Oxford Cambridge and RSA

Friday 24 May 2019 – Morning

AS Level Biology B (Advancing Biology)

H022/02 Biology in depth

Time allowed: 1 hour 30 minutes

You must have:
- the Insert (inserted)

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

Please write clearly in black ink. **Do not write in the barcodes.**

Centre number | | | | | | Candidate number | | | | |

First name(s) _____

Last name StemUp Model Solution

INSTRUCTIONS
- Use black ink. HB pencil may be used for graphs and diagrams only.
- Answer **all** the questions.
- Where appropriate, your answer should be supported with working. Marks may be given for a correct method even if the answer is incorrect.
- 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.

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.

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Answer **all** the questions.

1 The structure of the monosaccharide fructose is shown below in Fig. 1.1.

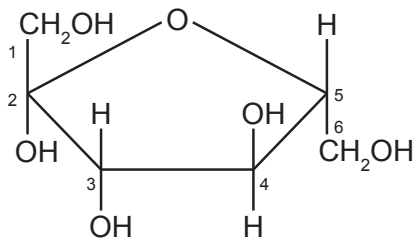

Fig. 1.1

(a) **(i)** Using Fig. 1.1, describe one **visible similarity** between fructose and α-glucose.

Both have the formula $C_6H_{12}O_6$ (6 carbon atoms). **[1]**

(ii) Using Fig. 1.1, describe one **visible difference** between fructose and α-glucose.

Fructose has two CH_2OH groups but α-glucose has only one. **[1]**

(b) Fructose and α-glucose can be joined together to make sucrose.

Sucrose produced in the leaves of a potato plant can be transported to the roots where it is converted into starch and stored.

Fig. 1.2, **on the insert**, shows a leaf of a sweet potato plant in transverse section.

(i) Through which of the tissues, labelled **W** to **Z** in Fig. 1.2, is sucrose transported?

Y **[1]**

(ii) The plant tissues in Fig. 1.2 have been stained.

State the type of stain and explain why it was used to prepare the slide.

A differential stain.

It allows the different tissues and cells to be distinguished, making structures visible. **[2]**

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(c) Starch can be hydrolysed using hydrochloric acid. A student was investigating the hydrolysis of potato starch.

Fig. 1.3 shows the procedure used.

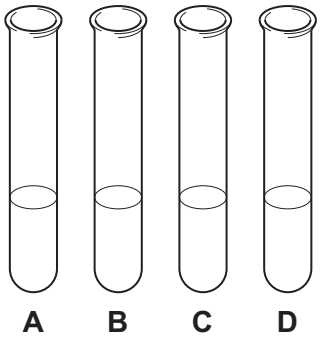
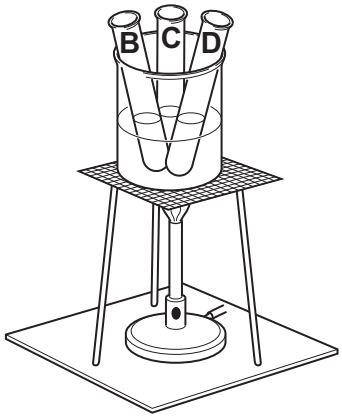
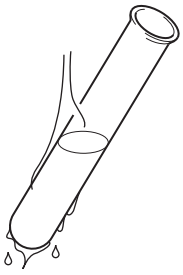
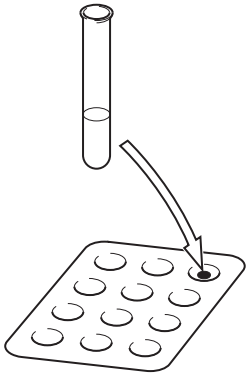
	Dilute hydrochloric acid was added to a sample of ground-up potato in each of four test tubes. These test tubes were labelled **A, B, C** and **D**.
	Test tubes **B, C** and **D** were placed into a boiling water bath. Test tube **A** moved directly to the next stage in the procedure.
	Sodium hydrogencarbonate was immediately added to test tube **A**. Test tube **B** was cooled at five minutes, **C** at ten minutes and **D** at fifteen minutes. Sodium hydrogencarbonate was added to each test tube.
	A small sample was removed from each test tube, and iodine solution was added.

Fig. 1.3

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The results are shown in the table below.

Test tube	Time in boiling water (min)	Observation with iodine solution
A	0	dark blue/black
B	5	dark blue
C	10	dark brown
D	15	

(i) Suggest the expected observation for test tube **D** and give a reason for your answer.

Brown, yellow or orange, because there is less (or no) starch remaining as more has been hydrolysed. **[1]**

(ii) Suggest why sodium hydrogencarbonate was added to all four test tubes.

To neutralise the acid (so the hydrolysis stops at that time). **[1]**

(iii) The student proposed that:

Dilute hydrochloric acid played a significant part in the hydrolysis of potato starch.

Describe a suitable control that the student could have carried out to test this hypothesis.

Repeat the procedure with the same conditions (same mass of ground potato, same volume, same times in the boiling water bath) but without acid, using the same volume of distilled water instead. **[2]**

(iv) The students found it difficult to compare each other's observations on the colour changes.

What method could they have used to obtain quantitative results?

Use a colorimeter to measure absorbance (or transmission). **[1]**

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2 Lung cancer is the second most common cancer diagnosed in the UK.

Fig. 2 shows the incidence rate of lung cancer in male and female smokers from 1979 to 2007.

'Lung cancer incidence trends over time', www.cancerresearchuk.org, Cancer Research UK. Item removed due to third party copyright restrictions. Link to material: https://www.cancerresearchuk.org/health-professional/cancer-statistics/statistics-by-cancer-type/lung-cancer/incidence#heading-Two

Fig. 2

(a) **(i)** Compare the changes in incidence rate for males **and** females from 1980 to 2000.

Use information from Fig. 2 to support your answer.

The incidence rate decreased in males but increased in females.

Males fell from about 175 to 115 per 100 000 (a decrease of about 60).

Females rose from about 40 to 55 per 100 000 (an increase of about 15).

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

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(ii) In 2007, a ban on smoking in indoor work and public places was introduced in the UK.

Explain what you would expect to happen to the incidence rates of lung cancer for the first three years after the ban was introduced.

The same trend would continue (rates would not change straight away).

This is because lung cancer takes a long time to develop (longer than 3 to 5 years), so any effect of the ban would only be seen later.

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

(iii) Cumulative incidence rate (CIR) can be used to estimate the risk of a disease in a population over a period of time.

In 2007, 41 000 cases of lung cancer were diagnosed. The incidence rate was 85 per 100 000 of the population.

Calculate the total number of people at risk of the disease in 2007.

Use the formula: $\text{CIR} = \dfrac{\text{number of new cases of the disease}}{\text{number of total population at risk of the disease}}$

Give your answer to **2** significant figures.

$(41\ 000 \div 85) \times 100\ 000 = 48\ 235\ 294$

number of people = ...48 000 000..... **[2]**

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(b)* Lung cancer is more prevalent in urban areas where there is a higher level of air pollution.

Describe the effects of pollutants on the respiratory system **and** why these may lead to the development of lung cancer.

Pollutants such as particulates, sulfur dioxide and nitrogen oxides have short-term effects: they irritate the nose and throat, can cause allergic reactions and upper respiratory infections such as bronchitis and pneumonia, and aggravate existing conditions such as asthma or emphysema.

Long-term exposure causes chronic respiratory disease, for example chronic bronchitis and emphysema (COPD): mucus builds up, cilia are damaged and alveolar walls break down, causing breathlessness and coughing.

Pollutants also contain carcinogens (mutagens). These cause mutations in the DNA of cells lining the airways, so proto-oncogenes become oncogenes (and tumour suppressor genes are inactivated).

The cell cycle is no longer controlled, so there is uncontrolled mitosis and a tumour forms. A benign tumour stays in one place, but a malignant tumour invades surrounding tissue and can spread to other parts of the body through the blood or lymph (metastasis), forming secondary tumours.

[6]

Additional answer space if required.

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3 Pressure varies in different parts of the circulatory system throughout the cardiac cycle. The valves in the heart are affected by these changes in pressure.

Table 3 shows pressure changes in the left side of the heart and aorta during one cardiac cycle.

Time (s)	Pressure (mmHg)		
	Left atrium	Left ventricle	Aorta
0.0	5	2	82
0.1	8	15	80
0.2	1	95	78
0.3	2	115	112
0.4	8	34	102
0.5	4	8	88
0.6	5	2	85
0.7	6	2	83

Table 3

(a) **(i)** Using Table 3, state the times during the cardiac cycle when the bicuspid valve is closed. Justify your answer.

From 0.1 s to 0.5 s.

During this time the pressure in the left ventricle is greater than the pressure in the left atrium, so the bicuspid valve is pushed shut.

[2]

(ii) Using Table 3, state the times during the cardiac cycle when the semilunar valve is open. Justify your answer.

From 0.2 s to 0.3 s.

During this time the pressure in the left ventricle is greater than the pressure in the aorta, so the semilunar valve is pushed open.

[2]

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(iii) Using Table 3, calculate the heart rate in beats per minute.

one cardiac cycle = 0.7 s

60 ÷ 0.7 = 85.7

heart rate = ...86..... beats per minute **[1]**

(b) Fig. 3.1 shows a device known as a 'coupler'.

A coupler is fitted between an artery and a vein in the upper leg of a patient who is suffering from hypertension (high blood pressure). It allows some of the blood to pass from the artery into the vein, through a hole in the vessel walls.

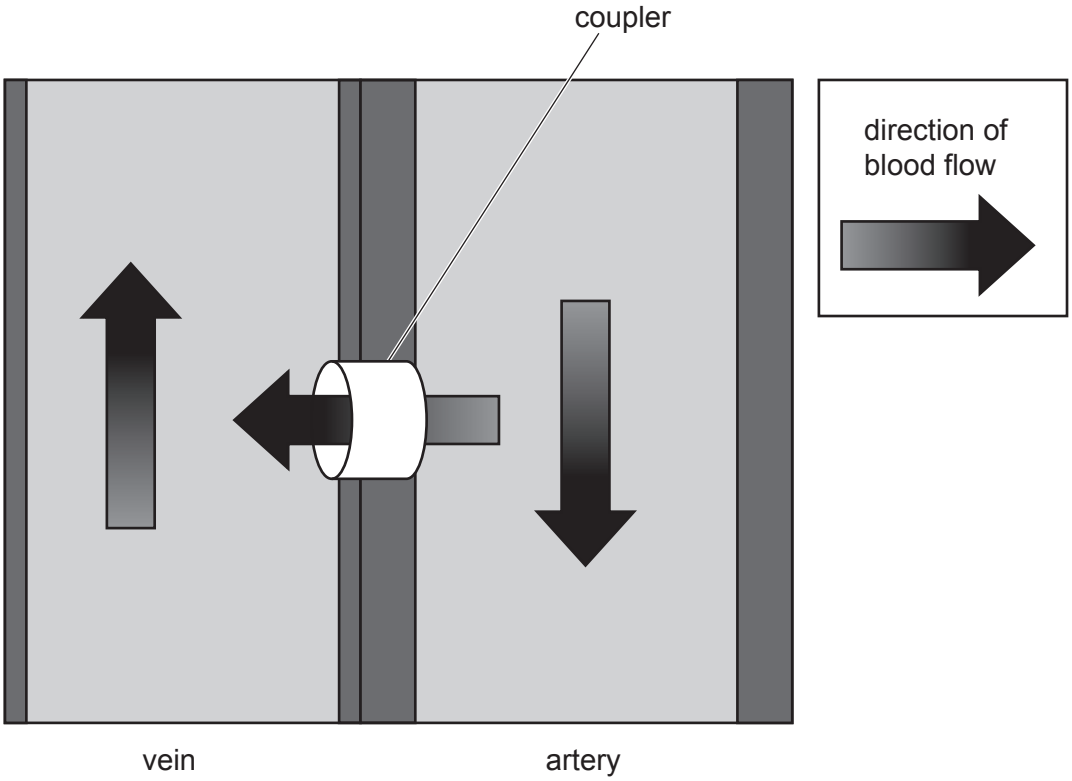

Fig. 3.1

Using your knowledge of the circulatory system, suggest **one** disadvantage of having a coupler fitted.

Oxygenated and deoxygenated blood mix, so the leg receives less oxygenated blood. **[1]**

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Question 3(c) begins on page 12

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(c) Researchers carried out a study into the effectiveness of a coupler in reducing hypertension.

A group of healthy people was compared with a group of patients with hypertension. Their blood pressures were taken before and after they were fitted with a coupler.

The results of this study are shown in Fig. 3.2.

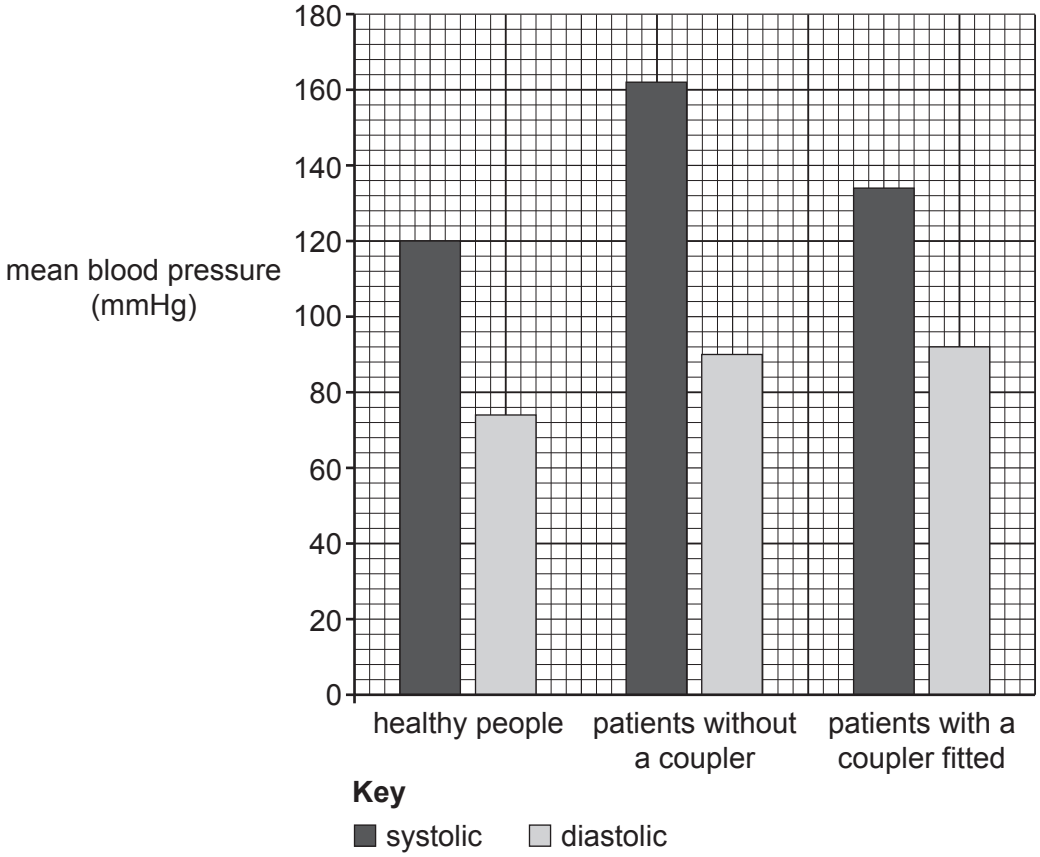

Fig. 3.2

(i) State **two** variables that would need to be controlled by the researchers in this study.

variable 1 ..age.....

variable 2 ..gender..(sex).....

[2]

(ii) Describe and explain the effect on blood pressure in the artery **and** the vein after having a coupler fitted.

..Arterial..pressure..decreases..and..venous..pressure..increases.....

..This..is..because..blood..flows..from..the..artery..into..the..vein,..decreasing.....

..the..volume..of..blood..in..the..artery..and..increasing..the..volume..of..blood.....

..in..the..vein.....

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

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(iii) Using the information in Fig. 3.2, calculate the mean percentage change in both systolic and diastolic blood pressure of the group of patients **after** the coupler had been fitted.

Give your answers to the **nearest whole number**.

systolic: (162 − 134) ÷ 162 × 100 = 17.3

decrease of 17%

percentage change in systolic pressure = ...−17..... %

diastolic: (92 − 90) ÷ 90 × 100 = 2.2

increase of 2%

percentage change in diastolic pressure = ...+2..... %

[4]

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4 **(a)*** A 25 year old pregnant woman visits her GP enquiring about antenatal care. She informs her GP that she has already stopped drinking alcohol.

Explain any further dietary changes **and** routine antenatal tests that the GP would recommend.

The GP would recommend a balanced diet with extra protein, needed for growth of the fetus and to make enzymes, antibodies and haemoglobin. Extra calcium for development of bones, teeth and muscles. Extra iron to make haemoglobin for the increased red blood cell count. Folic acid supplements, which are needed for DNA replication and protein synthesis and prevent neural tube defects such as spina bifida. Routine antenatal tests: a blood test for ABO blood group in case a transfusion is needed; a rhesus test, as a rhesus negative mother may make antibodies against a rhesus positive baby; blood tests for infectious diseases such as HIV, syphilis and hepatitis B so the baby can be treated before birth; a blood glucose test to detect gestational diabetes. Ultrasound scans check the development of the fetus for abnormalities; urine tests and blood pressure checks detect pre-eclampsia; her weight is also monitored.

..... **[6]**

Additional answer space if required.

.....

.....

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(b) A high consumption of alcohol during pregnancy may lead to birth defects in the developing fetus, but it can also result in the formation of ulcers in the small intestine of the mother.

The ulcers are caused by the death of the cells that line the small intestine.

Suggest how alcohol can lead to cell death.

Alcohol damages the cell surface membrane of the cells lining the small intestine.

The cells lose water and lyse, so the cell contents leak out.

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

Question 4(c) begins on page 16

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(c) Fig. 4 shows the effects of alcohol on a developing fetus.

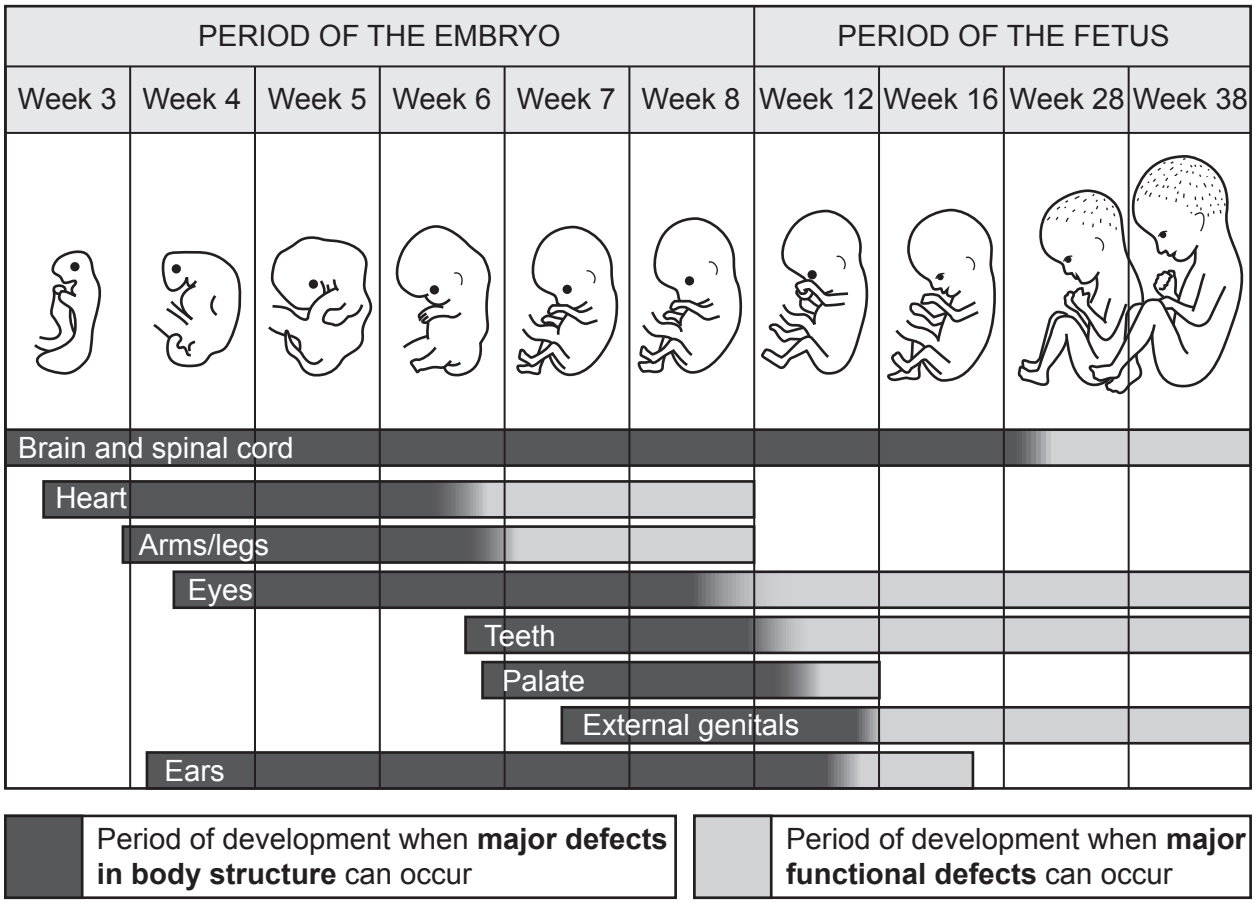

Fig. 4

Using Fig. 4, state which week of development results in the greatest number of:

(i) major defects in body structure

Week 6 ..... **[1]**

(ii) major functional defects.

Week 12 ..... **[1]**

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(d) Alcohol consumption during pregnancy can result in babies being born with syndactyly (webbed fingers and toes). During normal fetal development, syndactyly is prevented by a process that removes excess cells from the hands and feet.

Describe this process.

Apoptosis (programmed cell death). Enzymes break down the cell contents and the cytoplasm shrinks; chromatin condenses and the DNA breaks into fragments.

Blebs form, and these are taken up by phagocytosis.

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

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5 In 2004 a new species known as the harlequin ladybird, *Harmonia axyridis*, arrived in the south east of the UK and, since then, it has spread across the country.

Harlequin ladybirds are able to eat a wider range of food than native ladybirds and also predate on the eggs of other ladybirds.

(a) Explain how the introduction of a new species would affect biodiversity.

The new species takes the niches of native ladybirds.

It reduces the numbers of native ladybirds due to competition for food and predation on their eggs, so there may be fewer species.

Genetic variation decreases (smaller gene pool), so biodiversity is reduced.

[3]

(b) **(i)** A national survey was carried out in the UK to track the spread of the harlequin ladybird.

A class of students decided to take part in the survey by studying the ladybird species in a local meadow. During a morning lesson, the class counted the number of different ladybird species and the number of ladybirds in each species found in the meadow.

Outline the procedure the students should have followed to obtain valid results.

Sample a wide area of the meadow at random locations (e.g. random coordinates), using a collection technique such as sweep netting or a pooter.

Repeat at different times of day and on different days.

Use a key to identify each species, and mark or photograph each ladybird so it is not counted again.

[3]

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(ii) A national ladybird survey published the data for 2014.

The teacher asked the class to use the data to calculate the Simpson's Diversity Index (D) for ladybirds in this survey.

The formula they used was:

$$D = 1 - \left(\sum\left(\frac{n}{N}\right)^2\right)$$

where n = number of individuals of a species
N = total number of individuals of all species

Some of the data is shown in the table below.

Species	n	n/N	$(n/N)^2$
Harlequin	1824	0.2450	0.06004
2 spot	931	0.1251	0.01564
10 spot	1702	0.2286	0.05228
Cream spot	249	0.0334	0.00112
7 spot	1557	0.2092	0.04375
Pine	753	0.1012	0.01023
14 spot	428	0.0575	0.00331
		Sum ($\sum$)	0.18637
		D	0.81363

Complete the table with the three missing values. Record your answers in the table. **[2]**

(iii) In 2004, the Simpson's Diversity Index for ladybirds in the UK was approximately 0.8.

Using the Simpson's Diversity Index (D) calculated in (b)(ii), suggest what impact the introduction of the harlequin ladybird has had on native ladybird species between 2004 and 2014. Give a reason for your answer.

Little or no impact on native ladybird species.

The value calculated (0.81) is close to 0.8, so the community still has high species richness and evenness.

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

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6 Influenza (flu) is caused by a virus that is spread by droplet infection.

Fig. 6 shows the mortality rate from flu in the UK in 2011.

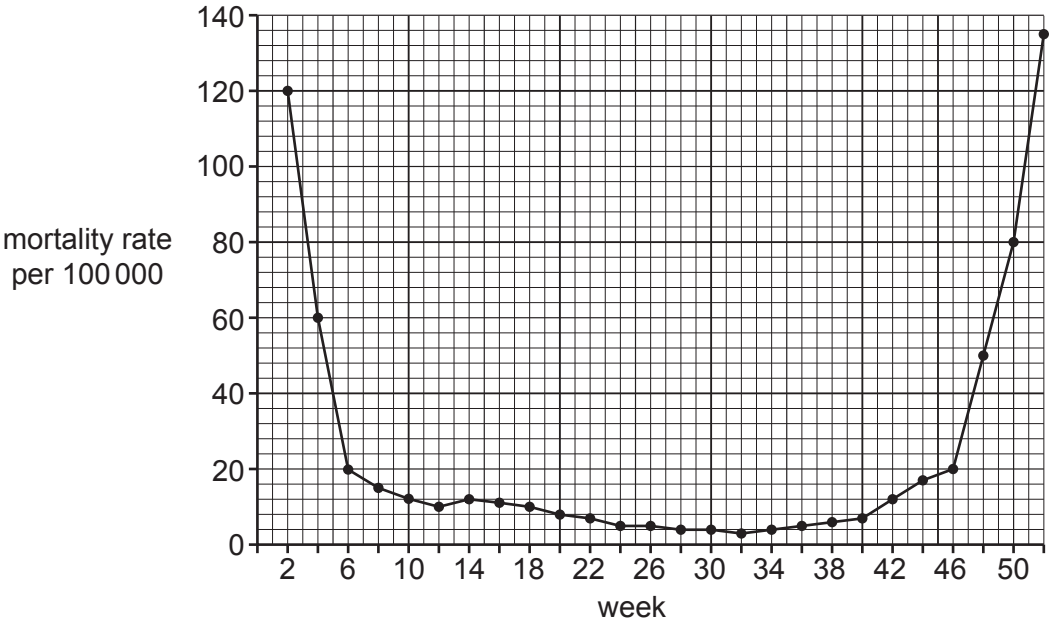

Fig. 6

(a) Using the information in Fig. 6, suggest why the mortality rate from flu changes throughout the year.

Mortality is highest in winter and lowest in summer. In winter more people stay indoors in closer proximity to each other, so droplets spread more easily; they are also more likely to have another illness. **[2]**

(b) Droplets containing the flu virus are released into the air when an infected person coughs.

Assume that:
- approximately 3000 droplets are produced in a single cough
- the volume of a flu virus is $5.0 \times 10^{-4}\ \mu m^3$ and the average diameter of a spherical droplet is $10\ \mu m$.

Calculate the maximum number of virus particles that could be released into the air in one cough.

Use the formula: volume of a sphere = $\frac{4}{3}\pi r^3$

Give your answer to **2** decimal places in standard form.

$r = 5\ \mu m$; droplet volume $= 4/3 \times \pi \times 5^3 = 523.6\ \mu m^3$

$(523.6 \div 5.0 \times 10^{-4}) \times 3000 = 3\ 141\ 600\ 000$

$= 3.14 \times 10^9$

[2]

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(c) **(i)** The UK has a routine flu vaccination programme which is free for 'at risk' groups. 'At risk' groups include diabetic and immuno-compromised patients.

Describe the role of the vaccination programme in reducing the number of deaths in 'at risk' groups.

As many people as possible in at-risk groups are vaccinated, and people living or working with them too, giving herd immunity. Fewer people can pass on the virus, so at-risk people are less likely to be infected. **[2]**

(ii) Suggest why a **different** flu vaccine is required each year.

The flu virus has a high mutation rate, so it can change its surface antigens. Antigenic drift (small changes in antigen shape) and antigenic shift (major changes) mean antibodies no longer bind. **[2]**

(d) In young children, the flu vaccine can be administered using a nasal spray containing antigens.

Explain how these antigens in the nasal spray cause an increase in antibody concentration of the blood.

The viral antigens pass through the mucous membranes of the nose and enter the blood. The antigens bind to the receptors of specific B cells with a complementary shape (clonal selection). These B cells divide by mitosis (clonal expansion). The B cells differentiate into plasma cells. The plasma cells produce and secrete large amounts of antibodies specific to the antigen, so the antibody concentration in the blood increases (memory cells are also made). **[4]**

END OF QUESTION PAPER

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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).

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