T-LEVELS | Institute for Apprenticeships & Technical Education

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

Paper B Elements 11–12

Paper number: **P002411**
Assessment date: **Friday 15 December 2023**
Time allowed: **2 hours 30 minutes**
Time: **9:00am – 11:30am**

Student instructions

- Use black 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 **9, 15 and 24,** 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 **7 (b), 10 (c)** and **17** 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

Student Name:

Provider Name:

Student Number: Provider Number:

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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 quality of written communication (QWC) and use of specialist terminology.

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

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1 Which group of pathogens does *Candida auris* belong to?

[1 mark]

A Bacteria

B Fungi

C Prions

D Viruses

Answer _____

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2 Which **one** of the following protein molecules is an example of a fibrous protein?

[1 mark]

A Antibodies

B Collagen

C Enzymes

D Haemoglobin

Answer _____

Please turn over for next question.

3 (a) Name **one** of the main groups of lipids.

[1 mark]

(b) State **four** roles of lipids in living organisms.

[4 marks]

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(c) Phagocytes are a type of white blood cell that ingest invading microbes into vesicles called phagosomes. Lysosomes containing enzymes, fuse with the phagosomes and the enzymes digest the microbes.

As well as containing lysosomes, the cytoplasm of phagocytes has increased levels of rough endoplasmic reticulum.

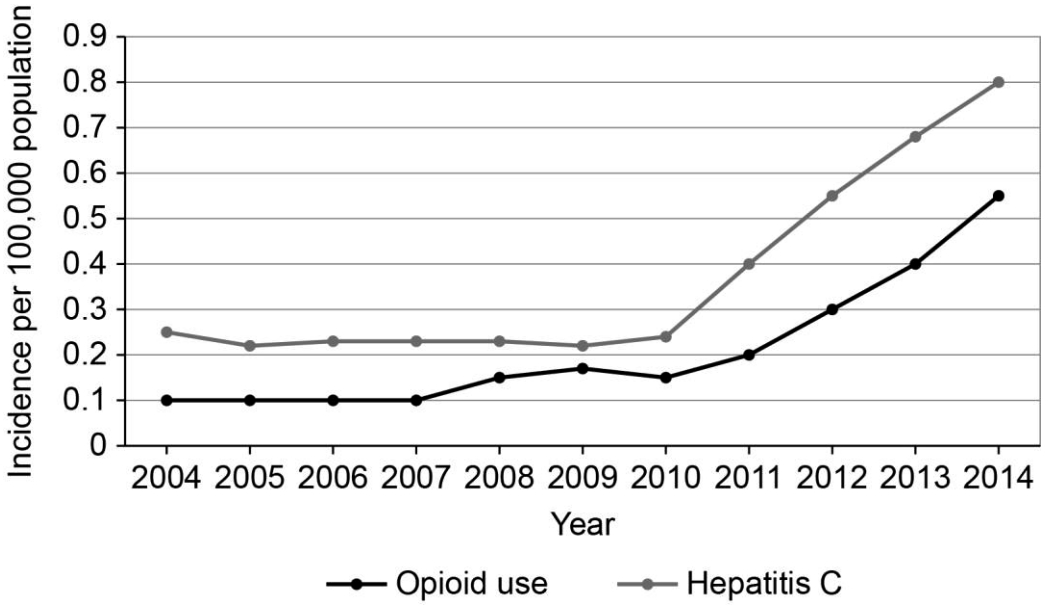
Explain how the cells having increased levels of rough endoplasmic reticulum benefits the process of phagocytosis.

[2 marks]

Please turn over for next question.

4 **Figure 1** shows the incidence of hepatitis C and opioid drug use in a state in the USA. The most common method of taking the drug was via intravenous injection.

Figure 1: Incidence of hepatitis C and opioid drug use in a state in the USA



(a) Using **Figure 1**, describe **two** trends showing the relationship between hepatitis C and opioid drug use.

[2 marks]

(b) Using your knowledge of transmission of disease, suggest **one** reason for the relationship shown in **Figure 1**.

[1 mark]

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5 A lecturer in infection control made the statement,

'The spread of infectious pathogens can always be reduced by avoiding physical contact with an infected person and increasing social distancing.'

(a) Define the term infection.

[1 mark]

(b) Discuss the validity of the lecturer's statement.

Your response should include reasoned judgements and a conclusion.

[3 marks]

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(c) A strain of antibiotic resistant bacteria that has caused numerous hospital-acquired infections is being investigated.

Initially scientists isolate and sequence the complete genetic material. They then go on to investigate the role of each gene within the genetic material to try and identify genes responsible for the resistance.

A student reading a report on the investigation states,

'This is an example of genomics rather than genetics.'

Discuss the validity of the student's statement.

Your response should include reasoned judgements and a conclusion.

[3 marks]

Please turn over for next question.

6 A laboratory technician uses a differential staining technique to prepare a slide of bacteria. Microscopic examination of the slide shows a mixture of bacteria; some are stained pink, and some are stained purple.

(a) Suggest which differential staining technique the technician used to prepare this slide.

[1 mark]

(b) Name **two** other differential staining techniques.

[2 marks]

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7 *Helicobacter pylori* is a bacterial species that is carried in the stomach of many people. About 10% of carriers will go on to develop stomach ulcers caused by the bacteria.

Bacteria that can move independently in their environment are described as being motile. *Helicobacter pylori* is highly motile. A research student is investigating whether motility of the bacteria is linked to their ability to cause ulcers and needs to observe the motility of the bacterium.

Helicobacter pylori cells are typically 3 μm long and 0.5 μm wide.

Resolution is the shortest distance between two points on a specimen that can still be seen as two different points.

Table 1: shows the maximum resolution of two different types of microscopes

Type of microscope	Maximum resolution
Light microscope	200 nm
Scanning electron microscope (SEM)	1–20 nm

1 μm = 1000 nm

(a) Using the information provided and your knowledge of different types of microscopes, assess which type of microscope would be the most appropriate for this investigation.

[3 marks]

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(b) On a photograph of *Helicobacter pylori,* taken from a microscope, each bacterial cell is 18 mm long.

Helicobacter pylori cells are typically 3 μm long and 0.5 μm wide.

You can use the following equation to calculate magnification:

$$\text{magnification} = \frac{\text{size of image}}{\text{size of object}}$$

Calculate the magnification used to create the photograph.

1 mm = 1000 μm

You must show your working.

[4 marks]

(c) *Helicobacter pylori* is a prokaryote.

Give **two** features of a prokaryotic cell that would **not** be found in a eukaryotic cell.

[2 marks]

8 Mitosis always produces two daughter cells that are genetically identical to the parent cell.

(a) State the role of the centrioles in mitosis.

[1 mark]

(b) Identify the stage in which the nuclear envelope reforms to produce two daughter cells.

[1 mark]

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9 The genetic code in DNA and RNA consists of 4 different bases arranged in groups of 3 called triplets. In total this arrangement leads to 64 different triplets. These 64 triplets have to code for 20 amino acids.

To promote discussion, a lecturer delivering a lesson on DNA made the following statement:

'If there were only 3 different bases, and these were still arranged in combinations of 3, this arrangement would lead to 27 different triplets. This suggests that the structure of DNA is unnecessarily complicated.'

With reference to the structure, function and mechanism of action of DNA and RNA, evaluate the accuracy of this statement.

Your response should include reasoned judgements and conclusions.

Calculations are not required.

[12 marks, plus 3 marks for QWC]

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This is the end of section A.
Please turn over for next section.

Section B: Chemistry

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

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

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10 (a) Which **one** of the following describes empirical formula?

[1 mark]

A The largest ratio of atoms of each element in a compound

B The simplest ratio of atoms of each element in a compound

C The total mass of all atoms of each element in a compound

D The total number of atoms of each element in a compound

Answer _____

(b) Give **one** use of mass spectrometry.

[1 mark]

_____

_____

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(c) Scientists are investigating a new compound they have synthesised in the laboratory. They understand the empirical formula of this compound to be $C_{10}H_7O$ and the mass of the atoms in the empirical formula to be 143.

Upon further analysis, scientists determine the relative molecular mass to be 286.

Work out the molecular formula of this compound.

You must show your working.

[2 marks]

Please turn over for next question.

11 A team of scientists is comparing isotopes of carbon-12 (^{12}C) and carbon-13 (^{13}C). They have recorded their findings in **Table 2**.

Table 2: Isotopic data for carbon

Isotope	Atomic mass	Atomic number	Number of neutrons
^{12}C	12	6	6

(a) Using **Table 2**, which details the isotopic data for ^{12}C, suggest **two** similarities the scientists would expect to see in the structure of ^{12}C and ^{13}C.

[2 marks]

(b) Using **Table 2**, describe **two** differences between ^{12}C and ^{13}C.

[2 marks]

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12 Titanium is a transition metal often used in surgical implants, such as hip replacements.

(a) Describe **one** property of titanium which makes it a good choice for a hip replacement.

[2 marks]

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(b) Laboratory technicians are developing a new material to use in electrical wiring. They combine titanium with copper, silver or gold. They also use a wire made of pure copper as a control as this is a common component in traditional electrical wiring. Wire options C, D and E use the same ratio of titanium to other metal.

A technician states that the combination of silver and titanium would be the most appropriate option to use in wiring.

Table 3: Initial results

Wire option	Combination of elements in the wire	Electrical conductivity	% Elongation (ductility)
A	Copper only	9.22×10^{3}	13
B	Titanium only	2.4×10^{-6}	20–40
C	Titanium and copper	3.11×10^{3}	11
D	Titanium and silver	4.21×10^{4}	12
E	Titanium and gold	3.21×10^{-1}	5

Using **Table 3**, assess the technician's statement.

[3 marks]

13 A technician dropped a small piece of potassium into some water contained within a glass beaker.

Below is the unbalanced symbol equation for the reaction that subsequently took place:

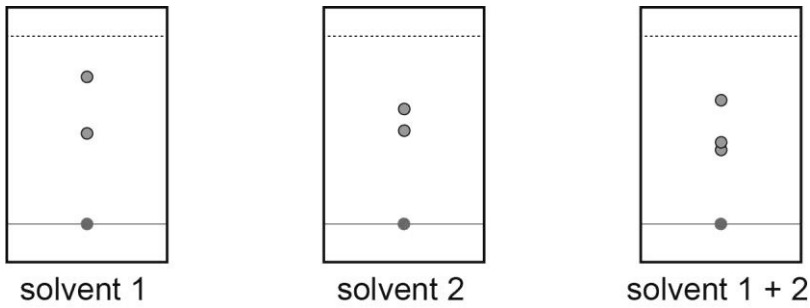
$$K(s) + H_2O(l) \rightarrow KOH(aq) + H_2(g)$$

Work out the balanced symbol equation for the reaction described above.

[2 marks]

14 A mixture of product A and product B needs to be purified. The lab manager asks for a thin layer chromatography (TLC) analysis using two different solvents.

Figure 2: Chromatograms after carrying out a TLC analysis



A colleague suggests that **solvent 1** should be used when carrying out future analysis as it shows the best separation.

Using **Figure 2**, assess the colleague's suggestion.

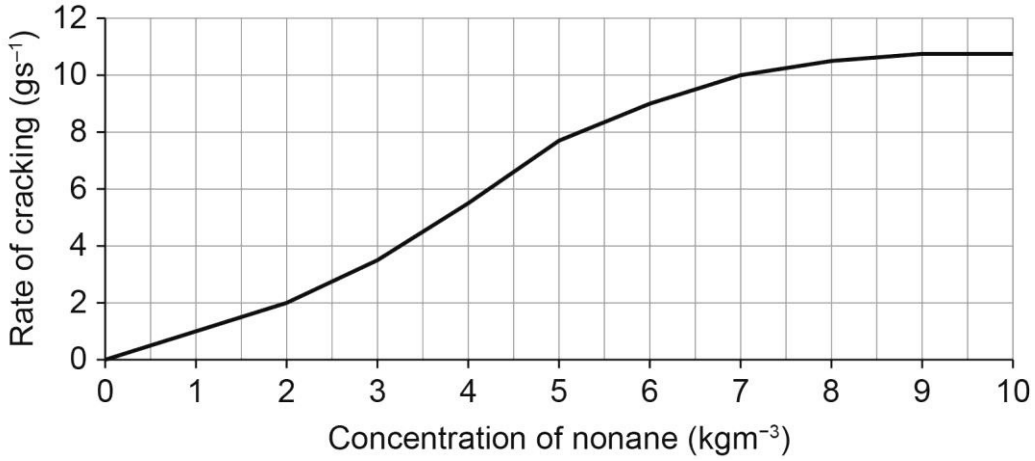
[3 marks]

Please turn over for next question.

15 A team of industrial scientists is studying a process that splits a very long molecule, called nonane, into shorter molecules using a catalyst.

The team started its investigation by using one type of catalyst at a fixed temperature and pressure. They changed the concentration of nonane and recorded the rate of reaction. Their results are shown in **Figure 3.**

Figure 3: Graph of nonane concentration against rate of reaction



One of the scientists suggests that if the temperature or pressure were increased, the rate of reaction would not level off at higher concentrations of nonane.

Using **Figure 3**, your knowledge of collision theory and factors affecting rate of reaction, evaluate the scientist's suggestion.

Your response should include reasoned judgements and conclusions.

[9 marks, plus 3 marks for QWC]

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This is the end of section B.
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Section C: Physics

This section is worth **18** marks.

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

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16 (a) Which **one** of the following states the area of a magnet where the magnetic forces are strongest?

[1 mark]

A The centre

B The north and south poles

C The north pole only

D The south pole only

Answer _____

(b) State **one** difference between permanent and induced magnets.

[1 mark]

_____

_____

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(c) An experiment is prepared in which an iron bar is placed inside a coil of wire.
A current is passed through the wire for 10 seconds, and then turned off.
The magnetic field around the iron bar is measured before, during and after the current is passed through.

Before the current is passed through the wire, the magnetic field strength measures zero.

State how the measurements for magnetic field strength would change as the current is passed through the wire and as the current is switched off again.

[2 marks]

Please turn over for next question.

17 A charge of 200 coulombs flows through a circuit for 10 seconds.

The following equation can be used to calculate charge:

$$Q = It$$

Using this equation, calculate the average current.

You must show your working and provide the correct units.

[4 marks]

18 State **one** difference between alternating current and direct current.

[1 mark]

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19 A physicist is investigating hydrostatic pressure by carrying out an experiment similar to the one carried out by the scientist Blaise Pascal in the 17th century.

The experiment involves filling a large glass jar with water, sealing the neck of the jar with a bung and a rubber tube extending from this. The physicist extends the tube from the glass jar on the ground floor up the outside of the building, to the 50th floor.

The physicist hypothesises that as they fill the tube with water, the glass jar will shatter.

Using your knowledge of hydrostatic pressure, justify the physicist's hypothesis.

Your response should include reasoned judgements and a conclusion.

[3 marks]

Please turn over for next question.

20 Nuclear scientists are investigating four synthetic isotopes of iodine:

- iodine-123 (^{123}I)
- iodine-129 (^{129}I)
- iodine-131 (^{131}I)
- iodine-135 (^{135}I).

They hope to find an isotope that allows a relatively safe way to study beta radiation.

Table 4 shows the data the scientists are provided with relating to the synthetic isotopes of iodine.

Table 4: Data relating to the four synthetic isotopes of iodine

Isotope	Half-life	Main type of ionising radiation emitted
^{123}I	13.2 hours	Gamma
^{129}I	15 700 000 years	Beta
^{131}I	8 days	Beta
^{135}I	6.6 hours	Beta

One nuclear scientist suggests that researching ^{129}I would be the safest isotope to use as its half-life is the longest and therefore it is the most stable. They reason that less specialised personal protective equipment (PPE) will be required due to the stability of the isotope.

With reference to radioactive decay, general laboratory safety and the data provided in **Table 4**, assess the scientist's suggestion.

Your response should include reasoned judgements and conclusions.

[6 marks]

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This is the end of section C.
Please turn over for next section.

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.

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21 Copper is ductile, an excellent electrical conductor and is used in electrical cabling. However, if the current rate of use continues, we may eventually run out of copper.

Explain **two** other properties a metal would need to be able to replace copper in electrical cables.

[4 marks]

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22 Scrap metal yards often use powerful magnets suspended from cranes to move scrap iron and steel around.

Explain **two** reasons why an electromagnet would be more useful than a permanent magnet in this situation.

[4 marks]

23 You are part of a team designing an electric motorbike to be used for racing. You are working on the outer casing for the battery pack to power the bike.

You are interested in investigating the use of a polymer. However, one of your colleagues states that the casing should be stainless steel, as stainless steel is strong, unreactive and can easily be moulded into the appropriate shape.

Assess the use of a polymer over stainless steel for the battery casing.

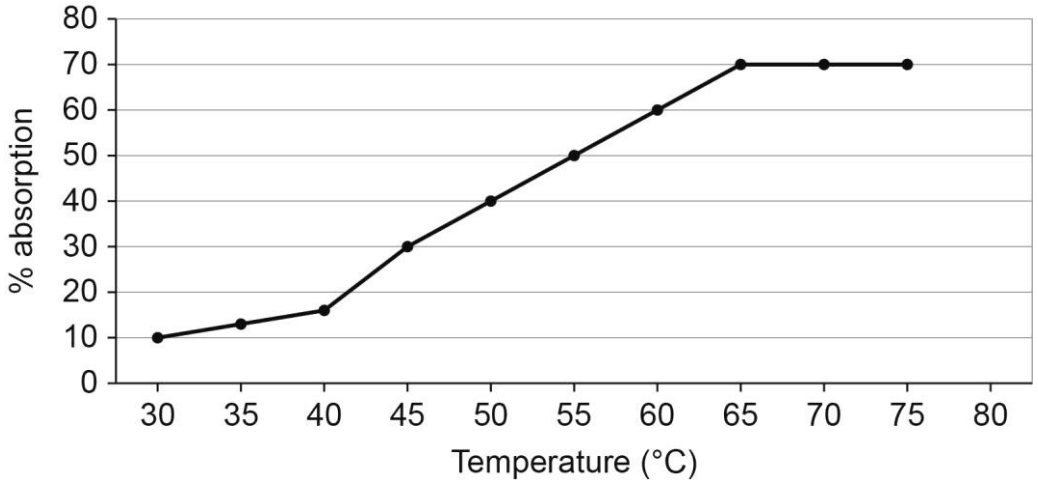
[3 marks]

24 An investigation was carried out into the relationship between membrane permeability and temperature using spinach leaves.

1 g of chopped spinach was placed into several boiling tubes with 10 ml of alcohol. The tubes were placed in water baths at different temperatures. After 15 minutes, the spinach was removed and the amount of chlorophyll released was obtained by measuring the amount of light absorbed by the chlorophyll: the higher the absorption, the higher the chlorophyll.

The results are shown in **Figure 4**.

Figure 4: A graph to show the effect of temperature on absorption



A student studying the results concludes:

'Cell surface membrane permeability in plants does increase as the temperature increases. This happens because the higher temperatures cause the cell surface membrane structure to break down.'

Considering the structure and properties of the cell surface membrane, and the processes used in the investigation, evaluate the validity of the student's conclusion.

Your response should include reasoned judgements and conclusions.

[9 marks, plus 3 marks for QWC]

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Owner: Head of Assessment Design

To be completed by the examiner			
Question	Mark	Question	Mark
1		10 (c)	
2		11 (a)	
3 (a)		11 (b)	
3 (b)		12 (a)	
3 (c)		12 (b)	
4 (a)		13	
4 (b)		14	
5 (a)		15	
5 (b)		16 (a)	
5 (c)		16 (b)	
6 (a)		16 (c)	
6 (b)		17	
7 (a)		18	
7 (b)		19	
7 (c)		20	
8 (a)		21	
8 (b)		22	
9		23	
10 (a)		24	
10 (b)			
		TOTAL MARK	