Cambridge Assessment International Education

Cambridge IGCSE™

CANDIDATE NAME

CENTRE NUMBER

CANDIDATE NUMBER

0074308036

CAMBRIDGE INTERNATIONAL MATHEMATICS **0607/61**

Paper 6 Investigation and Modelling (Extended) **May/June 2022**

1 hour 40 minutes

You must answer on the question paper.

No additional materials are needed.

INSTRUCTIONS

- Answer both part **A** (Questions 1 to 4) and part **B** (Questions 5 to 7).
- Use a black or dark blue pen. You may use an HB pencil for any diagrams or graphs.
- Write your name, centre number and candidate number in the boxes at the top of the page.
- Write your answer to each question in the space provided.
- Do **not** use an erasable pen or correction fluid.
- Do **not** write on any bar codes.
- You should use a graphic display calculator where appropriate.
- You may use tracing paper.
- You must show all necessary working clearly, including sketches, to gain full marks for correct methods.
- In this paper you will be awarded marks for providing full reasons, examples and steps in your working to communicate your mathematics clearly and precisely.

INFORMATION

- The total mark for this paper is 60.
- The number of marks for each question or part question is shown in brackets [ ].

This document has **16** pages. Any blank pages are indicated.

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Answer **both** parts **A** and **B**.

A INVESTIGATION (QUESTIONS 1 to 4)

STORAGE BINS (30 marks)

You are advised to spend no more than 50 minutes on this part.

This investigation looks at different methods to store items in storage bins.

Amara wants to use the smallest number of storage bins possible.
Each bin can hold a maximum total mass.

1 Amara uses this method.

Method 1 Put each item in the first bin that can hold its mass.

Example

These are the masses, in kg, of four items.

6 7 4 2

The maximum total mass that each bin can hold is **10 kg**.
The tables show how Amara puts these items into bins.

Amara puts the first item in bin 1.
4 kg of storage is unused in this bin.

Bin	Mass of items in bin	Unused mass in bin			
1	6	4			
2					
3					

The second item will not go in bin 1 because it is more than 4 kg.
Amara puts the second item in bin 2.

Bin	Mass of items in bin	Unused mass in bin			
1	6	4			
2	7	3			
3					

The third item is 4 kg.
Amara puts this in bin 1.
Bin 1 is now full.

The fourth item will go in bin 2.
Bin 3 is not used.

Bin	Mass of items in bin	Unused mass in bin			
1	6, 4	4	0		
2	7, 2	3	1		
3					

Amara needs two bins which can hold a total of 20 kg.
1 kg out of the total of 20 kg of storage is unused.

(a) These are the masses, in kg, of ten items.

38 6 21 50 32 7 15 9 27 25

The maximum total mass that each bin can hold is **60 kg**.
Amara uses Method 1 to put these ten items into bins.
The table shows how she puts the first 6 items into bins.

Bin	Mass of items in bin	Unused mass in bin				
1	38, 6, 7	22	16	9		
2	21, 32	39	7			
3	50	10				
4						
5						

Complete Amara's table to show that she needs 5 bins. [4]

(b) These are the masses, in kg, of six items.

8 16 13 10 5 3

The maximum total mass that each bin can hold is **20 kg**.

Bin	Mass of items in bin	Unused mass in bin				
1	8	12				
2						
3						
4						
5						

Use Method 1 to complete the table for all six items.
The first item has been put in for you.
You may not need all the bins. [2]

2 Amara wants to see if she can use fewer bins.
She puts her items in order of mass before she puts them in bins.
She uses this method.

Method 2 Put the masses in order, largest first.
Then use **Method 1**.

These are the masses, in kg, of the ten items from **Question 1(a)**.

38 6 21 50 32 7 15 9 27 25

(a) Write these ten masses in order, largest first.

.... , ... , ... , ... , ... , ... , ... , ... , ... , ... [1]

(b) The maximum total mass that each bin can hold is **60 kg**.

Complete the table using Method 2.

Bin	Mass of items in bin	Unused mass in bin				
1						
2						
3						
4						
5						

[2]

(c) Find and compare the percentage of unused storage for these ten items when using Method 1 and Method 2.
Use your answers from **Question 1(a)** and **Question 2(b)**.

[4]

(d) A *best solution* uses the smallest possible number of bins.

A set of items with a total mass of 270 kg is put into 4 bins.
The maximum total mass that each bin can hold is 80 kg.

Show that this is a best solution.

[2]

(e) Amara tries another way to improve Method 1.

Method 3 Look for items that combine to make as many full bins as possible and place these first.
For the remaining items, use **Method 2**.

These are the masses, in kg, of eight items.

21 10 30 19 13 7 28 4

The maximum total mass that each bin can hold is **40 kg**.

Does Method 3 give a best solution for these items?
Show how you decide.

Bin	Mass of items in bin	Unused mass in bin				
1						
2						
3						
4						
5						

[4]

3 Amara has six items.
The mass, in kg, of each item is an integer.

These are the masses of her six items.

9 4 7 15 x y

The maximum total mass that each bin can hold is **20 kg**.
Amara finds that Method 1 needs fewer bins than Method 2.

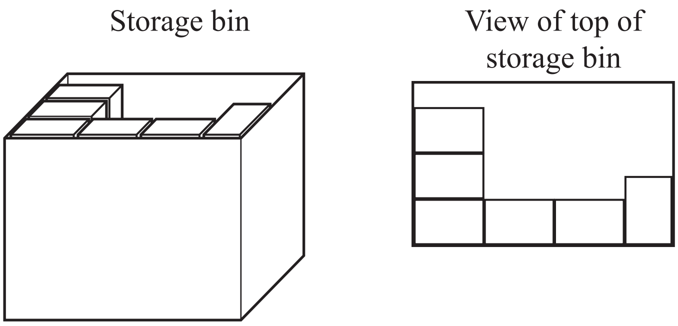
Find the value of x and the value of y.

x = ...

y = ... [4]

4 Amara now also uses the dimensions of each bin and of each item to find the maximum number of items that will go into a bin.

Each item is a cuboid and is the same height as the bin.
Amara looks at the rectangular top of each bin to work out the maximum number of items that will go into it.



NOT TO SCALE

A bin is now full **either** because it contains the maximum total mass
or because it contains the maximum number of items that will go into it.

She uses this method.

Method 4 Work out the maximum number of items for each bin using dimensions.
Then use **Method 2**.

(a) The rectangular top of Amara's bin measures 90 cm by 90 cm.
The rectangular top of each item measures 60 cm by 30 cm.

Find the maximum number of items that will go into a bin using these dimensions.

.... [2]

(b) These are the masses, in kg, of eleven items with tops measuring 60 cm by 30 cm.

41 33 22 18 16 14 8 7 6 5 4

The maximum total mass that each bin can hold is **90 kg**.
The top of each bin measures 90 cm by 90 cm.
Each bin costs $13.50 .

Use Method 4 to put these items into bins.
Show that this is a best solution and find the cost of this solution.

Bin	Mass of items in bin	Unused mass in bin					Number of items
1							
2							
3							
4							
5							

$ .... [5]

B MODELLING (QUESTIONS 5 to 7)

HALF-LIVES (30 marks)

You are advised to spend no more than 50 minutes on this part.

Some chemicals decay naturally. This means that their mass reduces.
This task is about the decreasing mass of these chemicals.
The *half-life* is the time it takes for the mass of a chemical to become half of its mass.

Lee uses different models to look at some of these chemicals.

5 **(a)** The half-life of chemical A is 100 minutes.
Lee has 400 grams of this chemical.
Lee uses this model for the mass, in grams, of chemical A which remains at time t minutes.

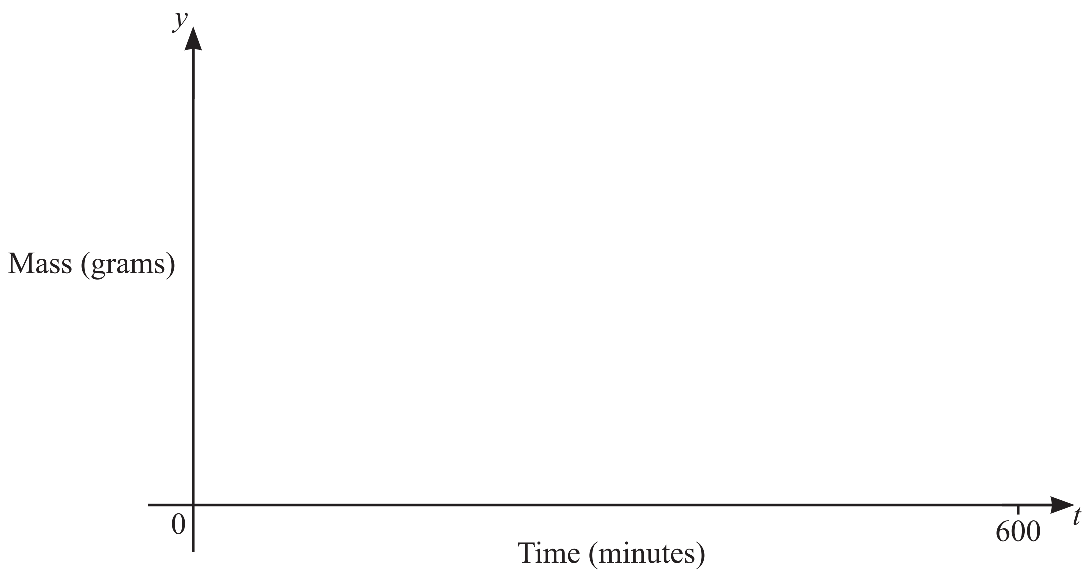
$$\mathrm{A}(t) = 400\left(\frac{1}{2}\right)^{\frac{t}{100}}$$

At the end of 1 half-life, $t = 100$ and half of the mass of chemical A, 200 g, remains.
At the end of 2 half-lives, $t = 200$ and 100 g of chemical A remains.

(i) Find the mass, in grams, of chemical A which remains at the end of 4 half-lives.

.... [2]

(ii) On the axes below, sketch the graph of $y = \mathrm{A}(t)$ for $0 \leqslant t \leqslant 600$.



[2]

(iii) Find the decrease in mass from $t = 50$ to $t = 100$.

.... [2]

(iv) Find the number of half-lives when the mass remaining is 10 grams.
Give your answer correct to 2 decimal places.

.... [3]

(b) The half-life of chemical B is 30 minutes.
Lee has 200 grams of this chemical.

(i) Change the model from **part (a)** to find the mass, in grams, of chemical B which remains at time t minutes.

$$\mathrm{B}(t) = \ldots\ldots \times \left(\frac{1}{2}\right)^{\ldots\ldots}$$

[1]

(ii) Find the fraction of the mass of chemical B which remains at the end of 300 minutes.

.... [2]

(c) The *quarter-life* is the time it takes for the mass of a chemical to become a quarter of its mass.
At the end of 1 *quarter-life*, one quarter of the mass remains.

The quarter-life of chemical C is 48 minutes.
Lee has 240 grams of this chemical.
He changes the model from **part (a)** so that it finds the mass, in grams, of chemical C which remains at time t minutes.
His model is valid for 6 quarter-lives.

Complete Lee's model.

$\mathrm{C}(t) =$ .... for .... $\leqslant t \leqslant$ .... [3]

6 Lee now uses this model in his calculations for the mass of a chemical which remains at time *t* minutes.

$$N(t) = N_0 \times 3^{kt} \quad \text{where } k \text{ is a constant}$$

(a) (i) Explain why N_0 is the mass of the chemical Lee starts with.

.... [1]

(ii) Write an expression in terms of N_0 for the mass remaining at the end of 1 half-life.

.... [1]

(iii) Lee thinks $3^{kH} = \frac{1}{2}$, for any starting mass N_0 and any half-life H minutes.

Show that Lee is correct.

[1]

(b) The half-life of chemical *D* is 10 minutes.

(i) Use logarithms to show that the value of *k* for chemical *D* is −0.063, correct to 3 decimal places.

[2]

(ii) Lee has 40 grams of chemical *D*.

Use N(t) to find the time it takes for the mass of chemical *D* to become 10% of its mass.

.... [4]

7 Lee has 60 grams of chemical *E*.
This decreases by 11 grams in 1.6 minutes.

(a) Use $N(t) = N_0 \times 3^{kt}$, where *k* is a constant, to find the half-life of chemical *E* in minutes.

.... [5]

(b) Change the model from **Question 5(a)** to find the mass, in grams, of chemical *E* which remains at time *t* minutes and use it to check your answer to **Question 7(a)**.

[1]

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