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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 identity  A1ft: Correct value (follow through their )  (ii) M1: Attempts to expand  A1: Correct expansion  A1: Correct value  **Alternative:**  M1: Substitutes (*x* + 2) for *x* in the given cubic  A1: Calculates the correct constant term  A1: Completes correctly by changing sign and dividing by 2  (iii) M1: Establishes the correct identity  A1ft: 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 model  A1: Correct simplified integral  M1: Uses a correct double angle identity on the integrand to achieve a suitable form for integration  A1: Correct integration  M1: Correct use of correct limits according to the model  A1: 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*  Re  Im | 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 drawn  A1: A circle entirely in the first quadrant with the centre marked at (10, 12)  (b) B1: Correct pair of rays added to their diagram  B1ft: Area between their rays and within the circle shaded  (c) M1: Correct strategy to find the base (or angle) of the triangular part  A1: Correct length or angle  M1: Correct method for the area of the triangle  M1: Correct strategy for the area of the sector  A1: Correct answer (awrt 66.1) | | | |

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| **Question** | **Scheme** | **Marks** | **AOs** |
| **4(a)** |  | M1  A1 | 3.1a  1.1b |
|  | M1 | 3.1a |
| *k* = 0 or 4 | A1 | 1.1b |
|  | **(4)** |  |
| **(b)(i)** |  | M1  A1 | 1.1b  1.1b |
|  | 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 determinant  M1: 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 matrix  A1: Correct inverse  M1: Multiplies their inverse by (7, 5, 1)T  A1: Correct exact coordinates  A1: 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 square  A1: Integrates to obtain an expression of the required form  A1: Correct answer with or without + *c*  (b)  M1: Correct use of limits and combines ln terms  M1: Correct applies the method for the mean value for their integration  A1: 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* = 1  M1: Makes a statement that assumes the result is true for *n* = *k*  M1: Attempts to multiply the correct matrices  A1: 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 corner  A1: 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 substitutes  M1: Expands the cubed bracket correctly  A1\*: Correct proof with no errors  (b)  M1: Uses the result from part (a) and collects terms to make progress in solving the equation  M1: Recalls the definition of cosh in terms of e or uses the definition of cosh-1x  A1: One correct solution  A1: 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)** |  | M1  A1 | 2.1  1.1b |
|  | 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 integration  M1: Adopts the correct strategy of splitting the integral into two with limits 0🡪2 and 2🡪5  M1: 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 above  A1: 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 | M1  A1ft | 3.4  3.2b | |
|  | **(2)** |  | |
| **(14 marks)** | | | | |
| **Notes** | | | | |
| (a)  M1: Forms and solves the auxiliary equation  A1: Deduces the correct complementary function  B1: Deduces the correct form of the PI given the outcome for the CF  M1: Complete method to establish the value of *k*  A1: Correct PI  A1: 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 maximum  M1: Uses their value of *t* and the model to find the maximum concentration  A1: Correct value  (d)  M1: Uses their model to finds the concentration when *t* = 8 in order to test the claim  A1ft: Follow through their solution but the comment must be consistent with their values. | | | | |