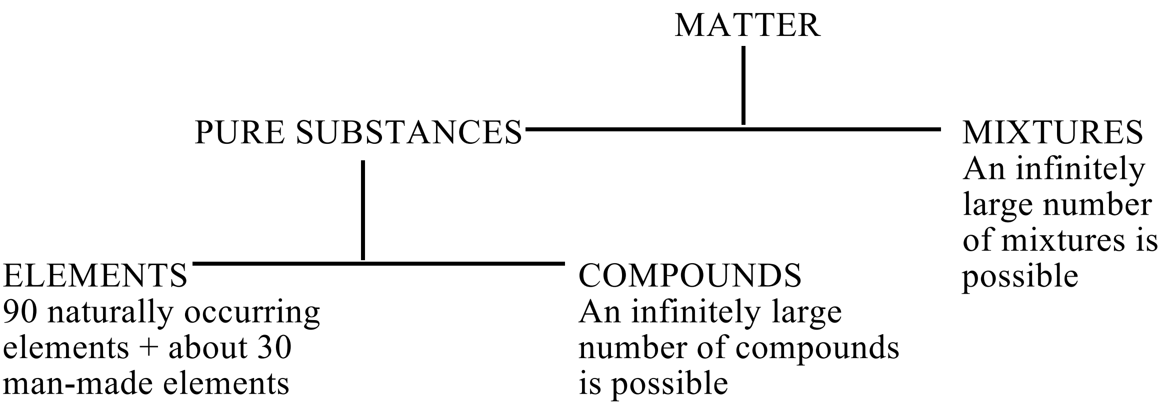
TOPIC 1.

ELEMENTS, COMPOUNDS AND MIXTURES.

What is chemistry?

Chemistry is the study of matter and the interconversion of matter. Matter is anything which has mass and occupies a volume. Sciences often begin by collecting and classifying. Subsequent observations lead to generalisations and laws. In the science of chemistry, there are numerous bases for classifying matter but the most fundamental is to subdivide matter into pure substances and mixtures. Pure substances can be further regarded as consisting of either elements or compounds.



What characterises each of these groups?

An **ELEMENT** is a substance which cannot be broken down into simpler component substances. An **ATOM** is the smallest possible unit of an element. Atoms are extremely small so any visible specimen of an element contains enormous numbers of atoms. Each element's atoms are unique to that element. There are only 90 naturally occurring elements so it follows that there are only 90 different types of naturally occurring atom. What distinguishes the atoms of each different element is the subject of another Topic.

Elements are conveniently further subdivided into two groups, **METALS** and **NON-METALS**, based on their physical and chemical properties. The physical properties of metals are probably already familiar - shiny when freshly cut, conduct heat and electricity well, malleable and ductile. The non-metals have the opposite properties to metals - they are usually powders or gases, do not conduct well and, if solids, are brittle. The chemical properties of each group will be discussed in future Topics.

Elements as they occur in nature rarely consist of discrete, individual atoms. Usually they consist of two or more atoms joined together by **CHEMICAL BONDS** of various types. For example, oxygen, the essential life-supporting element in air, is not present as individual oxygen atoms but instead, consists of two oxygen atoms bonded together. This unit is called a **MOLECULE** of oxygen. Some elements occur as discrete molecules containing even larger numbers of atoms such as 4, 6, 10 or 12 bonded atoms. However, most elements including all the metals do not normally exist as discrete molecules containing a fixed number of atoms but instead, consist of very large aggregates of atoms bonded together.

Regardless of whether an element occurs as single atoms or as atoms bonded together, each element always consists of the same type of atom which imparts its own unique properties to that element. For example, aluminium is recognised as a silver-coloured metal while copper has a different colour. Apart from the obvious difference in colour, there are many unique physical and chemical properties which each of these two elements possess and which are attributable to the differences between their atoms.

Table 1 (Page I-20) gives a complete alphabetical list of all the elements, including some of those synthesised. In Table 2 (Page I-21), most of those elements are listed in groups containing four to six elements. Some of the groups are given names - for example, the elements of the first group collectively are known as the alkali metals, the seventh group is the halogens and the eight group is the noble gases. Elements within each group have many properties in common. In addition, another 11 elements which are part of a much larger grouping known as the transition elements are listed in Table 2. Note that hydrogen does not belong to any group and is regarded as being an exceptional individual element.

Compounds.

A **COMPOUND** differs from an element in that an element contains only a single type of atom while a compound consists of smallest units which contain at least two different types of atom (i.e. atoms of at least two different elements) joined together by chemical bonds. Compounds always contain atoms of their constituent elements in the same numerical ratio regardless of how the compound was prepared. Consequently analysis of any pure compound always returns the same result. Therefore a compound when pure is **HOMOGENEOUS.** Many compounds exist as discrete molecules. The smallest unit of the compound carbon dioxide is the carbon dioxide molecule, each of which consists of one carbon atom bonded to two oxygen atoms - this molecule is the smallest particle of carbon dioxide that can exist. The ratio of one carbon atom to two oxygen atoms in the molecule of this compound applies equally well to the carbon dioxide which may originate from burning of natural gas or petrol or from chemical reactions such as when an acid is mixed with a substance such as limestone or washing soda. Carbon dioxide molecules always consist of one carbon atom bonded to two oxygen atoms regardless of the source of the compound.

However, not all compounds exist as discrete molecules - for example the compound sodium chloride also known as table salt exists not as individual sodium chloride molecules but as a highly structured crystal lattice, familiar as the rock salt commonly used in salt grinders. There are several types of chemical bonds that join atoms in elements and compounds and the type of bond present determines in part whether a given compound exists as discrete molecules. Chemical bonds are examined in later Topics.

Note that when elements have combined to form compounds, they lose their original properties and the compound formed has its own characteristic properties. For example, carbon - a black solid - combines with another element, the colourless gas oxygen which supports combustion, to form the compound carbon dioxide which is a colourless gas that is incapable of supporting combustion. Compounds can only be converted back to their component elements by breaking the chemical bonds which hold the atoms together in the compound. For example, the compound water, which contains two hydrogen atoms and one oxygen atom combined in each water molecule can be converted to the free elements oxygen and hydrogen by passing an electric current through the water, a process called **ELECTROLYSIS**.

Whenever chemical bonds are broken or formed, the process is called a **CHEMICAL CHANGE.** Processes such as the cooking of food, the burning of fuels and the corrosion of metals are all examples of common chemical changes.

You need more calcium in your diet.
A very common mistake made by the general population is the failure to differentiate between a pure element and compounds of that element, e.g. the poisonous gaseous element chlorine and essential compounds of chlorine such as sodium chloride. Likewise, the calcium referred to above is in the form of compounds of calcium and definitely **not** the free element.

Mixtures
A **MIXTURE**, as the name implies, consist of different elements or compounds which have been physically mixed together. Consequently, any given sample taken from a mixture would contain at least slightly different amounts of its various components compared with any other sample collected, because mixtures are **HETEROGENEOUS.** Analysis of a mixture often requires specified procedures in order to obtain a representative sample. Mixtures are always impure in that they contain more than one substance and therefore more than one type of constituent entity, whereas an element or compound can always be obtained as a pure substance because they contain only a single type of constituent entity.
Air is a good example of a mixture, containing principally the elements oxygen, nitrogen and argon and the compounds carbon dioxide and water vapour as well as dust and other solid particles. The observed composition of a sample of air varies, depending on the sample analysed. Figures published represent only the *average* composition obtained by analysis of many different samples. Note also that this composition is constantly changing, particularly with regard to the amounts of carbon dioxide and water present. As mixtures are simply physical mixtures of pure substances, they can be separated into their pure components by physical methods such as filtration, distillation or even by making use of the differing densities of the components. These processes do not involve the breaking of any chemical bonds and are therefore called **PHYSICAL CHANGES**. Some examples of physical processes used to separate mixtures include distillation of crude oil to obtain various fractions for petrol, lubricating oil, kerosene, diesel etc; density differences to extract gold in panning; filtering to remove solids from swimming pool water.

Check your understanding of this section.
How does a compound differ from an element?
How does a molecule differ from an atom?
What is the difference between a mixture and a compound?
List some properties of a metal and compare them with those of a non-metal.
How can water be converted to its component free elements?
Would an aspirin tablet be a mixture or a compound?
How does a chemical change differ from a physical change?

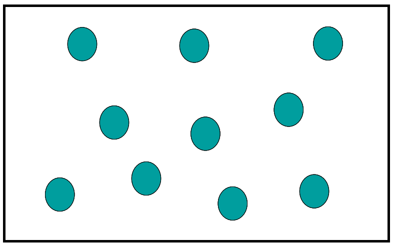
Chemical symbols.
Each type of atom (i.e. each element) is conveniently represented by a symbol which denotes a single atom of that element. For example,

H	hydrogen	O	oxygen	C	carbon
N	nitrogen	S	sulfur	Cl	chlorine
He	helium	Al	aluminium	Cu	copper

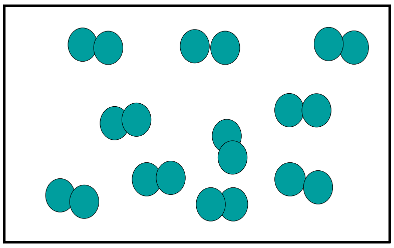
Note that each symbol always starts with an upper case letter, and that when a second letter is used, it is always written in lower case. Table 1 (page I-20) includes the symbols of all elements and Table 2 (page I-21) contains those elements whose symbols are frequently used in basic chemistry courses and which must be committed to memory.

Symbols can be used not just to represent single atoms of elements, but also in combinations to represent molecules of elements and also the formulas of compounds. In these cases, when there is more than a single atom of any element present, a subscript is used to show how many. For example, as water consists of molecules each containing two hydrogen atoms bonded to one oxygen atom, then the formula for the water molecule is H_2O. Similarly, carbon dioxide molecules each contain one carbon atom bonded to two oxygen atoms, so the formula for its molecule is CO_2. **Each subscript specifies the number of atoms of the element immediately preceding that subscript**. As another example, the formula for glucose, $C_6H_{12}O_6$, shows that each molecule of this compound contains 6 carbon atoms, 12 hydrogen atoms and 6 oxygen atoms bonded together.

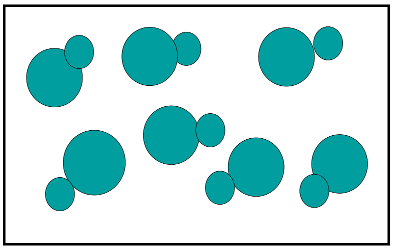
As mentioned earlier, most elements do not occur naturally as single atoms (**MONATOMIC**), but instead as discrete molecules containing 2, 3 or more atoms (**DIATOMIC, TRIATOMIC**) or as large numbers of atoms bonded together. As an example, the usual form of the element oxygen in the atmosphere is as diatomic molecules of formula O_2 rather than as individual O atoms. The few elements which do occur in nature as monatomic species are those listed in the eighth group of Table 2, viz helium (He), neon (Ne), argon (Ar), krypton (Kr), xenon (Xe) and radon (Rn). This group of elements is known as the **NOBLE GASES** because they are almost inert. The only elements which occur naturally as diatomic molecules are hydrogen, nitrogen, oxygen, plus all the halogens, fluorine, chlorine, bromine and iodine. These eight elements normally exist as the molecular species H_2, N_2,O_2, F_2, Cl_2, Br_2 and I_2 respectively rather than in the form of single atoms. All metals and some non-metals usually occur as extremely large aggregates of atoms bonded together and are not usually considered to be composed of discrete molecules, so generally just the formula of the atom is used to represent these elements. For example, the metallic element sodium consists of large numbers of sodium atoms bonded together and this element is represented just by its atomic symbol, Na, with no subscript. Similarly the symbol of the single atom is used to represent all other metals such as iron (Fe), copper (Cu) and aluminium (Al). While those non-metallic elements listed above such as chlorine (Cl_2), oxygen (O_2) and hydrogen (H_2) which occur as diatomic molecules are shown as such in their formulas, some other non-metals occur as large aggregates of atoms like the metals (although bonded differently) and are represented by their atomic formulas alone. A common example is the element carbon which occurs in nature as diamond, charcoal and graphite. Each of these forms of carbon contain large numbers of bonded carbon atoms but not discrete molecules, so carbon is represented by the atomic symbol C.



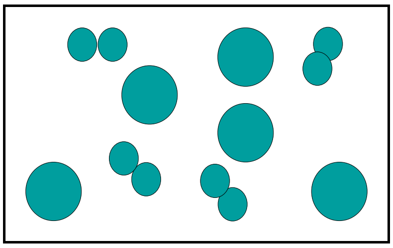
Atoms of a monatomic element



Molecules of a diatomic element



Molecules of a diatomic compound



A mixture

Allotropes.
A given element may occur with more than one arrangement of its constituent atoms. For example, carbon occurs naturally as the black amorphous powder called charcoal, as graphite which is used as the "lead" in pencils, and also as diamond. All three forms of carbon contain only carbon atoms, but the arrangement of those atoms in each form is different resulting in the very different physical properties of charcoal, graphite and diamond. The various forms in which an element may occur are called **ALLOTROPIC MODIFICATIONS** or simply **ALLOTROPES** of that element.

As another example, oxygen usually occurs in the atmosphere is a diatomic molecule. However, particularly in the upper atmosphere, a small amount of oxygen occurs as another, triatomic allotrope called ozone. What would the formulas be for these two allotropes?

Check your understanding of this section.
Which elements occur as diatomic molecules in nature?
Which elements occur naturally as monatomic species?
How would one recognise that the formula NaCl applied to a compound?
Why can't a mixture have a unique chemical formula?
What does the formula for the molecule HCl indicate?
Why would it be incorrect to write 2H rather than H_2 as the formula for the molecule of hydrogen?

Objectives of this Topic.
When you have completed this Topic, including the tutorial questions, you should have attained the following goals:

1. Know the symbols and names of the elements in Table 2 (page I-20) and know the Group to which each belongs.

2. Know what constitutes an element, compound or mixture.

3. Be able to distinguish metals from non-metals on the basis of their physical properties.

4. Know the distinction between a chemical and physical change.

5. Know the meaning of the terms: atom, molecule, allotrope, monatomic, diatomic, triatomic.

6. Know that different elements may occur in relatively few instances as single atoms or as diatomic molecules, but more commonly, as larger molecules or as infinitely large numbers of atoms in clusters.

7. Be able to recognise a formula as being that of an element or a compound.

8. Know the names of a short list of compounds.

CAL PROGRAMME.
A programme named "Elements" to assist you to memorise the names and symbols of the elements is available to download from the downloads site
www.chemlab.chem.edu.au/download.htm
For the latest version of windows, the screen will only be half size initially, but can be expanded by right clicking anywhere in the blue bar at the top (but not the maximise square), choosing "properties" and then "full screen".

SUMMARY

Chemistry is the study of matter and its interconversion. All matter is ultimately composed of atoms. Matter which consists of only one type of atom is called an element while matter whose constituent particles contain atoms of more than one element is called a compound. Elements can be classified in many different ways. Some classifications rely on simple physical properties while others also incorporate chemical properties. One useful classification of elements is into metals vs non-metals.

The basic units of most substances however consist not of single atoms but usually of atoms which are joined to each other by chemical bonds of various types. These basic units may consist of two or more atoms joined by chemical bonds to form discrete entities called molecules or they may consist of extremely large and indeterminate numbers of bonded atoms such as found in the metals or in crystalline compounds like sodium chloride. Pure substances contain just a single element or compound and are homogeneous while the mixtures which constitute most of the matter around us consist of more than one element and/or compound physically mixed rather than chemically bonded and are heterogeneous.

A given compound always has the same numerical ratio of its constituent atoms of each component element, regardless of the way that compound was produced. When elements are converted to compounds or compounds converted back to their constituent elements, chemical bonds are broken and new bonds formed between the constituent atoms - this is termed a chemical change. Chemical change results in the loss of the properties which characterised the original substances while the products resulting have their own characteristic properties.

Mixtures are inherently impure, their composition varying with the sample analysed. Mixtures can be separated into their pure components by physical processes such as distillation as there are no chemical bonds between those components. Such procedures are called physical changes.

Atoms of elements are conveniently denoted by a symbol which represents a single atom of the particular element. Compounds can then be represented by a combination of the symbols of the constituent atoms by using subscripts to show the number of each atom present in the formula. Thus H_2O represents two hydrogen atoms and one oxygen atom combined to form a molecule of water.

Of the elements, only the six noble gases occur in nature as the monatomic species. The elements hydrogen, oxygen, nitrogen, fluorine, chlorine, bromine and iodine occur naturally as the diatomic molecules of their atoms. Most elements including all metals do not occur as discrete molecules at all but instead consist of extremely large numbers of atoms bonded together. The number of constituent atoms in a given sample of such elements depends only on the size of the sample.

Some elements occur with more than one possible arrangement of the bonds between their constituent atoms, and these different forms are called allotropes. An example is the element carbon which occurs naturally as charcoal, graphite and diamond. The various allotropic modifications of an element normally result in different physical properties and also may have some differing chemical properties.

TUTORIAL QUESTIONS - TOPIC 1.

1. Define the following terms:

    Element
    Atom
    Compound
    Mixture
    Electrolysis
    Chemical change
    Physical change
    Diatomic molecule
    Allotropes
    Molecule
    Monatomic element

2. Give the name of each of the following elements. Avoid looking up the information in Table 2 as much as possible.

Li	....	Ga	....
Al	....	B	....
F	....	Na	....
Ne	....	Ar	....
I	....	S	....
Pb	....	N	....
K	....	Cl	....
Be	....	As	....
He	....	Rn	....
Cs	....	Mg	....
Br	....	Se	....
Ba	....	O	....
P	....	C	....
Kr	....	Ge	....
Tl	....	Te	....
Xe	....	Sr	....
Bi	....	Sn	....
Ca	....	Rb	....
In	....	Si	....
Sb	....		

3. Give the names for each of the following elements.

Mn	....	Ag	....
Fe	....	Cu	....
Ni	....	Zn	....
Cr	....	Pt	....
Au	....	Hg	....
Cd	....	H	....
Cl	....	Br	....
N	....	S	....
P	....	Si	....

4. Write the symbol for each of the following elements.

bromine	....	helium	....
nitrogen	....	oxygen	....
sulfur	....	lithium	....
beryllium	....	rubidium	....
carbon	....	xenon	....
silicon	....	selenium	....
lead	....	antimony	....
neon	....	boron	....
thallium	....	aluminium	....
iodine	....	radon	....
germanium	....	phosphorus	....
sodium	....	magnesium	....
potassium	....	krypton	....
calcium	....	caesium	....
strontium	....	indium	....
tin	....	arsenic	....
bismuth	....	barium	....
gallium	....	chlorine	....
argon	....	fluorine	....

5. The following formulas apply to either an element or to a compound. Write beside each formula "element" or "compound" as appropriate. If the formula is for a compound, write the names of all the component elements in the compound and the number of atoms of each element present in the molecule.

CO_2 ....

I_2 ....

$C_6H_{12}O_6$ ....

Na ....

N_2 ....

SO_2 ....

He ....

B ....

HCN ....

H_2CO_3 ....

H_2SO_4 ....

Cu ....

Pt ....

Al ....

Be ....

SiI_4 ....

PCl_3 ....

Rb ....

H_3PO_4 ....

Ag ....

N_2O_3 ....

As_2O_3 ....

HF ....

ClO_2 ....

Ba ....

Bi ....

6. A sample of some elements will be provided for your inspection during the tutorial session. A competition within the group based on recognition of these elements will be organised.

CHEMICAL CROSSWORD No. 1(a)
ELEMENTS AND THEIR SYMBOLS

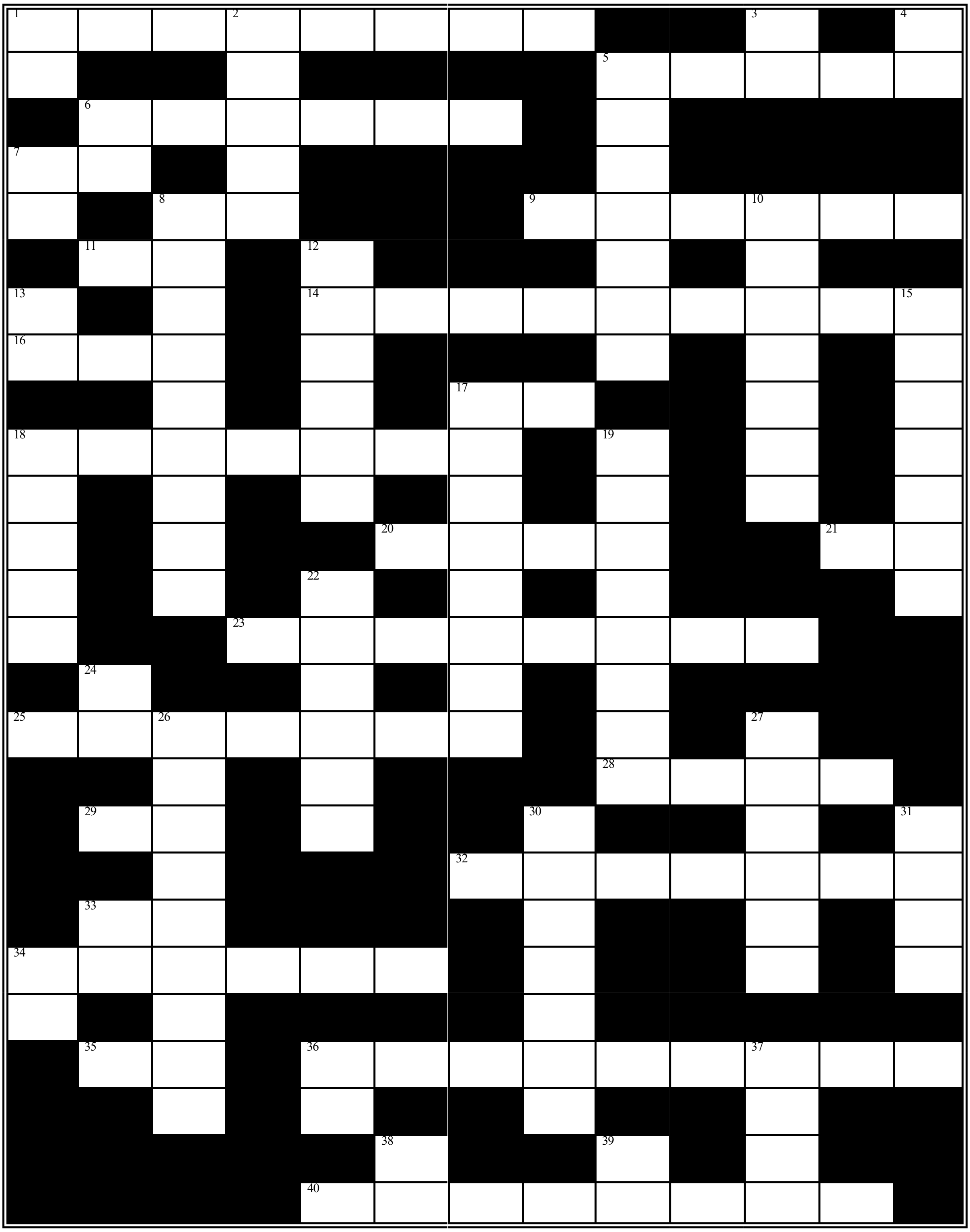
Rules for this crossword:
1. Give the symbol for any element where the name is provided or give the name of the element where a symbol is provided.
2. The symbols must observe proper upper and lower case conventions for chemical symbols.
3. Names may start with an upper case letter only where that letter is the initial letter of a formula to be entered in the other direction on the grid. All other letters in the name must be lower case.

ACROSS
1. N
3. hydrogen
5. Ar
6. I
7. tin
8. manganese
9. He
11. barium
13. phosphorus
14. Al
16. Sn
17. caesium
18. Bi
20. Au
21. chromium
22. iodine
23. Sb
24. sulfur
25. Li
28. Ne
29. aluminium
30. potassium
32. Br
33. copper
34. Ba
35. gold
36. Sr
40. F

DOWN
1. neon
2. Rn
3. mercury
4. zinc
5. As
6. indium
7. strontium
8. Mg
10. Ir
11. boron
12. Ra
13. platinum
15. Hg
17. Cr
18. B
19. H
21. carbon
22. In
24. silicon
26. Te
27. Na
30. Kr
31. Pb
33. calcium
34. bismuth
36. selenium
37. Fe
38. thallium
39. argon

CHEMICAL CROSSWORD No. 1(a)

ELEMENTS AND THEIR SYMBOLS



CHEMICAL CROSSWORD No. 1(b)
ELEMENTS AND THEIR SYMBOLS

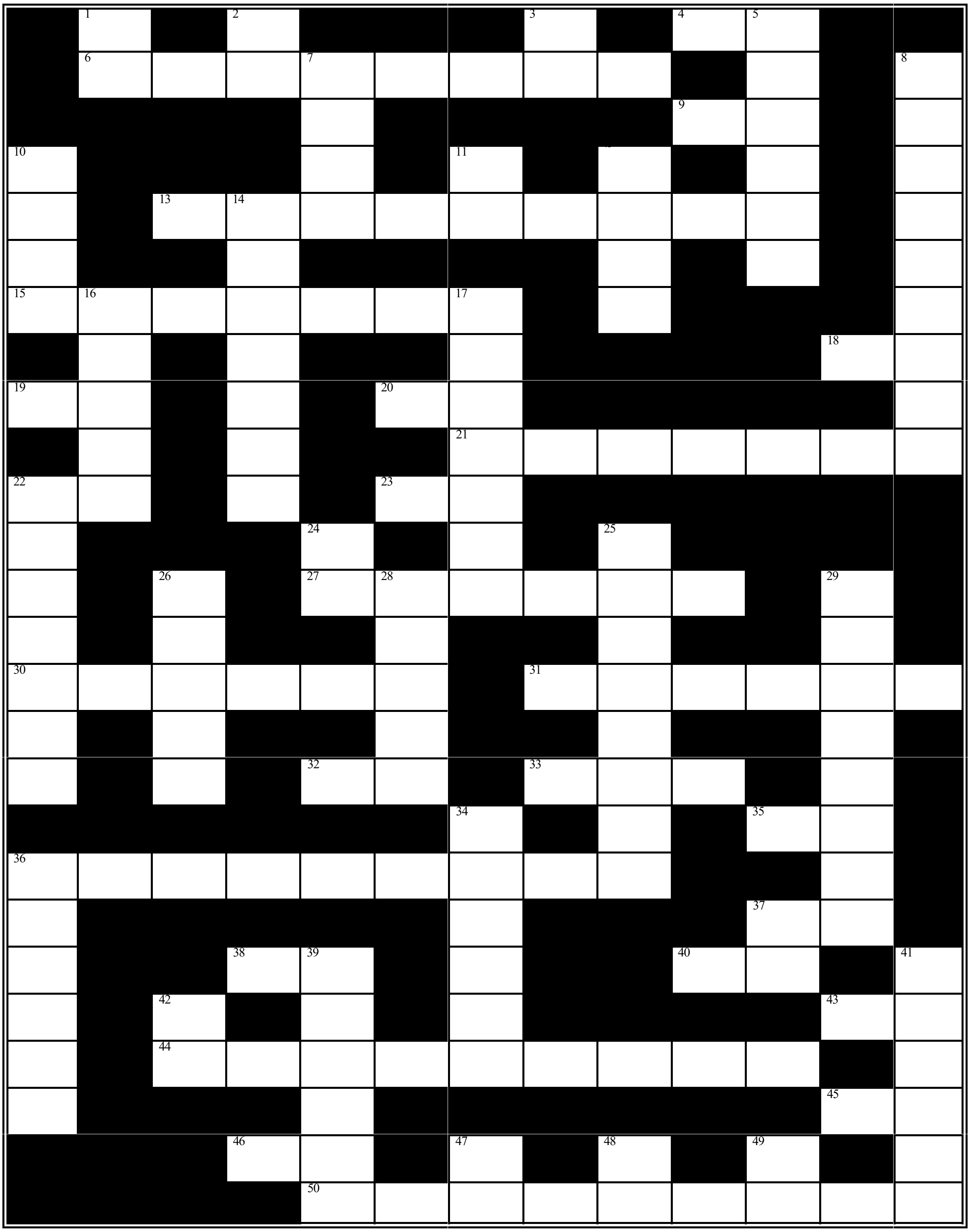
Rules for this crossword:
1. Give the symbol for any element where the name is provided or give the name of the element where a symbol is provided.
2. The symbols must observe proper upper and lower case conventions for chemical symbols.
3. Names may start with an upper case letter only where that letter is the initial letter of a formula to be entered in the other direction on the grid. All other letters in the name must be lower case.

ACROSS
1. nitrogen
2. phosphorus
3. iodine
4. arsenic
6. Sb
9. aluminium
11. carbon
13. Mn
15. Cs
18. silicon
19. silver
20. chromium
21. Ca
22. tin
23. copper
25. sulfur
27. O
30. C
31. He
32. manganese
33. Sn
35. bismuth
36. Sr
37. beryllium
38. antimony
40. strontium
43. radon
44. Be
45. lithium
46. gold
48. hydrogen
50. Mg

DOWN
1. sodium
2. platinum
3. indium
5. Ag
7. Fe
8. Ge
10. Zn
11. calcium
12. Pb
14. As
16. Ar
17. Hg
18. sulfur
22. Si
24. cobalt
25. Se
26. B
28. Xe
29. F
34. Ni
36. Na
37. bromine
39. Ba
41. In
42. rubidium
47. magnesium
48. helium
49. nickel

CHEMICAL CROSSWORD No. 1(b)

ELEMENTS AND THEIR SYMBOLS



ANSWERS TO TUTORIAL TOPIC 1

1. **Element:** A substance that cannot be broken down into simpler component substances by any chemical process.
Atom: The smallest possible unit of an element.
Compound: A substance that contains at least two component elements joined by chemical bonds. A pure compound is always homogeneous and always has the same component atoms joined in the same numerical ratios.
Mixture: Two or more elements or compounds physically mixed, never pure, always heterogeneous. Can be separated by physical methods.
Electrolysis: The process of breaking down compounds into their elements by means of passing a direct electric current through the molten compound or a solution of that compound.
Chemical change: Any interconversion of matter that involves the breaking and making of chemical bonds.
Physical change: Processes other than those involving chemical changes.
Diatomic molecule: Two atoms chemically bonded together to form a molecule.
Allotropes: An element occurring in different forms as a result of different arrangements of their constituent atoms.
Molecule: Two or more atoms of the same or different elements joined together by chemical bonds.
Monatomic element: An element that occurs as single atoms. The only monatomic elements are helium, neon, argon, krypton, xenon and radon.

2.

Li	lithium	Ga	gallium
Al	aluminium	B	boron
F	fluorine	Na	sodium
Ne	neon	Ar	argon
I	iodine	S	sulfur
Pb	lead	N	nitrogen
K	potassium	Cl	chlorine
Be	beryllium	As	arsenic
He	helium	Rn	radon
Cs	caesium	Mg	magnesium
Br	bromine	Se	selenium
Ba	barium	O	oxygen
P	phosphorus	C	carbon
Kr	krypton	Ge	germanium
Tl	thallium	Te	tellurium
Xe	xenon	Sr	strontium
Bi	bismuth	Sn	tin
Ca	calcium	Rb	rubidium
In	indium	Si	silicon
Sb	antimony		

3.

Mn	manganese	Ag	silver
Fe	iron	Cu	copper
Ni	nickel	Zn	zinc
Cr	chromium	Pt	platinum
Au	gold	Hg	mercury
Cd	cadmium	H	hydrogen
Cl	chlorine	Br	bromine
N	nitrogen	S	sulfur
P	phosphorus	Si	silicon

4.

	Symbol		Symbol
bromine	Br	helium	He
nitrogen	N	oxygen	O
sulfur	S	lithium	Li
beryllium	Be	rubidium	Rb
carbon	C	xenon	Xe
silicon	Si	selenium	Se
lead	Pb	antimony	Sb
neon	Ne	boron	B
thallium	Tl	aluminium	Al
iodine	I	radon	Rn
germanium	Ge	phosphorus	P
sodium	Na	magnesium	Mg
potassium	K	krypton	Kr
calcium	Ca	caesium	Cs
strontium	Sr	indium	In
tin	Sn	arsenic	As
bismuth	Bi	barium	Ba
gallium	Ga	chlorine	Cl
argon	Ar	fluorine	F

5.	CO_2	compound; 1 carbon atom + 2 oxygen atoms
	I_2	element
	$C_6H_{12}O_6$	compound; 6 carbon atoms + 12 hydrogen atoms + 6 oxygen atoms
	Na	element
	N_2	element
	SO_2	compound; 1 sulfur atom + 2 oxygen atoms
	He	element
	B	element
	HCN	compound; 1 hydrogen atom + 1 carbon atom + 1 nitrogen atom
	H_2CO_3	compound; 2 hydrogen atoms + 1 carbon atom + 3 oxygen atoms.
	H_2SO_4	compound; 2 hydrogen atoms + 1 sulfur atom + 4 oxygen atoms
	Cu	element
	Pt	element
	Al	element
	Be	element
	SiI_4	compound; 1 silicon atom + 4 iodine atoms
	PCl_3	compound; 1 phosphorus atom + 3 chlorine atoms
	Rb	element
	H_3PO_4	compound; 3 hydrogen atoms + 1 phosphorus atom + 4 oxygen atoms
	Ag	element
	N_2O_3	compound; 2 nitrogen atoms + 3 oxygen atoms
	As_2O_3	compound; 2 arsenic atoms + 3 oxygen atoms
	HF	compound; 1 hydrogen atom + 1 fluorine atom
	ClO_2	compound; 1 chlorine atom + 2 oxygen atoms
	Ba	element
	Bi	element

CHEMICAL CROSSWORD No .1(a)

ELEMENTS AND THEIR SYMBOLS

N	i	t	r	o	g	e	n			H		Z
e			a					a	r	g	o	n
	I	o	d	i	n	e		r				
S	n		o					s				
r		M	n				h	e	l	i	u	m
	B	a		r				n		r		
P		g		a	l	u	m	i	n	i	u	m
t	i	n		d				c		d		e
		e		i		C	s			i		r
b	i	s	m	u	t	h		h		u		c
o		i		m		r		y		m		u
r		u			g	o	l	d			C	r
o		m		I		m		r				y
n			a	n	t	i	m	o	n	y		
	S			d		u		g				
l	i	t	h	i	u	m		e		s		
		e		u				n	e	o	n	
	A	l		m			K			d		l
		l				b	r	o	m	i	n	e
	C	u					y			u		a
B	a	r	i	u	m		p			m		d
i		i					t					
	A	u		S	t	r	o	n	t	i	u	m
		m		e			n			r		
					T			A		o		
				f	l	u	o	r	i	n	e	

CHEMICAL CROSSWORD No.1(b)

ELEMENTS AND THEIR SYMBOLS

	N		P				I		A	s		
	a	n	t	i	m	o	n	y		i		g
				r					A	l		e
z				o		C		l		v		r
i		m	a	n	g	a	n	e	s	e		m
n			r					a		r		a
c	a	e	s	i	u	m		d				n
	r		e			e					S	i
A	g		n		C	r						u
	o		i			c	a	l	c	i	u	m
S	n		c		C	u						
i				C		r		s				
l		b		o	x	y	g	e	n		f	
i		o			e			l			l	
c	a	r	b	o	n		h	e	l	i	u	m
o		o			o			n			o	
n		n		M	n		t	i	n		r	
						n		u		B	i	
s	t	r	o	n	t	i	u	m			n	
o						c				B	e	
d			S	b		k			S	r		i
i		R		a		e					R	n
u		b	e	r	y	l	l	i	u	m		d
m				i							L	i
			A	u		M		H		N		u
				m	a	g	n	e	s	i	u	m

TABLE 1 - ALPHABETIC LIST OF THE ELEMENTS

ELEMENT	SYMBOL	ATOMIC NUMBER	ATOMIC MASS*
Actinium	Ac	89	(227)
Aluminium	Al	13	26.98
Americium	Am	95	(243)
Antimony	Sb	51	121.8
Argon	Ar	18	39.95
Arsenic	As	33	74.92
Astatine	At	85	(210)
Barium	Ba	56	137.3
Berkelium	Bk	97	(247)
Beryllium	Be	4	9.012
Bismuth	Bi	83	209.0
Bohrium	Bh	107	(262)
Boron	B	5	10.81
Bromine	Br	35	79.90
Cadmium	Cd	48	112.4
Calcium	Ca	20	40.08
Californium	Cf	98	(249)
Carbon	C	6	12.01
Cerium	Ce	58	140.1
Caesium	Cs	55	132.9
Chlorine	Cl	17	35.45
Chromium	Cr	24	52.00
Cobalt	Co	27	58.93
Copper	Cu	29	63.55
Curium	Cm	96	(247)
Dubnium	Db	105	(262)
Dysprosium	Dy	66	162.5
Einsteinium	Es	99	(254)
Erbium	Er	68	167.3
Europium	Eu	63	152.0
Fermium	Fm	100	(253)
Fluorine	F	9	19.00
Francium	Fr	87	(223)
Gadolinium	Gd	64	157.3
Gallium	Ga	31	69.72
Germanium	Ge	32	72.59
Gold	Au	79	197.0
Hafnium	Hf	72	178.5
Hassium	Hs	108	(265)
Helium	He	2	4.003
Holmium	Ho	67	164.9
Hydrogen	H	1	1.008
Indium	In	49	114.8
Iodine	I	53	126.9
Iridium	Ir	77	192.2
Iron	Fe	26	55.85
Krypton	Kr	36	83.80
Lanthanum	La	57	138.9
Lawrencium	Lr	103	(257)
Lead	Pb	82	207.2
Lithium	Li	3	6.941
Lutetium	Lu	71	175.0
Magnesium	Mg	12	24.31
Manganese	Mn	25	54.94
Meitnerium	Mt	109	(266)
Mendelevium	Md	101	(256)
Mercury	Hg	80	200.6
Molybdenum	Mo	42	95.94
Neodymium	Nd	60	144.2
Neon	Ne	10	20.18
Neptunium	Np	93	(244)
Nickel	Ni	28	58.70
Niobium	Nb	41	92.91
Nitrogen	N	7	14.01
Nobelium	No	102	(253)
Osmium	Os	76	190.2
Oxygen	O	8	16.00
Palladium	Pd	46	106.4
Phosphorus	P	15	30.97
Platinum	Pt	78	195.1
Plutonium	Pu	94	(242)
Polonium	Po	84	(209)
Potassium	K	19	39.10
Praseodymium	Pr	59	140.9
Promethium	Pm	61	(145)
Protactinium	Pa	91	(231)
Radium	Ra	88	(226)
Radon	Rn	86	(222)
Rhenium	Re	75	186.2
Rhodium	Rh	45	102.9
Rubidium	Rb	37	85.47
Ruthenium	Ru	44	101.1
Rutherfordium	Rf	104	(261)
Samarium	Sm	62	150.4
Scandium	Sc	21	44.96
Seaborgium	Sg	106	(266)
Selenium	Se	34	78.96
Silicon	Si	14	28.09
Silver	Ag	47	107.9
Sodium	Na	11	22.99
Strontium	Sr	38	87.62
Sulfur	S	16	32.07
Tantalum	Ta	73	180.9
Technetium	Tc	43	(98)
Tellurium	Te	52	127.6
Terbium	Tb	65	158.9
Thallium	Tl	81	204.4
Thorium	Th	90	232.0
Thulium	Tm	69	168.9
Tin	Sn	50	118.7
Titanium	Ti	22	47.90
Tungsten	W	74	183.9
Uranium	U	92	238.0
Vanadium	V	23	50.94
Xenon	Xe	54	131.3
Ytterbium	Yb	70	173.0
Yttrium	Y	39	88.91
Zinc	Zn	30	65.39
Zirconium	Zr	40	91.22

*All atomic masses are given to four significant figures. Values in parentheses represent the mass number of the most stable isotope.

TABLE 2 - NAMES AND SYMBOLS OF SOME GROUPS OF ELEMENTS.

hydrogen (H) [not part of any group of elements]

alkali metals	*alkali earth metals*		
lithium (Li)	beryllium (Be)	boron (B)	carbon (C)
sodium (Na)	magnesium (Mg)	aluminium (Al)	silicon (Si)
potassium (K)	calcium (Ca)	gallium (Ga)	germanium (Ge)
rubidium (Rb)	strontium (Sr)	indium (In)	tin (Sn)
caesium (Cs).	barium (Ba)	thallium (Tl)	lead (Pb)

		halogens	*noble gases*
nitrogen (N).	oxygen (O)	fluorine (F)	helium (He)
phosphorus (P)	sulfur (S)	chlorine (Cl)	neon (Ne),
arsenic (As)	selenium (Se)	bromine (Br)	argon (Ar),
antimony (Sb)	tellurium (Te)	iodine (I)	krypton (Kr)
bismuth (Bi)			xenon (Xe)
			radon (Rn)

In addition the following are the more common elements which form part of a much larger group sometimes called "transition elements":
chromium (Cr), manganese (Mn), iron (Fe), nickel (Ni), copper (Cu), zinc (Zn), silver (Ag), cadmium (Cd), platinum (Pt), gold (Au), mercury (Hg).

These groups of elements are often conveniently arranged as shown in the following table.

		H						He
Li	Be		B	C	N	O	F	Ne
Na	Mg		Al	Si	P	S	Cl	Ar
K	Ca	Cr, Mn, Fe, Ni	Ga	Ge	As	Se	Br	Kr
Rb	Sr	Cu, Zn, Ag, Cd	In	Sn	Sb	Te	I	Xe
Cs	Ba	Pt, Au, Hg	Tl	Pb	Bi			Rn