# A-level MATHEMATICS 7357/3

Paper 3

**Mark scheme**

June 2025

Version: 1.0 Final

256A7357/3/MS

Mark schemes are prepared by the Lead Assessment Writer and considered, together with the relevant questions, by a panel of subject teachers. This mark scheme includes any amendments made at the standardisation events which all associates participate in and is the scheme which was used by them in this examination. The standardisation process ensures that the mark scheme covers the students' responses to questions and that every associate understands and applies it in the same correct way. As preparation for standardisation each associate analyses a number of students' scripts. Alternative answers not already covered by the mark scheme are discussed and legislated for. If, after the standardisation process, associates encounter unusual answers which have not been raised they are required to refer these to the Lead Examiner.

It must be stressed that a mark scheme is a working document, in many cases further developed and expanded on the basis of students' reactions to a particular paper. Assumptions about future mark schemes on the basis of one year's document should be avoided; whilst the guiding principles of assessment remain constant, details will change, depending on the content of a particular examination paper.

No student should be disadvantaged on the basis of their gender identity and/or how they refer to the gender identity of others in their exam responses.

A consistent use of 'they/them' as a singular and pronouns beyond 'she/her' or 'he/him' will be credited in exam responses in line with existing mark scheme criteria.

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# Mark scheme instructions to examiners

## General

The mark scheme for each question shows:

- the marks available for each part of the question
- the total marks available for the question
- marking instructions that indicate when marks should be awarded or withheld including the principle on which each mark is awarded. Information is included to help the examiner make his or her judgement and to delineate what is creditworthy from that not worthy of credit
- a typical solution. This response is one we expect to see frequently. However credit must be given on the basis of the marking instructions.

If a student uses a method which is not explicitly covered by the marking instructions the same principles of marking should be applied. Credit should be given to any valid methods. Examiners should seek advice from their senior examiner if in any doubt.

**Key to mark types**

| | |
|---|---|
| M | mark is for method |
| R | mark is for reasoning |
| A | mark is dependent on M marks and is for accuracy |
| B | mark is independent of M marks and is for method and accuracy |
| E | mark is for explanation |
| F | follow through from previous incorrect result |

**Key to mark scheme abbreviations**

| | |
|---|---|
| CAO | correct answer only |
| CSO | correct solution only |
| FT | follow through from previous incorrect result |
| 'their' | indicates that credit can be given from previous incorrect result |
| AWFW | anything which falls within |
| AWRT | anything which rounds to |
| ACF | any correct form |
| AG | answer given |
| SC | special case |
| OE | or equivalent |
| NMS | no method shown |
| ISW | ignore subsequent working |
| PI | possibly implied |
| sf | significant figure(s) |
| dp | decimal place(s) |

## AS/A-level Maths/Further Maths assessment objectives

| AO | | Description |
|---|---|---|
| **AO1** | AO1.1a | Select routine procedures |
| | AO1.1b | Correctly carry out routine procedures |
| | AO1.2 | Accurately recall facts, terminology and definitions |
| **AO2** | AO2.1 | Construct rigorous mathematical arguments (including proofs) |
| | AO2.2a | Make deductions |
| | AO2.2b | Make inferences |
| | AO2.3 | Assess the validity of mathematical arguments |
| | AO2.4 | Explain their reasoning |
| | AO2.5 | Use mathematical language and notation correctly |
| **AO3** | AO3.1a | Translate problems in mathematical contexts into mathematical processes |
| | AO3.1b | Translate problems in non-mathematical contexts into mathematical processes |
| | AO3.2a | Interpret solutions to problems in their original context |
| | AO3.2b | Where appropriate, evaluate the accuracy and limitations of solutions to problems |
| | AO3.3 | Translate situations in context into mathematical models |
| | AO3.4 | Use mathematical models |
| | AO3.5a | Evaluate the outcomes of modelling in context |
| | AO3.5b | Recognise the limitations of models |
| | AO3.5c | Where appropriate, explain how to refine models |

Examiners should consistently apply the following general marking principles:

**No Method Shown**

Where the question specifically requires a particular method to be used, we must usually see evidence of use of this method for any marks to be awarded.

Where the answer can be reasonably obtained without showing working and it is very unlikely that the correct answer can be obtained by using an incorrect method, we must award **full marks**. However, the obvious penalty to students showing no working is that incorrect answers, however close, earn **no marks**.

Where a question asks the student to state or write down a result, no method need be shown for full marks.

Where the permitted calculator has functions which reasonably allow the solution of the question directly, the correct answer without working earns **full marks**, unless it is given to less than the degree of accuracy accepted in the mark scheme, when it gains **no marks**.

**Otherwise we require evidence of a correct method for any marks to be awarded.**

**Diagrams**

Diagrams that have working on them should be treated like normal responses. If a diagram has been written on but the correct response is within the answer space, the work within the answer space should be marked. Working on diagrams that contradicts work within the answer space is not to be considered as choice but as working, and is not, therefore, penalised.

**Work erased or crossed out**

Erased or crossed out work that is still legible and has not been replaced should be marked. Erased or crossed out work that has been replaced can be ignored.

**Choice**

When a choice of answers and/or methods is given and the student has not clearly indicated which answer they want to be marked, mark positively, awarding marks for all of the student's best attempts. Withhold marks for final accuracy and conclusions if there are conflicting complete answers or when an incorrect solution (or part thereof) is referred to in the final answer.

## Section A

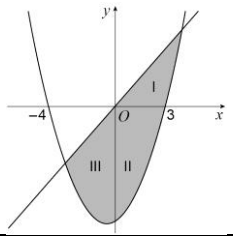
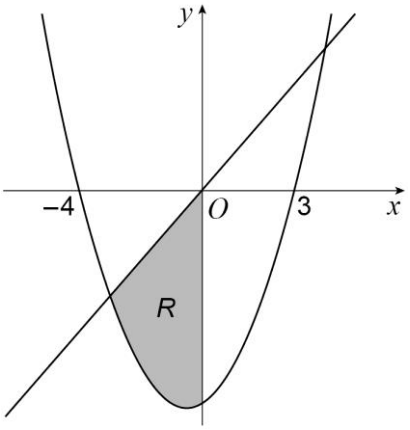
| Q | Marking instructions | AO | Marks | Typical solution |
|---|---|---|---|---|
| **1** | Circles the second answer | 2.3 | R1 | $\frac{1}{\pi} \times \pi = 1$ |
| | **Question 1 Total** | | **1** | |

| Q | Marking instructions | AO | Marks | Typical solution |
|---|---|---|---|---|
| **2** | Circles the third answer | 1.2 | B1 | $\frac{\pi}{2}$ |
| | **Question 2 Total** | | **1** | |

| Q | Marking instructions | AO | Marks | Typical solution |
|---|---|---|---|---|
| **3** | Ticks the fourth box | 2.2a | R1 | Increasing and convex |
| | **Question 3 Total** | | **1** | |

| Q | Marking instructions | AO | Marks | Typical solution |
|---|---|---|---|---|
| **4(a)** | Obtains 2 | 1.2 | B1 | 2 |
| | **Subtotal** | | **1** | |

| Q | Marking instructions | AO | Marks | Typical solution |
|---|---|---|---|---|
| **4(b)** | Uses at least one log rule correctly<br><br>or<br><br>substitutes a value of $a>0$ correctly into the full expression leading to a positive value | 1.1a | M1 | $\log_a \sqrt{a} - \log_a \frac{1}{a^2} = \frac{1}{2} - -2$<br>$= \frac{5}{2}$ |
| | Obtains 2.5<br>Do not **ISW** | 1.1b | A1 | |
| | **Subtotal** | | **2** | |
| | **Question 4 Total** | | **3** | |

| Q | Marking instructions | AO | Marks | Typical solution |
|---|---|---|---|---|
| **5** | Shades one of regions I, II or III only<br>or<br>shades two of regions I, II or III only<br>or<br>shades regions I, II and III only<br><br> | 1.1a | M1 | <br> |
| | Shades correct region III only | 1.1b | A1 | |
| | **Question 5 Total** | | **2** | |

| Q | Marking instructions | AO | Marks | Typical solution |
|---|---|---|---|---|
| **6(a)** | Uses<br>${}^5C_1 \times 2^4 \times (-3x)$ or $2^5 \times 5 \times \left(-\frac{3}{2}x\right)$<br>or<br>${}^5C_2 \times 2^3 \times (-3x)^2$ or $2^5 \times 10 \times \left(-\frac{3}{2}x\right)^2$<br>with or without $x$<br>**PI** by correct answer or $-240x$ or $720x^2$ | 1.1a | M1 | $p = {}^5C_1 \times 2^4 \times (-3)$<br>$= -240$<br><br>$q = {}^5C_2 \times 2^3 \times (-3)^2$<br>$= 720$ |
| | Obtains $p = -240$ and $q = 720$<br>Allow if seen in $\ldots -240x + 720x^2 \ldots$<br>Condone $p = -240x$ and $q = 720x^2$ | 1.1b | A1 | |
| | **Subtotal** | | **2** | |

| Q | Marking instructions | AO | Marks | Typical solution |
|---|---|---|---|---|
| **6(b)** | Substitutes $x = 0.02$ into $32 + px + qx^2 - 1080x^3$ with their $p$ and $q$<br>**PI** by correct answer<br>Ignore any additional terms | 2.2a | M1 | $32 - 240 \times 0.02 + 720 \times 0.02^2 - 1080 \times 0.02^3$<br>$= 27.47936$ |
| | Obtains 27.47936<br>**CAO ISW** | 1.1b | A1 | |
| | **Subtotal** | | **2** | |

| | | | | |
|---|---|---|---|---|
| | **Question 6 Total** | | **4** | |

| Q | Marking instructions | AO | Marks | Typical solution |
|---|---|---|---|---|
| 7 | Obtains $a+5$, $2a+5$ and $3a+5$<br><br>**PI** by correct answer or $6a+15$<br>**ACF** | 2.5 | B1 | $a+5+2a+5+3a+5=57$<br>$6a+15=57$<br>$6a=42$<br>$a=7$ |
| | Forms an equation using sum of three terms with at least two of $a+5$, $2a+5$ or $3a+5$<br><br>or<br>uses $S_n=\frac{n}{2}\left(2a+(n-1)d\right)$<br>with at least two of $n=3$, first term $a+5$ and $d=a$<br><br>or<br>uses $S_n=\frac{n}{2}(a+L)$<br>with at least two of $n=3$, first term $a+5$ and $L=3a+5$<br><br>or<br><br>uses $6a+15$ in an equation<br><br>Must use 57 in the equation<br><br>**PI** by correct answer | 3.1a | M1 | |
| | Obtains 7 | 1.1b | A1 | |
| | **Question 7 Total** | | **3** | |

| Q | Marking instructions | AO | Marks | Typical solution |
|---|---|---|---|---|
| **8(a)** | Uses a suitable method **and** finds a value for $A$ or $B$.<br><br>eg<br>rearranges and substitutes values<br><br>or<br><br>compares coefficients<br><br>or<br><br>uses cover-up method<br><br>or<br><br>uses inspection<br><br>**PI** by $A = 1$ or $B = -1$ | 1.1a | M1 | $x = A(2x+1) + B(x+1)$<br><br>$x = -1 \Rightarrow -1 = -A$<br>$A = 1$<br><br>$x = -\frac{1}{2} \Rightarrow -\frac{1}{2} = \frac{1}{2}B$<br>$B = -1$ |
| | Obtains $A = 1$<br>Allow if seen in $\frac{1}{x+1}$ | 1.1b | A1 | |
| | Obtains $B = -1$<br>Allow if seen in $\frac{-1}{2x+1}$ | 1.1b | A1 | |
| | **Subtotal** | | **3** | |

| Q | Marking instructions | AO | Marks | Typical solution |
|---|---|---|---|---|
| **8(b)** | Uses partial fractions with their $A$ and $B$ to obtain<br>$A\ln(x+1)$ or $\frac{B}{2}\ln(2x+1)$<br>**OE**<br>Condone $B$ rather than $\frac{B}{2}$<br>Condone missing bracket or sign error of $A$ or $B$ | 1.1a | M1 | $\int_0^4 \frac{x}{2x^2+3x+1}\mathrm{d}x = \int_0^4 \frac{1}{x+1} - \frac{1}{2x+1}\mathrm{d}x$<br>$= \left[\ln(x+1) - \frac{1}{2}\ln(2x+1)\right]_0^4$<br>$= \ln 5 - \frac{1}{2}\ln 9 - \left(\ln 1 - \frac{1}{2}\ln 1\right)$<br>$= \ln 5 - \ln 3$<br>$= \ln\frac{5}{3}$ |
| | Obtains $\ln(x+1) - \frac{1}{2}\ln(2x+1)$<br>**OE** | 1.1b | A1 | |
| | Substitutes both limits correctly into their integrated expression of two $\ln$ terms (the subtraction does not need to be seen)<br>Condone 0 for $\left(\ln 1 - \frac{1}{2}\ln 1\right)$ | 1.1a | M1 | |
| | Completes reasoned argument to obtain $\ln\frac{5}{3}$<br>Allow unsimplified fraction or correct recurring decimal for $\frac{5}{3}$<br>**CSO** | 2.1 | R1 | |
| | **Subtotal** | | **4** | |

| | | | | |
|---|---|---|---|---|
| | **Question 8 Total** | | **7** | |

| Q | Marking instructions | AO | Marks | Typical solution |
|---|---|---|---|---|
| **9(a)** | States **one** of the following transformations<br><br>A Stretch in the $y$-direction, scale factor of 3<br>or<br>B translation $\begin{bmatrix}4\\0\end{bmatrix}$<br>or<br><br>C stretch in the $x$-direction, scale factor of 3<br>or<br>D translation $\begin{bmatrix}\frac{4}{3}\\0\end{bmatrix}$<br><br>Only accept vectors for translations<br><br>Allow 'parallel' or 'axis' for direction of stretch | 3.1a | M1 | Stretch in the $y$-direction by scale factor 3 and<br><br>followed by translation $\begin{bmatrix}4\\0\end{bmatrix}$ |
| | Describes the sequence of **two** transformations in the correct order<br><br>A followed by B<br>or<br>B followed by A<br>or<br>C followed by B<br>or<br>D followed by C<br><br>Only accept vectors for translations<br><br>Allow 'parallel' or 'axis' for direction of stretch | 1.1b | A1 | |
| | **Subtotal** | | **2** | |

| Q | Marking instructions | AO | Marks | Typical solution |
|---|---|---|---|---|
| **9(b)** | States $x = 4$ | 1.1b | B1 | $x = 4$ |
| | **Subtotal** | | **1** | |

| Q | Marking instructions | AO | Marks | Typical solution |
|---|---|---|---|---|
| **9(c)** | Explains that there could be more than one solution between the two points (3 and 5) | 2.2b | E1 | There could be more than one solution between the two points.<br><br>The two points are either side of the asymptote. |
| | Explains that the two points (3 and 5) are either side of the asymptote<br>or<br>explains that it is discontinuous between the two points (3 and 5) | 2.3 | E1 | |
| | **Subtotal** | | **2** | |

| | | | | |
|---|---|---|---|---|
| | **Question 9 Total** | | **5** | |

| Q | Marking instructions | AO | Marks | Typical solution |
|---|---|---|---|---|
| **10(a)** | Obtains $R=\sqrt{29}$<br>**AWFW** [5.38, 5.4] | 1.1b | B1 | $R=\sqrt{29}$<br>$\tan\alpha=\frac{5}{2}$<br>$\alpha=68.2$<br>Hence $\sqrt{29}\sin\left(x+68.2\right)$ |
| | Uses compound angle identity to obtain $R\sin\alpha=5$ or $R\cos\alpha=2$<br>or<br>obtains $\tan\alpha=\frac{5}{2}$ or<br>$\alpha$ = **AWFW** [68, 68.2]<br>Allow angle in radians | 1.1a | M1 | |
| | Obtains $\sqrt{29}\sin\left(x+68.2\right)$<br>For $\sqrt{29}$, **AWFW** [5.38, 5.4]<br>and for 68.2, **AWFW** [68, 68.2] | 2.1 | R1 | |
| | **Subtotal** | | **3** | |

| Q | Marking instructions | AO | Marks | Typical solution |
|---|---|---|---|---|
| **10(b)(i)** | Deduces 90 – their 68.2<br>Ignore rounding after value of 90 – their 68.2 seen | 2.2a | B1F | $90-68.2=21.8$ |
| | **Subtotal** | | **1** | |

| Q | Marking instructions | AO | Marks | Typical solution |
|---|---|---|---|---|
| **10(b)(ii)** | Deduces 14.2 + their $\sqrt{29}$<br>Condone missing or wrong units<br>Accept answer with more than 1 decimal place | 2.2a | B1F | $14.2+\sqrt{29}=19.6^{\circ}C$ |
| | **Subtotal** | | **1** | |

| Q | Marking instructions | AO | Marks | Typical solution |
|---|---|---|---|---|
| **10(b)(iii)** | Equates a complete model for the temperature to 15<br>eg<br>$14.2-\textit{their}'\sqrt{29}\sin(d+68.2)'=15$<br>or<br>$14.2-(2\sin d^\circ+5\cos d^\circ)=15$<br><br>Allow use of inequality<br>Condone use of another letter for $d$ throughout<br><br>**PI** by correct answer or angles | 3.4 | M1 | $14.2-\sqrt{29}\sin(d+68.2)=15$<br><br>$\sin(d+68.2)=-\dfrac{0.8}{\sqrt{29}}$<br><br>$d+68.2=-8.54,188.54,351.46$<br><br>$d=120.34,283.26$<br><br>$\dfrac{283.26-120.34}{7}=23$ weeks |
| | Rearranges their equation correctly to obtain<br>$\sin(d+\textit{their}68.2)=...$<br><br>Allow use of inequality<br><br>**PI** by correct answer or angles | 1.1a | M1 | |
| | Obtains **AWFW** [188.2, 189]<br>**and AWFW** [351, 351.5]<br>or<br>obtains **AWFW** [120, 120.8] **and AWFW** [282.8, 283.3]<br>Ignore additional values<br>**PI** by correct answer | 1.1b | A1 | |
| | Subtracts their two **positive** values of $d$ or their two **positive** values of $d$ + their 68.2<br>**and** divides by 7<br>**PI** by correct answer | 3.1b | M1 | |
| | Obtains **AWFW** [23.1, 23.4]<br>or 23<br>**ISW** | 1.1b | A1 | |
| | **Subtotal** | | **5** | |

| | | | | |
|---|---|---|---|---|
| | **Question 10 Total** | | **10** | |

| Q | Marking instructions | AO | Marks | Typical solution |
|---|---|---|---|---|
| **11(a)** | Forms a correct expression for the surface area of the block of ice<br>Can be unsimplified terms<br><br>or<br>states that the surface area is proportional to $x^2$ | 3.1b | B1 | $S.A. = 2\left(8x^2 + 2x^2 + 4x^2\right) = 28x^2$<br><br>$\frac{\mathrm{d}V}{\mathrm{d}t} = -28kx^2$<br><br>$x = 4, \frac{\mathrm{d}V}{\mathrm{d}t} = -7$<br>$\Rightarrow -7 = -28k \times 16$<br>$\Rightarrow k = \frac{7}{28 \times 16} = \frac{1}{64}$<br><br>$\Rightarrow \frac{\mathrm{d}V}{\mathrm{d}t} = -\frac{28}{64}x^2 = -0.4375x^2$ |
| | States<br>$\frac{\mathrm{d}V}{\mathrm{d}t} = m(SA)$ or $\frac{\mathrm{d}V}{\mathrm{d}t} = -m(SA)$<br>or<br>$\frac{\mathrm{d}V}{\mathrm{d}t} = m(their 28x^2)$ or $\frac{\mathrm{d}V}{\mathrm{d}t} = -m(their 28x^2)$<br>or<br>$\frac{\mathrm{d}V}{\mathrm{d}t} = mx^2$ or $\frac{\mathrm{d}V}{\mathrm{d}t} = -mx^2$<br><br>Accept any letter for $m$ | 3.3 | M1 | |
| | Substitutes $\frac{\mathrm{d}V}{\mathrm{d}t} = -7$ and<br>SA = their '28' $\times 4^2$ into their differential equation<br>$\frac{\mathrm{d}V}{\mathrm{d}t} = m(SA)$ or $\frac{\mathrm{d}V}{\mathrm{d}t} = -m(SA)$<br>or<br>substitutes $\frac{\mathrm{d}V}{\mathrm{d}t} = -7$ and $x = 4$<br>into their differential equation of the form<br>$\frac{\mathrm{d}V}{\mathrm{d}t} = m(28x^2)$ or $\frac{\mathrm{d}V}{\mathrm{d}t} = -m(28x^2)$<br>or<br>$\frac{\mathrm{d}V}{\mathrm{d}t} = mx^2$ or $\frac{\mathrm{d}V}{\mathrm{d}t} = -mx^2$<br><br>Accept any letter for $m$ | 3.3 | M1 | |
| | Completes reasoned argument to show the given result with no incorrect expression for surface area and no incorrect substitution seen.<br>**AG**<br>To be awarded R1, marks M1M1 must be scored as the minimum<br>Ignore units | 2.1 | R1 | |
| | **Subtotal** | | **4** | |

| Q | Marking instructions | AO | Marks | Typical solution |
|---|---|---|---|---|
| **11(b)** | Forms a correct expression for the volume of the block of ice or states $8x^3$ | 3.1b | M1 | $V = 4x \times 2x \times x$<br>$= 8x^3$<br>$\frac{dV}{dx} = 24x^2$ |
| | Obtains $24x^2$ | 1.1b | A1 | |
| | **Subtotal** | | **2** | |

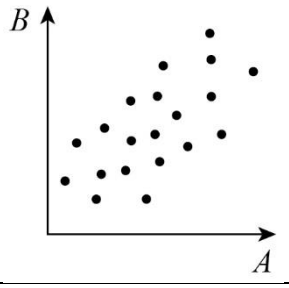
| Q | Marking instructions | AO | Marks | Typical solution |
|---|---|---|---|---|
| **11(c)(i)** | Uses the chain rule to connect $\frac{dV}{dt} = -0.4375x^2$, $their \frac{dV}{dx} = 24x^2$ from part **(b)** and $\frac{dx}{dt}$ | 3.1a | M1 | $\frac{dx}{dt} = \frac{dx}{dV} \times \frac{dV}{dt}$<br>$= \frac{1}{24x^2} \times -0.4375x^2$<br>$= -\frac{7}{384}$ |
| | Obtains $-\frac{7}{384}$<br>**AWFW** $-[0.018, 0.0183]$ | 1.1b | A1 | |
| | **Subtotal** | | **2** | |

| Q | Marking instructions | AO | Marks | Typical solution |
|---|---|---|---|---|
| **11(c)(ii)** | Identifies the height/width/length/edge/side/ dimension/measurement is **decreasing** at a **constant** rate | 3.5a | E1 | The height is decreasing at a constant rate of 0.018 cm per minute. |
| | States it occurs at the rate of $\frac{7}{384}$ or [0.018, 0.0183] or [0.036, 0.0366] or [0.072, 0.0732] **cm per minute**<br>**FT** their constant $\frac{dx}{dt}$ from part **c(i)** | 3.5a | E1F | |
| | **Subtotal** | | **2** | |

| | | | | |
|---|---|---|---|---|
| | **Question 11 Total** | | **10** | |

| Q | Marking instructions | AO | Marks | Typical solution |
|---|---|---|---|---|
| **12** | States $a$ **and** $b$ are rational | 2.1 | B1 | Let $a$ and $b$ be rational<br><br>$a=\frac{m}{n}$ and $b=\frac{p}{q}$<br><br>$c=ab=\frac{m}{n}\times\frac{p}{q}=\frac{mp}{nq}$<br><br>Hence $c$ is rational which contradicts that $c$ is irrational.<br><br>Therefore, if $c$ is irrational at least one of $a$ or $b$ is irrational. |
| | Forms the product of two rational numbers<br>$\frac{m}{n}\times\frac{p}{q}$ | 3.1a | M1 | |
| | Concludes the argument fully correctly by stating that<br><br>$c$ is rational<br>**and**<br>contradicts $c$ is irrational<br>**and**<br>if $c$ is irrational at least one of $a$ or $b$ is irrational.<br><br>To be awarded R1, marks B1M1 must be scored with their $\frac{mp}{nq}$ seen | 2.1 | R1 | |
| | **Question 12 Total** | | **3** | |

**Section B**

| Q | Marking instructions | AO | Marks | Typical solution |
|---|---|---|---|---|
| **13** | Ticks the bottom right box | 2.2b | B1 |   |
| | **Question 13 Total** | | **1** | |

| Q | Marking instructions | AO | Marks | Typical solution |
|---|---|---|---|---|
| **14** | Ticks the second box | 1.1b | B1 | $a = 6$ and $b = 12$ |
| | **Question 14 Total** | | **1** | |

| Q | Marking instructions | AO | Marks | Typical solution |
|---|---|---|---|---|
| **15(a)(i)** | Obtains **AWFW** [0.00377,0.0038] | 1.1b | B1 | 0.00378 |
| | **Subtotal** | | **1** | |

| Q | Marking instructions | AO | Marks | Typical solution |
|---|---|---|---|---|
| **15(a)(ii)** | Obtains **AWFW** [0.616, 0.62] | 1.1b | B1 | 0.617 |
| | **Subtotal** | | **1** | |

| Q | Marking instructions | AO | Marks | Typical solution |
|---|---|---|---|---|
| **15(a)(iii)** | Finds<br>$P(X \leq 8) =$ [0.953, 0.954] or<br>$P(X \leq 9) =$ [0.982, 0.983] or<br>$P(X > 9) =$ [0.017, 0.0174] or<br>$P(X \geq 9) =$ [0.0467, 0.047]<br><br>Condone incorrect or no labels | 1.1a | M1 | $P(X \geq 9) = 1 - 0.9532$<br>$= 0.0468$ |
| | Obtains<br>**AWFW** [0.0467, 0.047] | 1.1b | A1 | |
| | **Subtotal** | | **2** | |

| Q | Marking instructions | AO | Marks | Typical solution |
|---|---|---|---|---|
| **15(b)** | States one of the following assumptions in context<br>• probability/proportion of a diner being vegan is constant or always 20% or fixed or the same or does not change<br>• event of a diner is vegan is independent from one diner to the next<br>• only two types of diners vegan or non-vegan<br><br>Do not ignore incorrect statements about any of the above<br><br>Must use '**vegan**' and '**diner**'<br><br>Allow equivalent statements for non-vegan diners for the reference to probability or independence<br><br>Do not allow statements which imply probabilities are independent<br><br>Ignore statement which implies there is a fixed number of diners | 3.5b | E1 | The event of a diner is vegan is independent from one diner to the next. |
| | **Subtotal** | | **1** | |

| | | | | |
|---|---|---|---|---|
| | **Question 15 Total** | | **5** | |

| Q | Marking instructions | AO | Marks | Typical solution |
|---|---|---|---|---|
| **16(a)(i)** | Adds the correct area of each rectangle using scale factor<br>eg. $17x$<br>or<br>states that there are 34 big (cm) squares<br>or<br>states that there are 850 small (2mm) squares<br><br>**PI** by their ratio or 1cm = 20 seen on the vertical scale or by correct answer | 3.1a | M1 | Total area of rectangles<br>$= 2 \times 1 + 1 \times 2 + 0.5 \times 3 + 1.5 \times 7 + 0.5 \times 2$<br>$= 17$<br><br>$340 \div 17 = 20$<br><br>Total number of individuals who travel between 3 km and 5 km<br><br>$= 20 \times (0.5 \times 2 + 0.5 \times 3 + 1 \times 7)$<br>$= 20 \times 9.5$<br>$= 190$ |
| | Calculates their ratio<br>**PI** by eg<br>340 ÷ their 17 or 20<br>or 340 ÷ their 34 or 10<br>or 340 ÷ their 850 or 0.4<br>or by correct answer<br><br>May be been seen in calculation<br><br>**PI** by their ratio or 1cm = 20 seen on the vertical scale without incorrect working | 1.1a | M1 | |
| | States one of<br>340 ÷ their 17 × 9.5<br>340 ÷ their 34 × 19<br>340 ÷ their 850 × 475<br><br>May be embedded in calculation<br><br>**PI** by correct answer | 3.1a | M1 | |
| | Obtains 190 | 1.1b | A1 | |
| | **Subtotal** | | **4** | |

| Q | Marking instructions | AO | Marks | Typical solution |
|---|---|---|---|---|
| **16(a)(ii)** | States one of the following reasons<br>• The actual **distance** for each person is unknown<br>• The **distances** are grouped<br>• **Distances** are not evenly distributed | 3.5b | E1 | The actual distance for each person is unknown |
| | **Subtotal** | | **1** | |

| Q | Marking instructions | AO | Marks | Typical solution |
|---|---|---|---|---|
| **16(b)** | States 'negative' | 2.2b | B1 | Negative |
| | **Subtotal** | | **1** | |

| Q | Marking instructions | AO | Marks | Typical solution |
|---|---|---|---|---|
| **16(c)** | States one of the following reasons<br>• widths/intervals of class/group are different<br>• gives an accurate/better representation of the data | 2.4 | E1 | Class widths are different. |
| | **Subtotal** | | **1** | |

| | | | | |
|---|---|---|---|---|
| | **Question 16 Total** | | **7** | |

| Q | Marking instructions | AO | Marks | Typical solution |
|---|---|---|---|---|
| **17(a)** | Obtains 3 | 1.1b | B1 | Mean = 3 |
| | **Subtotal** | | **1** | |

| Q | Marking instructions | AO | Marks | Typical solution |
|---|---|---|---|---|
| **17(b)** | Obtains 1.5<br>Accept **AWRT** 1.7 | 1.1b | B1 | Variance = 1.5 |
| | **Subtotal** | | **1** | |

| Q | Marking instructions | AO | Marks | Typical solution |
|---|---|---|---|---|
| 17(c) | Calculates the mean or variance of the given model B(30, 0.1)<br>or<br>forms a correct equation in one variable to find $n$ or $p$ for binomial model using their mean from part **(a)** and their variance from part **(b)** | 3.1a | M1 | Mean $= 30 \times 0.1$<br>$= 3$<br><br>Variance $= 30 \times 0.1 \times 0.9$<br>$= 2.7$<br><br>The mean is the same but the variance is different, so this is not a suitable model. |
| | Obtains the correct mean 3 **and** variance 2.7<br>or<br>obtains the correct $n=6$ **and** $p=0.5$ for binomial model<br><br>Accept $n=7$ **and** $p=0.43$ for binomial model if using variance 1.7 | 1.1b | A1 | |
| | Infers that it is not suitable because of different variance<br>or<br>infers teacher's belief not supported because of different variance<br>or<br>infers that it is not suitable because of different $n$ and $p$ from $n = 30$ and $p = 0.1$<br><br>Must make a single overarching conclusion<br><br>Must have obtained correct mean from part **(a)** and correct variance from part **(b)**<br><br>To be awarded R1, marks M1A1 must be scored | 2.2b | R1 | |
| | **Subtotal** | | **3** | |

| Q | Marking instructions | AO | Marks | Typical solution |
|---|---|---|---|---|
| **17(d)(i)** | Recalls 'opportunity' or 'convenience' or 'opportunistic' sampling method | 1.2 | B1 | Opportunity sampling. |
| | **Subtotal** | | **1** | |

| Q | Marking instructions | AO | Marks | Typical solution |
|---|---|---|---|---|
| **17(d)(ii)** | States one of the following advantage of sampling method<br>• easy/simple<br>• quick/fast<br>• cheap/not expensive<br>**OE**<br><br>Do not accept 'convenient' | 3.5a | E1 | Easy to do. |
| | **Subtotal** | | **1** | |

| | | | | |
|---|---|---|---|---|
| | **Question 17 Total** | | **7** | |

| Q | Marking instructions | AO | Marks | Typical solution |
|---|---|---|---|---|
| **18(a)** | States the $z$ value $(\pm)$ 0.67(45) for the inverse normal distribution<br><br>**PI** by [4.89, 4.9] or [6.5, 6.51] seen | 3.4 | M1 | $a = 4.89$<br><br>$b = 6.51$<br><br>IQR $= 6.51 - 4.89$<br><br>$= 1.62$ mmol/l |
| | Obtains correct lower quartile **AWFW** [4.89, 4.9]<br>or<br>obtains correct upper quartile **AWFW** [6.5, 6.51]<br><br>**CAO** | 1.1b | A1 | |
| | Uses a complete method to find the IQR<br>e.g. $b - a$ or $2\times(5.7 - a)$ or $2\times(b - 5.7)$<br>or<br>states or calculates their $b$ – their $a$ | 3.4 | M1 | |
| | Obtains **AWFW** [1.6, 1.62]<br>Condone missing units | 1.1b | A1 | |
| | **Subtotal** | | **4** | |

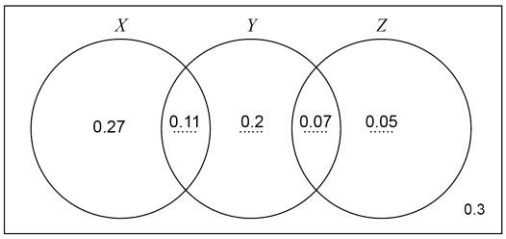
| Q | Marking instructions | AO | Marks | Typical solution |
|---|---|---|---|---|
| **18(b)** | States<br>$H_0 : \mu = 5.7$<br>$H_1 : \mu < 5.7$ | 2.5 | B1 | $H_0 : \mu = 5.7$<br>$H_1 : \mu < 5.7$<br><br>$\overline{X} \sim N(5.7, \frac{1.2^2}{160})$<br><br>$P(\overline{X} < 5.6) = 0.146$<br><br>$0.146 > 0.05$<br><br>Do not reject $H_0$<br><br>There is insufficient evidence to suggest that the mean cholesterol level has reduced after taking the dietary supplement. |
| | States or uses correct model<br><br>**PI** by normal with mean 5.7 **and** variance $\frac{1.2^2}{160}$ or 0.009<br>or standard deviation $\frac{1.2}{\sqrt{160}}$<br>or 0.095 or better **OE**<br><br>or by correct probability<br>**AWFW** [0.145, 0.147]<br><br>or test statistic $(\pm)\frac{5.6-5.7}{1.2\div\sqrt{160}}$<br><br>or test statistic value<br>**AWFW** (±) [1.05, 1.1]<br><br>or critical value<br>**AWFW** [5.54, 5.55] | 1.1a | M1 | |
| | Obtains **AWFW** [0.145, 0.147]<br><br>or the correct test statistic value<br>**AWFW** – [1.05, 1.1]<br><br>or the correct critical value<br>**AWFW** [5.54, 5.55]<br>May be seen in expression for critical/acceptance regions | 1.1b | A1 | |

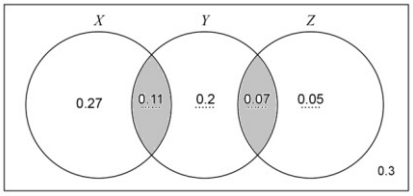
**Mark scheme continues on the next page**

| Q | Marking instructions | AO | Marks | Typical solution |
|---|---|---|---|---|
| **18(b) cont.** | Correctly compares their value of $P(< \text{ or } \leq 5.6)$ with 0.05<br><br>or correctly compares their negative test statistic with **AWFW** – [1.64, 1.65]<br><br>or correctly compares 5.6 with their acceptance region or critical region or critical value<br><br>May be seen on a diagram | 3.5a | M1 | |
| | Infers $H_0$ not rejected or $H_0$ accepted<br>**FT** their comparison<br>Condone reject $H_1$ | 2.2b | A1F | |
| | Concludes, from a fully correct comparison, in context by stating that there is insufficient evidence to suggest the **mean cholesterol** level has **reduced** after taking the dietary supplement.<br><br>Conclusion must not be definite, eg use of 'suggest', 'support' etc<br><br>To be awarded R1, marks M1A1M1A1 must be scored as the minimum | 3.2a | R1 | |
| | **Subtotal** | | **6** | |

| | | | | |
|---|---|---|---|---|
| | **Question 18 Total** | | **10** | |

| Q | Marking instructions | AO | Marks | Typical solution |
|---|---|---|---|---|
| **19(a)** | Obtains 0.12 | 1.1a | B1 | 0.12 |
| | **Subtotal** | | **1** | |

| Q | Marking instructions | AO | Marks | Typical solution |
|---|---|---|---|---|
| **19(b)** | Obtains at least **one** of 0.11 or 0.2 or 0.07 or 0.05 in the correct place | 1.1a | M1 |  |
| | Obtains at least **two** of 0.11 or 0.2 or 0.07 or 0.05 in the correct place | 1.1a | M1 | |
| | Completes the Venn diagram correctly | 1.1b | A1 | |
| | **Subtotal** | | **3** | |

| Q | Marking instructions | AO | Marks | Typical solution |
|---|---|---|---|---|
| **19(c)** | States their 0.11 + their 0.07<br><br>**PI** by correct answer<br> | 1.1a | M1 | 0.11 + 0.07 = 0.18 |
| | Obtains 0.18<br>**FT** their values provided the final positive answer is $<0.38$ | 1.1b | A1F | |
| | **Subtotal** | | **2** | |

| Q | Marking instructions | AO | Marks | Typical solution |
|---|---|---|---|---|
| **19(d)** | States $P(Y' \mid Z') = \dfrac{P(Y' \cap Z')}{P(Z')}$<br>**OE**<br>Condone missing $P(Y' \mid Z')$<br><br>or<br>calculates $P(Y' \cap Z')$<br>**PI** by 0.57 seen on numerator<br>or<br>calculates 1 – their $P(Z)$ from part **19(a)**<br>**PI** by 0.88 seen on denominator<br><br>**PI** by correct answer | 1.1a | M1 | $P(Y' \mid Z') = \dfrac{P(Y' \cap Z')}{P(Z')}$<br>$= \dfrac{0.3 + 0.27}{1 - 0.12}$<br>$= \dfrac{0.57}{0.88}$<br>$= \dfrac{57}{88}$ |
| | Obtains $\dfrac{57}{88}$<br>or **AWFW** [0.647, 0.65] | 1.1b | A1 | |
| | **Subtotal** | | **2** | |

| Q | Marking instructions | AO | Marks | Typical solution |
|---|---|---|---|---|
| **19(e)** | States their $P(Z)$ from part **19(a)** × 0.38<br><br>or<br>compares their $P(Y \mid Z)$ with 0.38<br><br>or<br>compares their $P(Z \mid Y)$ with their $P(Z)$ from part **19(a)**<br><br>or any other valid comparison with one correct probability to at least 2 sf | 1.1a | M1 | $P(Y) \times P(Z) = 0.38 \times 0.12$<br>$= 0.0456$<br><br>$P(Y \cap Z) = 0.07$<br><br>$0.0456 \neq 0.07$<br><br>$P(Y \cap Z) \neq P(Y) \times P(Z)$<br><br>Hence events $Y$ and $Z$ are not independent. |
| | Completes a reasoned argument with correct values and concludes that $Y$ and $Z$ are **not independent** | 2.1 | R1 | |
| | **Subtotal** | | **2** | |

| | | | | |
|---|---|---|---|---|
| | **Question 19 Total** | | **10** | |

| Q | Marking instructions | AO | Marks | Typical solution |
|---|---|---|---|---|
| **20(a)** | Obtains **AWFW** [0.387, 0.39] | 1.1b | B1 | 0.3875 |
| | **Subtotal** | | **1** | |

| Q | Marking instructions | AO | Marks | Typical solution |
|---|---|---|---|---|
| **20(b)** | Obtains **AWFW** [0.84, 0.843] | 1.1b | B1 | 0.8427 |
| | **Subtotal** | | **1** | |

| Q | Marking instructions | AO | Marks | Typical solution |
|---|---|---|---|---|
| **20(c)(i)** | Obtains **AWFW** [0.003, 0.0034] | 1.1b | B1 | 0.0033 |
| | **Subtotal** | | **1** | |

| Q | Marking instructions | AO | Marks | Typical solution |
|---|---|---|---|---|
| **20(c)(ii)** | Deduces that P($F = 0.6$) = 0 | 2.2a | E1 | P($F = 0.6$) = 0 since $F$ is continuous. |
| | Explains the **continuous** nature of the normal distribution | 2.4 | E1 | |
| | **Subtotal** | | **2** | |

| Q | Marking instructions | AO | Marks | Typical solution |
|---|---|---|---|---|
| **20(d)** | Concludes correctly in context for the means<br><br>Comparison must include the word such as 'on average' or 'typically' or 'in general' etc<br><br>Must use '**oxides**' or '**emissions**' and '**2000**' or '**2010**' at least once throughout<br><br>Ignore values | 2.2b | E1 | The oxides of nitrogen emissions by cars in 2000 are greater on average and less varied than those in 2010. |
| | Concludes correctly in context for the standard deviations<br><br>Comparison must include the word such as 'varies', 'spread' 'disperse' 'variation' or 'consistent' etc<br><br>Do not allow comparison that only includes 'range' or 'variety' | 2.2b | E1 | |
| | **Subtotal** | | **2** | |

| Q | Marking instructions | AO | Marks | Typical solution |
|---|---|---|---|---|
| **20(e)** | States that there are some blanks in the LDS<br>or<br>states that there are some missing data in the LDS<br>or<br>states that the emissions are not known for every car in LDS | 2.4 | E1 | There are some blanks on the oxides of nitrogen emissions in the LDS. |
| | **Subtotal** | | **1** | |

| Q | Marking instructions | AO | Marks | Typical solution |
|---|---|---|---|---|
| **20(f)** | States that there are no Nissan cars in the LDS<br>or<br>states that the LDS only has BMW, Ford, Toyota, Vauxhall and Volkswagen cars | 2.4 | E1 | There are no Nissan cars in the LDS. |
| | **Subtotal** | | **1** | |

| | | | | |
|---|---|---|---|---|
| | **Question 20 Total** | | **9** | |

| | | | | |
|---|---|---|---|---|
| | **Question Paper Total** | | **100** | |