Answers Matter

Year 9 Science Chapter 4

p78

1 All matter such as solids, liquids, and gases, is made up of atoms. **Atoms** are considered the building blocks of matter.

2 **An atom** has a nucleus, made of protons and neutrons.

3 The atom is surrounded by fast orbiting negative electrons.

4 The proton has a small positive nucleus.

5 Neutrons have no electrical charge.

6 True. Almost all of an atom is empty space.

7 The nucleus is only around a trillionth of the volume of the atom.

What is a trillionth? A trillion can be 1 000 000 000 000 or 1 000 000 000 000 000 000

A trillionth is then 1/1 000 000 000 000 ($1x10^{12}$) or 1/1 000 000 000 000 000 000 ($1x10^{18}$)

Can you give a practical example of a trillionth?

A pile of 1 trillion ($1x10^{12}$) five dollar notes would be about 110 000 kilometres high.

One of the five dollar notes would then be one trillionth the height of the pile.

p80

1 An atom has an atomic number of 9. The atom has 9 protons and 9 electrons.

2 An atom has an atomic number of 15 and an atomic mass number of 31. The atom has 15 protons, 15 electrons, 31-15 = 16 neutrons.

3 A sketch of the oxygen atom.

Oxygen

Atomic number = 8

Number of protons = 8

Number of electrons = 8

Atomic mass number = 16

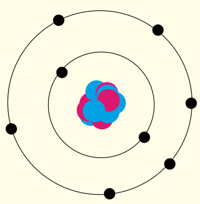
Number of neutrons = 16 -86 = 8

Electron shells (2 - 8 - 18)

8 electrons thus: 2 electrons first shell

6 electrons second shell

16
O
Oxygen
8



p80

4 Draw a sketch of the potassium atom.

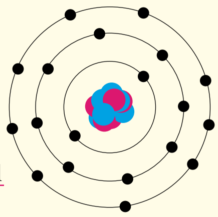
Potassium

39
K
Potassium
19

Atomic number = 19
Number of protons = 19
Number of electrons = 19

Atomic mass number = 39
Number of neutrons = 39 - 19 = 20

Electron shells (2 - 8 - 18)
19 electrons thus: 2 electrons first shell
8 electrons second shell
9 electrons third shell



5 Draw a sketch of the magnesium atom.

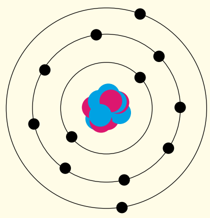
Magnesium

24
Mg
Magnesium
12

Atomic number = 12
Number of protons = 12
Number of electrons = 12

Atomic mass number = 24
Number of neutrons = 24 - 12 = 12

Electron shells (2 - 8 - 18)
12 electrons thus: 2 electrons first shell
8 electrons second shell
2 electrons third shell



6 Draw a sketch of the neon atom.

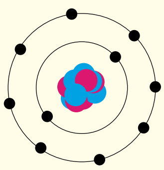
Neon

20
Ne
Neon
10

Atomic number = 10
Number of protons = 10
Number of electrons = 10

Atomic mass number = 20
Number of neutrons = 20 - 10 = 10

Electron shells (2 - 8 - 18)
10 electrons thus: 2 electrons first shell
8 electrons second shell



p81

1 One mole of a substance (the atomic mass number in grams) contains: **6.02214154 x 10^{23} atoms**. This number is **Avagadro's Number** (Sometimes rounded to 6.02 x 10^{23}).

2 One mole of a substance is the atomic mass number in grams.

3 One mole of carbon has **6.02 x 10^{23} atoms**.

4 One mole of helium has **6.02 x 10^{23} atoms**.

5 How many atoms in 23 grams of sodium?

> **Calcium**
> 1 mole of calcium = 423grams
> 23 grams of boron will have:
> = 602,000,000,000,000,000,000,000 atoms
> = 6.02 x 10^{23} atoms
>
> 23
> Na
> Sodium
> 11

6 How many atoms in 40 grams of calcium?

> **Calcium**
> 1 mole of calcium = 40 grams
> 40 grams of boron will have:
> = 602,000,000,000,000,000,000,000 atoms
> = 6.02 x 10^{23} atoms
>
> 40
> Ca
> Calcium
> 20

7 Most uranium atoms have an atomic mass number of 238 (^{238}U) and a few uranium atoms have an atomic mass number of 235 (^{235}U). Guess the atomic mass number of uranium (^{238}U and ^{235}U together).

If most uranium atoms have an atomic mass number of 238 (^{238}U) and a few uranium atoms have an atomic mass number of 235 (^{235}U). Then the atomic mass number of uranium (^{238}U and ^{235}U together would be a little under 238, possibly 237.8.

p83

1 **Isotopes** are different atoms of the same element. **Isotopes** are atoms with the same number of protons but **a different number of neutrons**. For example, **Neon has three isotopes**: ^{20}Ne, ^{21}Ne, ^{22}Ne.

2 Chlorine has two isotopes: ^{35}Cl, ^{37}Cl

a) ^{35}Cl has 17 electrons, 17 protons, and 35-17 = 18 neutrons

b) ^{37}Cl has 17 electrons, 17 protons, and 37-17 = 20 neutrons

> 35 Cl Chlorine 17
>
> 37 Cl Chlorine 17

3 Neon has three isotopes: ^{20}Ne, ^{21}Ne, ^{22}Ne
How many electrons, protons, and neutrons in each of:

a) ^{20}Ne has 10 electrons, 10 protons, and 20-10 = 10 neutrons
b) ^{21}Ne has 10 electrons, 10 protons, and 21-10 = 11 neutrons
c) ^{22}Ne has 10 electrons, 10 protons, and 22-10 = 12 neutrons

> 20 Ne Neon 10
>
> 21 Ne Neon 10
>
> 22 Ne Neon 10

4 Find the number of electrons, protons, and the average number of neutrons in an atom of:

a) Boron has 5 electrons, 5 protons, and an average of 10.81-5 = 5.81 neutrons
b) Calcium has 20 electrons, 20 protons, and an average of 40.078-20 = 20.078 neutrons
c) Argon has 18 electrons, 18 protons, and an average of 39.948-18= 21.948 neutrons

5 How many atoms in a mole of:

a) One mole of Boron has **6.02 x 10^{23} atoms**.
b) One mole of Calcium has **6.02 x 10^{23} atoms**.
c) One mole of Argon has **6.02 x 10^{23} atoms**.

> 10.810 B Boron 5
>
> 40.078 Ca Calcium 20
>
> 39.948 Ar Argon 18

p84

1 Electrons have a negative charge.

2 Neutrons and protons are found in the nucleus of the atom.

3

Subatomic particle	Proton	Electron
Location in the atom	Nucleus	Electron cloud around the nucleus
Relative charge	+1 positive	1 negative
Relative mass	1800	1

4

Subatomic particle	Proton	Neutron
Location in the atom	Nucleus	Nucleus
Relative charge	+1 positive	0 no charge
Relative mass	1800	1800

5 A 50 cent coin (3 cm diameter and mass of 16 grams) is used to model the nucleus of a hydrogen atom.

An electron model would need to be about 1/1800 th the mass of the 50 cent coin (About 16/1800 = 0.009 grams = 9 milligrams). The diameter of the hydrogen atom is about 10,000 times the size of the nucleus (About 10,000x3cm = 300m). The electron model would have a mass of about 9 milligrams and be placed about 300m from the 50 cent coin. A bread grain?

p85

1 It is theorised that protons and neutrons can be broken up into fundamental particles called 'quarks'.

Quark	Symbol	Charge
Up	u	$+\frac{2}{3}$
Down	d	$-\frac{1}{3}$
Strange	s	$-\frac{1}{3}$
Charm	c	$+\frac{2}{3}$
Bottom	b	$-\frac{1}{3}$
Top	t	$+\frac{2}{3}$

2 Protons (charge of +1) are made up of three quarks: one down quark and two up quarks.

one down quark + two up quarks = $-\frac{1}{3} + 2\times+\frac{2}{3} = -\frac{1}{3} + 4/3 = 3/3 = 1$

3 Neutrons (0 charge) are made up of three quarks: one up quark and two down quarks. Is the sum of the charges on these three quarks equal to 0?

one up quark + two down quarks = $+\frac{2}{3} + 2\times -\frac{1}{3} = +\frac{2}{3} + -\frac{2}{3} = 0$

p87

1 Radioactive decay happens when an unstable nucleus breaks apart.

2 Some examples of substances with an unstable nucleus and can undergo radioactive decay are:

Uranium-235 (^{235}U), Uranium-238 (^{238}U), Carbon-14 (^{14}C), Iodine-131 (^{131}I)
Cobalt-60 (^{60}Co), Plutonium-239 (^{239}Pu), Lead-210 (^{210}Pb)

3 As the nucleus breaks apart, it can release three types of radiation:

Alpha radiation (α), Beta radiation (β), Gamma radiation (γ)

4 The first five letters of the Greek alphabet. are: Alpha, Beta, Gamma, Delta, Epsilo

5 Alpha particles consist of two protons and two neutrons and don't have any electrons.

6 Alpha particles tend to be safe because they quickly lose their energy, pick up free electrons and become stable helium atoms. Alpha particles are unable to penetrate the outer layers of skin or even a sheet of paper.

7 Copy and complete each of the following radioactive decay equations:

a) Uranium-238 ➔ Thorium-238 + Alpha particle

$$^{238}_{92}U \rightarrow {}^{234}_{90}Th + {}^{4}_{2}He$$

b) Radium-222 ➔ Polonium-218 + Alpha particle

$$^{222}_{86}Ra \rightarrow {}^{218}_{84}Po + {}^{4}_{2}He$$

c) $$^{208}_{84}Po \rightarrow {}^{204}_{82}Pb + {}^{4}_{2}He$$

p89

1 As the nucleus breaks apart, it can release three types of radiation:
Alpha radiation (α), Beta radiation (β), Gamma radiation (γ)

2 A **beta particle**, identical to an electron, is small, with a negative charge, and can travel with a speed in the air of up to 270,000,000 metres per second (2.7×10^8 m/s). Beta particles can travel several metres in air and are stopped by thin layers of plastic or metal.

3 Copy and complete each of the following radioactive equations:

a) $^{214}_{82}Pb \rightarrow {}^{214}_{83}Bi + {}^{0}_{-1}e$

b) $^{90}_{38}Sr \rightarrow {}^{90}_{39}Y + {}^{0}_{-1}e$

c) $^{247}_{95}Am \rightarrow {}^{247}_{96}Cm + {}^{0}_{-1}e$

4 While alpha radiation or beta radiation is happening, the nucleus may rearrange itself from a high energy state to a lower energy state and emit **gamma rays**. Gamma rays are similar to light rays, and X-rays. The emission of gamma rays doesn't change the number of protons or neutrons in the nucleus.

5 A half-life is used to describe the rate of radioactive decay. The **half-life** is the time taken for half of the radioactive isotope to decay.

6 The radioactive isotope erbium-160 has a half-life of 10 hours.

^{160}Er	Time	Amount
	0 hrs	0.08 grams
	10 hrs	0.04 grams
	20 hrs	0.02 grams

p90

1 Carbon-14 dating is used to calculate the age of organic material up to 50,000 years old. Carbon-14 dating has been used to decide the age of organic material such as bone, wood, and cloth.

2 The half-life of carbon-14 is 5,730 ± 40 years.

3 A fossil is found to have 50% of its original carbon-14. The fossil is 5,730 ± 40 years old.

4 A fossil is found to have 20% of its original carbon-14. How old is the fossil?

From the graph on p90: 20% on the vertical axis matches with roughly 13000 on the horizontal axis. The fossil is approx. 13,000 years old.

5 A fossil is found to have 60% of its original carbon-14. How old is the fossil?

From the graph on p90: 60% on the vertical axis matches with roughly 5000 on the horizontal axis. The fossil is approx. 5,000 years old.

6 Would carbon-14 be useful for dating fossils suspected of being more than 200,000 years old?

Carbon-14, with a half-life of about 5,700 years, would have too small a half-life to date 200,000 year old fossils. There would be virtually no Carbon-14 left after 200,000 years. A radioactive material with a half-life somewhere around 50,000 to 100,000 years may be more suitable.

p91

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p94

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6 True. Almost all of an atom is empty space.

7 The nucleus is only around a trillionth of the volume of the atom.

What is a trillionth? A trillion can be 1 000 000 000 000 or 1 000 000 000 000 000 000

A trillionth is then 1/1 000 000 000 000 ($1x10^{12}$) or 1/1 000 000 000 000 000 000 ($1x10^{18}$)

Can you give a practical example of a trillionth?

A pile of 1 trillion ($1x10^{12}$) five dollar notes would be about 110 000 kilometres high.

One of the five dollar notes would then be one trillionth the height of the pile.

p94

8 In 1911, Rutherford fired a stream of α-particles at a thin foil of gold.

a) What is the evidence that almost all of the atom is empty space?

Most of the α-particles passed straight through the gold foil.

b) What is the evidence that the nucleus is very small compared to the size of the atom?

A few α-particles were deflected at very large angles after passing through the gold foil. One α-particles was reflected back in the direction from which it came suggesting that just one of the α-particles hit the nucleus.

c) The atom is about 10,000 times the diameter of the nucleus. If the nucleus is represented by a 2 cm diameter $2 coin, what would be the diameter of the circle that represents the atom?

$10{,}000 \times 2$ cm = 20,000 cm = 200 m

p95

1 An atom has an atomic number of 9. The atom has 9 protons and 9 electrons.

2 An atom has an atomic number of 15 and an atomic mass number of 31. The atom has 15 protons, 15 electrons, 31-15 = 16 neutrons.

3 One mole of a substance (the atomic mass number in grams) contains:
6.02214154 x 10^{23} atoms. This number is **Avagadro's Number** (Sometimes rounded to 6.02 x 10^{23}).

4 One mole of a substance is the atomic mass number in grams.

5 One mole of carbon has **6.02 x 10^{23} atoms**.

6 Draw a sketch of the carbon atom.

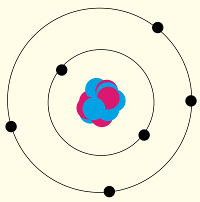
Carbon

12
C
Carbon
6

Atomic number = 6
Number of protons = 6
Number of electrons = 6

Atomic mass number = 12
Number of neutrons = 12 - 6 = 6

Electron shells (2 - 8 - 18)
6 electrons thus: 2 electrons first shell
4 electrons second shell



7 One mole of neon has **6.02 x 10^{23} atoms**.

8 Draw a sketch of the neon atom.

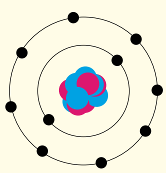
Neon

20
Ne
Neon
10

Atomic number = 10
Number of protons = 10
Number of electrons = 10

Atomic mass number = 20
Number of neutrons = 20 - 10 = 10

Electron shells (2 - 8 - 18)
10 electrons thus: 2 electrons first shell
8 electrons second shell



p95

9 One mole of silicon has **6.02×10^{23} atoms**.

10 Draw a sketch of the silicon atom.

Silicon

28
Si
Silicon
14

Atomic number = 14

Number of protons = 14

Number of electrons = 14

Atomic mass number = 28

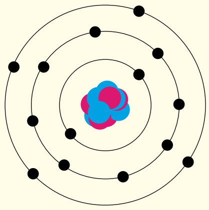
Number of neutrons = 28 - 14 = 14

Electron shells (2 - 8 - 18)

14 electrons thus: 2 electrons first shell

8 electrons second shell

4 electrons third shell



11 One mole of potassium has **6.02×10^{23} atoms**.

12 Draw a sketch of the potassium atom.

Potassium

39
K
Potassium
19

Atomic number = 19

Number of protons = 19

Number of electrons = 19

Atomic mass number = 39

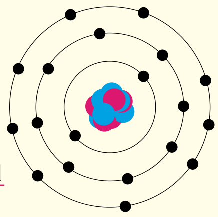
Number of neutrons = 39 - 19 = 20

Electron shells (2 - 8 - 18)

19 electrons thus: 2 electrons first shell

8 electrons second shell

9 electrons third shell



13 Most uranium atoms have an atomic mass number of 238 (^{238}U) and a few uranium atoms have an atomic mass number of 235 (^{235}U). Guess the atomic mass number of uranium (^{238}U and ^{235}U together).

If most uranium atoms have an atomic mass number of 238 (^{238}U) and a few uranium atoms have an atomic mass number of 235 (^{235}U). Then the atomic mass number of uranium (^{238}U and ^{235}U together would be a little under 238, possibly 237.8.

p96

1 **Isotopes** are different atoms of the same element. **Isotopes** are atoms with the same number of protons but **a different number of neutrons**. For example, **Neon has three isotopes**: ^{20}Ne, ^{21}Ne, ^{22}Ne.

2 Chlorine has two isotopes: ^{35}Cl, ^{37}Cl

a) ^{35}Cl has 17 electrons, 17 protons, and 35-17 = 18 neutrons

35
Cl
Chlorine
17

b) ^{37}Cl has 17 electrons, 17 protons, and 37-17 = 20 neutrons

37
Cl
Chlorine
17

3 Neon has three isotopes: ^{20}Ne, ^{21}Ne, ^{22}Ne

How many electrons, protons, and neutrons in each of:

a) ^{20}Ne has 10 electrons, 10 protons, and 20-10 = 10 neutrons

b) ^{21}Ne has 10 electrons, 10 protons, and 21-10 = 11 neutrons

c) ^{22}Ne has 10 electrons, 10 protons, and 22-10 = 12 neutrons

20
Ne
Neon
10

21
Ne
Neon
10

22
Ne
Neon
10

p96

4 Find the number of electrons, protons, and the average number of neutrons in an atom of:

a) Boron has 5 electrons, 5 protons, and an average of 10.81-5 = 5.81 neutrons

b) Calcium has 20 electrons, 20 protons, and an average of 40.078-20 = 20.078 neutrons

c) Argon has 18 electrons, 18 protons, and an average of 39.948-18= 21.948 neutrons

5 How many atoms in a mole of:

a) One mole of Boron has **6.02 x 10^{23} atoms**.

b) One mole of Calcium has **6.02 x 10^{23} atoms**.

c) One mole of Argon has **6.02 x 10^{23} atoms**.

10.810 B Boron 5	40.078 Ca Calcium 20	39.948 Ar Argon 18

6 Electrons have a negative charge.

7 Neutrons and protons are found in the nucleus of the atom.

8

Subatomic particle	**Proton**	**Electron**
Location in the atom	Nucleus	Electron cloud around the nucleus
Relative charge	+1 positive	1 negative
Relative mass	1800	1

9

Subatomic particle	**Proton**	**Neutron**
Location in the atom	Nucleus	Nucleus
Relative charge	+1 positive	0 no charge
Relative mass	1800	1800

10

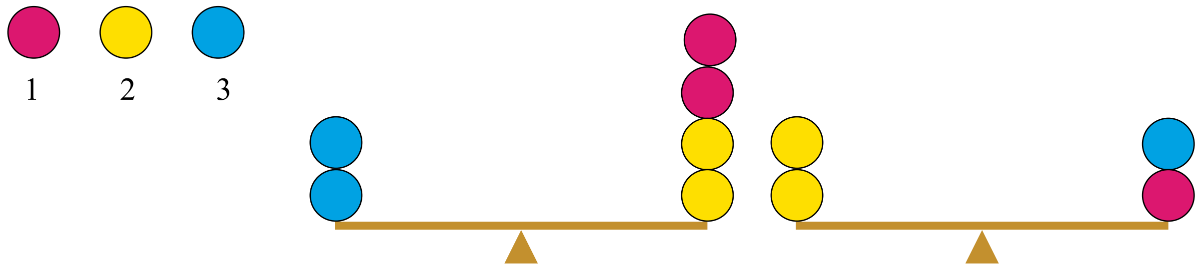
Subatomic particle	**Neutron**	**Electron**
Location in the atom	Nucleus	Electron cloud around the nucleus
Relative charge	0 no charge	1 negative
Relative mass	1800	1

11 A 50 cent coin (3 cm diameter and mass of 16 grams) is used to model the nucleus of a hydrogen atom.

An electron model would need to be about 1/1800 th the mass of the 50 cent coin (About 16/1800 = 0.009 grams = 9 milligrams). The diameter of the hydrogen atom is about 10,000 times the size of the nucleus (About 10,000x3cm = 300m). The electron model would have a mass of about 9 milligrams and be placed about 300m from the 50 cent coin. A bread grain?

p97

1



2 The large cog needs to move 1.5 teeth to make the A upright. Thus the small cog needs to also move 1.5 teeth out of 5 teeth for a full turn. No turns = 1.5 out of 5

= 1.5 ÷ 5 = 0.3 of a turn

3

p98

1 Radioactive decay happens when an unstable nucleus breaks apart.

2 Some examples of substances with an unstable nucleus and can undergo radioactive decay are:

Uranium-235 (^{235}U), Uranium-238 (^{238}U), Carbon-14 (^{14}C), Iodine-131 (^{131}I)
Cobalt-60 (^{60}Co), Plutonium-239 (^{239}Pu), Lead-210 (^{210}Pb)

3 As the nucleus breaks apart, it can release three types of radiation:

Alpha radiation (α), Beta radiation (β), Gamma radiation (γ)

4 The first five letters of the Greek alphabet. are: Alpha, Beta, Gamma, Delta, Epsilo

5 Alpha particles consist of two protons and two neutrons and don't have any electrons.

6 Alpha particles tend to be safe because they quickly lose their energy, pick up free electrons and become stable helium atoms. Alpha particles are unable to penetrate the outer layers of skin or even a sheet of paper.

7 Copy and complete each of the following radioactive decay equations:

a) Uranium-238 ➔ Thorium-238 + Alpha particle

$$^{238}_{92}U \rightarrow {}^{234}_{90}Th + {}^{4}_{2}He$$

b) Radium-222 ➔ Polonium-218 + Alpha particle

$$^{222}_{86}Ra \rightarrow {}^{218}_{84}Po + {}^{4}_{2}He$$

c) $$^{208}_{84}Po \rightarrow {}^{204}_{82}Pb + {}^{4}_{2}He$$

8 As the nucleus breaks apart, it can release three types of radiation:
Alpha radiation (α), Beta radiation (β), Gamma radiation (γ)

9 A **beta particle**, identical to an electron, is small, with a negative charge, and can travel with a speed in the air of up to 270,000,000 metres per second ($2.7\text{x}10^8$ m/s). Beta particles can travel several metres in air and are stopped by thin layers of plastic or metal.

p98

10 Copy and complete each of the following radioactive equations:

a) ${}^{214}_{82}Pb \rightarrow {}^{214}_{83}Bi + {}^{0}_{-1}e$

b) ${}^{90}_{38}Sr \rightarrow {}^{90}_{39}Y + {}^{0}_{-1}e$

c) ${}^{247}_{95}Am \rightarrow {}^{247}_{96}Cm + {}^{0}_{-1}e$

11 While alpha radiation or beta radiation is happening, the nucleus may rearrange itself from a high energy state to a lower energy state and emit **gamma rays**. Gamma rays are similar to light rays, and X-rays. The emission of gamma rays doesn't change the number of protons or neutrons in the nucleus.

12 A half-life is used to describe the rate of radioactive decay. The **half-life** is the time taken for half of the radioactive isotope to decay.

13 The radioactive isotope erbium-160 has a half-life of 10 hours.

^{160}Er	Time	Amount
	0 hrs	0.32 grams
	10 hrs	0.16 grams
	20 hrs	0.08 grams

p99

1

^{14}C	Time	Amount
	0	100%
	5,730 years	50%
	10,460 years	25%
	20.920 years	12.5%
	41.840 years	6.25%

2 Two-tenths is 20%. From the table in question 1, this suggests the fossil is a little over 11,000 years old.

3 Mass number of $C_6H_{12}O_6$ = 6×mass of C + 12×mass of H + 6×mass of O
= 6×12.011 + 12×1.008 + 6×15.999
= 180.156

p100

1 M = Alpha radiation (α), N = Beta radiation (β), O = Gamma radiation (γ)

2 **Isotopes** are different atoms of the same element. **Isotopes** are atoms with the same number of protons but different neutrons.

a) Atoms with the same number of neutrons are not isotopes.

b) Atoms, of the same element, with the same number of protons but different number of neutrons are isotopes.

3 There is 100 ÷ 20 = 5 moles of neon in 100 grams of neon.
5 moles of potassium would have a mass of 5×39 = 195 grams.
195 grams of potassium would have the same number of atoms as 20 grams of neon.

4 The table shows that if C-14 is useful for dating up to 50,000 years, then U-234 would be useful for dating up to 100,000 years

Amount ^{14}C	Time ^{14}C	Time ^{234}U
100%	0	0
50%	5,730 years	80,000 years
25%	10,460 years	160,000 years
12.5%	20,920 years	320,000 years
6.25%	41,840 years	640,000 years
3.125%	83,680	1,280.000 years

5 Half-life approximately 20 years (For half 50% of the material to decompose).