GCSE

Edexcel GCSE in Additional Science
Putting Radiation to Use

(Concept approach)

June 2006

Support material

Edexcel GCSE in Additional Science
Putting Radiation to Use
(Concept approach)

Edexcel, a Pearson company, is the UK's largest awarding body offering academic and vocational qualifications and testing to more than 25,000 schools, colleges, employers and other places of learning here and in over 100 countries worldwide. We deliver 9.4 million exam scripts each year, with 3 million marked onscreen in 2005. Our qualifications include GCSE, AS and A Level, GNVQ, NVQ and the BTEC suite of vocational qualifications from entry level to BTEC Higher National Diplomas and Foundation Degrees. We also manage the data collection, marking and distribution of the National Curriculum Tests at Key Stages 2 and 3, and the Year 7 Progress Tests.

Authorised by Roger Beard
Prepared by John Crew

Contents

Topic 11: Putting Radiation to Use

Introduction

1 This booklet contains a concept-driven scheme of work and some suggested activities for the Edexcel GCSE Additional Science Unit P2 Topic 11: Putting Radiation to Use.

2 Two schemes of work are available for each topic in separate booklets. One of these booklets contains a scheme of work that is concept-driven, ie scientific ideas are presented before their applications are explored. The other booklet contains a scheme of work that is context-driven, ie applications of science are presented before the scientific principles used in these applications are explored.

3 Booklets for each GCSE Additional Science topic are provided free of charge to centres offering the Edexcel GCSE suite of Science qualifications via the secure area of the Edexcel website (www.edexcel.org.uk).

4 Although Edexcel owns the copyright for the booklets, they are provided in Word format so that Edexcel centres may customise the schemes if required.

5 Each lesson is designed to last for 50 minutes although the total teaching time is not stated in the specification; teachers may adjust the schemes of work to accommodate the time available in individual centres.

6 Centres are responsible for the overall risk assessment of experimental work undertaken by students.

7 Attention is drawn to the need for safe practice when students carry out laboratory experiments or observe demonstrations. Particular attention is drawn to the possible hazards associated with electrical equipment, the handling of micro-organisms and ionising radiation. Strict aseptic conditions should be used when undertaking practical work. Reference must be made to COSHH regulations and any specific local education authority restrictions.

Relevant advice can be obtained from the following publications:

- *CLEAPSS Laboratory Handbook* (available from CLEAPSS School Science Service, website www.cleapss.org.uk)
- C*ontrol of Substances Hazardous to Health Regulations* (HSE, 2005) ISBN 0717629813
- *Hazcards* (2004 update available from CLEAPSS School Science Service)
- *Topics in Safety, Third Edition* (ASE, January 2001) ISBN 0863573169.

Scheme of work for Topic 11: Putting Radiation to Use

LESSON 1: What happened to that?							
Spec. code	**Links and concept building from KS3**	**Learning objectives**	**Teaching activities**	**Resources**	**Learning outcomes**	**Key skills**	**Safety issues**
P2 11.14 P2 11.7 P2 11.15	No explicit links; KS3 curriculum does not feature radioactivity.	Invisible rays are emitted from some substances. These materials are described as radioactive. Need for care, as we do not know what the rays are. There is a background count that needs to be allowed for in experiments. Background radiation is random.	**Initial demonstration** Show the effect of a radioactive source on a detector. Discuss serendipity and mysterious rays as part of how science works. Mention how X-rays were named (scientists did not know what the new, invisible rays were). Try to get across the excitement involved in Becquerel's original discovery of radioactivity by telling a story. Discuss basic safety precautions as they arise. **First demonstration** Measure the background count and show that radioactivity is unpredictable (random). Mention the need for repeating the measurement of background count. Maybe investigate a hypothesis such as 'blonds are more radioactive than brunettes/are watches radioactive'? **Second demonstration** Alpha, beta and gamma (compare mysterious X-rays) penetrate materials by different amounts, particularly alpha which only goes about 6 cm in air.	A detector of radiation preferably a G-M tube and counter scaler. www.chemcool.com/biography/becquerel.htm www.phy.ntnu.edu.tw/ntnujava/viewtopic.php?t=291 — applet showing random nature of decay and a graph. Show a cloud chamber if available. Labmouse Software CD ROM BNFL.	Explain what is meant by the background radiation we all experience and describe how regional variations within the UK are caused by radon in particular gas. Explain that alpha and beta particles and gamma rays are ionising radiations emitted from unstable nuclei in a random process. Describe the dangers of ionising radiation in terms of tissue damage and possible mutations and relate this to the precautions taken while carrying out demonstrations at school.		Standard precautions when storing, moving and handling radioactive materials. NB: Only teachers should handle radioactive materials.

Scheme of work for Topic 11: Putting Radiation to Use

LESSON 1: What happened to that? (*continued*)
Homework: Ask students to write a news item to announce the discovery of radioactivity — for the more able, specify the type of newspaper (‘red-top’ or ‘quality’). Higher-level students can research the causes of background radiation from Earth and space.

Scheme of work for Topic 11: Putting Radiation to Use

LESSON 2: What are these rays?							
Spec. code	**Links and concept building from KS3**	**Learning objectives**	**Teaching activities**	**Resources**	**Learning outcomes**	**Key skills**	**Safety issues**
P2 11.4 P2 11.7 P2 11.1	No explicit links.	There are three types of rays α, ß and γ. A bigger thickness absorbs more gamma rays. Alpha particles are commonly used, safely, in houses.	Identify the alpha, beta and gamma rays. **Demonstration** Demonstration 11.2: Gamma ray absorption. Measure the variation of count rate with different thickness of lead absorber for a gamma source. Students should plot a graph and describe what it tells them. **Discussion** Discuss the use of alpha rays in smoke detectors.	www.lbl.gov/abc/Basic.html#Radioactivity G-M tube, γ-source and absorbers. BNFL Labmouse 4. http://science.howstuffworks.com	Describe the nature of each of the ionising radiations and compare their abilities to penetrate and to ionise. Explain that alpha and beta particles and gamma rays are ionising radiations emitted from unstable nuclei in a random process. Describe how radioactivity is used in household fire (smoke) alarms and for treating food so that it keeps longer.	N: 2.1 2.2 2.3	Standard precautions when storing, moving and handling radioactive materials. NB: Only teachers should handle radioactive materials.
Homework: Ask students to describe how a smoke detector works. Include at least one diagram, or two: one with no smoke and one when smoke is around. Research the use of gamma rays in measuring the thickness of sheet metal.							

Scheme of work for Topic 11: Putting Radiation to Use

LESSON 3: How can we find leaks in underground pipes?							
Spec. code	**Links and concept building from KS3**	**Learning objectives**	**Teaching activities**	**Resources**	**Learning outcomes**	**Key skills**	**Safety issues**
P2 11.4	No explicit links; KS3 curriculum does not feature radioactivity.	Know about the absorption effect of aluminium on gamma rays. Continue applying information about the properties of the rays to useful situations and see some of the possibilities.	**Practical** Use different thicknesses of greaseproof paper between a light source and an LDR circuit/light sensor to draw an absorption graph. **Discussion** Use the past examination question as an introduction to the sort of problem that can be solved using the penetrating power of the different radiations. **Discussion** Use of beta and gamma rays to measure the thickness of materials. **Written work** Describe the use of the relevant ray in quality control.	See Experiment sheet 11.3. Question 4, part (B) from the Edexcel Science B paper 4P, 2003. www.nei.org — industrial radioactivity using penetration and tracers. www.rogerfrost.com/shortc.htm for video of BBC Short Circuit series — radioactivity. IoP video: Isotopes in action.	Describe the nature of each of the ionising radiations and compare their ability to penetrate and to ionise.	N: 2.1 2.2 2.3	
Homework: Students could write two applications for an imaginary job detecting the thickness of aluminium foil — one as if they are a ß-particle and the other as if they are a γ-ray. Students should give their name and address, state the experiences they have had in the past, point out why they are suitable for the job and say how well they will do if they are given the job.							

Scheme of work for Topic 11: Putting Radiation to Use

LESSON 4: X-rays can be good but are gamma rays dangerous?							
Spec. code	**Links and concept building from KS3**	**Learning objectives**	**Teaching activities**	**Resources**	**Learning outcomes**	**Key skills**	**Safety issues**
P2 11.2 P2 11.3 P2 11.1	Ideas about the electromagnetic spectrum.	X- and γ-rays can have the same frequency and once they are emitted there is no difference between them. Gamma rays can have a variety of diagnostic and therapeutic uses. Food can be sterilised by irradiation after being sealed, so re-contamination cannot occur. Gamma rays are just energy, like light and so are not dangerous when absorbed.	**Discussion** Compare the properties of X- and gamma rays and point out that the name used depends on the method of production. **Research** Research and describe one medical use of radioactivity in diagnosis and one in treatment of cancer. **Discussion** Describe use in sterilisation of instruments and in treating food. Discuss what happens to each of the three types of radiation after they have been stopped by the food. **Written work** Why do you think some people do not like to buy food which has been sterilised by radiation?	http://en.wikipedia.org IoP video: Whatever became of X-rays? IoP video: Medical Physics. www.mayoclinic.com/health/cancer-diagnosis — methods for diagnosing cancer www.webmd.com/hw/health_guide — bone scan http://whyfiles.org/054irradfood www.umich.edu/~radinfo	Explain that X-rays and gamma rays have similar properties, including their ionising abilities, but are emitted from different sources. Describe the uses of radioactivity in medical applications for both diagnosis and treatment for patients and also for sterilisation of equipment. Describe how radioactivity is used in household fire (smoke) alarms and for treating food so it keeps for longer.		
Homework: Write a letter to your grandmother explaining that irradiated food is not dangerous to eat.							

Scheme of work for Topic 11: Putting Radiation to Use

LESSON 5: Are all hydrogen nuclei the same?							
Spec. code	**Links and concept building from KS3**	**Learning objectives**	**Teaching activities**	**Resources**	**Learning outcomes**	**Key skills**	**Safety issues**
P2 11.5 P2 11.6	Ideas about atoms.	Atoms contain protons, neutrons and electrons in their relative positions. We can use shorthand to describe the structure of an atom. Isotopes of an element can have different numbers of neutrons giving the isotopes different properties.	**Discussion and model making/diagram drawing** Draw/make 2D models (from plasticine or coloured paper circles from hole punch) of various atoms from given symbolic representations. **Discussion** Discuss how Geiger and Marsden's experiment (experimental details not required) showed that there is a tiny nucleus in the centre of an atom which contains the positive charge and most of the mass of the atom. **Research and display** Research the number of isotopes of, for example, hydrogen and carbon. Draw a diagram to show the structure of each and list how many are radioactive using the symbolic representation. **Written work** Find a precise way of explaining what isotopes are.	Plasticene of three colours, or holes cut with hole punch from three pieces of coloured paper. Activity sheet 11.5: Simple atomic structure. http://micro.magnet.fsu.edu/electromag/java/rutherford Parts of Boardworks Radioactive Decay. All GCSE texts have some suitable material and reference can be made to tables such as the Nuffield data book and/or Kaye and Laby.	Describe the structure of an atom in terms of protons, neutrons and electrons and describe particular nuclei using symbols in the format: $^{m}_{p}X$. Use the terms atomic (proton) number and mass (nucleon) number to explain the existence of isotopes.		

LESSON 5: Are all hydrogen nuclei the same? (*continued*)
Homework: Students could write a five-line poem: Line 1: Title (noun) — one word Line 2: Description of title — two words Line 3: What it does — three words Line 4: How you feel about it (phrase) — four words Line 5: Title (synonym for the title) — one word. Eg, water, cold wetness, dissolves-cleans-rusts, a useful frightening necessity, H_2O. Describe some other uses of radioactivity.

LESSON 6: For how long does something stay radioactive?							
Spec. code	**Links and concept building from KS3**	**Learning objectives**	**Teaching activities**	**Resources**	**Learning outcomes**	**Key skills**	**Safety issues**
P2 11.8 P2 11.10 P2 11.9	No explicit links; KS3 curriculum does not feature radioactivity.	Understand the concept of half-life and develop a mental picture. Compare different methods for presenting data. Improve understanding of the concept of half-life by working through an example.	**Practical** Demonstrate a radon gas decay kit if available and then let students use a burette or a long tube with narrow opening at the other end to simulate decay. Discuss the similarity between the rate at which water runs out of the tube and the rate of radioactive decay. **Written work** Plot a graph with some students using paper and pencil and others on computer and then swap over. Discuss which was easiest and which was best. **Written work** Give students data or a pre-drawn graph and show how to work out the time for the original count rate to change to half. Ask them to do it for the next decay and halve that value. What do they notice? Ask for a prediction. Try any suggestions or, if needed, suggest one yourself.	Radon decay kit or show simulation www.walter-fendt.de Experiment sheet 11.6: Half-life. Long tube (eg a burette) from which water can flow at a controllable rate, clock/watch. Parts of Boardworks Radioactivity http://lectureonline.cl.msu.edu www.hazelwood.k12.mo.us BNFL video: Working with radioactivity.	Describe how the activity of a radioactive source decreases over time. Demonstrate an understanding of how graphical representations of half-life can be made using suitable software, and compare this to traditional methods of creating graphical representation. Use the concept of half-life to carry out simple calculations including graphical representations.	C: 2.1 N: 2.1 2.2 2.3 WO: 2.1 PS: 2.1 2.2 2.3	
Homework: Complete Activity sheet 11.6: Half-life. Research causes of background radiation, especially radon gas, including regional variations.							

Scheme of work for Topic 11: Putting Radiation to Use

LESSON 7: How old is the Earth?							
Spec. code	**Links and concept building from KS3**	**Learning objectives**	**Teaching activities**	**Resources**	**Learning outcomes**	**Key skills**	**Safety issues**
P2 11.11	No explicit links; KS3 curriculum does not feature radioactivity.	Understand the process of carbon dating. Discuss experimental errors and assumptions made.	**Discussion/research** In groups, research radioactive carbon dating and dating involving another material such as potassium or uranium. **Discussion** Ask for suggestions and discuss the random nature of radioactivity and any other factors which may contribute to uncertainty, such as the possibility that the ratio of C-12 to C-14 is not constant or that there is a preferential intake of C-14 by some plants etc. These will all make the technique inaccurate to greater or lesser degrees. **Discussion** Mention that the amount of uranium now is about half the amount it was when the Earth formed. The half-life of the uranium has been measured so we can estimate the age of the Earth.	www.c14dating.com Science in Focus: Radioactivity video from www.channel4.com/schools	Recognise that scientific conclusions, such as those from radioactive dating, often carry significant uncertainties.	WO: 2.2 2.3	
Homework: Describe how radioactive dating works.							

Scheme of work for Topic 11: Putting Radiation to Use

LESSON 8: Marie Curie won two Nobel prizes — but how did she die?							
Spec. code	**Links and concept building from KS3**	**Learning objectives**	**Teaching activities**	**Resources**	**Learning outcomes**	**Key skills**	**Safety issues**
P2 11.12 P2 11.15	No explicit links; KS3 curriculum does not feature radioactivity.	Understand that ideas change with time. Understand the need for safety precautions and the result of not taking them. Marie did not know the dangers and so was unaware of the need for safety. Radioactive material could be attached to a conventional bomb to spread the dangerous substance over a large area.	**Discussion** Some of the old 'cures' for ailments used radioactive materials. Why are they no longer used? **Discussion** What are the dangers of radiation and the safety precautions taken in their use, storage and transportation, both in school and in everyday life? Monitoring of short-term and longer exposure should be mentioned. **Written work** Research the manner of Marie Curie's death and write a brief account of the importance of long-term assessment of risk. **Discussion** Mention should also be made of the more recent risk from terrorists.	http://womenshistory.about.com/od/mariecurie/p/marie_curie.htm www.ncrponline.org — publications commentary 10 IoP video: 'I work in atomic energy'	Discuss how scientific ideas, such as the risks associated with radioactive sources, develop over time. Describe the dangers of ionising radiation in terms of tissue damage and possible mutations and relate this to the precautions taken while carrying out demonstrations at school.	C: 2.2 2.3	
Homework: Draw a poster illustrating one or more safety aspects for the use of radioactive materials.							

Scheme of work for Topic 11: Putting Radiation to Use

LESSON 9: Radioactivity in depth							
Spec. code	**Links and concept building from KS3**	**Learning objectives**	**Teaching activities**	**Resources**	**Learning outcomes**	**Key skills**	**Safety issues**
	No explicit links; KS3 curriculum does not feature radioactivity.	Ability to concentrate on one aspect of radioactivity and develop those ideas before communicating them to others. While this is going on, higher-level discussion can take place on previously researched topics including causes of background radiation.	**Poster/fact sheet** Produce a poster or fact sheet that does one of the following: • advertises a product which is to be used in a factory to control thickness of sheet metal • compares the good and bad points of radioactivity • gives information to a patient who is to undergo radiotherapy — trying to set their mind at rest • emphasises the safety aspects of using radioactive sources • illustrates the scientific importance of the discovery of radioactivity • provides an historical account of the discovery of radioactivity and our understanding of the atom. The poster/fact sheet should: • include the correct and relevant science • be in an appropriate form • have the required impact.	Variety of materials suitable for posters which may show colour, texture, 3D, motion etc. Activity sheet 11.9.		C: 2.1 2.2 2.3 ICT: 2.1 2.2 2.3 LP: 2.1 2.2 2.3	
Homework: Finish poster/fact sheet.							

Scheme of work for Topic 11: Putting Radiation to Use

LESSON 10: What are the Northern Lights?							
Spec. code	**Links and concept building from KS3**	**Learning objectives**	**Teaching activities**	**Resources**	**Learning outcomes**	**Key skills**	**Safety issues**
P2 11.16	8J: Magnets and electromagnets.	The Earth has a magnetic field which can deflect charged particles into circular paths so that they do not reach the surface. Gases in the atmosphere are ionised by some cosmic rays and so reduce their energy. People use folklore and science to explain some natural phenomena.	All students can do this topic but foundation students can at any time complete their poster/write a poem/revise or research a future topic. **Demonstration** Demonstrate the effect of a magnet on the rays, particularly beta (television) and show animation of charged particle movement in magnetic field. **Discussion/research** Research exposure to cosmic/solar rays in aeroplanes at altitude. Planes are protected from space due to Earth's magnetic field. Explain how atmosphere also helps. **Research** What causes the 'Northern lights' or 'Aurora Borealis'? Give the folklore explanation and scientific explanations. Are there any 'Southern lights' or 'Eastern/Western lights'?	www.schulphysik.de	Explain that the Earth's atmosphere and magnetic field protects it from radiation from space.		

LESSON 10: What are the Northern Lights? *(continued)*		
Homework: Compose a limerick — a comic poem — written in five lines and rhyming as: a a b b a, as in the example.		
A Teacher from Harrow	There was a young teacher from Harrow Whose nose was too long and too narrow. It gave so much trouble That he bent it up double And wheeled it round school in a barrow.	There was an electron …….. Which/Who ….. ….. ...... …..

Demonstration 11.2: Gamma ray absorption

What you will learn from this demonstration

In this demonstration you will find out about the absorption of gamma rays.

What you will know after you see this demonstration

1 Gamma rays are absorbed differently by different materials.
2 The greater the thickness of absorber, the greater the amount of absorption.
3 Predictions and results can be displayed on sketches or plotted graphs.
4 The amount of absorption can sometimes be predicted statistically.

What you do

1 Draw a labelled diagram of the arrangement in the space below.

2 How would you carry out the demonstration?

a What would you change?

____

b What would you measure?

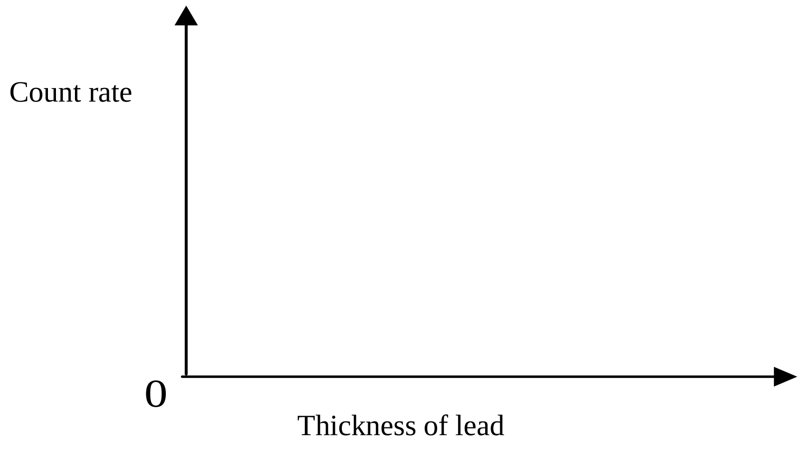
____

c What things would you keep the same?

____

Demonstration 11.2: Gamma ray absorption

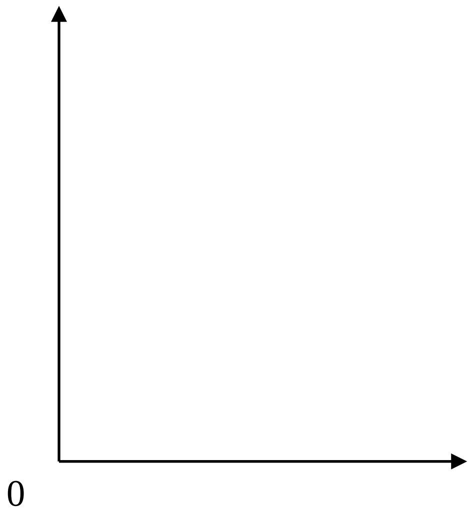
3 Sketch what you think a graph of count rate against thickness will look like.



4 Complete a table of results.

Material of absorber	Thickness of absorber (cm)	Count rate (counts/min)
Paper		
Aluminium		
Glass		
Copper		
Lead		

5 Sketch the type of graph you would now expect if you plotted your results of the activity against thickness.



6 Plot a graph of activity on the y- (vertical) axis against thickness on the x- (horizontal) axis.

7 What would you expect the count rate to be if you used lead of 0.3 mm thickness?

____

Demonstration 11.2: Gamma ray absorption

8 What would the thickness be for a value of 100 counts per minute?

9 Explain why the count rate heads towards a constant value which is above zero.

10 Lead is made into sheets by passing it between rollers.

Explain, with a diagram, how you could check the thickness of the lead sheet as it is made.

Demonstration 11.2: Gamma ray absorption

Notes for teachers and technicians

Aim

In this demonstration students will find out about the absorption of gamma rays.

Skills, knowledge and understanding

This demonstration will enable students to gain the following skills, knowledge and understanding.

1 Gamma rays are absorbed differently by different materials.

2 The greater the thickness of a given absorber the greater the amount of absorption.

3 Predictions and results can be displayed on sketches or plotted graphs.

4 The amount of absorption can sometimes be predicted statistically.

Previous skills, knowledge and understanding required

1 Origins of gamma rays.

2 Lead absorbs gamma rays.

3 How gamma rays can be detected.

Equipment and chemicals required

1 A (reasonably) pure gamma ray source (or set the distance between source and g-m tube more than 6 cm).

2 A gamma-radiation detector, eg a Geiger counter/scaler.

3 Thin sheets of various materials, eg paper, aluminium, copper.

4 Lead sheet with a range of thicknesses up to 1 cm.

5 A means of mounting the source a fixed distance from the detector with space for the absorbers to be placed between them.

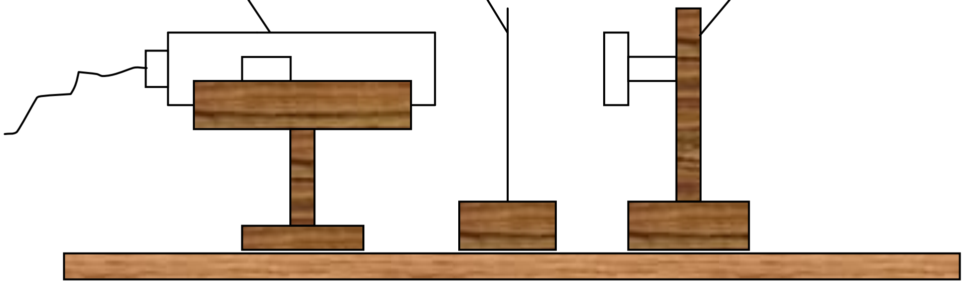
Health and safety issues

The demonstrator **must** have consulted the **named person** responsible for the storage, transportation and use of radioactive materials in their institution. Safety precautions dictated by that person must be obeyed during the demonstration. Only teachers should handle radioactive materials.

Delivery strategies

- The teacher can introduce the demonstration by asking students if they think gamma rays can pass through all materials.
- Then show that they can pass through thin sheets of all materials with little loss using the following appraratus.

Demonstration 11.2: Gamma ray absorption



- Ask students to draw the apparatus, answer the planning questions 2 a–c and sketch a graph to show their prediction. Discuss their suggestions to produce a good plan.
- Carry out the demonstration, using student assistants to take readings, with sources safely packed away while changing absorbers and/or taking readings.
- Ask students to sketch a graph of the shape they expect, just by looking at the numbers.
- Ask them now to plot the graph and compare it with their sketch.
- They can then answer the rest of the questions.

Websites

http://science.howstuffworks.com

www.lbl.gov

Suggestions for further work

Early finishers could look up how a smoke detector works.

Experiment 11.3: Does greaseproof paper absorb light in a similar way to the way lead absorbs gamma rays?

What you will learn from this experiment

In this experiment you will find out about absorption. The greaseproof paper absorbs some of the light and you will see the effect of allowing light to pass through several sheets in succession.

What you will know when you finish this experiment

1 Some light can pass through a piece of greaseproof paper.

2 The more sheets, the greater the amount of absorption.

How you may be assessed

Your teacher may mark you on how well you:

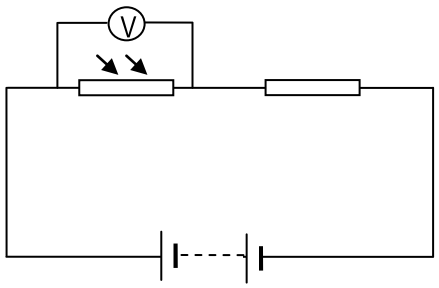
1 follow instructions

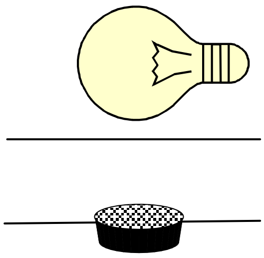
2 collect your results

3 present your results.

What you do

1 Set up this circuit.





2 Place the LDR below the lamp.

3 Take the reading of the voltmeter.

4 Record your results in a suitable table.

5 Insert one sheet of greaseproof paper between the lamp and LDR.

6 Take the new reading of the voltmeter.

7 Repeat instructions 4 to 6 for two, three, four and five sheets of paper.

8 Plot a graph with voltmeter readings on the y- (vertical) axis and number of sheets of paper on the x- (horizontal) axis.

9 Describe what happens to the voltage as the thickness of paper increases.

____

____

Experiment 11.3: Does greaseproof paper absorb light in a similar way to the way lead absorbs gamma rays?

10 How is this linked to the absorption of radiations from a radioactive material?

____

____

11 How could you improve the experiment to make it more reliable?

____

____

Experiment 11.3: Does greaseproof paper absorb light in a similar way to the way lead absorbs gamma rays?

Note for teachers and technicians

Aim

In this experiment students will find out about absorption. The greaseproof paper absorbs some of the light and students will see the effect of allowing light to pass through several sheets.

Previous skills, knowledge and understanding required

(This section has links to Key Stage 3.)

1 The effect of different thicknesses of lead on gamma rays.

2 Light and gamma rays are both part of the electromagnetic spectrum.

Skills, knowledge and understanding

This experiment will enable students to gain the following skills, knowledge and understanding.

1 Following instructions.

2 Setting up a simple circuit and arranging apparatus.

3 Recording results suitably.

4 Analyse the results by plotting and interpreting a graph.

Equipment and chemicals required

1 LDR.

2 Lamp and power supply.

3 Five sheets of greaseproof paper.

4 A battery suitable for the LDR.

5 A resistor (about 1 kΩ).

6 A voltmeter.

Health and safety issues

Include warnings concerning health and safety issues in this section, eg glasses/protective gloves must be worn.

Delivery strategies

- Remind students about the results of the gamma ray absorption experiment.
- The experiment works best in the dark or if the lamp and LDR are covered with a dark cloth.
- The extension work with coloured filters can motivate less able students to think about different materials and more able students to consider other factors.
- The graph can be compared to that for gamma rays and a conclusion reached about any similarities.
- Give any students who finish early some colour filters to use instead of the greaseproof paper.

Experiment 11.3: Does greaseproof paper absorb light in a similar way to the way lead absorbs gamma rays?

Ask them to investigate the effects as follows:

- make a prediction
- try their idea
- draw conclusions from their results.

Assessment strategies

This experiment can contribute to the internal 10% assessment of practical skills particularly a) following instructions (0–6), collecting data (0–4) and presenting results (0–4).

If students work in pairs/groups, you can ask anyone being assessed to explain how they are doing the experiment (to assess following instructions), how to take the next set of results (for collecting data) and watch as the student(s) draw up the table (for presenting results).

Activity 11.5: Simple atomic structure

What you will learn from this activity

In this activity you will find out about the structure of the atom.

What you will know when you finish this activity

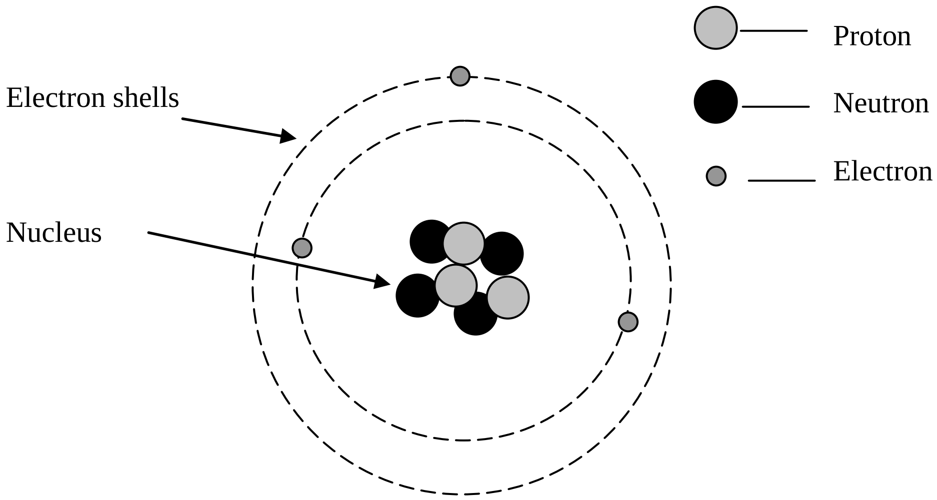
1 The arrangement of the proton, neutron and electron in the atom.

2 The charges and relative masses of the proton, neutron and electron.

3 The meaning of proton number Z, nucleon number A and isotopes.

Constituents of the atom

The simplest model of the **atom** is shown in the diagram below:



This is the layout of a **lithium** atom, with three protons, three electrons, and four neutrons. The protons and neutrons are found in the **nucleus**. They are called **nucleons**. The electrons are found in shells **orbiting** the nucleus.

How many of each of these are there in this atom?

(a) Protons	
(b) Neutrons	
(c) Electrons	
(d) Nucleons	

Activity 11.5: Simple atomic structure

A carbon atom has six protons and six neutrons. Draw the carbon atom in a similar way to the lithium atom in the diagram overleaf.

It is important to understand that the nucleus is very small compared to the atom, about 10, 000 times smaller.

Property	Electron	Proton	Neutron
Charge	–1 *e*	+1 *e*	0
Relative mass	1/1836	1	1

The nucleus contains _______________ and __________________.

A nucleus is identified by the proton number and the nucleon number, ie $^{A}_{Z}X$.

The ***proton number*** is ____

____

The ***nucleon number*** is ____

____

The superscript **A** is ____ .

The subscript **Z** is ____ .

The total **number of nucleons** is given by _______________________________________ .

Using this notation write the symbol for:

A proton _______________. A neutron _______________. An electron _______________.

Activity 11.5: Simple atomic structure

Complete this table:

Isotope	Number of nucleons	Number of protons	Number of neutrons	Number of electrons
${}^{13}_{6}C$				
${}^{3}_{2}He$				
${}^{7}_{4}Be$				
${}^{33}_{17}Cl$				
${}^{133}_{55}Cs$				
${}^{197}_{79}Au$				
${}^{239}_{94}Pu$				

Isotopes

- **Isotopes** have the same numbers of protons, but different numbers of

  _____________________________.

- Isotopes have the **same** chemical properties.
- If the proton number is altered, the element changes.

Some isotopes are radioactive, as the nuclei are unstable.

______________________ reactions involve the electrons of the outer shells. Nuclei are not involved in any way, and remain totally unaltered even in the fiercest chemical reactions.

Below draw nuclei of the three isotopes of hydrogen.

Activity 11.5: Simple atomic structure

Carbon 14 is an isotope of carbon. Complete the table:

Number of protons	
Number of neutrons	
Number of electrons	
Write carbon-14 in the form ${}_{Z}^{A}X$	
Draw the isotope	

If we turn one of the neutrons into a proton, we can see what happens.

In the space below, draw the atom that you would get if you turn one neutron into a proton in the carbon-14 atom.	
How many protons are there?	
How many neutrons are there?	
How many electrons are there?	
What atom is this?	

Activity 11.6: Half-life

1 How does the title below illustrate radioactive decay?

____

____

Half-life of radio-active materials

2 Jane was doing an experiment with 1000 mg of a radioactive material. The half-life of the material was 30 years. How much would she have left after each of these times?

a) 30 years ______ mg   b) 60 years ______ mg   c) 90 years ______

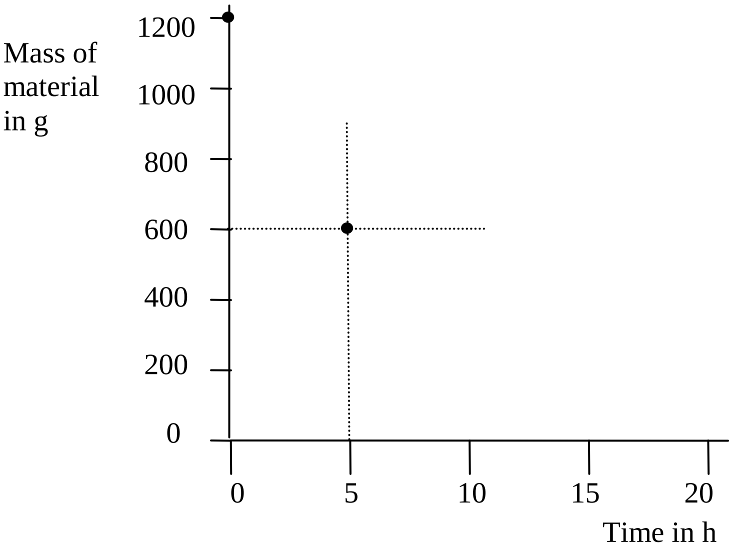
3 Akim measured the half-life of a material as five hours. What fraction of his original sample will still be present after:

a) 5 hours ______   b) 10 hours ______   c) 15 hours ______   d) 20 hours ______?

4 Chei had 32 g of radioactive material of half-life 0.5 s. How much would have decayed after:

a) 0.5 s ______   b) 1.0 s ______   c) 1.5 s ______   d) 2.0 s ______   e) 3.0 s ______?

5 Two points have been plotted on this graph. Carry it on as far as you can.



6 What mass of material would you expect after 12 h? How sure are you?

____

7 In some medical treatments, radioactive material is put into the body. Would you expect the material to have a long or short half-life? Why? How long might the half-life be?

____

Activity 11.6: Half-life

Answers to half-life homework

1 The title is of a similar shape to the graph for radioactive decay.

2 a) 1000 mg b) 500 mg c) 250 mg [make sure the unit is there for c]

3 a) ½ b) ¼ c) 1/8 d) 1/16

4 a) ½ b) ¾ c) 7/8 d) 15/16 e) 63/64

5 They can do another three half-lives.

6 Somewhere between 190 and 220 should do but read from their graph.

Not very sure because thickness of lines, marking lines horizontal and vertical, and random nature of decay etc all contribute to errors.

7 Quite short half-lives (few hours maximum) so sufficient activity but not dangerous in body for long.

Experiment 11.6: Half-life of water running from a tube

What you will learn from this experiment

In this experiment, you will find how the rate of water flowing from a tube changes as water runs out.

What you will know when you finish this experiment

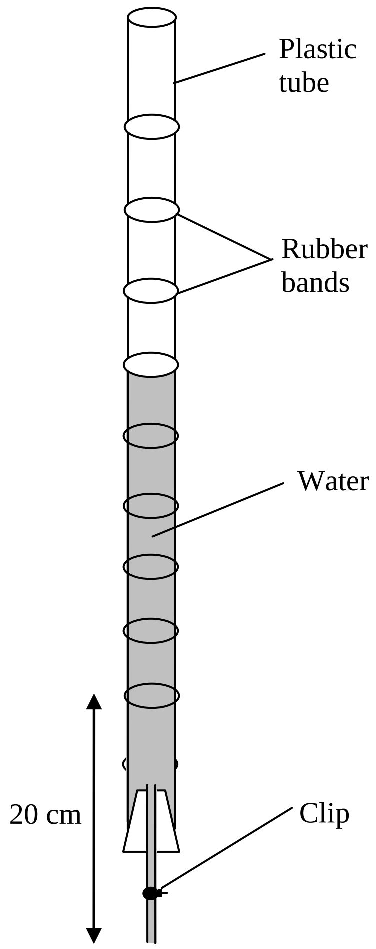
1. You can find the rate of flow by measuring the time for the water surface to move a certain distance.
2. We can plot a graph of height of water in the tube against time, to picture the change.

How you may be assessed

1. Can you plot a graph?
2. Can you interpret a graph?
3. Can you understand radioactivity by comparing it to the water model to make a mental picture?

What you do

1. Put the bung in one end of the plastic tube.
2. Measure up 20 cm from the bottom opening of the tube (out of the bung).
3. Either tie a piece of cotton round the tube or slide a rubber band there.
4. Repeat this every 10 cm up the length of the tube as shown.



Height of water (cm)	Time (s)	Group average time (s)
100		
90		
80		
70		
60		
50		
40		
30		
20		

Experiment 11.6: Half-life of water running from a tube

5 Clamp the tube vertically (two clamps if possible).

6 Fill the tube half-full of water.

7 Adjust the clip so that the water takes **about** 25 s to lower the surface by 10 cm.
Leave the clip setting in this position for the rest of the experiment.

8 Ask a friend to put a finger over the lower end of the narrow tube.

9 Fill the main tube with water.

10 Place a beaker under the narrow tube to collect the water.

11 Ask your friend to move the finger and start the clock as soon as the water reaches the first piece of cotton or rubber band.

12 Record the time as the water surface reaches each piece of cotton or rubber band.

Analysis

13 What happens to the speed of the water as it moves down the tube?

____

14 Plot your results on a graph with height of water surface on the y- (vertical) axis and (class averages of) time on the x- (horizontal) axis.

15 Describe your graph in terms of the rate at which the water runs out of the tube.

____

____

16 Starting at zero time, find the time it takes for the height of water to fall to half its starting value.

____

17 Start at this half value and find the time it takes to fall to half of this.

____

18 What do you notice?

____

19 Repeat for half again. Does this confirm any pattern you had noticed in 18?

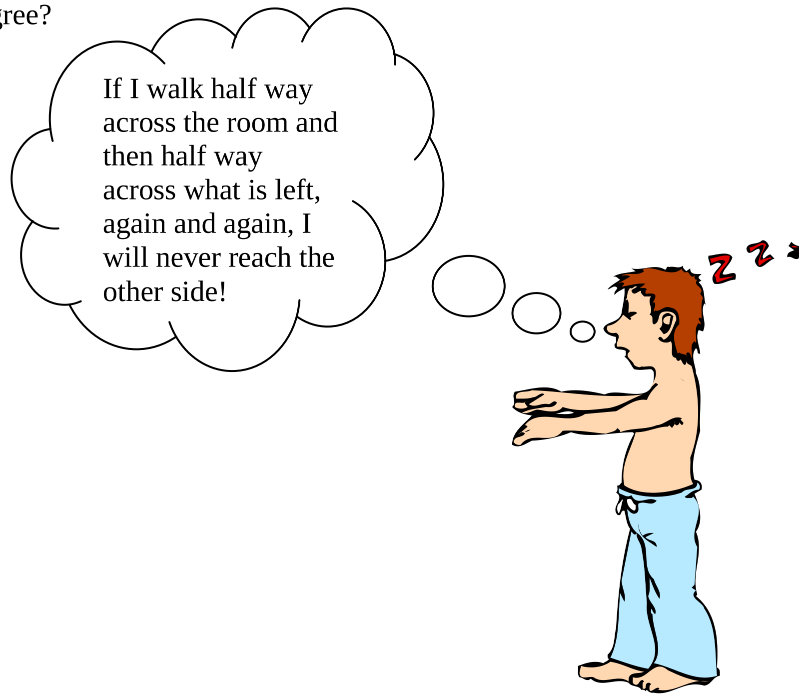
____

Experiment 11.6: Half-life of water running from a tube

Suggestions for further work/homework

1 Try the effect of varying the rate of flow by adjusting the clip/tap. Predict what will happen first.

2 Do you agree?



Write a couple of sentences to explain.

Experiment 11.6: Half-life of water running from a tube

Note for teachers and technicians

Aim

In this experiment, students will find how the rate of water flowing from a tube changes as water runs out. They should get some idea about half-life which they can then relate to radioactive decay.

Skills, knowledge and understanding

This experiment will enable students to gain the following skills, knowledge and understanding.

1 The rate of flow decreases with time.

2 The rate of flow depends on the height of water in the tube.

3 The rate of decay depends on the number of particles which have not decayed.

4 We should expect a curve similar to that for water.

Equipment and chemicals required

1 Burette or a long plastic tube with a bung containing a short length of tubing.

2 Clock/watch.

3 Cotton thread or small rubber bands.

4 Metre rule.

5 Container to help fill the tube/burette and then to collect water as it runs out.

6 Filter funnel to help fill the tube/burette.

Health and safety issues

Take care that the tube is clamped securely and does not become unstable.

Delivery strategies

- The idea is to develop a mental model to help understand the difficult concept of half-life.
- Point out the idea that the height of water is pushing water out of the bottom of the narrow tube — the greater the height the more push and so the faster the water will flow out.
- Discuss that the rate at which a radioactive material decays depends on the number of radioactive particles.
- So the two ideas are similar — let's try to see what happens with the water.
- Students can follow the instructions on the worksheet.
- They should carefully plot the results, with less able students receiving a graph that has the axes already labelled and maybe scaled.
- While some are struggling with the graphs, others can answer the questions. These can then be discussed together.
- Show that a radioactive material does decay with a fixed half-life. Maybe get a couple of students to act out the walking across the room idea. Show an animation/applet from the internet.

Experiment 11.6: Half-life of water running from a tube

Assessment strategies

This experiment might contribute to the non-moderated practical assessment in setting up the apparatus fairly accurately according to the instructions and collecting data (although here you would need to discuss the reliability individually). With the table being given, it is not suitable for more than two marks for presenting results.

The more able can try to spot ways in which the model differs from real life, eg smooth flow versus individual atoms decaying (random), no background count, other factors like evaporation and change with temperature.

Activity 11.9: Exploring radioactivity

What you will learn from this activity

In this activity you will explore one aspect of radioactivity in greater detail.

What you will know when you finish this activity

1 A greater amount about your chosen topic.

2 How to better communicate information appropriately.

How you may be assessed

You may be assessed on:

1 the visual impact of your poster/fact-sheet

2 the amount and accuracy of the science it contains

3 how appropriate the presentation is

4 originality.

What you do

Choose one of the following and produce an A3 or A4 poster or fact sheet on it:

- advertising a product which is to be used in a factory to control thickness of sheet metal
- comparing the good and bad points of radioactivity
- giving information to a patient who is to undergo radiotherapy — trying to set their mind at rest
- emphasising the safety aspects of using radioactive sources
- illustrating the scientific importance of the discovery of radioactivity
- providing an historical account of the discovery of radioactivity.

Research your topic from books and the internet.

Presentation

Your poster may convey ideas more clearly and strikingly if you can include some or all of the following in your poster:

Timing

You have this lesson and your homework to prepare the poster/fact sheet ready for presentation next lesson.

Activity 11.9: Exploring radioactivity

Notes for teachers and technicians

Aim

In this activity students will explore one aspect of radioactivity in greater detail and produce a presentation, eg a poster/fact sheet about it.

Skills, knowledge and understanding

This activity will enable students to gain the following skills, knowledge and understanding.

1 Greater communications ability.

2 Enhanced research skills.

Previous skills, knowledge and understanding required

Work done earlier in the module.

Materials required

Paper/card plus other resources which will enable students to explore the range of display possibilities outlined in the worksheet, ie:

- colour pens/pencils
- fabrics
- paper fasteners.

Delivery strategies

- Set this as a challenge for students.
- You may offer prizes/merits etc for a variety of outcomes such as impact, content, originality of display/appropriateness.
- Provide reference books to supplement any texts you have.
- Try to provide internet access for research.

Assessment strategies

- After completion, have a display and let peers judge 'impact' by giving them two votes (which must be different, so they can vote once for themselves). You should judge other criteria you have set.
- You may also reward any scientific errors which are pointed out by individuals. This will encourage students to take a more critical look at each poster.

Links

Links with other GCSE Science topics.

This activity is related to:

- P2 Topic 12. Topic 11 is probably best done first as, for example, an understanding of atomic structure and radioactive decay (Topic 11) is needed before doing decay series fission, etc (Topic 12).

Activity 11.9: Exploring radioactivity

Resources

Radioactivity and its uses are dealt with in all KS4 textbooks and can also be found in publications from the Institute of Physics, the Association for Science Education and organisations such as BNFL, NIREX and the National Radiological Protection Board.

Use may also be made of many multimedia materials, eg Plato learning and websites accessed by Google through ‘virtual physics laboratories’.

Glossary for Topic 11: Putting Radiation to Use

What you do

Complete the glossary for each key word or phrase.

You will be expected to be able to recall, explain, describe and use the words appropriately.

Key word(s)	Definition
Alpha particle	
Atom	
Atomic mass	
Background radiation	
Beta particle	
Electron	
Gamma ray	
Half-life	
Ionising radiation	
Isotope	
Magnetic field	
Mutation	
Neutron	
Nucleus	
Mass nucleon number	
Proton	
Proton number	
Radioactive dating	
Radioactivity	
Radon gas	
Sterilisation	
X-rays	

June 2006

For more information on Edexcel and BTEC qualifications please contact our
Customer Services on 0870 240 9800
or http://enquiries.edexcel.org.uk
or visit our website: www.edexcel.org.uk

Edexcel Limited. Registered in England and Wales No. 4496750
Registered Office: One90 High Holborn, London WC1V 7BH