OCR
RECOGNISING ACHIEVEMENT

ADVANCED GCE UNIT **2845**

SCIENCE

Synthesis of Scientific Concepts

THURSDAY 12 JUNE 2008 Afternoon

Time: 1 hour 30 minutes

Candidates answer on the question paper
Additional materials (enclosed): None

Additional materials (required):
Electronic calculator

CUP/T57735

Candidate Forename		Candidate Surname	
Centre Number		Candidate Number	

INSTRUCTIONS TO CANDIDATES

- Write your name in capital letters, your Centre Number and Candidate Number in the boxes above.
- Use blue or black ink. Pencil may be used for graphs and diagrams only.
- Read each question carefully and make sure that you know what you have to do before starting your answer.
- Answer **all** the questions.
- Do **not** write in the bar codes.
- Write your answer to each question in the space provided.

INFORMATION FOR CANDIDATES

- The number of marks for each question is given in brackets [ ] at the end of each question or part question.
- The total number of marks for this paper is **90**.
- You will be awarded marks for the quality of written communication where this is indicated in the question.
- You may use an electronic calculator.
- You are advised to show all the steps in any calculations.

FOR EXAMINER'S USE		
Qu.	**Max.**	**Mark**
1	**13**	
2	**12**	
3	**10**	
4	**10**	
5	**23**	
6	**22**	
TOTAL	**90**	

This document consists of **17** printed pages and **3** blank pages.

[Turn over

Answer **all** the questions.

1 Some types of animal – for example tortoises – exist as different species with very different body sizes. The largest tortoise is the Galapagos Giant tortoise which has a body up to 2 m long, whereas one of the smallest is the Cape tortoise with a body length of around 6 cm.

It is thought that it would be impossible for the Galapagos tortoise to evolve to be even larger.

(a) A very simple diagram of the body of a tortoise is shown in Fig. 1.1. It can be thought of as a "half-sphere" resting on four short legs.

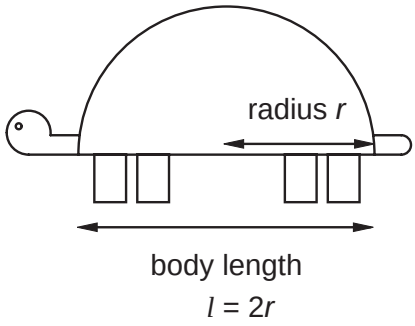

Fig. 1.1

The volume of a "half-sphere" is $\frac{2}{3}\pi r^3$, where r is the radius of the half-sphere.

The volume of the legs, head and tail should be ignored in the following calculations.

(i) A Galapagos tortoise has a body length of 1.2 m. Calculate the volume of the body in m^3.

volume = ... m^3 [1]

(ii) The volume of the body of a small Cape tortoise is 4.0×10^{-4} m^3, and it has an average density of 980 kg m^{-3}. Calculate the mass of this Cape tortoise.

mass = ... kg [2]

(iii) The mass of a Galapagos tortoise is 450 kg. Show that the density of its body is similar to that of a Cape tortoise.

[1]

(iv) Many tortoises are partly aquatic (live in water). The density of water is 1000 kg m^{-3}. Comment on the significance of the density of the body of these tortoise species.

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..... [1]

(b) A problem for very large land-based tortoises is that the weight of the body may be too great to be supported by the bones in their legs.

The weight of any object is the force of gravity exerted on it, which can be calculated by the equation $F = m\,g$ ($g = 9.81\,\text{N kg}^{-1}$).

(i) A Galapagos tortoise has a mass of 450 kg. Show that the force on each of the four legs is about 10 000 N.

[1]

(ii) Assume that a leg bone of a giant tortoise is cylindrical and has a radius of 5 cm. Calculate the cross-sectional area of the bone in m^2 and hence the pressure exerted by the weight of the tortoise on the leg bone.
(area of a circle = πr^2 ; $\pi = 3.14$)

pressure on leg bone = ... $N\,m^{-2}$ [2]

(iii) Bones can break if they are subjected to a pressure of around $2 \times 10^6\ Nm^{-2}$. From your calculations, are Galapagos giant tortoises at risk of breaking their leg while moving about on land? Justify your answer.

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..... [1]

(iv) Use a similar method to decide whether the Cape tortoise is more or less at risk of breaking its leg while moving. Show your working. Assume the leg bone of a Cape tortoise has a radius of 0.25 cm. The other necessary information will be found in earlier parts of the question.

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(v) Use the calculations in this question and any other scientific idea to suggest **two** reasons why there is a limit to the size of all species of animals.

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..... [2]

[Total: 13]

2 Atomic emission spectroscopy can be used to identify the different atoms in a sample. The simplest emission spectrum is produced by hydrogen gas. A high voltage is applied to hydrogen gas in a tube at low pressure. A mixture of visible and ultraviolet light is emitted and the light can be analysed to produce the spectrum of atomic hydrogen.

The spectrum consists of a number of lines. The lines get closer together as the frequency increases, as shown in Fig. 2.1.

Fig. 2.1

The spectrum can be explained from our knowledge of the structure of atoms. One model of atomic structure is shown in Fig. 2.2.

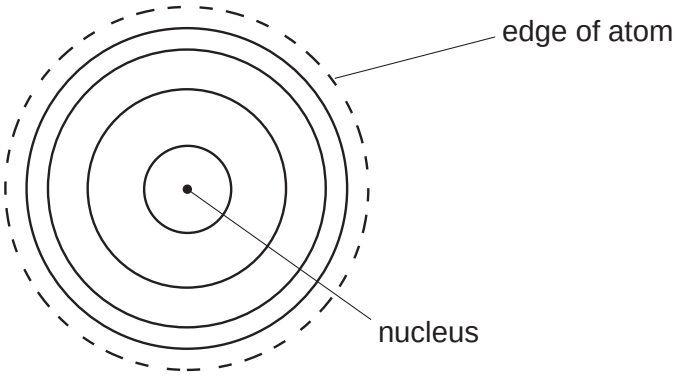

Fig. 2.2

(a) Use this information to explain how atoms give out electromagnetic radiation in atomic emission spectroscopy. In your answer you should suggest:

- why separate lines are seen in the spectrum
- why the lines get closer together at high frequencies.

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(b) The data for the frequency of the lines can be used to provide important information about hydrogen. One piece of information which can be deduced is the *ionisation energy* – the energy required to ionise an atom in the gaseous state.

(i) Describe what happens to an atom when it is *ionised*.

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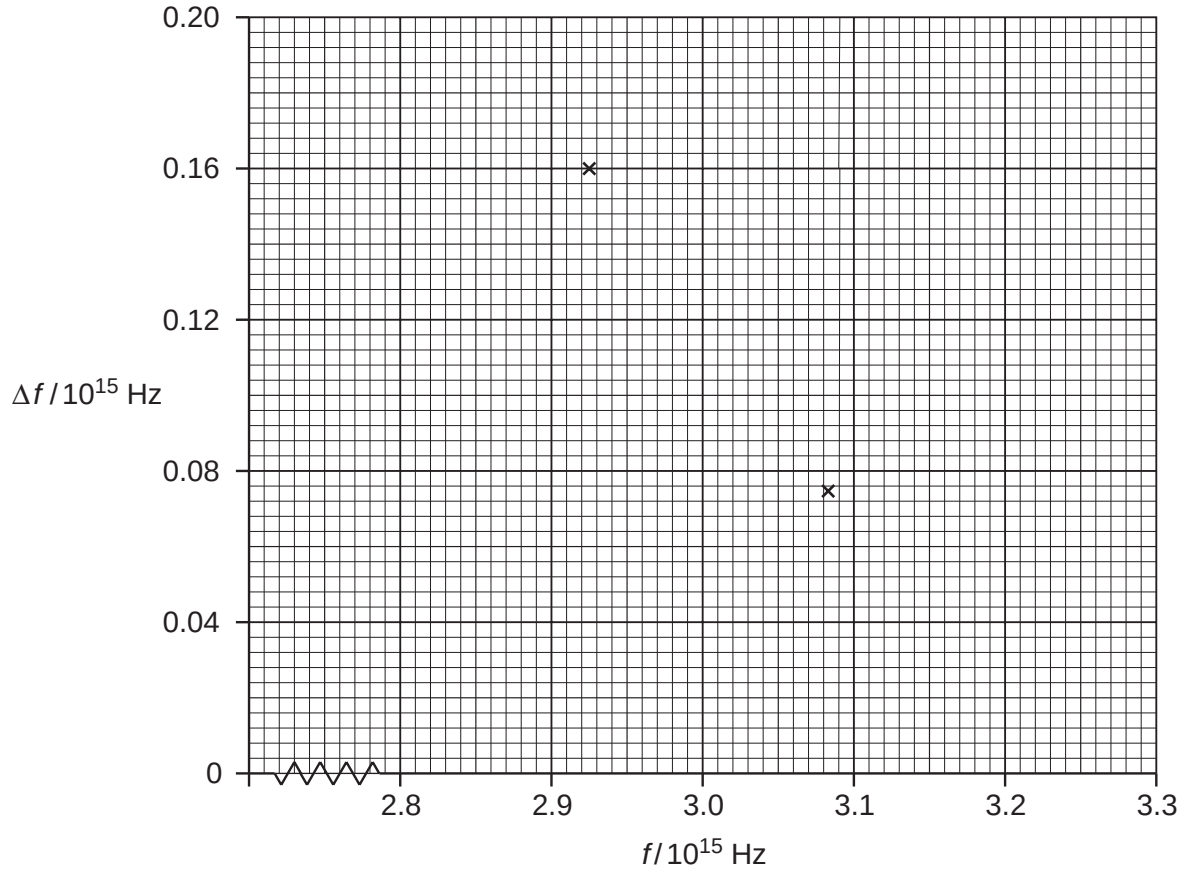
..... [2]

The frequencies, f, and the differences in frequencies, Δf, between successive lines in the spectrum are shown in the table below:

$f/10^{15}$Hz	2.923	3.083	3.157	3.197	3.221	3.237	3.248
$\Delta f/10^{15}$Hz	0.160	0.074		0.024	0.016	0.011	0.008

(ii) Complete the table by calculating the missing value of Δf. [1]

(iii) Plot a graph of difference in frequency, Δf, against frequency, f. Draw a smooth curve to show the pattern in the data. The first two points have been plotted for you.



[2]

(iv) Use the graph to find the frequency, f at which the Δf value would be zero.

frequency = ... × 10^{15} Hz [1]

(v) This frequency corresponds to the ionisation energy.

Use the relationship $E = hf$, where h is Planck's constant (6.63×10^{-34} J Hz^{-1}), to calculate the energy corresponding to this frequency. Give your answer to 3 significant figures.

energy = ... J [2]

[Total: 12]

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3 Nitrogen is an element which is essential for the growth of plants. Fig. 3.1 shows some of the natural processes involving nitrogen in a small field ecosystem.

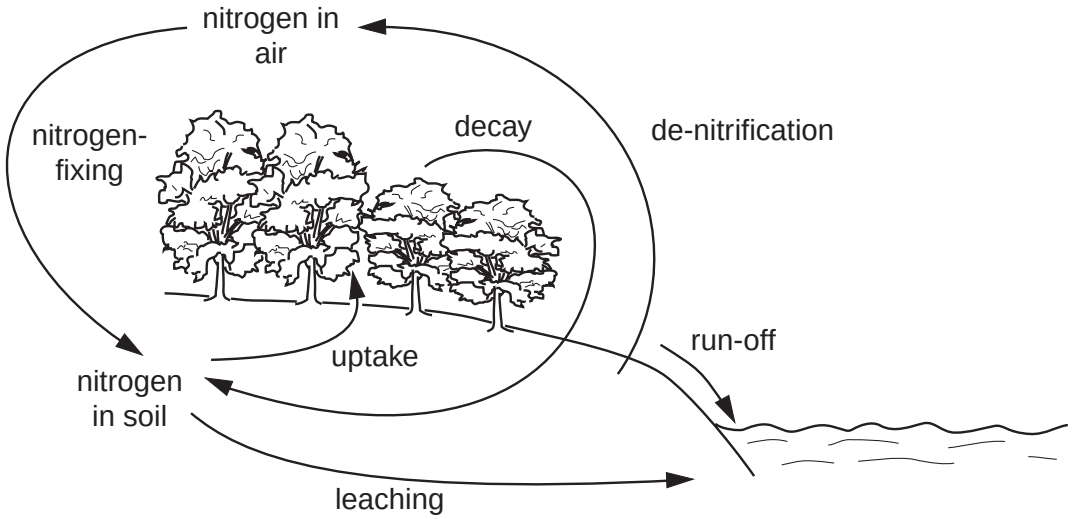

Fig. 3.1

Use the diagram and your knowledge of science to explain

- why nitrogen is needed by plants
- the effect of farming on these natural processes
- how modern agrichemicals have been use to ensure a continued supply of nitrogen to the crops
- the potential problems caused by the use of these agrichemicals.

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[Total: 10]

4 The structural formula of aspirin is shown in Fig. 4.1.

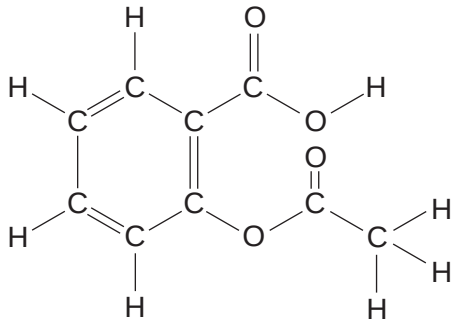

Fig. 4.1

(a) Describe the bonding in this substance.

You should consider:

- the bonds within this structure
- the likely intermolecular forces between molecules of aspirin.

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(b) The effectiveness of aspirin is sometimes limited by the fact that it is not very soluble in water. This means that it is more slowly absorbed by the bloodstream. This problem can be overcome by using so-called “soluble aspirin”. The structure of soluble aspirin is shown in Fig. 4.2.

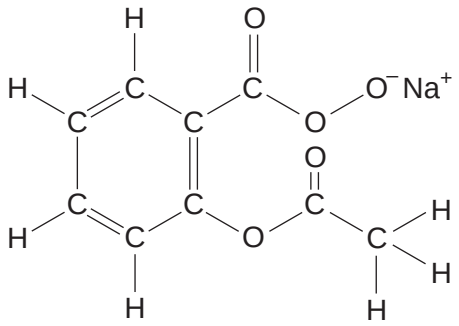

Fig. 4.2

Describe the differences in the structure of aspirin and soluble aspirin and hence suggest why soluble aspirin is more soluble in water.

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..... [3]

[Total: 10]

5 In this question, four marks are available for the quality of written communication.

Read the passage below carefully.

SUN CAN DAMAGE YOUR HEALTH!

In the United Kingdom a suntan has become associated with fitness, youth and health. Cheap air travel has made travel to sunnier climates accessible to the majority of the population. This has led to an increase in exposure to the Sun and hence to ultraviolet radiation (UVR).

Unfortunately the consequent rise in UVR exposure has led to a greater risk of damage to the skin caused by sunlight, called photodamage. This can affect molecules such as DNA in our cells, causing mutations which may result in a risk of developing cancer. Scientific studies have proved that increased exposure to UVR is linked to a higher rate of skin cancer cases.

The problem has been made worse in recent years because pollution has damaged the ozone layer which plays an essential role in preventing UVR reaching the Earth's surface.

So how can holiday-makers enjoy their sunny holiday safely? The key to it is to prevent the UVR reaching the skin. This means using sun creams which absorb the radiation or, even better, sun-block which reflects it.

The passage is taken from an information leaflet aimed at the general public and includes very little scientific detail.

Explain the scientific principles which are relevant to the issue of the danger of UVR and the methods of protection.

You should aim to deal with the following points in your answer:

- the nature of ultraviolet radiation
- the importance of avoiding mutations in DNA
- the type of scientific studies used to assess the dangers of UVR
- the ozone layer and the damage that has been caused
- the processes of absorption and reflection.

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.... [19]

Quality of Written Communication [4]

[Total: 23]

6 In this question, four marks are available for the quality of written communication.

Read the passage below about the isolation of enzymes.

> Biochemists frequently need to extract enzymes from organisms in order to study them in the laboratory. The technique of centrifugation is particularly valuable if enzymes need to be extracted from particular organelles.
>
> One such method for obtaining an enzyme from rat-liver mitochondria is described below:
>
> "Firstly a humane method of killing must be found which does not affect the biochemistry of the animal. For example, poisons cannot be used as they might inhibit some of the enzymes being studied. The required organ – in this case the liver – must then be rapidly removed and kept in ice and buffer solution to maintain low temperature and neutral pH.
>
> The cell membranes must then be broken open gently to release their contents without damaging cell organelles.
>
> The cell organelle mixture is then subjected to centrifugation. This involves spinning the test-tube round at increasingly rapid speeds, subjecting the mixture to increasing acceleration. This causes the densest organelles to sediment (sink to the bottom of the tube) most rapidly.
>
> The nuclei sediment first, then the mitochondria, and finally the ribosomes and lysosomes, leaving the cytoplasm as a fluid at the top of the tube. The sedimented organelles are removed from the tube at the end of each period of centrifugation.
>
> Enzymes can be extracted, identified and purified from these organelles. One method for doing this involves a process similar to thin-layer chromatography."

Write an account of the relevant scientific principles mentioned in the passage.

You may wish to organise your answer to cover the following points:

- the structure of cells in terms of the organelles present
- the nature of enzymes and the factors affecting their activity
- the practical techniques mentioned in the passage.

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Quality of Written Communication [4]

[Total: 22]

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