Eton College King's Scholarship Examination 2010

SCIENCE (SECTION 1) (60 minutes)

*Candidate Number:*____________________________

INSTRUCTIONS

Write your candidate number, not your name, in the space provided above.

You should attempt ALL the questions. Write your answers in the spaces provided: continue on a separate sheet of paper if you need more space to complete your answer to any question.

Allow yourself about 12 minutes for each question.

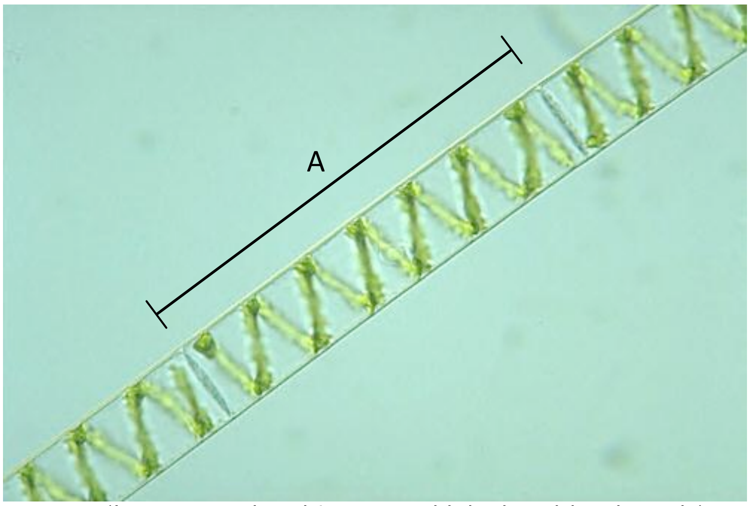
The maximum mark for each question or part of a question is shown in square brackets.

In questions involving calculations, all your working must be shown.

For examiners' use only.

1	2	3	4	5	TOTAL

1. In the late 19th century a German scientist called Thomas Engelmann carried out a series of experiments using algae (including *Spirogyra*, pictured below).



(Image reproduced from www.biologie.uni-hamburg.de)

(a) *Spirogyra* forms long filaments, consisting of many cells joined end-to-end. Each individual *Spirogyra* cell contains one large, corkscrew-shaped chloroplast.

(i) The length of one *Spirogyra* cell is indicated on the image above by a scale bar labelled with an 'A'. The magnification of the cell image is x500. Calculate the actual size of the cell depicted above, expressing your answer in millimetres.

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____ [2]

(ii) With which characteristic of life is chloroplast function associated?

____ [1]

(iii) Explain why chloroplasts appear green when viewed under white light.

____

____ [2]

In one of Engelmann's experiments, some motile bacteria (bacteria which can swim) were placed in water containing *Spirogyra*. Engelmann observed that the bacteria clustered around the *Spirogyra* when it was illuminated with white light. He thought that the bacteria were attracted towards something being released by the algal cells.

(b) Suggest what the *Spirogyra* was producing which was attracting the bacteria and explain what the bacteria might be using it for.

____

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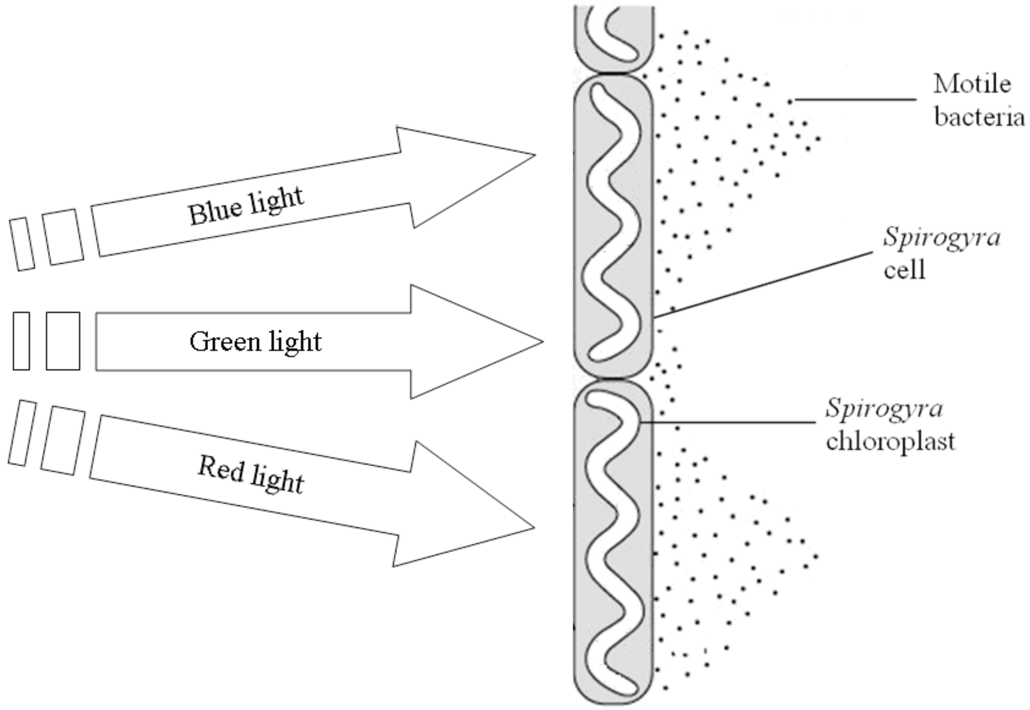
____ [2]

In another experiment Engelmann used the same type of bacteria, but this time he investigated what happened when sections of a *Spirogyra* filament were illuminated with different colours of light. He used a prism to split light into the colours of the visible spectrum. The diagram below shows what Engelmann observed.



(Image modified from www.wissenschaft-online.de)

(c) Describe and explain the results Engelmann obtained.

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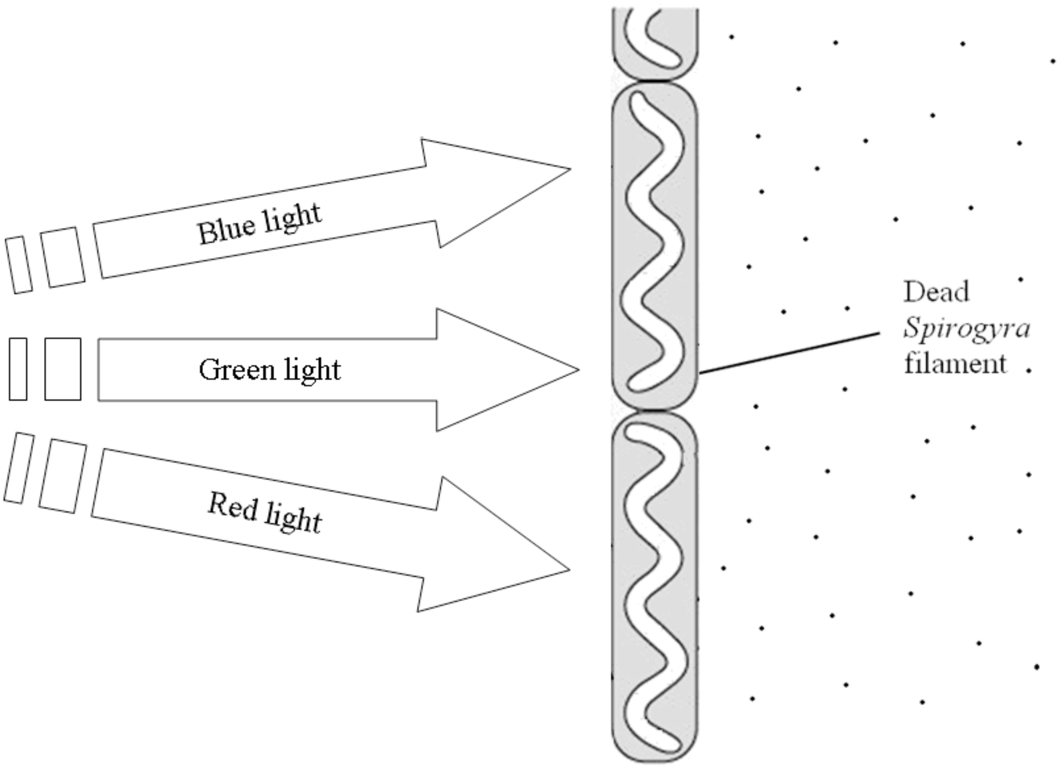
____

____ [2]

[Turn over]

(d) A student decided to perform a modified version of Engelmann's experiment. The student kept everything the same, except he used a dead filament of *Spirogyra* rather than a live one. The student observed the following result:



(i) Explain why the student's results differed from those obtained by Engelmann.

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____ [1]

(ii) This experiment is important when it comes to interpreting Engelmann's results using different colours of light. What name is given to this type of experimental set-up, and why is it so important?

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____ [2]

2. In a typical resting person, the volume of blood pumped around the body by the left side of the heart is approximately 5 600 cm^3 per minute. During exercise, this volume typically rises to 16 800 cm^3 per minute.

(a) Give the general name for the large blood vessels which carry blood away from the heart.

____ [1]

(b) Calculate the percentage increase in blood pumped by the left side of the heart during exercise. Show your working.

____

____

____ [2]

(c) The resting pulse rate of a typical human is 70 beats per minute. Calculate the volume of blood pumped per heart beat (an amount known as the stroke volume) when the body is at rest. Show your working.

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____ [1]

(d) During exercise, the heart rate typically increases to 175 beats per minute. Taking this into account, explain how the heart manages to achieve the massive increase in blood flow to the body during exercise that you calculated in part (b)?

____

____

____

____ [2]

[Turn over]

Consider the data in the table below, which shows the volume of blood distributed to various parts of the body at rest and during exercise.

	At rest (cm^3 per minute)	During exercise (cm^3 per minute)
Total outflow	5 600	16 800
Brain	750	750
Heart	250	750
Muscle	1 200	12 500
Skin	500	1 900
Intestines	1 400	600

(Data derived from Lecture Notes in Human Physiology)

(e) The blood flow to the skin increases markedly during exercise. Suggest a biological reason why this is so.

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____ [1]

(f) The volume of blood flowing out of the heart increases significantly during exercise compared to the resting state. The volume of blood flowing to the actual tissue making up the heart also increases dramatically. Explain why this is necessary.

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____ [2]

(g) A colleague studying the table above suggests that muscle tissue has considerably more blood flowing through it than brain tissue. You tell him that he might well be mistaken and that he needs to know one other piece of information before he can safely make that conclusion. What additional factor should he take into account?

____

____ [1]

(h) How much blood flows from the heart to the lungs when the body is at rest? Explain how you came to this conclusion.

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____ [2]

[Turn over]

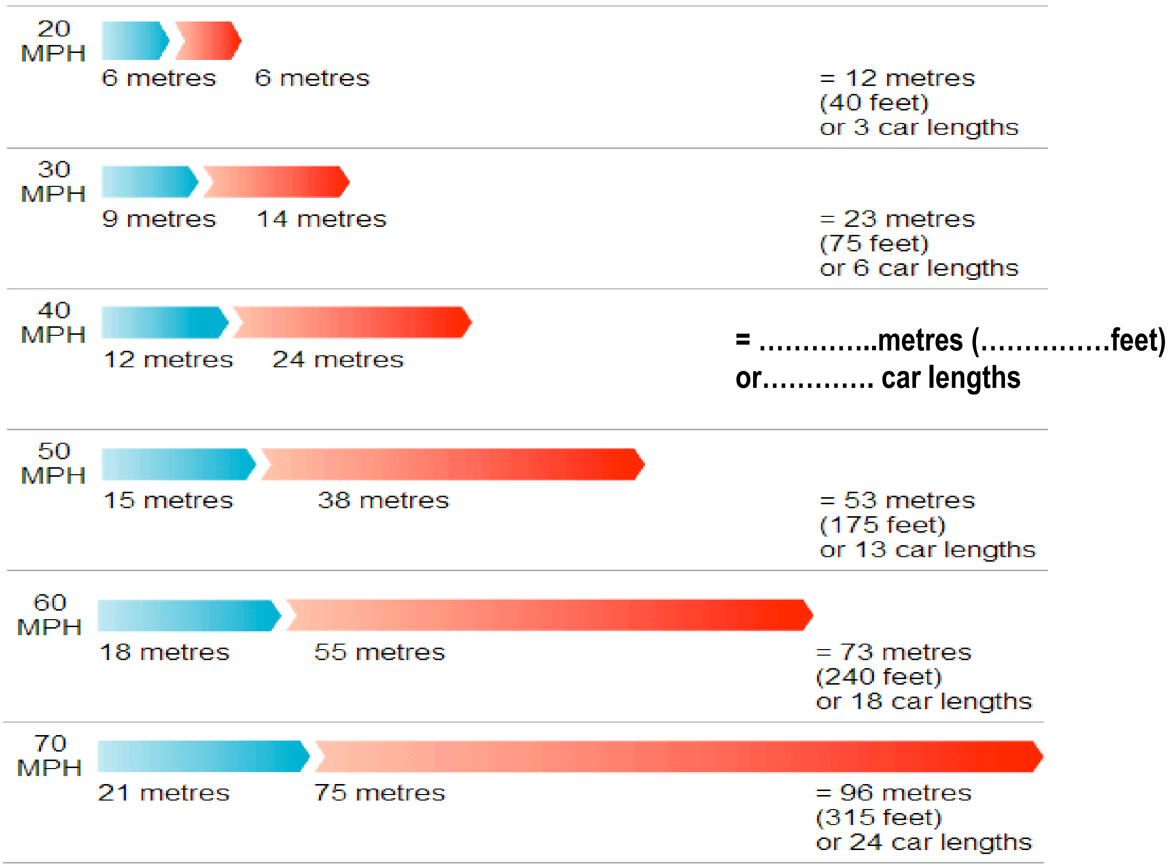
LST

3. When a driver sees a pedestrian stepping out into the road in front of him, he will make an emergency stop. The government publishes a list of the distances an average car will cover in the time between the driver seeing the pedestrian and the car coming to a stop. These are called the stopping distances. Stopping distance is made up of two parts. The first is called the thinking distance and is the distance the car travels in the time it takes for the driver to get his foot onto the brake pedal. The second is called the braking distance and is the distance the car travels whilst the brakes are being applied.

e.g. at 60 MPH (miles per hour) the thinking distance is 18 m, the braking distance is 55 m and therefore the stopping distance is 18 + 55 = 73 m.

A complete set of data is shown below. Unfortunately the data is provided in a mixture of modern units (metres) and old-fashioned units (feet).

Typical Stopping Distances



Adapted from: www.beseenonabike.com

(a) Look at the information provided and work out how long the government assumes an average car is. Give your answer to the nearest metre and show your working.

Length of an average car is ....metres [1]

(b) Select some data from the diagram to work out the relationship between metres and feet. Show your working.

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____

1 foot = …..…………metres 1 metre = ……………..feet [1]

(c) Use your answers from parts (a) and (b) to complete the information on the diagram above for 40 MPH.

[2]

(d) Convert 20 MPH into metres per second, given that 1 mile = 1609 m.

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____ [2]

(e) Use your answer to part (d) to calculate the thinking time at 20 MPH. (i.e. the time it takes for the driver to get his foot onto the brake pedal). Show your working.

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____ [2]

(f) It has been suggested that the thinking time is always the same, regardless of the speed of the car. Use another set of data to test this suggestion.

____

____

____ [2]

(g) It has been suggested that when the speed is doubled, the braking distance increases by a factor of four. Use the information in the diagram to test this suggestion.

____

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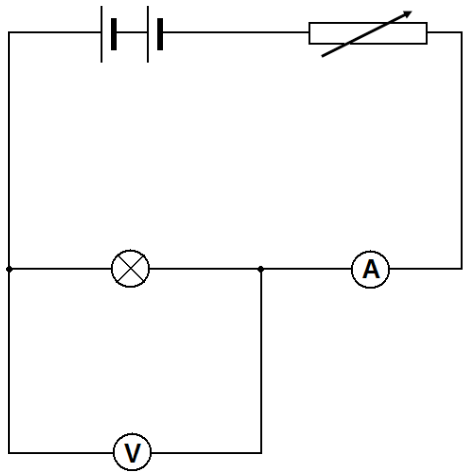
____ [2]

[Turn over]

LST

4. In an electrical circuit, charged particles known as electrons travel through the wires making up the circuit. This flow of charge is called an electric current, which can be measured with an ammeter.



To help you understand electrical measurements, the table below gives examples of some general physical quantities and the standard unit used when measuring them.

Quantity	Unit
Length	Metre
Time	Second
Charge	Coulomb
Current	Amp
Voltage	Volt

If an ammeter shows a current of 1 amp, then 1 coulomb of charge is flowing through the ammeter each second.

(a) How could you increase the current flowing in the circuit shown above?

____ [1]

(b) Suppose the ammeter in the circuit above shows a current of 0.50 amp. How much charge flows through the ammeter in fifteen minutes?

____

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____ [2]

(c) An ammeter is designed to have a very small (ideally zero) resistance. Explain why this is the case.

____

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____ [2]

(d) What will happen to the bulb if the ammeter is connected in parallel with it, rather than in series as shown above?

____ [1]

A current will only flow if the circuit includes a voltage source, such as a cell. Cells provide energy to the electrons to enable the current to flow.

The size of a voltage can be measured with a voltmeter. In the circuit above, the voltmeter has a very high resistance compared to the light bulb.

(e) What does this tell you about the current flowing through the voltmeter?

____

____ [1]

There are two cells in the circuit above, each providing a voltage of 1.5 volt. The ammeter then reads 0.50 amp, as stated above.

(f) Suggest what the new ammeter reading will be if:

(i) one of the cells is removed?

____ [1]

(ii) one of the cells is reversed?

____ [1]

(iii) the voltmeter is connected in series with the bulb?

____ [1]

A student suggests that the addition of a second, identical bulb in series with the first would reduce the ammeter reading to 0.25 amp.

(g) Explain briefly why this student is incorrect.

____

____

____ [2]

[Turn over]

5. The reactivity series of metals lists the order of reactivity of the metals with the most reactive first.

(a) Complete a word equation for the reaction between the following chemicals. If there is no reaction, state 'no reaction'.

(i) zinc chloride + magnesium → ______________________________ [1]

Zinc oxide reacts with strontium but not with chromium. Magnesium sulphide reacts with strontium but does not react with chromium.

(ii) Using the information above, put the four metals chromium, magnesium, zinc and strontium in a reactivity series with the most reactive first and least reactive last.

____ [1]

(b) The reaction between iron oxide and carbon is an example of a redox reaction. This is used in a blast furnace to produce iron.

$$\text{iron oxide}_{(s)} + \text{carbon}_{(s)} \rightarrow \text{iron}_{(s)} + \text{carbon dioxide}_{(g)}$$

(i) What process is the iron oxide undergoing?

____ [1]

(ii) Why might the rain in areas around a blast furnace have a slightly lower pH value than normal?

____

____ [1]

Limestone is also added to a blast furnace along with iron oxide and carbon. The main compound found in limestone is $CaCO_3$. This reacts according to the following equation.

$$CaCO_{3\,(s)} \rightarrow CaO_{(s)} + CO_{2\,(g)}$$

(iii) What are the chemical names of the following two compounds in the reaction above?

$CaCO_3$ ____ [1]

CaO ____ [1]

[Turn over]

(iv) What type of chemical reaction has the $CaCO_3$ undergone?

____ [1]

(v) Suggest what possible use might adding limestone to a blast furnace have?

____

____ [1]

(vi) Why do farmers sometimes spread crushed limestone on their fields? What kind of reaction takes place when they do this?

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____ [2]

(vii) Why might you advise a farmer to add CaO to his fields instead of $CaCO_3$?

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____ [2]

(End of Paper)