| **Question** | **Scheme** | | **Marks** |
| --- | --- | --- | --- |
| **1** |  | |  |
|  | | M1 |
|  | | A1 |
|  | | M1 |
|  | | B1  A1 |
|  |  | | **(5 marks)** |
| **2** |  | | M1 |
|  | | M1 |
|  | | A1A1  A1A1 |
|  |  | | **(6 marks)** |
| **3** | (b) | | M1  A1 |
| Attempts to differentiate *x* to give *k* | | M1 |
| o.e. | | A1 |
|  |  | | **(4 marks)** |
| **4(a)** |  | |  |
|  | | M1 |
|  | | A1 A1 A1 |
|  |  | | **(4)** |
| **4(b)** |  | | M1 A1 |
|  |  | | **(2)** |
|  |  | | **(6 marks)** |
| **5(a)** | or **equivalent exact** (not decimal) expression e.g. | | B1 |
|  |  | | **(1)** |
| **5(b)** | or  or  may not be simplified and may appear on separate lines | | B1 |
| Either  or As  then | | M1 |
|  | | A1 cso |
|  |  | | **(3)** |
| **5(c)** | or | | M1 A1 |
| implies  (Use of > 0 or < 0 is M0 then M0A0) | | M1 |
| or answers which round to 2.12 ( –2.12 is A0) | | dM1 A1 |
|  |  | | **(5)** |
| **5(d)** | , = 85 (only ft *x* = 2 or 2.1 – both give 85) | | M1 A1 |
|  |  | | **(2)** |
| **5(e)** | **Either**   and sign considered ( May appear in (c) ) | **Or** *(method 2)* considers gradient to left and right of their 2.12 (e.g. at 2 and 2.5)  **Or** (*method 3*) considers value of *A* either side | M1 |
| which is > 0 and therefore minimum (most substitute 2.12 but it is not essential to see a substitution ) (may appear in (c)) | Finds numerical values for gradients and observes gradients go from negative to zero to positive so concludes minimum  **OR** finds numerical values of *A* , observing greater than minimum value and draws conclusion | A1 |
|  |  |  | **(2)** |
|  |  | | **(13 marks)** |
| **6(a)** | Either: (Cost of polishing top and bottom (two circles) is )  **or (**Cost of polishing curved surface area is) or both - just need to see at least one of these products | | B1 |
| Uses volume to give  or (simplified)  (if *V* is misread – see below) | | B1ft |
|  | |  |
|  | Substitutes expression for *h* into area or cost expression of form | M1 |
| \* | | A1\* |
|  |  | | **(4)** |
| **6(b)** | or (then isw). | | M1 A1 ft |
| **so**  where | | dM1 |
| Use **cube** root to obtain *r* = *their* (= 2.92)  allow *r* = 3, and thus *C* = | | ddM1 |
| Then *C* = awrt 483 or 484 | | A1cao |
|  |  | | **(5)** |
| **6(c)** | **so minimum** | | B1ft |
|  |  | | **(1)** |
|  |  | | **(10 marks)** |
| **7(a)** | or | | M1 |
|  | | A1 |
| \* | | B1 cso |
|  |  | | **(3)** |
| **7(b)** | *P* = 2*x* + *cy* + *k π r*  where *c =* 2 or 4 and *k*  = ¼ or ½ | | M1 |
| or o.e. | | A1 |
| so  \* | | A1 |
|  |  | | **(3)** |
| **7(c)** |  | | M1 A1 |
|  | | M1 |
| and so *x* = 2 o.e. (ignore extra answer *x* = –2) | | A1 |
| *P* = 4 + 4 = 8 (m) | | B1 |
|  |  | | **(5)** |
| **7(d)** | , (and so width) = 21 (cm) | | M1 A1 |
|  |  | | **(2)** |
|  |  | | **(13 marks)** |
| **8(a)** |  | | M1A1 |
| \* | | A1 \* |
|  |  | | **(3)** |
| **8(b)** |  | | B1 |
|  | | M1 |
|  | |  |
|  | | A1 \* |
|  |  | | **(3)** |
| **8(c)** |  | | M1A1 |
|  | | M1 |
|  | | A1 |
|  | awrt 27.7 | A1 |
|  |  | | **(5)** |
| **8(d)** |  | | M1A1ft |
| Note: parts(c) and (d) can be marked together | |  |
|  |  | | **(2)** |
|  |  | | **(13 marks)** |
| **9(a)** | *V* = 4*x*(5 – *x*)2  So, *V* = 100*x* – 4*x*2 + 4*x*3  = 100 – 80*x* + 12*x*2 | |  |
| ± *αx* ± *βx*2 ± *γx*3, *α*, *β*, *γ* 0 | | M1 |
| *V* = 100*x* – 4*x*2 + 4*x*3 | | A1 |
| At least two of their expanded terms differentiated correctly | | M1 |
| 100 – 80*x* + 12*x*2 | | A1 cao |
|  |  | | **(4)** |
| **9(b)** | 100 – 80*x* + 12*x*2 = 0  { 4(3*x*2 – 20*x* + 25) = 0  4(3*x* – 5)(*x* – 5) = 0}  {As 0 < *x* < 5} *x* =  *x* = , *V* = 4()(5 – )2  So, *V* = | |  |
| Sets their  from part (a) = 0 | | M1 |
| *x* =  or *x* = awrt 1.67 | | A1 |
| Substitute candidate’s value of *x* **where** 0 < *x* < 5 into a formula for *V* | | dM1 |
| Either  or  or awrt | | A1 |
|  |  | | **(4)** |
| **9(c)** | = – 80 + 24*x*  When *x* = , = – 80 + 24()  = – 40 < 0  *V* ia a maximum | |  |
| Differentiates their  **correctly** to give | | M1 |
| = – 40 and < 0 or negative and maximum | | A1 cso |
|  |  | | **(2)** |
|  |  | | **(10 marks)** |
| **10(a)** | *θ* = 20 + *A*e*–kt* (eqn \*)  {*t* = 0, *θ* = 90 } 90 = 20 + *A*e*–k*(0)  90 = 20 + *A*  *A* = 70 | |  |
| Substitutes *t* = 0 and *θ* = 90 into eqn \* | | M1 |
| *A* = 70 | | A1 |
|  |  | | **(2)** |
| **10(b)** | *θ* = 20 + 70e*–kt*  {*t* = 5, *θ* = 55 } 55 = 20 + *A*e*–k*(5)  = e*–*5*k*  ln () = – 5*k*  – 5*k* = ln ()  – 5*k* = ln 1 – ln 2  – 5*k* = – ln 2  *k* =  ln 2 | |  |
| Substitutes *t* = 5 and *θ* = 55 into eqn \* and rearranges eqn \* to make e5*k* the subject | | M1 |
| Takes ‘lns’ and proceeds to make ‘±5*k*’ the subject | | dM1 |
| Convincing proof that *k* =  ln 2 | | A1 |
|  |  | | **(3)** |
| **10(c)** | *θ* = 20 + 70    When *t* = 10, = – 14ln 2 e*–*2ln2  ln 2 = – 2.426015132 …  Rate of decrease of *θ* = 2.426° C/min (3dp.) | |  |
| ± *α* e*–kt* where *k* =  ln 2 | | M1 |
| – 14ln 2 | | A1 oe |
| awrt ± 2.426 | | A1 |
|  |  | | **(3)** |
|  |  | | **(8 marks)** |
| **11(a)** | *p* = 7.5 | | B1 |
|  |  | | **(1)** |
| **11(b)** | 2.5 = 7.5 e*–*4*k* | | M1 |
| e*–*4*k* = | | M1 |
| – 4*k* = ln () | | dM1 |
| – 4*k* = – ln (3) | |  |
| *k* = ln (3) | | A1 |
|  |  | | **(4)** |
| **11(c)** | = – *kp* e*–kp*  ft on their *p* and *k* | | M1A1ft |
| –ln 3 × 7.5 = – 0.6ln 3 | |  |
| = (0.32) | | M1A1 |
| –(ln 3)*t* = ln (0.32) | | dM1 |
| *t* = 4.1486 … 4.15 or awrt 4.1 | | A1 |
|  |  | | **(6)** |
|  |  | | **(11 marks)** |

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|  | **Source paper** | **Question number** | **New spec references** | **Question description** | **New AOs** |
| 1 | C1 2017 | 2 | 2.2 and 7.2 | Differentiation | 1.1b |
| 2 | C1 2016 | 7 | 2.1 and 7.2 | Differentiation | 1.1b |
| 3 | C1 2014 | 7 | 7.2 | Differentiation and related sums and differences | 1.1b |
| 4 | C1 2012 | 4 | 7.1 and 7.2 | Differentiation | 1.1b |
| 5 | C2 2012 | 8 | 7.3 | Differentiation | 2.1, 2.4, 3.1b, 3.4 |
| 6 | C2 2015 | 9 | 7.1, 7.2 and 7.3 | Applications of differentiation | 1.1b, 2.1, 2.4, 3.1b, 3.4 |
| 7 | C2 Jan 2012 | Q8 | 5.1 and 7.3 | Trigonometry, Differentiation | 1.1b, 2.1, 3.1b, 3.2, 3.4 |
| 8 | C2 June 2014R | 9 | 7.1, 7.2 and 7.3 | Differentiation | 1.1b, 2.1, 2.2a, 2.4, 3.1b, 3.4 |
| 9 | C2 Jan 2011 | 10 | 2.6, 7.1, 7.2, 7.3 | Differentiation | 1.1b, 2.4 |
| 10 | C3 Jan 2011 | 4 | 6.2, 6.3, 6.7 | Exponentials and logarithms, Differentiation | 1.1b, 3.1a, 3.4 |
| 11 | C3 2011 | Q5 | 6.2, 6.3, 6.7 | Exponentials and logarithms, Differentiation | 1.1b, 2.1, 3.1a, 3.4 |