - 25 = 171$ ***(M1)***

Note: Award ***(M1)*** for correct quadratic with their
a and
b substituted.

$c = 3.5$ ***(A1)*(ft)** ***(C2)***

Note: Accept
x instead of
c.
Follow through from part (b).
Award ***(A1)*** only, for an answer of
± 3.5 with or without working.

[2 marks]

Examiners report

This question was answered reasonably well with many candidates able to write down the two equations and solve them for a and b. Errors such as mistaking the equation given for
$3a^2 + b = 119$ meant that marks were lost even though the candidates appeared to know what they needed to do. Most candidates who were able to set up the equation in part (c) solved it correctly. Follow through marks were awarded to many candidates for correct working with their substituted values from part (b).

7a.

[2 marks]

Markscheme

$200 \times (1.9)^{0.85 \times 6}$ ***(M1)***

Note: Award ***(M1)*** for correct substitution into given formula.

$= 5280$ ***(A1)*** ***(C2)***

Note: Accept
5281 or
5300 but no other answer.

[2 marks]

Examiners report

This question was answered very well, although some candidates were not awarded the final mark because the answer was not an integer number of computers. In part (b), some candidates neglected to give their answer correct to the nearest hour and lost the final mark.

7b.

[4 marks]

Markscheme

$1\,000\,000 < 200 \times (1.9)^{0.85t}$ ***(M1)(M1)***

Note: Award ***(M1)*** for setting up the inequality (accept an equation), and ***(M1)*** for $1\,000\,000$ seen in the inequality or equation.

$t = 15.6$
$(15.6113\ldots)$ ***(A1)***
16 hours ***(A1)*(ft)** ***(C4)***

Note: The final ***(A1)*(ft)** is for rounding **up** their answer to the nearest hour.
Award ***(C3)*** for an answer of 15.6 with no working.
Accept $1\,000\,001$ in an equation.

[4 marks]

Examiners report

This question was answered very well, although some candidates were not awarded the final mark because the answer was not an integer number of computers. In part (b), some candidates neglected to give their answer correct to the nearest hour and lost the final mark.

8a.

[2 marks]

Markscheme

$\frac{3}{4}(-2)^4 - (-2)^3 - 9(-2)^2 + 20$ ***(M1)***

Note: Award ***(M1)*** for substituting $x = -2$ in the function.

$= 4$ ***(A1)(G2)***

Note: If the coordinates $(-2,\ 4)$ are given as the answer award, at most, ***(M1)(A0)***. If no working shown award ***(G1)***.
If $x = -2,\ y = 4$ seen then award full marks.

[2 marks]

Examiners report

Surprisingly, a correct method for substituting the value of –2 into the given function led many candidates to a variety of incorrect answers. This suggests a poor handling of negative signs and/or poor use of the graphic display calculator. Many correct answers were seen in part (b) as candidates seemed to be well-drilled in the process of differentiation. Part (c), however, proved to be quite a discriminator. There were 5 marks for this part of the question and simply showing that
$x-3$ is a turning point was not sufficient for all of these marks. Many simply scored only two marks by substituting
$x-3$ into their answer to part (b). Once they had shown that there was a turning point at
$x-3$, candidates were not expected to use the second derivative but to show that the function decreases for
$x<3$ and increases for
$x>3$. Part (d) required a sketch which could have either been done on lined paper or on graph paper. The majority of candidates obtained at least two marks here with the most common errors seen being incomplete labelled axes and curves which were far from being smooth. In part (e), many candidates identified the correct coordinates for the two marks available. But for many candidates, this is where responses stopped as, in part (f), connecting the gradient function found in part (b) to the given coordinates proved problematic and only a significant minority of candidates were able to arrive at the required answer of –24. Indeed, there were many NR (no responses) to this part and the final part of the question. As many candidates found part (f) difficult, even more candidates found getting beyond the gradient of L very difficult indeed. A minority of candidates wrote down the gradient of their perpendicular but then did not seem to know where to proceed from there. Substituting their gradient for b and the coordinates (2, –12) into the equation
$x+by+c=0$ was a popular, but erroneous, method. It was a rare event indeed to see a script with a correct answer for this part of the question.

8b. *[3 marks]*

Markscheme

$3x^3-3x^2-18x$ ***(A1)(A1)(A1)***

Note: Award ***(A1)*** for each correct term, award at most ***(A1)(A1)(A0)*** if extra terms seen.

[3 marks]

Examiners report

Surprisingly, a correct method for substituting the value of –2 into the given function led many candidates to a variety of incorrect answers. This suggests a poor handling of negative signs and/or poor use of the graphic display calculator. Many correct answers were seen in part (b) as candidates seemed to be well-drilled in the process of differentiation. Part (c), however, proved to be quite a discriminator. There were 5 marks for this part of the question and simply showing that
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$x+by+c=0$ was a popular, but erroneous, method. It was a rare event indeed to see a script with a correct answer for this part of the question.

8c. [5 marks]

Markscheme

$f'(3) = 3 \times (3)^3 - 3 \times (3)^2 - 18 \times 3$ ***(M1)***

Note: Award ***(M1)*** for substitution in their
$f'(x)$ of
$x = 3$.

$= 0$ ***(A1)***

OR

$3x^3 - 3x^2 - 18x = 0$ ***(M1)***

Note: Award ***(M1)*** for equating their
$f'(x)$ to zero.

$x = 3$ ***(A1)***

$f'(x_1) = 3 \times (x_1)^3 - 3 \times (x_1)^2 - 18 \times x_1 < 0$ where
$0 < x_1 < 3$ ***(M1)***

Note: Award ***(M1)*** for substituting a value of
x_1 in the range
$0 < x_1 < 3$ into their
f' and showing it is negative (decreasing).

$f'(x_2) = 3 \times (x_2)^3 - 3 \times (x_2)^2 - 18 \times x_2 > 0$ where
$x_2 > 3$ ***(M1)***

Note: Award ***(M1)*** for substituting a value of
x_2 in the range
$x_2 > 3$ into their
f' and showing it is positive (increasing).

OR

With or without a sketch:

Showing
$f(x_1) > f(3)$ where
$x_1 < 3$ and
x_1 is close to 3. ***(M1)***

Showing
$f(x_2) > f(3)$ where
$x_2 > 3$ and
x_2 is close to 3. ***(M1)***

Note: If a sketch of
$f(x)$ is drawn **in this part of the question and**
$x = 3$ is identified as a stationary point on the curve, then

(i) award, at most, ***(M1)(A1)(M1)(M0)*** if the stationary point has been found;

(ii) award, at most, ***(M0)(A0)(M1)(M0)*** if the stationary point has not been previously found.

Since the gradients go from negative (decreasing) through zero to positive (increasing) it is a local minimum ***(R1)(AG)***

Note: Only award ***(R1)*** if the first two marks have been awarded *ie*
$f'(3)$ has been shown to be equal to
0.

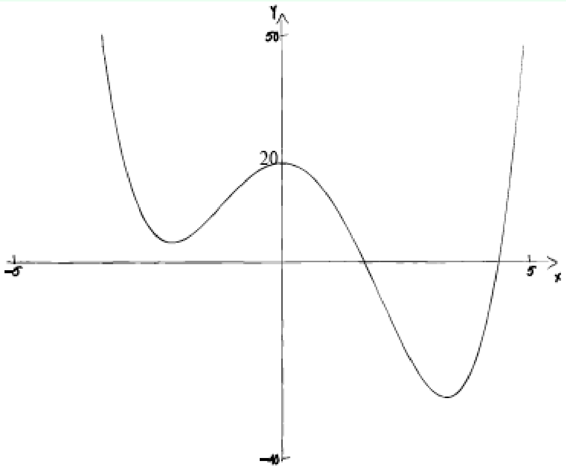
[5 marks]

Examiners report

Surprisingly, a correct method for substituting the value of –2 into the given function led many candidates to a variety of incorrect answers. This suggests a poor handling of negative signs and/or poor use of the graphic display calculator. Many correct answers were seen in part (b) as candidates seemed to be well-drilled in the process of differentiation. Part (c), however, proved to be quite a discriminator. There were 5 marks for this part of the question and simply showing that
$x - 3$ is a turning point was not sufficient for all of these marks. Many simply scored only two marks by substituting
$x - 3$ into their answer to part (b). Once they had shown that there was a turning point at
$x - 3$, candidates were not expected to use the second derivative but to show that the function decreases for
$x < 3$ and increases for
$x > 3$. Part (d) required a sketch which could have either been done on lined paper or on graph paper. The majority of candidates obtained at least two marks here with the most common errors seen being incomplete labelled axes and curves which were far from being smooth. In part (e), many candidates identified the correct coordinates for the two marks available. But for many candidates, this is where responses stopped as, in part (f), connecting the gradient function found in part (b) to the given coordinates proved problematic and only a significant minority of candidates were able to arrive at the required answer of –24. Indeed, there were many NR (no responses) to this part and the final part of the question. As many candidates found part (f) difficult, even more candidates found getting beyond the gradient of L very difficult indeed. A minority of candidates wrote down the gradient of their perpendicular but then did not seem to know where to proceed from there. Substituting their gradient for b and the coordinates (2, –12) into the equation
$x + by + c = 0$ was a popular, but erroneous, method. It was a rare event indeed to see a script with a correct answer for this part of the question.

8d. *[4 marks]*

Markscheme



(A1)(A1)(A1)(A1)

Notes: Award ***(A1)*** for labelled axes and indication of scale on both axes.

Award ***(A1)*** for smooth curve with correct shape.

Award ***(A1)*** for local minima in 2^{nd} and 4^{th} quadrants.

Award ***(A1)*** for *y* intercept $(0, 20)$ seen and labelled. Accept 20 on y-axis.

Do **not** award the third ***(A1)*** mark if there is a turning point on the x-axis.

If the derivative function is sketched then award, at most, ***(A1)(A0)(A0)(A0)***.

For a smooth curve (with correct shape) there should be **ONE** continuous thin line, no part of which is straight and no (one to many) mappings of x.

[4 marks]

Examiners report

Surprisingly, a correct method for substituting the value of –2 into the given function led many candidates to a variety of incorrect answers. This suggests a poor handling of negative signs and/or poor use of the graphic display calculator. Many correct answers were seen in part (b) as candidates seemed to be well-drilled in the process of differentiation. Part (c), however, proved to be quite a discriminator. There were 5 marks for this part of the question and simply showing that $x - 3$ is a turning point was not sufficient for all of these marks. Many simply scored only two marks by substituting $x - 3$ into their answer to part (b). Once they had shown that there was a turning point at $x - 3$, candidates were not expected to use the second derivative but to show that the function decreases for $x < 3$ and increases for $x > 3$. Part (d) required a sketch which could have either been done on lined paper or on graph paper. The majority of candidates obtained at least two marks here with the most common errors seen being incomplete labelled axes and curves which were far from being smooth. In part (e), many candidates identified the correct coordinates for the two marks available. But for many candidates, this is where responses stopped as, in part (f), connecting the gradient function found in part (b) to the given coordinates proved problematic and only a significant minority of candidates were able to arrive at the required answer of –24. Indeed, there were many NR (no responses) to this part and the final part of the question. As many candidates found part (f) difficult, even more candidates found getting beyond the gradient of *L* very difficult indeed. A minority of candidates wrote down the gradient of their perpendicular but then did not seem to know where to proceed from there. Substituting their gradient for *b* and the coordinates (2, –12) into the equation $x + by + c = 0$ was a popular, but erroneous, method. It was a rare event indeed to see a script with a correct answer for this part of the question.

8e. *[2 marks]*

Markscheme

$(0,20)$ ***(G1)(G1)***

Note: If parentheses are omitted award ***(G0)(G1)***.

OR

$x = 0,\ y = 20$ ***(G1)(G1)***

Note: If the derivative function is sketched in part (d), award ***(G1)*(ft)*(G1)*(ft)** for $(-1.12, 12.2)$.

[2 marks]

Examiners report

Surprisingly, a correct method for substituting the value of –2 into the given function led many candidates to a variety of incorrect answers. This suggests a poor handling of negative signs and/or poor use of the graphic display calculator. Many correct answers were seen in part (b) as candidates seemed to be well-drilled in the process of differentiation. Part (c), however, proved to be quite a discriminator. There were 5 marks for this part of the question and simply showing that $x - 3$ is a turning point was not sufficient for all of these marks. Many simply scored only two marks by substituting $x - 3$ into their answer to part (b). Once they had shown that there was a turning point at $x - 3$, candidates were not expected to use the second derivative but to show that the function decreases for $x < 3$ and increases for $x > 3$. Part (d) required a sketch which could have either been done on lined paper or on graph paper. The majority of candidates obtained at least two marks here with the most common errors seen being incomplete labelled axes and curves which were far from being smooth. In part (e), many candidates identified the correct coordinates for the two marks available. But for many candidates, this is where responses stopped as, in part (f), connecting the gradient function found in part (b) to the given coordinates proved problematic and only a significant minority of candidates were able to arrive at the required answer of –24. Indeed, there were many NR (no responses) to this part and the final part of the question. As many candidates found part (f) difficult, even more candidates found getting beyond the gradient of *L* very difficult indeed. A minority of candidates wrote down the gradient of their perpendicular but then did not seem to know where to proceed from there. Substituting their gradient for *b* and the coordinates (2, –12) into the equation $x + by + c = 0$ was a popular, but erroneous, method. It was a rare event indeed to see a script with a correct answer for this part of the question.

8f. *[2 marks]*

$f'(2) = 3(2)^3 - 3(2)^2 - 18(2)$

$x = 2$

$f'(x)$

$= -24$

Examiners report

Surprisingly, a correct method for substituting the value of –2 into the given function led many candidates to a variety of incorrect answers. This suggests a poor handling of negative signs and/or poor use of the graphic display calculator. Many correct answers were seen in part (b) as candidates seemed to be well-drilled in the process of differentiation. Part (c), however, proved to be quite a discriminator. There were 5 marks for this part of the question and simply showing that
$x - 3$ is a turning point was not sufficient for all of these marks. Many simply scored only two marks by substituting
$x - 3$ into their answer to part (b). Once they had shown that there was a turning point at
$x - 3$, candidates were not expected to use the second derivative but to show that the function decreases for
$x < 3$ and increases for
$x > 3$. Part (d) required a sketch which could have either been done on lined paper or on graph paper. The majority of candidates obtained at least two marks here with the most common errors seen being incomplete labelled axes and curves which were far from being smooth. In part (e), many candidates identified the correct coordinates for the two marks available. But for many candidates, this is where responses stopped as, in part (f), connecting the gradient function found in part (b) to the given coordinates proved problematic and only a significant minority of candidates were able to arrive at the required answer of –24. Indeed, there were many NR (no responses) to this part and the final part of the question. As many candidates found part (f) difficult, even more candidates found getting beyond the gradient of L very difficult indeed. A minority of candidates wrote down the gradient of their perpendicular but then did not seem to know where to proceed from there. Substituting their gradient for b and the coordinates (2, –12) into the equation
$x + by + c = 0$ was a popular, but erroneous, method. It was a rare event indeed to see a script with a correct answer for this part of the question.

8g. *[5 marks]*

Markscheme

(i) Gradient of perpendicular

$= \frac{1}{24}$

$(0.0417, 0.041666\ldots)$ ***(A1)*****(ft)*****(G1)***

Note: Follow through from part (f).

(ii)

$y + 12 = \frac{1}{24}(x - 2)$ ***(M1)(M1)***

Note: Award ***(M1)*** for correct substitution of

$(2, -12)$, ***(M1)*** for correct substitution of their perpendicular gradient into equation of line.

OR

$-12 = \frac{1}{24} \times 2 + d$ ***(M1)***

$d = -\frac{145}{12}$

$y = \frac{1}{24}x - \frac{145}{12}$ ***(M1)***

Note: Award ***(M1)*** for correct substitution of

$(2, -12)$ and gradient into equation of a straight line, ***(M1)*** for correct substitution of the perpendicular gradient and correct substitution of

d into equation of line.

$b = -24,\ c = -290$ ***(A1)*****(ft)*****(A1)*****(ft)*****(G3)***

Note: Follow through from parts (f) and g(i).

To award **(ft)** marks,

b and

c must be integers.

Where candidate has used

0.042 from g(i), award ***(A1)*****(ft)** for

-288.

[5 marks]

Examiners report

Surprisingly, a correct method for substituting the value of –2 into the given function led many candidates to a variety of incorrect answers. This suggests a poor handling of negative signs and/or poor use of the graphic display calculator. Many correct answers were seen in part (b) as candidates seemed to be well-drilled in the process of differentiation. Part (c), however, proved to be quite a discriminator. There were 5 marks for this part of the question and simply showing that
$x - 3$ is a turning point was not sufficient for all of these marks. Many simply scored only two marks by substituting
$x - 3$ into their answer to part (b). Once they had shown that there was a turning point at
$x - 3$, candidates were not expected to use the second derivative but to show that the function decreases for
$x < 3$ and increases for
$x > 3$. Part (d) required a sketch which could have either been done on lined paper or on graph paper. The majority of candidates obtained at least two marks here with the most common errors seen being incomplete labelled axes and curves which were far from being smooth. In part (e), many candidates identified the correct coordinates for the two marks available. But for many candidates, this is where responses stopped as, in part (f), connecting the gradient function found in part (b) to the given coordinates proved problematic and only a significant minority of candidates were able to arrive at the required answer of –24. Indeed, there were many NR (no responses) to this part and the final part of the question. As many candidates found part (f) difficult, even more candidates found getting beyond the gradient of L very difficult indeed. A minority of candidates wrote down the gradient of their perpendicular but then did not seem to know where to proceed from there. Substituting their gradient for b and the coordinates (2, –12) into the equation
$x + by + c = 0$ was a popular, but erroneous, method. It was a rare event indeed to see a script with a correct answer for this part of the question.

9a. *[1 mark]*

Markscheme

1.5 ***(A1)*** ***(C1)***

[1 mark]

Examiners report

[N/A]

9b. *[2 marks]*

Markscheme

$C = 2.5$ (accept
$y = 2.5$) ***(A1)(A1)*** ***(C2)***

Notes: Award ***(A1)*** for
C (or y) $=$ a positive constant, ***(A1)*** for the constant
$= 2.5$.
Answer must be an equation.

[2 marks]

Examiners report

[N/A]

9c. *[3 marks]*

Markscheme

$2.4 = 2.5 - 2^{-t}$ ***(M1)***

Note: Award ***(M1)*** for setting the equation equal to 2.4 or for a horizontal line drawn at approximately $C = 2.4$. Allow x instead of t.

OR

$-t\ln(2) = \ln(0.1)$ ***(M1)***

$t = 3.32192\ldots$ ***(A1)***

$t = 3 \text{ hours and } 19 \text{ minutes } (199 \text{ minutes})$ ***(A1)*(ft)** ***(C3)***

Note: Award the final ***(A1)*(ft)** for correct conversion of **their** time in hours to the nearest minute.

[3 marks]

Examiners report

[N/A]

10a. *[1 mark]*

Markscheme

5 ***(A1)*** ***(C1)***

[1 mark]

Examiners report

[N/A]

10b. *[3 marks]*

Markscheme

at least one of the following equations required

$a(4)^2 + 4b + 5 = 13$

$4 = -\frac{b}{2a}$

$a(8)^2 + 8b + 5 = 5$ ***(A2)(A1)*** ***(C3)***

Note: Award ***(A2)(A0)*** for one correct equation, or its equivalent, and ***(C3)*** for any two correct equations. Follow through from part (a). The equation $a(0)^2 + b(0) = 5$ earns no marks.

[3 marks]

Examiners report

[N/A]

10c.

[2 marks]

Markscheme

$a = -\frac{1}{2}$, $b = 4$ ***(A1)*(ft)*(A1)*(ft)** ***(C2)***

Note: Follow through from their equations in part (b), but only if their equations lead to unique solutions for
a and
b.

[2 marks]

Examiners report

[N/A]

11a.

[3 marks]

Markscheme

$600 + (20 - 1) \times 17$ ***(M1)(A1)***

Note: Award ***(M1)*** for substituted arithmetic sequence formula, ***(A1)*** for correct substitutions. If a list is used, award ***(M1)*** for at least 6 correct terms seen, award ***(A1)*** for at least 20 correct terms seen.

$= 923$ ***(A1)(G3)***
[3 marks]

Examiners report

[N/A]

11b.

[3 marks]

Markscheme

$\frac{10}{2}[2 \times 600 + (10 - 1) \times 17]$ ***(M1)(A1)***

Note: Award ***(M1)*** for substituted arithmetic series formula, ***(A1)*** for their correct substitutions. Follow through from part (a). For consistent use of geometric series formula in part (b) with the geometric sequence formula in part (a) award a maximum of ***(M1)(A1)(A0)*** since their final answer cannot be an integer.

OR
$u_{10} = 600 + (10 - 1)17 = 753$ ***(M1)***
$S_{10} = \frac{10}{2}(600 + \text{their } u_{10})$ ***(M1)***

Note: Award ***(M1)*** for their correctly substituted arithmetic sequence formula, ***(M1)*** for their correctly substituted arithmetic series formula. Follow through from part (a) and **within** part (b).

Note: If a list is used, award ***(M1)*** for at least 10 correct terms seen, award ***(A1)*** for these terms being added.

$= 6765$ (accept
6770) ***(A1)*(ft)*(G2)***
[3 marks]

Examiners report

[N/A]

11c. *[3 marks]*

Markscheme

3×2^{9} ***(M1)(A1)***

Note: Award ***(M1)*** for substituted geometric sequence formula, ***(A1)*** for correct substitutions. If a list is used, award ***(M1)*** for at least 6 correct terms seen, award ***(A1)*** for at least 8 correct terms seen.

$= 1536$ ***(A1)(G3)***

Note: Exact answer only. If both exact and rounded answer seen, award the final ***(A1)***.

[3 marks]

Examiners report

[N/A]

11d. *[3 marks]*

Markscheme

$\frac{3 \times (2^{8} - 1)}{2 - 1}$ ***(M1)(A1)*****(ft)**

Note: Award ***(M1)*** for substituted geometric series formula, ***(A1)*** for their correct substitutions. Follow through from part (c). If a list is used, award ***(M1)*** for at least 8 correct terms seen, award ***(A1)*** for these 8 correct terms being added. For consistent use of arithmetic series formula in part (d) with the arithmetic sequence formula in part (c) award a maximum of ***(M1)(A1)(A1)***.

$= 765$ ***(A1)*****(ft)*****(G2)***
[3 marks]

Examiners report

[N/A]

11e. *[3 marks]*

Markscheme

$3 \times 2^{k-1} > 600 + (k-1)(17)$ ***(M1)***

Note: Award ***(M1)*** for their correct inequality; allow equation.
Follow through from parts (a) and (c). Accept sketches of the two functions as a valid method.

$k > 8.93648\ldots$ (may be implied) ***(A1)*(ft)**

Note: Award ***(A1)*** for
$8.93648\ldots$ seen. The GDC gives answers of
-34.3 and
8.936 to the inequality; award ***(M1)(A1)*** if these are seen with working shown.

OR
$v_8 = 384$
$u_8 = 719$ ***(M1)***
$v_9 = 768$
$u_9 = 736$ ***(M1)***

Note: Award ***(M1)*** for
v_8 and
u_8 both seen, ***(M1)*** for
v_9 and
u_9 both seen.

$k = 9$ ***(A1)*(ft)*(G2)***

Note: Award ***(G1)*** for
$8.93648\ldots$ and
-34.3 seen as final answer without working. Accept use of
n.

[3 marks]

Examiners report

[N/A]

12a. *[1 mark]*

Markscheme

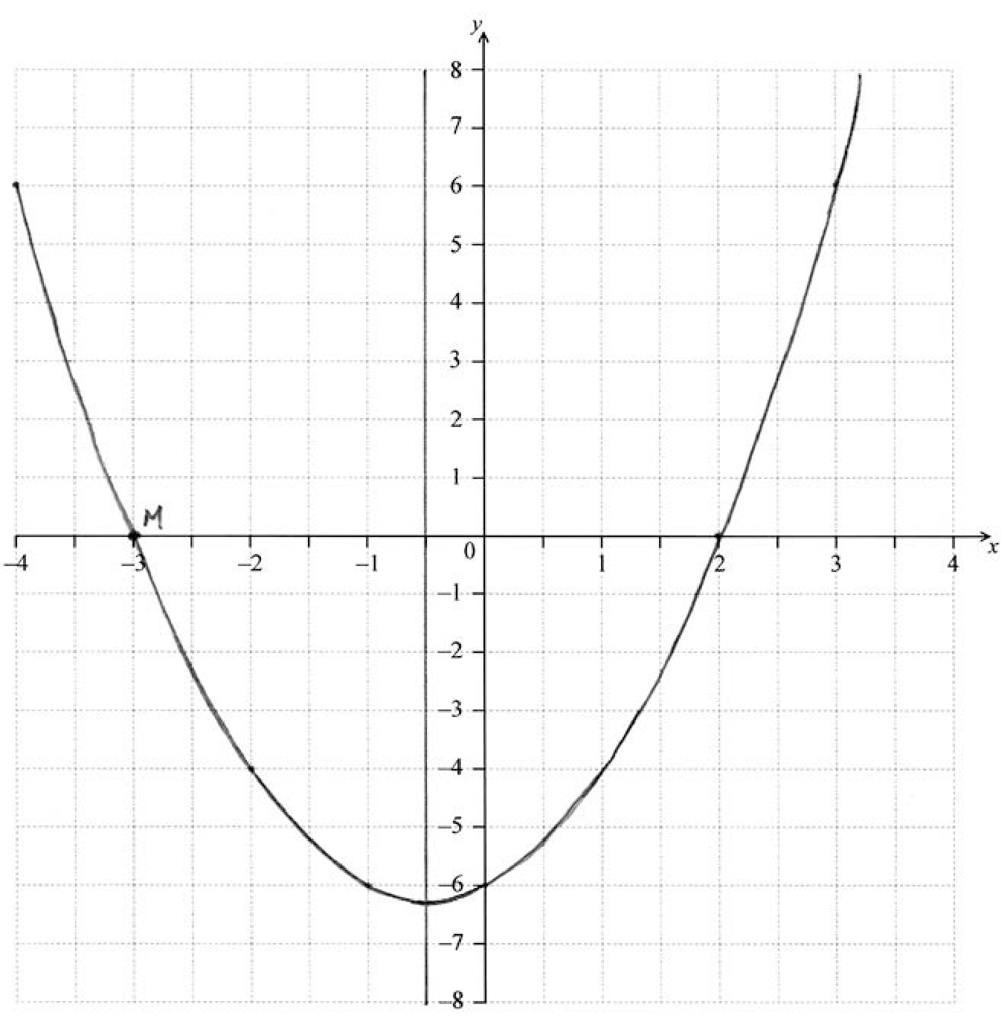
vertical straight line which may be dotted passing through $\left(-\frac{1}{2}, 0\right)$ ***(A1)*** ***(C1)***

Examiners report

[N/A]

12b. *[1 mark]*

Markscheme



vertical straight line which may be dotted passing through $\left(-\frac{1}{2},\ 0\right)$ ***(A1)*** ***(C1)***

Examiners report

[N/A]

12c. *[1 mark]*

Markscheme

point $\mathrm{M}\ (-3,\ 0)$ correctly marked on the x-axis ***(A1)*****(ft)** ***(C1)***

Note: Follow through from part (a).

Examiners report

[N/A]

12d. *[4 marks]*

Markscheme

(i)

$b = 1, c = -6$ ***(A1)*(ft)*(A1)*(ft)**

Notes: Follow through from (b).

(ii) smooth parabola passing through M and N ***(A1)*(ft)**

Note: Follow through from their point M from part (b).

parabola passing through $(0, \ -6)$ and symmetrical about $x = -0.5$ ***(A1)*(ft) *(C4)***

Note: Follow through from part (c)(i).

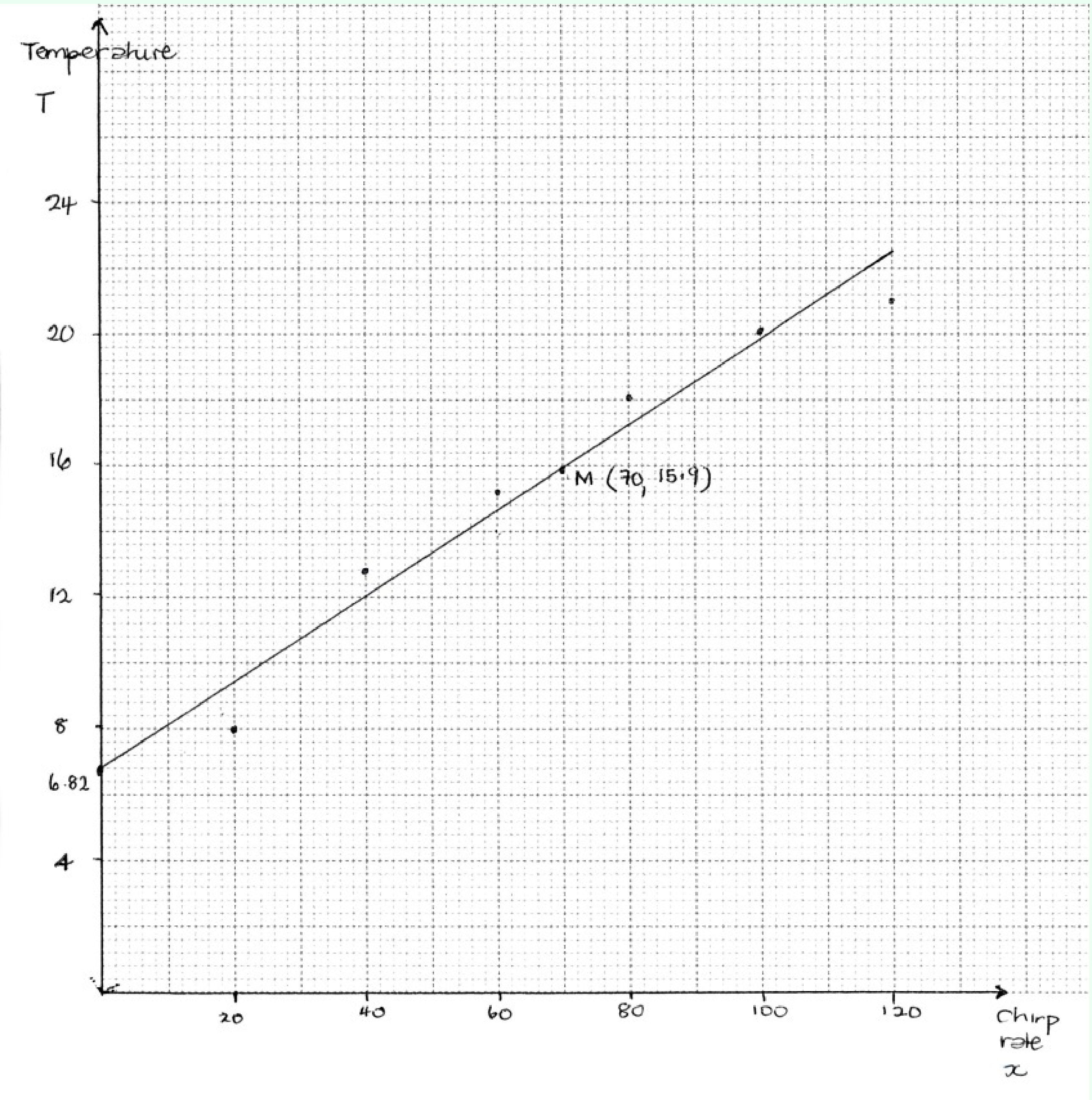
If parabola is not smooth and not concave up award at most ***(A1)(A0)***.

Examiners report

[N/A]

13a. *[4 marks]*

Markscheme



(A4)

Notes: Award ***(A1)*** for correct scales and labels.

Award ***(A3)*** for all six points correctly plotted,

(A2) for four or five points correctly plotted,

(A1) for two or three points correctly plotted.

Award at most ***(A0)(A3)*** if axes reversed.

Accept tolerance for T-axis.

Examiners report

[N/A]

13b. *[2 marks]*

Markscheme

$0.977 \quad (0.977324\ldots)$ ***(G2)***

Notes: Award ***(G1)*** for 0.97.

Examiners report

[N/A]

13c. *[2 marks]*

Markscheme

(Very) strong positive correlation ***(A1)*(ft)*(A1)*(ft)**

Notes: Award ***(A1)*** for (very) strong, ***(A1)*** for positive.

Follow through from part (b).

Examiners report

[N/A]

13d. *[2 marks]*

Markscheme

$T = 0.129x + 6.82$ ***(G2)***

Notes: Award ***(G1)*** for $0.129x$, ***(G1)*** for $+6.82$.

Award a maximum of ***(G0)(G1)*** if the answer is not an equation.

Examiners report

[N/A]

13e. *[2 marks]*

Markscheme

$0.129 \times 70 + 6.82$ ***(M1)***

Note: Award ***(M1)*** for substitution of 70 into their equation of regression line.

OR

$\frac{8+12.8+\ldots+21.1}{6}$ ***(M1)***

$= 15.9\,(15.85)$ ***(A1)*(ft)*(G2)***

Note: Follow through from part (d) without working.

Examiners report

[N/A]

13f. *[2 marks]*

Markscheme

regression line through $(70,\ 15.9)$ ***(A1)*(ft)**

Note: Accept 15.9 ± 0.2.

Follow through from part (e).

with T-intercept, 6.82 ***(A1)*(ft)**

Note: Follow through from part (d). Accept 6.82 ± 0.2.

In case the regression line is not straight (ruler not used), award ***(A0)(A1)*(ft)** if line passes through both their $(70,\ 15.9)$ and $(0,\ 6.82)$, otherwise award ***(A0)(A0)***.

Do not penalize if line does not intersect the T-axis.

Examiners report

[N/A]

13g. *[1 mark]*

Markscheme

$T = 0.45z + 10$ ***(A1)***

Examiners report

[N/A]

13h. *[6 marks]*

Markscheme

(i) $0.45(20) + 10$ ***(M1)***

Note: Award ***(M1)*** for correct substitution of 20 into their formula from part (g).

$= 19 \quad (^\circ\mathrm{C})$ ***(A1)*(ft)*(G2)***

Note: Follow through from part (g).

(ii) $= 18.2 \quad (^\circ\mathrm{C})$ ***(A1)***

(iii) $\left|\frac{19-18.2}{18.2}\right| \times 100\%$ ***(M1)(A1)*(ft)**

Note: Award ***(M1)*** for substitution in the percentage error formula, ***(A1)*** for correct substitution.

$4.40\% \quad (4.39560\ldots)$ ***(A1)*(ft)*(G2)***

Notes: Follow through from parts (h)(i) and (h)(ii).

Examiners report

[N/A]

14a. *[4 marks]*

Markscheme

$f'(x) = \frac{-10}{x^3} + 3$ ***(A1)(A1)(A1)(A1)***

Note: Award ***(A1)*** for -10, ***(A1)*** for x^3 (or x^{-3}), ***(A1)*** for 3, ***(A1)*** for no other constant term.

[4 marks]

Examiners report

A large number of candidates were not able to answer this question well because of the first term of the function's negative index. Many candidates who did make an attempt lacked understanding of the topic.

Most candidates could score 4 marks.

14b. *[2 marks]*

Markscheme

$4 = 5 + 3 + c$ ***(M1)***

Note: Award ***(M1)*** for substitution in $f(x)$.

$c = -4$ ***(A1)(G2)***

[2 marks]

Examiners report

A large number of candidates were not able to answer this question well because of the first term of the function's negative index. Many candidates who did make an attempt lacked understanding of the topic.

A good number of candidates correctly substituted into the original function.

14c. *[4 marks]*

Markscheme

$f'(x) = 0$ ***(M1)***

$0 = \frac{-10}{x^3} + 3$ ***(A1)*****(ft)**

$(1.49, 2.72)$ (accept $x = 1.49$ $y = 2.72$) ***(A1)*****(ft)*****(A1)*****(ft)*****(G3)***

Notes: If answer is given as $(1.5, 2.7)$ award ***(A0)(AP)(A1)***.

Award at most ***(M1)(A1)(A1)(A0)*** if parentheses not included. **(ft)** from their (a).

If no working shown award ***(G2)(G0)*** if parentheses are not included.

OR

Award ***(M2)*** for sketch, ***(A1)*****(ft)*****(A1)*****(ft)** for correct coordinates. **(ft)** from their (b). ***(M2)(A1)*****(ft)*****(A1)*****(ft)**

Note: Award at most ***(M2)(A1)*****(ft)*****(A0)*** if parentheses not included.

[4 marks]

Examiners report

A large number of candidates were not able to answer this question well because of the first term of the function's negative index. Many candidates who did make an attempt lacked understanding of the topic.

Very few managed to answer this part algebraically. Those candidates who were aware that they could read the values from their GDC gained some easy marks.

14d. *[3 marks]*

Markscheme

$0 < x < 1.49$ **OR** $0 < x \leq 1.49$ ***(A1)(A1)*(ft)*(A1)***

Notes: Award ***(A1)*** for 0, ***(A1)*(ft)** for 1.49 and ***(A1)*** for correct inequality signs.

(ft) from their x value in (c) (i).

[3 marks]

Examiners report

A large number of candidates were not able to answer this question well because of the firstterm of the function's negative index. Many candidates who did make an attempt lacked understanding of the topic.

Proved to be difficult for many candidates as increasing/decreasing intervals were not well understood by many.

14e. *[2 marks]*

Markscheme

For P(1, 4)
$f'(1) = -10 + 3$ ***(M1)(A1)***

$= -7$ ***(AG)***

Note: Award ***(M1)*** for substituting
$x = 1$ into their
$f'(x)$. ***(A1)*** for
$-10 + 3$.

-7 must be seen for ***(A1)*** to be awarded.

[2 marks]

Examiners report

A large number of candidates were not able to answer this question well because of the first term of the function's negative index. Many candidates who did make an attempt lacked understanding of the topic.

As this part was linked to part (a), candidates who could not find the correct derivative could not show that the gradient of T was -7. Many candidates did not realize that they had to substitute into the first derivative. For those who did, finding the equation of T was a simple task.

14f. *[2 marks]*

Markscheme

$4 = -7 \times 1 + c$
$11 = c$ ***(A1)***

$y = -7x + 11$ ***(A1)***

[2 marks]

Examiners report

A large number of candidates were not able to answer this question well because of the firstterm of the function's negative index. Many candidates who did make an attempt lacked understanding of the topic.

As this part was linked to part (a), candidates who could not find the correct derivative could not show that the gradient of *T* was –7. Many candidates did not realize that they had to substitute into the first derivative. For those who did, finding the equation of *T* was a simple task.

14g. *[2 marks]*

Markscheme

Point of intersection is R(–0.5, 14.5) ***(A1)*(ft)*(A1)*(ft)*(G2)*(ft)**

Notes: Award ***(A1)*** for the *x* coordinate, ***(A1)*** for the *y* coordinate.

Allow **(ft)** from candidate's (d)(ii) equation and their (b) even with no working seen.

Award ***(A1)*(ft)*(A0)*** if brackets not included and not previously penalised.

[2 marks]

Examiners report

A large number of candidates were not able to answer this question well because of the first term of the function's negative index. Many candidates who did make an attempt lacked understanding of the topic.

For those who had part (d) (ii) correct, this allowed them to score easy marks. For the others, it proved a difficult task because their equation in (d) would not be a tangent.

15a. *[1 mark]*

Markscheme

$x(x - k)$ ***(A1)*** ***(C1)***

[1 mark]

Examiners report

This question was poorly answered by all but the best candidates. The links between the parts were not made. The idea of the line of symmetry for the graph was seldom investigated. The "minimum value of the function" was often incorrectly given as a coordinate pair.

15b. *[1 mark]*

Markscheme

$x = 0$ **or**
$x = k$ ***(A1)*** ***(C1)***

Note: Both correct answers only.

[1 mark]

Examiners report

This question was poorly answered by all but the best candidates. The links between the parts were not made. The idea of the line of symmetry for the graph was seldom investigated. The "minimum value of the function" was often incorrectly given as a coordinate pair.

15c. *[1 mark]*

Markscheme

$k = 3$ ***(A1)*** ***(C1)***

[1 mark]

Examiners report

This question was poorly answered by all but the best candidates. The links between the parts were not made. The idea of the line of symmetry for the graph was seldom investigated. The "minimum value of the function" was often incorrectly given as a coordinate pair.

15d. *[3 marks]*

Markscheme

Vertex at $x = \frac{-(-3)}{2(1)}$ ***(M1)***

Note: ***(M1)*** for correct substitution in formula.

$x = 1.5$ ***(A1)*****(ft)**

$y = -2.25$ ***(A1)*****(ft)**

OR

$f'(x) = 2x - 3$ ***(M1)***

Note: ***(M1)*** for correct differentiation.

$x = 1.5$ ***(A1)*****(ft)**
$y = -2.25$ ***(A1)*****(ft)**

OR

for finding the midpoint of their 0 and 3 ***(M1)***
$x = 1.5$ ***(A1)*****(ft)**
$y = -2.25$ ***(A1)*****(ft)**

Note: If final answer is given as
$(1.5, -2.25)$ award a maximum of ***(M1)(A1)(A0)***

[3 marks]

Examiners report

This question was poorly answered by all but the best candidates. The links between the parts were not made. The idea of the line of symmetry for the graph was seldom investigated. The “minimum value of the function” was often incorrectly given as a coordinate pair.

16a. *[4 marks]*

Markscheme

(i)

$100 \times 1.06 = 106$ ***(M1)(A1)(G2)***

Note: ***(M1)*** for multiplying by 1.06 or equivalent. ***(A1)*** for correct answer.

(ii)

$100 \times 1.06^3 = 119$ ***(M1)(A1)(G2)***

Note: ***(M1)*** for multiplying by 1.06^3 or equivalent or for list of values. ***(A1)*** for correct answer.

[4 marks]

Examiners report

This question was well answered by the majority of the candidates. Most of the candidates were able to distinguish between the arithmetic and the geometric progression. A number of candidates worked out term by term by hand for which they needed more time than those that used the formulae to find the requested terms. Some of the students that found the terms the long way also lost a mark for premature rounding. It was pleasing to see how the last part of the question was answered using different methods. Those candidates that worked throughout the question using AP and GP formulae used either the solver or a graph to find the solution of the inequality. Those candidates that worked throughout the question in the long way also managed to compare the terms and find the correct year.

16b. *[2 marks]*

Markscheme

$100 \times 1.06^7 = 150.36\ldots = 150$ correct to the nearest whole ***(M1)(A1)(AG)***

Note: ***(M1)*** for correct formula or for list of values. ***(A1)*** for correct substitution or for 150 in the correct position in the list. Unrounded answer must be seen for the ***(A1)***.

[2 marks]

Examiners report

This question was well answered by the majority of the candidates. Most of the candidates were able to distinguish between the arithmetic and the geometric progression. A number of candidates worked out term by term by hand for which they needed more time than those that used the formulae to find the requested terms. Some of the students that found the terms the long way also lost a mark for premature rounding. It was pleasing to see how the last part of the question was answered using different methods. Those candidates that worked throughout the question using AP and GP formulae used either the solver or a graph to find the solution of the inequality. Those candidates that worked throughout the question in the long way also managed to compare the terms and find the correct year.

16c. *[2 marks]*

Markscheme

$110 + 3 \times 10 = 140$ ***(M1)(A1)(G2)***

Note: ***(M1)*** for adding
30 or for list of values. ***(A1)*** for correct answer.

[2 marks]

Examiners report

This question was well answered by the majority of the candidates. Most of the candidates were able to distinguish between the arithmetic and the geometric progression. A number of candidates worked out term by term by hand for which they needed more time than those that used the formulae to find the requested terms. Some of the students that found the terms the long way also lost a mark for premature rounding. It was pleasing to see how the last part of the question was answered using different methods. Those candidates that worked throughout the question using AP and GP formulae used either the solver or a graph to find the solution of the inequality. Those candidates that worked throughout the question in the long way also managed to compare the terms and find the correct year.

16d. *[4 marks]*

Markscheme

In (d) and (e) follow through from (c) if consistent wrong use of correct AP formula.

$110 + (n-1) \times 10 > 176$ ***(A1)(M1)***

$n = 8 \therefore$ year 2007 ***(A1)(A1)*****(ft)*****(G2)***

Note: ***(A1)*** for
176 or
66 seen. ***(M1)*** for showing list of values and comparing them to
176 or for equating formula to
176 or for writing the inequality. If
$n = 8$ not seen can still get ***(A2)*** for 2007. Answer
$n = 8$ with no working gets ***(G1)***.

OR

$110 + n \times 10 > 176$ ***(A1)(M1)***

$n = 7 \therefore$ year 2007 ***(A1)(A1)*****(ft)*****(G2)***

[4 marks]

Examiners report

This question was well answered by the majority of the candidates. Most of the candidates were able to distinguish between the arithmetic and the geometric progression. A number of candidates worked out term by term by hand for which they needed more time than those that used the formulae to find the requested terms. Some of the students that found the terms the long way also lost a mark for premature rounding. It was pleasing to see how the last part of the question was answered using different methods. Those candidates that worked throughout the question using AP and GP formulae used either the solver or a graph to find the solution of the inequality. Those candidates that worked throughout the question in the long way also managed to compare the terms and find the correct year.

16e. *[5 marks]*

Markscheme

In (d) and (e) follow through from (c) if consistent wrong use of correct AP formula.

(i)
180 ***(A1)*(ft)**

Grove School gets the money. ***(A1)*(ft)**

Note: ***(A1)*** for
180 seen. ***(A1)*** for correct answer.

(ii)
$100 \times 1.06^{n-1} > 110 + (n-1) \times 10$ ***(M1)***

$n = 20 \therefore$ year 2019 ***(A1)(A1)*(ft)*(G2)***

Note: ***(M1)*** for showing lists of values for each school and comparing them or for equating both formulae or writing the correct inequality. If
$n = 20$ not seen can still get ***(A2)*** for 2019. Follow through with ratio used in (b) and/or formula used in (d).

OR

$100 \times 1.06^{n} > 110 + n \times 10$ ***(M1)***

$n = 19 \therefore$ year 2019 ***(A1)(A1)*(ft)*(G2)***

OR

graphically

Note: ***(M1)*** for sketch of both functions on the same graph, ***(A1)*** for the intersection point, ***(A1)*** for correct answer.

[5 marks]

Examiners report

This question was well answered by the majority of the candidates. Most of the candidates were able to distinguish between the arithmetic and the geometric progression. A number of candidates worked out term by term by hand for which they needed more time than those that used the formulae to find the requested terms. Some of the students that found the terms the long way also lost a mark for premature rounding. It was pleasing to see how the last part of the question was answered using different methods. Those candidates that worked throughout the question using AP and GP formulae used either the solver or a graph to find the solution of the inequality. Those candidates that worked throughout the question in the long way also managed to compare the terms and find the correct year.

17a. *[2 marks]*

Markscheme

$T(0) = 20 + 70 \times 2.72^{-0.4 \times 0} = 90$ ***(M1)(A1)(AG)***

Note: ***(M1)*** for taking
$m = 0$, ***(A1)*** for substituting
0 into the formula. For the ***A*** mark to be awarded
90 must be justified by correct method.

[2 marks]

Examiners report

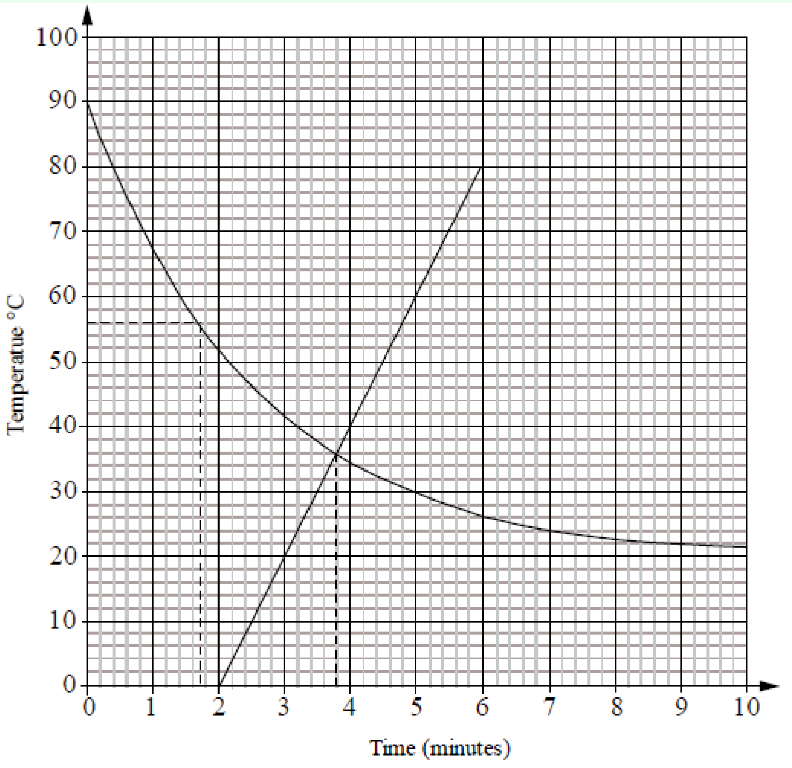
Good marks were gained in this question, mainly from parts (a) to (d). Very few students answered the show that question using a backwards process. These students did not gain full marks. Labelled and neat exponential graphs were drawn. Marks were lost sometimes for starting the curve at point
$(1, 66.9)$ instead of at
$(0, 90)$. Also there were students using a ruler to help them joined up the points for which they lost one mark as the graph must be smooth. Candidates managed to find the time at which the temperature was
56. However, those students that gave their answer as a coordinate pair lost the answer mark. Some students justified the behaviour of the curve by mentioning the asymptote but the big majority said that the room temperature was
20 and it was awarded full marks. Most of the students drew the straight line correct and in the given domain. Those students that drew the line in a separate set of axes could not answer the last part of the question. This part question proved to be difficult for many students and so worked as a discriminating one. One of the most common errors seen in part (b)(iii) and (e)(i) was to give the answer as a point instead of giving just the first coordinate of that point.

17b. *[9 marks]*

Markscheme

(i) 21.3 ***(A1)***

(ii)



(A4)**(ft)**

Note: Scales and labels ***(A1)***. Smooth curve ***(A1)***. All points correct including the y-intercept ***(A2)***, 1 point incorrect ***(A1)***, otherwise ***(A0)***. Follow through from their value of s.

(iii)
$m = 1.7$ minutes *(Accept* ± 0.2 *)* ***(A2)*****(ft)**

Note: Follow through from candidate's graph. Accept answers in minutes and seconds if consistent with graph. If answer incorrect and correct line(s) seen on graph award ***(M1)(A0)***.

(iv)
$20^\circ\mathrm{C}$ ***(A1)*****(ft)**

The curve behaves asymptotically to the line $y = 20$ or similar. ***(A1)***

OR

The room temperature is 20 or similar

OR

When m is a very large number the term $70 \times 2.72^{-0.4\mathrm{m}}$ tends to zero or similar.

Note: Follow through from their graph if appropriate.

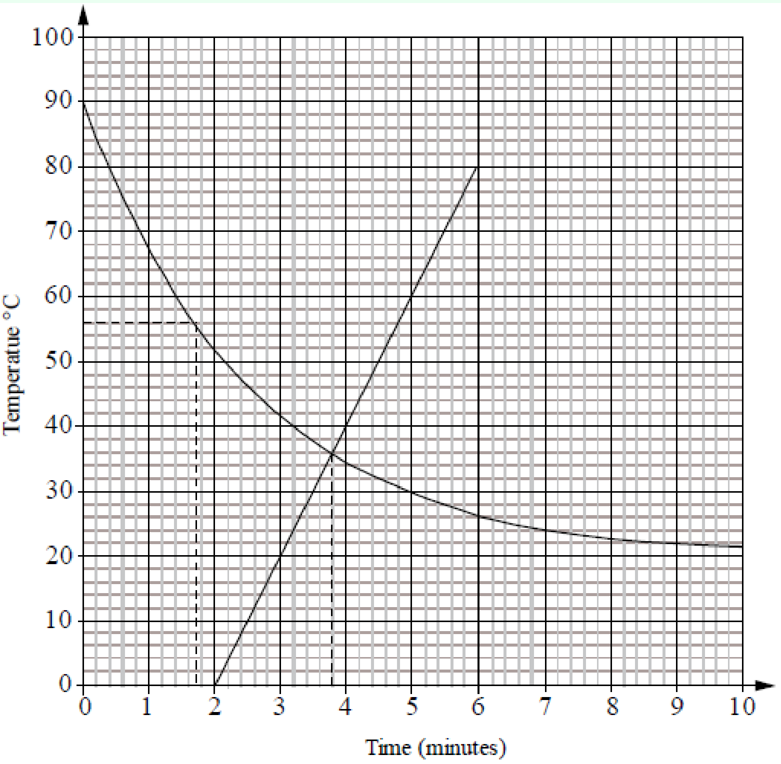
[9 marks]

Examiners report

Good marks were gained in this question, mainly from parts (a) to (d). Very few students answered the show that question using a backwards process. These students did not gain full marks. Labelled and neat exponential graphs were drawn. Marks were lost sometimes for starting the curve at point
$(1, 66.9)$ instead of at
$(0, 90)$. Also there were students using a ruler to help them joined up the points for which they lost one mark as the graph must be smooth. Candidates managed to find the time at which the temperature was
56. However, those students that gave their answer as a coordinate pair lost the answer mark. Some students justified the behaviour of the curve by mentioning the asymptote but the big majority said that the room temperature was
20 and it was awarded full marks. Most of the students drew the straight line correct and in the given domain. Those students that drew the line in a separate set of axes could not answer the last part of the question. This part question proved to be difficult for many students and so worked as a discriminating one. One of the most common errors seen in part (b)(iii) and (e)(i) was to give the answer as a point instead of giving just the first coordinate of that point.

17c. *[2 marks]*

Markscheme



(A1)(A1)

Notes: ***(A1)*** for correct line, ***(A1)*** for domain. If line not drawn on same set of axes award at most ***(A1)(A0)***.

[2 marks]

Examiners report

Good marks were gained in this question, mainly from parts (a) to (d). Very few students answered the show that question using a backwards process. These students did not gain full marks. Labelled and neat exponential graphs were drawn. Marks were lost sometimes for starting the curve at point
$(1, 66.9)$ instead of at
$(0, 90)$. Also there were students using a ruler to help them joined up the points for which they lost one mark as the graph must be smooth. Candidates managed to find the time at which the temperature was
56. However, those students that gave their answer as a coordinate pair lost the answer mark. Some students justified the behaviour of the curve by mentioning the asymptote but the big majority said that the room temperature was
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17d. *[1 mark]*

Markscheme

It indicates by how much the temperature increases per minute. ***(A1)***

[1 mark]

Examiners report

Good marks were gained in this question, mainly from parts (a) to (d). Very few students answered the show that question using a backwards process. These students did not gain full marks. Labelled and neat exponential graphs were drawn. Marks were lost sometimes for starting the curve at point $(1, 66.9)$ instead of at $(0, 90)$. Also there were students using a ruler to help them joined up the points for which they lost one mark as the graph must be smooth. Candidates managed to find the time at which the temperature was 56. However, those students that gave their answer as a coordinate pair lost the answer mark. Some students justified the behaviour of the curve by mentioning the asymptote but the big majority said that the room temperature was 20 and it was awarded full marks. Most of the students drew the straight line correct and in the given domain. Those students that drew the line in a separate set of axes could not answer the last part of the question. This part question proved to be difficult for many students and so worked as a discriminating one. One of the most common errors seen in part (b)(iii) and (e)(i) was to give the answer as a point instead of giving just the first coordinate of that point.

17e. *[4 marks]*

Markscheme

(i)

$m = 3.8$ *(Accept* ± 0.1 *)* ***(A2)*(ft)**

Note: Follow through from candidate's graph. Accept answers in minutes and seconds if consistent with graph. If answer incorrect and correct line(s) seen on graph award ***(M1)(A0)***.

(ii)

$3.8 < m \leqslant 6$ ***(A1)(A1)*(ft)**

Note: ***(A1)*** for $m > 3.8$ and ***(A1)*** for $m \leqslant 6$. Follow through from candidate's answer to part (e)(i). If candidate was already penalized in (c) for domain and does not state $m \leqslant 6$ then award ***(A2)*(ft)**.

Examiners report

Good marks were gained in this question, mainly from parts (a) to (d). Very few students answered the show that question using a backwards process. These students did not gain full marks. Labelled and neat exponential graphs were drawn. Marks were lost sometimes for starting the curve at point $(1, 66.9)$ instead of at $(0, 90)$. Also there were students using a ruler to help them joined up the points for which they lost one mark as the graph must be smooth. Candidates managed to find the time at which the temperature was 56. However, those students that gave their answer as a coordinate pair lost the answer mark. Some students justified the behaviour of the curve by mentioning the asymptote but the big majority said that the room temperature was 20 and it was awarded full marks. Most of the students drew the straight line correct and in the given domain. Those students that drew the line in a separate set of axes could not answer the last part of the question. This part question proved to be difficult for many students and so worked as a discriminating one. One of the most common errors seen in part (b)(iii) and (e)(i) was to give the answer as a point instead of giving just the first coordinate of that point.

18a. [3 marks]

Markscheme

(i)

$y = 0$ *(A1)*

(ii)

$(0,\ -2)$ *(A1)(A1)*

Note: Award *(A1)(A0)* if brackets missing.

OR

$x = 0, y = -2$ *(A1)(A1)*

Note: If coordinates reversed award *(A0)(A1)*(**ft**). Two coordinates must be given.

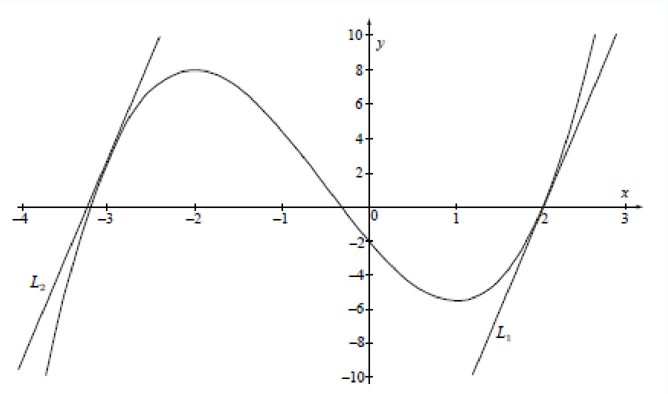
[3 marks]

Examiners report

Many candidates managed to gain good marks in this question as they were able to answer the first three parts of the question. Good sketches were drawn with the required information shown on them. Very few candidates did not recognise the notation $\frac{\mathrm{d}y}{\mathrm{d}x}$ but they showed that they knew how to differentiate as in (d)(i) they found the derivative to show that the gradient of L_1 was 12. Candidates found it difficult to find the other x for which the derivative was 12. However, some could draw both tangents without having found this value of x . In general, tangents were not well drawn. The last part question did act as a discriminating question. However, those candidates that had the function drawn either in their GDC or on paper recognised that at $x = -2$ there was a maximum and so wrote down the correct equation of the tangent at that point.

18b. [4 marks]

Markscheme



(A4)

Notes: *(A1)* for appropriate window. Some indication of scale on the x-axis must be present (for example ticks). Labels not required. *(A1)* for smooth curve and shape, *(A1)* for maximum and minimum in approximately correct position, *(A1)* for x and y intercepts found in (a) in approximately correct position.

[4 marks]

Examiners report

Many candidates managed to gain good marks in this question as they were able to answer the first three parts of the question. Good sketches were drawn with the required information shown on them. Very few candidates did not recognise the notation $\frac{\mathrm{d}y}{\mathrm{d}x}$ but they showed that they knew how to differentiate as in (d)(i) they found the derivative to show that the gradient of L_1 was 12. Candidates found it difficult to find the other x for which the derivative was 12. However, some could draw both tangents without having found this value of x . In general, tangents were not well drawn. The last part question did act as a discriminating question. However, those candidates that had the function drawn either in their GDC or on paper recognised that at $x = -2$ there was a maximum and so wrote down the correct equation of the tangent at that point.

18c. *[3 marks]*

Markscheme

$\frac{\mathrm{d}y}{\mathrm{d}x} = 3x^2 + 3x - 6$ ***(A1)(A1)(A1)***

Note: ***(A1)*** for each correct term. Award ***(A1)(A1)(A0)*** at most if any other term is present.

[3 marks]

Examiners report

Many candidates managed to gain good marks in this question as they were able to answer the first three parts of the question. Good sketches were drawn with the required information shown on them. Very few candidates did not recognise the notation $\frac{\mathrm{d}y}{\mathrm{d}x}$ but they showed that they knew how to differentiate as in (d)(i) they found the derivative to show that the gradient of L_1 was 12. Candidates found it difficult to find the other x for which the derivative was 12. However, some could draw both tangents without having found this value of x . In general, tangents were not well drawn. The last part question did act as a discriminating question. However, those candidates that had the function drawn either in their GDC or on paper recognised that at $x = -2$ there was a maximum and so wrote down the correct equation of the tangent at that point.

18d. *[8 marks]*

Markscheme

(i)

$3 \times 4 + 3 \times 2 - 6 = 12$ ***(M1)(A1)(AG)***

Note: ***(M1)*** for using the derivative and substituting $x = 2$. ***(A1)*** for correct (and clear) substitution. The 12 must be seen.

(ii) Gradient of L_2 is 12 (can be implied) ***(A1)***

$3x^2 + 3x - 6 = 12$ ***(M1)***

$x = -3$ ***(A1)(G2)***

Note: ***(M1)*** for equating the derivative to 12 or showing a sketch of the derivative together with a line at $y = 12$ or a table of values showing the 12 in the derivative column.

(iii) ***(A1)*** for L_1 correctly drawn at approx the correct point ***(A1)***

(A1) for L_2 correctly drawn at approx the correct point ***(A1)***

(A1) for 2 parallel lines ***(A1)***

Note: If lines are not labelled award at most ***(A1)(A1)(A0)***. Do not accept 2 horizontal or 2 vertical parallel lines.

[8 marks]

Examiners report

Many candidates managed to gain good marks in this question as they were able to answer the first three parts of the question. Good sketches were drawn with the required information shown on them. Very few candidates did not recognise the notation $\frac{\mathrm{d}y}{\mathrm{d}x}$ but they showed that they knew how to differentiate as in (d)(i) they found the derivative to show that the gradient of L_1 was 12. Candidates found it difficult to find the other x for which the derivative was 12. However, some could draw both tangents without having found this value of x . In general, tangents were not well drawn. The last part question did act as a discriminating question. However, those candidates that had the function drawn either in their GDC or on paper recognised that at $x = -2$ there was a maximum and so wrote down the correct equation of the tangent at that point.

18e. [5 marks]

Markscheme

(i)
$b = 1$ *(G2)*

(ii) The curve is decreasing. *(A1)*

Note: Accept any valid description.

(iii)
$y = 8$ *(A1)(A1)(G2)*

Note: *(A1)* for "
$y =$ a constant", *(A1)* for
8.

[5 marks]

Examiners report

Many candidates managed to gain good marks in this question as they were able to answer the first three parts of the question. Good sketches were drawn with the required information shown on them. Very few candidates did not recognise the notation
$\frac{\mathrm{d}y}{\mathrm{d}x}$ but they showed that they knew how to differentiate as in (d)(i) they found the derivative to show that the gradient of
L_1 was
12. Candidates found it difficult to find the other
x for which the derivative was
12. However, some could draw both tangents without having found this value of
x . In general, tangents were not well drawn. The last part question did act as a discriminating question. However, those candidates that had the function drawn either in their GDC or on paper recognised that at
$x = -2$ there was a maximum and so wrote down the correct equation of the tangent at that point.

19a. [3 marks]

Markscheme

	$\mathbb{N}$	$\mathbb{Z}$	$\mathbb{Q}$	$\mathbb{R}$
2	✓	✓	✓	✓
$\sqrt{3}$	✗	✗	✗	✓
$-\frac{2}{3}$	✗	✗	✓	✓

(A1)(A1)(A1) *(C3)*

Note: Accept any symbol for ticks. Do not penalise if the other boxes are left blank.

[3 marks]

Examiners report

There was a lack of familiarity with number systems and mappings - it was surprising to see how few knew what a mapping diagram involved. Part (c) (range) was also poorly answered with many giving an interval although they had correctly worked out the values for the function.

19b.

[1 mark]

Markscheme

Range $= \{2, 9, 14\}$ ***(A1)*(ft)** ***(C1)***

Note: Brackets not required.

[1 mark]

Examiners report

There was a lack of familiarity with number systems and mappings - it was surprising to see how few knew what a mapping diagram involved. Part (b) (range) was also poorly answered with many giving an interval although they had correctly worked out the values for the function.

20a.

[1 mark]

Markscheme

$a = 1800$ ***(A1)*** ***(C1)***

[1 mark]

Examiners report

Parts (a) and (b) were answered well with most candidates attempting and gaining marks. Very few candidates gained maximum marks for part (c) with most using a list to find the number of hours rather than the formula.

20b.

[2 marks]

Markscheme

200×3^6 (or 16200×9) $= 145800$ ***(M1)(A1)*** ***(C2)***

[2 marks]

Examiners report

Parts (a) and (b) were answered well with most candidates attempting and gaining marks. Very few candidates gained maximum marks for part (c) with most using a list to find the number of hours rather than the formula.

20c.

[3 marks]

Markscheme

$200 \times 3^n = 2 \times 10^6$ (where
n is each
4 hour interval)   ***(M1)***

Note: Award ***(M1)*** for attempting to set up the equation or writing a list of numbers.

$3^n = 10^4$

$n = 8.38$ (8.383613097) *correct answer only*   ***(A1)***

Time $= 33.5$ hours *(accept*
34,
35 *or*
36 *if previous **A** mark awarded)*   ***(A1)*(ft)**   ***(C3)***

Note: ***(A1)*(ft)** for correctly multiplying their answer by
4. If
34,
35 or
36 seen, or
$32 - 36$ seen, award ***(M1)(A0)(A0)***.

[3 marks]

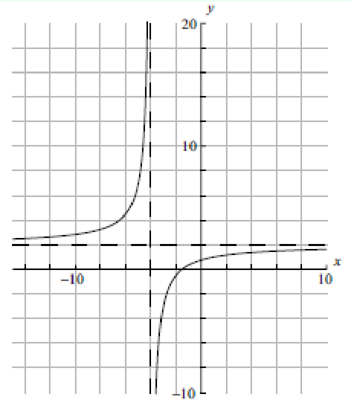
Examiners report

Parts (a) and (b) were answered well with most candidates attempting and gaining marks. Very few candidates gained maximum marks for part (c) with most using a list to find the number of hours rather than the formula.

21a.

[6 marks]

Markscheme



(A6)

Notes: ***(A1)*** for labels and some idea of scale.
(A1) for
x-intercept seen, ***(A1)*** for
y-intercept seen in roughly the correct places (coordinates not required).
(A1) for vertical asymptote seen, ***(A1)*** for horizontal asymptote seen in roughly the correct places (equations of the lines not required).
(A1) for correct general shape.

[6 marks]

Examiners report

This was not very well done. The graph was often correct but was so small that it was difficult to check if axes intercepts were correct or not. Often the vertical asymptote looked as if it were joined to the rest of the graph. Very few of the candidates put a scale and/or labels on their axes.

21b. *[2 marks]*

Markscheme

$x = -4$ *(A1)(A1)*(**ft**)

Note: *(A1)* for
$x =$, *(A1)*(**ft**) for
-4.

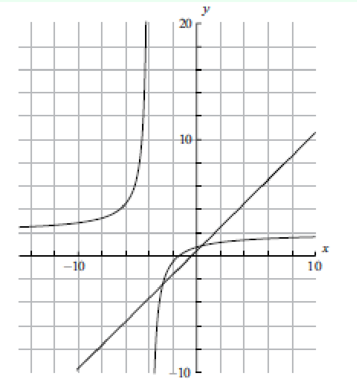
[2 marks]

Examiners report

Reasonably well done. Some put
$y = -4$ while others omitted the minus sign.

21c. *[2 marks]*

Markscheme



(A1)(A1)

Note: *(A1)* for correct axis intercepts, *(A1)* for straight line

[2 marks]

Examiners report

Fairly well done – but once again too small to check the axes intercepts properly. Also, many candidates did not appear to have a ruler to draw the straight line.

21d. *[3 marks]*

$(-2.85078,\ -2.35078)$
$(0.35078, 0.85078)$

x
y

$x = -2.85078$
$y = -2.35078$
$x = 0.35078$
$y = 0.85078$

Examiners report

Well done.

21e. *[1 mark]*

Markscheme

gradient $= 1$ ***(A1)***

[1 mark]

Examiners report

Most could find the gradient of the line.

21f. *[3 marks]*

Markscheme

gradient of perpendicular $= -1$ ***(A1)*(ft)**

(can be implied in the next step)

$y = mx + c$

$-3 = -1 \times -2 + c$ ***(M1)***

$c = -5$

$y = -x - 5$ ***(A1)*(ft)*(G2)***

OR

$y + 3 = -(x + 2)$ ***(M1)(A1)*(ft)*(G2)***

Note: Award ***(G2)*** for correct answer with no working at all but ***(A1)(G1)*** if the gradient is mentioned as -1 then correct answer with no further working.

[3 marks]

Examiners report

Many forgot to find the gradient of the perpendicular line. Others had problems with the equation of a line in general.

22a. *[2 marks]*

Markscheme

$(x - 5)(x + 2)$ ***(A1)(A1)*** ***(C2)***

Note: Award ***(A1)*** for
$(x + 5)(x - 2)$, ***(A0)*** otherwise. If equation is equated to zero and solved by factorizing award ***(A1)*** for both correct factors, followed by ***(A0)***.

[2 marks]

Examiners report

It was surprising how many candidates could not factorise this expression. Of those that could some went on to find the zeros of a quadratic equation which was not what the question was asking. Some confused domain and range and many did not write down all the values when they did know domain and range.

22b. *[4 marks]*

Markscheme

(i)
-3,
-2,
-1,
0,
1,
2,
3 ***(A1)(A1)*** ***(C2)***

Note: Award ***(A2)*** for all correct answers seen and no others. Award ***(A1)*** for 3 correct answers seen.

(ii)
-26,
-7, 0,1, 2, 9, 28 ***(A1)(A1)*** ***(C2)***

Note: Award ***(A2)*** for all correct answers seen and no others. Award ***(A1)*** for 3 correct answers seen. If domain and range are interchanged award ***(A0)*** for (b)(i) and ***(A1)*(ft)*(A1)*(ft)** for (b)(ii).

[4 marks]

Examiners report

It was surprising how many candidates could not factorise this expression. Of those that could some went on to find the zeros of a quadratic equation which was not what the question was asking. Some confused domain and range and many did not write down all the values when they did know domain and range.