Teaching radioactivity
Introduction

The rationale for our departmental KS4 scheme of work is based on typical starting points for students and the learning difficulties which they can encounter. (See a fuller description of these located after the scheme of work.) Activities mentioned are published for Twenty First Century Science by Oxford University Press - GCSE Science, module P3 *Radioactive Materials*.

Departmental scheme of work (based on 1 hour lessons)

Lesson	**Main ideas**	**Lesson structure**	**Resources**
1	Radiation is all around -background radiation -identifying natural and man-made radioactive materials -randomness of emissions	starter: what have you heard about radioactivity? what questions about radioactivity would you like to be able to answer? main: participative demonstrations using GM tube, audible counter plenary: complete a pie chart showing sources of background radiation introduce source-journey-detector model of radiation	• GM tube, audible counter • variety of materials such ordinary table salt, LO-salt, dust (from vacuum cleaner or collected with a balloon that has been given static charge, Brazil nuts (whole and ground), coffee (whole beans and ground), sulphate of potash (garden fertiliser), old gas mantle (infused with thorium). • unlabelled pie chart of sources of background radiation • textbook

2	Using radioactive materials -ionisation and why it is hazardous to living organisms -identify three types of radiation (alpha, beta and gamma) -protective measures: distance, absorbers, time	starter: Use concept cartoon to introduce the question 'What do radioactive materials do?' main: three experiments demonstrating ionising radiation, animation of ionisation (from Practical Physics expt. *Diffusion cloud chamber*), then EF film *Radiation and health* plenary: distinguish contamination v irradiation	• experiment: *Diffusion cloud chamber* www.practicalphysics.org/go/Experiment_583.html • experiment: *Ions produced by radiation carry a current* www.practicalphysics.org/go/Experiment_523.html • experiment: *The spark counter* www.practicalphysics.org/ • Energy Foresight (EF) film *Radiation and health* www.energyforesight.org
3	Radiation dose Risk = probability x consequences	starter: weighing up benefit and risk, in everyday situations main: Activity *Calculating risk* Case study, in small groups: *Radon in the home* and/or *Occupational health - film badges* plenary: return to Energy Foresight film *Radiation and health*	• textbook • Activity sheet AP3.7 *Calculating risk* • Energy Foresight film *Radiation and health* and Activity sheet *Balancing risks and benefits*

4	More about ionising radiations and their properties (range and absorption, deflection of beta)	starter: reminder of source-journey-detector model main: three experiments. students complete a table with results plenary: consolidate learning from previous lessons with *Radioactivity traffic lights*	• experiment *Beta radiation: range and stopping* www.practicalphysics.org/go/Experiment_588.html • experiment *Beta radiation: deflection in a magnetic field* www.practicalphysics.org/go/Experiment_617.html • experiment *Gamma radiation: range and stopping* http://www.practicalphysics.org/go/Experiment_589.html • Activity AP3.13 *Radioactivity traffic lights*
5	Half-life: with very large numbers, a random process produces a predictable pattern	starter: measuring the activity of a radioactive source main: investigating how the activity of protactinium changes with time, modelling decay, using half-life in simple calculations. plenary: how does probability of emission relate to lifetime of a radioactive material?	• experiment *Measuring the half-life of protactinium* http://www.practicalphysics.org/go/Experiment_577.html • experiment *Simple model of exponential decay* http://www.practicalphysics.org/go/Experiment_579.html • textbook
6	Nuclear structure and decay: nuclear structure of atom, protons and neutrons in the nucleus, isotopes, stable and unstable nuclei	starter: using textbook, outline the science main: simulation *what happens in radioactive decay?* plenary: *Happy families*	• textbook • computer simulation, with accompanying activity sheet AP3.16 *What happens in radioactive decay?* • Activity AP3.18 *Happy families* (card game about radioisotopes)
7	Using radioactive materials: an opportunity to revisit key ideas	Revision questions *The story so far* Activity *Solving problems with radioisotopes* (industrial uses)	• textbook • Activity AP3.17 *The story so far* • Activity AP3.19 *Solving problems with radioisotopes*

8	Nuclear power: thermal power stations, fission, basics of nuclear reactors	starter: discuss IAEA data, compare the two years, noting general decline in nuclear electricity - and exceptions. main: simulation *How a nuclear power station works,* plus related activities. plenary: press cutting 'UK Government plans nuclear build'. Why?	• IAEA data showing proportion of nuclear-generated electricity in a variety of countries, 2007 and 2001 • computer animation IP3.6 *How a nuclear reactor works* • Activity AP3.21 *Nuclear power – key ideas* • Activity 3.22 *How a nuclear power station works* (role play)
9	Disposing of nuclear waste. - HLW, ILW, LLW - precautionary principle	starter: categories of nuclear waste and methods of disposal, using textbook main: EF film *Managing nuclear waste* plus associated role play plenary: class vote on disposal method (long-term surface storage v deep geological disposal)	• textbook • Energy Foresight film *Managing nuclear waste*
10	Nuclear power stations and waste - consolidation of prior learning	Mock radio interview. Small group discussion, using questions from the Activity sheet, with plenary	• textbook • Activity AP3.31 *Nuclear power stations and waste*

Why the scheme of work is designed as it is

Many people fear radioactive materials. This is explainable perhaps by?

- a general sense that ionising radiation can be harmful
- ignorance of background radiation
- the fact that human senses cannot detect radiation, except at very high doses
- nuclear accidents and media scares which these generate

Education research[1] shows that

- basic misconceptions are widespread
- a conventional approach that puts theoretical ideas first can be a barrier to understanding.

Recognised ways of addressing these have been tried and prove effective.

misconceptions and difficulties	how teaching can address these
a failure to distinguish radiating source from the radiation it produces, evidenced by phrases such as ''a cloud of radiation from Chernobyl' and 'water unfit to drink because it contains radiation'	introduce a 'source – journey – detector' model of radiation
a belief that irradiated objects e.g. sterilised syringe or dressing (or food) become radioactive.	distinguish between contamination and irradiation
average and weaker students find the particle model of matter very difficult, so introducing radioactivity in terms of atomic and nuclear structures is unhelpful.	start from the phenomena **– effects of ionising emissions –** then lead into more formal thinking (measuring activity, half-life, dose) and end with atomic and nuclear explanations.

Note 1. 'Teaching about radioactivity and ionising radiation: an alternative approach' Robin Millar *et al* 1990 *Phys. Educ.* **25** 338-342