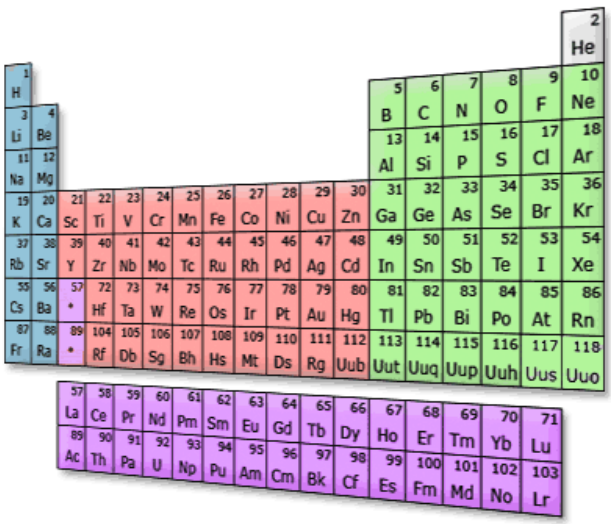
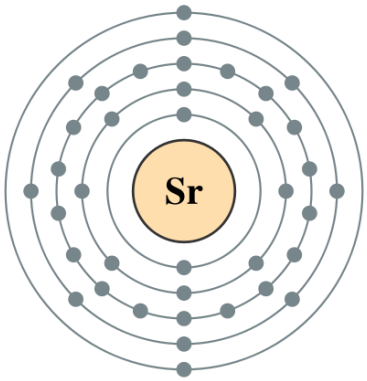
St. Luke's High School

2. Atomic Structure



38: Strontium **2,8,18,8,2**



Learning Outcomes

☐ Nat 4 outcomes ○ Nat 5 outcomes

By the end of this unit you should know the following:

- ☐ The structure of the Periodic Table
- ☐ Each element has its own unique symbol.
- ☐ The names and properties associated with elements in the alkali metals, transition metals, halogens and noble gases.
- ☐ Atoms are the building blocks of all substances.
- ☐ Atoms consist of a tiny nucleus containing protons and neutrons, surrounded by fast moving electrons.
- ☐ Protons have a mass of 1 amu and a positive charge, neutrons have a mass of 1 amu and no charge and electrons have a mass of effectively 0 amu and a negative charge.
- ☐ Electrons are arranged in specific energy levels around the nucleus.
- ☐ Each energy level can contain a maximum number of electrons.
- ☐ The atomic number is the number of protons, which for an atom will be the same as the number of electrons.
- ☐ The mass number is the number of protons plus neutrons.
- ○ Nuclide notation can be used to give important information about elements.
- ○ Isotopes are atoms of the same element but with a different mass number. They therefore have different numbers of neutrons.
- ○ Most elements have isotopes but some isotopes are more common than others.
- ○ A mass spectrometer can identify the different isotopes and work out their % abundance in a sample of the element.
- ○ The relative atomic mass is the average mass of the isotopes taking into account the relative proportions of each isotope.

Periodic Table and Elements

The Periodic Table contains all the elements, about 118 elements exist in total. Most elements exist naturally but some elements have been made by man.

Definition of an ELEMENT

An ELEMENT is made from only one type of ATOM.
An ELEMENT is a substance that cannot be broken down into anything chemically simpler.

Data Booklet

The data booklet contains lots of important information about elements and is a point of reference for all chemistry related information.

Questions on Elements

1. Use the data booklet to help you answer the following:-
   a. Which three noble gases were discovered in 1898?
   b. Which group 3 metal would melt in your hand?
   c. Name two alkali metals which float on water?
   d. Which two elements are liquids at room temperature (25°C)

2.
   a. Give chemical symbols for the following elements:
      copper _____
      zinc _____
      tin _____
      lead
   b. The transition metal _____ was known to the Romans as Aurum.
   c. The Transition metal _____ was known to the Romans as Agentum.

Quick Test 1

1. The alkali metals, the halogens and the noble gases are the names of groups of elements in the Periodic Table.
   Complete the table by circling a word in each box to give correct information about each group.

	Group	Metal or Non-Metal	Reactive or Non-Reactive
A	Alkali metals	metals / non-metals	reactive / non-reactive
B	Halogens	metals / non-metals	reactive / non-reactive
C	Noble gases	metals / non-metals	reactive / non-reactive

2 Complete the following table.

	NAME OF ELEMENT
a. Used in thermometers	
b. Used in weather balloons	
c. Used in swimming pools	
d. Makes up about 80% of the air	
e. Makes up about 20% of the air	
f. Used to make jewellery	
g. Used as "lead" in pencils	
h. Used to make computer chips	
i. Used in yellow street lamps	
j. Named after a planet	
k. Named after the scientist Albert Einstein	
l. Named after an American state	

Periodic Table

The Periodic Table consists of a series of columns, called groups, and also rows, which are called periods. Some of the groups have names and the elements making up the group have similar chemical properties.

ACTIVITY 1.2 **Reactivity of Groups 1 & 7**

Your teacher might demonstrate the reactivity of the alkali metals and/or displacement reactions of the halogens.

DISCUSS

After discussion with your teacher and others, can you describe the pattern in reactivity for both the alkali metals and halogens as you go down the group and identify the position of the alkali metals, the transition metals, the halogens and the noble gases.

NOTES

Briefly describe how the reactivity of alkali metals changes as you go down the group.

_____

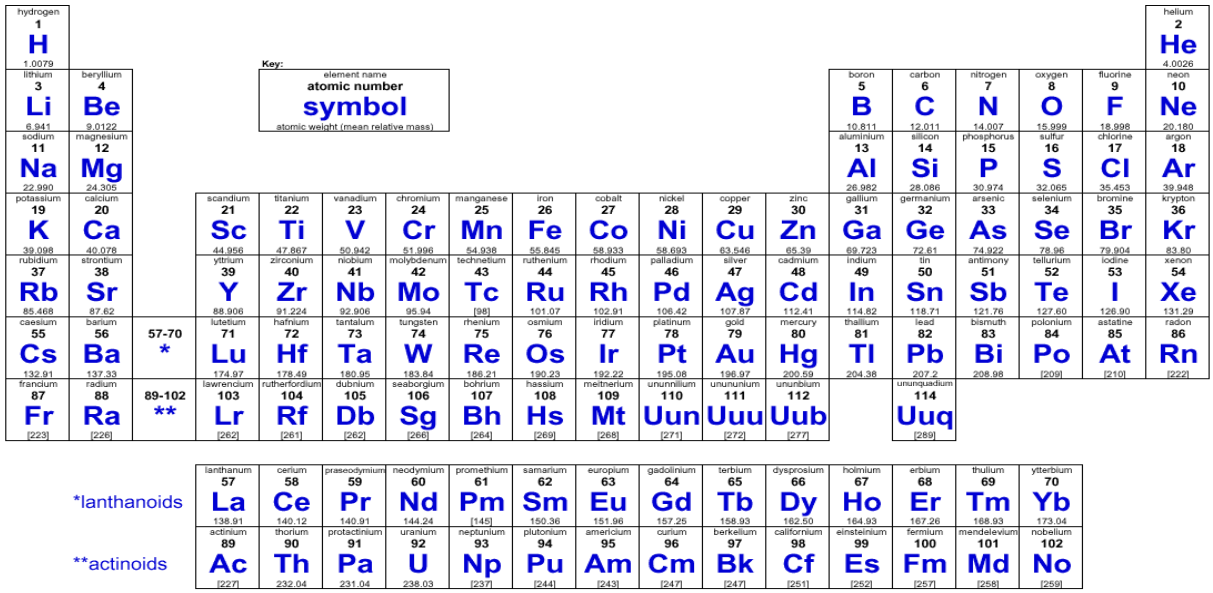
_____

Briefly describe how the reactivity of the halogens changes as you go down the group.

_____

_____

Using different colours, colour in and label the alkali metals, the transition



NOTES

Using the Periodic Table and what you know, complete the following tables, giving at least 3 elements in each column:

Solid	Liquid (only 2)	Gas

Metal	Non-metal

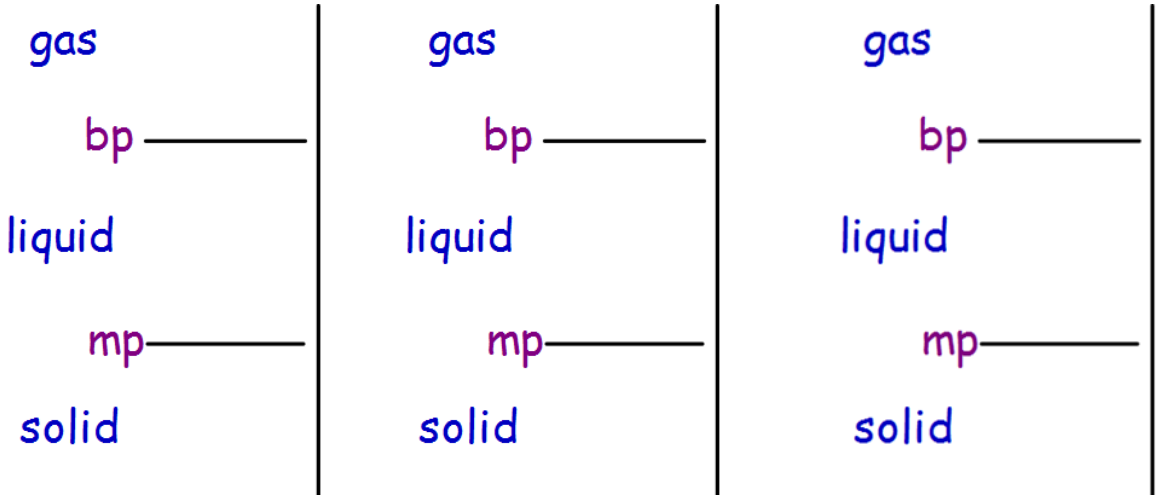
Naturally occurring	Made by scientists

Grouping Elements

* elements in the same group have similar chemical properties.

Group	Name	Properties
1		Very reactive (stored under oil)
7		Very reactive non-metals
0		Unreactive elements
between 2 & 3		Form coloured compounds and often used as catalysts

State of Elements at different Temperatures



1. At 40 °C phosphorus is in the _____ state

2. At -150 °C oxygen is in the _____ state

3. Argon is in the _____ state at -180 °C

4. Galium is in the _____ state at room temperature (25°C)

5. Helium is in the _____ state at -270 °C

6. At -85°C Nitrogen is in the _____ state

Quick Test 2

1. Which of the following elements is an alkali metal?

A. Ba
B. Co
C. Al
D. Cs

2. Which of the following pairs of elements are in the same period of the Periodic Table?

A. Na, Cl
B. Li, S
C. Al, Br
D. Ca, Ar

3. Which of the following elements is a halogen?

A. B
B. P
C. I
D. Kr

4. Which of the following elements is a transition metal?

A. K
B. V
C. Si
D. Sr

5. Which of the following elements is liquid at room temperature?

A. F
B. Cl
C. Br
D. I

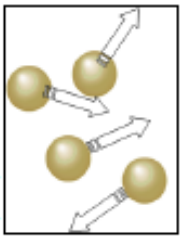
6. Which of the following elements is gaseous at room temperature?

A. H
B. S
C. P
D. Hg

ACTIVITY 1.4 The Idea of Atoms

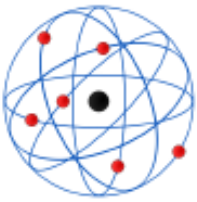
Take a sheet of paper and fold it carefully in half. Tear along the fold, take one half and fold it in half, then tear along the fold again. Repeat this as many times as you can. How small can you cut your piece of paper?

Two Greek philosophers, Democritus and Leucippus, are credited with being the first to come up with the idea that **if we crush something into smaller and smaller parts eventually you won't be able to break it down into anything smaller.** They called these particles *atoma*, meaning indivisible, the word atom comes from this.

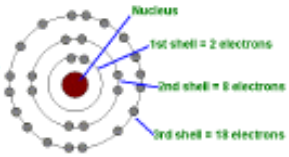


John Dalton, in 1808 suggested that **atoms in a gas could be thought of as tiny elastic balls bouncing around.** He suggested that they could bind together in different combinations to make compounds and that all atoms in a particular element were identical.

JJ Thomson, in 1897, discovered **that atoms contained smaller particles which became known as electrons**. These tiny negative particles were 1000's of times smaller than atoms and **Thomson suggested they were attached to the atom like bits of fruit in a plum pudding.**



In 1911 Ernest Rutherford conducted an experiment that led him to conclude that **most of the positive charge in an atom was concentrated in a tiny space in the very centre of the atom.** This became known as the nucleus, with electrons orbiting around it. The atom he said was therefore mainly empty space.

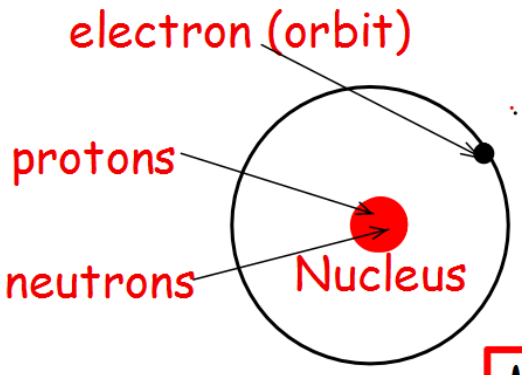


In 1913 Niels Bohr suggested that **the electrons orbited the nucleus in precise distances from the nucleus** a little bit like the planets around the sun in our solar system.

ACTIVITY 1.5 History of the Atom Card Game

Your teacher may show you a video and then let you play this game. Use the blank strips of paper to write out the correct descriptions.

Atomic Structure



ATOMIC STRUCTURE

proton = +ve charge
electron = -ve charge
neutrons = no charge

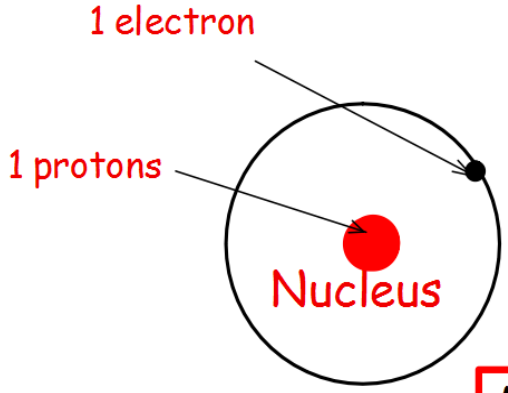
Mass = Protons + neutrons

Number of protons = Atomic number

Mass = Protons + neutrons

Atoms are neutral because the number of protons (+ve charges) equals the number of electrons (-ve charges) so the charge is balanced

Atomic Structure of Hydrogen



hydrogen

1 proton = 1 +ve charge
1 electron = 1 -ve charge
0 neutrons = no charge

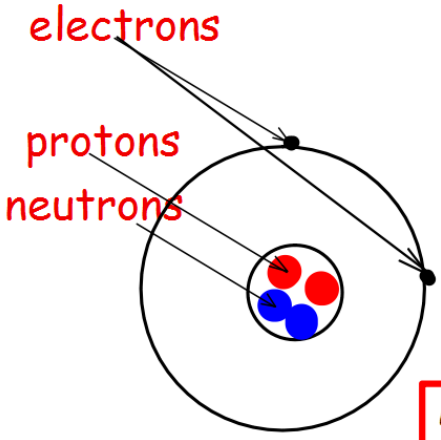
Mass = 1 amu (atomic mass units)

Number of protons = Atomic number

Mass = Protons + neutrons

Atoms are neutral because the number of protons (+ve charges) equals the number of electrons (-ve charges) so the charge is balanced

Atomic Structure of Helium



Helium

2 protons = 2 +ve charges

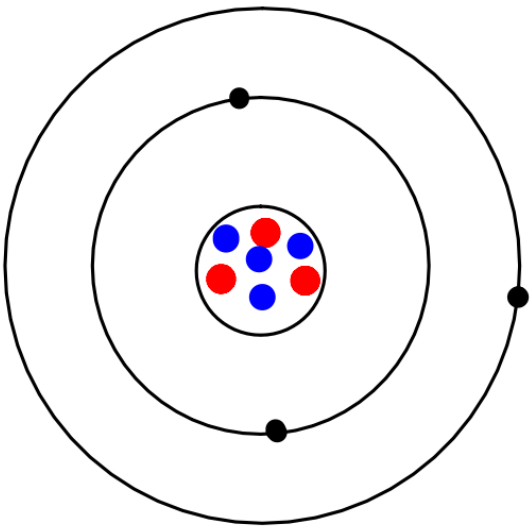
2 electrons = 2 -ve charges

2 neutrons = no charges

Mass =

The nucleus or 'core' of the atom is where the protons and neutrons are found.
The nucleus is therefore positively charged.
The core makes up the total mass of the atom.
The electrons orbit the core and are not included in the mass because they are so small.

Atomic Structure of Lithium



Lithium

Number of protons =

Number of electrons =

Number of neutrons = 4

Mass = protons + neutrons =

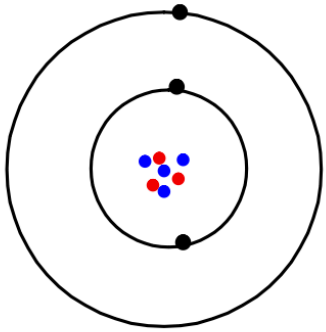
Sub-Atomic Particles

Copy and complete the table.

Subatomic particle	Mass	Charge	Location in atom
electron proton neutron			

Energy Levels

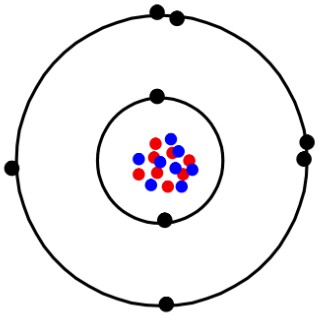
Li



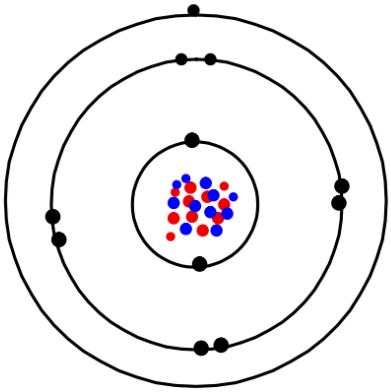
Electrons are arranged in different energy levels around the nucleus.
The first energy level holds a maximum of 2 electrons.
The second energy level holds a maximum of 8 electrons.

Energy Levels

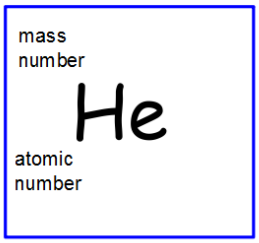
Electron arrangement for oxygen

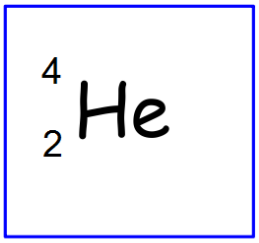


Electron arrangement for sodium



Nuclide Notation





Atomic number = the number of protons
Mass number = number of protons + number of neutrons
Neutron number = mass number - atomic number

Write the atomic notation for the following atoms.

1. calcium with 40 neutrons
2. oxygen with 8 neutrons
3. carbon with a mass of 12
4. Hydrogen with a mass of 2

Quick Test 3

1. An atom has atomic number 17 and mass number 35.

   How many neutrons does the atom contain?

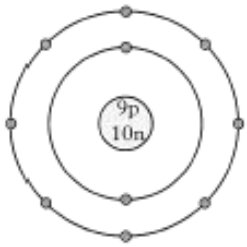
2. Which of the following is an electron arrangement of a group 1 metal?

   A 2, 8, 8
   B 2, 8, 5
   C 2, 8, 7
   D 2, 8, 1

3. What is the electron arrangement of chlorine?

4. Draw the electron arrangement of calcium in the space below:

5. Complete the table for the particle shown below.



Key:

p = proton
n = neutron
= electron

Atomic Number	Symbol for the element	Mass number	Overall charge of the particle

Important Numbers

Complete the table with numbers of protons, neutrons, elecrons and mass number and atomic number.

Atom or ions	Atomic number	Number of neutrons	Number of protons	Mass number	Number of elecrons
Na	11			23	
H		0			
	12				
				32	16
C					
	10	10			

Mass number and ISOTOPES

Isotopes are atoms with the same atomic number but different mass numbers. They therefore have different numbers of neutrons.

ISOTOPES of Hydrogen

ISOTOPES and Relative Atomic Mass

Isotopes will therefore have the same number of protons but different numbers of neutrons.

e.g. $^{35}_{17}Cl$ $^{37}_{17}Cl$

Chlorine atoms come in two different isotopes. Most chlorine atoms have a mass of 35 (i.e. 18 neutrons) but some chlorine atoms have a mass of 37 (20 neutrons).

The relative atomic mass (RAM) is therefore closer to 35 than 37 since 35 is the most common isotope. The RAM of Chlorine is 35.5.

RAM table in data booklet

e.g. 2 Bromine

Bromine has two different isotopes

$^{79}_{35}Br$ $^{81}_{35}Br$

The RAM of bromine is 80. This tells us that the relative abundance of each isotope of bromine is _____

Relative Atomic Mass

The relative atomic mass is the average mass of all the isotopes of an element.

Calculating Relative Atomic Mass (RAM)

$$\text{RAM} = \text{sum of } \left(\frac{\%\ \text{X}\ \text{mass number}}{100}\right)$$

e.g. chlorine $\text{RAM} = \frac{75 \times 35}{100} + \frac{25 \times 37}{100}$

$26.25 + 9.25$

$= 35.5$

RAM of Chlorine = 35.5

Quick Test 4

1. The most common isotope of potassium is ^{39}K

(a) Complete the table to show the number of particles in an atom of K.

Type of particle	Number of particles
proton	
neutron	
electron	

(b) How do isotopes of potassium differ from each other?

_____

2.

(a) An isotope of bromine has atomic number 35 and mass number 81.

(i) Complete the nuclide notation for this isotope of bromine.

Br

(ii) How many neutrons are there in this isotope?

_____

(b) Bromine has two isotopes. One has a mass number of 81 and the other has a mass number of 79.
The relative atomic mass of bromine is 80.
What does this tell you about the percentage of each isotope in bromine?

_____

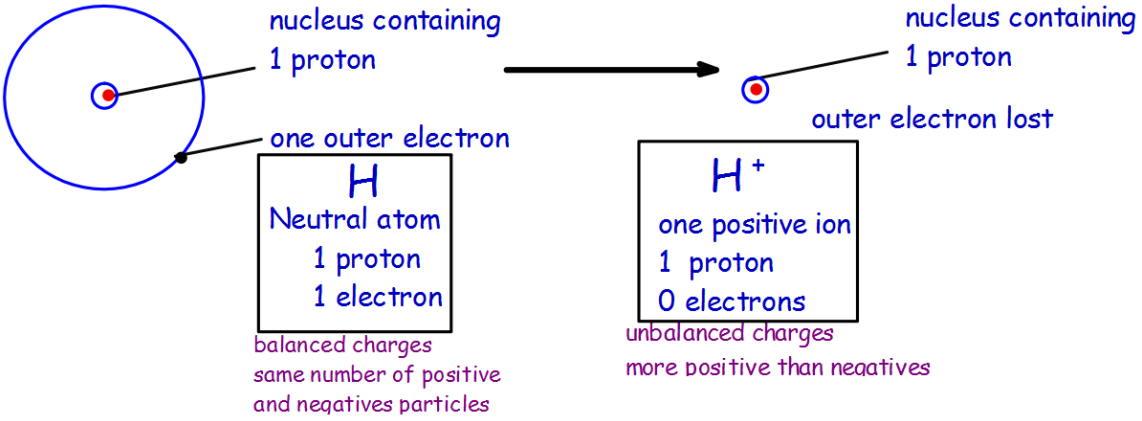
_____

Ions

Forming Positive Ions

hydrogen

Hydrogen has one outer electron. Hydrogen loses this electron to become an ion with one positive charge.

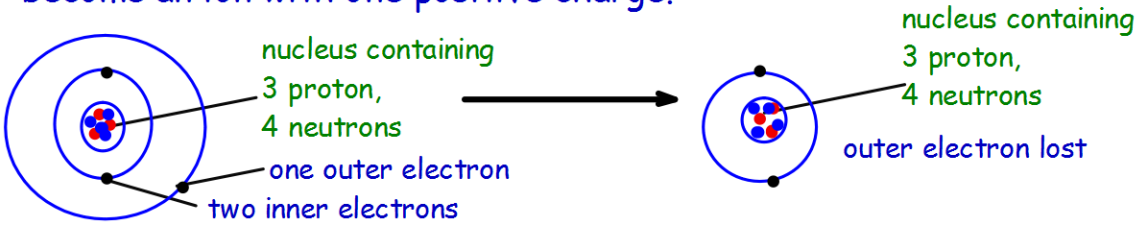


nuclide notation

$^{1}_{1}H^{+}$

Lithium

Lithium has one outer electron. Lithium loses this electron to become an ion with one positive charge.



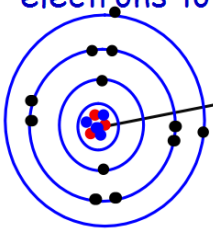
Li
Neutral atom
2,1 electrons

Li +
one positive ion
2 electrons

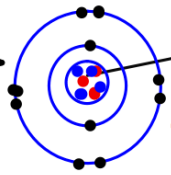
Forming Positive Ions

Magnesium

Magnesium has two outer electron. Magnesium loses two outer electrons to become an ion with two positive charges.



nucleus containing
12 proton,
12 neutrons
2 electrons in shell 1
8 electrons in shell 2
2 outer electrons



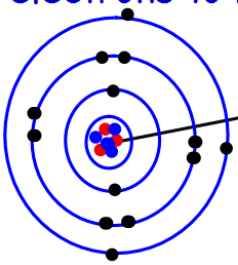
nucleus containing
12 proton,
12 neutrons
2 electrons in shell 1
8 electrons in shell 2
2 outer electrons **lost**

Mg
Neutral atom
2,8,2 electrons
12 protons
12 electrons

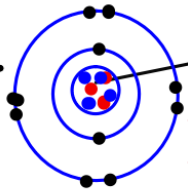
Mg^{2+}
two positive ion
2,8 electrons
12 protons
10 electrons

Aluminium

Aluminium has _____ outer electron. Aluminium _____ _____ outer electrons to become an ion with _____ positive charges.



nucleus containing
___ proton,
14 neutrons
___ electrons in shell 1
___ electrons in shell 2
___ outer electrons



nucleus containing
___ proton,
14 neutrons
___ electrons in shell 1
___ electrons in shell 2
___ outer electrons **lost**

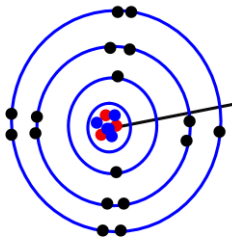
Al
Neutral atom
_,_,_ electrons
___ protons
___ electrons

$Al^{\_\_\_}$
___ _____ ion
_,_,_ electrons
___ protons
___ electrons

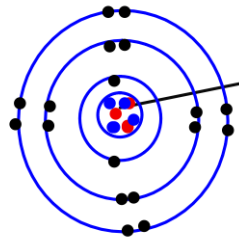
Forming Negative Ions

Chlorine

Chlorine has seven outer electron. Chlorine gains one outer electron to become a stable ions with one negative charge.



nucleus containing
17 proton,
18 neutrons
2 electrons in shell 1
8 electrons in shell 2
7 outer electrons



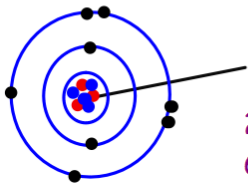
nucleus containing
17 proton,
18 neutrons
2 electrons in shell 1
8 electrons in shell 2
8 outer electrons

Cl
Neutral atom
2,8,7 electrons
17 protons
17 electrons

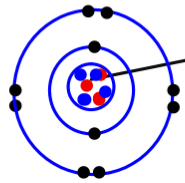
Cl^-
One negative ions
2,8,8 electrons
17 protons
18 electrons

Oxygen

Oxygen has six outer electron. Oxygen gains two outer electron to become a stable ions with two negative charges.



nucleus containing
8 proton,
8 neutrons
2 electrons in shell 1
6 outer electrons



nucleus containing
8 proton,
8 neutrons
2 electrons in shell 1
8 outer electrons

O
Neutral atom
2,6 electrons
___ protons
___ elelctrons

O^{2-}
Two negative ion
2,8 electrons
___ protons
___ elelctrons

Ions And Reactivity

Reactivity and IONS

Elements in the same group of the periodic table react in a similar way because _____

* During chemical reactions, atoms can gain and lose electrons.
* Atoms which gain/lose electrons are no longer neutral,
  - they become charged ions.

+ = elecron lost
- = electron gained

An atom which loses an electron, loses a negative charge to become a positive ion.

e.g. $Na_{(s)} \longrightarrow Na^{+}_{(aq)} + e^{-}$

one less electron than proton

p =_____
e =_____

An atom which gains an electron, gains a negative charge to become a negative ion.

e.g. 2 $Cl_{2(g)} + 2e^{-} \longrightarrow 2Cl^{-}_{(aq)}$

one more electron than proton

p =_____
e =_____

ION Notation

mass, charge, atomic number

Symbol

$^{23}_{11}Na^{+}$

Number of protons = atomic number = 11 protons
Number of electrons = protons -1 = 10 electrons
Number of neutrons = mass number - protons, 23-11 = 12 neutrons

$^{39}_{19}K^{+}$

Protons = _____
Neutrons = _____
electrons = _____

$^{80}_{35}Br^{-}$

Protons = _____
Neutrons = _____
electrons = _____

Flame Tests

When chemicals are heated up the electrons inside the atoms get excited and move to energy levels further away from the nucleus. The electrons then move back to where they started but rather than giving the energy back out as heat they give it out as bands of light of a particular colour. As each element has its own unique number of electrons, each element will often give out its own particular colour. Normal light is made up of 7 colours, which you can see in a rainbow or with a prism.

The diagram below shows the spectra of colour that strontium gives out when it or its compounds are heated. The predominance of the red bands causes the flame colour to appear red.

ACTIVITY 1.9 Flame Colours

Heat a splint using a roaring blue Bunsen flame that has been soaked in a solution containing the different metals to see what colour the flame is.

DISCUSS

After discussion with your teacher and others, make sure you can explain how different metal compounds produce different coloured flames.

NOTES

Complete the table and compare your results with p4 of your data booklet:

Metal Compound Solution	Flame Colour
Copper	
Sodium	
Strontium	
Potassium	

Important Numbers

Complete the table with numbers of protons, neutrons, elecrons and mass number and atomic number.

Atom or ions	Atomic number	Number of neutrons	Number of protons	Mass number	Number of elecrons
Ca	20			40	
O		8			
Li	3	3			
	5	5			5
F^-				19	
K^+		20			
Mg^{2+}		13			
S^{2-}				32	
	17			35	18
		12	11		10

Group IONS

Group or complex ions contain two or more atoms. The formulae of these ions are given in the data booklet. Some common complex group ions are listed below and should be memorised

Name of ions	Formula	Charge on ion
ammonium	NH_4^+	1 positive
hydroxide	OH^-	1 negative
nitrate	NO_3^-	1 negative
sulphite	SO_3^{2-}	2 negative
sulphate	SO_4^{2-}	2 negative
carbonate	CO_3^{2-}	2 negative
phosphate	PO_4^{3-}	3 negative

Quick Test 5

1. The potassium has a lilac flame colour, what is it's electron arrangement?

A. 2.8.1
B. 2.8.8.1
C. 2.8.8
D. 2.8.18.8.1

2. A blue powder is heated in a flame and a green colour appears. Using your data booklet identify which of the following compounds it is.

A. Sodium chloride
B. Lithium nitrate
C. Copper sulfate
D. Strontium phosphate

3. Calcium gives an orange flame when heated. In the space below draw the electron arrangement of calcium atoms.