Lesson 1

Topic: What is an atom?

Exploring the similarities and difference of atoms

Lesson concepts:

- All matter is made of atoms, which are composed of protons, neutrons and electrons
- Scientific ideas and information can be communicated using scientific language, conventions and representations

Learning alerts

Be aware of students thinking that the charges on protons, neutrons and electrons are similar.

Suggested next steps for learning

- Remind students that electrons are negatively charged, protons are positively charged and neutrons have no charge.

Science prior knowledge notes

In this activity students will recall the subatomic particles.

Lesson notes

In this lesson students will identify the number and type of subatomic particles present in the atoms of different elements. They will also define atomic number and mass number.

Government of South Australia
Department for Education

Science prior knowledge Answers

Is it possible to see atoms?

1. a)

		I am **sure** this is right	I **think** this is right	I **think** this is wrong	I am **sure** this is wrong
A	Atoms can be seen with a school microscope.				✓
B	Atoms can be seen with a powerful microscope				✓
C	Scientists have seen atoms using other equipment			✓	

Recognise that atoms are not visible under any type of microscope and that scientists have never 'seen' the structure of an atom.

b) The eye of the needle

c) The three particles discovered are electrons, protons and neutrons. The electrons have negligible mass and are located in the space around the nucleus. The protons are positively charged, have a mass of 1 u and are in the nucleus. The neutrons have no charge, are the same mass as a proton and are in the nucleus.

2.

Word			Meaning	
1	element	D	**A**	Chemical sciences: the collection of protons and neutrons in the centre of an atom
2	atom	**G**	**B**	a neutral particle in the nucleus of the atom, of approximately the same size and mass as a proton
3	electron	**H**	**C**	the total of the number of protons and neutrons in an atom
4	neutron	**B**	**D**	a substance which cannot be split into simpler substances; atoms with the same number of protons, a pure substance that consists of the same type of particle
5	proton	**F**	**E**	equal to the number of protons in its atom
6	nucleus	**A**	**F**	a positively-charged particle in the nucleus of an atom
7	atomic number	**E**	**G**	the smallest particle of matter that cannot be divided by chemical or physical means
8	mass number	**C**	**H**	a very small negatively-charged subatomic particle that moves rapidly and is located outside the nucleus of an atom

3. **Sheet 2 —** Subatomic particles (see page **7** for answers)

   a) Protons and electrons are oppositely charged. Protons carry a positive charge while electrons carry a negative charge. When these two particles occur in equal numbers in an atom, the positive and negative charges are equalled out, so the atom as a whole has a neutral charge.

4.

Clues	Element
an atomic number of 8	**oxygen**
7 protons and 8 neutrons	**nitrogen**
4 protons, 5 neutrons and 4 electrons	**beryllium**
an atomic number of 20	**calcium**
one proton and one electron	**hydrogen**

Topic: Understanding mass number and isotopes

Learning alerts

Be aware of:

- Students thinking that isotopes of an element are a different element.
- Students thinking that mass number and atomic number are similar.
- Students thinking that the presence of decimals in mass numbers is due to the mass of electrons present.

Suggested next steps for learning

- Explain that the identity of the element depends on the number of protons.
- Explain that atomic number refers to the number of protons only, while mass number includes both protons and neutrons.

Lesson notes

In this lesson students will learn about the important role neutrons play in the nucleus of an atom. They will have the opportunity to do a practical activity where they will model how the mass number of an element is calculated. Students should check they have the required materials and equipment, and conduct a risk assessment before doing this activity.

Science start-up answers

1. a) electron — a very small negatively-charged subatomic particle that moves rapidly and is located outside the nucleus of an atom
   b) proton — a positively-charged particle in the nucleus of an atom
   c) neutron — a neutral particle in the nucleus of the atom, of approximately the same size and mass as a proton
   d) atomic number — equal to the number of protons in the atom
   e) mass number — the total of the number of protons and neutrons in an atom

2. Inside the nucleus you would see 29 protons and 35 neutrons. Moving around the nucleus would be 29 electrons.
3. No response required.

Lesson answers

4. No response required. Make sure that students realise that the atomic number determines which element it is and also shows the number of protons in the nucleus of atoms of that element.

5. a) The mass number is very similar to the mass of each element. This reinforces that the mass of the nuclear particles (protons and neutrons) provides the majority of the mass of the atom.
   b) Personal response required. Differences are due to the various isotopes that can exist — slightly heavier or lighter versions of the atoms of an element.

6. **Sheet 3 —** Calculating average mass number (see page **8** for answers).

7. No response required.

8. **Sheet 4 —** Isotopes and atomic mass (see page **11** for answers).

Lesson 3

Topic: Exploring isotopes

Lesson concepts:

- All matter is made of atoms, which are composed of protons, neutrons and electrons
- Advances in science and emerging sciences and technologies can significantly affect people's lives, including career opportunities
  - » Data can be collected and recorded systematically and accurately using appropriate equipment
  - » The validity of information in secondary sources can be critically analysed and approaches to solving problems can be evaluated.
  - » Scientific ideas and information can be communicated using scientific language, conventions and representations

Learning alerts

Be aware of:

- Students thinking that each atom of the same element contains a different number of protons
- Students thinking that isotopes of an element are a different element.
- Students thinking that atomic number and mass number are similar.

Suggested next steps for learning

- Explain that each atom of the same element contains the same number of protons.
- Remind students that isotopes are atoms with the same number of protons but different numbers of neutrons.
- Remind students that mass number is a measurement of the mass of an atom which is a result of the number of protons and neutrons, while atomic number refers to how many protons an element contains..

Science start-up notes

In this activity, students will recall and consolidate understandings about isotopes.

Lesson notes

In this lesson, students will develop a set of criteria for evaluating secondary sources of information. They will use this criteria to help them evaluate a secondary source of information.

Science prior knowledge answers

1. The atomic number of an element tells you the number of protons each atom of the element has in its nucleus. A neutral atom contains the same number of electrons and protons. Neutrons are uncharged particles found in the nucleus of atoms. Every atom of an element has the same number of protons, but may have different numbers of neutrons. Atoms with different numbers of neutrons but the same number of protons are called isotopes. The atomic mass of an element is an average of the masses of all the isotopes of the element. Hydrogen has three common isotopes: hydrogen-1, hydrogen-2 (also known as deuterium) and hydrogen-3 (also known as tritium). Hydrogen-1 has one proton in its nucleus, hydrogen-2 has one proton and one neutron in its nucleus, hydrogen-3 has one proton and two neutrons in its nucleus.
2. No response required
3. No response required
4. No response required

5. a) For example:

- Carbon-12 is a stable isotope
- Carbon has three natural isotopes: carbon-12, carbon-13, and carbon-14.
- The difference between carbon-12 and carbon-14 is the number of neutrons in each of their atoms.
- Isotopes are variations of an element; the number of protons in each isotope is the same, but the number of neutrons differs.

b) For example:

- Unstable isotopes are atoms that have unstable nuclei. These are radioactive isotopes.
- Unstable Isotopes will degrade through radioactive decay into other types of atoms.
- An unstable isotope emits some kind of radiation, that is it is radioactive. A stable isotope is one that does not emit radiation, or, if it does its half-life is too long to have been measured. It is believed that the stability of the nucleus of an isotope is determined by the ratio of neutrons to protons.

c) For example:

- Carbon-14 is a rare version of carbon with eight neutrons. It is radioactive and decays over time.
- When carbon-14 decays, a neutron turns into a proton and it loses an electron to become nitrogen-14.
- The length of time it will take for half the amount of carbon-14 to decay is known as its half-life.

d) For example:

- Carbon dating measures the ratio of carbon-14 to carbon-12 and uses the known half-life of carbon-14 to estimate the age of organic material.
- Measuring the difference in the ratio between carbon-12 and carbon-14 is useful for dating the age of organic matter since a living organism is exchanging carbon and maintaining a certain ratio of isotopes. In a diseased organism, there is no exchange of carbon, but the carbon-14 that is present undergoes radioactive decay, so over time the change in isotope ratio becomes greater and greater.

6. **Sheet 5 —** Researching the use of an isotope. Answers will vary (see page **12** for example).

Subatomic particles

Instructions

Fill in the table below by looking up these elements on **Sheet 2 —** Periodic table of the elements.

Remember:

- In a neutral atom, the number of protons equals the number of electrons.
- mass number = number of protons + number of neutrons
- The mass of each element is given just below the name. It is measured in u.

element	symbol	atomic number	mass number	mass (u)	protons	neutrons	electrons
aluminium	Al	13	26	**26.98**	**13**	13	**13**
beryllium	Be	4	9	**9.01**	**4**	**5**	**4**
calcium	Ca	**20**	40	**40.08**	20	**20**	**20**
carbon	C	**6**	12	**12.01**	6	**6**	**6**
chlorine	Cl	17	**35**	**35.45**	**17**	18	**17**
hydrogen	H	**1**	**1**	**1.01**	1	0	**1**
neon	Ne	10	**20**	**20.18**	**10**	10	**10**
nitrogen	N	**7**	14	**14.01**	**7**	**7**	7
oxygen	O	8	**16**	**16.00**	**8**	8	**8**
silicon	Si	**14**	28	**28.09**	**14**	**14**	14

Calculating average mass number

Aim	To model the calculation of the mass number of an element. To model how isotopes contribute to the average mass number.
Materials	• 10 balloons containing dried peas or similar (Each balloon should have either 10, 12 or 14 peas. Your 10 balloons should contain a range of numbers of peas.) • Electronic scales, preferably showing two decimal places
Risk assessment	What are the risks? Dropping balloons/peas How can you manage these risks? Clean up all spills immediately
Method	1. Use the electronic scales to weigh the first balloon. Record the mass to two decimal places. 2. Repeat for each of the remaining balloons.
Data collection	Masses of baloons Answers will vary depending on objects used

Balloon	Mass (g)
1	
2	
3	
4	
5	
6	
7	
8	
9	
10	

Analysis of results and observations	Calculate the average mass of the balloons. Remember: $\text{Average mass} = \frac{\text{Total mass of all balloons}}{\text{Number of balloons}}$ Average should be based on student data and may reflect more than two decimal places.
Discussion	What is the average mass of a balloon in your sample? Answers will vary based on student data. Does every balloon have the average mass? Explain your answer. Not every balloon will have the average mass. Some will be heavier and some lighter. (The different number of peas represents differences in the number of neutrons — so consequently there are isotopes.)

Take it further – Applying averages to atomic masses	A chemist determined the mass of some carbon atoms and recorded the results below.

Sample number	Mass (atomic mass units)	Sample number	Mass (atomic mass units)
1)	12	6)	12
2)	12	7)	13
3)	14	8)	12
4)	12	9)	12
5)	13	10)	12

Calculate the average mass of a carbon atom.

Average mass = $\frac{\text{Sum of all masses}}{\text{Number of atoms}} = \frac{123}{10} = 12.3$ u

The atomic number of carbon is 6. How many protons and electrons must an atom of carbon contain?

Six protons and six electrons.

If an atom of carbon has a mass number of 12, how many protons and neutrons would it contain?

Six protons and six electrons.

If an atom of carbon has a mass number of 13, how many protons and neutrons would it contain?

Six protons and seven neutrons.

If an atom of carbon has a mass number of 14, how many protons and neutrons would it contain?

Six protons and eight neutrons.

Take it further – Applying averages to atomic masses

Consider the table above. Explain why atoms 3, 4 and 5 are all carbon atoms. (They are considered isotopes of carbon.)

Atoms 3, 4, and 5 all contain six protons. Any atom with six protons is an atom of carbon.

Another atom has seven protons and six neutrons. Is it a carbon isotope?

Explain your answer.

No, even though it has the same atomic mass as carbon-13, it has seven protons so it is a nitrogen atom.

Why do atoms 3, 4 and 5 have different masses?

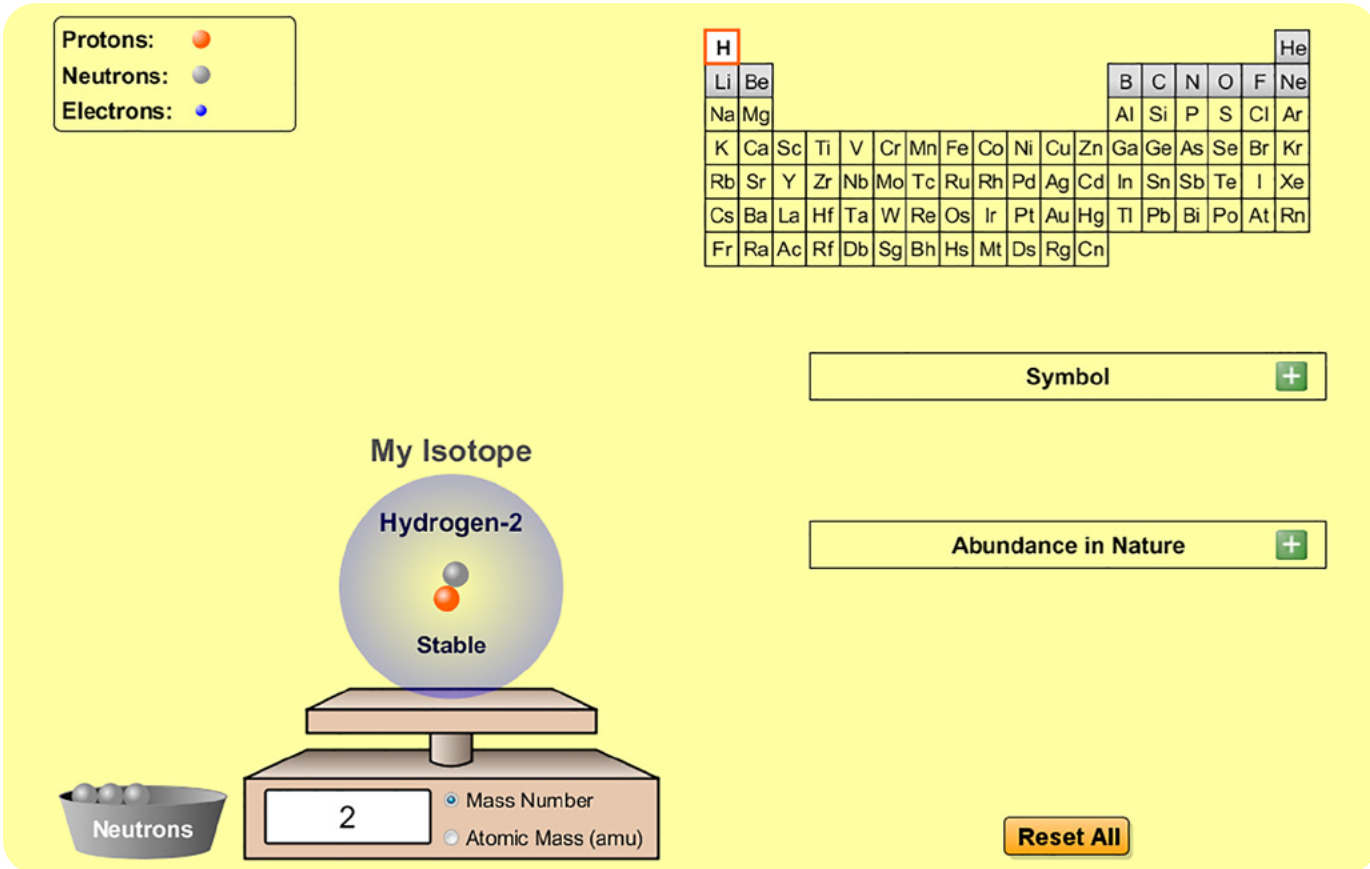
Atoms 3, 4 and 5 have different masses because they have different numbers of neutrons.

Isotopes and atomic mass

How to use the **Learning object** — Isotopes and atomic mass

Observe the number of subatomic particles the isotope contains.

Use your mouse to move the neutrons from this container into the atom's nucleus.



Select an element from the first two rows of the periodic table.

Select this icon to see the isotope's symbol.

Select this icon to see the isotope's abundance in nature.

If you make an isotope that is not stable, the nucleus shakes and the word 'Unstable' appears under the nucleus.

Activity

Use the **Learning object —** Isotopes and atomic mass to help you fill in the table below.

Isotope	Number of protons	Number of neutrons	Number of electrons	Is the nucleus stable? (Yes or No)	Symbol	Abundance in nature
hydrogen-3	1	2	1	YES NO ✓	$^{3}_{1}H$	very small
helium-3	2	1	2	YES ✓ NO	$^{3}_{2}He$	0.0001%
helium-4	2	2	2	YES ✓ NO	$^{4}_{2}He$	99.9999%
carbon-12	6	6	6	YES ✓ NO	$^{12}_{6}C$	98.93%
carbon-14	6	8	6	YES NO ✓	$^{14}_{6}C$	very small
carbon-11	6	5	6	YES NO ✓	$^{11}_{6}C$	0%

Researching the use of an isotope

Answer will depend on the isotope the student selected.

Part A — Researching an isotope

Select an isotope and research its uses.

Example: Chromium-51

Part B — Evaluating secondary sources of information

Evaluate a secondary source of information using your own checklist.

Example:

Checklist for evaluating secondary sources of information
Title and author (for example: of website or book) Professor Peter Doherty, immunologist (Australian Academy of Science — *Promoting excellence in Australian science*)
URL or access information https://www.science.org.au/node/335503
Date accessed 15 January 2016

Number	Criteria	Question	Evaluation
1	**credibility** (trustworthiness)	**Who** wrote the information? Is the author a scientist or expert in the topic? Does the work appear to be fair and impartial (not trying to persuade one type of view)?	The author, scientist Professor Peter Doherty, is a Nobel prize winner providing information on his particular area of study — the immune system.
2	**relevance** (connected to the topic)	**What** information is provided? Does the information relate to the topic? Does the information help my research? **Why** would I use this information?	The information is related to the topic but not specific to what I need to find out. I need to find more details about isotopes.
3	**reliability** (consistency with other sources) and **accuracy** (correctness)	**Where** has the information come from? Does the information presented in this source agree with other sources of information? Is the information from a recognised source? (Website URL endings: .gov, .edu, .org)	The information is on the University of Melbourne website. The information is credible if it is published here. The paper would be reviewed by other scientists (peerreviewed).

Number	Criteria	Question	Evaluation
4	**currency** (up-to-date)	**When** was the source created? Is the information current and up-to-date?	This page was modified in Jan 2016, which is current for the time I reviewed the website.
5	**readability**	Does the source provide information that I can understand? Can I make sense of the technical terms? Can I paraphrase the information to show my understanding?	There are many terms which are unfamiliar, so the source is not very useful because I have to look up the meanings and try to work out what is being said.

Evaluation:

The website was useful for some information as it was written by a credible author without bias and published on a respected university website. The information was up-to-date. Some information was relevant for my project but it was difficult to understand because of all the technical terms used.