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Eton College King's Scholarship Examination 2011

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

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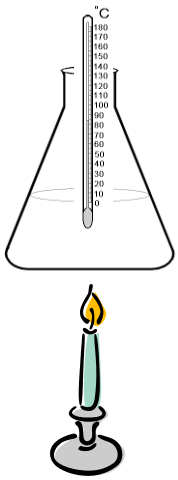
1. A candle is placed beneath a conical flask containing 100 cm³ of water as shown in the diagram below. The temperature of the water is measured and then the candle is lit and allowed to burn for 30 minutes.



As the candle burns the wax melts and is combusted in a non-reversible reaction.

(a) State one other physical change that occurs when the candle burns.

_____

_____ [1]

(b) What is the function of the wax?

_____ [1]

(c) What is the function of the wick?

_____

_____ [2]

As the candle burns smoke is given off, some of which collects on the bottom and sides of the conical flask.

(d) What does smoke consist of?

_____ [1]

(e) Name one gaseous product of this reaction and explain how you would test for it.

_____

_____ [2]

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(f) A candle usually burns with an orange flame, but when blown gently the flame blue colour. Explain this change.

_____

_____

_____ [2]

After 30 minutes the candle is blown out and the temperature of the water is measured.

(g) Starting with the chemical potential energy in the candle, describe the process of energy transfer that means the reading on the thermometer is now higher than at the start.

_____

_____ [1]

(h) From the overall temperature increase of the water it was calculated that less than 100% of the chemical potential energy in the candle had been transferred to the water. Explain the three major reasons that less than 100% of the energy in the candle was transferred to the water.

_____

_____

_____

_____ [2]

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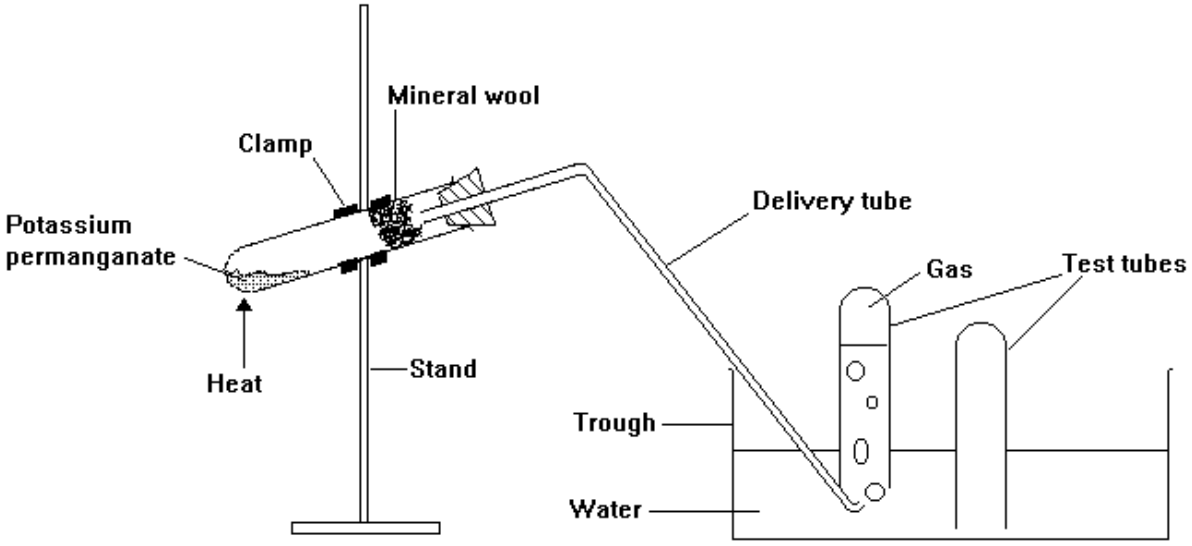
2. Potassium permanganate has the formula $KMnO_4$. If it is heated (as shown in the diagram below) oxygen gas is given off.



Below is a simplified version of the equation for the reaction, along with an equation for the same reaction using chemical formulae instead of words.

potassium permanganate → potassium manganate + manganese dioxide + oxygen

$2\ KMnO_4\ (s) \rightarrow K_2MnO_4\ (s) + MnO_2\ (s) + O_2\ (g)$

(a) What type of reaction is taking place?

_____ [1]

(b) A student carried out the experiment as shown above using 1 gram of potassium permanganate and was disappointed that the first tube of gas he collected did not relight a glowing splint. His teacher told him to collect another tube of gas and test it. This did relight the glowing splint. How do you account for this difference?

_____

_____

_____ [2]

(c) The student noticed that the rate of oxygen production was low during the first minute of the experiment, then greater during the second minute before slowing down again. Explain this observation.

_____

_____

_____

[2]

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(d) The teacher calculated how much oxygen should be produced in this reaction. De
making no experimental errors, the student collected less than the calculated amount.
Give two reasons to account for this difference.

_____

_____

_____

_____ [2]

(e) When the source of heat is removed there is a risk of 'suck-back' into the apparatus.
Use your scientific knowledge to explain what causes 'suck-back' to occur in this
experimental set up.

_____

_____

_____

_____

_____ [3]

(f) How can 'suck-back' be prevented in this case?

_____

_____ [2]

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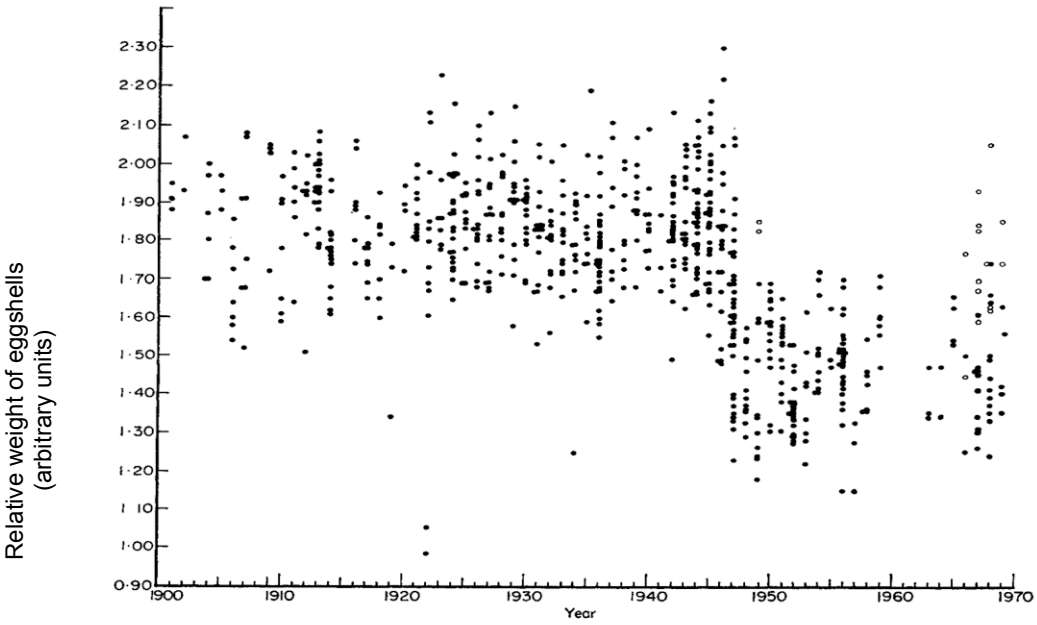
3. Peregrine falcons are birds of prey which live for up to 15 years. They feed almos
exclusively on medium-sized birds like starlings. Starlings feed on leaf beetles such
Chrysolina americana, which is a pest of the shrub Rosemary.

(a) In the space below, construct a food chain including Peregrine falcons.

[2]

In the mid-1940s organochlorine pesticides, such as DDT, were introduced in Britain to kill insect pests on crops, but this coincided with a dramatic fall in the Peregrine falcon population. To investigate this further a scientist called D.A. Radcliffe made measurements of eggshells collected from nests between 1900 and 1970 (see graph below). All the measurements were made on eggshells which had had their contents removed and the evidence suggested that the decrease in relative weight of Peregrine falcon eggshells was associated with increased numbers of eggs breaking in nests whilst being incubated by the parent birds.



The graph shows the change in relative weight of Peregrine falcon eggshells in Britain from 1900 - 1970. Each point is one egg. Data are from Radcliffe, D.A. (1970)

(b) Describe the data shown in the graph.

_____

_____

_____ [2]

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(c) Radcliffe was able to show that the overall size of eggs did not change through the period he studied. Suggest two ways in which eggs of the same size could weigh less.

_____

_____

_____ [2]

(d) Does Radcliffe's data prove that the use of DDT caused the decline in the Peregrine falcon population?

_____

_____

_____ [2]

The table below shows the relative weight of eggshells from Peregrine falcon populations before and after 1946.

	All regions of British Isles 1901 - 46	Central Highlands of Scotland 1947 - 69	All regions of British Isles except Central Highlands 1947 - 69
Relative weight (arbitrary units)	1.836	1.735	1.485

(e) Use the data to suggest why eggs from the Central Highlands are significantly heavier than eggs from the rest of the British Isles following 1946.

_____

_____

_____

_____ [2]

(f) Modern pesticides are now used which do not accumulate in food chains. Use your biological knowledge to suggest why modern pesticides do not accumulate in food chains.

_____

_____

_____

[2]

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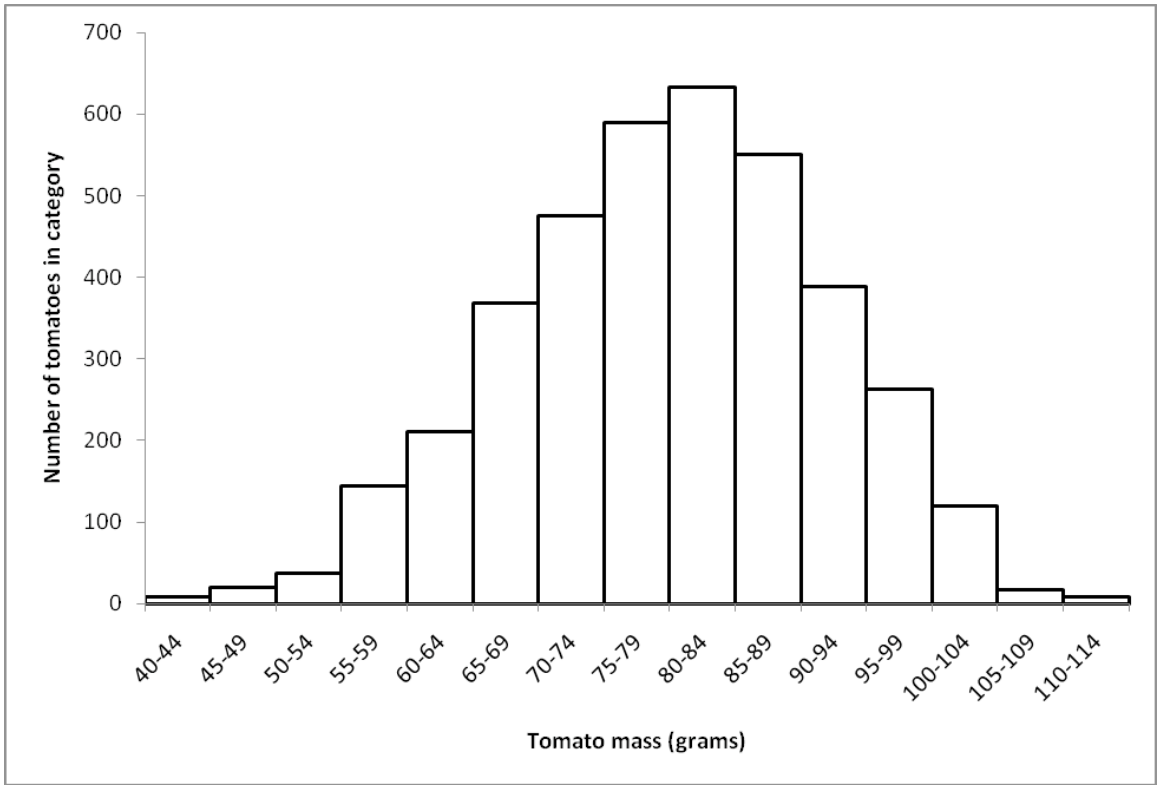
4. A farmer weighed all the tomatoes he grew during one year and plotted the data graph.



(a) Use your biological knowledge to explain what might have caused these differences in the size of tomatoes.

_____

_____

_____ [2]

(b) In order to increase the average size of his tomatoes, the farmer decided to try to selectively breed some of his plants over a ten year period. Explain what the farmer should do, including all the practical steps you believe are necessary for a successful breeding programme.

_____

_____

_____

_____

_____

_____ [6]

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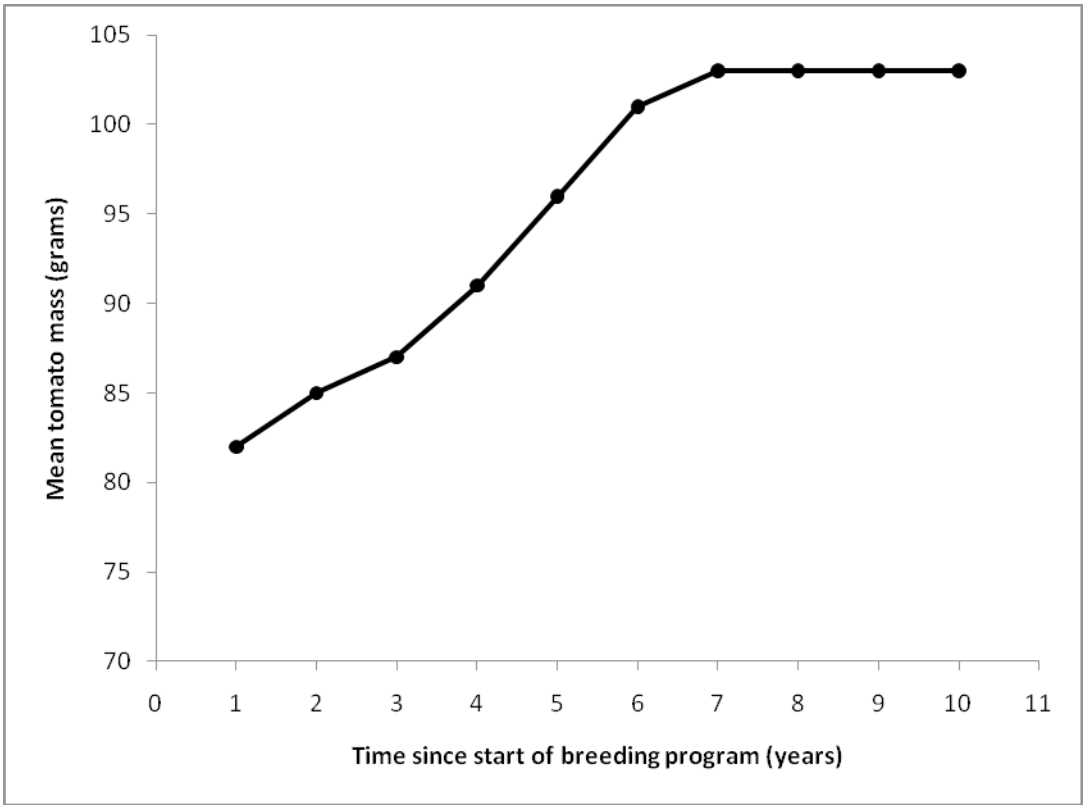
The graph below shows how the mean mass of the farmer's tomato crop changed year during the ten year breeding programme.



(c) Use your biological knowledge to explain these results.

_____

_____

_____

_____

_____

_____ [4]

[Turn over]

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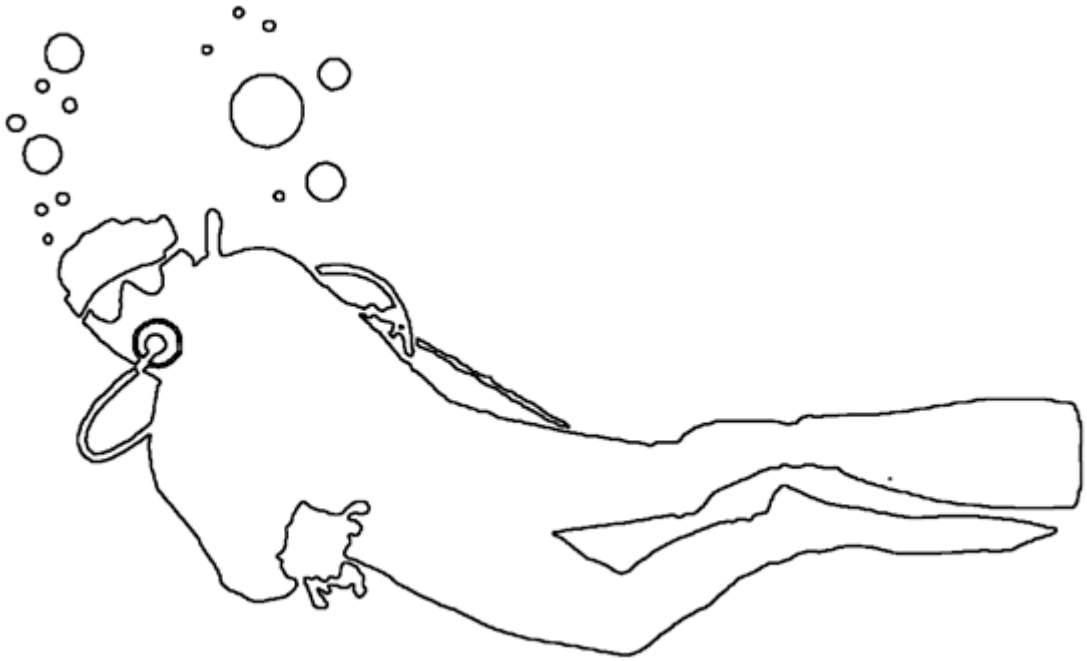
5. During training, a scuba-diver reads the following passage in a manual:

> It has long been known that air has weight. At sea level, the weight of the atmosphere exerts a pressure of 14.7 pounds of force per square inch. This is to say that a 1 square inch column of air as tall as the atmosphere weighs 14.7 pounds. We commonly call this one atmosphere of pressure (1 ATM).
>
> Water weighs considerably more than air, so it can exert much more pressure. A 1 square inch column of sea water that is only 33 feet tall weighs 14.7 pounds. This means that at a depth of 33 feet in the ocean, there is a total pressure of 29.4 pounds per square inch (PSI). This is equivalent to 2 ATM of pressure; 1 ATM from the air above and 1 ATM from the water. Every additional 33 feet of sea water, will add another 14.7 PSI of pressure, or a further 1 ATM.

After reading this, the diver cannot understand why the "weighty" air that he breathes out underwater rises rather than sinks.

(a) Add arrows to the picture below to show the direction and relative size of the two forces acting on the largest air bubble as it starts to move upwards. Label each arrow with the correct name of the force it represents.

[3]



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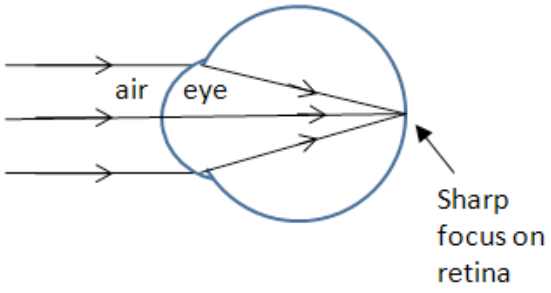
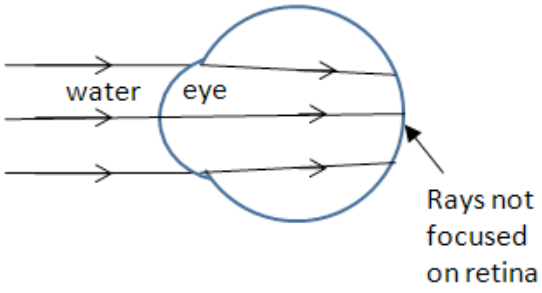
When swimming in the local leisure pool, the scuba diver notices that he cannot see objects clearly when his eyes are under water. The following diagrams explain why.

a) In air



Light travels more slowly in the eye than in air and is therefore refracted at the boundary.

b) Under water

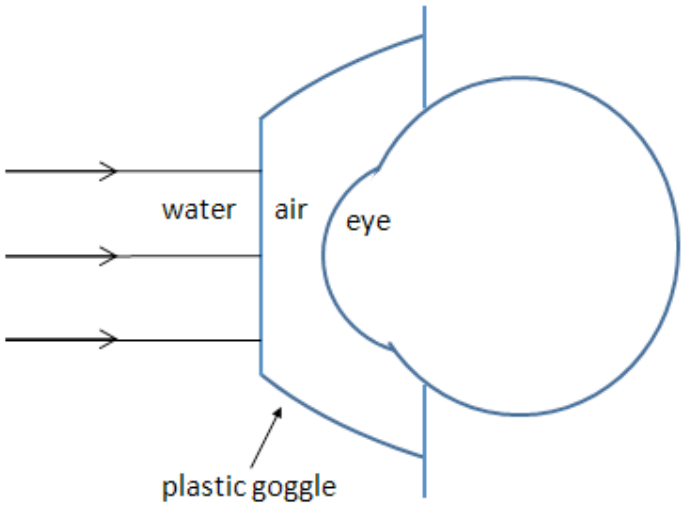


Light travels at nearly the same speed in the eye as in water so very little refraction occurs at the boundary.

He notices that when he puts his goggles on he can see clearly.

(b) Complete the three rays on the diagram below to show how the goggles allow his eye to focus.

[2]



(c) Calculate the pressure at a depth of 75 feet in pounds per square inch (PSI).

_____

_____ [2]

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Useful information:

- 1 pound = 0.454 kg
- 1 inch = 2.54 cm
- 1 kg weighs 9.81 newtons on Earth

(d) Calculate the pressure at a depth of 75 feet in newtons per square centimetre (N/cm^2).

_____

_____ [2]

The diver is told that his first dive will be to a depth of 75 feet. He decides to wear his goggles but his diving instructor tells him that using his rigid goggles on the dive will be very painful due to the extra pressure at that depth. Instead he is told to wear a scuba diving mask that covers his nose, so that he can exhale through his nose and into the mask.

(e) Use your answers to the questions above to estimate the force (in newtons) with which the goggles push against his face at this depth. Explain your calculation and any assumptions fully.

_____

_____

_____

_____ [2]

(f) Explain how this uncomfortable force can be reduced to zero when a scuba diving mask which covers the nose is worn.

_____

_____ [1]

[END OF PAPER]

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