

T Level Technical Qualification in Science**(603/6989/9)**

Paper B Elements 11–12

Paper number: **P001932**
Assessment date: **Friday 23 June 2023**Time allowed: **2 hours 30 minutes**
Time: **9:00am – 11:30am****Student instructions**

- Use black or blue ink.
- Fill in the boxes at the bottom of this page.
- Answer **all** questions.
- Read each question carefully.
- You **must** write your responses in the spaces provided. There may be more space than you need.
- You may do rough work in this answer book. Cross through any work you do not wish to be marked.

Student information

- The marks available for each question are shown in brackets. This is to help you decide how long to spend on each question.
- The maximum mark for this paper is **119**.
- In questions **8, 13 and 20**, you will be assessed on the quality of your written communication (QWC). Specifically, your ability to:
 - express and organise ideas clearly and logically
 - use appropriate technical terms.
- In questions **5(a), 5(b), 11(b)** and **16** you will be assessed on your application of maths
- You may use a calculator

Do not turn over until the invigilator tells you to do so.**Please complete / check your details below**

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Provider Name:

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For the multiple-choice questions, write **A, B, C** or **D** in the answer space. Do **not** circle **A, B, C** or **D** in the question.

For example:

Answer **C**

If you change your mind about an answer, you must put a cross through your original answer and then write your new answer next to it.

For example:

Answer ~~C~~ **B**

Section A: Biology

This section is worth **45** marks; plus **3** marks for the quality of written communication (QWC) and the use of specialist terminology.

Answer all questions in the spaces provided.

- 1** A pathology technician is using the Giemsa stain technique on a sample of sputum from a patient.

Which **one** of the following statements describes **one** purpose of the Giemsa stain technique?

[1 mark]

- A** To identify Gram-positive and Gram-negative bacteria
- B** To identify specific bacteria or parasites
- C** To give an image of the cytoplasmic components of an animal cell
- D** To stain viruses so they can be viewed under the light microscope

Answer _____



2 A virologist needs to examine the structure of the outer surface of a virus.

Which **one** of the following is the most appropriate type of microscope to examine the structure?

[1 mark]

- A Compound microscope
- B Light microscope
- C Scanning electron microscope
- D Transmission electron microscope

Answer _____

3 Two organisms have the following volumes:

organism A volume = $62,000\text{cm}^3$

organism B volume = 4.8cm^3

(a) Explain why **organism A** is most likely to require a specialised gaseous exchange surface.

[2 marks]

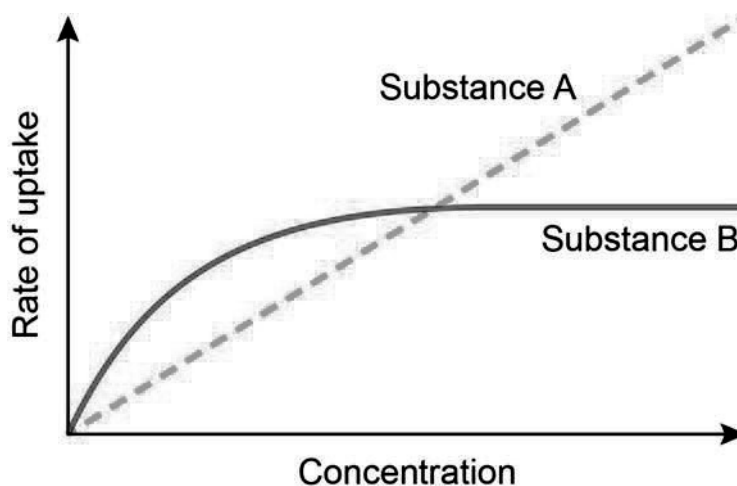
(b) Describe why these specialised gaseous exchange surfaces are often only one cell thick.

[1 mark]



- (c) A scientist wanted to investigate the differences between simple diffusion and facilitated diffusion. They did this by measuring the concentration of **two** different substances in the same cell over a period of time. They calculated the rate of uptake and produced the graph shown in **Figure 1**.

Figure 1: A graph to show rate of uptake of **two** different substances into the same cell



The scientist concluded that substance B moved into the cell by simple diffusion and substance A moved into the cell by facilitated diffusion.

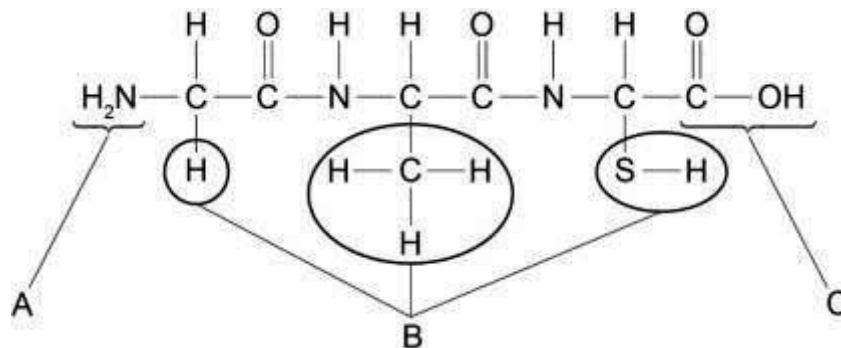
Assess the scientist's conclusion.

[3 marks]



4 **Figure 2** represents a simple diagram of three amino acids which have been joined together during the formation of a larger polypeptide.

Figure 2: Diagram of three amino acids joined together



(a) Identify groups **A**, **B** and **C**.

[3 marks]

(b) State the name of the reaction which occurs when amino acids join to form dipeptides and polypeptides.

[1 mark]



- 5 **Table 1** shows the amount of energy available from three different respiratory substrates, expressed as kilojoules of energy per gram (kJg^{-1}) of substrate.

Table 1: Amount of energy from three different substrates

Respiratory substrate	Energy value / kJg^{-1}
Carbohydrate	15.8
Lipid	39.4
Protein	17

A culture of bacteria was grown on an agar plate containing 12g of carbohydrate.

- (a) Calculate the maximum amount of energy available to the bacteria from this plate.

Show your working and include appropriate units.

[2 marks]

- (b) Calculate the **percentage** of energy that would be provided by carbohydrate, if 3g of protein was added to the plate in question 5a.

Show your working and give your answer to one decimal place.

[2 marks]



(c) Give **one** function of carbohydrates and **one** function of lipids, other than as a respiratory substrate.

[2 marks]

(d) 'Lipids are a better source of energy for respiration than carbohydrates.'

Use the information above and your knowledge of the structure and properties of carbohydrates and lipids to discuss the validity of this statement.

[3 marks]

Please turn over for the next question.

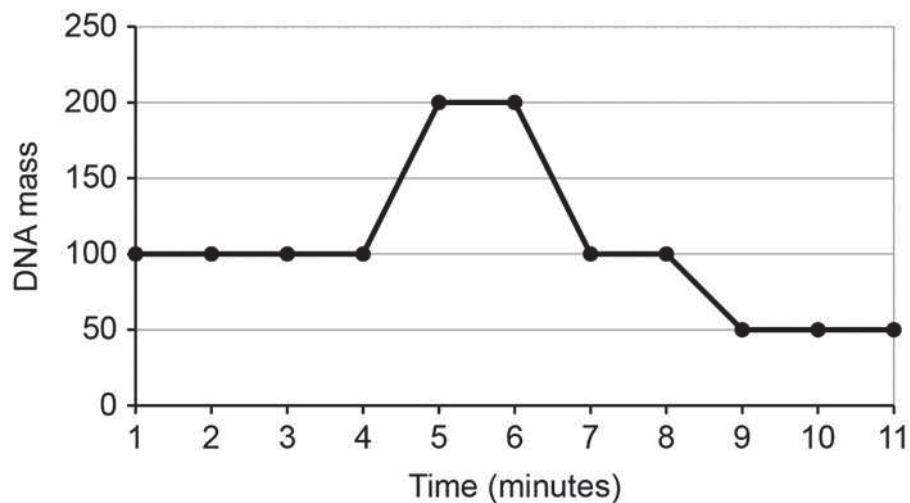


- 6(a) Describe what happens to the number of chromosomes per nuclei in **one** complete cycle of mitosis and **one** complete cycle of meiosis.

[2 marks]

- 6(b) **Figure 3** shows the changes in DNA mass during one complete cell cycle in a human.

Figure 3: Change in DNA mass during cell division over time



Explain whether **Figure 3** represents meiosis or mitosis.

[2 marks]



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6(c) Give the reason for the change in DNA mass between 4 and 6 minutes in **Figure 3** based on this type of cell division.

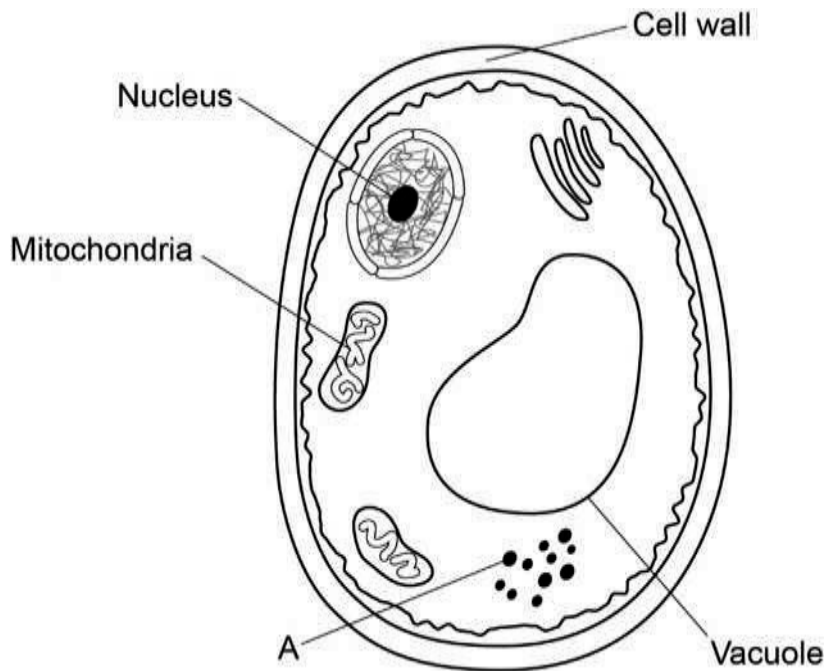
[1 mark]

Please turn over for the next question.



7(a) **Figure 4** is a diagrammatic representation of a single cell.

Figure 4: Representation of a single cell



(i) Identify the structure labelled as 'A' in the diagram.

[1 mark]

(ii) State the function of structure A.

[1 mark]



(b) Give **one** feature from **Figure 4** that proves this cell is a eukaryote **and** state its function. **[2 marks]**

(c) A student makes the conclusion that **Figure 4** represents a single plant cell from a plant root.

Discuss the extent to which this conclusion can be supported.

Your response must demonstrate reasoned judgements and conclusions.

[3 marks]

Please turn over for the next question.



Section B: Chemistry

This section is worth **27** marks, plus **3** marks for the quality of written communication (QWC) and use of specialist terminology.

Answer **all** questions in the spaces provided.

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- 9** Reacting hydrochloric acid and sodium hydroxide produces a salt and water.

Which of the following is the name of the salt produced in this acid-base reaction?

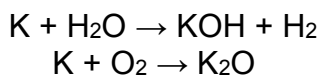
[1 mark]

- A** Calcium chloride
- B** Sodium chloride
- C** Sodium sulfate
- D** Zinc hydroxide

Answer _____

- 10** Potassium (K) reacts violently in water (H₂O) and oxygen (O₂).

The unbalanced chemical equations are shown below:



- (a)** Give the balanced equation for the reaction of potassium with water.

[1 mark]



- (b) Give the balanced equation for the reaction of potassium with oxygen. [1 mark]

- (c) A scientist is trying to find out the quickest way to produce a large volume of hydrogen gas. They carry out the same reaction using two different metals and record the rate of each reaction in **Table 2**.

Table 2: Results from the scientist's preliminary investigation, where gs^{-1} is grams per second

Metal	Rate of reaction (gs^{-1})
Potassium(${}^{39}_{19}\text{K}$)	0.23
Caesium(${}^{133}_{55}\text{Cs}$)	0.35

The scientist then concludes that the best metal to use would be caesium.

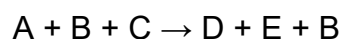
Evaluate the scientist's initial conclusion.

Your evaluation must include reference to the electronic configuration and reactivity of the metals.

[3 marks]



11(a) Consider the following reaction:



Scientists obtain the data in **Table 3** for this reaction.

Table 3: Data obtained from reaction

Conditions	Rate (gs^{-1})
Without reagent B at 25°C	0.00561
Without reagent B at 35°C	0.00667
With reagent B at 25°C	0.00788

Using the information provided above, explain the role of reagent known as **B** in this reaction.

[2 marks]



- 11(b)** Scientists then conduct the following timed experiments on this reaction without reagent **B** at an increased temperature of 70°C.

They obtain the following kinetic data:

Table 4: Mass of A+B+C after 120 seconds

Time (seconds)	Mass of 'A+B+C' (grams)
0	6.7
120	5.3

Calculate the rate of reaction in gs^{-1} (grams per second).

Show your working and give your answer to two significant figures.

[2 marks]

- 11(c)** An industry is interested in using reagent **B** for this reaction for large scale production of substance D.

Using the data provided in **Table 3**, describe **one** advantage of using reagent **B** in an industrial reaction.

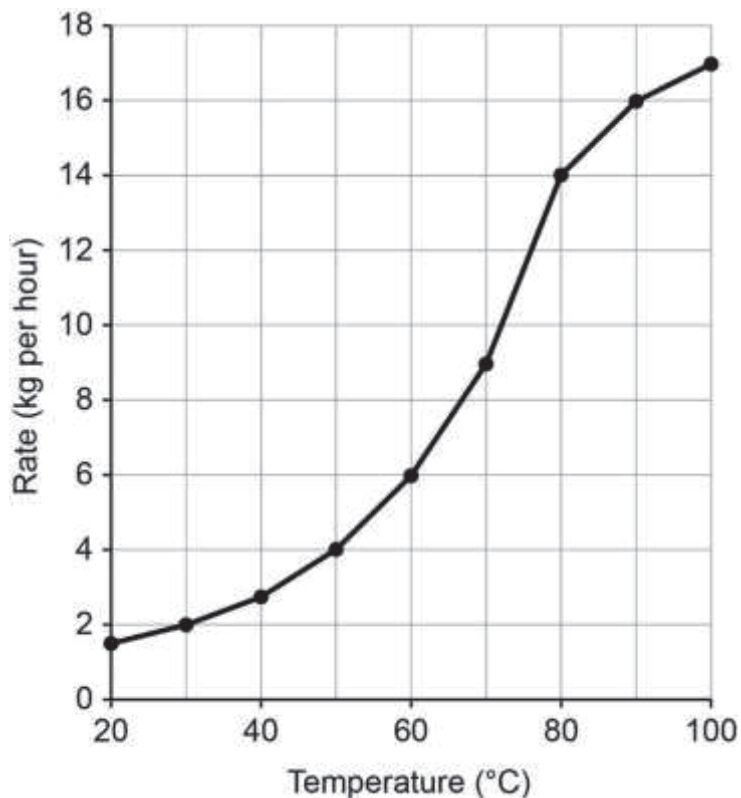
Ensure your answers are different to what you have provided in question **11a**.

[2 marks]



- 11(d) Scientists conduct an initial investigation of the industrial reaction, without the use of reagent **B**, using different temperatures. They obtain the graph shown in **Figure 5**.

Figure 5: Graph to show how temperature affects rate of reaction when not using reagent B



A scientist states: 'Based on the graph, temperatures of greater than 100°C are needed in order to acquire the highest rate of reaction and therefore make the most amount of money.'

With reference to activation energy, discuss the scientist's statement.

[3 marks]



12 A manufacturing company that produces cooking utensils is investigating which material is best suited to use within the food industry.

Prior to the investigation, they have produced utensils using metal but are now considering using a high-density polymer instead.

Give **three** reasons why the company might choose to use the high-density polymer.

[3 marks]

Please turn over for the next question.



Section C: Physics

This section is worth **18** marks.

Answer **all** questions in the spaces provided.

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14 Which of the following is the correct definition of the half-life of a radioactive element? **[1 mark]**

- A** The length of time taken for half of a population of living organisms to die
- B** The length of time taken for an unstable nucleus to split in half
- C** The length of time taken for half the unstable nuclei in a sample to decay
- D** The length of time taken for the weight of the sample to halve

Answer _____

15(a) A town obtains its electricity supply from a coal-powered power plant. Electricity at the plant is generated by steam turbines that spin a magnet inside a coil of wire.

It generates electricity at a voltage of 230V and 50Hz.

To supply enough electricity during peak times, an engineer plans to increase the turbine speed to meet this demand.

Using your knowledge of electromagnetic induction, suggest how increasing the frequency of the turbine's rotation would affect the properties of the electricity being generated.

[2 marks]



15(b) An alternative generator that produces electricity at a voltage of 330V and 60Hz is also available.

The engineer suggests that this can be used to provide additional power directly into the network if needed.

Using your knowledge of the requirements and properties of mains electricity, evaluate this plan.

Your response should include reasoned judgements and conclusions.

[3 marks]

Please turn over for the next question.



- 16** Sonar waves are transmitted through water with a wavelength of 0.75m and a frequency of 2.1kHz.

The equation used to calculate wave speed is:

$$v = f\lambda$$

Calculate the speed of these waves through water.

Show your working and include the correct units in your answer.

$$1 \text{ kHz} = 1000\text{Hz}$$

[3 marks]



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17(a) Give **three** properties of alpha particles.

[3 marks]

17(b) A scientist is performing an experiment using a source of gamma radiation.

For safety reasons, the scientist decides to perform the experiment inside an airtight containment cabinet, where they are always shielded from the sample by 5mm of plastic.

The experiment will last 3 hours, during which time the scientist plans to wear standard personal protective equipment (PPE). This consists of a standard laboratory coat and safety goggles, along with a device to monitor levels of radiation exposure.

The laboratory manager states that the planned safety measures are not robust enough and need improving.

Using your knowledge of gamma radiation and its properties, justify the laboratory manager's statement.

Your answer should include reasoned judgements and conclusions.

[6 marks]



Section D: Scientific concepts

This section is worth **20** marks, plus **3** marks for quality of written communication (QWC) and use of specialist terminology.

Answer **all** questions in the spaces provided.

18 Biological washing powders contain enzymes which can break down the biological materials that cause stains on clothing.

For optimum effectiveness, biological washing powders should not be used at temperatures over 40°C.

Use your knowledge of the effect of temperature on enzyme structure to explain why.

[2 marks]

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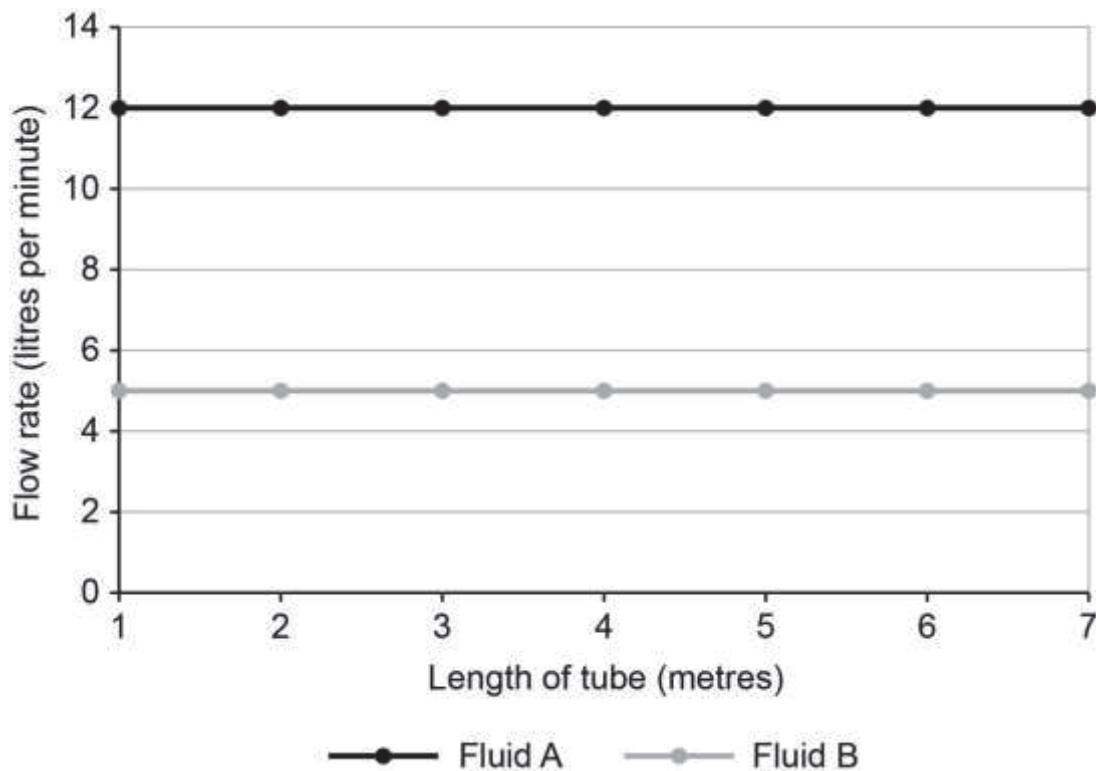
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- 19 **Figure 7:** Information about two different fluids flowing through the same tube at different times



- (a) Explain the type of flow rate shown on the graph.

[2 marks]



- (b) (i) In relation to liquids, define the term 'viscosity.' **[1 mark]**
- (ii) Assuming the same pump is used to create the flow of each fluid, explain which fluid is likely to have the highest viscosity. **[2 marks]**

(c) A student states that increasing flow rate would cause turbulent flow, as the friction between the tube walls and the parts of the fluid in contact with the tube walls would increase.

- (i) Define the term 'turbulent flow'. **[1 mark]**
- (ii) Evaluate the validity of the student's statement. **[3 marks]**



- 20** Invertase is an enzyme which breaks down sucrose into glucose and fructose. It is used in the food industry as fructose is much sweeter than sucrose and can therefore be used in smaller amounts.

A student investigated the rate of sucrose breakdown with two different arrangements of invertase. The student wanted to measure the concentrations of the three sugars after each process and detect if enzymes were present in the product.

The procedure is described below:

Arrangement A

- 1ml of 1% invertase suspension was added to 100ml of 5% sucrose solution in a beaker
- the beaker was stirred constantly
- after 20 minutes, a sample was taken from the beaker and the concentration of any substance present was measured using gas chromatography.

Arrangement B

- invertase was immobilised by attaching the enzyme to small inert beads
- 1ml of a 1% suspension of these beads was added to 100ml of 5% sucrose solution in a beaker
- the beaker was incubated at 40°C and stirred constantly
- after 20 minutes, the contents of the beaker were passed through a filter which retained the beads
- a sample of the filtrate was taken, and the concentration of any substance present was measured using gas chromatography.

Table 5: Results of Arrangements A and B

	Arrangement A - Relative concentration of substances in arbitrary units	Arrangement B - Relative concentration of substances in arbitrary units
Sucrose	12	32
Glucose	44	34
Fructose	44	34
Protein	0	0

A student studying the results concluded:

- **Arrangement A** is better for fructose production as there is a higher relative concentration of fructose in arbitrary units.
- **Arrangement B** may have reduced the ability of invertase to break down sucrose.



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To be completed by the examiner			
Question	Mark	Question	Mark
1		10 (b)	
2		10 (c)	
3 (a)		11 (a)	
3 (b)		11 (b)	
3 (c)		11 (c)	
4 (a)		11 (d)	
4 (b)		12	
5 (a)		13	
5 (b)		14	
5 (c)		15 (a)	
5 (d)		15 (b)	
6 (a)		16	
6 (b)		17 (a)	
6 (c)		17 (b)	
7 (a)		18	
7 (b)		19 (a)	
7 (c)		19 (b)	
8		19 (c)	
9		20	
10 (a)			
		TOTAL MARK	

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