Unit R071 – How scientific ideas have an impact on our lives

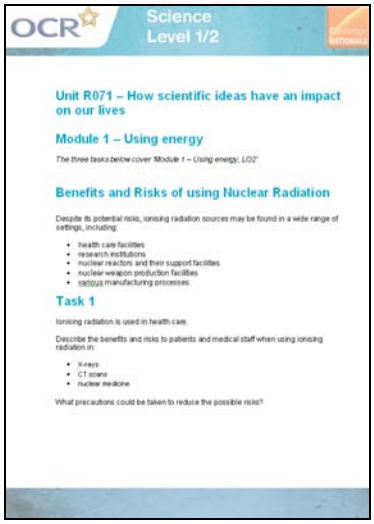
Module 1 – Using energy

Benefits and Risks of using Nuclear Radiation

Instructions and answers for teachers

These instructions should accompany the learner tasks - OCR resource 'Benefits and risks of using nuclear radiation', which supports Cambridge Nationals in Science Level 1/2 Unit R071 – How scientific ideas have an impact on our lives.

The learner tasks cover 'Module 1 – Using energy, LO2'



Associated Files:
Benefits and Risks of using Nuclear Radiation

Expected Duration:
Task 1 approx 60 minutes
Task 2 approx 30 minutes
Task 3 approx 30 minutes

The learner tasks aim to develop research skills and may provide opportunities and grammar. Learners should be encouraged to identify their sources and to reference correctly.

Despite its potential risks, ionising radiation sources may be found in a wide range of settings, including:

- health care facilities
- research institutions
- nuclear reactors and their support facilities
- nuclear weapon production facilities
- various manufacturing processes.

Task 1

Ionising radiation is used in health care.

Describe the benefits and risks to patients and medical staff when using ionising radiation in:

- X-rays
- CT scans
- nuclear medicine

What precautions could be taken to reduce the possible risks?

This is a research task. Below are some examples of possible answers learners may give. These answers are not exhaustive; learners may include alternative or additional answers.

X-Rays	
Benefits	• None invasive medical diagnosis. • Painless. • Very small dose of radiation. • Fast and easy to locate, view, assess bone fractures, sprains, torn muscles, stoppages etc. • Gives a precise diagnosis, so a better chance of recovery. • Portable machine so can be used at primary and secondary medical locations. • No radiation remains in the body.
Risks	• Theoretical risk of triggering cancer, at a later date, although this risk is very small. • Typical radiation doses (the strength of radiation is measured in millisieverts (mSv): o Medical chest X-ray 0.2 mSv. o A year's worth of medical tests 0.4mSv. (Source: NHS Choices, 2012, http://www.nhs.uk/conditions/X-ray/Pages/Introduction.aspx
Precautions	• Ultra-sound used on pregnant women rather than X-ray. • X-ray beam targeted at specific area. • Lead protectors worn. • Operators leave the room during procedure. • Restricted number of X-rays per person per year. • Radiation dose governed by Ionising Radiations Regulations 1999. • Radiation workers – exposed to no more than 20 mSv in any calendar year.

CT scans	
Benefits	• Provide a 3D view of the body. • Fast and accurate and often eliminate the need for invasive surgery. • More detailed images produced than in standard x-rays. • Identifies internal structures, shape, size, density and texture. • Can help determine when surgery is necessary. • Improves cancer diagnosis and treatment. • A guide when treating cardiac disease and stroke etc.

Risks	• Examinations give doses of radiation equivalent to that received from background radiation in three to four years.
	• Typical rradiation doses:
	  ○ CT head scan - 1.4 mSv
	  ○ CT chest scan - 6.6 mSv
	  ○ whole body CT scan -10 mSv.

Precautions	• Scans are not recommended for pregnant women. • Radiation dose governed by Ionising Radiations Regulations 1999.
Nuclear medicine	
Benefits	• Determine whether organs, such as kidney, stomach, lung, are functioning normally. • Very small dose of radiation. • Show adequate blood supply to heart. • Detect cancers at an early stage. • Determine the extent of cancer. • Assess the response of cancer to treatment. • Identify brain abnormalities. • Assess bone density. • Locate a bone fracture before it can be seen on an x-ray.
Risks	• Radiation dose given. • After use, may have radiation in body 1 to 4 days. • Iodine-131 treatment of thyroid cancer might last as long as 3 months.
Precautions	• Following medication, a patient going home should be kept separate for up to four days and movement outside restricted from public. • Pregnant women and small children housed away from patient.

Task 2

Explain how ionising radiation is used in the following industrial applications:

- quality control of materials
- checking welds and flaws in a pipe
- monitoring the thickness or consistency of paper.

This is a research task. Below are some examples of possible answers learners may give. These answers are not exhaustive; learners may include alternative or additional answers.

Industrial applications	**How ionising radiation is used**
Quality control of materials	Devices which monitor industrial processes consist of radiation sources and detectors. When the material between the radioactive source and the detector changes thickness or density, the level of radiation detected also changes. The process can be controlled by weakening or strengthening the signal from the detector.
Checking welds and flaws in a pipe	Radiation is passed through the pipe to be tested and exposes the x-ray film placed behind it. Dark patches in the developed film reveal flaws.
Monitoring the thickness or consistency of paper	Thickness of paper can be tested using a radioactive source. This source emits beta particles. The source is on one side of the paper and the detector (Geiger Muller Tube) is on the other side. The paper rolls between rollers. Some of the radioactivity is absorbed by the paper and some passes through to the detector. The thicker the paper then the less radioactivity passes through it to the detector. The thickness of the paper is controlled by the gap between the rollers - too little radiation then the gap decreases; if too much then the gap increases.

Task 3

The amount (dose) of radiation that our bodies absorb is measured in units called sieverts (usually written as Sv). If you absorbed 1 Sv of radiation all at once, it would be enough to make you ill. In a year, most people absorb about 4 mSv of background radiation. A mSv (millisievert) is one thousandth of a sievert.

What are the symptoms of radiation sickness for different doses of ionising radiation?

This is a research task. Below are some examples of possible answers learners may give. These answers are not exhaustive; learners may include alternative or additional answers.

Dose	Symptoms	Treatment
100 mSv	No acute effects, small additional cancer risk of < 1%. Lowest annual dose at which any increase in cancer is clearly evident.	None required.
400 mSv	Dose causing symptoms of radiation sickness if received in a short time e.g. fatigue, headache, weakness. No noticeable symptoms. Number of erythrocytes or red blood cells may decrease temporarily.	None required.
1 Sv	Causes (temporary) radiation sickness such as nausea and decreased white blood cell count, but not death.	Drugs are available that increase white blood-cell production to counter any damage that may have occurred to the bone marrow, and to reduce the risk of further infections due to immune-system damage. There are also specific drugs that can help to reduce the exposure of internal organs caused by radioactive material by speeding up its removal from the body.
2 Sv	Moderate radiation poisoning Symptoms present 1 to 6 hours after irradiation and last for 1 to 2 days. After that, there is a 7 to 14	Drugs are available that increase white blood-cell production to counter any damage that may have occurred to the bone marrow, and to

	day latent phase, after which the following symptoms appear: loss of hair all over the body, fatigue and general illness. There is a massive loss of white blood cells, increasing the risk of infection. Permanent female sterility is possible. Recovery takes one to several months.	reduce the risk of further infections due to immune-system damage. There are also specific drugs that can help to reduce the exposure of internal organs caused by radioactive material by speeding up its removal from the body.
4 Sv	Severe radiation poisoning, 50% fatality after 30 days. Other symptoms are similar to a 2–3 Sv dose, with uncontrollable bleeding in the mouth, under the skin and in the kidneys after the latent phase.	Drugs are available that increase white blood-cell production to counter any damage that may have occurred to the bone marrow, and to reduce the risk of further infections due to immune-system damage. There are also specific drugs that can help to reduce the exposure of internal organs caused by radioactive material by speeding up its removal from the body.
8 Sv	Very Acute radiation poisoning, near 100% fatality after 14 days. Survival depends on intense medical care. Bone marrow is nearly or completely destroyed. Gastric and intestinal tissue is severely damaged. Symptoms start 15 to 30 minutes after irradiation and last for up to 2 days. Subsequently, there is a 5 to 10 day latent phase, after which the person dies of infection or internal bleeding. Recovery would take several years and probably would never be complete.	Bone marrow transplant is required.

These activities offer an opportunity for English skills development.