

Links to the Australian Curriculum: Senior Secondary Chemistry (Unit 1) and Physics (Unit 1)

## **Science understanding concepts include:**

### **Properties and structure of atoms**

- Isotopes are atoms of an element with the same number of protons but different numbers of neutrons; different isotopes of elements are represented using atomic symbols (for example,  ${}^6\text{C}_{12}$ ,  ${}^6\text{C}_{13}$ ) (ACSCH021)
- Isotopes of an element have the same electron configuration and possess similar chemical properties but have different physical properties, including variations in nuclear stability (ACSCH022)

### **Ionising radiation and nuclear reactions**

- The nuclear model of the atom describes the atom as consisting of an extremely small nucleus, which contains most of the atom's mass and is made up of positively charged protons and uncharged neutrons surrounded by negatively charged electrons (ACSPH026)
- Nuclear stability is the result of the strong nuclear force, which operates between nucleons over a very short distance and opposes the electrostatic repulsion between protons in the nucleus (ACSPH027)
- Some nuclides are unstable and spontaneously decay, emitting alpha, beta and/or gamma radiation over time until they become stable nuclides (ACSPH028)
- Each species of radionuclide has a specific half-life (ACSPH029)
- Alpha, beta and gamma radiation have sufficient energy to ionise atoms (ACSPH030)
- Einstein's mass/energy relationship, which applies to all energy changes, enables the energy released in nuclear reactions to be determined from the mass change in the reaction (ACSPH031)
- Alpha and beta decay are examples of spontaneous transmutation reactions, while artificial transmutation is a managed process that changes one nuclide into another (ACSPH032)
- Neutron-induced nuclear fission is a reaction in which a heavy nuclide captures a neutron and then splits into two smaller radioactive nuclides, with the release of neutrons and energy (ACSPH033)
- Nuclear fusion is a reaction in which light nuclides combine to form a heavier nuclide, with the release of energy (ACSPH035)
- More energy is released per nucleon in nuclear fusion than in nuclear fission because a greater percentage of the mass is transformed into energy (ACSPH036)

## **Science as a human endeavour concepts include:**

- The use of scientific knowledge may have beneficial and/or harmful and/or unintended consequences (ACSPH013, ACSCH03)
- Advances in science understanding in one field can influence other areas of science, technology and engineering (ACSCH011, ACSPH011)
- Scientific knowledge can enable scientists to offer valid explanations and make reliable predictions (ACSPH014, ACSCH014)

## **Science inquiry skills concepts include:**

- Identify, research, construct and refine questions for investigation; propose hypotheses; and predict possible outcomes (ACSPH001)
- Design investigations, including the procedure/s to be followed, the materials required, and the type and amount of primary and/or secondary data to be collected; conduct risk assessments; and consider research ethics (ACSPH002)
- Interpret a range of scientific and media texts, and evaluate processes, claims and conclusions by considering the quality of available evidence; and use reasoning to construct scientific arguments (ACSCH005, ACSPH005)
- Select, use and interpret appropriate mathematical representations, including linear and non-linear graphs and algebraic relationships representing physical systems, to solve problems and make predictions (ACSPH007)
- Communicate to specific audiences and for specific purposes using appropriate language, nomenclature, genres and modes, including scientific reports (ACSCH008, ACSPH008)

## Background

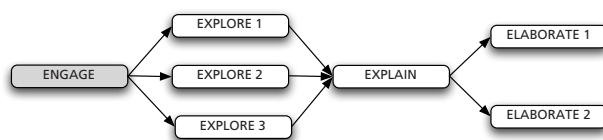
This collection of SPICE resources can be drawn together into a learning pathway for students to develop their understanding of nuclear physics and nuclear chemistry. The pathway is structured around a constructivist model based on the 5-Es that are interwoven throughout the sequence where teachers can:

- **Engage** students' interest and minds in issues such as the mining of uranium ore and the use of radioisotopes in medicine;
- enable students to **Explore** processes and dilemmas that link uranium ore mining to the use of radioisotopes in medicine, and which properties of nuclear materials raise questions regarding products of the nuclear industry;
- **Explain** concepts that relate to atomic structure and radioactivity;
- provide opportunities for students to **Elaborate** on concepts. Here students can apply their knowledge in different contexts and extend their knowledge of science; and
- **Evaluate** students' progress throughout the pathway.

Unit 1 of the Senior Secondary Chemistry Curriculum (properties and structure of atoms) and Unit 1 of the Senior Secondary Physics Curriculum (ionising radiation and nuclear reactions) have some overlap, and this sequence, *Nuclear reactions*, can be applied to aspects of both. The table below shows which parts of the sequence are more applicable to chemistry students, and which to physics students.

Chemistry Unit 1	<i>Nuclear reactions</i>	Physics Unit 1
	<b>ENGAGE</b>	
Nuclear technology is an emotive issue. This resource uses two short video clips to engage student interest in nuclear chemistry/physics.	<i>Mines to medicine</i>	Nuclear technology is an emotive issue. This resource uses two short video clips to engage student interest in nuclear chemistry/physics.
	<b>EXPLORE</b>	
The background sheet, <i>What is nuclear radiation</i> , contains useful information for teachers. Activities in this resource may be omitted by chemistry students.	<i>Nuclear radiation</i>	Several alternative activities, all suitable for physics students, are described here.
This activity will be useful for both chemistry and physics students.	<i>Nuclear decay</i>	This activity will be useful for both chemistry and physics students.
	<i>Decay chains</i>	This resource is primarily aimed at physics students.
	<b>EXPLAIN</b>	
	<i>Fission and fusion</i>	This resource is primarily aimed at physics students.
This resource will be useful for both chemistry and physics students.	<i>Nuclear medicine</i>	This resource will be useful for both chemistry and physics students.
	<b>ELABORATE</b>	
Case studies in this resource include applications of isotopes in chemistry and biology.	<i>Radioisotopes in research</i>	

## Learning pathway



### Nuclear reactions 1: Mines to medicine

*Mines to medicine* comprises a teacher guide, background sheet, two videos and student worksheet.

This resource engages students by encouraging them to discuss issues involved in a protest against uranium mining. Students are then exposed to a case study involving a scientist, working at Royal Perth Hospital, who makes use of radioisotopes in the treatment of cancer patients. See the teacher guide for detailed information on the purpose and use of this resource.

### Activity: nuclear issues

The purpose of this activity is for students to explore processes involved in production of medical isotopes and other useful materials from uranium ore, thereby raising awareness of issues underpinning concerns about the nuclear industry.

#### The activity:

Students think about their attitude towards nuclear industry. In pairs, they discuss their opinions and attitudes. This is an excellent follow-up to the 'human graph' activities that followed videos included in the preceding SPICE resource, *Nuclear reactions 1: Mines to medicine*.

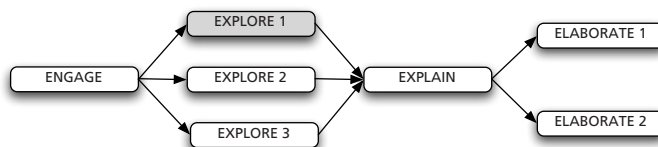
Using focus questions suggested in **Guiding the discussion**, students participate in a whole-class discussion covering the main concerns relating to the nuclear industry. This assists in student preparation for subsequent SPICE resources on nuclear physics.

#### Guiding the discussion

Students may research background information before being led through a whole-class discussion. The following focus questions may help them:

- What are benefits of the nuclear industry?
- What are concerns about the nuclear industry?
- What have you learned about the nuclear industry?
- Have your opinions about the nuclear industry changed?
- Is radiation the main threat from nuclear materials? If not, what is?
- What would you like to know more about in relation to the nuclear industry?

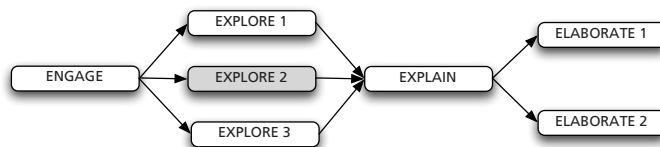
This discussion should lead to the next resource in this sequence, *Nuclear reactions 2: Nuclear radiation*, which focuses on finding out more about characteristics of nuclear radiation.



### Nuclear reactions 2: Nuclear radiation

*Nuclear radiation* comprises a teacher guide, background sheet, procedure sheet and two student worksheets.

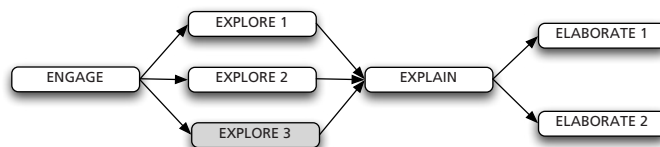
This resource provides three alternative ways to investigate penetrative properties of alpha, beta and gamma radiation. See the teacher guide for detailed information on the purpose and use of this resource.



### Nuclear reactions 3: Nuclear decay

*Nuclear decay* comprises a teacher guide, fact sheet, interactive learning object and two student worksheets.

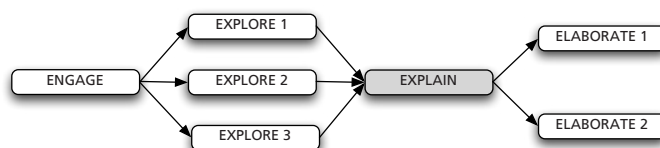
This resource allows students to explore how the atomic structure of elements is changed through radioactive decay. See the teachers guide for detailed information on the purpose and use of this resource.



### Nuclear reactions 4: Decay chains

*Decay chains* comprises a teacher guide, interactive learning object and worksheet.

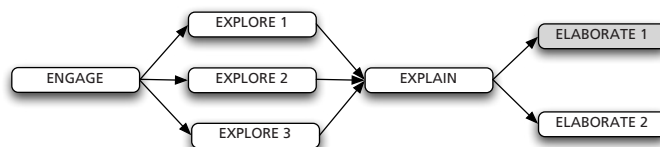
This resource allows students to explore mechanisms and products of nuclear decay through an interactive learning object. See the teachers guide for detailed information on the purpose and use of this resource.



### Nuclear reactions 5: Fission and fusion

*Fission and fusion* comprises a teacher guide, fact sheet and two student worksheets.

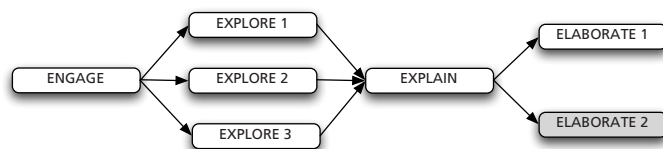
This resource explains how mass defect and binding energy are calculated for fission and fusion reactions. Information on the ITER experimental fusion reactor is included. See the teachers guide for detailed information on the purpose and use of this resource.



### Nuclear reactions 6: Nuclear medicine

*Nuclear medicine* comprises a teacher guide, video and student worksheet.

This resource enables students to build on their knowledge of radioactive substances through viewing a video about safe handling of radioisotopes. An associated worksheet contains information about how radioisotopes are used in medicine. See the teachers guide for detailed information on the purpose and use of this resource.



## Nuclear reactions 7: Radioisotopes in research

*Radioisotopes in research* comprises a teacher guide and four fact sheets.

This resource shows how four scientists use isotopes to investigate the natural world. See the teachers guide for detailed information on the purpose and use of this resource.

## Acknowledgements

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