

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

Core knowledge and understanding

Paper B – Biology, Chemistry, Physics
and Science in Context

Paper number: Sample

Specimen 2021

Morning/Afternoon

Time allowed: 2 hours 30 minutes

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 **5**, **8** and **14 (c)**, you will be assessed on your quality of written communication (QWC) and use of specialist terminology.
- In questions **3 (a) (ii)**, **3 (b)**, **6 (b)**, **6 (c)**, **7 (a)**, **7 (b)** and **7 (c)**, you will be assessed on your application of maths.
- You may use a calculator.

Please complete the details below clearly and in BLOCK CAPITALS.

Student name _____

Provider name _____

Student number

Provider number

Do not turn over until the invigilator tells you to do so.

BARCODE - TQ/SCI/CKU/PAPERB

To be completed by the examiner			
Question	Mark	Question	Mark
1(a) (i)		7 (a)	
1 (a) (ii)		7 (b)	
1 (b)		7 (c)	
1 (c)		7 (d)	
2 (a)		8	
2 (b)		9 (a)	
2 (c)		9 (b)	
2 (d)		9 (c)	
2 (e)		9 (d)	
3 (a)		9 (e)	
3 (a) (i)		10	
3 (a) (ii)		11	
3 (b)		12	
3 (c)		13	
4		14 (a)	
5		14 (b)	
6 (a)		14 (c)	
6 (b)			
6 (c)			
			TOTAL MARK

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 ~~B~~ **B**

Section A: Biology

This section is worth 45 marks, plus 3 marks for QWC and use of specialist terminology. Answer **all** questions in the spaces provided.

1 (a) (i) Select which **one** of the following statements describes a role of the plasma membrane of cells.

[1 mark]

- A. They are the site of antibody production in the immune system.
- B. They are the site of glucagon receptors involved in blood glucose control.
- C. They are the site of pores allowing mRNA transfer into the cytoplasm.
- D. They are the site of mRNA translation in the production of insulin.

Answer _____

1 (a) (ii) Which **one** of the following groups of organelles shows **all** the organelles involved in the manufacture and secretion of digestive enzymes?

[1 mark]

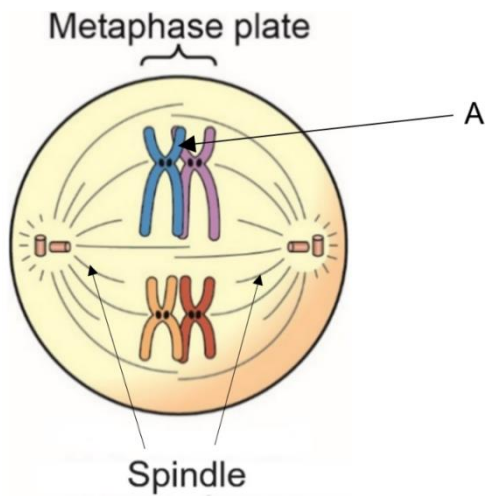
- A. Nucleus, ribosomes, Golgi apparatus, permanent vacuole.
- B. Nucleus, ribosomes, centrioles, permanent vacuole.
- C. Nucleus, ribosomes, Golgi apparatus, centriole.
- D. Nucleus, ribosomes, endoplasmic reticulum, Golgi apparatus.

Answer _____

1 (b)

The diagram below shows a cell during meiotic cell division.

Crossing over occurred at the point indicated by the arrow marked A.



Describe **two** ways in which the diagram shows that this is meiotic rather than mitotic division.

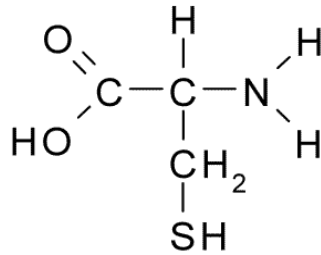
[2 marks]

1 (c)

Describe **two** differences between cells produced from meiosis and cells produced from mitosis.

[2 marks]

- 2 (a)** The diagram below shows the structure of a specific amino acid.



Explain the unique tertiary protein structure.

role this amino acid can play in a

[2 marks]

- 2 (b)** The table below shows the base sequence of two DNA codons and their complementary mRNA codons.

	Codon			Codon		
Coding strand of DNA	T	A	C	G	T	C
mRNA transcribed	A	U	G	C	A	G
tRNA anticodon						

Complete the table to show the base sequence of the corresponding tRNA anticodons.

[2 marks]

2 (c)

The table below shows the mRNA codons and the amino acids coded for by each codon.

		2 nd letter					
		U	C	A	G		
1 st letter	U	UUU Phe UUC UUA Leu UUG	UCU UCC Ser UCA UCG	UAU Tyr UAC UAA Stop UAG Stop	UGU Cys UGC UGA Stop UGG Trp	U C A G	
	C	CUU CUC Leu CUA CUG	CCU CCC Pro CCA CCG	CAU His CAC CAA Gln CAG	CGU CGC Arg CGA CGG	U C A G	
	A	AUU AUC Ile AUA AUG Met	ACU ACC Thr ACA ACG	AAU Asn AAC AAA Lys AAG	AGU Ser AGC AGA Arg AGG	U C A G	
	G	GUU GUC Val GUA GUG	GCU GCC Ala GCA GCG	GAU Asp GAC GAA Glu GAG	GGU GGC Gly GGA GGG	U C A G	

The genetic code is described as degenerate.

Use information from the table to explain the implications of a degenerate code for mutation.

[3 marks]

2 (d) In a class discussion, a student stated that primary protein structure is the most important factor in the formation of functional enzymes.

Assess the validity of this statement.

Your response should demonstrate:

- reasoned judgements and/or conclusions.

[4 marks]

2 (e) The Human Genome project determined the base pair sequence that makes up human DNA and mapped the entire human genetic material.

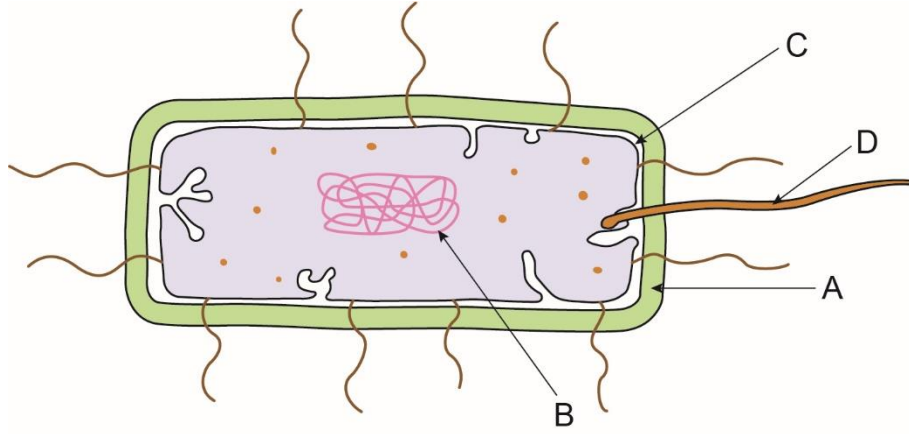
Explain why this would not be regarded as genetics.

[2 marks]

3 (a) The diagram below represents a micrograph of a typical bacterium. In the micrograph, the width of part A is measured as 2mm.

The magnification used was $\times 25\ 000$.

- (i) Name parts A, B, C and D
- (ii) Calculate the actual width of part A in nm.



[5 marks]

3 (b)

A laboratory grew a culture of a bacterium with glucose solution as the bacterial substrate. The starting population of the bacteria in the culture was 1.5×10^4 cells per ml.

Assume that each cell divides every 30 minutes and that no cell dies during this time.

Calculate how many cells there would be in 1ml of the culture after 3 hours.

Give your answer to the calculation in standard form.

[2 marks]

3 (c)

Describe **two** factors which could prevent this rate of growth from being achieved.

[2 marks]

**This page is intentionally left blank.
Please turn over for the next question.**

SAMPLE

4 A scientist removed four identical squares of the small intestine of a rat and placed these in four separate beakers: A, B, C and D.

The scientist then added two different sugars and a respiratory inhibitor as shown in the table.

After 20 minutes, they measured the amount of sugar absorbed in each, in mg per minute.

	Beaker A	Beaker B	Beaker C	Beaker D
Type of sugar added	Sugar X	Sugar X	Sugar Y	Sugar Y
Respiratory inhibitor added	No	Yes	No	Yes
Amount of sugar absorbed mg per minute	25	25	42	4

The scientist made the following conclusions:

- sugar X was transported passively by diffusion
- sugar Y was mainly transported actively
- sugar Y was also transported to a lesser extent passively by diffusion
- sugar Y may be a significantly larger molecule than sugar X.

(a)

Describe the effect the respiratory inhibitor would have.

(b)

Use the results from the table above to evaluate **each** of the scientist's conclusions.

[5 marks]

SAMPLE

Please turn over for the next question.

5

Human influenza viruses can undergo antigenic drift and antigenic shift.

Antigenic drift

Minor changes occurring frequently in the viral genes can lead to changes in the surface proteins of the virus, which form antigens, creating new closely related viruses with slightly altered antigens.

Over time, the small changes accumulate, producing viruses with significantly different antigens.

Antigenic shift

Major changes occurring much less frequently but abruptly in the viral genes can lead to significant and sudden changes in the antigens, forming a new viral sub-type that most of the human population will not have encountered.

Using the information above, evaluate the relative impact of antigenic drift and antigenic shift to human health.

[12 marks plus 3 marks for QWC]

SAMPLE

This is the end of section A.

Section B: Chemistry

This section is worth 27 marks, plus 3 marks for QWC and use of specialist terminology.
Answer **all** questions in the spaces provided.

- 6 (a)** A compound with the empirical formula CH_2 has the relative molecular mass of 28.
Which of the following gives the molecular formula for this compound?

[1 mark]

- A** CH_8
B CH_4
C C_2H_4
D C_3H_6

Answer _____

- 6 (b)** Half a litre of saline solution is made up using 9g of sodium chloride.
Calculate the concentration and molarity of the saline solution.

23	35.5
Na	Cl
11	17

[3 marks]

6 (c)

A concentration of 3.2×10^{-2} g of NaF per kg of body mass causes significant physiological problems and could be lethal.

Calculate the mass of NaF in mg a child of 30kg would need to consume to reach the potentially lethal level.

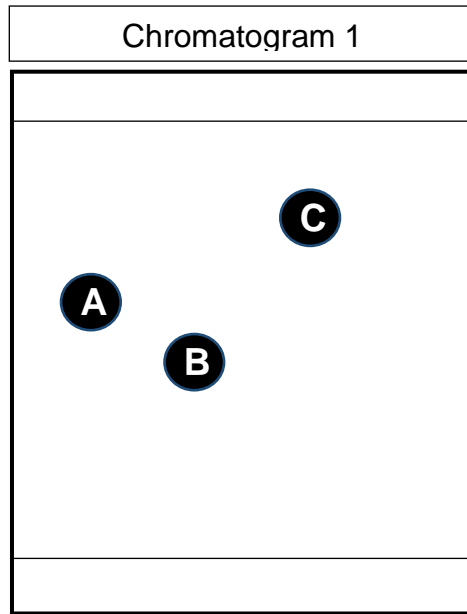
Show your working.

[2 marks]

Please turn over for the next question.

SAMPLE

7 (a)



The diagram above shows a thin layer chromatogram.

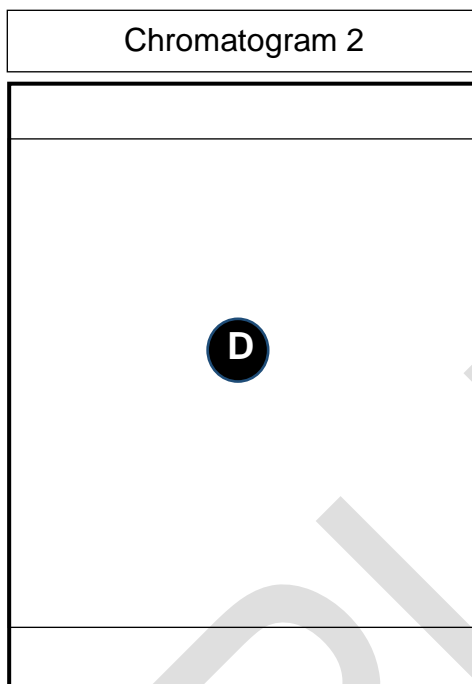
The chromatogram had run for 30 minutes using the following standard solutes:

- solute A = sucrose standard
- solute B = fructose standard
- solute C = glucose standard.

Calculate the R_f values for solutes A, B and C.

[3 marks]

- 7 (b)** Solute D is an unknown sugar and was run for 30 minutes, in identical conditions to chromatogram 1, on a second thin layer chromatogram, shown below.



A scientist concludes that solute D is sucrose.

Explain why this is correct.

[2 marks]

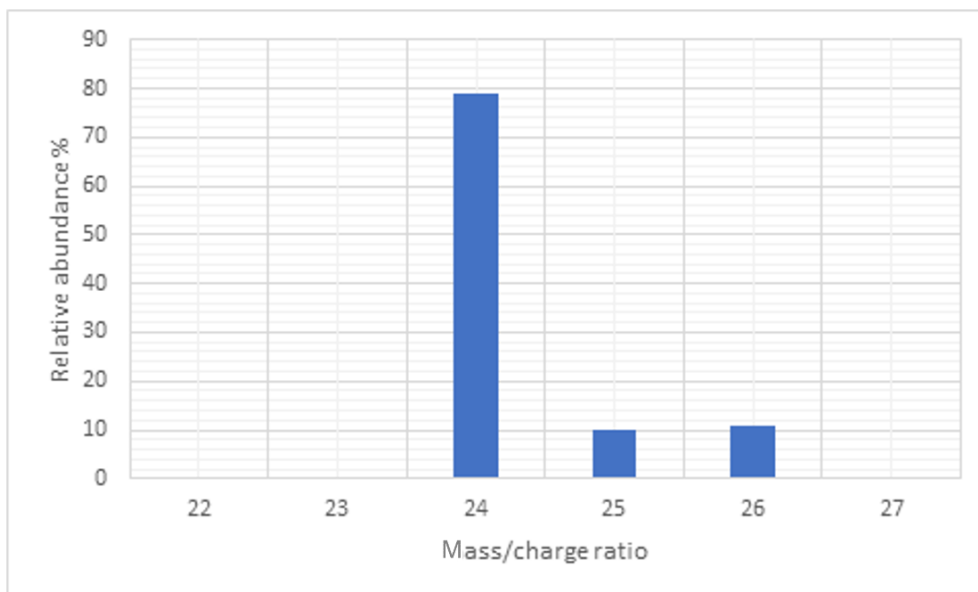
- 7 (c)** If solute D had run for 60 minutes in the same conditions, what would its R_f value have been?

[1 mark]

7 (d)

A sample of magnesium is being investigated to find out if it came from the same source as a batch of stolen magnesium. The stolen batch has an A_r of 24.34.

Mass spectrometry was used to analyse the magnesium sample and produced this spectrum:



A scientist draws the following conclusions from the data about the sample of magnesium:

- the sample of magnesium is an alloy of magnesium consisting of only 3 isotopes
- these have the mass numbers 24, 25 and 26
- the relative abundance of the isotopes is 78%, 10% and 12% respectively
- the A_r for this sample of magnesium is 24.34
- the sample is from the same source as the stolen batch of magnesium.

Evaluate the scientist's conclusions.

Your response should demonstrate:

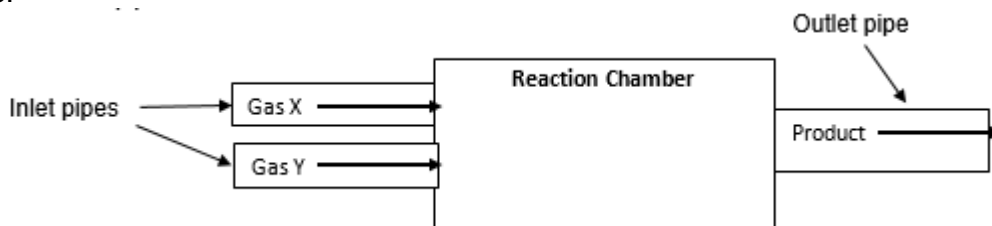
- reasoned judgements and/or conclusions.

[6 marks]

SAMPLE

Please turn over for the next question.

8 A scientist wanted to maximise production rate by finding out the optimum distribution for using a catalyst. He passed two gases, gas X and gas Y, through a reaction chamber. He measured the rate of production in the outlet pipe to determine reaction rate.



The same mass of catalyst was used in arrangements A, B and C.

The reaction was carried out at different temperatures.

The rate of reaction is given in arbitrary units.

Temperature of reaction chamber °C	A Reaction chamber lined with a layer of catalyst	B Reaction chamber with the catalyst in granular form at the bottom	C Reaction chamber divided into a 'honeycomb' of hundreds of smaller tubes each lined with catalyst
50	0	0	0
60	0	0	0
70	0	0	0
80	5	4	6
90	10	8	12
100	22	17	25
110	40	33	48
120	150	164	210

Evaluate the methods used to find the optimum distribution for the catalyst. Use data from the table to support your answer.

Your response should include:

- reasoned judgements and/or conclusions.

[9 marks plus 3 marks for QWC]

SAMPLE

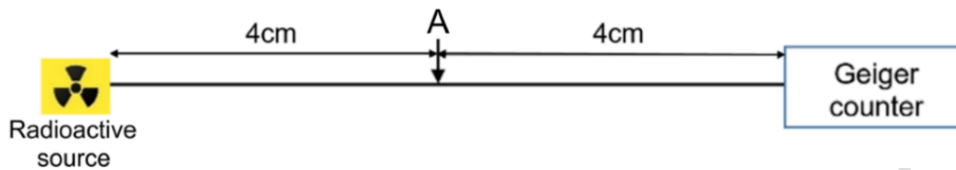
This is the end of section B.

Section C: Physics

This section is worth 18 marks.

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

9 (a) Study the diagram below:



A physicist places sheets of different materials at point A.

The readings from the Geiger counter are shown below:

Material at point A	Reading from Geiger counter
No material	750
Paper	750
Aluminium foil	150
Lead sheeting	25

What type or types of radiation is the source emitting?

[1 mark]

- A β and γ only.
- B α and β only.
- C γ only.
- D β only.

Answer _____

9 (b) Petri dishes are packed and sealed in plastic and sterilised as part of the manufacturing process.

The petri dishes are packaged before being sterilised by irradiation.

Comparing alpha and gamma radiation, recommend which would be the most suitable for sterilisation and explain why.

[3 marks]

9 (c)

Colour	Red	Orange	Yellow	Green	Blue	Violet
Wavelength nm		590–620	570–590	495–570		380–450
How deep the light penetrates in metres	10	20	35	45	100	80

The table above shows the wavelength range of visible light and penetration of clear water.

Use the information from the table to fill in the blank wavelength ranges.

[2 marks]

9 (d) A marine biologist makes this hypothesis:

“We should expect to find marine animals which have a red or black colouration living in water below depths of 15m because this will give them an advantage.”

Assess the marine biologist's hypothesis.

Your response should include reasoned judgements and/or conclusions.

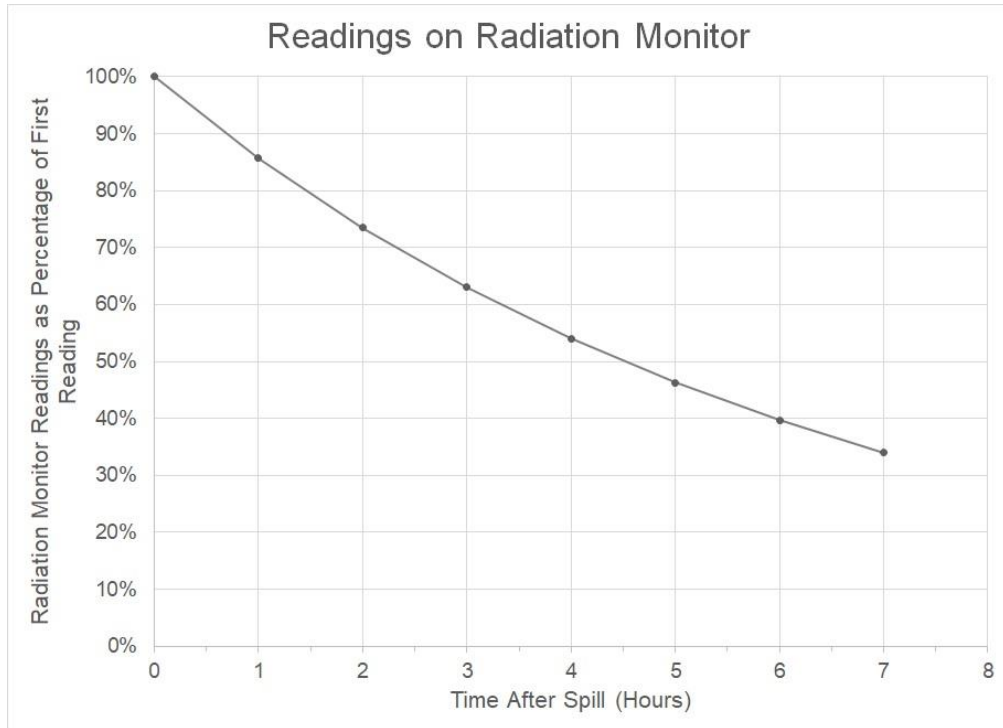
[4 marks]

9 (e) Describe the differences between longitudinal and transverse waves.

[2 marks]

10

A workbench has become contaminated by a gamma-emitting radioactive material, and radiation monitor readings have been taken throughout the day. The results are shown below:



The lab is closed at weekends, so the manager is considering two options to deal with the spill:

- have staff manually decontaminate the workbench now
- temporarily seal the lab and resume work on Monday.

Evaluate which option would be better. Your response should consider:

- the concept of 'half-life'
- a discussion of the two options
- reasoned judgements and/or conclusions about which would be better.

[6 marks]

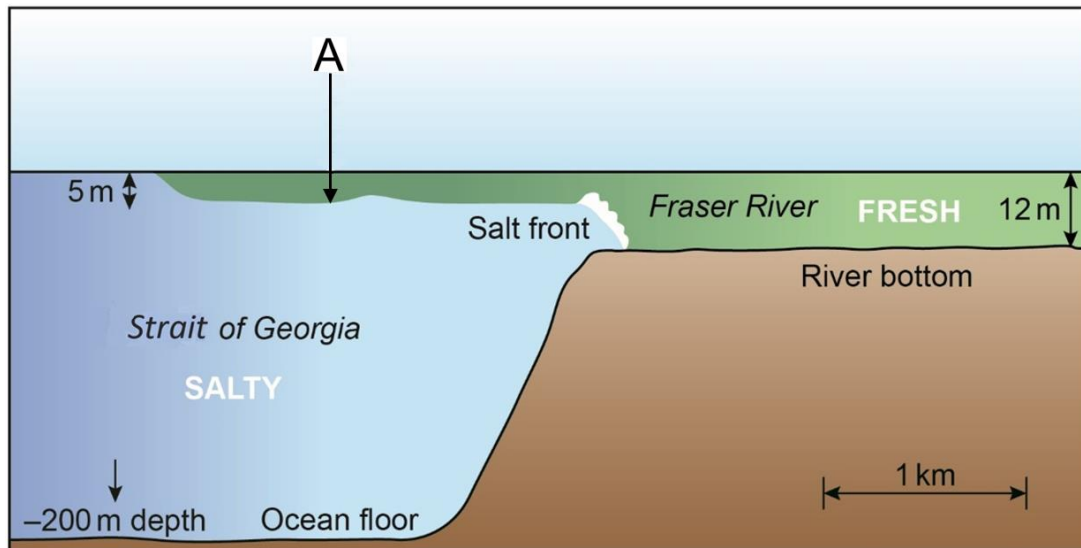
SAMPLE

This is the end of section C.

Section D: Scientific concepts

This section is worth 20 marks, plus 3 marks for QWC and use of specialist terminology. Answer **all** questions in the spaces provided.

- 11 A solid rubber ball is accidentally dropped from a boat. The ball sinks **slowly** through the water but stops at the point marked by arrow A, as shown on the diagram below.

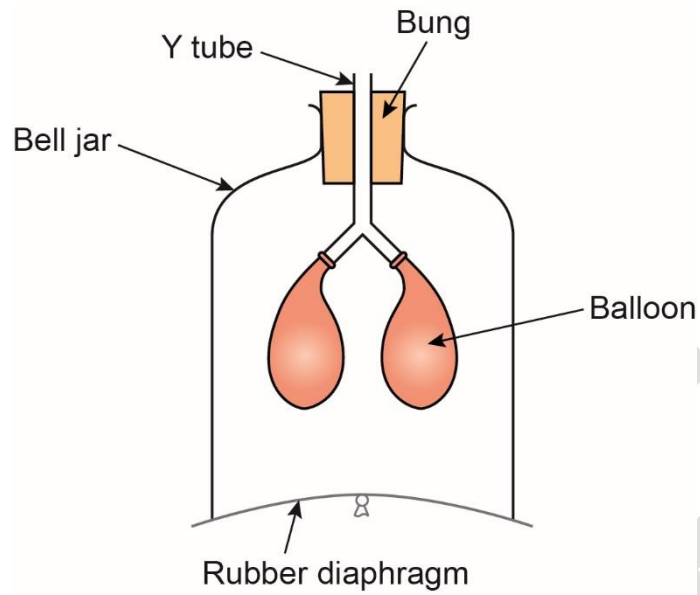


Explain why the ball behaved in this way.

[3 marks]

12

The model shown below is used to explain the mechanism of inhalation.



When the rubber diaphragm is pulled down, the volume of the bell jar increases.

Explain what happens to the pressure inside the bell jar and why this will cause the balloons to inflate if the temperature remains constant.

[2 marks]

13

Viruses should **not** be regarded as living organisms.

Discuss this statement.

Your response should demonstrate:

- reasoned judgements and/or conclusions.

[3 marks]

Please turn over for the next question.

SAMPLE

14

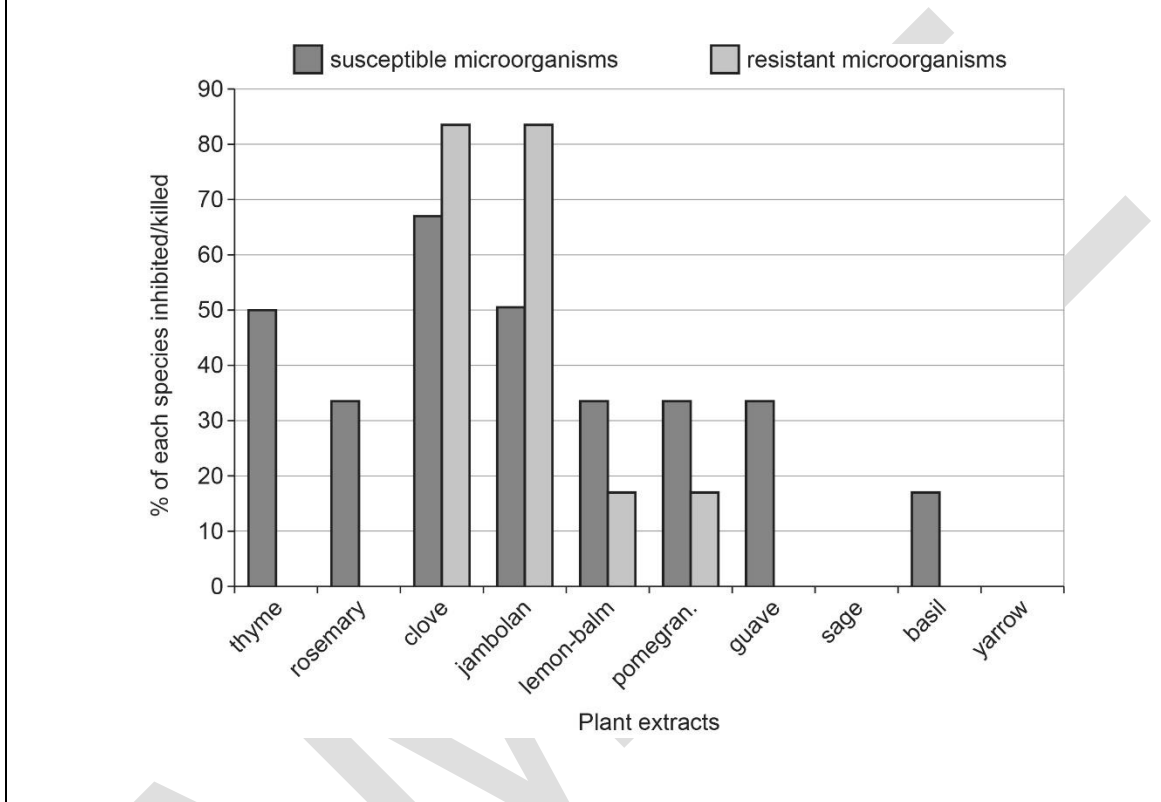
Scenario

Scientists studied the effectiveness of extracts from 10 different plants on 14 different pathogenic bacteria.

Some bacteria were susceptible to antibiotics and others had significant resistance.

The plant extracts were applied to the bacteria growing on agar plates, followed by examination to see if the bacteria had been inhibited.

The graph below shows their results.



- 14 (a)** The scientists realised that each of the plant extracts contained a variety of molecules. Identify a procedure the scientists could use to separate these.

[1 mark]

14 (b) Give **two** reasons why clove extract may be the **most** effective against pathogenic bacteria.

[2 marks]

This question continues on the next page.

SAMPLE

14 (c)

A student studied the results shown on the chart given in the scenario at the beginning of this question.

The student concluded that:

- some plant extracts are effective against pathogenic bacteria and could be used in the control of infection and disease
- sage and yarrow extracts were not effective.

Evaluate the student's conclusions. Use information from the scenario to support your answer.

Your response should demonstrate reasoned judgements and/or conclusions.

[9 marks plus 3 marks for QWC]



This is the end of the external assessment.

SAMPLE

SAMPLE

This page is intentionally left blank.

SAMPLE

This page is intentionally left blank

SAMPLE

This page is intentionally left blank.

Document information

The T Level Technical Qualification is a qualification approved and managed by the Institute for Apprenticeships and Technical Education.

Copyright in this document belongs to, and is used under licence from, the Institute for Apprenticeships and Technical Education, © 2020-2023.

'T-LEVELS' is a registered trade mark of the Department for Education.

'T Level' is a registered trade mark of the Institute for Apprenticeships and Technical Education.

'Institute for Apprenticeships & Technical Education' and logo are registered trade marks of the Institute for Apprenticeships and Technical Education.

Owner: Head of Assessment Design

Change History Record

Version	Description of change	Approval	Date of Issue
v1.0	Published.		2020
v1.1	NCFE rebrand.		September 2021
v1.2	Sample added as a watermark	November 2023	22 November 2023