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 2022 **Morning/Afternoon**

Time allowed: 2 hours 30 minutes

To be completed by the examiner			
Question	Mark	Question	Mark
1		13	
2		14	
3 (a)		15 (a)	
3 (b)		15 (b)	
3 (c)		16	
4 (a)		17	
4 (b)		18	
5 (a)		19 (a)	
5 (b)		19 (b)	
5 (c)		20	
6 (a) (i)		21	
6 (a) (ii)		22	
6 (b)		23	
7		24 (a)	
8		24 (b)	
9		25 (a)	
10		25 (b)	
11		25 (c)	
12 (a)		26	
12 (b)			
		TOTAL MARK	

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 **10, 17** and **26**, you will be assessed on your quality of written communication (QWC) and use of specialist terminology. Specifically, your ability to:
  - use good English
  - express and organise ideas clearly and logically
  - use appropriate technical terms.
- In questions **5 (c), 6 (b), 13 and 20** you will be assessed on your application of mathematics.
- 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

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 QWC and use of specialist terminology.
Answer **all** questions in the spaces provided.

1 Identify which of the following is a major component of a bacterial cell wall.

[1 mark]

A Cellulose

B Cytoplasm

C Peptidoglycan

D Phospholipids

Answer _____

2 Which of the following statements best describes triglycerides?

[1 mark]

A They are the precursors of steroid hormones

B They contain one glycerol and three fatty acid molecules

C They contain one glycerol, two fatty acid molecules and a phospholipid molecule

D They have a hydrophilic tail

Answer _____

3 (a) State the name of the type of reaction that produces a dipeptide.

[1 mark]

3 (b) **Figure 1** below represents a dipeptide.

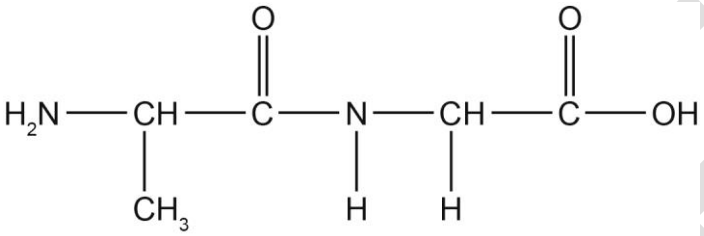


Figure 1

Suggest how many different types of amino acid are present in this dipeptide.

[1 mark]

3 (c) A particular polypeptide is made up of 250 amino acids.

(i) State the maximum number of different types of amino acids that could be present in this polypeptide.

(ii) Give the number of water molecules that would be produced in its formation.

[2 marks]

4 (a) Identify **three** organelles only found in plant cells and not in animal cells.

[3 marks]

4 (b) Name **one** organelle which is not found in plant root cells.

[1 mark]

5 (a) A section of a nucleic acid is 120 base pairs long, 45 of the bases are adenine and 45 are thymine.

Give **one** piece of evidence, from the information provided, that the nucleic acid is DNA rather than RNA**.**

[1 mark]

5 (b) Complete the table in **Figure 2**, to show how many cytosine and guanine bases there will be.

Base	**Adenine**	**Cytosine**	**Guanine**	**Thymine**
Number of each base	45			45

Figure 2: Number of bases

[2 marks]

5 (c) Express the number of guanine bases as a percentage of the total number of bases in this section of DNA and give your answer to **one** decimal place.

Show your working.

[2 marks]

6 **Figure 3** below shows a diagram created using a photomicrograph of a stained slide of various bacteria viewed under a light microscope.

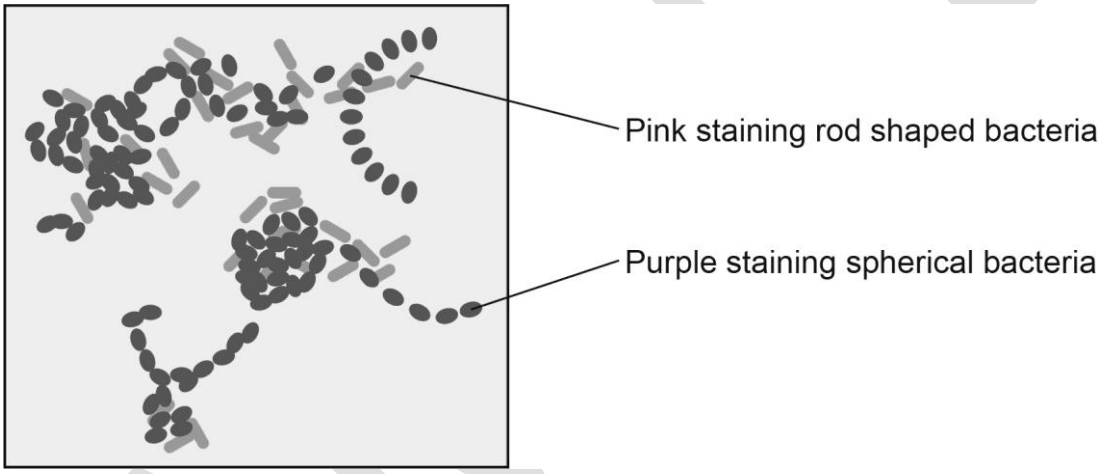


Figure 3: Stained slide

6 (a) (i) State **one** advantage of using a light microscope over an electron microscope when studying bacteria.

(ii) Give the name of the staining technique used to prepare the slide in figure 3.

[2 marks]

6 (b) The length of one of the rod-shaped bacteria on the original photomicrograph in figure 3 was 6 mm, the actual length was 4 µm.

The equation used to calculate magnification is:

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

Calculate the magnification used in the photomicrograph.

1mm = 1000µm

[2 marks]

7 Give the names of **two** disaccharides.

[2 marks]

This page is intentionally left blank.

Please turn over for the next question.

8 Bacteria can be grown on agar plates. Agar is a gel that contains the nutrients bacteria require to grow. The type of nutrients in the agar gel can be changed depending on the investigation.

Molten agar is poured into a sterile petri dish and left to cool and set forming an agar plate. As the bacteria grow, they form round colonies on the surface of the agar.

A student investigated the ability of a non-pathogenic species of bacteria to grow using different carbohydrate sources.

They used the following method:

1. Prepared an agar plate with glucose as the energy source
2. Added 0.1 ml of a suspension of the bacteria to the centre of the agar plate
3. Placed the lid on the agar plate
4. Incubated the agar plate at 37 °C for 48 hours
5. Measured the diameter of the bacterial colony, if present, after 48 hours
6. Repeated steps 1 to 5 with four other carbohydrates.

The results are shown in **Figure 4** below:

Carbohydrate	**Diameter of colony after 48 hours (mm)**
Glucose	12
Fructose	11
Sucrose	8
Maltose	8
Starch	2

Figure 4: Results

The student made the following conclusion:

'Glucose is the best energy source for bacteria, as it is a monosaccharide and therefore the easiest for bacteria to use.'

Evaluate this conclusion.

Your response should demonstrate:

- an understanding of the role of carbohydrates in metabolism
- reasoned judgements and / or conclusions.

[6 marks]

9 Mitosis and meiosis are both types of cell division employed by a range of organisms. To promote a discussion among their students a biology teacher made the following statements:

- for the survival of an individual member of a species, mitosis is more important than meiosis
- for the survival of the species, meiosis is more important than mitosis.

Evaluate the extent to which the statements can be justified.

Your response should demonstrate reasoned judgements and or conclusions.

[6 marks]

This page is intentionally left blank.

Please turn over for the next question.

10 A year 12 student examined a root tip squash of an onion to observe the stages of mitosis.

They used the following procedure:

- placed the root tip onto a clean slide
- broke up the root tip using mounted needles
- added a stain readily absorbed by chromosomes
- covered the stained root tip with a coverslip and pressed this down firmly
- examined the slide using a light microscope.

The total number of cells observed was 188.

The student recorded the number of cells at each stage of mitosis, as well as the number of cells where the observation was not clear.

The results are shown in **Figure 5** below.

Stage	**Number of cells observed at each stage**	**Percentage of cells at each stage (%)**
Interphase	56	30
Prophase	29	15
Metaphase	8	4
Anaphase	9	5
Telophase	13	7
Cells where observation was unclear	73	39

Figure 5: Table showing number of cells at each stage of mitosis

The student concluded that during mitosis in a root tip:

- the majority of cells will be undergoing mitosis
- most cells will be in interphase.

Evaluate the method used to observe mitosis **and** the student's conclusions.

Your answer should include reasoned judgements and / or conclusions.

[12 marks, plus 3 marks for QWC]

Examiner use only

DO NOT WRITE IN THIS SPACE

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.

11 Citric acid is a chemical found naturally in exotic fruits such as lemons and limes, and is what gives them their tart, sour flavour.

Which one of the following pH ranges would you expect the juice of a lemon to fall in?

[1 mark]

A pH 4–6

B pH 7–9

C pH 10–12

D pH 13–15

Answer _____

12 (a) Helium-4 ($^{4}_{2}He$) is a light atom found in group 8 of the periodic table, it is often used to fill carnival and party balloons.

Describe the arrangement of the $^{4}_{2}He$ atom.

[3 marks]

12 (b) Much like the other gases in group 8, $^{4}_{2}He$ is a noble gas and is considered inert.

With reference to the electronic structure of $^{4}_{2}He$, explain why this atom is inert.

[2 marks]

13 Scientists were interested in studying the effect of heat on a reaction flask containing $^{4}_{2}He$. They took a 2 L flask containing 1 L of $^{4}_{2}He$ at 373 K and heated this to 473 K.

Calculate to **two** decimal places the volume within the flask that $^{4}_{2}He$ occupies at this new temperature. Show your working.

The equation for this calculation is:

$$V_1/T_1 = V_2/T_2$$

[2 marks]

14 The acidity of two solutions in a laboratory is determined by analysing the concentration of hydrogen ions (H^+). Scientists record the following pH values for the two different solutions:

Solution A: pH 1

Solution B: pH 4

With reference to acid / base equilibrium, discuss the pH differences between these solutions.

[2 marks]

15 (a) The group 1 elements in the periodic table are the alkali metals. They are found as the first vertical column on the left-hand side of the periodic table. The second metal within this group is sodium (Na).

Give the balanced symbol equation for the chemical reaction to describe what happens when Na is dropped into water (H_2O).

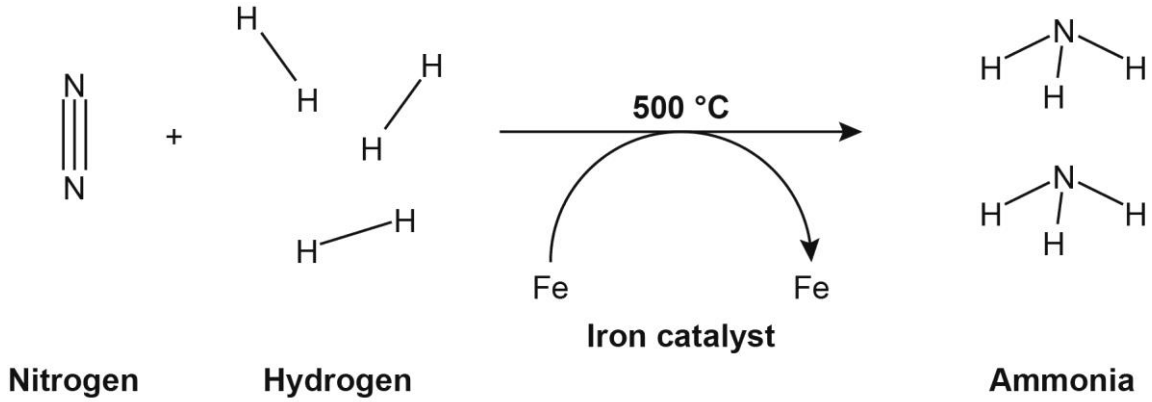
[2 marks]

15 (b) A scientist states that: 'reactions between group 1 metals and water become more reactive as you move down the group'.

Evaluate this statement.

[3 marks]

16 The Haber process is an industrial method of producing ammonia (NH_3). This involves the combination of atmospheric nitrogen (N_2) with hydrogen (H_2). The chemical process is depicted in **Figure 6** below:



Conditions	Rate (gs^{-1})
With catalyst	2.5
Without catalyst	1.5

Figure 6: The Haber process

gs^{-1} = grams per second

During reactions on an industrial scale, an iron (Fe) catalyst is often incorporated into this reaction.

With reference to **Figure 6** and the effect of a catalyst, discuss the use of iron in the Haber process.

[3 marks]

This page is intentionally left blank.

Please turn over for the next question.

17 A team of scientists has potentially synthesised the compound phenylethanone pictured in **Figure 7** below. The team need to confirm the skeletal structure of the compound and are considering mass spectrometry as the analytical technique.

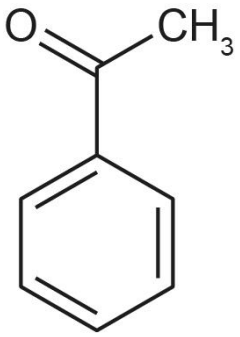


Figure 7: Chemical structure of phenylethanone

Considering other analytical techniques, evaluate the suitability of mass spectrometry in this instance.

Your answer should include reasoned judgements and conclusions.

[9 marks, plus 3 marks for QWC]

Please turn over for the next question.

Section C: Physics

This section is worth 18 marks.
Answer **all** questions in the spaces provided.

18 Which one of the following is a type of electromagnetic radiation commonly used in radiotherapy treatment to kill cancerous cells and shrink tumours in patients who have been diagnosed with cancer?

[1 mark]

A Gamma rays

B Microwaves

C Radio waves

D X-rays

Answer _____

19 **Figure 8** below shows an explosion deep below the surface of the sea occurring at point A.

The energy released during the explosion creates a shock wave that travels out in all directions and reaches a submarine positioned at point B.

The wave causes the submarine to oscillate in the directions indicated by the arrows.

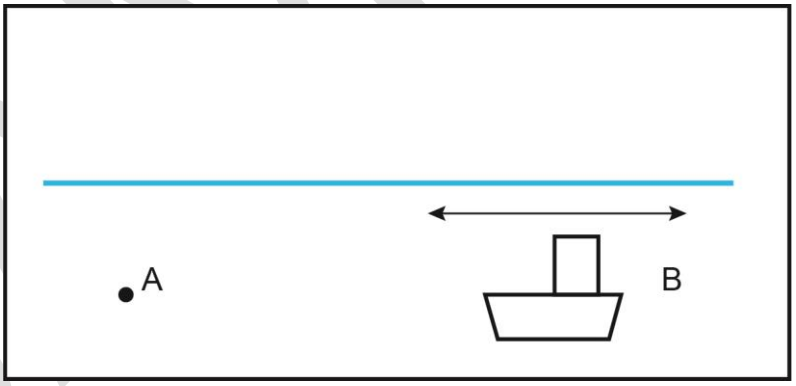


Figure 8: A diagram to show position of an underwater explosion and submarine

19 (a) Identify what type of wave the shockwave is.

[1 mark]

19 (b) Give a reason for your answer to part (a).

[1 mark]

20 When a violinist plays a note of a certain pitch, the violin string vibrates and omits a sound wave with a unique frequency.

Middle C is a musical note with a frequency of 262 Hz.

Assuming the speed of sound is 330 m/s, calculate the wavelength of the wave that is produced when the violinist plays a middle C.

The wave equation is $v = f\lambda$

Show your working and give your answer to **two** decimal places.

[4 marks]

21 Describe **one** difference between direct and alternating current.

[2 marks]

This page is intentionally left blank.

22 A scientist is characterising how an unknown radioactive isotope decays in the laboratory.

A Geiger counter is positioned at varying distances from the sample, ranging from 0–50 cm, and the activity is recorded. The scientist then repeats this experiment, but this time covers the sample in tissue paper.

The readings on the Geiger counter at each distance are shown in **Figure 9** below.

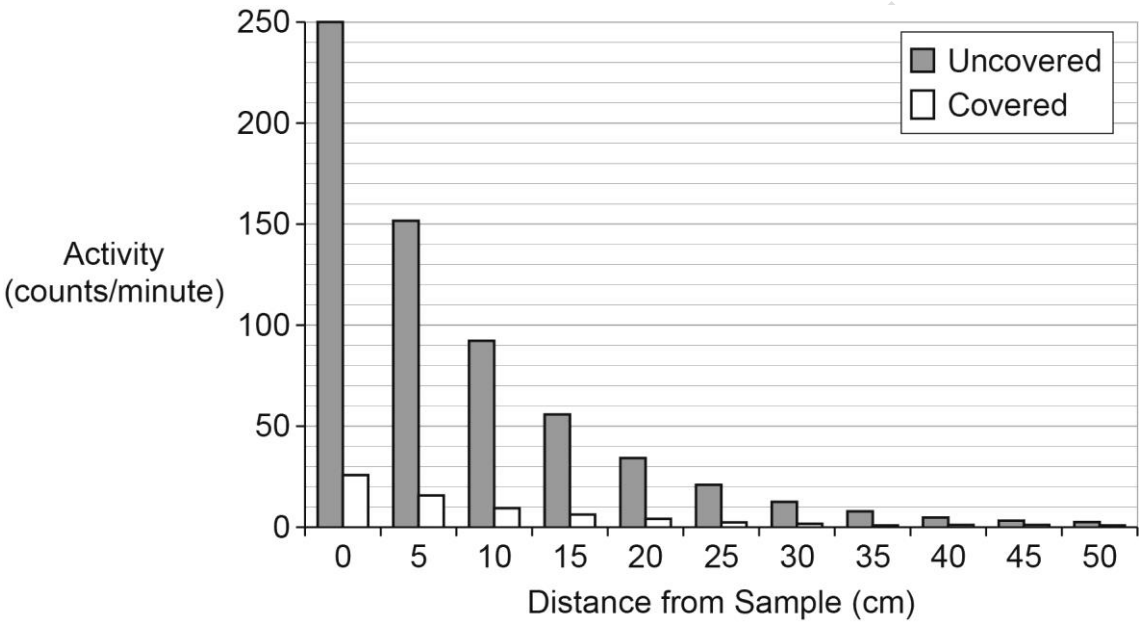


Figure 9: A graph to show levels of radioactivity at different distances from a source

Based on these findings, the scientist concludes that the sample emits beta radiation, and not alpha or gamma.

Evaluate this conclusion.

[3 marks]

23 A scientist is comparing two small bar magnets, magnet 1 and magnet 2.

Each magnet is passed through a coil of wire. A current in the wire is then measured using an ammeter. Graphs showing these currents are given in **Figure 10**.

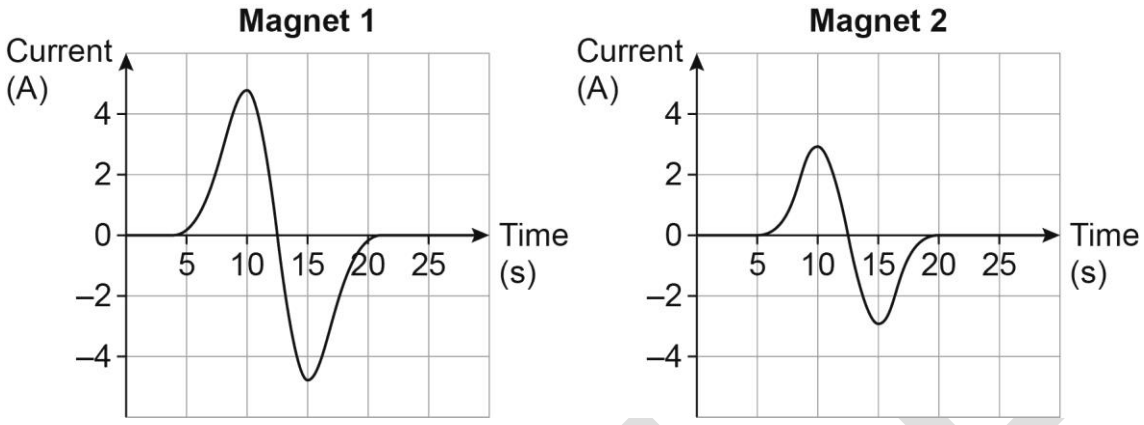


Figure 10: Currents generated by passing two different magnets through a coil of wire

Based upon these observations, the scientist concludes that magnet 1 is a stronger magnet than magnet 2.

Explain how the scientist reached this conclusion.

Your answer should include:

- a description of the process of electromagnetic induction
- a comparison of the two graphs
- reasoned judgements and / or conclusions about the strength of the two magnets.

[6 marks]

Please turn over for the next question.

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.

24 (a) Iron is a transition metal, describe **four** ways in which the properties of transition metals differ from the properties of group 1 metals.

[4 marks]

24 (b) Explain how **one** of these differences makes iron a useful building material.

[1 mark]

25 Biological oxygen demand (BOD) is a concept used to measure the levels of organic pollutants in waterways. This represents the oxygen consumed by microorganisms as they decompose the organic pollutants under aerobic condition. The rate of oxygen consumption can be used as a direct measure of the level of pollutant.

A student set up the apparatus shown in **Figure 11** to measure BOD:

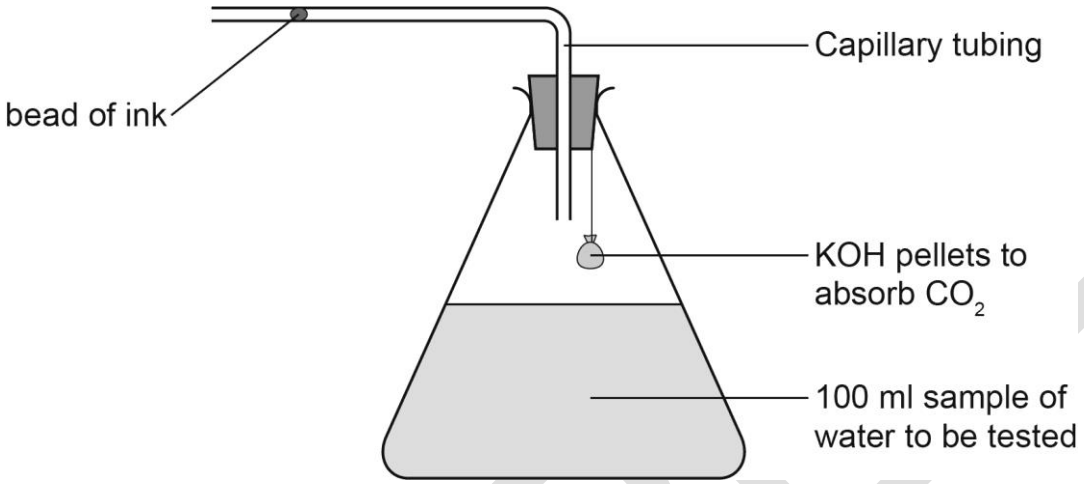


Figure 11: The student's apparatus for measuring BOD

The student planned to measure the BOD of the water sample by measuring the rate at which the bead of ink moved along the capillary tube in **one** minute.

As the microorganisms respired, they would use up the oxygen in the apparatus and the bead of ink would move to the right. Carbon dioxide (CO_2) produced in respiration would be absorbed by the potassium hydroxide (KOH).

25 (a) Suggest **one** external independent variable which would need to be controlled. Explain why it is important to control this variable.

[2 marks]

25 (b) Explain why it is important to remove the CO_2 produced during this investigation.

[1 mark]

25 (c) The student used the apparatus to measure the BOD of water from four different ponds (samples A to D) and of sterile water sample E. The results are shown in **Figure 12** below:

Sample	**A**	**B**	**C**	**D**	**E**
Rate of movement (mm per minute)	9	10	4	2	2

Figure 12: Shows the results from four different ponds and sterile water

The student concluded that sample B was the most polluted.

To what extent do the results support this conclusion?

Your response should include reasoned judgements and / or conclusions.

[3 marks]

26 An investigation was carried out into the rate of the aerobic respiration of maltose by brewer's yeast at different temperatures:

- a mixture of 100 ml of 2% yeast suspension in 5% maltose solution was prepared
- 10 water baths were prepared at temperatures increasing at 5 ˚C intervals from 15 to 60 ˚C
- the yeast maltose mixture was divided into 10 x 10 ml quantities and placed into 10 boiling tubes
- a boiling tube was placed into each of the water baths and after 10 minutes the number of bubbles of CO_2 were counted in each tube
- the process was repeated five times.

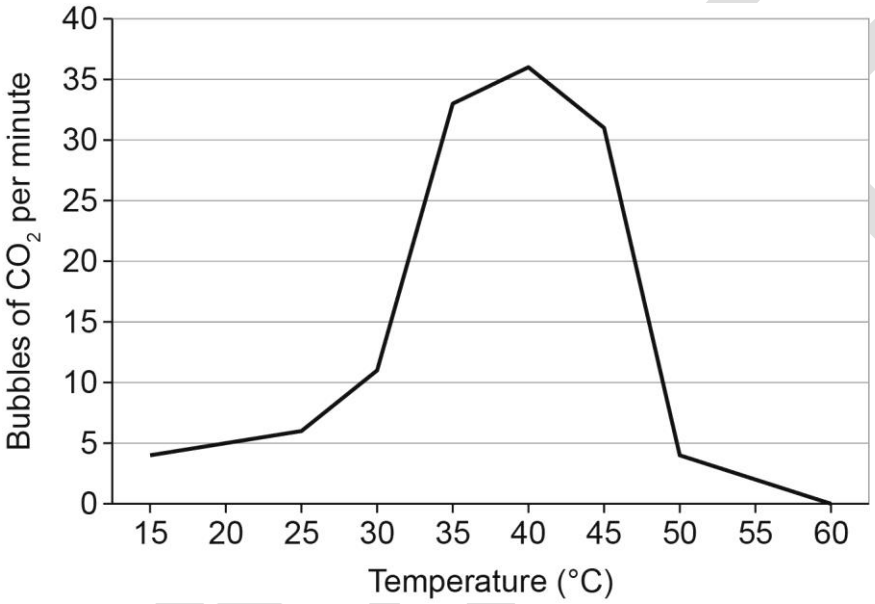


Figure 13: Mean number of bubbles of CO_2 per minute at different temperatures

The results from each repetition were similar, and a graph of the mean number of bubbles per minute at each temperature is shown in **Figure 13** above.

When the investigation was complete a second short investigation was carried out as described below:

- after 15 minutes the boiling tube at 60 ˚C was placed into the water bath at 45 ˚C for 10 minutes, and no bubbles were produced.

Analyse the information provided to explain the results.

Your response should demonstrate:

- an understanding of respiration, enzymes and collision theory
- reasoned judgements and / or conclusions.

[9 marks, plus 3 marks for QWC]

Examiner use only

DO NOT WRITE IN THIS SPACE

This is the end of the external assessment.

This page is intentionally left blank.

This page is intentionally left blank.

This page is intentionally left blank.

Document information

Owner: Head of Assessment Design

Change History Record

Version	Description of change	Approval	Date of Issue
v1.0	Additional specimen assessment materials		November 2022
v1.1	Sample added as a watermark	November 2023	21 November 2023