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| **Question** | **Scheme** | **Marks** | **AOs** |
| **1(i)** |  | B1 | 3.1a |
|  | M1 | 1.1b |
|  | A1ft | 1.1b |
|  | **(3)** |  |
| **(ii)** |  | M1 | 1.1b |
|  | A1 | 1.1b |
|  | A1 | 1.1b |
|  | **(3)** |  |
| **Alternative** |  |  |
|  | M1 | 1.1b |
|  | A1 | 1.1b |
|  | A1 | 1.1b |
|  | **(3)** |  |
| **(iii)** |  | M1 | 3.1a |
|  | A1ft | 1.1b |
|  | **(2)** |  |
| **(8 marks)** |
| **Notes** |
| (i) B1: Identifies the correct values for all 3 expressions (can score anywhere)M1: Uses a correct identityA1ft: Correct value (follow through their )(ii) M1: Attempts to expandA1: Correct expansionA1: Correct value**Alternative:**M1: Substitutes (*x* + 2) for *x* in the given cubicA1: Calculates the correct constant termA1: Completes correctly by changing sign and dividing by 2(iii) M1: Establishes the correct identityA1ft: Correct value (follow through their ) |
| **Question** | **Scheme** | **Marks** | **AOs** |
| **2(a)(i)** |  | M1 | 3.4 |
| *a* = 4 | A1 | 2.2b |
| **(ii)** |  | M1 | 3.4 |
|  | A1 | 2.2b |
|  | **(4)** |  |
| **(b)** |  | M1 | 3.4 |
|  | A1 | 1.1b |
|  | M1 | 3.1a |
|  | A1 | 1.1b |
|  | M1 | 3.4 |
| = 22.8 cm3 | A1 | 1.1b |
|  |  | **(6)** |  |
| **(10 marks)** |
| **Notes** |
| (a)M1: Interprets the information from the model and uses the parametric form of *x* to determine the value of *a*A1: Correct value for *a*M1: Interprets the information from the model and uses the parametric form of *y* to find *b*A1: Correct value for *b*(b)M1: Uses the correct volume of revolution formula and the parametric equations for the modelA1: Correct simplified integralM1: Uses a correct double angle identity on the integrand to achieve a suitable form for integrationA1: Correct integrationM1: Correct use of correct limits according to the modelA1: Correct volume (allow exact or awrt 22.8) |

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| **Question** | **Scheme** | **Marks** | **AOs** |
| **3(a)** | Im(10, 12)*O*Re | M1 | 1.1b |
| A1 | 1.1b |
|  | **(2)** |  |
| **(b)** | (10, 10)*A**O*ReIm | B1 | 1.1b |
| B1ft | 1.1b |
|  | **(2)** |  |
| **(c)** |  | M1 | 3.1a |
|  | A1 | 1.1b |
|  | M1 | 2.1 |
| or  | M1 | 3.1a |
| = 66.1 | A1 | 1.1b |
|  | **(5)** |  |
| **(9 marks)** |
| **Notes** |
| (a) M1: A circle drawnA1: A circle entirely in the first quadrant with the centre marked at (10, 12) (b) B1: Correct pair of rays added to their diagramB1ft: Area between their rays and within the circle shaded(c) M1: Correct strategy to find the base (or angle) of the triangular partA1: Correct length or angleM1: Correct method for the area of the triangleM1: Correct strategy for the area of the sectorA1: Correct answer (awrt 66.1) |

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| **Question** | **Scheme** | **Marks** | **AOs** |
| **4(a)** |  | M1A1 | 3.1a1.1b |
|  | M1 | 3.1a |
| *k* = 0 or 4 | A1 | 1.1b |
|  | **(4)** |  |
| **(b)(i)** |  | M1A1 | 1.1b1.1b |
|  | M1 | 1.1b |
|  | A1 | 1.1b |
| **(b)(ii)** | Three planes that meet at a point. | A1 | 2.2a |
|  | **(5)** |  |
| **(9 marks)** |
| **Notes** |
| (a)M1: Starts by attempting to find the determinant in terms of *k*A1: Correct determinantM1: Realises that the condition for non-uniqueness is a zero determinant and solves to find *k*A1: Correct values(b)M1: Uses *k* = 5 and attempts the inverse matrixA1: Correct inverseM1: Multiplies their inverse by (7, 5, 1)TA1: Correct exact coordinatesA1: Deduces the correct interpretation |

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| **Question** | **Scheme** | **Marks** | **AOs** |
| **5(a)** |  | M1 | 3.1a |
|  | M1 | 1.1b |
|  | A1 | 1.1b |
|  | **(3)** |  |
| **(b)** |  | M1 | 1.1b |
|  | M1 | 2.1 |
| or e.g.  | A1 | 2.2a |
|  | **(3)** |  |
| **(6 marks)** |
| **Notes** |
| (a)M1: Recognises the need to and attempts to complete the squareA1: Integrates to obtain an expression of the required formA1: Correct answer with or without + *c*(b)M1: Correct use of limits and combines ln termsM1: Correct applies the method for the mean value for their integrationA1: Deduces a correct expression |

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| **Question** | **Scheme** | **Marks** | **AOs** |
| **6** | So the statement is true for *n* = 1 | B1 | 2.2a |
| Assume true for *n* = *k* so  | M1 | 2.4 |
|  | M1 | 1.1b |
|  | A1 | 1.1b |
|  | A1 | 2.1 |
| If the statement is true for *n* = *k* then it has been shown true for *n* = *k* + 1 and as it is true for *n* = 1, the statement is true for all positive integers *n*. | A1 | 2.4 |
|  | **(6)** |  |
| **(6 marks)** |
| **Notes** |
| B1: Shows the statement is true for *n* = 1M1: Makes a statement that assumes the result is true for *n* = *k*M1: Attempts to multiply the correct matricesA1: Correct matrix in terms of *k*A1: Correct matrix in terms of *k* + 1 including sufficient explanation for the element at the top right hand cornerA1: Correct complete conclusion |

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| **Question** | **Scheme** | **Marks** | **AOs** |
| **7(a)** |  | M1 | 1.2 |
|  | M1 | 1.1b |
|  | A1\* | 2.1 |
|  | **(3)** |  |
| **(b)** |  | M1 | 3.1a |
|  | M1 | 1.1b |
|  **or**  | A1 | 1.1b |
|  **and** With no “solutions” being found by attempts to solve or  | A1 | 2.3 |
|  | **(4)** |  |
| **(7 marks)** |
| **Notes** |
| (a)M1: Recalls the definition of cosh*x* in terms of exponentials and substitutesM1: Expands the cubed bracket correctlyA1\*: Correct proof with no errors(b)M1: Uses the result from part (a) and collects terms to make progress in solving the equationM1: Recalls the definition of cosh in terms of e or uses the definition of cosh-1xA1: One correct solutionA1: Both correct solutions and no others from or  |

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| **Question** | **Scheme** | **Marks** | **AOs** |
| **8(a)** | Because is undefined at *x* = 2 and the limits of the integration are either side of this discontinuity | B1 | 2.4 |
|  | **(1)** |  |
| **(b)** |  | M1A1 | 2.11.1b |
|  | M1 | 3.1a |
|  | M1 | 2.1 |
|  | A1 | 2.2a |
|  | **(5)** |  |
| **(6 marks)** |
| **Notes** |
| (a)B1: A correct explanation why the integral is improper(b)M1: Integrates to obtain an expression of the form A1: Correct integrationM1: Adopts the correct strategy of splitting the integral into two with limits 0🡪2 and 2🡪5M1: Produces a rigorous argument that includes an upper limit for the first integral that approaches 2 from below and a lower limit for the second integral that starts from 2 from aboveA1: Correct expression (allow exact equivalents) |

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| **Question** | **Scheme** | **Marks** | **AOs** |
| **9(a)** |  | M1 | 1.1b |
|  | M1 | 2.2a |
|  | B1 | 2.2a |
|  | M1 | 1.1b |
|  | A1 | 1.1b |
|  | A1 | 1.1a |
|  | **(6)** |  |
| **(b)** |  | M1 | 3.4 |
|  | M1 | 3.4 |
|  | A1 | 1.1b |
|  | **(3)** |  |
| **(c)** |   | M1 | 3.1a |
|  | M1 | 3.4 |
|  | A1 | 1.1b |
|  | **(3)** |  |
| **(d)** | * This is close to 1 so the model supports the suggestion that the concentration returns to its initial value after around 8 hours
 | M1A1ft | 3.43.2b |
|  | **(2)** |  |
| **(14 marks)** |
| **Notes** |
| (a)M1: Forms and solves the auxiliary equationA1: Deduces the correct complementary functionB1: Deduces the correct form of the PI given the outcome for the CFM1: Complete method to establish the value of *k*A1: Correct PIA1: Correct GS(b)M1: Uses the model and the initial conditions to find the value of *B*M1: Uses the model by differentiating and using the other initial condition to find a value for *A*A1: Correct PS(c)M1: Solves  to find *t* when the concentration is a maximumM1: Uses their value of *t* and the model to find the maximum concentrationA1: Correct value(d)M1: Uses their model to finds the concentration when *t* = 8 in order to test the claimA1ft: Follow through their solution but the comment must be consistent with their values. |