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Examiners' report

AS LEVEL

MATHEMATICS B (MEI)

OCR Level 3 Advanced Subsidiary GCE in Mathematics B (MEI)

H630

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Introduction

Our examiners' reports are produced to offer constructive feedback on candidates' performance in the examinations. They provide useful guidance for future candidates.

The reports will include a general commentary on candidates' performance, identify technical aspects examined in the questions and highlight good performance and where performance could be improved. A selection of candidate responses is also provided. The reports will also explain aspects which caused difficulty and why the difficulties arose, whether through a lack of knowledge, poor examination technique, or any other identifiable and explainable reason.

Where overall performance on a question/question part was considered good, with no particular areas to highlight, these questions have not been included in the report.

A full copy of the question paper and the mark scheme can be downloaded from Teach Cambridge.

Paper 1 series overview

This paper produced a wide spread of marks. Questions 1, 3, 7, 8 and 11 proved to be accessible to almost all candidates whereas Questions 10, 12 and 13 were much more challenging. Most candidates had enough time to complete the paper, although many did not complete Question 12.

Candidates who did well on this paper generally:	Candidates who did less well on this paper generally:
• had accurate algebra manipulation • used their calculator efficiently • showed a good understanding of vector methods • annotated required diagrams well • demonstrated good problem-solving skills.	• made errors in their algebra • either did not use their calculator to its full advantage or relied too heavily on its functionality and not show enough evidence of their method • found working with vectors difficult • demonstrated less precise sketching skills, lacking indications of scale or the coordinates of the plotted points • omitted the more challenging questions.

Question 1

1 Expand $(2a-b)^4$. You must simplify your answer. **[3]**

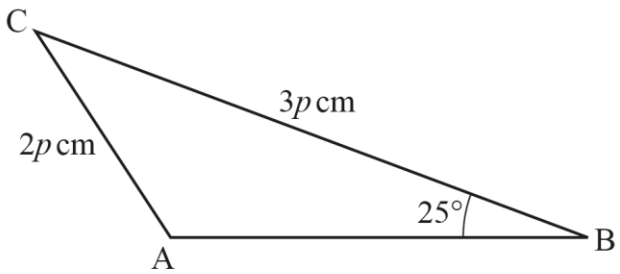
This was generally well done, with sign errors being a common error. The first accuracy mark could be given for the unsimplified expansion even where errors were made in simplifying. Candidates who did not use binomial expansion but used an expanding bracket method instead generally made too many slips in their algebra to get more than 1 mark here, but all marks were available if entirely correct.

Assessment for learning

Candidates who wrote their expansion with brackets such as $(2a)$ and $(-b)$, were more successful in this question.

Question 2

2 Triangle ABC is shown in the diagram. The length of AC is $2p$ cm and the length of BC is $3p$ cm, where p is a positive constant. The angle ABC is 25°.



Calculate the size of the **obtuse** angle CAB. **[2]**

The unknown lengths of the sides added an extra layer of difficulty here compared with a GCSE question. Most candidates knew to use the sine rule but some were confused by the unknown lengths in the question and did not realise the p's cancel.

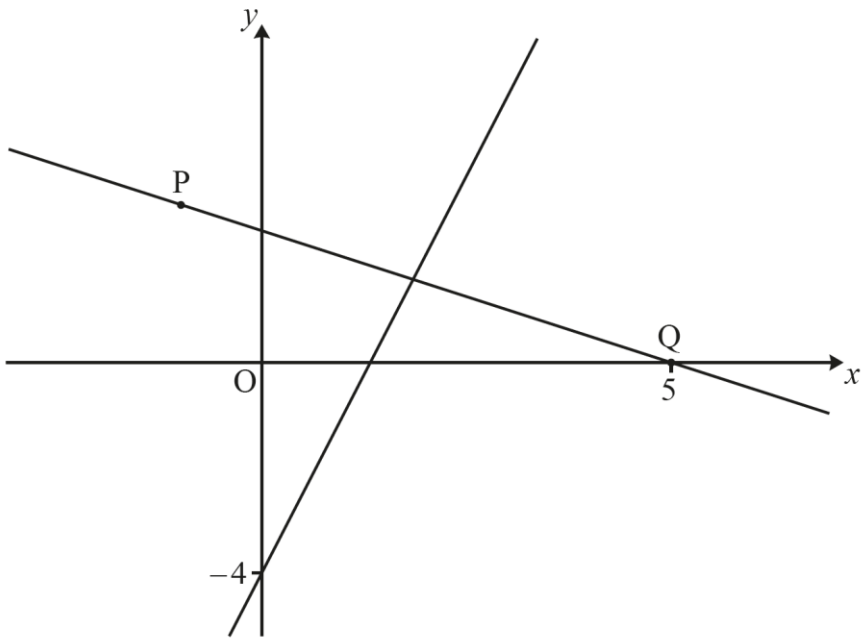
Misconception

Many candidates who found $\sin^{-1} 1.5 \sin 25 = 39.3°$ left this as their final response where the question and the diagram both indicate an obtuse angle is needed. Some gave wrong responses for an obtuse angle either by adding $90°$ or calculating $180° - 39.3° - 25°$.

Question 3

3 In this question you must show detailed reasoning.

The graph below shows the line $y = 3x - 4$ and the line through P and Q where P is (–1, 3) and Q is (5, 0).



Use an **algebraic** method to find the coordinates of the point of intersection of the two lines. **[4]**

Most candidates knew that the solution to this question relied on solving the equations of the two lines simultaneously. As this was question expected detailed reasoning, some working was needed in the solving of the simultaneous equations. A common mistake was to misremember the gradient formula and a gradient of ± 2 instead of $\pm\frac{1}{2}$ received no marks.

Misconception

A number of candidates looked at the diagram and assumed the lines were perpendicular and so used a gradient of $-\frac{1}{3}$ for PQ. This is not possible from the description of P and Q in the question. Had the lines been perpendicular it likely would have said so explicitly in the question. The diagram may look perpendicular, but without right angles labelled candidates should not assume it.

Question 4 (a)

4 **(a)** Show that the equation $x^2 + kx - k^2 = 0$ has real roots for all real values of k. **[2]**

Most candidates realised that they needed to calculate the discriminant for this question, but we saw many errors in identifying $(-k^2)$ as the constant term. Common incorrect responses used $k^2 - 4k^2$ or $k^2 - 4 \times 1 \times 1$ as the discriminant and candidates went on to find wrong A values or range of values for k. We also saw responses where the correct expression $5k^2$ was seen but instead of arguing that this is positive for all values of k, $k > 0$ was deduced. The final mark was not given for responses that only showed that $5k^2$ is always positive without drawing the conclusion that the equation had real roots or indicating at the start that real roots would happen if the discriminant were positive.

Question 4 (b)

(b) Show that the roots of the equation $x^2 + kx - k^2 = 0$ are $\left(\frac{-1 \pm \sqrt{5}}{2}\right)k$. **[2]**

As this equation could not be solved using a calculator, we expected to see the use of the quadratic formula or completing the square. Enough working was needed to demonstrate that the candidate had not simply copied the given response at the end of their working.

Question 5 (a)

5 Two blocks A and B have masses 5 kg and 2 kg respectively. The blocks are joined together by a light rigid horizontal bar and slide across a horizontal surface. The resistances on the blocks A and B are modelled as 7 N and 1.75 N respectively. There are no other external horizontal forces.

(a) Calculate the acceleration of the system, according to the model. **[3]**

The only horizontal force acting on the blocks in this question were resistances, so we expected to see a negative value for acceleration here, or a clear indication that the direction of travel was not the positive sense in the response. The response $a = 1.25$ ms^{-2} from correct working was given 2 out of 3 marks.

Question 5 (b)

(b) In reality, the acceleration of the system is **not** constant. State an improvement that could be made to the model so that it will produce results which are closer to the real situation. **[1]**

Very few candidates realised that in order to have acceleration that is not constant, there must be at least one variable force acting. Some candidates stated that the model for velocity should be quadratic or exponential without any reference to the forces acting but this received no credit as it did not consider the forces acting.

Question 6

6 In this question you must show detailed reasoning.

Solve the equation $6\cos^2 x = 5 - \sin x$ giving all the roots in the interval $0° < x < 360°$. **[4]**

Many fully correct responses were seen, but some candidates did not find the two values of x in the given interval for which $\sin x = -\frac{1}{3}$. A common error was to use $180° - 19.3°$ instead of $180° + 19.3°$.

This was a question requiring detailed reasoning, so we expected to see a method for solving the quadratic equation in $\sin x$. However, as this skill was also needed in Question 11, candidates did not lose a mark here if they gave correct roots of their equation without working.

Misconception

When $\sin x$ is negative, there may be positive angles of x to be found.

Question 7 (a)

7 The point A has position vector $\begin{pmatrix} -2 \\ 1 \end{pmatrix}$. The vector $\overrightarrow{AB}$ is $\begin{pmatrix} 8 \\ 6 \end{pmatrix}$.

(a) On the axes in your Printed Answer Book, draw the position of the points A and B. **[2]**

The axes in the Printed Answer Book were blank, and we expected to see some indication of a scale on each axis, perhaps by labelling the points or writing at least one number on each axis.

It was common to see candidates misread the information in the question and work with $\begin{pmatrix} 8 \\ 6 \end{pmatrix}$ as the position vector of B. A mark was lost here, but follow-through marks were available for the later parts of the question.

Question 7 (b)

(b) Calculate the distance AB. **[1]**

This was generally well done, but some candidates gave a vector as their response here. Follow-through was given here if their coordinates of B were not correct.

Question 7 (c)

(c) Show that the midpoint of AB lies on the line $y = 2x$. **[2]**

The mark scheme gives 1 mark for finding the midpoint of AB, even if the point B had been misunderstood or miscalculated. Some evidence was needed after (2, 4) seen that this was on the line $y = 2x$.

Question 8 (a)

8 On the planet Mars, acceleration due to gravity is $3.71\,\text{m}\,\text{s}^{-2}$.

(a) Calculate the time it would take an object to fall to the planet's surface from rest from a point 2 m above the surface. There are no resistances to the motion of the object. **[2]**

This question was well done and very few candidates seemed confused by the different value for g given in the question.

Assessment for learning

In this question, the acceleration and displacement are in the same direction, so must have the same sign. If there is a sign error, the value for t^2 will be negative. For full credit it was expected that candidates go back and change the working as opposed to ignoring the minus sign.

Question 8 (b)

(b) The mass of the object is 2.5 kg.

Calculate the magnitude of the normal contact force when the object is at rest on the planet's surface. **[1]**

Most candidates correctly gave the weight of the object as the magnitude of the contact force, although some reverted to using $g = 9.8\ \text{ms}^{-2}$ here when they had used 3.71 in part (a).

Question 9 (a)

9 **(a)** Write the expression $\frac{1}{x^2}\left(3+x^{\frac{5}{2}}\right)$ in the form $3x^p+x^q$. **[1]**

This part tested an understanding of the laws of indices which the majority of candidates got right. The fractional power caused the most problems to candidates and a response of $3x^{-2}-x^{-5}$ was often seen. Where this response was incorrect, the method marks and 1 follow-through A mark were available in part (b).

Question 9 (b)

(b) A curve has gradient function $\frac{dy}{dx}=\frac{1}{x^2}\left(3+x^{\frac{5}{2}}\right)$. The curve passes through the point $(1, -2)$.

Determine the equation of the curve. **[4]**

This was generally well done, with a small number of candidates omitting the constant, meaning maximum of 2 marks could be given. The question word 'determine' indicates that a method must be seen.

Question 10 (a)

10 In this question, the **i** direction is horizontal and the **j** direction is vertically upwards.

A particle of mass 3 kg is in equilibrium.

(a) Explain what is meant by a particle. **[1]**

Candidates are not always clear about modelling assumptions and do not recognise that to model an object as a particle means that the size, shape and potential spin can be ignore. A description of a point mass was accepted, but not just that all the forces on the object act at the same point. Where a correct description went on to include incorrect comments, such as no air resistance, the mark was not awarded.

Assessment for learning

Often, several modelling assumptions are used at once. Be clear what each of them means. A question like this which asks for the meaning of one assumption needs the candidate to pick out the specific meaning of that one. Marks are lost if a description of other modelling assumptions, such as 'no air resistance' are included as well as the correct explanation.

Question 10 (b)

The following forces are acting on the particle:
- the weight of the particle
- a horizontal force of $h\mathbf{i}$ N
- the force $\mathbf{F} = k\mathbf{i} + (k-5)\mathbf{j}$ N.

(b) Calculate the value of h. **[3]**

Candidates working in two separate directions generally did better than those who worked with vectors, as many vector attempts included the weight as a scalar term. Another common error was to equate h and k rather than have their sum to be zero.

Assessment for learning

Where a vector equation is attempted, all the terms must be in vector form. Here the weight needs to be included as $-3g\mathbf{j}$. A vector question can also be tackled by looking at scalar equations in the $\mathbf{i}$ direction and the $\mathbf{j}$ directions separately. Take care to reconstruct a vector where needed, as in part (c) in this question.

Question 10 (c)

(c) The force $\mathbf{F}$ is removed.

State the vector equation of motion of the particle. **[1]**

Many candidates did not realise that a complete vector Newton's Second Law was required here and just under a third of candidates omitted this altogether. No credit was given for a resultant force on its own without $= 3\mathbf{a}$.

Question 11 (a)

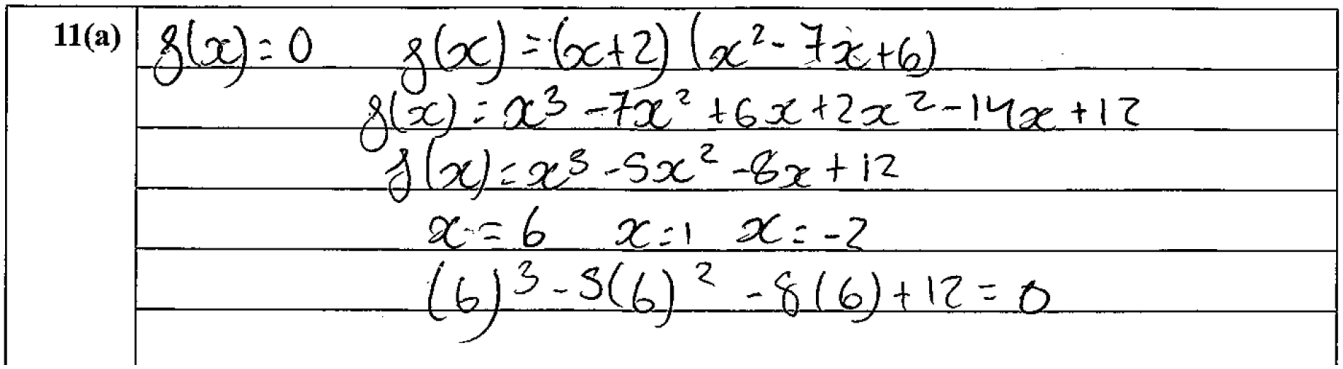
11 In this question you must show detailed reasoning.

You are given that $\mathrm{f}(x) = (x+2)(x^2-7x+6)$.

(a) Solve the equation $\mathrm{f}(x) = 0$. **[3]**

This question was designed to test the algebraic skills needed to solve a cubic equation. The function was already given as the product of a linear and a quadratic factor. Here the detailed reasoning requirement meant that it was necessary to show some working, so only the B1 mark for $x = -2$ was available to candidates who had no working seen. Most candidates showed the product of linear factors, and the three roots as required.

Exemplar 1



This exemplar shows an attempt to solve the equation by calculator which in this case was not given the method mark therefore was not given the dependent A mark. The B mark was given for this response. Showing that $x = 6$ is a root of the equation is sufficient working. In a question where detailed reasoning is required, candidates should show a detailed and complete analytical method, using their calculators to check or to help with the process of factorisation.

Question 11 (b)

(b) Show that there is a minimum point on the curve $y = \mathrm{f}(x)$ when $x = 4$. **[4]**

Most candidates realised they needed to find an expression for the derivative and most were successful. The question gave the value for x so it was only necessary to verify rather than solve their quadratic $\frac{\mathrm{d}y}{\mathrm{d}x} = 0$ equation. It was quite common to see a response which did not show that $\mathrm{f}'(4) = 0$ but did evaluate $\mathrm{f}''(4)$ so show the point was indeed a minimum point. Only 1 mark was lost for that mistake. Several candidates often stopped after $\frac{dy}{dx} = 0$ and didn't think to include the second derivative. Those who chose to compare gradients either side of the turning point did well.

Question 11 (c)

(c) Find the exact coordinates of the other stationary point on the curve $y = \mathrm{f}(x)$. **[2]**

Candidates had to solve their $\frac{\mathrm{d}y}{\mathrm{d}x} = 0$ equation and should have shown their factorisation here also. Marks were not deducted here for solving their equation by calculator, as this was dealt with in the scheme for part (a). Some candidates struggled with evaluating the y –coordinate as a fraction. Decimal approximations were not accepted here, as the question required exact coordinates.

Assessment for learning

Exact coordinates were required here. Students should make sure they can use their calculator to get responses expressed as fractions or recurring decimals rather than rounding decimal responses.

Question 12 (a)

12 A student dissolves 0.5 kg of salt in a bucket of water. Water leaks out of a hole in the bucket so the student lets fresh water flow in so that the bucket stays full.

They assume that the salty water remaining in the bucket mixes with the fresh water that flows in, so the concentration of salt is uniform throughout the bucket.

They model the mass M kg of salt remaining after t minutes by $M = ak^t$ where a and k are constants.

(a) Show that the model for M can be rewritten in the form $\log_{10} M = t\log_{10} k + \log_{10} a$. **[1]**

This was done well by roughly three quarter of candidates, with credit being given when the expression $\log k^t + \log a$ was seen on the way to the given response.

Question 12 (b) (i)

The student measures the concentration of salt in the bucket at certain times to estimate the mass of the salt remaining. The results are shown in the table below.

t minutes	8	13	21	35	50
M kg	0.4	0.3	0.2	0.1	0.05

The student uses this data and plots $y = \log_{10} M$ against $x = t$ using graph drawing software. The software gives $y = -0.0214x - 0.2403$ for the equation of the line of best fit.

(b) (i) Find the values of a and k that follow from the equation of the line. **[3]**

The values for $\log a$ and $\log k$ had to be extracted from the equation of the line of best fit given in the question. Sometimes candidates thought these were the values of a and k. Notice both the logs were negative but only positives value for a and k made sense in this context.

Question 12 (b) (ii)

(ii) Interpret the value of k in context. **[1]**

Very few candidates were able to explain that the model $M = a \times 0.95^t$ meant that the mass of salt at time t would be reduced to 95% of that value in the next second. Generic statements about the rate of loss were not acceptable here. Many suggested k was the gradient of the line, which was not correct and also did not refer to the context.

Question 12 (c)

(c) It is known that when $t = 0$ the mass of salt in the bucket is 0.5 kg.

Comment on the accuracy when the model is used to estimate the initial mass of the salt. **[2]**

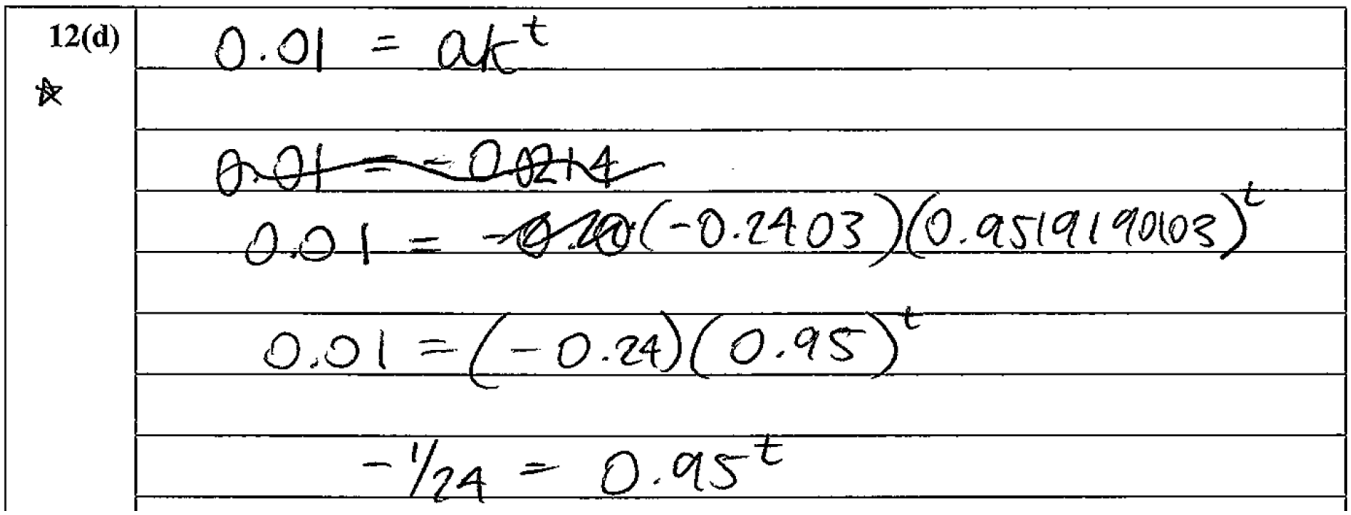
Most of the candidates who had obtained values for a and k were able to substitute $t = 0$ into their equation and compare their response with the given initial mass. Some compared the log of the given initial mass with their value of $\log k$ which was equally acceptable. Answers which argued the values were close so the model is fairly accurate and those which argued the values were not very close so the model is not very accurate were both accepted as long as correct working had been seen.

Question 12 (d)

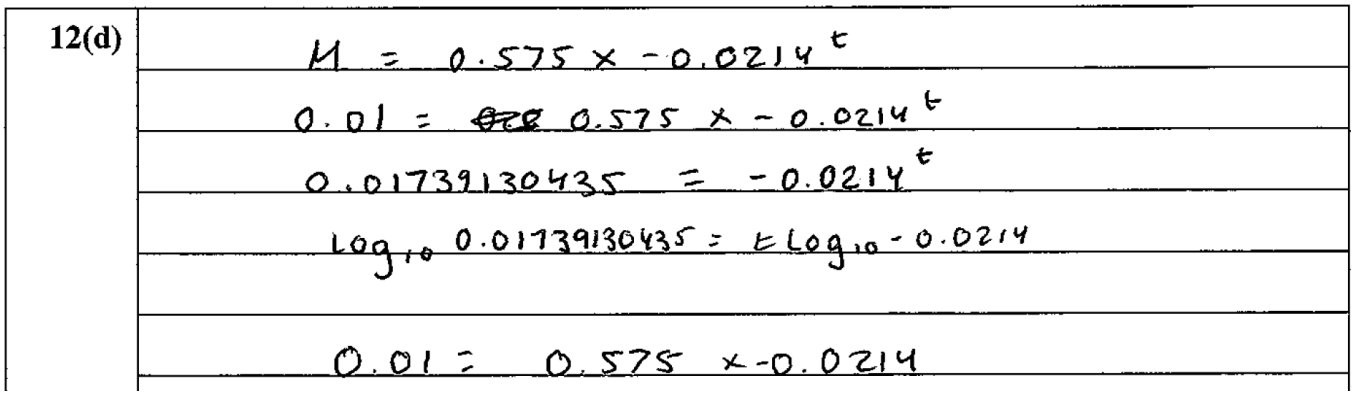
(d) Use the model to predict the value of t at which $M = 0.01\text{kg}$. **[2]**

Many sensible attempts were seen from candidates who had obtained values for a and k. Substituted values into the equation for $\log M$ made the algebra easier and there were no problems with premature rounding. Those who used their rounded values had responses which were not so precise. A wide range of responses were accepted, so values correct to two significant figures would give a value for t in the acceptable range. Using a calculator to solve the indicial equation was perfectly acceptable here and the method mark could be implied from a correct response. However, method marks are not implied by an incorrect response, so it is good practice to state the equation being solved clearly as evidence of the method.

Exemplar 2



Exemplar 3



In both responses, the candidates had made a mistake so that their value for a was negative. Both attempted to solve the resulting equation. In Exemplar 2, the candidate has no attempt to solve the indicial equation, and it is likely they tried to use their calculator to solve the equation and were unable to do so. In Exemplar 3, there is a step towards solving the indicial equation using logs, so this was given a method mark when the Exemplar 2 was not. This shows the value in writing an algebraic attempt rather than relying solely on calculator methods.

Question 12 (e)

(e) Rewrite the model for M in the form $M = ae^{-ht}$ where h is a constant to be determined. **[2]**

The expected method was to compare the two expressions for M and has $e^{-h} = k$ as the key step. Some candidates used their value of a and the point $(82.2, 0.01)$ as the key to finding h which gave a suitable value for h. Some used one of the points from the data table to estimate k which generally is only a partial solution and did not give a value in the allowable range so was awarded 1 out of 2 marks.

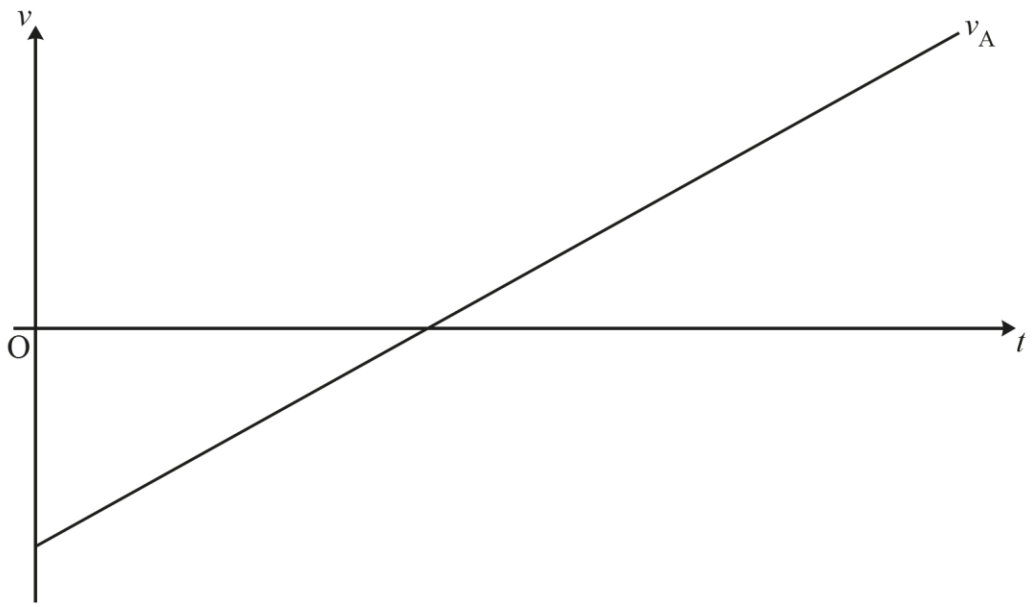
Question 12 (f)

(f) Find the rate at which the mass of salt is decreasing when $t = 10$. **[2]**

Only a small proportion of candidates used the fact that the gradient of e^{kx} is ke^{kx} which is a specification point at AS. Over half of the candidates omitted this question.

Question 13 (a)

13 Particles A and B are moving along the same straight line. The graph below is the velocity–time graph for particle A with velocity $v_A\,\text{m s}^{-1}$ at time t s. Particle A travels with constant acceleration. It has an initial velocity of $-3\,\text{m s}^{-1}$ and is instantaneously at rest when $t = 4$.



The velocity for particle B at time t s is given by $v_B = 1.5 + 0.03t^2\,\text{m s}^{-1}$. The particles are **first** travelling at the same velocity at time $t = T$ s. You are given that A and B do not collide.

(a) Show that $T = 10$. **[3]**

The B mark was given for an expression for the velocity of particle A and then the method mark was given for equating this to the velocity of B. This leads to two times at which the particles have the same velocity and candidates were expected to say the $T = 10$ was the first time at which this happened. A good proportion of candidates used this method successfully. Some candidates verified that at $T = 10$ both particles had the same velocity which was awarded 2 out of 3 marks as it did not establish that their velocities had not been equal at an earlier time. No marks were awarded to responses where candidates equated the velocity of B to the initial velocity of A.

Question 13 (b)

(b) Hence, or otherwise, determine which particle has travelled the greater **distance** by time Ts and by how much. **[6]**

The focus of this question was to test an understanding of the difference between distance travelled and displacement. Candidates should have been aware that particle A changes the direction of travel at $t = 4$. 3 marks were awarded for a correct calculation of the distance A travels in two parts and only one for the correct displacement (7.5 m). The velocity of B is positive for all positive times, so most candidates obtained a correct integral of velocity to give the distance travelled. A small number of candidates stated which particle they thought had travelled further but did not mention by how much, so lost the final mark. There was a follow-through mark for this which was dependent on both method marks, so candidates who inappropriately used a $suvat$ equation for particle B were not eligible for this mark.

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