The function $f(x) = 5 - 3(2^{-x})$ is defined for $x \geq 0$.

1a. On the axes below sketch the graph of $f(x)$ and show the behaviour of the curve as $x$ increases. 

**Markscheme**

![Graph of $f(x) = 5 - 3(2^{-x})$]

**Notes:** Award (A1) for labels and scale on $y$-axis. Award (A1) for smooth increasing curve in the given domain. Award (A1) for asymptote implied (gradient $\to 0$).

1b. Write down the coordinates of any intercepts with the axes.
Consider the function \( f(x) = p(0.5)^x + q \) where \( p \) and \( q \) are constants. The graph of \( f(x) \) passes through the points \((0, 6)\) and \((1, 4)\) and is shown below.

2a. Write down two equations relating \( p \) and \( q \). [2 marks]
2b. Find the value of $p$ and of $q$. [2 marks]

**Markscheme**

$p = 4, q = 2$ (A1)(A1) (ft) (C2)

**Notes:** If both answers are incorrect, award (MI) for attempt at solving simultaneous equations.

[2 marks]

2c. Write down the equation of the horizontal asymptote to the graph of $f(x)$. [2 marks]

**Markscheme**

$y = 2$ (A1)(A1)(ft) (C2)

**Notes:** Award (A1) for "$y = a$ constant", (A1)(ft) for 2. Follow through from their value for $q$ as long as their constant is greater than 2 and less than 6.

An equation must be seen for any marks to be awarded.

[2 marks]

The function $g(x)$ is defined as $g(x) = 16 + k(e^{-x})$ where $c > 0$.

The graph of the function $g$ is drawn below on the domain $x \geq 0$.

The graph of $g$ intersects the $y$-axis at $(0, 80)$.

3a. Find the value of $k$. [2 marks]
3b. The graph passes through the point (2, 48).
Find the value of $c$.

\[
80 = 16 + k(c^0) \quad (M1)
\]

\[
k = 64 \quad (A1) \quad (C2)
\]

[2 marks]

\[
3c. \quad \text{The graph passes through the point (2, 48).}
\]
\[
\text{Write down the equation of the horizontal asymptote to the graph of } y = g(x).
\]

\[
y = 16 \quad (A1)(A1) \quad (C2)
\]

\[
\text{Note: Award } (MI) \text{ for substitution of their } k \text{ and (2, 48) into the equation for } g(x).
\]

\[
c = \sqrt{2} \quad (1.41) \quad (1.41421 \ldots) \quad (A1)(ft) \quad (C2)
\]

\[
\text{Notes: Award } (MI)(A1)(ft) \text{ for } c = \pm \sqrt{2}. \text{ Follow through from their answer to part (a).
}[2 marks]

4a. Find the value of

(i) $p$;

(ii) $q$.

A function $f(x) = px^2 + q$ is defined by the mapping diagram below.
Markscheme

(i) \(2p + q = 11\) and \(4p + q = 17\) \((M1)\)

Note: Award \((M1)\) for either two correct equations or a correct equation in one unknown equivalent to \(2p = 6\).

\(p = 3\) \((A1)\)

(ii) \(q = 5\) \((A1)\) \((C3)\)

Notes: If only one value of \(p\) and \(q\) is correct and no working shown, award \((M0)(A1)(A0)\).

[3 marks]

4b. Write down the value of \(r\).

[1 mark]

Markscheme

\(r = 8\) \((A1)(ft)\) \((C1)\)

Note: Follow through from their answers for \(p\) and \(q\) irrespective of whether working is seen.

[1 mark]

4c. Find the value of \(s\).

[2 marks]

Markscheme

\(3 \times 2^4 + 5 = 197\) \((M1)\)

Note: Award \((M1)\) for setting the correct equation.

\(s = 6\) \((A1)(ft)\) \((C2)\)

Note: Follow through from their values of \(p\) and \(q\).

[2 marks]
The diagram shows part of the graph of \( y = 2^{-x} + 3 \), and its horizontal asymptote. The graph passes through the points \((0, a)\) and \((b, 3.5)\).

5a. Find the value of

(i) \( a \);

(ii) \( b \).

**Markscheme**

(i) \( 2^0 + 3 \quad (M1) \)

*Note: Award (MI) for correct substitution.*

\[ = 4 \quad (A1) \quad (C2) \]

(ii) \( 3.5 = 2^{-b} + 3 \quad (M1) \)

*Note: Award (MI) for correct substitution.*

\[ b = 1 \quad (A1) \quad (C2) \]

[4 marks]

5b. Write down the equation of the horizontal asymptote to this graph.

**Markscheme**

\[ y = 3 \quad (A1)(A1) \quad (C2) \]

*Notes: \( y = \text{constant (other than 3)} \) award \( A1)(A0) \).

[2 marks]
Consider the function \( f(x) = 1.25 - a^{-x} \), where \( a \) is a positive constant and \( x \geq 0 \). The diagram shows a sketch of the graph of \( f \). The graph intersects the \( y \)-axis at point \( A \) and the line \( L \) is its horizontal asymptote.

6a. Find the \( y \)-coordinate of \( A \).

**Markscheme**

\[ y = 1.25 - a^0 \quad 1.25 - 1 \quad (MI) \]

\[ = 0.25 \quad (A1) \quad (C2) \]

Note: Award \( (MI)(A1) \) for \((0, 0.25)\).

[2 marks]

6b. The point \((2, 1)\) lies on the graph of \( y = f(x) \). Calculate the value of \( a \).

**Markscheme**

\[ 1 = 1.25 - a^{-2} \quad (MI) \]

\[ a = 2 \quad (A1) \quad (C2) \]

[2 marks]

6c. The point \((2, 1)\) lies on the graph of \( y = f(x) \). Write down the equation of \( L \).

**Markscheme**

\[ y = 1.25 \quad (A1)(A1) \quad (C2) \]

Note: Award \( (A1) \) for "a constant", \( (A1) \) for 1.25.

[2 marks]

George leaves a cup of hot coffee to cool and measures its temperature every minute. His results are shown in the table below.

<table>
<thead>
<tr>
<th>Time, ( t ) (minutes)</th>
<th>0</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
</tr>
</thead>
<tbody>
<tr>
<td>Temperature, ( y ) (°C)</td>
<td>94</td>
<td>54</td>
<td>34</td>
<td>24</td>
<td>k</td>
<td>16.5</td>
<td>15.25</td>
</tr>
</tbody>
</table>

7a. Write down the decrease in the temperature of the coffee

(i) during the first minute (between \( t = 0 \) and \( t = 1 \));

(ii) during the second minute;

(iii) during the third minute.
7b. Assuming the pattern in the answers to part (a) continues, show that \( k = 19 \). [2 marks]

Markscheme

24 \(- k = 5 \) or equivalent \((A1)(M1)\)

Note: Award \((A1)\) for 5 seen, \((M1)\) for difference from 24 indicated.

\[ k = 19 \] \((AG)\)

Note: If 19 is not seen award at most \((A1)(M0)\).

7c. Use the seven results in the table to draw a graph that shows how the temperature of the coffee changes during the first six minutes. [4 marks]

Use a scale of 2 cm to represent 1 minute on the horizontal axis and 1 cm to represent 10 °C on the vertical axis.
Markscheme

Note: Award (A1) for scales and labelled axes (t or "time" and y or "temperature").

Accept the use of x on the horizontal axis only if “time” is also seen as the label.

Award (A2) for all seven points accurately plotted, award (A1) for 5 or 6 points accurately plotted, award (A0) for 4 points or fewer accurately plotted.

Award (A1) for smooth curve that passes through all points on domain [0, 6].

If graph paper is not used or one or more scales is missing, award a maximum of (A0)(A0)(A0)(A1).

7d. The function that models the change in temperature of the coffee is \( y = p(2^{-t}) + q \). 

   (i) Use the values \( t = 0 \) and \( y = 94 \) to form an equation in \( p \) and \( q \).

   (ii) Use the values \( t = 1 \) and \( y = 54 \) to form a second equation in \( p \) and \( q \).

Markscheme

   (i) \( 94 = p + q \) (A1)

   (ii) \( 54 = 0.5p + q \) (A1)

   Note: The equations need not be simplified; accept, for example \( 94 = p(2^{-1}) + q \).
Markscheme

\[ p = 80, \quad q = 14 \quad (G1)(G1)(ft) \]

Note: If the equations have been incorrectly simplified, follow through even if no working is shown.

7f. The graph of this function has a horizontal asymptote. [2 marks]

Write down the equation of this asymptote.

Markscheme

\[ y = 14 \quad (A1)(A1) \]

Note: Award (A1) for \( y = a \) constant, (A1) for their 14. Follow through from part (e) only if their \( q \) lies between 0 and 15.25 inclusive.

7g. George decides to model the change in temperature of the coffee with a linear function using correlation and linear regression. [4 marks]

Use the seven results in the table to write down

(i) the correlation coefficient;
(ii) the equation of the regression line \( y \) on \( t \).

Markscheme

(i) \(-0.878 (-0.87787...)\) (G2)

Note: Award (G1) if \(-0.877\) seen only. If negative sign omitted award a maximum of (A1)(A0).

(ii) \( y = -11.7t + 71.6 \) (\( y = -11.6517...t + 71.6336... \)) (G1)(G1)

Note: Award (G1) for \(-11.7t\), (G1) for 71.6.

If \( y = \) is omitted award at most (G0)(G1).

If the use of \( x \) in part (c) has not been penalized (the axis has been labelled “time”) then award at most (G0)(G1).

7h. Use the equation of the regression line to estimate the temperature of the coffee at \( t = 3 \). [2 marks]

Markscheme

\[-11.6517...\( (3) + 71.6339... \) \quad (MI)\]

Note: Award (MI) for correct substitution in their part (g)(ii).

\[ = 36.7 (36.6785...) \quad (A1)(ft)(G2) \]

Note: Follow through from part (g). Accept 36.5 for use of the 3sf answers from part (g).

7i. Find the percentage error in this estimate of the temperature of the coffee at \( t = 3 \). [2 marks]
Shiyun bought a car in 1999. The value of the car $V$, in USD, is depreciating according to the exponential model

$$V = 25000 \times 1.5^{-0.2t}, \quad t \geq 0$$

where $t$ is the time, in years, that Shiyun has owned the car.

8a. Write down the value of the car when Shiyun bought it. [1 mark]

8b. Calculate the value of the car three years after Shiyun bought it. Give your answer correct to two decimal places. [2 marks]

8c. Calculate the time for the car to depreciate to half of its value since Shiyun bought it. [3 marks]
The number of bacteria in a colony is modelled by the function $N(t) = 800 \times 3^{0.5t}$, $t \geq 0$, where $N$ is the number of bacteria and $t$ is the time in hours.

9a. Write down the number of bacteria in the colony at time $t = 0$. [1 mark]

\textbf{Markscheme} \\
800 \quad (AI) \quad (C1)

9b. Calculate the number of bacteria present at 2 hours and 30 minutes. Give your answer correct to the nearest hundred bacteria. [3 marks]

\textbf{Markscheme} \\
$800 \times 3^{(0.5 \times 2.5)}$ \quad (M1) \\
\textit{Note: Award (M1) for correctly substituted formula.}

$= 3158.57...$ \quad (AI) \\
$= 3200$ \quad (AI) \quad (C3) \\
\textit{Notes: Final (AI) is given for correctly rounding their answer. This may be awarded regardless of a preceding (A0).}

9c. Calculate the time, in hours, for the number of bacteria to reach 5500. [2 marks]

\textbf{Markscheme} \\
$5500 = 800 \times 3^{(0.5 \times t)}$ \quad (M1) \\
\textit{Notes: Award (M1) for equating function to 5500. Accept correct alternative methods.}

$= 3.51 \text{ hours (3.50968...)}$ \quad (AI) \quad (C2)

In a trial for a new drug, scientists found that the amount of the drug in the bloodstream decreased over time, according to the model $D(t) = 1.2 \times (0.87)^t$, $t \geq 0$ where $D$ is the amount of the drug in the bloodstream in mg per litre (mg l$^{-1}$) and $t$ is the time in hours.

10a. Write down the amount of the drug in the bloodstream at $t = 0$. [1 mark]

\textbf{Markscheme} \\
$1.2 \text{ (mg l}^{-1})$ \quad (AI) \quad (C1) \\
[1 mark]

10b. Calculate the amount of the drug in the bloodstream after 3 hours. [2 marks]
10c. Use your graphic display calculator to determine the time it takes for the amount of the drug in the bloodstream to decrease to

0.333 mg\(^{-1}\).  

**Markscheme**

\[ 1.2 \times (0.87)^3 \quad (MI) \]

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

\[ = 0.790 \text{ (mg}^{-1}\text{)} \times 0.790203\ldots \quad (AI) \quad (C2) \]

[2 marks]

A computer virus spreads according to the exponential model

\[ N = 200 \times (1.9)^{0.85t}, \quad t \geq 0 \]

where \( N \) is the number of computers infected, and \( t \) is the time, in hours, after the initial infection.

11a. Calculate the number of computers infected after 6 hours.  

\[ 2 \text{ marks} \]
11b. Calculate the time for the number of infected computers to be greater than 1000000.
Give your answer correct to the nearest hour.

**Markscheme**

\[ 1000000 < 200 \times (1.9)^{0.85t} \quad (MI)(MI) \]

**Note:** Award (MI) for setting up the inequality (accept an equation), and (MI) for 1000000 seen in the inequality or equation.

\[ t = 15.6 \quad (15.6113\ldots) \quad (AI) \]

16 hours \quad (AI)(ft) \quad (C4)

**Note:** The final (AI)(ft) is for rounding up their answer to the nearest hour.

Award (C3) for an answer of 15.6 with no working.
Accept 1000001 in an equation.

[4 marks]
12c. To download a game to the mobile phone, an electrical charge of 2.4 units is needed. Find the time taken to reach this charge. Give your answer correct to the nearest minute.

**Markscheme**

\[
2.4 = 2.5 - 2^{-t} \quad (MI)
\]

**Note:** Award (MI) 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**

\[-t \ln(2) = \ln(0.1) \quad (MI)\]

\[t = 3.32192... \quad (AI)\]

\[t = 3 \text{ hours and 19 minutes (199 minutes)} \quad (AI)(ft) \quad (C3)\]

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

[3 marks]
13c. Determine the length of time it would take for 150 teenagers to have heard the rumour. **Give your answer correct to the nearest minute.** [3 marks]

**Markscheme**

\[ 150 = 2 \times (1.81)^{0.7t} \] (MI)
\[ t = 10.39\ldots \text{h} \] (AI)
\[ t = 624 \text{ minutes} \] (AI)(ft) (C3)

**Notes:** Accept 10 hours 24 minutes. Accept alternative methods. Award last (AI)(ft) for correct rounding to the nearest minute of their answer. Unrounded answer must be seen so that the follow through can be awarded. [3 marks]

---

14a. Find the range of \( f(x) = 2 \times 3^x \) for \(-2 \leq x \leq 5\). [4 marks]

**Markscheme**

\[ f(-2) = 2 \times 3^{-2} \] (MI)
\[ = \frac{2}{9} \times 0.222 \] (AI)
\[ f(5) = 2 \times 3^5 \]
\[ = 486 \] (AI)

Range \( \frac{2}{9} \leq f(x) \leq 486 \) OR \( [\frac{2}{9} , 486] \) (AI) (C4)

**Note:** Award (MI) for correct substitution of \(-2\) or \(5\) into \( f(x) \), (AI)(AI) for each correct end point. [4 marks]

---

14b. Find the value of \( x \) given that \( f(x) = 162 \). [2 marks]

**Markscheme**

\[ 2 \times 3^x = 162 \] (MI)
\[ x = 4 \] (AI) (C2) [2 marks]
15a. Sketch the graph of \( y = 2^x \) for \(-2 \leq x \leq 3\). Indicate clearly where the curve intersects the y-axis. [3 marks]

**Markscheme**

Note: Award \( (A1) \) for correct domain, \( (A1) \) for smooth curve, \( (A1) \) for y-intercept clearly indicated.

[3 marks]

15b. Write down the equation of the asymptote of the graph of \( y = 2^x \). [2 marks]

**Markscheme**

\( y = 0 \) \( (A1)(A1) \)

Note: Award \( (A1) \) for \( y = \text{constant} \), \( (A1) \) for 0.

[2 marks]

15c. On the same axes sketch the graph of \( y = 3 + 2x - x^2 \). Indicate clearly where this curve intersects the x and y axes. [3 marks]

**Markscheme**

Note: Award \( (A1) \) for smooth parabola, \( (A1) \) for vertex (maximum) in correct quadrant, \( (A1) \) for all clearly indicated intercepts \( x = -1, x = 3 \) and \( y = 3 \). The final mark is to be applied very strictly. \( (A1)(A1)(A1) \)

[3 marks]

15d. Using your graphic display calculator, solve the equation \( 3 + 2x - x^2 = 2^x \). [2 marks]
markscheme

\[ x = -0.857 \quad x = 1.77 \quad (G1)(G1) \]

Note: Award a maximum of (G1) if \(x\) and \(y\) coordinates are both given.

[2 marks]

15e. Write down the maximum value of the function \(f(x) = 3 + 2x - x^2\).

markscheme

\[ 4 \quad (G1) \]

Note: Award (G0) for (1, 4).

[1 mark]

15f. Use Differential Calculus to verify that your answer to (e) is correct.

markscheme

\[ f'(x) = 2 - 2x \quad (AI)(AI) \]

Note: Award (AI) for each correct term.

Award at most (AI)(A0) if any extra terms seen.

\[ 2 - 2x = 0 \quad (M1) \]

Note: Award (M1) for equating their gradient function to zero.

\[ x = 1 \quad (AI)(ft) \]

\[ f(1) = 3 + 2(1) - (1)^2 = 4 \quad (AI) \]

Note: The final (AI) is for substitution of \(x = 1\) into \(f(x)\) and subsequent correct answer. Working must be seen for final (AI) to be awarded.

[5 marks]

15g. The curve \(y = px^2 + qx - 4\) passes through the point (2, -10).

Use the above information to write down an equation in \(p\) and \(q\).
# Markscheme

\[ 2^2 \times p + 2q - 4 = -10 \quad (MI) \]

**Note:** Award (MI) for correct substitution in the equation.

\[ 4p + 2q = -6 \quad \text{or} \quad 2p + q = -3 \quad (A1) \]

**Note:** Accept equivalent simplified forms.

**[2 marks]**

15h. The gradient of the curve \( y = px^2 + qx - 4 \) at the point (2, -10) is 1. Find \( \frac{dy}{dx} \)

**Markscheme**

\[ \frac{dy}{dx} = 2px + q \quad (A1)(A1) \]

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

**[2 marks]**

15i. The gradient of the curve \( y = px^2 + qx - 4 \) at the point (2, -10) is 1. Hence, find a second equation in \( p \) and \( q \).

**Markscheme**

\[ 4p + q = 1 \quad (A1)(F) \]

**[1 mark]**

15j. The gradient of the curve \( y = px^2 + qx - 4 \) at the point (2, -10) is 1. Solve the equations to find the value of \( p \) and of \( q \).

**Markscheme**

\[ 4p + 2q = -6 \]

\[ 4p + q = 1 \quad (M1) \]

**Note:** Award (M1) for sensible attempt to solve the equations.

\[ p = 2, q = 7 \quad (A1)(A1)(F)(G3) \]

**[3 marks]**
The number of cells, \( C \), in a culture is given by the equation \( C = p \times 2^{0.5t} + q \), where \( t \) is the time in hours measured from 12:00 on Monday and \( p \) and \( q \) are constants.

The number of cells in the culture at 12:00 on Monday is 47.

The number of cells in the culture at 16:00 on Monday is 53.

16a. Use the above information to write down two equations in \( p \) and \( q \):

**Markscheme**

\[ p + q = 47 \quad (AI) \]
\[ 4p + q = 53 \quad (AI) \quad (C2) \]

[2 marks]

16b. Use the above information to calculate the value of \( p \) and of \( q \):

**Markscheme**

Reasonable attempt to solve their equations \( (M1) \)

\[ p = 2, \quad q = 45 \quad (AI) \quad (C2) \]

**Note:** Accept only the answers \( p = 2, \quad q = 45 \).

[2 marks]

16c. Use the above information to find the number of cells in the culture at 22:00 on Monday.

**Markscheme**

\[ C = 2 \times 2^{0.5(10)} + 45 \quad (MI) \]
\[ C = 109 \quad (AI)(ft) \quad (C2) \]

**Note:** Award \( (MI) \) for substitution of 10 into the formula with their values of \( p \) and \( q \).

[2 marks]
The following curves are sketches of the graphs of the functions given below, but in a different order. Using your graphic display calculator, match the equations to the curves, writing your answers in the table below.

(the diagrams are not to scale)

<table>
<thead>
<tr>
<th>Function</th>
<th>Graph label</th>
</tr>
</thead>
<tbody>
<tr>
<td>(i) $y = x^3 + 1$</td>
<td>A</td>
</tr>
<tr>
<td>(ii) $y = x^2 + 3$</td>
<td>B</td>
</tr>
<tr>
<td>(iii) $y = 4 - x^2$</td>
<td>C</td>
</tr>
<tr>
<td>(iv) $y = 2^x + 1$</td>
<td>D</td>
</tr>
<tr>
<td>(v) $y = 3^{-x} + 1$</td>
<td>E</td>
</tr>
<tr>
<td>(vi) $y = 8x - 2x^3 - x^3$</td>
<td>F</td>
</tr>
</tbody>
</table>
On the grid below sketch the graph of the function \( f(x) = 2(1.6)^x \) for the domain \( 0 \leq x \leq 3 \).
18b. Write down the coordinates of the y-intercept of the graph of \( y = f(x) \).

**Markscheme**

\( (0, 2) \) (A1) (CI)

*Note: Accept \( x = 0, y = 2 \)*

18c. On the grid draw the graph of the function \( g(x) = 5 - 2x \) for the domain \( 0 \leq x \leq 3 \).

**Markscheme**

Straight line in the given domain (A1)
Axes intercepts in the correct positions (A1) (C2)

18d. Use your graphic display calculator to solve \( f(x) = g(x) \).

**Markscheme**

\( x = 0.943 \) (0.94259...) (A1) (CI)

*Note: Award (A0) if y-coordinate given.*
The following graph shows the temperature in degrees Celsius of Robert’s cup of coffee, $t$ minutes after pouring it out. The equation of the cooling graph is $f(t) = 16 + 74 \times 2.8^{-0.2t}$ where $f(t)$ is the temperature and $t$ is the time in minutes after pouring the coffee out.

19a. Find the initial temperature of the coffee. 

**Markscheme**
Unit penalty (UP) is applicable in part (i)(a)(c)(d)(e) and (f)

(UP) 90°C  (AI) 

[1 mark]

19b. Write down the equation of the horizontal asymptote. 

**Markscheme**

$y = 16$  (AI) 

[1 mark]

19c. Find the room temperature. 

**Markscheme**
Unit penalty (UP) is applicable in part (i)(a)(c)(d)(e) and (f)

(UP) 16°C (ft) from answer to part (b)  (AI)(ft) 

[1 mark]

19d. Find the temperature of the coffee after 10 minutes. 

**Markscheme**
Unit penalty (UP) is applicable in part (i)(a)(c)(d)(e) and (f)

(UP) 25.4°C  (AI) 

[1 mark]

19e. Find the temperature of Robert’s coffee after being heated in the microwave for 30 seconds after it has reached the temperature in part (d). 

[3 marks]
19f. Calculate the length of time it would take a similar cup of coffee, initially at 20°C, to be heated in the microwave to reach 100°C.

\[
20 \times 2^{1.56} = 100
\]

Markscheme
Unit penalty (UP) is applicable in part (i)(a)(c)(d)(e) and (f)
for seeing $2^{0.75}$ or equivalent (A1)
for multiplying their (d) by their $2^{0.75}$ (M1)
(UP) 42.8°C (A1)(ft)(G2)

[3 marks]

Robert, who lives in the UK, travels to Belgium. The exchange rate is 1.37 euros to one British Pound (GBP) with a commission of 3 GBP, which is subtracted before the exchange takes place. Robert gives the bank 120 GBP.

19g. Calculate correct to 2 decimal places the amount of euros he receives.

\[
120 - 3 = 117
\]

\[
117 \times 1.37 = 160.29 \text{ euros (correct answer only)}
\]

Markscheme
Financial accuracy penalty (FP) is applicable in part (ii) only.
120 – 3 = 117
(FP) 117 $\times$ 1.37 (A1)
= 160.29 euros (correct answer only) (M1)
first (A1) for 117 seen, (MI) for multiplying by 1.37 (A1)(G2)

[3 marks]

19h. He buys 1 kilogram of Belgian chocolates at 1.35 euros per 100 g.

Calculate the cost of his chocolates in GBP correct to 2 decimal places.

\[
13.5 \div 1.37 = 9.85 \text{ GBP (answer correct to 2dp only)}
\]

Markscheme
Financial accuracy penalty (FP) is applicable in part (ii) only.
(FP) $\frac{13.5}{1.37}$ (A1)(MI)
9.85 GBP (answer correct to 2dp only)
first (A1) is for 13.5 seen, (MI) for dividing by 1.37 (A1)(ft)(G3)

[3 marks]
The temperature in °C of a pot of water removed from the cooker is given by $T(m) = 20 + 70 \times 2.72^{-0.4m}$, where $m$ is the number of minutes after the pot is removed from the cooker.

20a. Show that the temperature of the water when it is removed from the cooker is 90°C. [2 marks]

**Markscheme**

$T(0) = 20 + 70 \times 2.72^{-0.4\times0} = 90$ \(\text{(MI)(AI)(AG)}\)

Note: \(\text{(MI)}\) for taking \(m = 0\), \(\text{(AI)}\) for substituting 0 into the formula. For the A mark to be awarded 90 must be justified by correct method.

[2 marks]

20b. The following table shows values for $m$ and $T(m)$.

<table>
<thead>
<tr>
<th>(m)</th>
<th>1</th>
<th>2</th>
<th>4</th>
<th>6</th>
<th>8</th>
<th>10</th>
</tr>
</thead>
<tbody>
<tr>
<td>$T(m)$</td>
<td>66.9</td>
<td>51.4</td>
<td>34.1</td>
<td>26.3</td>
<td>22.8</td>
<td>s</td>
</tr>
</tbody>
</table>

(i) Write down the value of $s$.
(ii) Draw the graph of $T(m)$ for $0 \leq m \leq 10$. Use a scale of 1 cm to represent 1 minute on the horizontal axis and a scale of 1 cm to represent 10°C on the vertical axis.
(iii) Use your graph to find how long it takes for the temperature to reach 56°C. Show your method clearly.
(iv) Write down the temperature approached by the water after a long time. Justify your answer.
20c. Consider the function \( S(m) = 20m - 40 \) for \( 2 \leq m \leq 6 \). \[ 2 \text{ marks} \]

The function \( S(m) \) represents the temperature of soup in a pot placed on the cooker two minutes after the water has been removed. The soup is then heated.

Draw the graph of \( S(m) \) on the same set of axes used for part (b).
20d. Consider the function \( S(m) = 20m - 40 \) for \( 2 \leq m \leq 6 \). \[1 \text{ mark}\]

The function \( S(m) \) represents the temperature of soup in a pot placed on the cooker two minutes after the water has been removed. The soup is then heated.

Comment on the meaning of the constant 20 in the formula for \( S(m) \) in relation to the temperature of the soup.

**Markscheme**

It indicates by how much the temperature increases per minute. \((A1)\) \[1 \text{ mark}\]

20e. Consider the function \( S(m) = 20m - 40 \) for \( 2 \leq m \leq 6 \). \[4 \text{ marks}\]

The function \( S(m) \) represents the temperature of soup in a pot placed on the cooker two minutes after the water has been removed. The soup is then heated.

(i) Use your graph to solve the equation \( S(m) = T(m) \). Show your method clearly.

(ii) Hence describe by using inequalities the set of values of \( m \) for which \( S(m) > T(m) \).
200 \times 3^6 \text{ or } 16200 \times 9 = 145800 \quad (M1)(A1) \quad (C2) \\
[2 \text{ marks}]

\begin{table}[h!]
\centering
\begin{tabular}{|c|c|c|c|c|}
\hline
\textbf{Hours} & 0 & 4 & 8 & 12 & 16 \\
\hline
\textbf{No. of bacteria} & 200 & 600 & a & 5400 & 16200 \\
\hline
\end{tabular}
\caption{Bacteria growth over time.}
\end{table}

21a. Find the value of \(a\). \quad [1 \text{ mark}]

\textbf{Markscheme}

\[ a = 1800 \quad (A1) \quad (C1) \]

[1 \text{ mark}]

21b. Calculate how many bacteria there will be after one day. \quad [2 \text{ marks}]

\textbf{Markscheme}

\[ 200 \times 3^6 \text{ or } 16200 \times 9 = 145800 \quad (M1)(A1) \quad (C2) \]

[2 \text{ marks}]

21c. Find how long it will take for there to be two million bacteria. \quad [3 \text{ marks}]

\textbf{Markscheme}

\[ 200 \times 3^n = 2 \times 10^6 \text{ (where } n \text{ is each 4 hour interval)} \quad (M1) \]

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

\[ 3^n = 10^4 \]

\[ n = 8.38 \text{ (8.383613097)} \text{ correct answer only} \quad (A1) \]

\[ \text{Time} = 33.5 \text{ hours (accept 34, 35 or 36 if previous A mark awarded)} \quad (A1)(A1) \quad (C3) \]

\textbf{Note}: \((A1)(A1)\) for correctly multiplying their answer by 4. If 34, 35 or 36 seen, or 32 – 36 seen, award \((M1)(A0)(A0)\). 

[3 \text{ marks}]
A deep sea diver notices that the intensity of light, $I$, below the surface of the ocean decreases with depth, $d$, according to the formula

$$I = k(1.05)^{-d},$$

where $I$ is expressed as a percentage, $d$ is the depth in metres below the surface and $k$ is a constant.

The intensity of light at the surface is 100%.

### 22a. Calculate the value of $k$. [2 marks]

**Markscheme**

$$d = 0, k = 100\quad (MI)(A1)(G2)$$

>Note: Award (MI) for $d = 0$ seen.

### 22b. Find the intensity of light at a depth 25 m below the surface. [2 marks]

**Markscheme**

$$I = 100 \times (1.05)^{-25} = 29.5\% \ (29.5302\ldots) \quad (MI)(A1)(ft)(G2)$$

### 22c. To be able to see clearly, a diver needs the intensity of light to be at least 65%. Using your graphic display calculator, find the greatest depth below the surface at which she can see clearly. [2 marks]

**Markscheme**

$$65 = 100 \times (1.05)^{-d} \quad (MI)$$

>Note: Award (MI) for sketch with line drawn at $y = 65$. 

$$d = 8.83 \ (8.82929\ldots) \quad (A1)(ft)(G2)$$

### 22d. The table below gives the intensity of light (correct to the nearest integer) at different depths. [4 marks]

<table>
<thead>
<tr>
<th>Depth ($d$)</th>
<th>0</th>
<th>10</th>
<th>20</th>
<th>50</th>
<th>80</th>
</tr>
</thead>
<tbody>
<tr>
<td>Intensity ($I$)</td>
<td>100</td>
<td>61</td>
<td>38</td>
<td>9</td>
<td>2</td>
</tr>
</tbody>
</table>

Using this information draw the graph of $I$ against $d$ for $0 \leq d \leq 100$. Use a scale of 1 cm to represent 10 metres on the horizontal axis and 1 cm to represent 10% on the vertical axis.
Some sea creatures have adapted so they can see in low intensity light and cannot tolerate too much light. [2 marks]

Indicate clearly on your graph the range of depths sea creatures could inhabit if they can tolerate between 5% and 35% of the light intensity at the surface.

**Markscheme**

(A1) for labels and scales
(A2) for all points correct, (A1) for 3 or 4 points correct
(A1) for smooth curve asymptotic to the x-axis  (A4)