OCR
Oxford Cambridge and RSA

A Level Biology A

H420/03 Unified Biology

Monday 26 June 2017 – Morning

Time allowed: 1 hour 30 minutes

6821758309

You must have:
- the Insert (inserted)

You may use:
- a scientific or graphical calculator
- a ruler (cm/mm)

H420/03

First name									
Last name									
Centre number						Candidate number				

INSTRUCTIONS
- The Insert will be found inside this document.
- Use black ink. HB pencil may be used for graphs and diagrams only.
- Complete the boxes above with your name, centre number and candidate number.
- Answer **all** the questions.
- Write your answer to each question in the space provided. If additional space is required, use the lined page(s) at the end of this booklet. The question number(s) must be clearly shown.
- Do **not** write in the barcodes.

INFORMATION
- The total mark for this paper is **70**.
- The marks for each question are shown in brackets **[ ]**.
- Quality of extended responses will be assessed in questions marked with an asterisk (*).
- This document consists of **24** pages.

Answer **all** the questions.

1 Fig. 1.1 shows the structure of the amino acid leucine.

(a) (i) On Fig. 1.1, draw a circle around the R group of leucine.

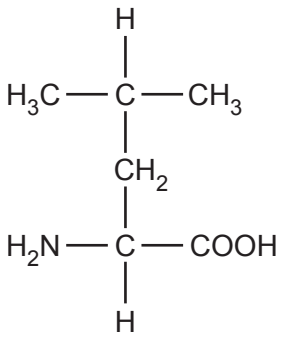

Fig. 1.1

[1]

(ii) Students used thin layer chromatography to separate leucine from other amino acids. The chromatogram they produced is shown in Fig. 1.2.

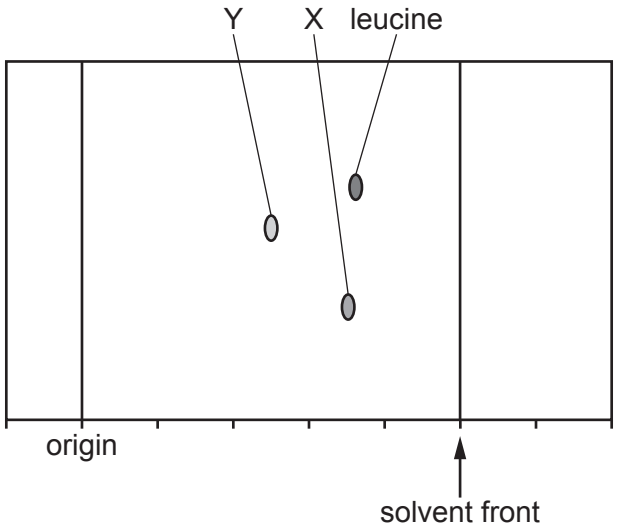

Fig. 1.2

What can you conclude about the chemical properties of leucine and amino acid X?

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..... **[1]**

(iii) Amino acid Z was in the mixture analysed by the students. It is not shown on the chromatogram in Fig. 1.2. Amino acid Z has an R_f value that is 0.20 lower than that of amino acid Y.

Place a dot on the chromatogram in Fig. 1.2 to show the distance moved by amino acid Z.

Show your working.

[3]

(b) Thin layer chromatography can also be used to separate photosynthetic pigments.

(i) State a material that can be used as the stationary phase in thin layer chromatography.

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(ii) State the precise location of photosynthetic pigments in a chloroplast.

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(c) When sequencing DNA, fragments of DNA are separated by electrophoresis.

Describe **three** differences between the process of thin layer chromatography and the form of electrophoresis used to sequence DNA.

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2 Bread contains a mixture of polypeptides known as gluten.

Gluten consists of two types of polypeptide: gliadins and glutenins.

(a) (i) The table below contains statements about the structures of gluten polypeptides.

In the boxes next to each statement, write the level of protein structure (primary, secondary, tertiary, or quaternary) to which the statement refers.

Statement	Level of protein structure
Short α-helical sections are present in both polypeptides because of their high proline content	
Intermolecular bonds form between glutenin and gliadin polypeptides	
Up to 45% of the amino acids in gliadins are glutamine	
Hydrophobic amino acids such as glutamine and proline are not found on the surface of gluten proteins	

[2]

(ii) Coeliac disease is caused by an immune reaction to gliadins in a person's digestive system. The immune system produces antibodies that bind to part of the gliadin polypeptides, which causes inflammation.

Some people who stop eating foods that contain gluten still occasionally experience the symptoms of coeliac disease.

What can you conclude about:

- the structure of the antibody that causes coeliac disease; and
- what the antibody binds to when producing the symptoms of coeliac disease?

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(b) Gluten helps to trap carbon dioxide within bread dough. This enables bread to rise when it is baked.

The carbon dioxide is produced by baker's yeast, *Saccharomyces cerevisiae*. This species of yeast is able to convert ethanol to acetyl CoA at low glucose concentrations.

Fig. 2 shows the oxygen consumption and carbon dioxide production of a population of *S. cerevisiae* grown in batch culture. The population was provided with glucose as their only initial source of carbon.

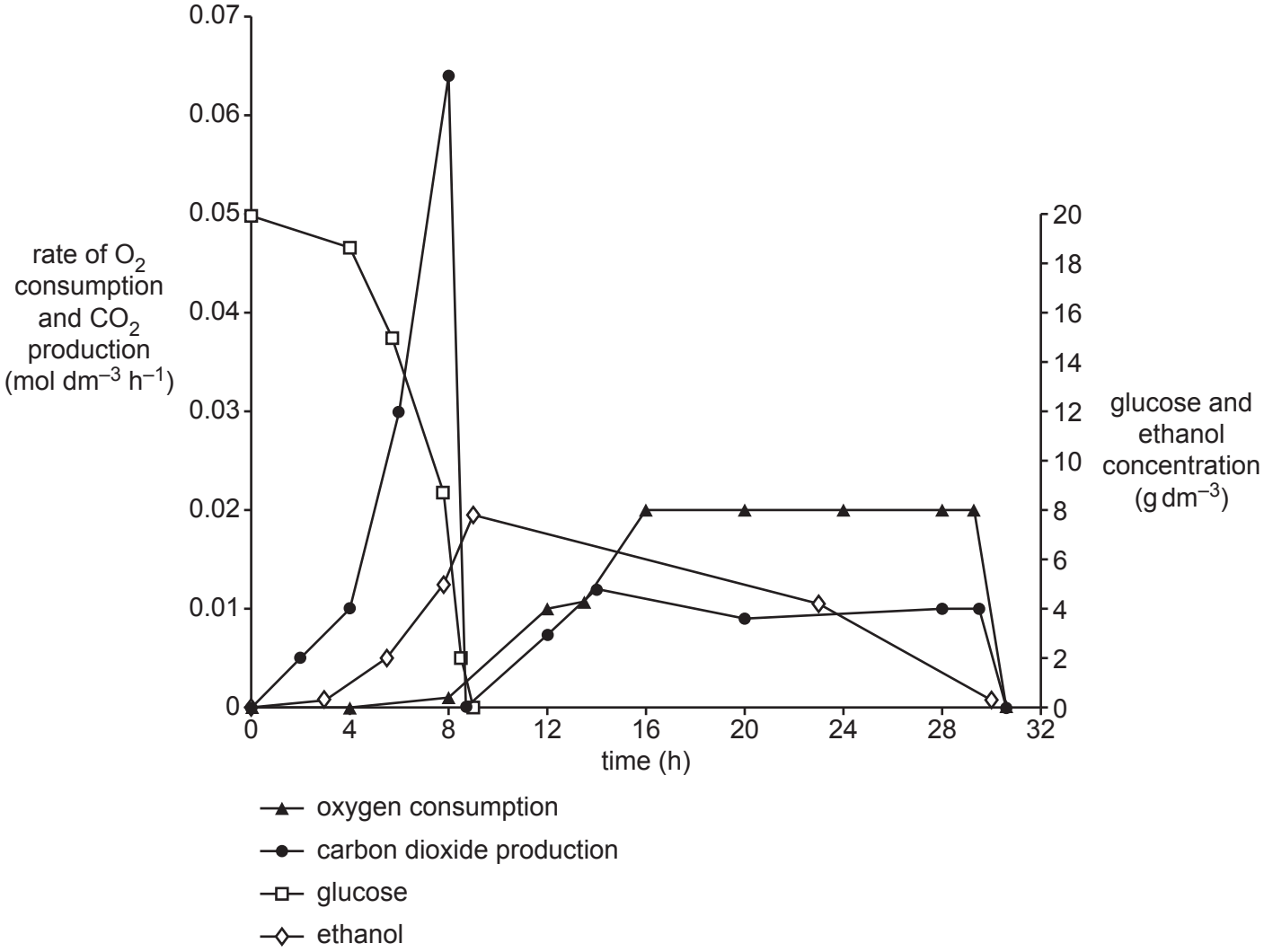

Fig. 2

(i) Suggest and explain what conclusions can be drawn from Fig. 2 about the factors that affected the rate and type of respiration carried out by *S. cerevisiae* in this batch culture.

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(ii) Describe **two** practical considerations to ensure the *S. cerevisiae* population grows successfully when the initial culture is established.

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(iii) Scientists wanted to estimate the number of yeast cells in a 25 cm^3 solution of *S. cerevisiae*. They carried out the following two dilutions:

- 1 cm^3 of the original solution was mixed with 9 cm^3 of nutrient solution to make solution 2.
- 1 cm^3 of solution 2 was mixed with 9 cm^3 of nutrient solution to make solution 3.

The scientists transferred 0.1 cm^3 of solution 3 onto an agar plate. 15 separate colonies grew on the plate.

Calculate the number of yeast cells in the original 25 cm^3 solution.

Express your answer in standard form to **three** significant figures. Show your working.

Answer ..... **[2]**

(iv) A group of students were designing an experiment to investigate the effect of temperature on the respiration rate of *S. cerevisiae*.

Their planned method included the following:

- *S. cerevisiae* yeast suspension will be divided into six equal volumes to form the experimental groups.
- Six temperatures will be tested: 15 °C, 20 °C, 25 °C, 30 °C, 35 °C and 40 °C.
- Beakers of *S. cerevisiae* will be placed in water baths to control the temperature.
- Respiration rate will be measured by using a pH probe to monitor changes in the pH of the suspensions.
- The experiment will be repeated four times.

Evaluate whether the students' method is likely to produce **valid** results.

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(v) The students used a Student's *t*-test to compare the results at 30 °C and 35 °C.

They calculated a *t* value of 2.200.

The critical value for $p = 0.05$ is 2.306.

Assuming their final method was valid, what can the students conclude from the result of the *t*-test?

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..... **[1]**

3 Tigers, *Panthera tigris*, are predatory mammals. They have evolved striped patterns on their fur (as shown in Fig. 3.1a **on the insert**), which provide camouflage in their habitats.

(a) (i) Adaptations can be divided into three types.

State the type of adaptation represented by the tiger's stripes.

..... **[1]**

(ii)* Describe and explain how a tiger with striped fur may have evolved from a non-striped ancestor.

In your answer you should discuss the different types of genes that might be involved in the creation of the striped pattern in the tiger's fur.

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(b) One subspecies of tiger is the Bengal tiger. One in 10 000 Bengal tiger births results in a white Bengal tiger.

White Bengal tigers (shown in Fig. 3.1b **on the insert**) have black stripes but lack orange fur.

The allele that causes white fur is recessive and is a result of a mutation to a gene called SLC45A2.

According to the Hardy-Weinberg principle, the following equations can be used to estimate allele frequency within a population:

$$p^2 + 2pq + q^2 = 1$$

$$p + q = 1$$

Use the Hardy-Weinberg equations to calculate the percentage of Bengal tigers that are heterozygous for the SLC45A2 gene.

Give your answer to **one** significant figure.

Show your working.

Answer: ..... % **[3]**

4 Nitrogen cycling within ecosystems is controlled by various bacterial species. The table below lists four groups of bacterium that are involved in the nitrogen cycle.

(a) Complete the table to show the locations of each type of bacterium in the cycle and the reactions they perform.

Type of bacteria	Location	Reactant(s)	Product	Oxidation or reduction of nitrogen?
Rhizobium		N_2 and H^+ ions	NH_3	reduction
Nitrosomonas	soil			oxidation
Nitrobacter	soil		NO_3^-	
Denitrifiying bacteria		NO_3^-		

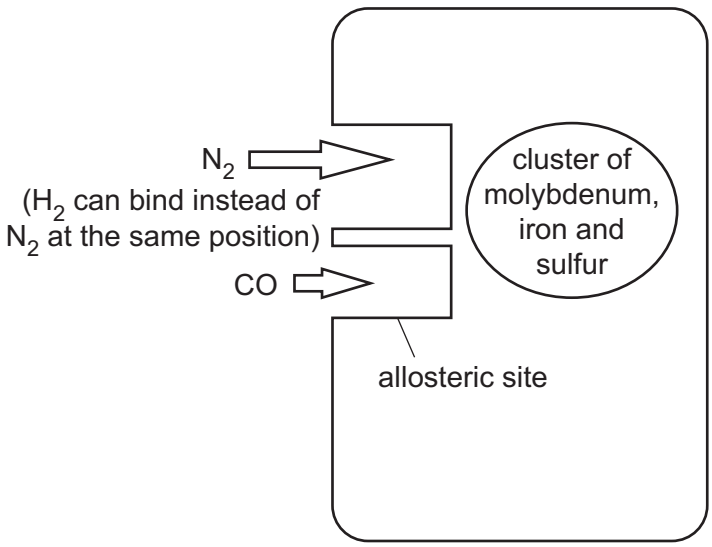
[4]

(b) Nitrogen fixation is an important part of the nitrogen cycle.

The rate of nitrogen fixation is reduced by the presence of oxygen.

Rhizobium uses the enzyme nitrogenase to fix atmospheric nitrogen.

Fig. 4 shows a simplified representation of the structure of nitrogenase and the reaction that it catalyses.



Overall reaction: $N_2 + 8H^+ + 8e^- + 16ATP \rightarrow 2NH_3 + H_2 + 16ADP + 16P_i$

Fig. 4

(i) What can you conclude from Fig. 4 about the molecules or ions that affect the functioning of the nitrogenase enzyme?

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(ii) Leghaemoglobin is a molecule that improves the performance of nitrogenase. It has very similar properties to mammalian haemoglobin.

Suggest **two** ways in which leghaemoglobin improves the performance of the nitrogenase enzyme.

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(c) Many species of bacteria act as decomposers within ecosystems by breaking down organic material.

Scientists analysed the energy flow within a grassland ecosystem.

They estimated that the energy in the decomposers' trophic level was 950 000 $J\,m^{-2}\,yr^{-1}$.

The energy within the producers' trophic level was 800% greater than that of the decomposers.

(i) Calculate the energy in the producers' trophic level in **$kJ\,m^{-2}\,yr^{-1}$**.

Answer: ..... $kJ\,m^{-2}\,yr^{-1}$ **[2]**

(ii) Calculate the percentage efficiency of the energy transfer from producers to decomposers.

Give your answer to **two** significant figures.

Answer: ..... % **[1]**

5 Multiple sclerosis (MS) is an autoimmune disease that damages the nervous system.

(a) (i) Suggest how the immune system causes damage to the nervous system.

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(ii) Fig. 5 **on the insert** shows three neurones of different sizes from a person with MS.

One of the neurones has been affected by MS.

MS causes changes to neurones, which reduce the speed at which nervous impulses are conducted.

Using information from Fig. 5, what can you conclude about how MS causes a reduction in the speed of nervous impulses?

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(b) Guillain–Barré syndrome is another autoimmune condition in which neurones are damaged and the rate of nervous impulses is reduced.

MS affects the central nervous system.

Guillain–Barré syndrome affects the peripheral nervous system.

(i) Suggest **two** symptoms of MS that might **not** be present in people with Guillain–Barré syndrome.

Explain your answers.

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[2]

(ii) Multiple sclerosis and Guillain–Barré syndrome both cause muscle weakness and loss of muscle function.

Suggest and describe how the function of neuromuscular junctions will be affected by multiple sclerosis and Guillain–Barré syndrome.

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6* A student investigated the heart rates of smokers and non-smokers.

- Each test subject had their resting heart rate measured using an electronic heart rate monitor.
- They ran 1 km on a running track and their heart rate after running 500 m was recorded.
- Their heart rate was recorded for a third time 3 minutes after the completion of the exercise.

All test subjects were 18 years old. Subjects were tested between 9 am and 4 pm on one day, one at a time. Each test lasted approximately 20 minutes in total. The tests were repeated one week later using the same method. Mean heart rates were calculated for each subject.

The student's plan was to compare the heart rates of smokers and non-smokers using Student's *t*-test.

The student's results are shown in Table 6.

Student	Smoker?	Gender	Resting heart rate (bpm)	Heart rate during exercise	Heart rate after exercise
1	Y	Male	60.5	130.0	66.5
2	N	Female	67.0	145.5	73
3	Y	Male	70.0	120	77.0
4	Y	Male	65.5	100	69
5	Y	Male	66.0	128.5	75.5
6	Y	Female	65.5	115.5	74.5
7	Y	Female	73.5	120.5	81
8	N	Female	63.0	118	66
9	N	Female	71.0	95.5	80.5
10	N	Female	65.5	110	71
11	N	Male	64.0	145.5	68
12	N	Male	52.5	140.0	58.5
13	N	Male	54.0	137.5	63
14	N	Female	73.0	130.5	81
15	N	Female	61.5	124	67
16	N	Female	71.0	130	81.5
17	N	Male	60.0	122.5	63
18	N	Female	64.5	118	69
19	N	Female	67.5	130.5	73.5
20	Y	Male	72.0	135	82
21	Y	Female	69.5	110	75.5

Table 6

Suggest and explain improvements that the student could make to his experimental method **and** his presentation of data.

In your answer you should explain the benefits of your suggested improvements.

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7 Many organisms have evolved specialised gas exchange surfaces. One feature of these structures is their large surface area to volume ratio.

(a) (i) Describe how the structures of the insect tracheal system and fish gills provide a large surface area for gas exchange.

insect tracheal system .....

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fish gills .....

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[2]

(ii) The lugworm, *Arenicola marina*, is a species of segmented worm that lives in burrows in damp sand. They have hair-like external gills that increase the surface area available for gas exchange.

Many other species of segmented worm do not have external gills.

Suggest why lugworms have evolved external gills

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(b) Mammals use lungs for gas exchange. The following passage describes how gases are moved in and out of the lungs.

Complete the passage using the most appropriate words or phrases.

When air enters the trachea, mucus secreted by ..... cells traps dust and microorganisms. Air diffuses through the bronchi and the bronchioles. Smooth muscle in the bronchioles relaxes during the 'fight or flight' response. This response is produced by the sympathetic nervous system, which contains neurones that secrete the neurotransmitter ..... . During inspiration, both the ..... and external intercostal muscles contract. The internal intercostal muscles only contract when expiration is ..... .

[4]

END OF QUESTION PAPER

ADDITIONAL ANSWER SPACE

If additional space is required, you should use the following lined page(s). The question number(s) must be clearly shown in the margin(s).