

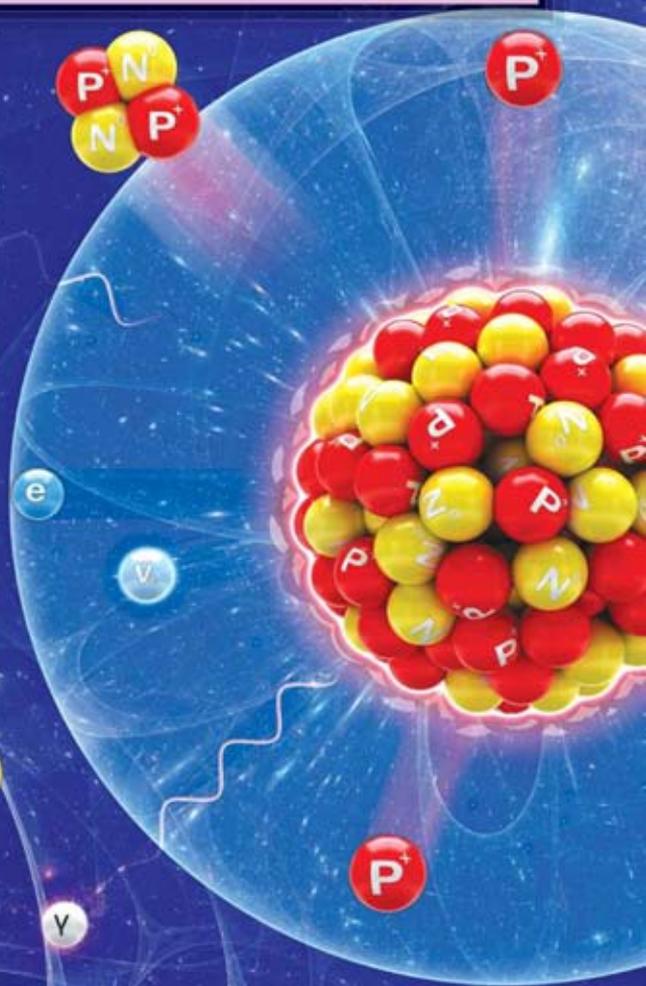
Radioactivity

When was radioactivity first discovered?

What are atom and nucleus?

What are ionising radiation and non-ionising radiation?

What are the uses of radioactive radiation in daily life?



Let's study

- ▶ Discovery of radioactivity
- ▶ Atom and nucleus
- ▶ Ionising radiation and non-ionising radiation
- ▶ Uses of radioactive radiation

Science Gallery



The Sun is the largest radioactive source which is close to Earth. However, many scientific investigations show that the Sun's rays are normal and do not contain any radioactive radiation. Due to this, the Sun is considered a safe radioactive source because no radioactive radiation is released. Is this fact true?

The analysis of gathered data about the coronal mass ejection in the Sun on 6 September 2017 from the astronomical telescope, Fermi, shows that the Sun's rays also contain gamma rays (radioactive radiation). How do we protect ourselves from these gamma rays?

The UV umbrella shown in the photograph below is used to block the ultraviolet rays from the Sun's rays. Can the UV umbrella protect our body from gamma rays as well? Suggest one material to make an umbrella which is able to block gamma rays. Is the material practical? Explain your answer.



UV umbrella (Umbrella that can block ultraviolet rays)

Keywords

- ◆ Radioactivity
- ◆ Radioactive radiation
- ◆ Radioactive substance
- ◆ Radioactive decay
- ◆ Half-life
- ◆ Becquerel (Bq)
- ◆ Curie (Ci)
- ◆ Dalton's Atomic Theory
- ◆ Ionising power
- ◆ Cosmic ray
- ◆ Archaeology
- ◆ Geochronology

8.1

Discovery of Radioactivity

History of Radioactivity

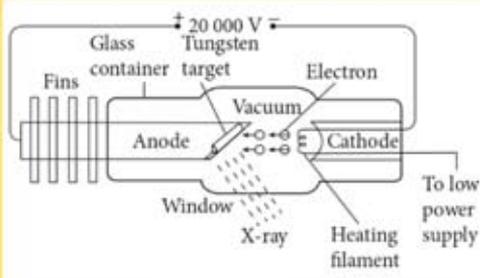
Study Figure 8.1 on the discovery of radioactivity.



Wilhelm Roentgen



Wilhelm Roentgen's X-ray photograph of his wife's hand



X-ray tube

In 1895, **Wilhelm Conrad Roentgen**, a German physicist, discovered X-ray. He had unintentionally taken an X-ray photograph of his wife's hand. This success led Wilhelm Conrad Roentgen to receive the first **Nobel Prize** in Physics in 1901 for the discovery of X-ray.



Science Careers

Various types of careers exist in the field of radioactivity.

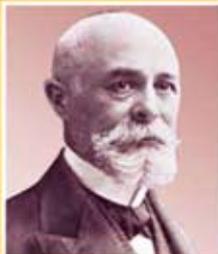
Among them are:

- researcher at Malaysian Nuclear Agency
- nuclear physicist
- nuclear engineer
- nuclear medical specialist



However, Marie Curie died at the age of 67 from a disease caused by prolonged exposure to gamma rays. Since the discovery of radium, the gamma rays emitted by radium have been used in various fields including medicine in cancer treatment.

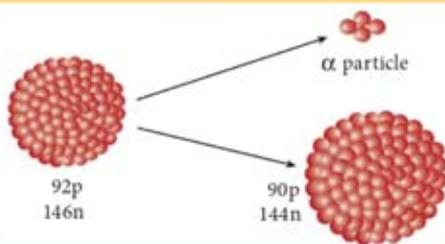
Figure 8.1 The discovery of radioactivity



Henri Becquerel



Blackened photographic plate



Rays emitted from the nucleus of uranium

In 1896, **Antoine Henri Becquerel**, a French physicist, became the first person to successfully discover **radioactivity**. He found a radioactive compound, uranium and unintentionally produced rays that can blacken a photographic plate even in the dark. The rays were detected based on the ionising property. Due to this, Antoine Henri Becquerel received the **Nobel Prize** in Physics in 1903 for the discovery of radioactivity.

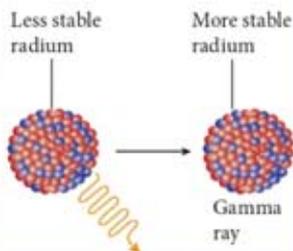


Today in history

After attending a session of the paperwork presentation by Roentgen on 20 January 1896, Becquerel was surprised because his study could not produce the X-ray. Hence, Becquerel replaced the material being studied with uranium compound.



Marie and Pierre Curie with their child



Gamma ray from radium

At the end of 1897, Marie and Pierre Curie, a married couple from Poland, successfully detected radioactive radiation through its ionising power and not through the photographic effect. Beginning with uranium ore which is known as **pitchblende**, they successfully extracted two radioactive elements, **polonium** and **radium**.



SCIENCE INFO

Marie Curie is the only woman who received two Nobel Prizes, the Nobel Prize in Physics in 1903 and the Nobel Prize in Chemistry in 1911.



Today in history

The rays discovered by Becquerel cannot produce X-ray of bones, thus nobody was interested to pursue Becquerel's study for one and a half years! Perhaps this was what attracted the interest of Marie and Pierre Curie.

Radioactivity

Radioactivity is a random and spontaneous decay process of an unstable nucleus by emitting radioactive radiation as shown in Figure 8.2. Radioactive radiation consists of:

- alpha particles (alpha radiation), α
- beta particles (beta radiation), β
- gamma ray, γ

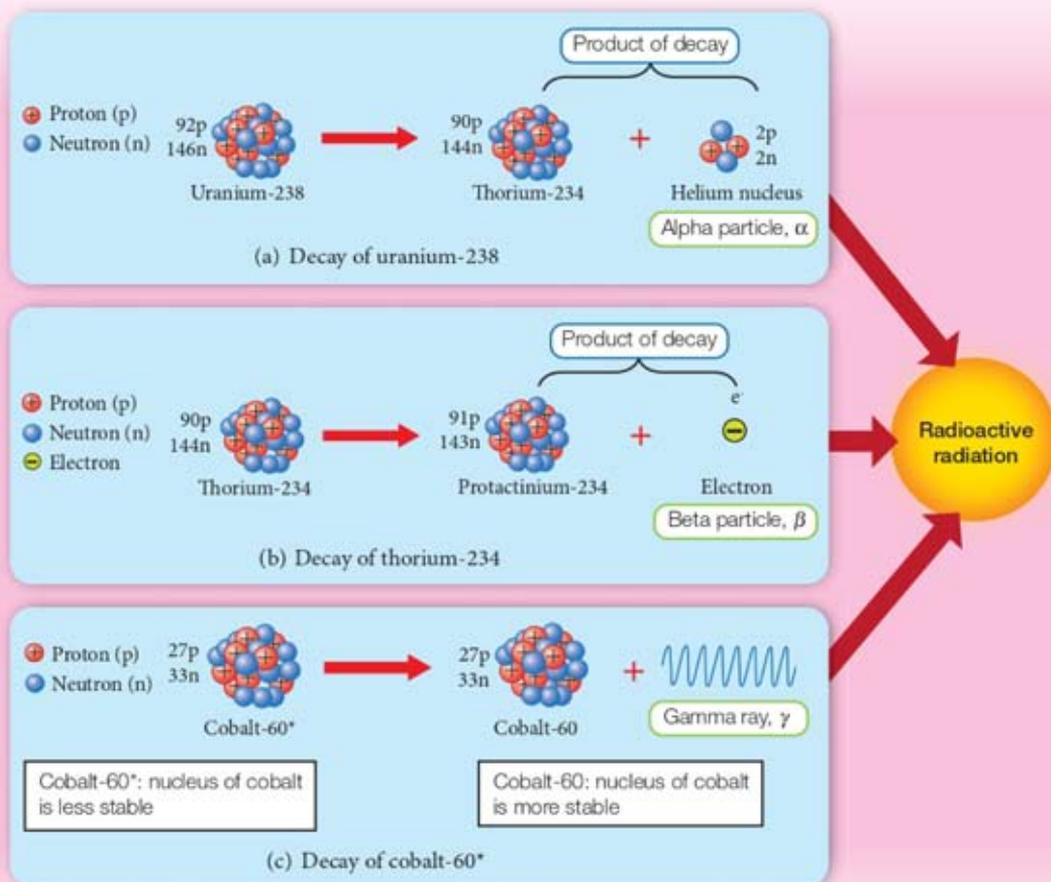


Figure 8.2 Three types of radioactive radiation emitted from the spontaneous decay of nuclei

Radioactive decay is a random and spontaneous process where an unstable nucleus emits radioactive radiation until the nucleus becomes more stable. Examples of radioactive elements that have unstable nuclei and decay spontaneously by emitting radioactive radiation are as follows:

- Carbon-14 (C-14)
- Thorium-234 (Th-234)
- Radon-222 (Rn-222)
- Uranium-238 (U-238)

Units of Radioactivity

The first unit of radioactivity introduced was **curie (Ci)**. The rate of unstable nuclei decay (or **activity** in nuclei decay) is measured in curie. One curie is 3.7×10^{10} decays per second, that is:

$$1 \text{ Ci} = 3.7 \times 10^{10} \text{ decays/s}$$

The S.I. unit of radioactivity is **becquerel (Bq)**. 1 becquerel (Bq) is 1 decay per second, that is:

$$1 \text{ Bq} = 1 \text{ decay/s}$$

SCIENCE INFO

1 Ci is approximately the number of decays per second in 1 g of Radium-226 (Ra-226). Radium-226 is a radioactive substance studied by Marie and Pierre Curie.

BRAIN TEASER

Complete the following:

- (a) $1 \text{ Ci} = \underline{\hspace{2cm}} \text{ Bq}$
 (b) $1 \text{ Bq} = \underline{\hspace{2cm}} \text{ Ci}$

Half-life of Radioactive Decay

Half-life, $T_{\frac{1}{2}}$ is the time taken for the number of undecayed nuclei to be reduced to half of its original number (value). The graphic description of the situation when the number of undecayed nuclei decreases with time is shown in Figure 8.3. What is the S.I. unit for half-life?

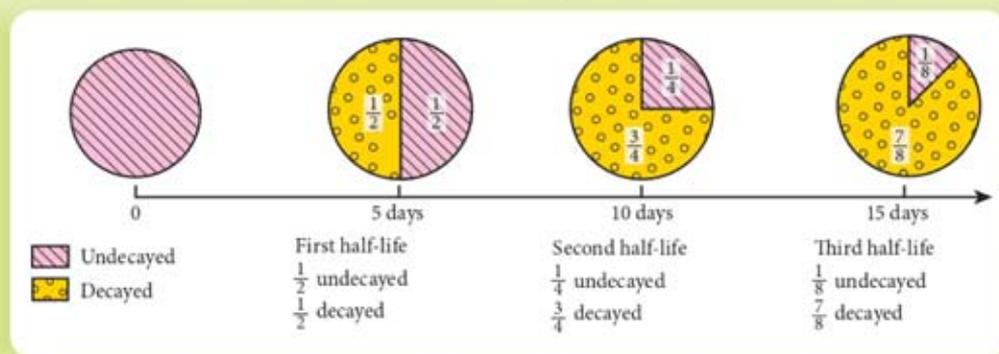


Figure 8.3 Nuclei decay of a radioactive element with half-life of 5 days

Example 1

Protactinium-234 (Pa-234) decays to Uranium-234 (U-234) with half-life, $T_{\frac{1}{2}}$, of 5.2 hours. Calculate the mass of Pa-234 after 20.8 hours with its original mass of 80 g.

Solution

0 hours \longrightarrow 5.2 hours \longrightarrow 10.4 hours \longrightarrow 15.6 hours \longrightarrow 20.8 hours
 80 g \longrightarrow 40 g \longrightarrow 20 g \longrightarrow 10 g \longrightarrow 5 g

Thus, the remaining mass of Pa-234 after 20.8 hours is 5 g.

Example 2

A graph of activity against time for radioactive substance P is shown in Figure 8.4.

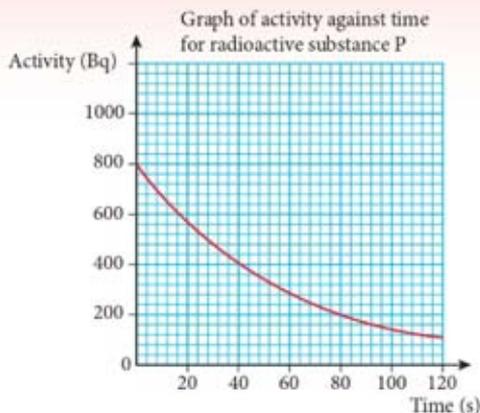


Figure 8.4

Based on the graph, what is the half-life of P?

Solution

Original activity = 800 Bq

$$\begin{aligned}\text{Activity at half-life} &= \frac{1}{2} \times 800 \text{ Bq} \\ &= 400 \text{ Bq}\end{aligned}$$

When the activity is 400 Bq, the corresponding time is 40 s as shown by the dotted line on the graph in Figure 8.5.

Thus, the half-life of P is 40 s.

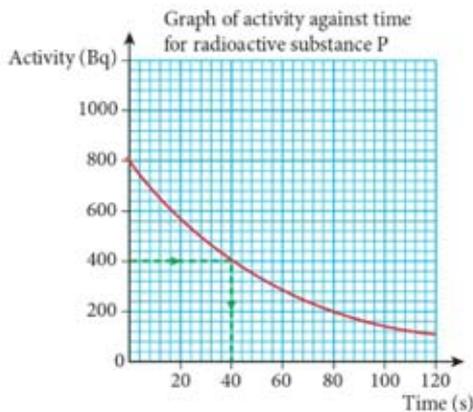


Figure 8.5

Example 3

The activity of radioactive substance Q against time is shown in Table 8.1.

Table 8.1

Time (minutes)	0	5	10	15	20	25
Activity (Bq)	120	80	56	40	28	20

- Draw a graph of activity against time on a piece of graph paper.
- Based on the graph, what is the half-life of Q?

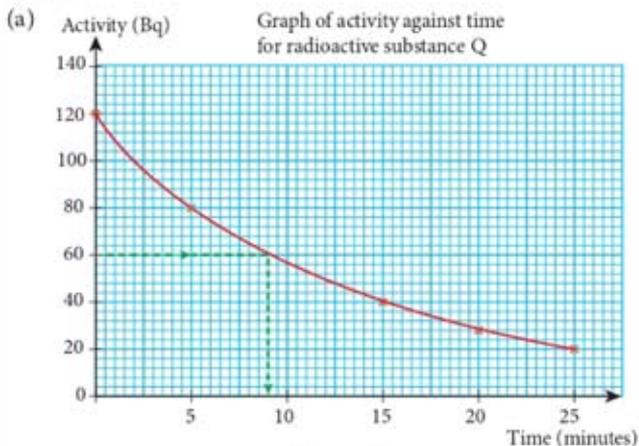
Solution

Figure 8.6

- (b) Original activity = 120 Bq
 Activity at half-life
 $= \frac{1}{2} \times 120 \text{ Bq}$
 $= 60 \text{ Bq}$
 From the graph in Figure 8.6, the half-life of Q is 9 minutes.

Activity 8.1

To gather information on a cloud chamber to view the tracks produced by radioactive substances

Instructions

1. Work in groups.
2. Gather information on the method to build a cloud chamber to view the tracks produced by radioactive substances.
3. Present the findings of your group.

21st Century Skills

- ICS
- Inquiry-based activity

Formative Practice 8.1

1. Name the first person who discovered:
 - (a) the X-ray
 - (b) radioactive radiation
 - (c) gamma rays emitted by radium
2. What is the meaning of radioactivity?
3. (a) Name **two** units of radioactivity.
 (b) What is the quantity measured in radioactivity unit?
4. Give **three** examples of radioactive elements.
5. What is the meaning of half-life?

8.2

Atom and Nucleus

Atoms originate from the word 'atomos' which means indivisible. In 1808, John Dalton, introduced a theory on the structure of atom. According to **Dalton's Atomic Theory**, an atom is the smallest particle and cannot be further divided. However, the development of science has succeeded in finding particles that are even smaller called protons, electrons and neutrons.

Structure of Atom

Recall the three subatomic particles in the structure of an atom that you have learnt in Form 1 as shown in Figure 8.7.

When the number of protons in an atom is the same as the number of its electrons, the atom is **neutral**.

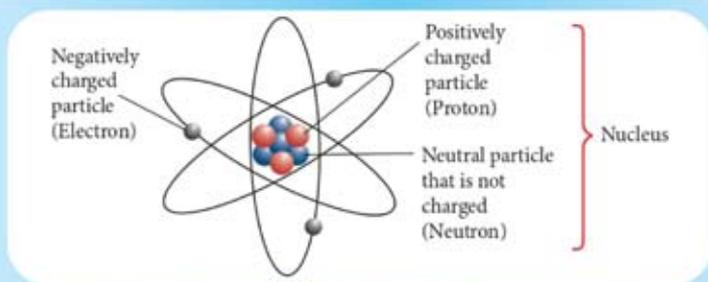


Figure 8.7 Structure of atom

Formation of Positive Ions and Negative Ions

When an atom loses or gains electrons, the atom becomes a charged particle known as **ion**.

Positive Ion (Cation)

An atom that **loses** electrons forms a **positive ion (cation)**.

Example

Table 8.2 Formation of sodium ion, Na^+

Sodium atom, Na				Sodium ion, Na^+		
Subatomic particle	Number	Charge		Subatomic particle	Number	Charge
neutron, n	12	0	loses $1 e^-$ →	neutron, n	12	0
proton, p	11	+11		proton, p	11	+11
electron, e	11	-11		electron, e	10	-10
The charge on sodium atom, Na	0			The charge on sodium ion, Na^+	+1	

Negative Ion (Anion)

An atom that **gains** electrons forms a **negative ion (anion)**.

Example

Table 8.3 Formation of chloride ion, Cl^-

Chlorine atom, Cl				Chloride ion, Cl^-		
Subatomic particle	Number	Charge		Subatomic particle	Number	Charge
neutron, n	18	0	gains 1 e^-	neutron, n	18	0
proton, p	17	+17		proton, p	17	+17
electron, e	17	-17		electron, e	18	-18
The charge on chlorine atom, Cl	0			The charge on chloride ion, Cl^-	-1	



Formative Practice 8.2

- State the property of an atom according to Dalton's Atomic Theory.
- Explain how the following ions are formed.
 - Positive ion
 - Negative ion
- Table 1 shows the number of protons and electrons of particles P, Q, R, S and T.
 - Which particle is a positive ion? Explain your answer.
 - Which particle is a negative ion? Explain your answer.
 - Which particle is neutral? Explain your answer.
- Table 2 shows the formation of an ion.

Table 1

Particle	Number of protons	Number of electrons
P	4	4
Q	12	10
R	17	18
S	29	27
T	35	36

Table 2

Bromine atom, Br				Ion X		
Subatomic particle	Number	Charge		Subatomic particle	Number	Charge
neutron, n	45	0	electron transfer	neutron, n	45	0
proton, p	35	+35		proton, p	35	+35
electron, e	35	-35		electron, e	36	-36
The charge on bromine atom, Br	0			The charge on ion, X	-1	

- How many electrons are lost or gained by the bromine atom in the formation of ion X?
- Explain your answer in 4(a).
- Name ion X that is formed and write its symbol.

8.3

Ionising Radiation and Non-ionising Radiation

Ionising Radiation and Non-ionising Radiation

When a radiation such as radioactive radiation passes through air and produces positive and negative ions, it is known as **ionising radiation** as shown in Figure 8.8.

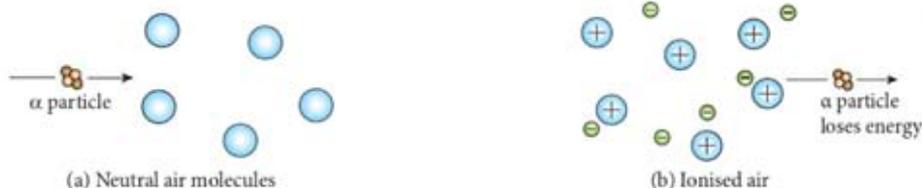


Figure 8.8 Radioactive radiation as ionising radiation

What is the meaning of **non-ionising radiation**? Examples of ionising radiation and non-ionising radiation are shown in Figure 8.9.

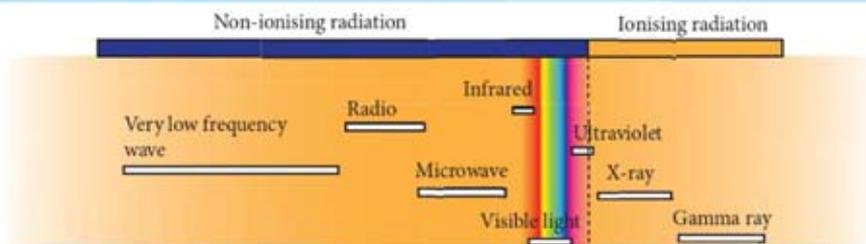


Figure 8.9 Ionising radiation and non-ionising radiation in an electromagnetic spectrum

Let us carry out Activity 8.2 to learn more about ionising radiation, namely alpha radiation, beta radiation, gamma ray and X-ray.

Activity 8.2

Surf the Internet and share information on ionising radiation

Instructions

1. Work in groups.
2. Surf the Internet to gather information on the following ionising radiation:

(a) Alpha radiation, α (alfa particle)	(c) Gamma ray, γ
(b) Beta radiation, β (beta particle)	(d) X-ray
3. Discuss several aspects such as size of particle, ionising power, penetration power, deflection by magnetic field and deflection by electric field.
4. Present the outcome of your group discussion using multimedia presentation.

21st Century Skills

- ICS
- Discussion activity

Types of Ionising Radiation

Three types of radioactive radiation which are ionising radiation are **alpha radiation**, α , **beta radiation**, β and **gamma ray**, γ . Study Table 8.4.

Table 8.4 Differences between the three types of ionising radioactive radiations

Type of radioactive radiation	Alpha radiation, α	Beta radiation, β	Gamma ray, γ
Natural characteristic	Helium nucleus	High speed electron	Electromagnetic wave
Charge of particle	Positive	Negative	Neutral
Ionising power	High	Moderate	Low
Penetration power			
	Low	Moderate	High
Deflection by electric field			
Deflection by magnetic field			

Sources of Ionising Radiation in the Environment

In the environment, sources of ionising radiation are classified as **natural sources of ionising radiation** and **man-made sources of ionising radiation** as shown in Figure 8.10.

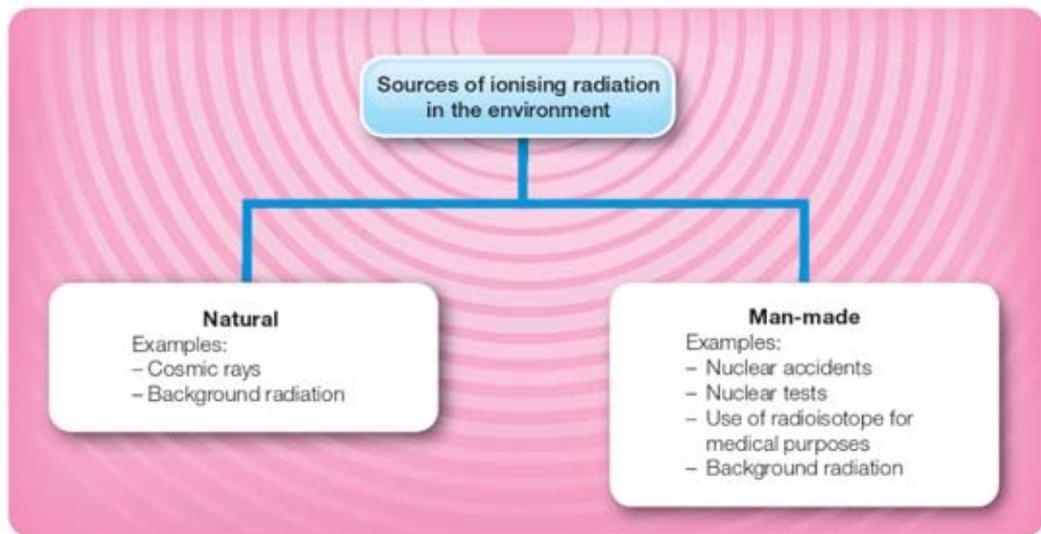


Figure 8.10 Classification of sources of ionising radiation in the environment

Let us carry out Activity 8.3 to detect natural sources of ionising radiation in the environment.

Activity 8.3

To gather information on natural sources of ionising radiation in the environment

Instructions

1. Work in groups.
2. Gather information on natural sources of ionising radiation in the environment.

Gather information on natural sources of ionising radiation in the environment

<http://bt.sasbadi.com/sc3242>



21st Century Skills

- CPS
- Inquiry-based activity

3. Present your group findings.

Cosmic Rays

Cosmic rays are high-energy radiation produced outside the Solar System or from another galaxy. These cosmic rays are also known as galactic cosmic rays.



Photograph 8.1 Cherenkov telescope on Mount Hopkins, United States of America used to detect cosmic rays

Background Radiation

Background radiation is made up of various types of ionising radiation in the environment. Background radiation is released from various sources including natural sources and man-made sources. Sources of background radiation include:

- cosmic rays
- radioactive radiation from natural radioactive substances in the surroundings
- radioactive wastes from nuclear accidents and nuclear tests
- radioisotopes from medical use

Unit of Dose Rate Measurement for Background Radiation

Ionising radiation that is absorbed into the human body will damage body cells. Due to this, the biological effect from ionising radiation on human body is measured in a quantity known as **dose**. A dose of 1 Sv is equivalent to 1 joule of ionising radiation energy that is absorbed by 1 kilogram of living tissue. The unit of background radiation dose that is commonly used is **microSievert/hour ($\mu\text{Sv/h}$)**.



What is the meaning of $1 \mu\text{Sv/h}$?



(a) In the garden



(b) In the school compound

Photograph 8.2 Measuring background radiation using a Geiger counter

Study and compare the readings of the dose rate of background radiation on a Geiger Counter in Photograph 8.2. What is the unit of dose rate measurement for background radiation shown in the readings on the counter?

Safe Background Radiation Dose in Daily Life

Background radiation or ionising radiation dose of **less than $0.2 \mu\text{Sv/h}$** is the **normal level or safe level**. Based on Photograph 8.2, the garden and school compound are safe areas because both areas have background radiation dose of less than $0.2 \mu\text{Sv/h}$.

The estimation of dose rate of ionising radiation from various sources in daily life are shown in Figure 8.11. Identify which sources are safe for an individual.

i SCIENCE INFO

Safe level of background radiation dose is:

- $< 0.2 \mu\text{Sv/h}$
- $< 0.0002 \text{ mSv/h}$
- $< 1\,752 \mu\text{Sv/year}$
- $< 1.752 \text{ mSv/year}$

Websites

Exposure to radiation in daily life



<http://bt.sasbadi.com/sc3244>



Figure 8.11 Estimation of dose rate of ionising radiation

Risks from Exposure to Natural Ionising Radiation

Absorption of ionising radiation by the human body imposes health risks which are affected by the dose of ionising radiation received. Several actions can be taken so that the ionising radiation dose received does not exceed the safe level for the human body as shown in Table 8.5.

Table 8.5 Among the safety measures that need to be taken so that the ionising radiation dose received does not exceed the safe level for the human body

Source of ionising radiation dose received	Safety measures
Background radiation	Use appropriate protective equipment such as spectacles fitted with anti-ultraviolet film, anti-ultraviolet umbrellas and others
Taking X-ray	X-ray taken with doctor's prescription
Television	Ensure the distance between the television and the viewer is at least 2 m.
Food contaminated with radioactive substances	Do not eat food produced in areas contaminated with radioactive substances such as fish from the sea contaminated with radioactive substances.
Cosmic rays	Working hours of a pilot are limited to a certain period of time because the pilot is exposed to cosmic rays.

i SCIENCE INFO

Marie and Irene Curie are the only mother and daughter to have received three Nobel Prizes. Marie Curie received two Nobel Prizes, which are Nobel Prize in Physics in 1903 and Nobel Prize in Chemistry in 1911. Irene Curie, Marie Curie's daughter, received her Noble Prize in Chemistry in 1935. Without realising the risks of being exposed to ionising radiation, they died of cancer caused by excessive exposure to gamma rays during their research.

Activity 8.4

To interpret data on health risks related to the absorption level of ionising radiation by the human body

Instructions

1. Work in groups.
2. Gather information from various sources on the health risks related to the absorption level of ionising radiation by the human body.
3. Discuss the health risks to the human body due to absorption of the following doses of ionising radiation in a year.
 - (a) Doses of 10 Sv.
 - (b) Doses in the range of 1 Sv to 10 Sv.
 - (c) Doses in the range of 0.1 Sv to 1 Sv.
 - (d) Doses of less than 0.1 Sv.
4. Share the outcome of your group discussion in class.

21st Century Skills

- ICS
- Simulation activity

Examples of Absorption of Ionising Radiation Exceeding the Safe Level and Safety Measures that Need to be Taken

As most cosmic rays are absorbed by the atmosphere, the dose of cosmic rays on the surface of Earth is normally at a value of less than $0.2 \mu\text{Sv/h}$, which is a normal or safe level. The higher a person is from the surface of Earth, the stronger the cosmic rays he receives. Name an example of a career that involves working at high altitudes.



Photograph 8.3 Pilots

 **Websites** 

Safety measures for airline crew members who are exposed to cosmic rays.



<http://bt.sasbadi.com/sc3246>

Airline crew members such as pilots (Photograph 8.3), stewards and stewardesses normally receive cosmic ray doses exceeding the safety level. They are exposed to strong cosmic rays in flights at high altitudes. Due to this, their working hours in the sky are limited to a certain period of time.



Formative Practice 8.3

- What is ionising radiation? Give **one** example of ionising radiation.
 - What is non-ionising radiation? Give **one** example of non-ionising radiation.
- Underline the correct answers.
 - The ionising power of beta radiation is (higher/lower) than the ionising power of alpha radiation but (higher/lower) than the ionising power of gamma ray.
 - The penetration power of beta radiation is (higher/lower) than the penetration power of alpha radiation but (higher/lower) than the penetration power of gamma ray.
- State **two** natural sources of ionising radiation.
 - State **three** man-made sources of ionising radiation.
- State the unit of dose rate measurement for background radiation.
 - What is 1 sievert (Sv)?
 - What is considered a safe level of background radiation dose?
- Why does the absorption level of ionising radiation for an individual working in the aviation sector normally exceed the safety level?
- A student watches television for 2 hours every day. Calculate the dose rate of ionising radiation received by the student after 5 days. (Dose rate of ionising radiation from television = 0.01 mSv/h)

8.4 Uses of Radioactive Radiation

Radioactive Radiation in Daily Life

Radioactive radiation such as alpha radiation (α), beta radiation (β) and gamma ray (γ) are used in various fields in daily life as follows:

Archeology and geochronology

Carbon dioxide in the air is made up of carbon-12 (C-12) which is stable and carbon-14 (C-14) which is radioactive. As carbon dioxide is absorbed and released by the body of living organisms, the percentage of C-14 in the tissues of the organisms does not change.

As soon as the organisms die, the amount of C-14 in their tissues begins to decline because they decay by emitting beta radiation with a half-life, $T_{\frac{1}{2}}$, of 5 700 years. By measuring the activity of C-14, the age of the remains can be determined. This method is known as **carbon-14 dating** and is used by archeologists or geochronologists to determine the age of fossil and artifacts.



Photograph 8.4 Dinosaur bones

Monitoring the thickness of metal sheets (Industry)

A thickness control device monitors the thickness of metal sheets in factories. A metal sheet is passed in between a beta radiation source and a beta radiation detector. If the beta radiation detector detects too much beta radiations, this means that the metal sheet is too thin.



Photograph 8.5 Monitoring the thickness of metal sheets

Agriculture

In agriculture, the rate at which beta radiation is emitted during the nuclei decay of phosphorus-32 (P-32) is used to determine the absorption rate of phosphate fertiliser in plants. Radioactive radiation is also used to kill beetles, control the population of pests by sterilisation, determine the best type of phosphate fertiliser, and modify the characteristics of plants.



Figure 8.12 Determining the absorption rate of phosphorus-32 (P-32) fertiliser

Defence

Radioactive substances can be used in the field of defence such as the nuclear bomb. Besides heat, radioactive radiation released from the explosion of a nuclear bomb destroys almost all living things including humans and its effect exists for generations.



Photograph 8.6 Atomic bomb explosion



Today in history

On 20 September 2017, Malaysia signed the ICAN agreement to ban nuclear weapons at a United Nations (UN) Conference.

Food preservation

The Radura logo in Figure 8.13 is used to label food preserved using radioactive radiation such as gamma rays. Gamma rays are used in the preservation of food such as fruits to kill bacteria in the food.



Figure 8.13 Radura logo



Photograph 8.7 Preservation of food using gamma rays

Medical

Gamma rays from caesium-137 (Cs-137) or cobalt-60 (Co-60) are used to kill cancer cells. Radioactive radiation is also used to determine the location of blood clots using sodium-24 (Na-24), treat tumours in the brain using technetium-99 (Tc-99), destroy germs using cobalt-60 (Co-60) and treat thyroid glands using iodine-131 (I-131).



Photograph 8.8 Gamma rays used to treat cancer

Activity 8.5

To carry out a Gallery Walk on the use of radioactive radiation in various fields

Instructions

1. Work in groups.
2. Gather information from the Internet, print media and other electronic media on the use of radioactive radiation in the areas of agriculture, defence, medicine, archeology or geochronology, industry and food preservation.
3. Discuss the following:
 - (a) Types of radioactive radiation used
 - (b) Ways of using radioactive radiation
 - (c) Careers related to the use of radioactive radiation
4. Carry out the gallery walk activity.

21st Century Skills

- ICS
- Technology-based activity
- STEM

Safe and Proper Handling of Radioactive Substances and Radioactive Waste

Safety measures in the handling of radioactive sources and radioactive waste are shown in Figure 8.14.

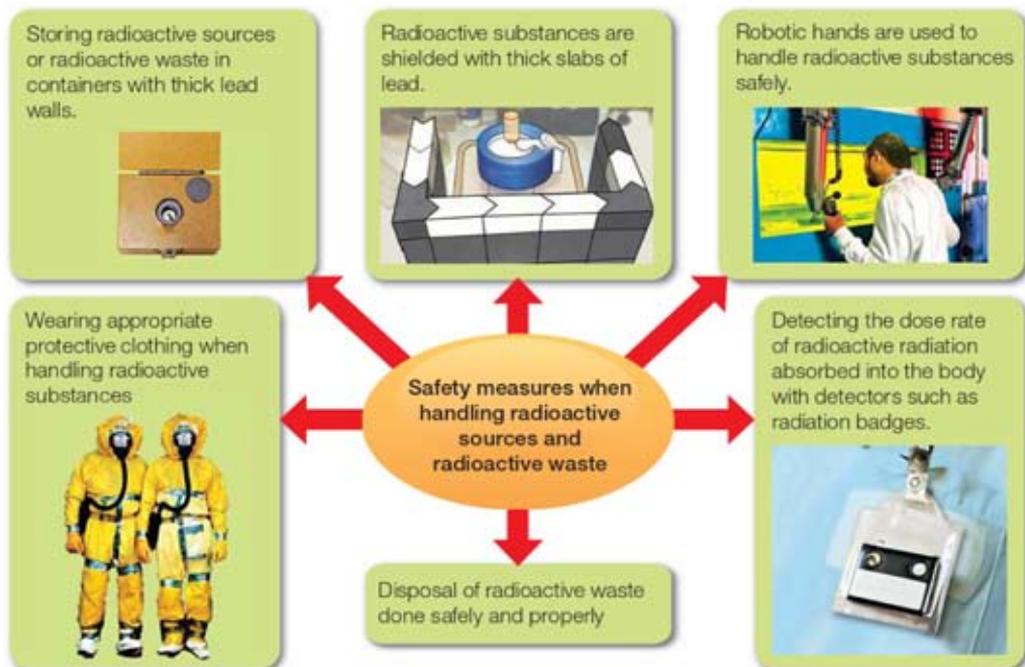


Figure 8.14 Safety measures in the handling of radioactive sources and radioactive waste

Appreciating the Importance of Radioactive Radiation

The importance of radioactive radiation for the well-being of humans makes us grateful to the Almighty for creating radioactive particles that have many uses to sustain life.

The first artificial radioactive element, phosphorus-30 (P-30), was created by Irene Joliot-Curie, the daughter of Marie Curie. Since 1934, many artificial radioactive elements have been produced by scientists. Artificial radioactive elements cannot be produced without the radioactive particles.

 **Websites** 

Handling the disposal of radioactive waste safely and properly



<http://bt.sasbadi.com/sc3250>



Formative Practice 8.4

1. State **one** example of the use of radioactive radiation in the following fields:
 - (a) Archeology and geochronology
 - (b) Medicine
 - (c) Agriculture
 - (d) Defence
 - (e) Industry
2. (a) State the type of radioactive radiation used in the preservation of food.
(b) How can this type of radioactive radiation preserve food?
3. Why are radioactive sources or radioactive waste kept in boxes with thick lead walls?
4. Figure 1 shows a warning symbol.

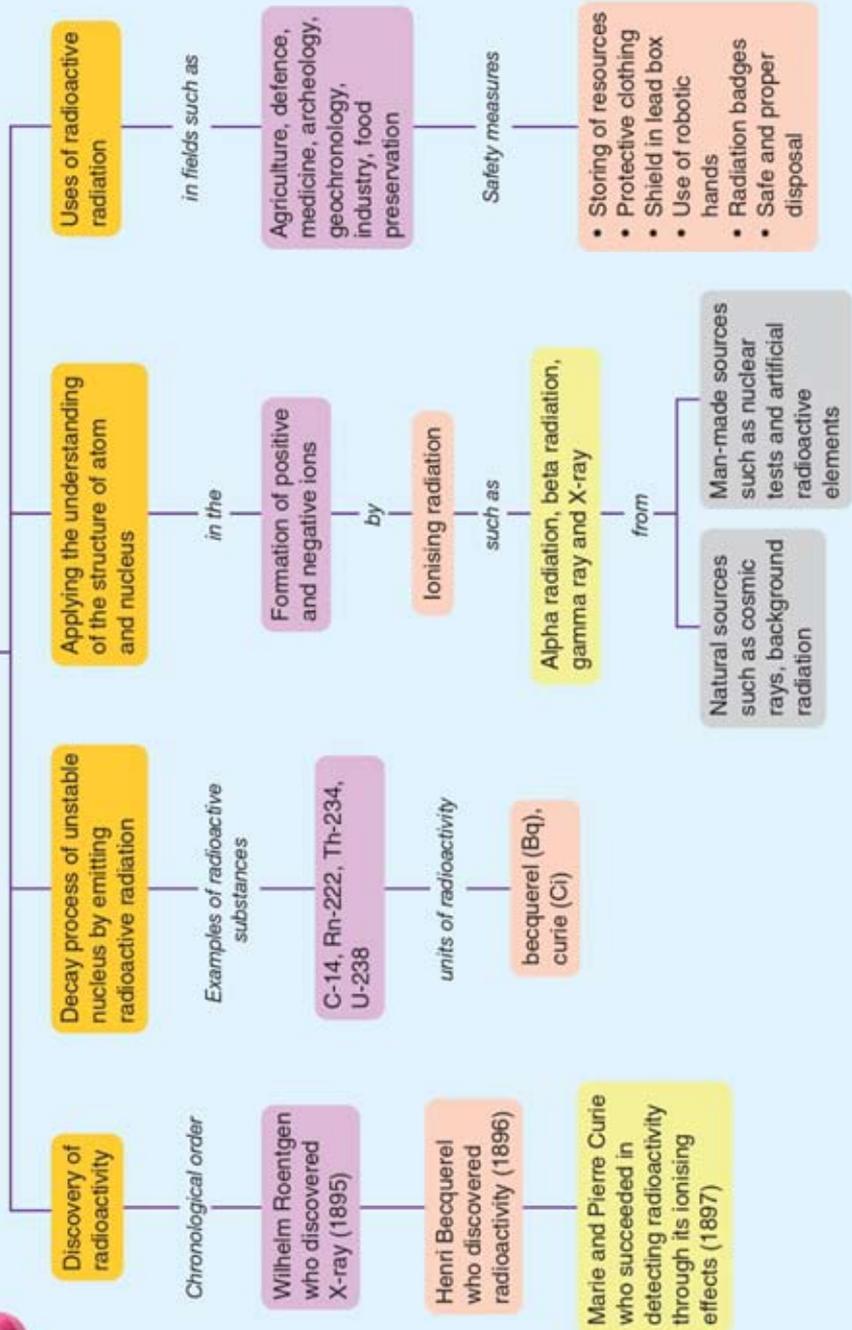


Figure 1

- (a) What is the meaning of the warning symbol shown in Figure 1?
 - (b) Name **one** example of a place or area which displays this warning symbol.
 - (c) Among the three types of radioactive radiations, which is the least dangerous? Explain your answer. 
5. (a) State **one** metal that is used to make appropriate protective clothing to handle radioactive substances.
(b) State **one** advantage and **one** disadvantage of using the metal to make the protective clothing mentioned in 5(a).

Summary

Radioactivity





Self-reflection

After studying this chapter, you are able to:

8.1 Discovery of Radioactivity

- Describe the history of the discovery of radioactivity.
- Explain with examples radioactive substances, radioactivity and the concept of half-life.

8.2 Atom and Nucleus

- Draw an atomic structure in a stable state.
- Explain the formation of positive ions and negative ions.

8.3 Ionising Radiation and Non-ionising Radiation

- Describe ionising radiation and non-ionising radiation.
- Differentiate the three types of ionising radiation in radioactive decay.
- Explain with examples sources of ionising radiation in the environment, natural sources and man-made sources.
- Discuss ways to manage the risks from exposure to natural and man-made ionising radiation.

8.4 Uses of Radioactive Radiation

- Communicate the use of radioactive radiation for well-being.
- Justify the importance of proper handling radioactive substances and radioactive waste.



Summative Practice 8

Answer the following questions:

1. Mark '✓' for the correct statements and '×' for the incorrect statements.
 - (a) Wilhelm Roentgen discovered the X-ray. ()
 - (b) Henri Becquerel used the element radium in his investigations on radioactivity. ()
 - (c) The death of Marie Curie is caused by the exposure to gamma rays. ()
2. What is the meaning of radioactive decay?
3. Name the radioactive substance in the common salt used in the medical field.
4. Pa-234 decays to U-234 by emitting beta radiation. If the half-life of Pa-234 is 5.2 hours, what is the remaining mass of Pa-234 after 20.8 hours given its original mass is 32 g? 

5. Tables 1(a) and 1(b) show the formation of ions.

Magnesium atom, Mg			Magnesium ion, Mg ²⁺		
Subatomic particle	Number	Charge	Subatomic particle	Number	Charge
neutron, n	12	0	neutron, n	12	0
proton, p	12	+12	proton, p	12	+12
electron, e	12	-12	electron, e	10	-10
The charge on magnesium atom, Mg		0	The charge on magnesium ion, Mg ²⁺		+2

loses two electrons →

Fluorine atom, F			Fluoride ion, F ⁻		
Subatomic particle	Number	Charge	Subatomic particle	Number	Charge
neutron, n	10	0	neutron, n	10	0
proton, p	9	+9	proton, p	9	+9
electron, e	9	-9	electron, e	10	-10
The charge on fluorine atom, F		0	The charge on fluorine ion, F ⁻		-1

gains one electron →

- (a) Is the ion formed in Table 1(a) a positive ion or negative ion? Explain your answer.
 (b) Is the ion formed in Table 1(b) a positive ion or negative ion? Explain your answer.

Focus on HOTS

6. (a) State **three** similarities between X-ray and gamma ray.
 (b) Figure 1 shows the condition of two samples of strawberries, X and Y, before and after 7 days.



Figure 1

- Which sample has been preserved? Explain your answer.
- What is the radioactive radiation used to preserve food?
- How can this radioactive radiation preserve food?
- Is food preserved using this radioactive radiation safe to be consumed?
Explain your answer.

7. (a) Figure 2(a) shows an activity that is normally carried out in a laboratory to study radioactive substances.



Figure 2(a)

Based on the activity in Figure 2(a), describe the safety measures taken when handling radioactive substances.

- (b) Figure 2(b) shows an example of the use of beta radiation in an industry. Beta radiation is used to monitor the volume of drink in bottles. Beta radiation is directed towards the passing bottle as shown in Figure 2(b). If the bottle is not filled sufficiently, the beta radiation will pass through the bottle and is then detected by a detector. The circuit attached to the detector then removes the bottle.

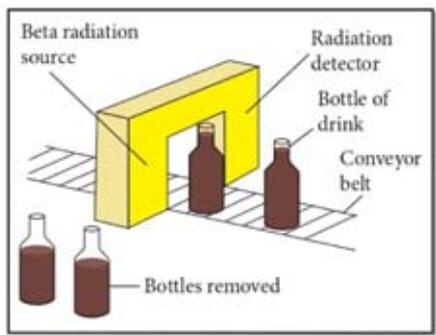


Figure 2(b)

You are required to create a model to show the quality control system that monitors the volume of drink in bottles as shown in Figure 2(b) using the materials below.

- LED
- Empty mineral water bottle
- Newspaper
- Mirror