AQA

A-level
SCIENCE IN SOCIETY

Unit 3   Exploring Key Scientific Issues

Thursday 16 June 2016   Afternoon   Time allowed: 2 hours

Materials
For this paper you must have:
● a pencil
● a ruler
● a calculator.

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.
● Show the working of your calculations.

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.
● You are expected to use a calculator where appropriate.

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

1 Learning involves the formation of new synapses in the brain. Synapses link the axon of one neuron to dendrites on other neurons.

1 (a) At what stage in our lives are most new synapses formed?

[1 mark]

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1 (b) A group of scientists carried out an investigation to test the hypothesis:

'sleep after learning helps consolidate learning of facts and skills'.

Human subjects were divided into two groups and trained in a skill. They were tested on their performance of the skill three times:
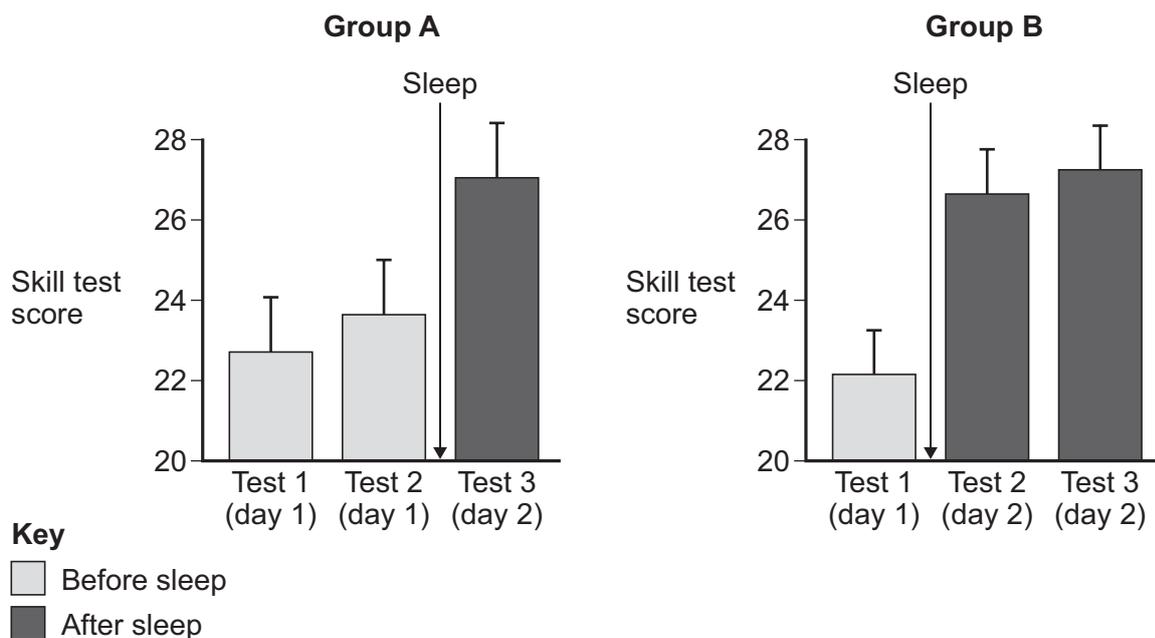
- Test 1 – immediately after learning the skill
- Test 2 – 12 hours after learning the skill
- Test 3 – 24 hours after learning the skill.

For Group **A** Test 2 was after a day awake.
For Group **B** Test 2 was after a night's sleep.

Figure 1 shows the results.

Figure 1

Key
☐ Before sleep
■ After sleep

1 (b) (i) Which **one** of the following conclusions from the data in **Figure 1** is **wrong**?

  A In both groups there is a significant increase in skill test score after sleep.

  B In both groups there is no significant increase in skill test score after 12 hours awake.

  C Group **A** shows significantly higher skill test score than Group **B** immediately after learning.

Write the correct letter in the box.

[1 mark]

1 (b) (ii) Explain why the scientists could **not** use the results from Group **A** alone to draw any conclusions about the effect of sleep on learning.

[2 marks]

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Question 1 continues on the next page

Turn over ▶

1 (c) Synapses in mouse brains can now be observed directly, using a new technique. This technique has been used to study formation of the new synapses that are involved in learning.

Some mice were trained in a skill and then divided randomly into two equal groups. Over the following 8 hours:

- Group 1 were allowed to sleep normally
- Group 2 were sleep-deprived and kept awake by gentle stroking.

After 8 hours, scientists observed the number of new synapses formed on two different sets of dendrites:

- X-dendrites, known **not** to form synapses when this skill is learned
- L-dendrites, known to form synapses when this skill is learned.

The results are shown in **Figure 2**.

Figure 2
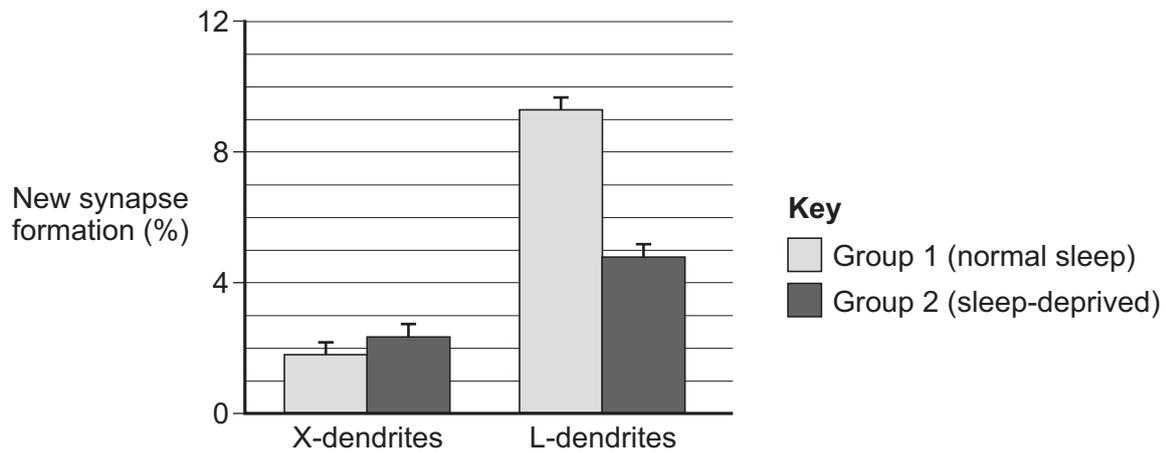
1 (c) (i) Complete the empty boxes in **Table 1** to summarise the results from **Figure 2**.

[4 marks]

Table 1

	Percentage of new synapses formed	
	Group 1 (normal sleep)	
	1.8%	
L-dendrites, known to form synapses when this skill is learned		

1 (c) (ii) The scientists also measured the performance of the mice on the skill after one day without extra training. They found that Group 1 had improved their performance by 40% and Group 2 by 20%. They said that their findings suggest a mechanism by which sleep helps strengthen new memories.

Write a brief description of **one** mechanism that could explain the results of the research described in part **(c)**.

[3 marks]

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Question 1 continues on the next page

1 (d) The research described in part **(c)** resulted in a lot of comment in the media. Below are two examples.

'This study shows the importance of sleep for children.'

'Sleep's memory role discovered.'

Evaluate how accurately these comments represent the research described in part **(c)**.

[4 marks]

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2 Psychology research has consistently shown a link between stressful experiences in childhood and behavioural problems later in life.

In recent research, neuroscientists have investigated how stressful experiences in childhood affect the structure of the brain.
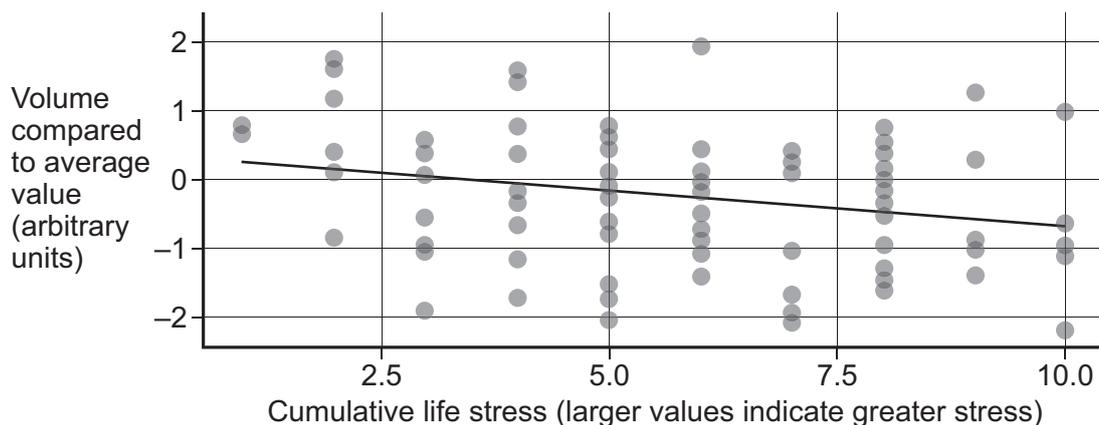
In one study, researchers investigated 128 children, aged about 12 years, who had experienced different levels of stress in their lives. The sources of stress considered were early neglect, poverty and physical abuse.

The researchers:
- did MRI brain scans on the children
- rated each child's overall cumulative life stress on a 10-point scale
- rated each child's behavioural problems on a 5-point scale.

The volume of the right hippocampus in each child was observed in the MRI scan and compared to an average value for children of that age. The results are shown in **Figure 3A** and **Figure 3B**.

Figure 3A
Cumulative life stress

correlation coefficient, r = −0.263
probability, p = 0.015

Volume compared to average value (arbitrary units)

Cumulative life stress (larger values indicate greater stress)

Figure 3B
Behaviour problems

correlation coefficient, r = −0.272
probability, p = 0.012

Volume compared to average value (arbitrary units)

Behaviour problems (larger values indicate greater problems)
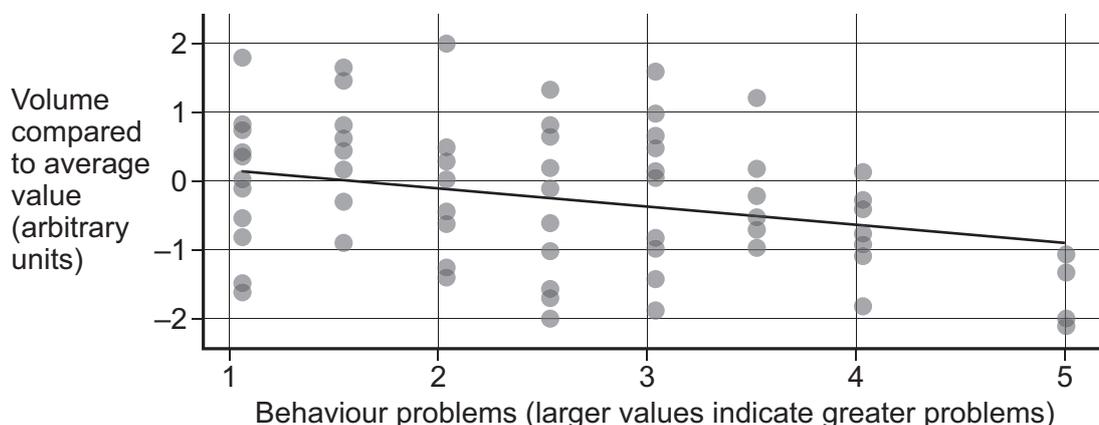
2 (a) (i) Describe the relationship between cumulative life stress and the volume of the right hippocampus as shown in **Figure 3A**.

[2 marks]

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2 (a) (ii) What is the percentage probability that this relationship is due to chance?

[1 mark]

_____%

2 (a) (iii) **Figure 3B** shows a relationship between behavioural problems and the volume of the right hippocampus.

Which of the two relationships shown in **Figure 3A** and **Figure 3B** is the stronger? Explain your choice.

[1 mark]

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2 (b) The researchers published their research. In the paper, they describe in some detail how their results agree and disagree with the results of previous research.

Explain why researchers compare their results with the results of other researchers.

[2 marks]

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Question 2 continues on the next page

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2 (c)   The researchers comment that their results suggest a causative mechanism for the link
between very stressful childhood experiences and behavioural problems later in life.

The mechanism they suggest is:
stress leads to a smaller hippocampus, and a smaller hippocampus causes behavioural
problems.

Discuss the extent to which the data presented here support this causative mechanism.

[4 marks]

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2 (d) Neuroscience research, like that described in this question, is reported in the popular media and is becoming part of popular understanding. The following quotes summarise this understanding.

'Early life stress leaves lasting impacts on the brain'.

'Events that happen to children and babies lead to structural changes that have life-long consequences'.

Such popular understanding is being used to advise parents that bad parenting will permanently harm their children's brains. It is also being used as evidence to support child protection policies that remove children from 'bad' parents.

Discuss the advantages and disadvantages of such popular use of neuroscience research.

[6 marks]

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3 In 2014 the International Panel on Climate Change (IPCC) published its fifth report. All data in this question are from the report.

3 (a) **Figure 4A** shows predictions of annual change in global mean surface air temperature, up to the year 2050. **Figure 4B** shows how precipitation, as rain or snow, is predicted to change across different latitudes for the period 2016–2035.

Both changes are relative to the mean for 1986–2005. Both sets of data are modelled using the same predictions for future carbon dioxide concentrations.

Figure 4A
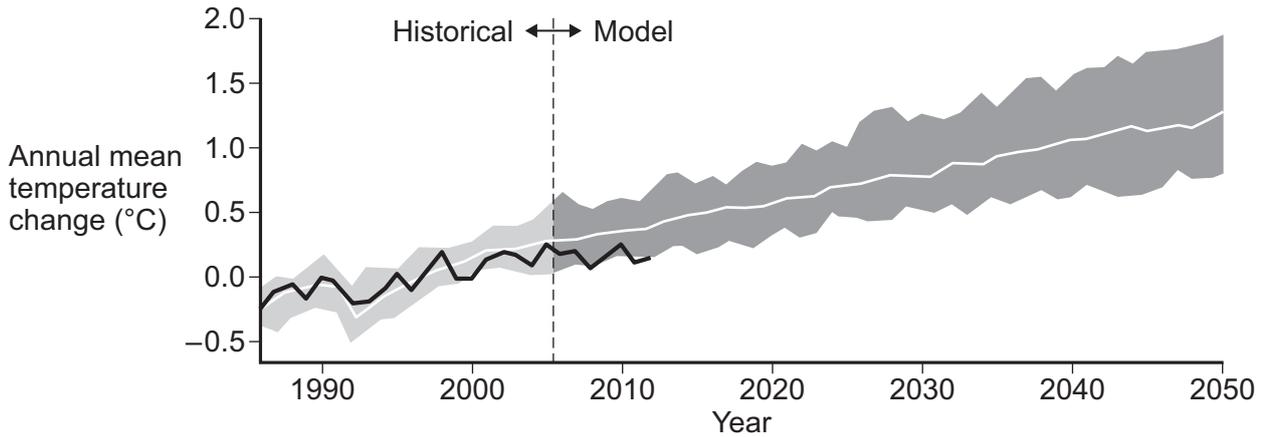
Figure 4B
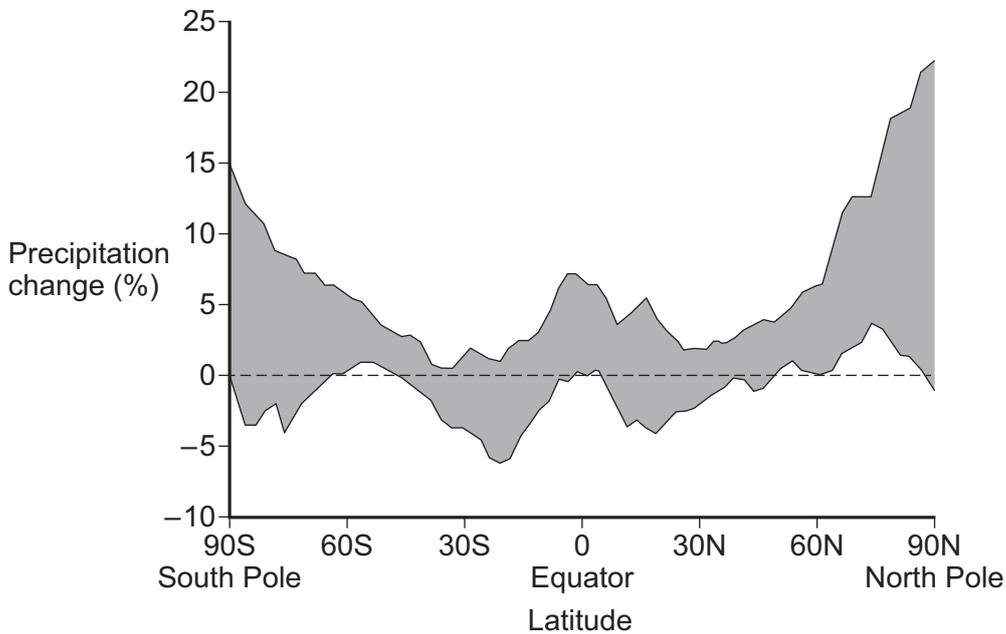
Key
Shading – 5–95% range of results
4A
Black line – observations 1986–2012
White line – median of predictions

3 (a) (i) **Figure 4A** includes the results of 42 models. These give a range of temperature predictions even though they all use the same carbon dioxide concentration.

Why might different climate models give different results?

[3 marks]

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3 (a) (ii) Why is it useful to know the 5–95% range of results as well as the mean value?

[1 mark]

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3 (a) (iii) Describe how precipitation is predicted to change at different latitudes, as shown in **Figure 4B**.

[2 marks]

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Question 3 continues on the next page

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3 (a) (iv) Suggest why an increase in global mean surface air temperature might cause these precipitation changes near the North Pole and South Pole.

[2 marks]

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3 (b) Climate change is likely to affect the yields of important crops such as wheat and rice because both temperature and rainfall affect yields.

The impact of climate change on crop yield is being studied. The annual number of research papers published on the topic doubled between 2005 and 2010.

3 (b) (i) Suggest **two** reasons why more research on this topic is being carried out.

[2 marks]

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3 (b) (ii) Changes in crop yields due to climate change are likely to cause most harm in developing countries. However, only a small proportion of the research is done by researchers based in these countries. For example, only 2.3% are from Africa.

Suggest why research in this topic is likely to be more useful to farming in developing countries if more of the research is based in these countries.

[2 marks]

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3 (c) One area of research is the use of modelling to determine the impacts of climate change on crop yield.

Figure 5 shows predictions of how mean crop yields will change every decade. It shows a spread of results from different peer-reviewed papers. It also includes estimates of change that has already happened.

Figure 5
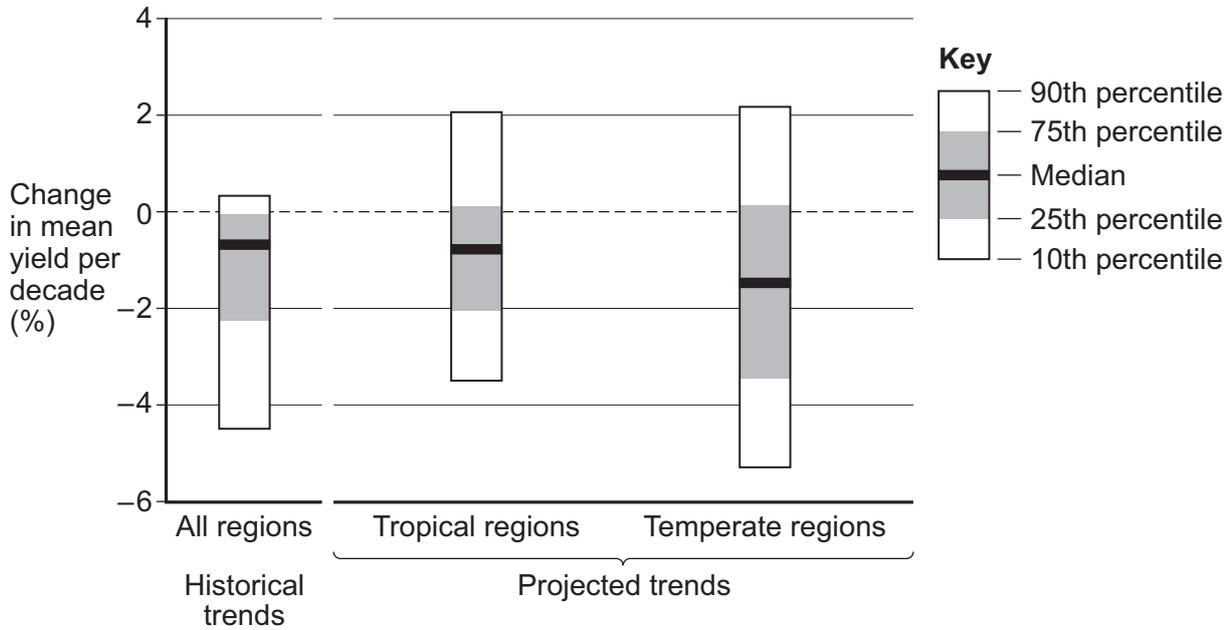
3 (c) (i) The results for the historical trends show that the 75th percentile, the 90th percentile and the median value are all very close together.

What does this suggest about the spread of the values?

[1 mark]

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Question 3 continues on the next page

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3 (c) (ii) State **two** changes in mean crop yield predicted by the data in **Figure 5**.

[2 marks]

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3 (c) (iii) It is also predicted that, on current trends, the global demand for food will rise by 14% per decade. This prediction and the data in **Figure 5** imply that there are likely to be worrying food shortages.

Suggest **two** policies that could be introduced to minimise these shortages and explain why the policies would be effective.

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4 The UK Government has a commitment to 'keep the lights on'. This means that the Government promises to make sure that there is always enough electricity for all demands. The total electric power that could be generated at one time is called the generating capacity.

4 (a) Demand for electricity changes throughout the day and between winter and summer, as shown in **Figure 6**.

Figure 6
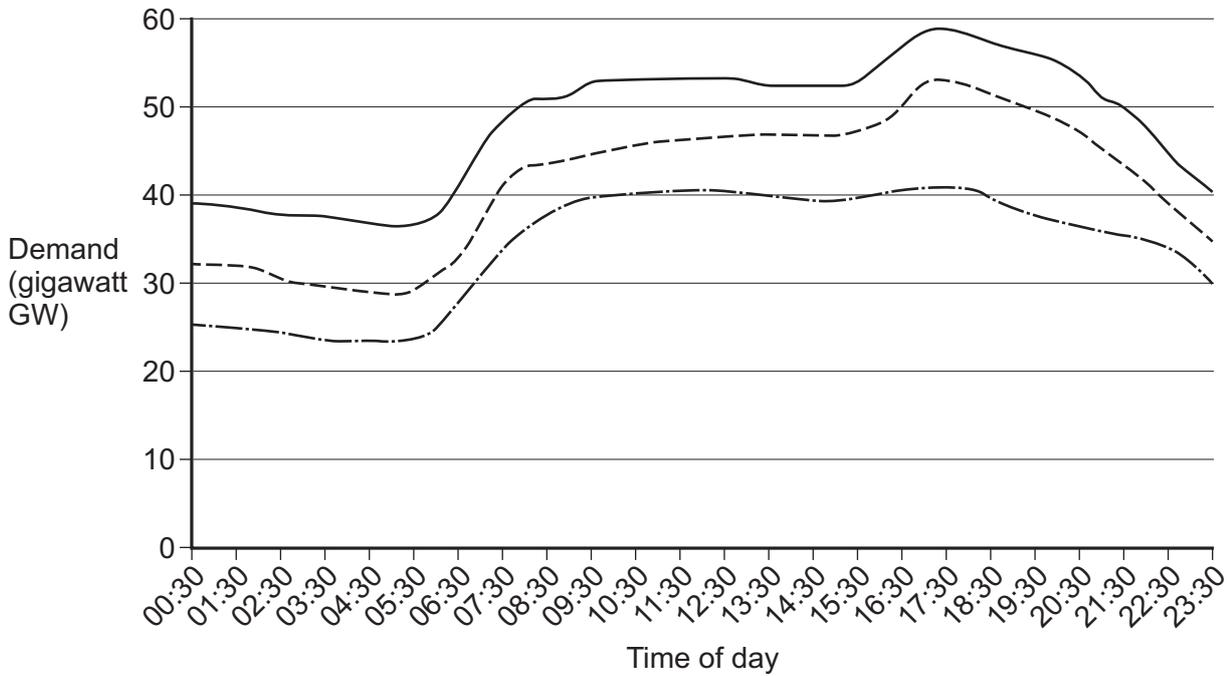
Key

———— Winter maximum

– – – – Typical winter

—··—··— Typical summer

4 (a) (i) What total generating capacity must be reliably available to make sure that UK demand for electricity can be met at all times?

[1 mark]

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4 (a) (ii) What percentage of this capacity is not required at any time in a typical summer? Show your working.

[2 marks]

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Question 4 continues on the next page

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4 (b) The UK Government has also made a second commitment: to reduce greenhouse gas emissions, relative to 1990 levels, by 50% by 2025 and by 80% by 2050.

Table 2 shows the generating capacity of the different generating technologies in the UK in 2013, and some predictions for 2035, made by the UK Government. To meet the second commitment, priority is always given to using renewable generating capacity.

Table 2

	Generating capacity (GW)	
	2013	**2035**
Coal	21	0
Coal (using carbon capture and storage)	0	14
Nuclear	10	14
Gas	31	25
Wind (on-shore and off-shore)	11	36
Solar	2	22
Other (includes biofuel and hydro)	16	27
Total capacity	91	138
Predicted peak demand	61	65

A much larger spare capacity is predicted for 2035 than that available in 2013.

Explain why a larger spare capacity will be needed to make sure that the supply never fails.

[2 marks]

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4 (c) A different way of making sure that supply never fails, while still using mostly renewable sources, is to store electricity on a large scale.

Energy from electricity can be stored:

*   by pumping water from a lower to an upper reservoir
*   by compressing large volumes of air
*   in batteries.

Explain why it makes sense to store electricity from a wind turbine but not from a gas turbine.

[2 marks]

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Question 4 continues on the next page

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4 (d) At present the UK Government is planning to build spare generating capacity to meet its two commitments, as the data in **Table 2** show. It is investing very little in storage technologies.

An alternative approach would be to invest in storage capacity. About 3 GW of storage is currently available in the UK. More research and development would be needed to provide a higher capacity. Estimates of the storage capacity required range from 20 to 45 GW.

Discuss the advantages and disadvantages of the Government's plan, relative to the alternative of more investment in storage of electricity.

[4 marks]

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5 **Figure 7** shows a simplified diagram of the relationships that used to exist between some species in Yellowstone, a very large National Park in the USA. As **Figure 7** shows, wolves were the top predators in this ecosystem.

Figure 7

Yellowstone National Park food web
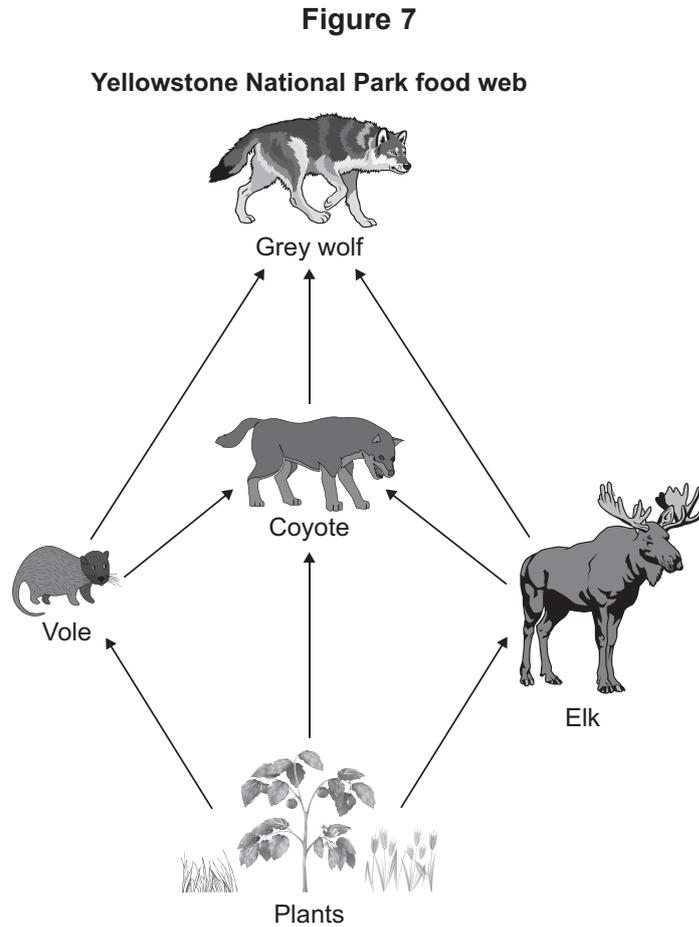
Elks are a species of large, plant-eating deer. In winter, young trees are one of their main foods. Wolves are carnivorous and kill and eat elks. By 1926 all wolves in Yellowstone had been killed.

From the 1920s onwards, the number of trees in Yellowstone declined. Beavers, which are dependent on willow trees, also declined in number.

5 (a) Use this information and **Figure 7** to suggest how the loss of wolves might explain the decline in trees in Yellowstone since the 1920s.

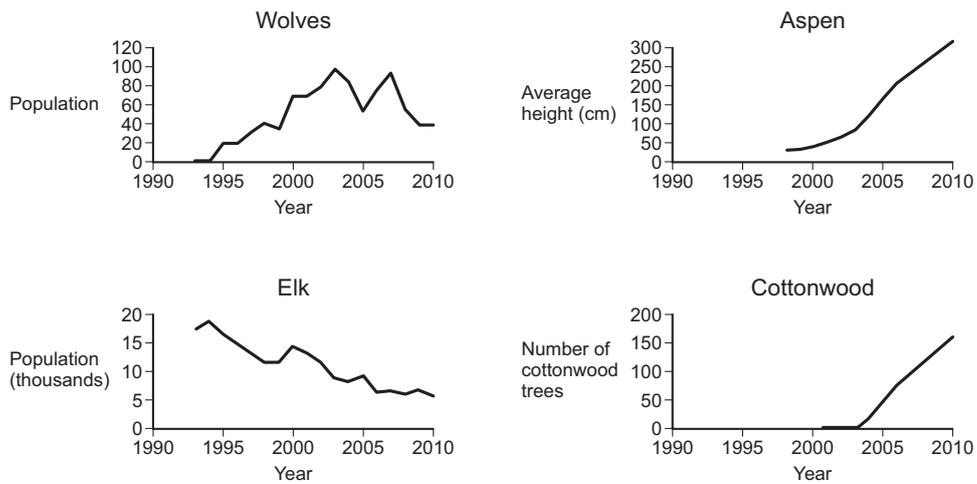**[2 marks]**

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5 (b) All over the world, many ecosystems have lost biodiversity. Attempts are now being made to restore some ecosystems.

A group of scientists proposed the theory that re-introducing the top predator is all that is needed to restore an original ecosystem. In 1995 wolves were re-introduced into Yellowstone. This created a natural experiment to test the predictions of the theory.

Some of the results of this natural experiment are shown in **Figure 8**. It shows how the populations of wolves and elks in Yellowstone have changed since about 1995. It also shows how the height of aspen trees and the number of cottonwood trees have changed.

Figure 8

Evaluate the extent to which the data in **Figure 8** agree with the predictions from the theory that reintroduction of top predators will restore the ecosystem.

[4 marks]

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Question 5 continues on the next page

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5 (c) Other scientists claim that the top predator theory is too simplistic and that a more complex range of interactions needs to be considered to restore an ecosystem. These scientists studied willow trees in Yellowstone over 10 years between 2001 and 2010.

Their results showed that:

- protecting willow trees from elks led to almost no increase in the growth of these trees
- willow tree growth only increased significantly when the trees were grown in a wet environment like that created by beavers.

Evaluate the extent to which these data on willows support the theory that reintroduction of top predators is all that is needed to restore the ecosystem.

[3 marks]

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5 (d) The two groups of scientists described in part **(b)** and part **(c)** have used the media to publicise their different theories and results.

Discuss the advantages and disadvantages of such a public disagreement between scientists.

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Question 5 continues on the next page

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5 (e) Some campaigners are suggesting that wolves should be reintroduced to Scotland to improve biodiversity. They believe wolves would reduce the red deer population and allow the native forests to regrow.

Do you think wolves should be reintroduced to Scotland? Explain your answer.

[4 marks]

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6 Society has ways of controlling the development and application of science and technology.

Official regulations apply to many kinds of scientific activity.

Examples include controls on:

- levels of emission of radioactive materials or other hazardous chemicals
- use of human tissue in research
- use of animals in research.

Some scientists and industrialists believe that there is too much regulation and that this stifles research.

Why is official regulation of science and technology necessary? Explain your answer using appropriate examples.

[12 marks]

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