

| Question | Scheme | Marks | AOs |
|-------------|---|-------|------|
| 9(a) | $t = 0, \theta = 18 \Rightarrow 18 = A - B$ <p style="text-align: center;">or</p> $t = 10, \theta = 44 \Rightarrow 44 = A - Be^{-0.7}$ | M1 | 3.1b |

| | | | |
|------------------|---|-------------------------|------|
| | $t = 0, \theta = 18 \Rightarrow 18 = A - B$ and $t = 10, \theta = 44 \Rightarrow 44 = A - Be^{-0.7}$ and $\Rightarrow A = \dots, B = \dots$ | M1 | 3.1a |
| | At least one of: $A = 69.6, B = 51.6$ but allow awrt 70/awrt 52 | A1 M1 on EPEN | 1.1b |
| | $\theta = 69.6 - 51.6e^{-0.07t}$ | A1 | 3.3 |
| | | (4) | |
| (b) | The maximum temperature is “69.6”(°C) (according to the model) (The model has an) upper limit of “69.6”(°C) (The model suggests that) the boiling point is “69.6”(°C) | B1ft | 3.4 |
| | Model is not appropriate as 69.6(°C) is much lower than 78(°C) | B1ft | 3.5a |
| | | (2) | |
| (6 marks) | | | |

Notes:

(a)

M1: Makes the first key step in the solution of the problem. Substitutes $t = 0$ and $\theta = 18$ **or** $t = 10$ and $\theta = 44$ into the equation of the model to obtain an equation connecting A and B .

Note that $18 = A - Be^0$ scores M0 unless $18 = A - B$ is seen or implied later.

If they do not obtain an equation in A and B using the first conditions e.g. they have $18 = A - 1$ then they can score this mark if they substitute $A = 19$ directly into $44 = A - Be^{-0.7}$ as an equation in A and B is implied.

M1: Substitutes $t = 0$ and $\theta = 18$ **and** $t = 10$ and $\theta = 44$ to obtain 2 equations connecting A and B **and** then proceeds to solve their equations in A and B simultaneously to obtain values for both constants. Do not be too concerned with the processing as long as values for A and B are obtained.

A1(M1 on EPEN): For $A =$ awrt 70 **or** $B =$ awrt 52

A1: For $\theta = 69.6 - 51.6e^{-0.07t}$ **Must be a fully correct equation as shown but allow recovery if seen in (b).**

Note that some candidates evaluate e^0 as 0 and so obtain $A = 18$ and then write $44 = 18 - Be^{-0.7}$ and solve for B . Such attempts can score M1M0A0A0 only.

(b)

B1ft: Identifies A as the boiling point/maximum temperature in the model. Follow through their A .

B1ft: Makes a valid conclusion (valid/not valid, good/not good etc.) that refers to the 78 and includes a reference to a significant/large difference

Alternative provided their $A < 78$

B1ft: $\theta = 69.6 - 51.6e^{-0.07t} = 78 \Rightarrow 51.6e^{-0.07t} = 69.6 - 78 = -8.4$

$\Rightarrow e^{-0.07t} = -\frac{7}{43}$ and $\ln\left(-\frac{7}{43}\right)$ and makes a reference to the fact that the equation cannot be solved or e.g. cannot take log of a negative number. You can condone numerical slips in the calculation.

B1ft: Model is not appropriate as 69.6(°C) is much lower than 78(°C)

Minimum for both marks: The model is not appropriate as “69.6”(°C) is much lower than 78(°C)

Note that these marks are not available if their equation is solvable. Note also that B0B1 is not possible.