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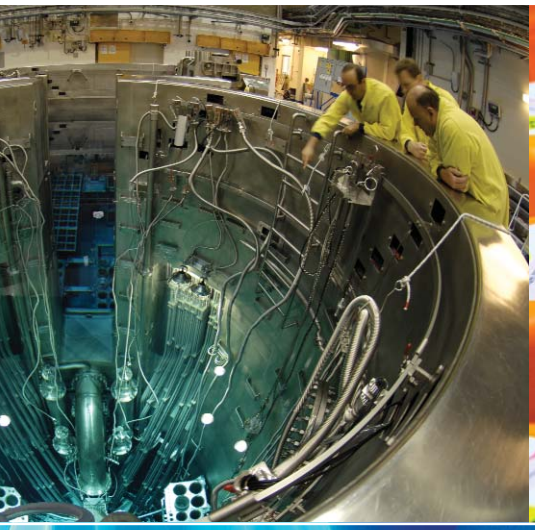
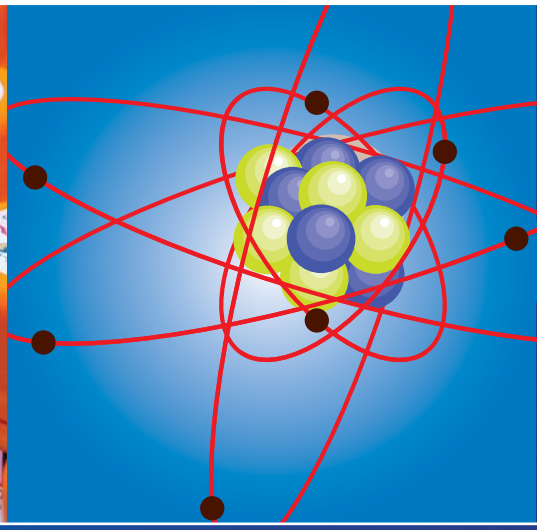
Nuclear-based science benefiting all Australians

Glossary of nuclear terms





Glossary of nuclear terms

Accelerator

A device that accelerates charged particles or ions to very high speeds.

Actinides

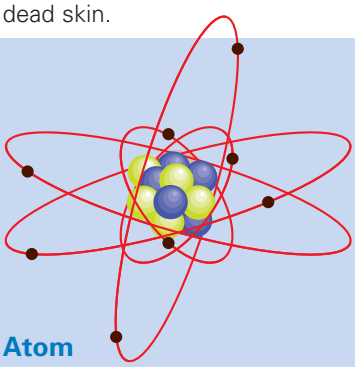
Elements with 89 or more protons in their nucleus that behave chemically like actinium. All are radioactive and many are long lived alpha-emitters.

Activity (of a substance)

The number of disintegrations per unit time taking place in a radioactive material. The unit of activity is the Becquerel (Bq), one disintegration per second.

Alpha particle (α)

A positively charged particle emitted from the nucleus of an atom during radioactive decay. Consists of two protons and two neutrons (a helium-4 nucleus). Although alpha particles are normally highly energetic, they travel only a few centimetres in air and are stopped by a sheet of paper or the outer layer of dead skin.



Atom

A particle of matter that cannot be broken up by chemical means. Atoms have a nucleus consisting of positively charged protons and uncharged neutrons of about the same mass. In a neutral atom the positive charges of the protons in the nucleus are balanced by the same number of negatively charged electrons in motion around the nucleus.

Atomic mass unit (amu)

One-twelfth of the mass of a carbon-12 atom. It is approximately equal to the mass of a single proton or neutron.

Atomic number (Z)

Number of protons in the nucleus of an atom, which also indicates the position of that element in the periodic table.

Background radiation

The ionising radiation in the environment to which we are all exposed. It comes from many sources including outer space, the sun, rocks, soil, buildings, the air we breathe, the food we eat, and our own bodies. The average annual background radiation dose in Australia is about two millisieverts (see Dose, effective).

Becquerel (Bq)

Unit of activity equal to one radioactive disintegration per second. Replaces the older unit, the Curie (Ci): 1 Ci = 3.7×10^{10} Bq.

Beta particle (β)

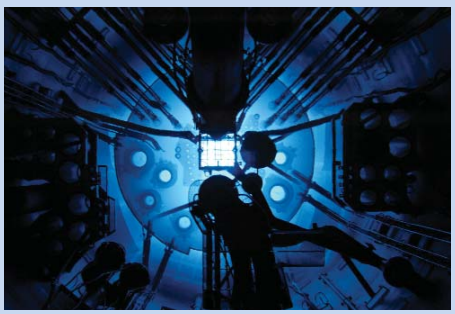
A particle emitted from the nucleus of an atom during radioactive decay. Beta particles are electrons with either negative or positive electric charge. High energy beta particles may travel metres in air and several millimetres into the human body; low energy betas are unable to penetrate the skin. Most beta particles may be stopped by a small thickness of a light material such as aluminium or plastic.

Burnup

Either the percentage of a nuclear fuel that has been 'fissioned', sometimes expressed as megawatt days per tonne (MWD/t), or the percentage change in other materials.

Carbon-14

A naturally occurring radioactive isotope: half-life approximately 5,730 years.



Cerenkov radiation

The emission of light by a charged particle passing through a transparent non-conducting liquid or solid material at a speed greater than the speed of light in that material. The high energy beta particles from spent nuclear fuel immersed in water give rise to blue Cerenkov radiation.

Chain reaction

A process in which one nuclear transformation sets up conditions for a similar nuclear transformation in another nearby atom. Thus, when fission occurs in uranium-235 atoms, neutrons are released, which in turn may produce fission in other uranium-235 atoms.

Containment, reactor

The prevention of release, even under the conditions of a reactor accident, of unacceptable quantities of radioactive material beyond a controlled area. Also, commonly, the containing system itself.

Contamination

Uncontained radioactive material which has been dispersed into unwanted locations.

Control rods

Rods, plates or tubes containing cadmium, hafnium or some other strong absorber of neutrons. They are used to control the rate of the nuclear reaction in a reactor.

Coolant

A fluid circulated through a nuclear reactor to remove or transfer heat generated by the fuel elements. Common coolants are water, air and carbon dioxide.

Core, reactor

That region of a nuclear reactor in which the fuel is located and where the fission chain reaction can take place. The fuel elements in the core of a reactor contain fissile material.

Criticality

A nuclear reactor is critical when the rate of neutrons produced is equal to the rate of neutrons lost and a self-sustaining chain fission reaction can occur.

Critical mass

The smallest mass of fissile material that will support a self-sustaining chain reaction under specified conditions.

Cross-section

A measure of the probability of a particular nuclear reaction occurring between a projectile and a target. The probability is expressed as an area that the target presents. The unit of measurement is the barn: $10^{-28} m^2$.

Curie (Ci)

A measure of radioactivity. Now superseded by the Becquerel: 1 Ci = 3.7×10^{10} Bq.

Cyclotron

A machine to accelerate charged particles to high energies by the application of electromagnetic forces. The accelerated particles may be used to bombard suitable target materials to produce radioisotopes.

Decay, radioactive

The spontaneous radioactive disintegration of an atomic nucleus resulting in the release of energy in the form of particles (for example, alpha or beta), gamma radiation, or a combination of these.

Decommissioning

In relation to a nuclear reactor, its shutdown, dismantling and eventual removal.

Deuterium

Also called 'heavy hydrogen', deuterium is a non-radioactive isotope of hydrogen having one proton and one neutron in the nucleus (that is, an atomic mass of two). It occurs in nature in the proportion of one atom to 6,500 atoms of normal hydrogen. (normal hydrogen atoms contain one proton and no neutrons).

Dose, absorbed

A measure of the amount of energy deposited in a material by ionising radiation. The unit is the joule per kilogram, given the name Gray (Gy).

Dose, equivalent

Equivalent dose is a measure of the biological effect of radiation on a tissue or organ and takes into account the type of radiation. The unit is the sievert (Sv), but doses are usually measured in millisieverts (mSv) or microsieverts (μSv).

Dose, effective

Effective dose is a measure of the biological effect of radiation on the whole body. It takes into account the equivalent dose and the differing radiosensitivities of body tissues. The unit is the sievert (Sv), but doses are usually measured in millisieverts (mSv) or microsieverts (μSv).

Dosimeter (or Dosemeter)

A device used to measure the radiation dose a person receives over a period of time.

Dose limits

The maximum radiation dose, excluding doses from background radiation and medical exposures, that a person may receive over a stated period of time. International recommended limits, adopted by Australia, are that occupationally exposed workers should not exceed 20mSv per year (averaged over five years, no single year to exceed 50mSv), and that members of the public should not receive more than 1mSv per year above background radiation.

Electron

The negatively charged particle that is a common constituent of all atoms. Electrons surround the positively charged nucleus and determine the chemical properties of the atom.

Element

A chemical substance that cannot be divided into simpler substances by chemical means; all atoms of a given element have the same number of protons.

Enrichment, isotope

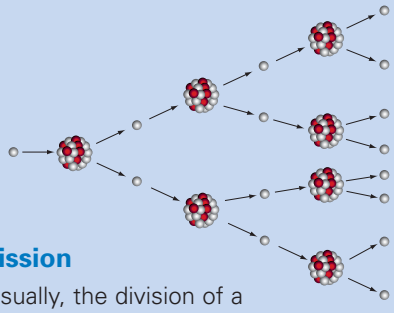
The elevation of the content of a specified isotope in a sample of a particular element (or compound thereof). To be used as fuel for power reactors, uranium usually has to be enriched – the natural isotopic abundance of uranium-235 (~0.71 per cent) has to be increased to about 3 per cent. Material at 20 per cent or greater enrichment is called high enriched uranium (HEU); below 20 per cent is low enriched uranium (LEU). Isotope enrichment processes include gas centrifugation and gaseous diffusion.

Fertile material

A material not itself fissionable by thermal neutrons that can be converted directly or indirectly into a fissile material by neutron capture. There are two basic fertile materials, uranium-238 and thorium-232. When these fertile materials capture neutrons they are converted into fissile plutonium-239 and uranium-233 respectively.

Fissile material

Any material capable of undergoing fission by thermal (or slow) neutrons. For example, uranium-235 and plutonium-239 are fissile nuclides.



Fission

Usually, the division of a heavy nucleus into two unequal masses and the emission of neutrons, gamma radiation, and a great deal of energy.

Fission fragments

The two atoms initially formed from the fission of a heavier atom, such as uranium-235 or plutonium-239. The fission fragments resulting from each fission of uranium-235, for example, are not necessarily the same. Various pairs of atoms can be produced. When initially formed, most fission fragments are radioactive and emit beta particles and gamma rays and decay into other atoms.

Fission products

The collective term for the various fission fragments and their resulting decay products formed after fission of a heavy atom.

Flux, neutron

The number of neutrons that pass through one square centimetre per second.

Fuel cycle, nuclear

The series of steps involved in supplying fuel for nuclear reactors and managing the waste products. It includes the mining, refining and enrichment of uranium, fabrication of fuel elements, their use in a reactor, reprocessing to recover the fissionable material remaining in the spent fuel, possible re-enrichment of the fuel material, possible re-fabrication into more fuel, waste processing and long-term storage.

Fuel rod

A single rod of fissionable material encased in cladding. Fuel rods are assembled into fuel elements.

Glossary of nuclear terms

Fusion
The formation of a heavier nucleus from two lighter ones (such as hydrogen isotopes) with an attendant release of energy (as in a fusion reactor or the sun).

Gamma radiation (γ)
Gamma radiation is short wavelength electromagnetic radiation of the same physical nature as light, X-rays, radio waves etc. However, gamma radiation is highly penetrating and, depending on its energy, may require a considerable thickness of lead or concrete to absorb it. Since gamma radiation causes ionisation it constitutes a biological hazard. High energy gamma rays are commonly used to sterilise medical products.

Graphite, nuclear grade
A form of carbon that can be used as a neutron moderator and reflector in some reactors.

Gray (Gy)
A measure of absorbed dose. Replaces the rad. 1 Gy = 100 rad.

Half-life, radioactive ($t_{1/2}$)
For a single radioactive decay process, the time required for the activity to decrease to half its value by that process. Half-lives vary, according to the isotope, from less than a millionth of a second to more than a billion years.

Half-life, biological
The time required for the amount of a particular substance in a biological system to be reduced to one half of its value by biological processes when the rate of removal is approximately exponential.

Half-life, effective (λ)
The time required for the amount of a particular substance in a biological system to be reduced to one half of its value by the combined effect of biological processes and radioactive decay.

Heavy water (D_2O)
Water containing significantly more than the natural proportion (one in 6,500) of heavy hydrogen (deuterium atoms to normal hydrogen atoms). Heavy water is used as a moderator in some reactors because it effectively slows down neutrons to become thermalised.

Hot cell
A heavily shielded enclosure for handling highly radioactive materials. It may be used for their handling or processing by remote means or for their storage.

Ion
An atom that has lost or gained one or more orbiting electrons, thus becoming electrically charged.

Ionising radiation
Radiation capable of causing ionisation of the matter through which it passes. Ionising radiation may damage living tissue.

Ionisation
Any process by which an atom or molecule gains or loses electrons.

Irradiation
Exposure to any kind of radiation.

Isotopes
Atoms that have the same atomic number but different mass numbers. Different isotopes of the same element have the same chemical properties, but different physical properties.

Light water reactor (LWR)
Reactors that are moderated and cooled by normal water. They account for most of the worlds installed nuclear power generating capacity. Included in this group are pressurised water reactors (PWRs) and boiling water reactors (BWRs).

Mass defect (also mass deficiency)
The amount by which the mass of an atomic nucleus is less than the sum of the masses of its constituent particles.

Mass spectrometer
A device that uses magnetic fields, electric fields, or both to separate and thus analyse the masses of various isotopes in a sample.

Microsievert (μSv)
One millionth of a sievert.

Millisievert (mSv)
One thousandth of a sievert.

Moderator
A material used in a reactor to slow down high speed neutrons, thus increasing the likelihood of further fission. Examples of good moderators include normal water, heavy water, beryllium and graphite.

Monitoring, radiation
The collection and assessment of radiological information to determine the adequacy of radiation protection. Radiation can be monitored usuing equipment such as Geiger counters and scintillation counters.

Megawatt (MW)
Unit of power equal to one million watts. MWth denotes thermal heat output.

Neutron
An uncharged subatomic particle with a mass slightly greater than that of the proton and found in the nucleus of every atom except ordinary hydrogen. Neutrons are the links in a chain reaction in a nuclear reactor.

Neutron activation analysis
A method of analysis based on the identification and measurement of characteristic radiation from radionuclides formed by irradiating a sample of material with neutrons.

Neutron scattering

A technique for 'seeing' fine details of the structure of a substance. It involves firing a beam of neutrons at a sample and observing how they are scattered or diffracted. Most neutrons pass between atoms. Some of the neutrons collide with the nucleus of atoms and may be absorbed while others passing close to the nucleus are deflected by the intense electrostatic forces. Different structures and different atoms create different pathways for the neutrons.

Neutrons, delayed

Neutrons resulting from fission that are emitted by fission products after a significant time delay. They are important in the control of a nuclear reactor.

Neutrons, fast

Neutrons emitted from fission events. They are thousands of times faster than slow neutrons and maintain chain reactions in fast reactors.

Neutrons, thermal or slow

Neutrons travelling with energy comparable to those of everyday atoms, required as links in the chain reactions in thermal reactors.

Nuclear reactor

A structure in which a fission chain reaction can be maintained and controlled. It usually contains fuel, coolant, moderator, control absorbers and safety devices and is most often surrounded by a concrete biological shield to absorb neutron and gamma ray emission.

Nucleus

The positively charged core of an atom. It is about 1/10,000 the diameter of the atom but contains nearly all the atom's mass. All nuclei contain protons and neutrons, except the nucleus of normal hydrogen (atomic mass of one), which consists of a single proton.

Nuclide

A nucleus of a species of atom characterised by its mass number (protons and neutrons), atomic number (protons) and the nuclear energy state.

Particle detector, bubble chamber

An apparatus in which the movement and collision of ionising particles is determined by the examination of trails of gas bubbles that form in the paths of the particles as they move through a superheated liquid.

Particle detector, cloud chamber

A supersaturated vapour chamber in which the path of charged subatomic particles can be detected by the formation of chains of droplets on ions generated by their passage. It is also used to infer the presence of neutral particles and to study certain nuclear reactions.

Plutonium

A heavy radioactive, man-made metallic element. Its most important isotope is fissionable plutonium-239, produced by neutron irradiation of uranium-238. Plutonium-239 is used as a fuel for power reactors or at high concentrations as explosives for nuclear weapons.

Progeny

A nuclide formed in the radioactive decay of a radionuclide (called the parent).

Proton

A subatomic particle with a single positive electrical charge and a mass approximately 1,837 times that of the electron and slightly less than that of a neutron. Also, the nucleus of an ordinary or light hydrogen atom. Protons are constituents of all nuclei. Elements are defined by the number of protons.

Quark

Any of a group of six elementary fundamental matter particles having electric charges of a magnitude one-third or two-thirds that of the electron, regarded as constituents of all hadrons (which include neutrons and protons). Each quark type is called a flavour. Quarks only exist inside hadrons.

Rad

Measure of absorbed dose. Now superseded by the Gray (Gy).

Radiation, nuclear

Radiation originating from the nucleus of an atom. It includes electromagnetic waves (gamma rays) as well as streams of fast-moving charged particles (electrons, protons, mesons, etc) and neutrons of all velocities.

Radioactive material

Any natural or artificial material whether in the solid or liquid form, or in the form of a gas or vapour, that exhibits radioactivity. For regulatory purposes radioactive substances may be defined as any radioactive material that has an activity level of 100 becquerels per gram or greater.

Radioactive waste

Material that contains or is contaminated with radionuclides at concentrations or radioactivity levels greater than clearance levels established by the appropriate authority and for which no use is foreseen.

Radioactive waste, low level

Any waste material that contains quantities of radioactive material above the clearance level (as determined in regulations) that requires minimum standards of protection for personnel when the waste is handled, transported and stored.

Radioactive waste, intermediate

Any waste material that contains quantities of radioactive material above clearance levels, requires shielding and has a thermal power below two kilowatts per cubic metre.

Radioactive waste, high level

Waste which contains large concentrations of both short and long lived radioactive nuclides, and is sufficiently radioactive to require both shielding and cooling. It generates more than two kilowatts of heat per cubic metre.

Glossary of nuclear terms

Radioactivity
The ability of certain nuclides to emit particles, gamma rays or X-rays during their spontaneous decay into other nuclei. The final outcome of radioactive decay is a stable nuclide.

Radioisotope
An isotope that is radioactive. Most natural elements lighter than bismuth are not naturally radioactive. Three natural radioisotopes are radon-222, carbon-14 and potassium-40.

Radionuclide
The nucleus of a radioisotope.

Radiopharmaceutical
A radiopharmaceutical is a molecule that consists of a radioisotope tracer attached to a pharmaceutical. After entering the body, the radio-labelled pharmaceutical will accumulate in a specific organ or tumour. The radiopharmaceutical will spontaneously produce specific amounts of radiation that can be safely used to diagnose or treat diseases, injuries or infections.

Radon
A radioactive element and the heaviest known gas. It is a progeny of radium in the uranium decay series. Radon gives rise to a significant part of the radiation dose from natural background radiation. It emanates from the ground, bricks and concrete.

Rem
Measure of biological effect of radiation (dose). Now superseded by the sievert (Sv): 1 Sv = 100 rems.

Reprocessing
The chemical dissolution of spent fuel to separate unused uranium and plutonium from fission products and other transuranic elements. The recovered uranium and plutonium may then be recycled into new fuel elements.

Sievert
A measurement of equivalent dose and effective dose. Replaces the rem: 1 Sv = 100 rem.

Spent fuel
Nuclear fuel elements in which fission products have built up and the fissile material depleted to a level where a chain reaction does not operate efficiently. Also referred to as irradiated fuel.

Stable isotope
An isotope incapable of spontaneous radioactive decay.

Synchrotron
A cyclotron in which the magnetic field strength and frequency of accelerating voltage increases with the energy of the particles to keep their orbital radius constant.

Synroc
A man-made rock-like ceramic material which can be used to permanently trap high or intermediate level radioactive material or highly toxic non-radioactive waste for long-term storage.

Thermal reactor
A reactor in which the fission chain reaction is sustained primarily by slow or thermal neutrons.

Thorium
A naturally occurring radioactive element. With the absorption of neutrons thorium-232 is converted to the fissionable isotope uranium-233.

TLD
Thermo-luminescent dosimeter. A dosimeter which uses the thermo-luminescent properties of a material to measure the dose of ionising radiation over a period.

Tracer, radioisotope
A radioisotope introduced into a system as a tracking signal, the movement of which can be followed to trace the movement of parts of that system.

Transuranics
Elements with an atomic number above 92. They are produced artificially, for example, when uranium is bombarded with neutrons. Some are therefore present in spent fuel (see also actinides).

Tritium
The isotope of hydrogen of atomic mass of three (hydrogen-3). It is very rare, naturally radioactive, but can be made in a number of ways, including neutron absorption in a) lithium, b) deuterium, or c) heavy water.

Uranium
A radioactive element with two isotopes that are fissile (uranium-235 and uranium-233) and two that are fertile (uranium-238 and uranium-234). Uranium is the basic raw material of nuclear energy.

Uranium, depleted
Uranium having less than the naturally occurring percentage of uranium-235 (~0.71 per cent). As a by-product of enrichment in the fuel cycle it generally has 0.20-0.25 per cent uranium-235, the rest being uranium-238.

Uranium, enriched
Uranium in which the content of the fissile isotope uranium-235 has been increased above the ~0.71 per cent natural content. Enriched uranium with 20-40 per cent of uranium-235 is a fuel for many research and power reactors, whereas higher enriched uranium with over 90 per cent of uranium-235 is a fuel for fast breeder reactors and the explosive in nuclear weapons.

Uranium hexafluoride (UF_6)

A compound of uranium that is a gas above 56°C and is thus a suitable form for processing uranium to enrich it in the fissile isotope uranium-235.

Vitrification

The incorporation of intermediate and high-level radioactive waste into glass for long-term storage.

Whole-body contamination monitor

An assembly for measuring the total gamma radiation emitted from radioactivity on clothing or skin. The monitor uses one or more radiation detectors shielded against natural background radiation.

X-ray

Electromagnetic radiations with wavelengths much shorter than visible light but usually longer than gamma rays.

Yellowcake

The mixture of uranium oxides produced after milling uranium ore from a mine. It is usually represented by the formula U_3O_8. If dried at low temperature it is yellow. If dried at higher temperature it is light brown. Uranium is exported from Australia in this form. Also referred to as Uranium Ore Concentrate (UOC).

Acronyms and abbreviations

AGR Advanced Gas-cooled Reactor

AINSE Australian Institute of Nuclear Science and Engineering

amu Atomic Mass Unit

ANA Australian Nuclear Association

ANSTO Australian Nuclear Science and Technology Organisation

ARI ANSTO Radiopharmaceuticals

ARPANSA Australian Radiation Protection and Nuclear Safety Agency

ARPS Australasian Radiation Protection Society

ASNO Australian Safeguards and Non-proliferation Office

Bq Becquerel

BWR Boiling Water Reactor

Ci Curie

ECCS Emergency Core Cooling System

EIS Environmental Impact Statement

Euratom European Atomic Energy Community

FBR Fast Breeder Reactor

GCR Gas-cooled Reactor

HEU High Enriched Uranium

HIFAR High Flux Australian Reactor

HTR High Temperature Reactor

HWR Heavy Water Reactor

IAEA International Atomic Energy Agency

ICRP International Commission on Radiological Protection

ICRU International Commission on Radiation Units

INES International Nuclear Event Scale

INIS International Nuclear Information System

LEU Low Enriched Uranium

LOCA Loss-of-coolant Accident

LWR Light Water Reactor

mSv Millisievert

μSv Microsievert

MWD/t Megawatt days per tonne

MW Megawatt

NAA Neutron Activation Analysis

NPT Non-proliferation Treaty or Treaty on the Non-proliferation of Nuclear Weapons

OECD NEA Organisation of Economic Cooperation and Development Nuclear Energy Agency

OPAL Open Pool Australian Light water reactor

PET Positron Emission Tomography

PWR Pressurised Water Reactor

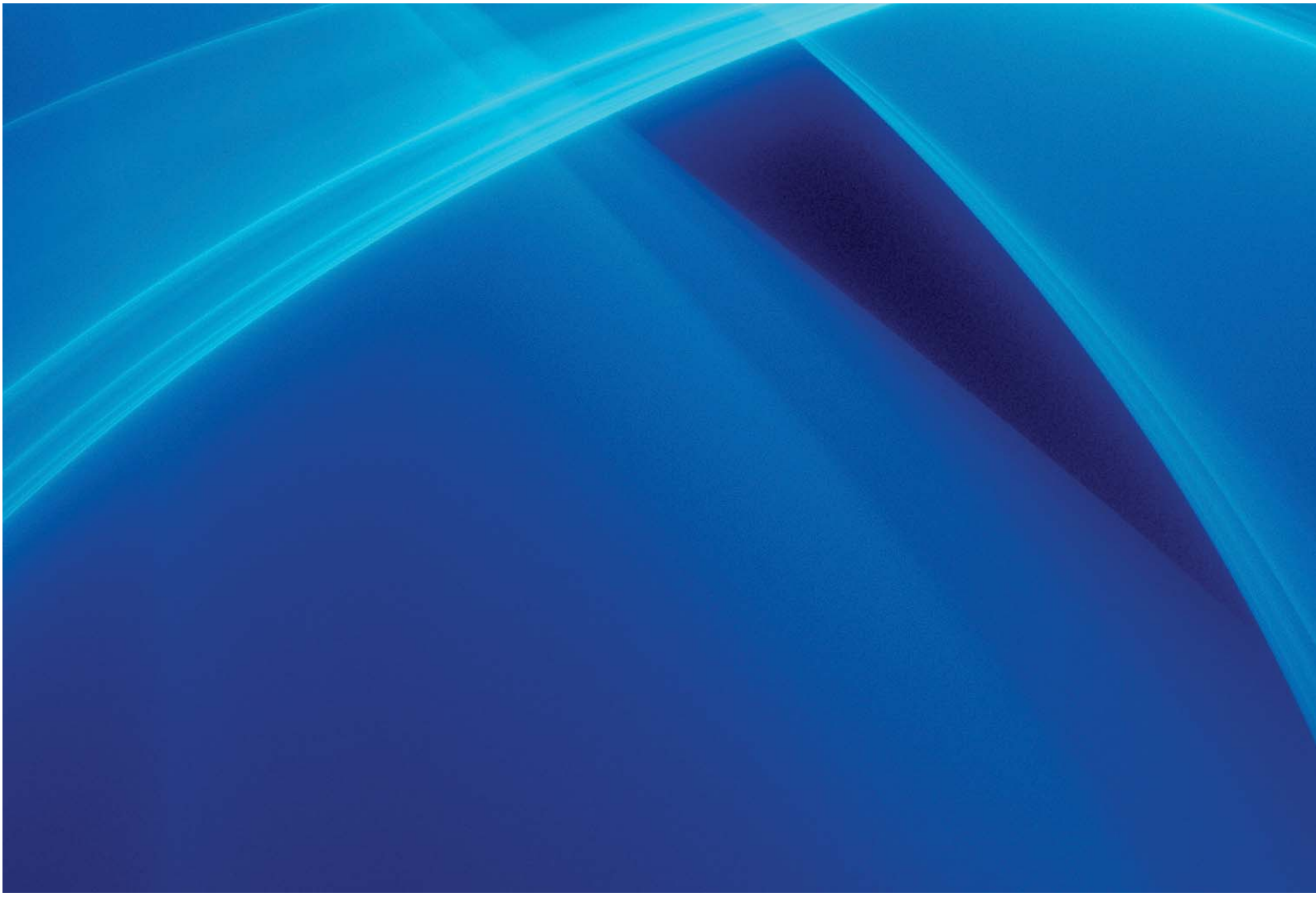
Sv Sievert

SPECT Single Photon Emission Computed Tomography

TLD Thermo-Luminescent Dosimeter

UIC Uranium Information Centre

Z Atomic number



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ANSTO is a Federal Government agency and operates Australia's only nuclear reactor OPAL - used for research and isotope production. ANSTO applies nuclear science in a wide range of areas for the benefit of all Australians.

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