OCR
Oxford Cambridge and RSA

Friday 16 June 2023 – Morning

A Level Biology B (Advancing Biology)

H422/02 Scientific literacy in biology

Time allowed: 2 hours 15 minutes

You must have:
- a clean copy of the Advance Notice Article (inside this document)
- the Insert (inside this document)

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

* H 4 2 2 0 2 *

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

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

First name(s) _____

Last name _____

INSTRUCTIONS
- Use black ink. You can use an HB pencil, but only for graphs and diagrams.
- Write your answer to each question in the space provided. If you need extra space use the lined pages at the end of this booklet. The question numbers must be clearly shown.
- Answer **all** the questions.
- Where appropriate, your answer should be supported with working. Marks might be given for using a correct method, even if your answer is wrong.

INFORMATION
- The total mark for this paper is **100**.
- The marks for each question are shown in brackets **[ ]**.
- Quality of extended response will be assessed in questions marked with an asterisk (*).
- This document has **28** pages.

ADVICE
- Read each question carefully before you start your answer.

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1 This question is based on the Advance Notice Article **'Development of therapeutic antibodies for the treatment of disease'**.

(a) (i) State what is meant by the term **antigen**.

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

(ii) Scientists can combine antibody fragments using phage display to produce many different antibodies, each specific to a different antigen.

Using the abbreviations from **Fig. 1** in the Advance Notice Article, explain how combining antibody fragments allows scientists to produce many different antibodies, each specific to a different antigen.

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

(iii) The B cell receptor is an IgG molecule with the same structure as the human IgG shown in **Fig. 1** in the Advance Notice Article.

Use an abbreviation from **Fig. 1** to identify the part of the B cell receptor that will be attached to the cell surface membrane of a B cell.

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

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(b) (i) Explain why mouse monoclonal antibodies (mAbs) have been largely replaced as therapeutic antibodies by humanised or fully human mAbs.

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(ii) Explain why the Fab and scFv antibody fragments shown in **Fig. 1** are effective as neutralizing or agglutinating antibodies but are less effective as opsonins or in activation of complement.

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(c) (i) Describe how therapeutic mAbs can be used in cancer treatment.

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(ii) The cost of treating a patient with advanced cancer using therapeutic mAbs can be extremely high. In some cases, the treatment can increase survival time by just a few months.

Pharmaceutical companies justify the high cost of treatment based on the high costs of developing and testing therapeutic mAbs.

Discuss whether the use of therapeutic mAbs to treat cancer justifies the high costs.

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(d)* Describe the role of T and B lymphocytes in the development of long-term immunity.

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Additional answer space if required.

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2 Aerobic fitness and muscle mass decrease as humans age. Both of these changes have an adverse effect on our general health.

(a) VO_2 max is a measure of aerobic fitness.

(i) State the definition of VO_2 max.

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

(ii) Describe how VO_2 max is measured.

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(b) In older people (over 60 years) resistance training (lifting or pulling against a resistance) is a way of increasing muscle mass and improving bone strength. These changes reduce the risks associated with osteoporosis, falls and bone fractures.

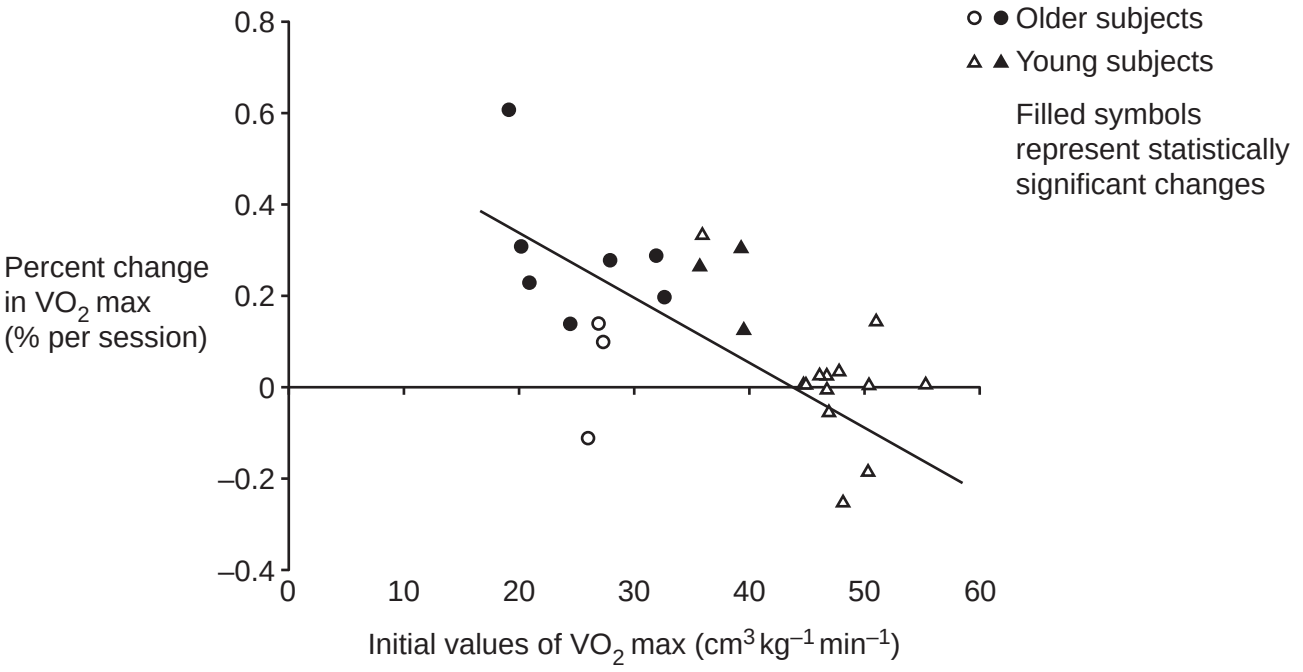
Aerobic training might not be advisable in some older people and can also inhibit the development of muscle mass through resistance training.

A group of scientists reviewed published studies of the effect of resistance training on aerobic fitness in both young people and older people. They calculated the percentage increase in VO_2 max after a course of resistance training.

Because the different studies used training courses of different lengths, they expressed their results as 'percentage change in VO_2 max per session'. Their results are shown in **Fig. 2.1**. Each symbol in **Fig. 2.1** represents the result of one study.

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Fig. 2.1



The scientists concluded that resistance training increases aerobic fitness in subjects of all ages who had a low starting level of aerobic fitness.

(i) Evaluate this conclusion.

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(ii) Suggest why an increase in muscle mass might lead to an increase in VO_2 max.

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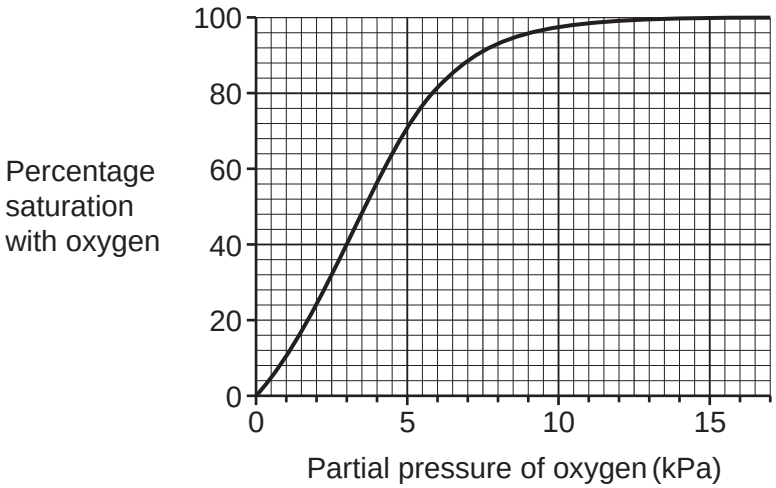
..... **[1]**

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(c) High intensity interval training (HIIT) can increase VO_2 max to a greater extent than traditional, long aerobic exercise.

Fig. 2.2 shows the oxygen dissociation curve of an adult male at rest.

Fig. 2.2



(i) Sketch the curve you would expect when the same person is undergoing a period of HIIT.

Answer on Fig. 2.2. **[1]**

(ii) Explain how the curve you have sketched on **Fig. 2.2** helps improve this person's performance.

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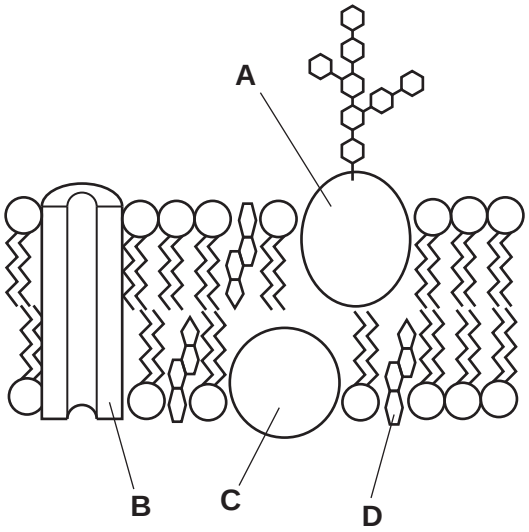
3 TLRs are receptors found on macrophages and are involved in the non-specific immune response.

Gram-negative bacteria have lipopolysaccharide (LPS) in their cell walls.

When Gram-negative bacteria infect a host, such as a human, they release LPS which binds to TLRs on macrophages. This causes the macrophages to release cytokines.

(a) **Fig. 3.1** shows a section of the plasma membrane of a macrophage.

Fig. 3.1



(i) State the letter on **Fig. 3.1** that identifies the component of the membrane that binds to LPS.

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

(ii) Explain why the membrane is described as a fluid mosaic.

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(iii) Describe **two** effects of cytokine release by macrophages.

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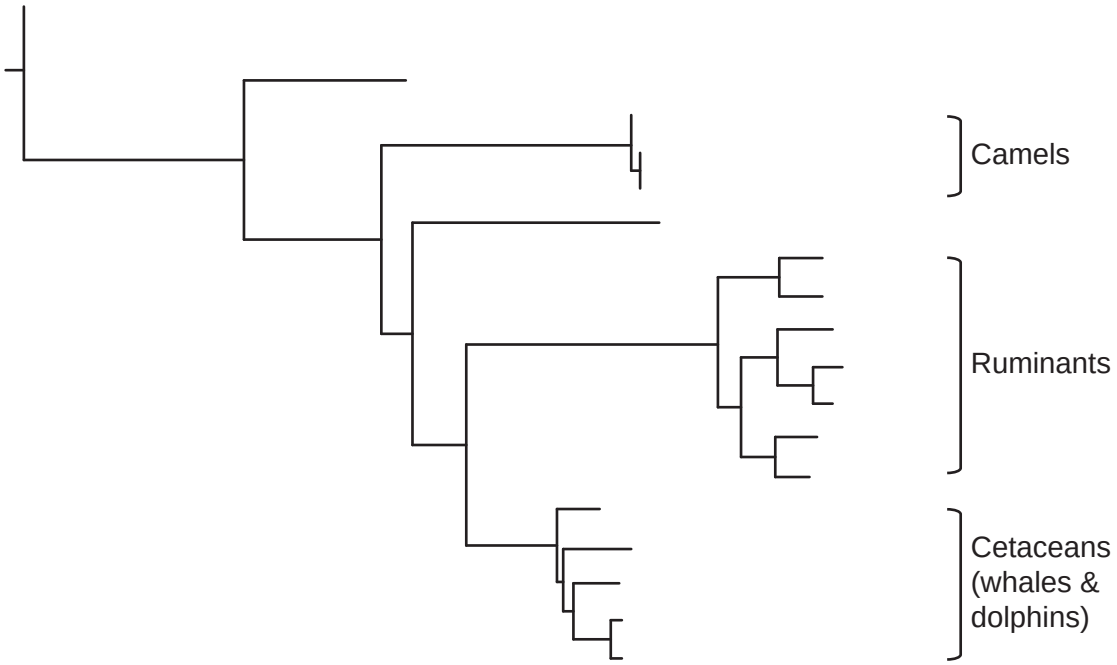
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(b) TLRs have been used to study the evolutionary relationships between ungulates, a group of mammals. Many species of ungulate have hooves.

Fig. 3.2 shows the evolutionary relationships in ungulates.

Fig. 3.2



(i) State the name given to the study of evolutionary relationships.

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(ii) Explain how the relationships shown in **Fig. 3.2**, based on TLRs, could have been worked out.

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(iii) Camels and ruminants are herbivores and both groups have an even number of toes. This led a student to conclude that camels and ruminants are the most closely related groups of ungulates.

Discuss whether the results support the student's conclusion.

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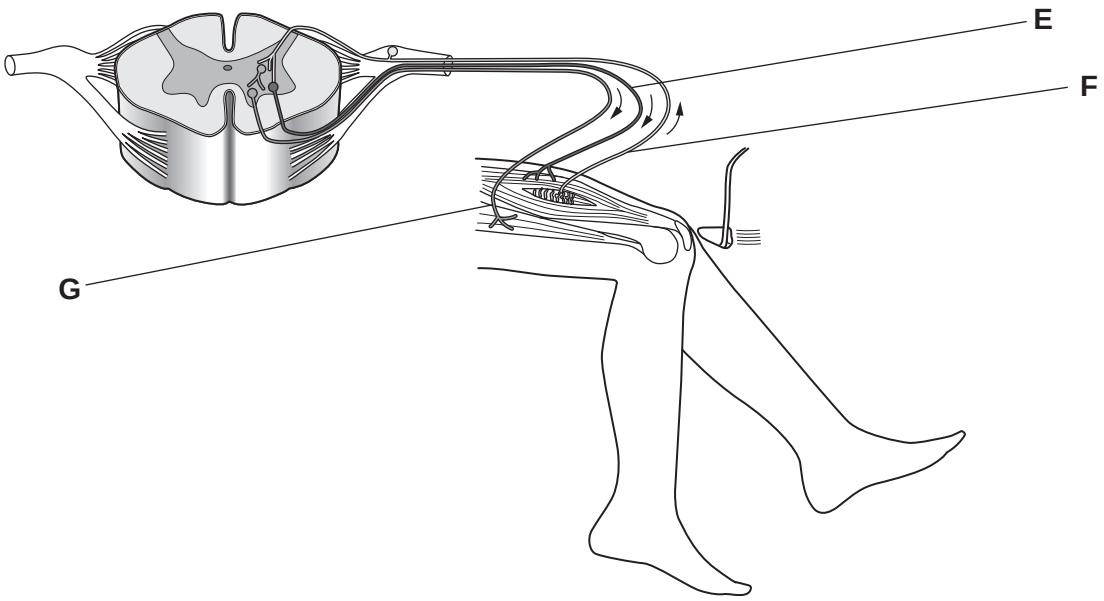
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4 The knee jerk reflex is used to identify disorders of nervous conduction. The kneecap is struck with a rubber hammer and the lower leg responds by flexing in a kicking action.

(a) The neurones involved in the knee jerk reflex are shown in the diagram.



(i) Identify structures **E** and **F** on the diagram.

E .....

F .....

[2]

(ii) The neurone labelled **G** inhibits muscle contraction.

Suggest the advantage of this inhibition.

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

(iii) Explain why reflexes give animals a survival advantage.

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

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(b) Physiotherapists use the knee jerk reflex to identify possible nerve damage in patients.

Based on the physiotherapist's assessment of the speed of response, the knee jerk reflex responses are categorised as:

- Level 0: No evidence of contraction
- Level 1: Decreased, but still present (hyporeflexia)
- Level 2: Normal
- Level 3: Super-normal (hyperreflexia)
- Level 4: Clonus (repetitive shortening of the muscle after a single stimulation).

(i) Explain the limitations of this method for collecting data.

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

(ii) Suggest improvements to this method for collecting data for analysis.

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(c) An investigation into reaction times was performed in a school laboratory.

The subjects sat in front of a laptop computer with a touchscreen. A blue square was shown on the screen. The subject was told to tap the screen as soon as the square changed colour to green. The computer measured the subject's reaction time as the time between the change of colour and the screen being tapped.

The study tested three groups, with 10 participants in each group:
- group 1 were all 16 – 18 year old male students
- group 2 were all 16 – 18 year old female students
- group 3 was a mixture of male and female staff members.

The results are shown in **Table 4.1**.

Table 4.1

	Reaction time (ms)		
	Group 1	**Group 2**	**Group 3**
	150	170	150
	158	225	275
	174	220	280
	186	205	350
	196	210	220
	205	195	195
	202	185	205
	188	206	320
	195	222	160
	179	199	153
Mean	183.3	203.7	230.8
Standard deviation	18.2640	17.2694	77.1303

A *t*-test was carried out to compare the reaction times of male and female students.

(i) State the null hypothesis that should be used.

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

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(ii) Use the data in **Table 4.1** to calculate a value for *t*.

Use the formula: $t = \dfrac{|\overline{x}_A - \overline{x}_B|}{\sqrt{\dfrac{s_A^2}{n_A} + \dfrac{s_B^2}{n_B}}}$

t = ... **[3]**

(iii) **Table 4.2** shows the critical values for *t*.

Table 4.2

Degrees of freedom	**p values**			
	0.10	**0.05**	**0.01**	**0.001**
1	6.31	12.71	63.66	636.60
2	2.92	4.30	9.92	31.60
4	2.13	2.78	4.60	8.61
6	1.94	2.45	3.71	5.96
8	1.86	2.31	3.36	5.04
10	1.81	2.23	3.17	4.59
16	1.75	2.12	2.92	4.02
18	1.73	2.10	2.88	3.92
20	1.72	2.09	2.85	3.85

Use your value for *t* and **Table 4.2** to explain the conclusions the researchers would have reached when comparing the reaction times of males and females.

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(iv) State the conclusion that can be drawn about group 3 compared with groups 1 and 2, based on the standard deviations shown in **Table 4.1**.

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(v) Suggest an explanation for the difference between group 3 and the other two groups.

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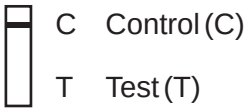
5 Ovulation lateral flow test kits are used by women who are trying to become pregnant.

The kits work on the same principle as pregnancy test kits. They show the presence of LH in urine, which coincides with ovulation.

The base of the test strip contains monoclonal antibodies specific to LH.

The test strip is dipped into a urine sample, and the results are read after a few minutes.

(a) The diagram shows the possible results of ovulation lateral flow tests.



Negative result



Positive results



Results not valid

(i) The control and test lines also have monoclonal antibodies attached.

State what would bind to the antibodies on each line.

Control line .....

Test line .....

[2]

(ii) Explain why no lines means that the result is **not** valid.

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

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(b) Describe **one** cause of infertility in males and **one** in females.

Males .....

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Females .....

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[2]

(c)* Discuss the different treatments for infertility.

You should include the ethical issues **and** draw conclusions based on risks and benefits associated with the different treatments in your answer.

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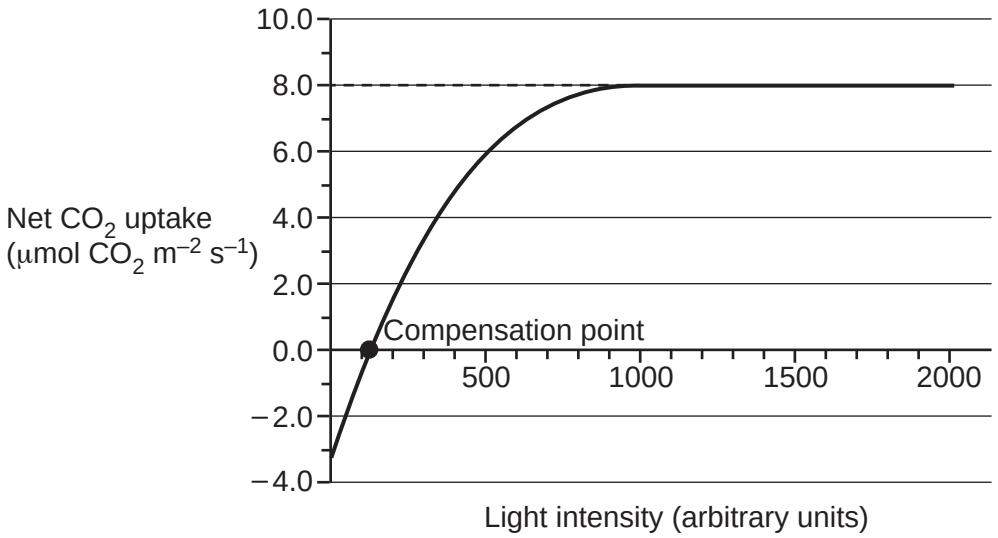
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6 **(a)** **Fig. 6.1** shows the relationship between light intensity and the net rate of photosynthesis, measured as net CO_2 uptake, in a plant growing at atmospheric CO_2 concentration (0.04%).

Fig. 6.1



(i) Explain the significance of the compensation point shown on **Fig. 6.1**.

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(ii) Use the data in **Fig. 6.1** to explain why crops growing in greenhouses during the winter months are often grown under artificial lights.

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(b) A student used hydrogen carbonate indicator solutions to investigate the compensation point in leaf samples from two different species of crop plant.

Leaf extracts were prepared and placed in glass bottles containing hydrogen carbonate indicator solution. The bottles were exposed to light for a fixed period of time, and the colours were compared with a set of standards, shown in **Fig. 6.2** on the Insert.

(i) Explain **two** steps that the student should take to ensure an accurate comparison of compensation points.

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[4]

(ii) The colour of the hydrogen carbonate indicator after each plant extract was exposed to light is indicated by the labels **H** and **J** in **Fig. 6.2** on the Insert.

On the basis of this result, the student concluded that crop plant **J** would be more suitable for growing in the winter months than crop plant **H**.

Evaluate the student's conclusions.

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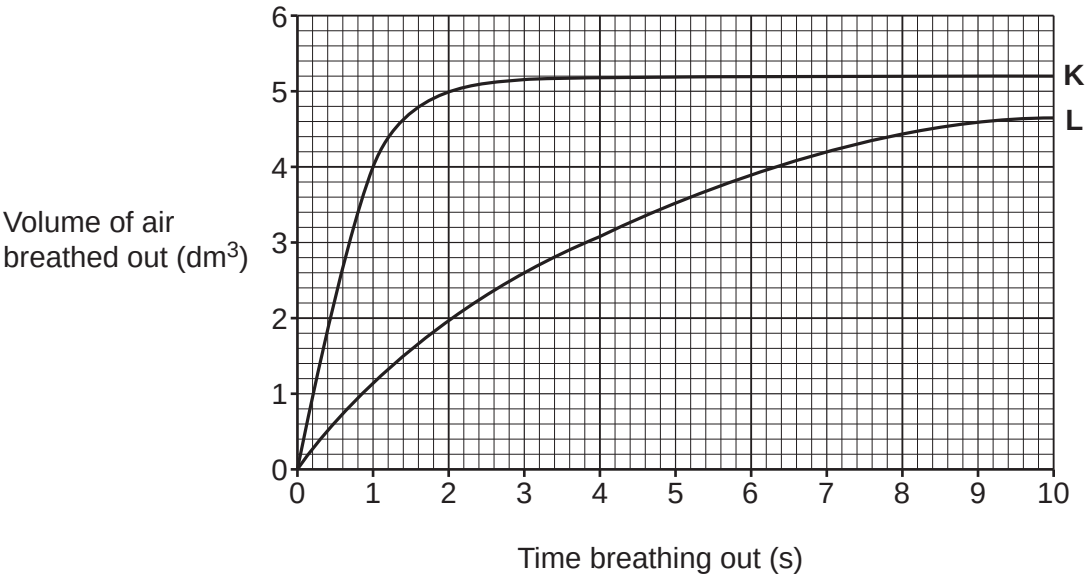
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7 **(a)** The graph shows data recorded during forced expiration (breathing out) in two subjects, **K** and **L**. One subject is a patient with chronic obstructive pulmonary disease (COPD) and the other is a normal control.



The table shows the effects of COPD on the vital capacity and forced expiratory volume in one second (FEV_1).

Measurement	Normal range	COPD
Vital capacity	3 – 5.5 dm^3	May be reduced
FEV_1	Calculation based on height and age	Reduced
Ratio of FEV_1 to vital capacity	Approximately 0.7 – 0.8	<0.7

(i) A student said that it was not possible to estimate vital capacity for subject **L** on the basis of the graph.

Evaluate the student's conclusion.

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

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(ii) With the aid of a calculation, show that it is possible to identify which of the two curves, **K** and **L**, is the normal control and which is the patient with COPD.

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(iii) FEV_1 is calculated using the formula:

(4.3 × height) – (0.029 × age) – 2.49

where height is in m and age is in years.

Use this formula to estimate the age in years of a healthy subject with FEV_1 = 4.4 and height = 1.76 m.

Age = ... years **[2]**

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(b) Asthma is another obstructive respiratory disease in which breathing out can be difficult. A severe asthma attack can lead to respiratory arrest, where the person stops breathing.

The first aid treatment for respiratory arrest is to administer expired air resuscitation (EAR).

(i) Explain the reasons for the following aspects of EAR.

1. Gloves and a mask should be worn.

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2. The patient's head should be held back.

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3. Watch to see if the chest rises whilst blowing into the mouth.

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4. If there is no pulse after two breaths, you must perform cardiopulmonary resuscitation (CPR).

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[4]

(ii) Suggest how EAR would differ if you were performing it on a small child.

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

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(c) Lung surfactant is a mixture of phospholipids and proteins that helps the alveoli stretch and expand during breathing in and prevents them collapsing when breathing out.

The following sentences compare the synthesis and secretion of lung surfactant proteins with other types of protein secreted by cells.

Complete the sentences using the most appropriate words or terms.

All secreted proteins are produced on ..... attached to the rough endoplasmic reticulum (RER). The assembled protein in the RER is then pinched off in ..... vesicles and moved to the ..... where it is processed and packaged into ..... vesicles.

In alveolar epithelial cells these are known as lamellar bodies. These move to the cell surface membrane and the surfactant is released by ..... .

Movement of these organelles requires motor proteins to move them along the ..... .

[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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