Surname		Other Names	
Centre Number			Candidate Number	
Candidate Signature			

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General Certificate of Education
June 2005
Advanced Subsidiary Examination

ASSESSMENT and QUALIFICATIONS ALLIANCE

SCIENCE FOR PUBLIC UNDERSTANDING SPU2
Unit 2 Issues in the Physical Sciences

Friday 10 June 2005 Morning Session

No additional materials are required.
You may use a calculator.

Time allowed: 1 hour 15 minutes

Instructions
- Use blue or black ink or ball-point pen.
- Fill in the boxes at the top of this page.
- Answer **all** questions in the spaces provided.
- Do all rough work in this book. Cross through any work you do not want marked.
- Show your working in **all** calculations.

Information
- The maximum mark for this paper is 60.
- Mark allocations are shown in brackets.
- In your answer to Question 1(b)(iv) and Question 3(c)(ii) you will be assessed on your ability to use an appropriate form and style of writing, to organise relevant information clearly and coherently, and to use specialist vocabulary, where appropriate. The degree of legibility of your handwriting and the level of accuracy of your spelling, punctuation and grammar will also be taken into account.

For Examiner's Use			
Number	Mark	Number	Mark
1			
2			
3			
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5			
Total (Column 1) →			
Total (Column 2) →			
TOTAL			
Examiner's Initials			

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

1

Can we keep the lights on?

Britain's looming energy crisis

The two headlines above appeared in recent newspapers.

The potential crisis in electricity supply is made up of several factors:

- Britain has always been self-sufficient in fuel used to generate electricity. That is about to change as North Sea gas and oil fields are exhausted. Coal mines have already closed down;
- nuclear power stations are coming to the end of their lives and being closed;
- demand for electricity continues to rise, though slowly;
- Britain has made a commitment to reduce carbon dioxide emissions by 10% by 2010 and by 60% by 2050;
- imported gas and oil will have to come long distances through vulnerable pipelines.

(a) **Figure 1** shows the changes in the fuel used to generate our electricity between 1990 and 2002.

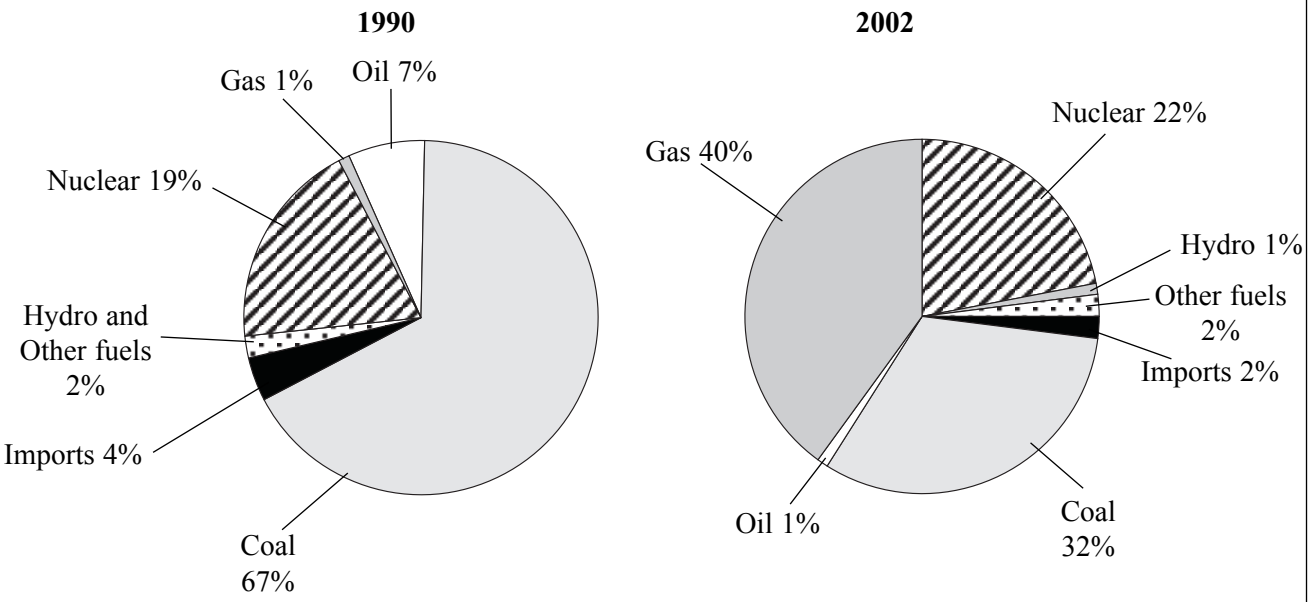

Figure 1

Give **two** of the main changes in fuel use over the 12 years from 1990 to 2002.

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(2 marks)

(b) In the long term it is recognised that Britain can only become more self-sufficient and meet its carbon dioxide emission targets if it generates electricity using renewable energy sources and possibly also nuclear fuels. **Figure 2** shows a projection of the generating capacity of several sources and the costs of the electricity from each in 2020.

	Practicable potential capacity by 2020 (TWh)	**Estimated cost of electricity in 2020 (pence/kWh)**
Onshore wind	8	1.5 – 2.5
Offshore wind	100	2.0 – 3.0
Wave and tidal	50	3.0 – 6.0
Energy crops	33	2.5 – 6.0
Photovoltaics	37	10 – 16
Nuclear	7	3.0 – 4.0
Gas (UK Production)	60	2.0 – 2.3
Potential total demand in 2020	**370 TWh**	

$1\ \text{TWh} = 10^9\ \text{kWh}$

Figure 2

(i) Explain what is meant by the term '*renewable energy source*'.

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(2 marks)

(ii) Choose **one** of the ways of generating electricity from a renewable energy source given in **Figure 2** and outline the process by which electricity is generated.

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(2 marks)

QUESTION 1 CONTINUES ON THE NEXT PAGE

(iii) On the basis of the information given in **Figure 2**, wind appears to be an attractive option, but it is not a total solution. Give **two** disadvantages of using wind to generate electricity.

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(2 marks)

(iv) How do you think Britain should plan to produce its electricity in 2020 to ensure that it can 'keep the lights on'? Include the advantages and disadvantages of your recommendations.

You may be awarded up to 2 additional marks for the quality of written communication in your answer.

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(4 marks)

Quality of Written Communication *(2 marks)*

14

TURN OVER FOR THE NEXT QUESTION

2 Air pollution caused by small particles is a major cause of ill health. The average level of the very small particles ($PM_{2.5}$) in the air in British cities is now about 20 µg per cubic metre.

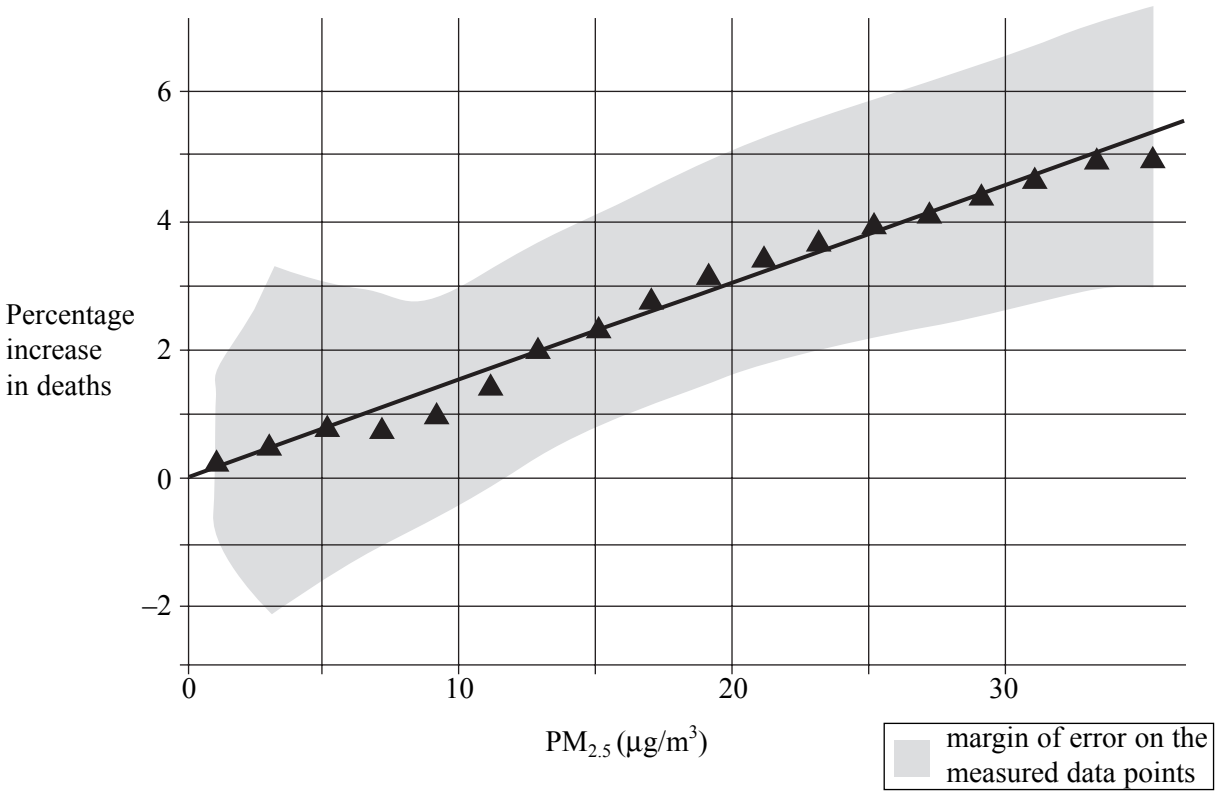

Figure 3

(a) It has proved extremely difficult to quantify the exact extent of the risk of $PM_{2.5}$ particles and to set safe levels. **Figure 3** shows how daily deaths vary with the level of $PM_{2.5}$ particles, based on data from one study in the U.S. The shaded area shows the margin of error on the measured data points.

(i) Complete this sentence:

When the level of $PM_{2.5}$ particles is 20 µg per cubic metre, daily deaths are

increased by ..... ± ..... percent, compared with daily deaths when there is

no pollution.

(2 marks)

(ii) The UK government sets targets for acceptable levels of air pollutants. Suggest the target for a safe level of $PM_{2.5}$ that you think would be appropriate. Justify why you have chosen this particular value using the information in **Figure 3**, and any other issues you think relevant.

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(2 marks)

(iii) Suggest **two** factors, apart from $PM_{2.5}$ levels, which might have a significant effect on deaths from respiratory disease.

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(2 marks)

(iv) How might the researchers design their study to minimise the effects of these other factors on their estimates of the risk associated with the level of $PM_{2.5}$ particles?

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(2 marks)

(b) Some cities in SE Asia with rapid economic development have particle levels as high as 300 µg per cubic metre. They are beginning to introduce measures to reduce such pollution. Suggest what measures these cities might adopt to reduce the health risks, without endangering their economic development.

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(3 marks)

11

3 For the last 15 years most scientists have accepted that carbon dioxide levels in the atmosphere are rising and that this is leading to climate change.

(a) Describe the chemical reaction involved in the production of carbon dioxide from a fossil fuel.

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(2 marks)

(b) **Figure 4** illustrates the main pathways by which radiation reaches and leaves the Earth. **Figure 5** shows one set of estimates of the average rate of energy transfer by each of these pathways.

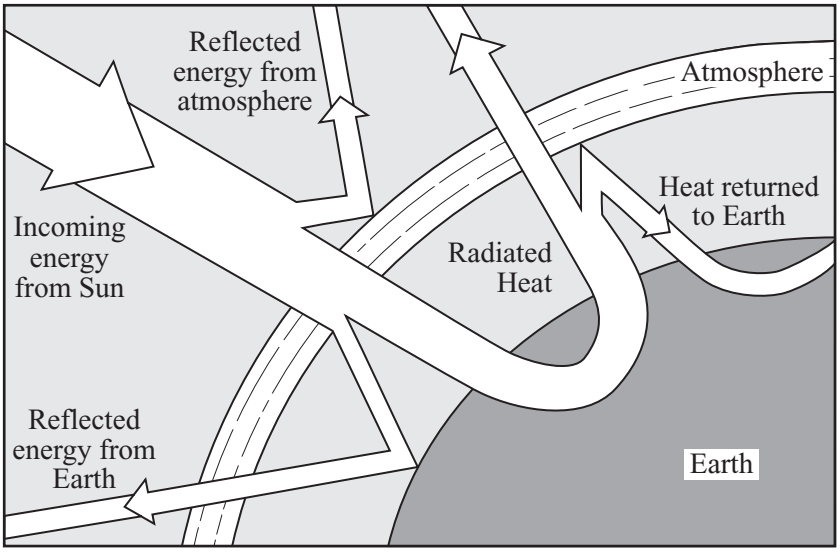

Figure 4

Incoming	Incoming energy from Sun	340 W per square metre
Outgoing – reflected	*Reflected energy from atmosphere and Earth's surface – natural processes.* *Reflected energy from atmosphere – human-made aerosol pollution*	*100 W per square metre* *1 W per square metre*
Outgoing – re-radiated	*Energy radiated from land and oceans by natural processes*	*240 W per square metre*
Incoming	Radiated energy from land and oceans returned to Earth again by human-made greenhouse gases.	2 W per square metre

Figure 5

(i) Incoming and outgoing radiation transfers are not in balance. Calculate the rate in watts per square metre, at which energy is retained by the Earth, according to these estimates.

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(2 marks)

(ii) What is the effect of this retained energy on the Earth?

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(1 mark)

(iii) The radiation from the Sun is at a shorter wavelength than that re-radiated from the Earth. Why is this so?

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(1 mark)

(iv) Why is this difference in wavelength important in explaining the greenhouse effect?

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(2 marks)

QUESTION 3 CONTINUES ON THE NEXT PAGE

(c) Many policy makers now believe that it will be necessary to find ways of minimising the effects of the increasing carbon dioxide emissions on our climate. Scientists are working on two main methods of doing this: removing carbon dioxide from the air, and reducing the amount of solar radiation reaching Earth by increasing reflection.

Method 1
Carbon dioxide can be removed from power station chimneys and pumped into storage, either in underground spaces such as old oil wells or under the deep oceans, where high pressure should retain it.

Method 2
Make the upper atmosphere more reflective, by sending millions of tiny reflective balloons into the upper atmosphere or by spraying sulphate particles, as happens naturally after volcanic eruptions.

(i) Choose **one** of these methods, give its number below and indicate with an asterisk (*) on **Figure 4** where it would alter the balance between incoming and outgoing radiation.

Method chosen .....

(1 mark)

(ii) Discuss the advantages and disadvantages of **one** of these methods compared with the enforcement of measures to reduce the use of fossil fuels.

You may be awarded up to 2 additional marks for the quality of written communication in your answer.

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(4 marks)

Quality of Written Communication *(2 marks)*

15

TURN OVER FOR THE NEXT QUESTION

4 Britain has a stockpile of radioactive waste. Most of this is spent fuel from nuclear power stations. The government aims to make a decision on what to do with Britain's nuclear waste by 2006.

The National Radiological Protection Board (NRPB) reports that Britain has

- 1800 cubic metres of high level waste
- 61.5 tonnes of plutonium
- 60 000 tonnes of uranium.

(a) Explain, in terms of the atoms involved, what is meant by saying that a substance is radioactive.

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(2 marks)

(b) High level waste has to be stored in cooling ponds for several years.
Explain what makes high level waste get hot.

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(2 marks)

(c) Some of the radioactive isotopes involved have very long half lives.
What is meant by a half life of 100 000 years?

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(2 marks)

(d) Only around 0.1% of the total radiation dose from all sources received by the public is as a result of the nuclear power industry.
Suggest **two** reasons why there is so much concern about the risk that this waste might pose.

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(2 marks)

(e) A recent government publication included the statement: "Radioactive waste issues should be made part of the Government's education strategy".

Which **one** of the following do you think would be the most useful part of your education to enable you to contribute to decision-making on the storage of radioactive waste? Explain your choice.

- an understanding of the science of radioactivity
- data on the different risks involved
- information about the proposed management of the waste disposal site and the safety checks that would be made.

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(2 marks)

10

TURN OVER FOR THE NEXT QUESTION

5

In 1915 Einstein used his theory of General Relativity to try to understand what the cosmos was like. His calculations led to the conclusion that the universe could not be stable; it should be either expanding or collapsing. As Einstein believed the universe was stable, he modified his equations to produce that result. He thought he was improving his theory, to make it match better to reality – but he later described this as 'the biggest blunder of my life'.

In 1929, the American astronomer Edwin Hubble made measurements that allowed him to estimate the speed at which galaxies were moving away from the Earth. His calculations indicated that the further away a galaxy was, the faster it was moving away from us. This implied that the universe was expanding. Hubble and other astronomers proposed that the universe had originated in a 'Big Bang'.

Some other astronomers were not convinced. Their research led them to think that matter was distributed uniformly throughout the universe – and did not get more spread out with time. They proposed an alternative theory, the Steady State theory, which proposed that matter was constantly being produced to keep the average density of the universe constant as it expanded.

By the 1950s there were still two competing theories on the origin of the universe: the Big Bang theory and the Steady State theory. One of the predictions of the Big Bang theory was that radiation produced in the Big Bang should still be detectable. This radiation was found in 1964 by Penzias and Wilson. This is one of the reasons why most astronomers now accept the Big Bang theory.

(a) Explain briefly what is meant by the Big Bang theory.

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(3 marks)

(b) From the account opposite briefly identify an example of each of the following

(i) an observation,

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(1 mark)

(ii) a correlation between two variables,

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(1 mark)

(iii) an explanation that involved conjecture and creative imagination,

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(1 mark)

(iv) a second explanation that also involved conjecture and creative imagination,

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(1 mark)

(v) a testable prediction from a theory,

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(1 mark)

(vi) the use of observation to increase confidence in an explanation or theory,

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(1 mark)

(vii) the way a person's views can influence their interpretations.

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(1 mark)

10

END OF QUESTIONS

THERE ARE NO QUESTIONS PRINTED ON THIS PAGE