AQA

General Certificate of Education
Advanced Level Examination
June 2012

Science in Society SCIS3

Unit 3   **Exploring Key Scientific Issues**

Wednesday 20 June 2012   1.30 pm to 3.30 pm

For this paper you must have:
- a calculator
- a ruler.

Time allowed
- 2 hours

Instructions
- Use black ink or black ball-point pen.
- Fill in the boxes at the top of this page.
- Answer **all** questions.
- You must answer the questions in the spaces provided. Do not write outside the box around each page or on blank pages.
- Do all rough work in this book. Cross through any work you do not want to be marked.

Information
- The marks for questions are shown in brackets.
- The maximum mark for this paper is 90.
- You will be marked on your ability to:
  – use good English
  – organise information clearly
  – use specialist vocabulary where appropriate.

Section A

Answer **all** questions in the spaces provided.

1   Schizophrenia is a serious mental illness. The symptoms include delusions, strange behaviour and social withdrawal. It is estimated that about 0.2% of the UK population is affected, a much higher proportion than any other mental illness.

1 (a)   To find out more about the role of genetic factors in causing the illness researchers studied the risk of developing schizophrenia in twins.

Figure 1

Risk of developing schizophrenia in twins

Twins	Lifetime risk of developing schizophrenia if twin already has it
Identical twins	30% - 50%
Non-identical twins	9% - 26%

1 (a) (i)   Explain how comparisons between identical and non-identical twins can provide evidence about the role of genes in a disease.

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(2 marks)

1 (a) (ii) What evidence do the data in **Figure 1** provide about the extent to which schizophrenia is caused by genetic factors?

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(3 marks)

1 (b) Most researchers agree that the risk of schizophrenia is also influenced by factors in the environment. These include stress and the type of parenting received. New research on epigenetics is beginning to discover mechanisms by which these factors could influence expression of genes in the brain. The expression of genes involved in the production of the *neurotransmitter* GABA is one area of research.

1 (b) (i) What is a neurotransmitter?

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(1 marks)

1 (b) (ii) What is meant by the term gene expression?

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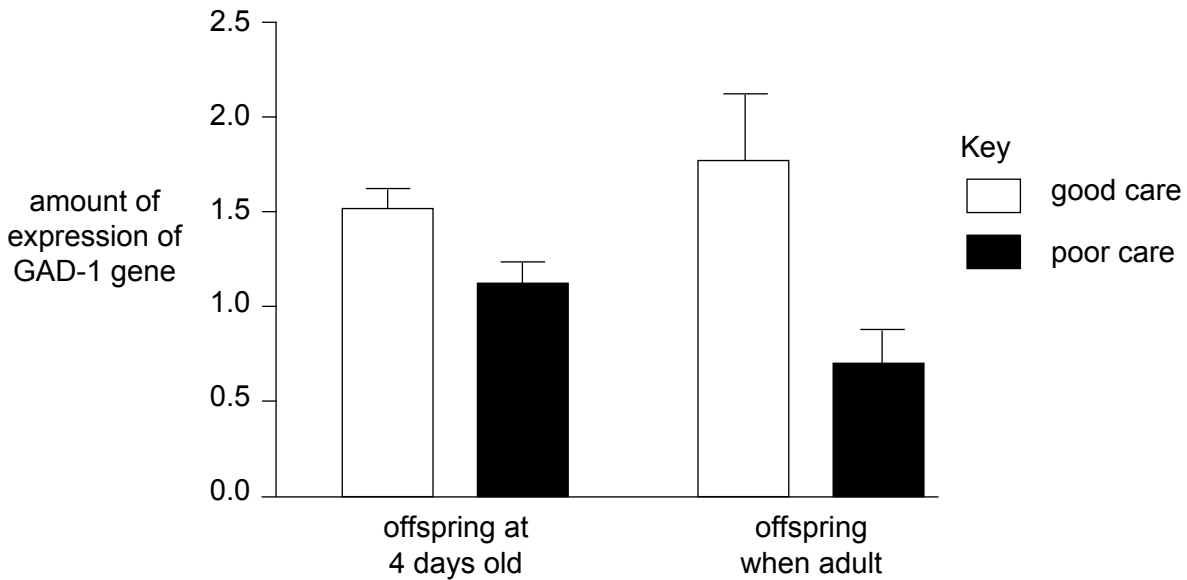*(2 marks)*

Question 1 continues on the next page

Turn over ▶

1 (b) (iii) A study looked at how maternal care in rats affected expression of the gene for the enzyme GAD-1 in the rats' hippocampus. GABA production is controlled by the GAD-1 enzyme. Some of the results are shown in **Figure 2**.

Figure 2

Influence of maternal care on expression of the gene for the enzyme GAD-1 in their offspring (error bars show the uncertainty in the data)

What conclusions can you draw from **Figure 2** about the influence of maternal care on expression of the GAD-1 gene?

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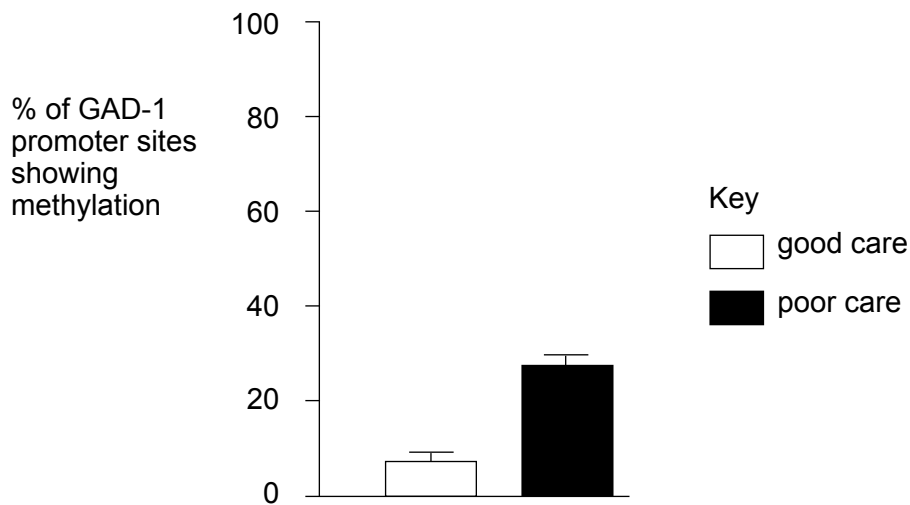
(3 marks)

1 (c) The expression of the GAD-1 gene is regulated by a section of DNA called the GAD-1 promoter. The activity of the GAD-1 promoter is affected by a chemical change to the DNA called methylation. This epigenetic change is not permanent but can be long-lasting and may be passed on to offspring.

Figure 3 shows how methylation of the GAD-1 promoter is influenced by maternal care in rats.

Figure 3

Influence of maternal care on methylation of DNA in the GAD-1 promoter. Samples from the hippocampus of adult rats (error bars show the uncertainty in the data)

To what extent do the data in **Figure 2** and **Figure 3** support the idea that

"Lack of maternal care may result in long-lasting epigenetic changes. These changes affect processes in the brain that are involved in human mental illness."?

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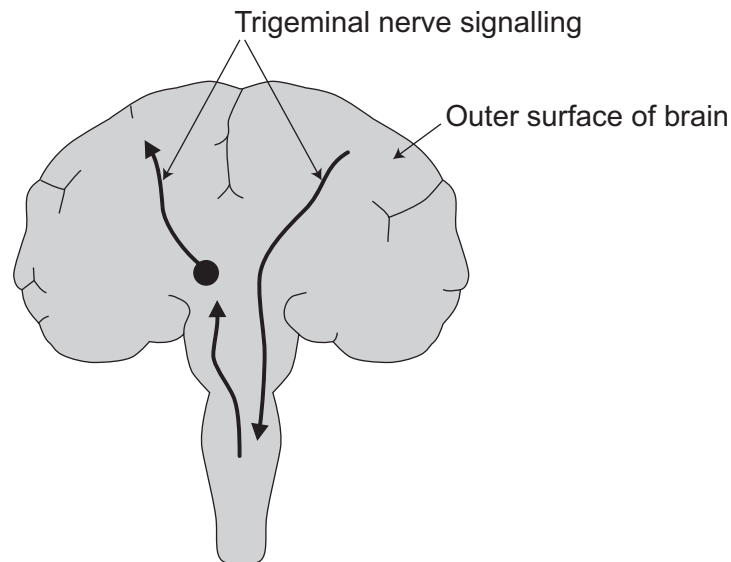
(4 marks)

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Turn over ▶

2 It is estimated that 11% of the world's adult population suffer from recurrent migraine attacks. The symptoms of migraine include several hours of severe throbbing head pain, nausea, and sometimes a set of strange visual images known as an aura. Head pain is felt when the cortex receives pain signals from the trigeminal nerves. These carry pain signals from the outer surface of the brain via the brain stem as shown in **Figure 4**.

The cause of migraines is still not fully understood. Two different explanations have been suggested. These are:

- **Vascular theory**: expansion of the blood vessels in the outer surfaces of the brain triggers a pain response in the trigeminal nerves.

- **Neurological theory**: a malfunction in the neurons in the brain stem makes the trigeminal nerves more readily activated.

Figure 4

Route of pain signals in brain

Trigeminal nerve signalling

Outer surface of brain

2 (a) On **Figure 4** label

- the brain stem
- the cortex

(2 marks)

2 (b) The vascular theory has been investigated using MRI scans to monitor the diameter of blood vessels in the outer surface of the brain. In one recent study scientists gave a drug known to expand blood vessels to 27 volunteers. Six different blood vessels in each subject's brain were measured at three times;

- before administration of the drug
- while getting the drug
- 6 hours after getting the drug.

After six hours, 20 of the subjects had developed a migraine and 7 had not. The results for one blood vessel are shown in **Figure 5**. Other blood vessels showed similar results.

Figure 5

**Mean diameter of one blood vessel in the outer surface of the brain
(error bars show the uncertainty in the data)**
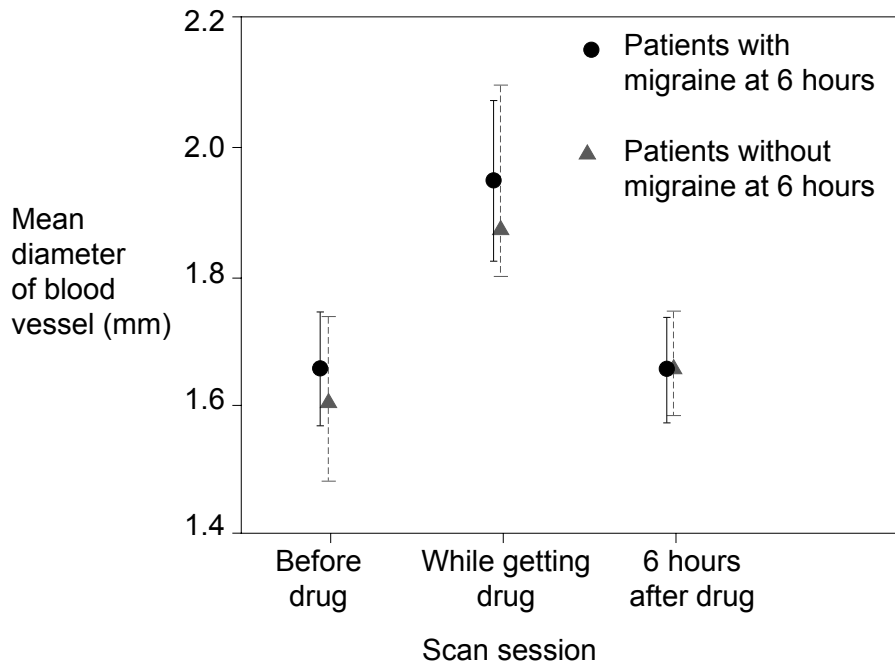
Does this evidence support the hypothesis that expansion of blood vessels is the source of the pain? Explain your answer.

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(3 marks)

Turn over ▶

2 (c) Sumatriptan is currently the most effective drug for relieving migraine. It is known to constrict blood vessels (to make them narrower). It also blocks the release of neurotransmitters from the trigeminal nerve in the brain stem.

Explain how both the vascular and the neurological theories might account for the effectiveness of sumatriptan.

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(2 marks)

2 (d) The neurological theory has been supported by brain scan evidence showing abnormal activity in parts of the brain stem during a migraine attack. The relevance of this is described in the quote:

"These particular brain stem areas receive input only from the area of the cortex that regulates arousal, attention and mood, the limbic cortex. Through its connection with the brain stem the limbic cortex affects the functioning of the rest of the cortex. This explains how emotional and psychological stress could catalyse migraines."
(adapted from a popular article written by scientists involved in the research)

2 (d) (i) In the above quote identify, by giving the first three words, **one** sentence that states generally accepted science **and one** sentence that is a conjecture. (There may be more than one correct answer.)

Accepted science...

Conjecture..
(2 marks)

2 (d) (ii) Why might conjecture be valuable in the development of an understanding of the causes of migraine?

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(2 marks)

2 (e) The causes of migraine are not yet known though understanding is improving. The following statements express two opinions on where most research effort should be directed.

Statement 1
"New technologies will allow us to understand the underlying causes of migraine. We should focus on fundamental research rather than on testing drugs based on theories that could well turn out to be wrong."

Statement 2
"New drugs are urgently needed by the many sufferers, we should use what we do know to develop new drugs. The nervous system is so complicated it will be many years before we can fully understand what causes migraine."

Discuss each statement and give your own opinion on which is the best way to proceed at this stage.

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(6 marks)

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Turn over for the next question

3   In autumn 2000 there were severe floods in Britain. Over 500 mm of rain fell. This was the wettest autumn since records began in 1766. Under these conditions rivers could no longer contain the water and it ran off over the land.

There is some evidence that global warming makes extreme weather more likely. In 2011 scientists published a paper claiming to show a link between climate change and the 2000 floods.

They used a complex *climate model* to simulate the autumn 2000 weather. The input was based on the known climate conditions in 2000. By running the model many times they obtained thousands of predictions of the run-off. From these predictions they estimated the probability of each level of run-off occurring during the autumn. **Figure 6** shows some of the results.

Figure 6

Probability of daily river run-off for England and Wales in autumn 2000 (a run-off of more than 0.41 mm leads to severe flooding)

Probability of each level of daily run-off per autumn
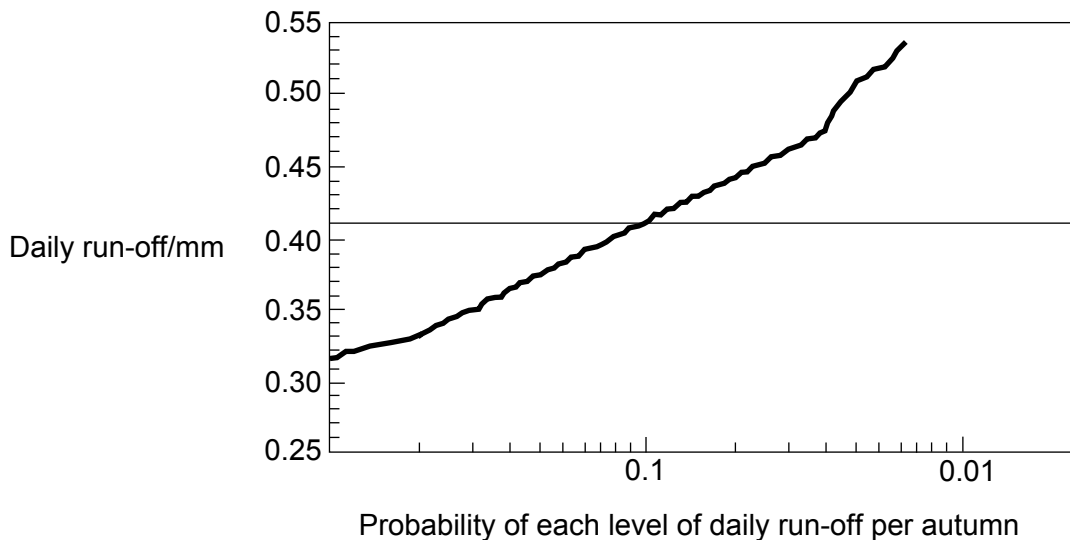
3 (a) (i)   Explain what is meant by a climate model.

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(2 marks)

3 (a) (ii) Explain why models are important in climate research.

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(2 marks)

3 (a) (iii) The average depth of run-off is a measure of the potential for flooding. A daily run-off of greater than 0.41 mm leads to severe flooding.
Use the data in **Figure 6** to predict how often a severe flood is likely to occur in autumn.

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(1 mark)

Question 3 continues on the next page

Turn over ▶

3 (b) They repeated the process but used different inputs representing climatic conditions as if greenhouse gases were still at 1900 levels. Some of the results are shown in **Figure 7**, which also includes the data from **Figure 6**.

Figure 7

**Probability of daily river run-off for England and Wales in autumn 2000
for two different levels of greenhouse gases**

Probability of each level of daily run-off per autumn

Key

——— 2000 greenhouse gases

------ 1900 greenhouse gases
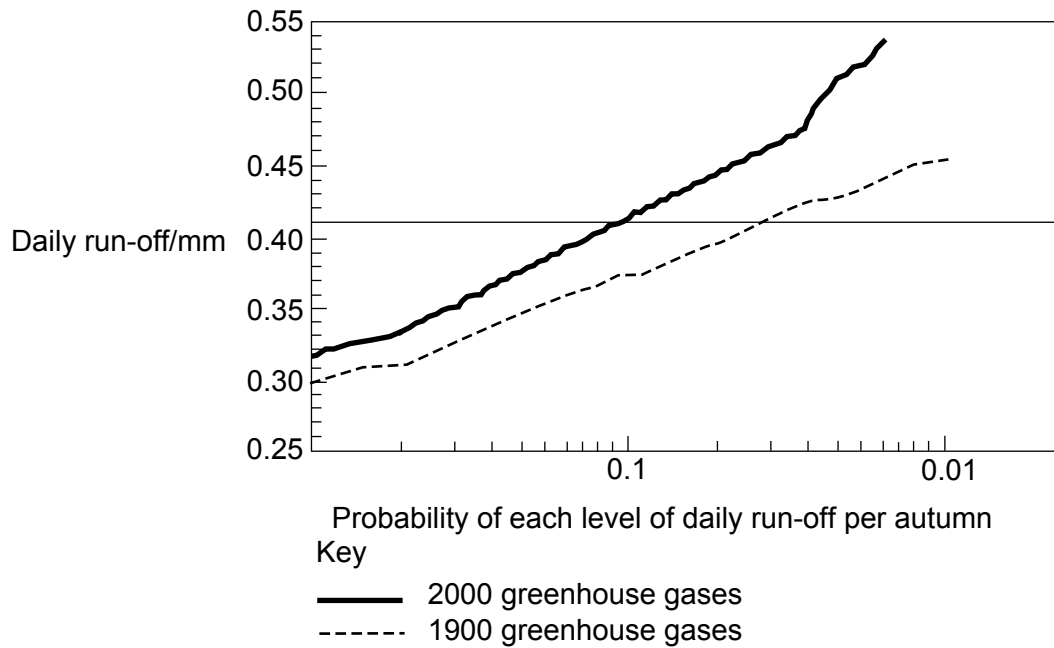
3 (b) (i) What does **Figure 7** suggest about the relationship between greenhouse gases and the risk of severe flooding?

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(2 marks)

3 (b) (ii) Data used in the model included the sea surface temperature. The scientists had to estimate the 1900 value of sea surface temperature.

Explain how changes in greenhouse gases would make this different from the 2000 value.

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(2 marks)

3 (b) (iii) Three headlines describing the research read as follows;

A   Climate Change doubled likelihood of devastating UK floods of 2000

B   Increased Flood Risk Linked to Global Warming

C   Blame human emissions for British floods

Comment on the accuracy of the three headlines in the light of the evidence in **Figure 7**. Show that one gives a more accurate summary of the research than the other two.

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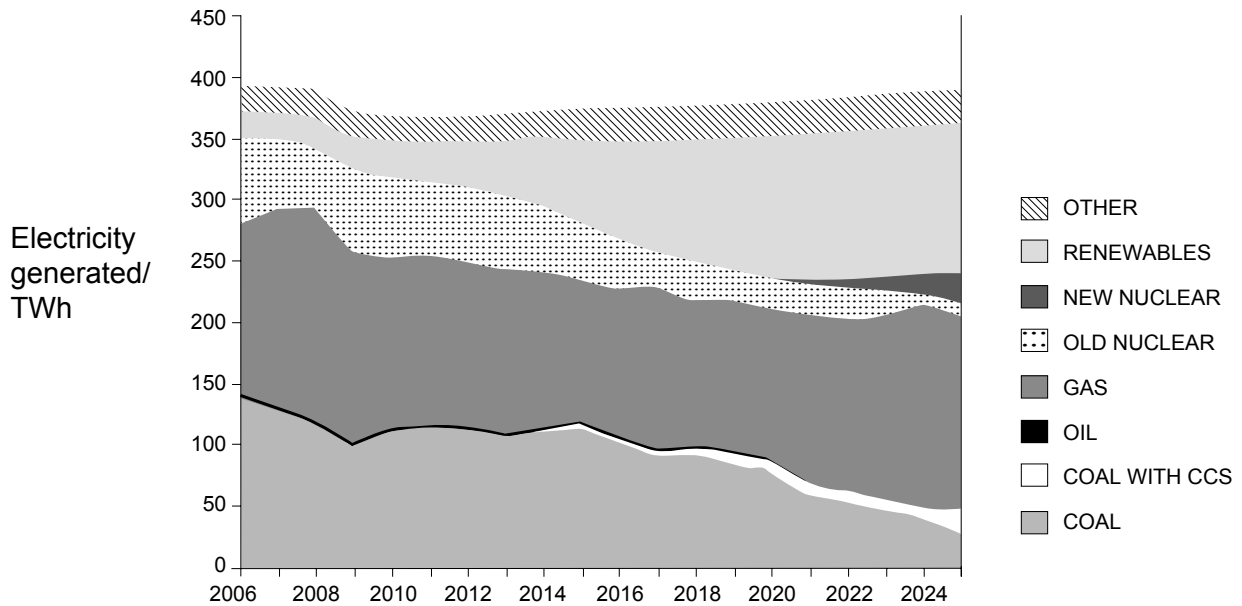
(6 marks)

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Turn over ▶

4 It is necessary to plan electricity generation well in advance to ensure that new generators are built in time to meet anticipated demand.

4 (a) **Figure 8** shows projections made in a report in 2010 by the UK government for how the UK's electricity needs will be generated over a twenty year period.

Figure 8

Projections of electricity generation in UK by fuel

Electricity generated/ TWh

Legend:
- OTHER
- RENEWABLES
- NEW NUCLEAR
- OLD NUCLEAR
- GAS
- OIL
- COAL WITH CCS
- COAL

4 (a) (i) How many terawatt hours, TWh, will be generated by renewables in 2025, according to **Figure 8**?

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(1 mark)

4 (a) (ii) Carbon capture and storage, CCS, is a new technology. By which year is it expected to be in use according to **Figure 8**?

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(1 mark)

4 (a) (iii) The projection of total demand for electricity shows almost no increase from the present. Suggest **two** assumptions that may have been made to reach this conclusion.

Assumption 1 ....

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Assumption 2 ....

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(2 marks)

4 (b) The UK government's stated energy policy for the next twenty years is to maintain electricity supplies whilst reducing carbon dioxide emissions. It plans to increase reliance on three types of new technology to help achieve this. These are: renewables, new nuclear power stations and CCS.

Figure 9

Estimates of UK energy data for different generation technologies

Technology	Cost range (£/MWh)	Carbon dioxide emissions (kg/MWh)	An estimate of theoretical maximum possible capacity in the UK (TWh/year)
New nuclear	55-85	4-5	360
Onshore wind	80-110	5-6	300
Offshore wind	150-210	5	400
Coal, no CCS	45-80	800	400
Coal with CCS	100-155	130	350
Natural gas, no CCS	55-110	500	180
Natural gas with CCS	60-130	250	100
Solar farms	125-180	20-55	50

4 (b) (i) Explain why using nuclear power to generate electricity gives rise to some carbon dioxide emissions as shown in **Figure 9**.

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(1 mark)

4 (b) (ii) CCS removes about 90% of the carbon dioxide from coal power station emissions to bury it underground in suitable geological spaces, such as empty oil wells.

Identify **two** disadvantages of introducing CCS technology, using the data in **Figure 9**.

Disadvantage 1...

Disadvantage 2...

(2 marks)

4 (b) (iii) Suggest an explanation for the importance of CCS technology in UK government policy.

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(2 marks)

Turn over ▶

4 (c) Comment on the projections in **Figure 8** in the light of the data in **Figure 9**. Do you think the projections are practicable and sustainable? Give your reasons.

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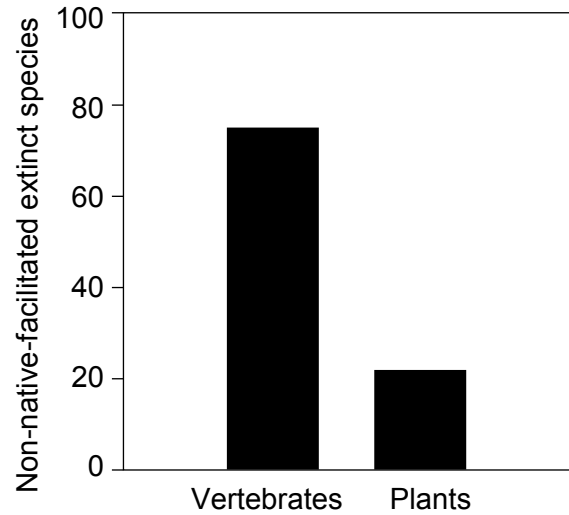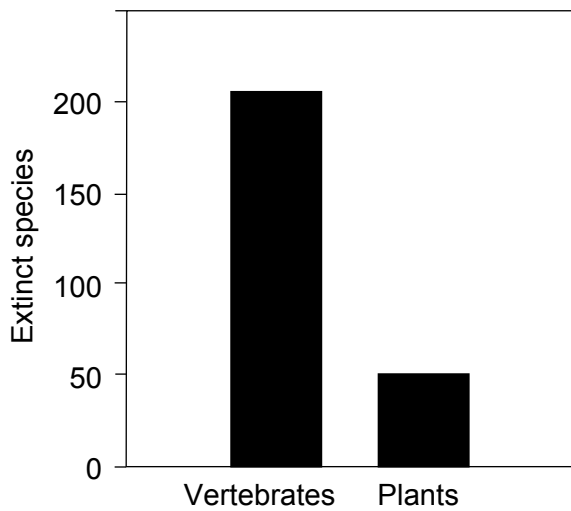
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5 There are some well-known examples of the damaging effects of non-native species on native species. **Figure 10** summarises research into the causes of well-documented extinctions over the last 500 years on islands.

Figure 10

Documented extinctions over last 500 years on islands

A All extinctions of vertebrates and plants

B All extinctions of vertebrates and plants in which non-native species are one of the causes of extinction

5 (a) (i) Use **Figure 10A** and **10B** to estimate the percentage of the extinction of vertebrates on islands thought to have been caused by non-native species.

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(1 mark)

5 (a) (ii) Name **two** ways in which human activity has caused extinctions.

Way 1...

Way 2...

(2 marks)

5 (a) (iii) How might competition from a non-native plant cause the extinction of a native plant?

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(2 marks)

Turn over ▶

5 (b) One research team has studied changes in biodiversity on islands of a wide range of sizes that are inhabited by humans.

When non-native species become naturalised on an island they may:
- cause extinctions and an overall reduction in biodiversity
- add to biodiversity
- replace extinct species.

Researchers studied these possible outcomes for both birds and plants on the islands.

Figure 11 shows some of the results for plants and for birds. Each point represents one island.

Figure 11

Species richness on islands. The relationships between extinctions of native species and naturalisations of non-native species
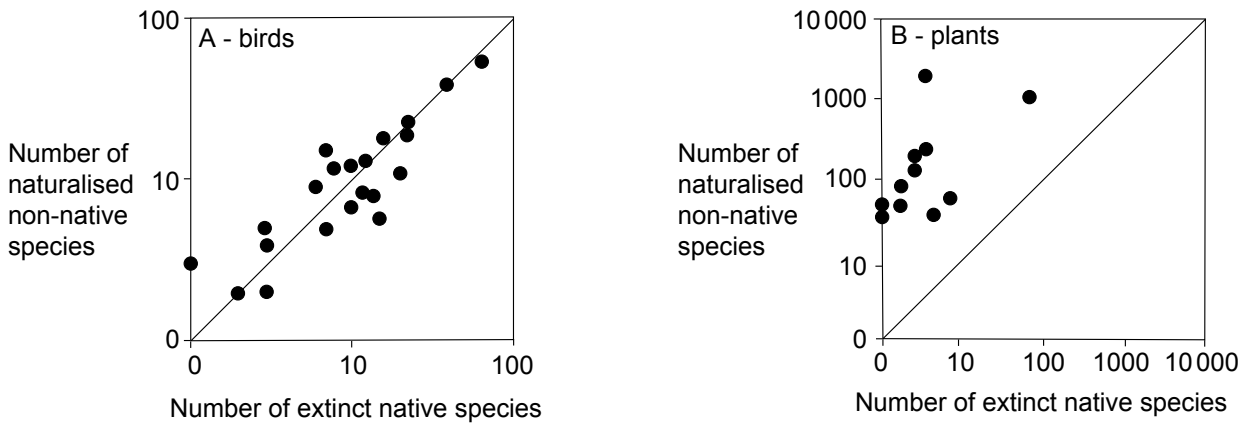
5 (b) (i) The graphs in **Figure 11** use a log scale. Why is a log scale used?

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(2 marks)

5 (b) (ii) What does **Figure 11** show about the change in bird biodiversity after the introduction of non-native species on islands?

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(2 marks)

5 (b) (iii) How does the effect differ for plants?

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(2 marks)

5 (c) Some experts think that invasive species are one of the greatest threats facing biodiversity today. They argue that we should give priority to the total elimination of non-native species.

Based on the evidence in this question – and any other information you wish to use – do you think elimination should be a conservation priority in all circumstances? Explain your answer.

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(4 marks)

5 (d) Give **three** reasons why it is important to preserve biodiversity.

Reason 1 ....

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Reason 2 ....

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Reason 3 ....

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(3 marks)

18

Turn over ▶

Section B

Answer the question in the space provided.

6   Making decisions about science and technology can be controversial. Some new technologies and areas of scientific research raise ethical issues. That is to say they raise questions about whether a particular action is right or wrong.

Choose one example of a new technology or area of scientific research which raises ethical issues. Using your example, discuss the different points of view that people may hold and the ethical principles on which these are based. Conclude by explaining your own point of view.

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(12 marks)

END OF QUESTIONS

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