

PRE-TEST

Directions: Circle the letter indicating whether the following statements are either true ("T") or false ("F").

- T F 1. Chemical elements with similar chemical properties are referred to as a "Period."
- T F 2. Atoms are composed of electrons and protons.
- T F 3. Mendeleev organized the known elements into a table based on atomic mass.
- T F 4. Argon is a highly reactive gas.
- T F 5. The rate of a chemical reaction is not affected by the addition of energy.
- T F 6. A chemical reaction is always indicated by the emission of light, heat and bubbles.
- T F 7. In the alkali metals group chemical reactivity increases as you go down the group.
- T F 8. Sodium metal is kept in oil for safe storage, but reacts violently with water.
- T F 9. Chemical formulas are a symbolic description of the type of atoms contained in a substance.
- T F 10. Silicon belongs to the class of elements called metalloids.

GLOSSARY

Alloy – a substance with metallic properties consisting of two or more elements; with few exceptions, these are usually metallic elements

Atomic mass – the mass of 6.02×10^{23} atoms of an element; it is an average of all isotope masses

Atomic mass unit (amu) – $1/12$ the mass of a carbon-12 atom; $1 \text{ amu} = 1.6605402 \times 10^{-24} \text{ g}$

Atomic number – the number of protons in the nucleus of an atom

Covalent bond – a chemical bond between atoms that results when those atoms share one or more electrons

Energy levels – distances from the nucleus of an atom in which electrons may be found

Ionic bond – a chemical bond that is the result of an attraction among positive and negative ions

Ionic compound – a compound in which the components are bonded ionically; they are generally composed of metal and non-metal that have formed as a result of electron transfer

Isotopes – atoms of the same element which have different masses; they have the same number of protons, but different numbers of neutrons in the nucleus

Mass number – the number of protons and neutrons in the nucleus of an atom of the element

Molecular compound – a compound in which the components are bonded covalently; they are composed of non-metal elements sharing electrons

Periodic law – when elements are arranged in order of increasing atomic mass, chemical and physical properties form patterns that repeat at regular intervals (John Newlands first stated this in 1863)

Representative elements – elements which follow the periodic law; most of the first three periods on the periodic table are included; all of the alkali metals, alkali earth metals, halogens and noble gases are representative elements

Transition elements – the elements in the middle of the periodic table, groups 3 to 12

Valence electrons – all electrons in the energy level farthest from the nucleus of an atom

THE FIRST PERIODIC TABLE

Predict the properties of an element with atomic number 118. It would appear below Radon (atomic number 86) on the modern periodic table.

Element 118 will be a member of the noble gases. We can predict that it will not participate in chemical reactions. Noble gases are unreactive under most conditions.

Mendeleev organized the known elements in sequence, according to increasing atomic mass, so that elements with similar chemical properties fell in the same column. He left gaps where no element fit at the time, and predicted the properties of the undiscovered element based on the properties of its neighbours.

Medeleev's 1872 Periodic Table

Group	I	II	III	IV	V	VI	VII	VIII
Formula of Compounds	R_2O	RO	R_2O_3	RO_2 H_4R	R_2O_5 H_3R	RO_3 H_2R	R_2O_7 HR	RO_4
1	H(1)							
2	Li(7)	Be(9.4)	B(11)	C(12)	N(14)	O(16)	F(19)	
3	Na(23)	Mg(24)	Al(27.3)	Si(28)	P(31)	S(32)	Cl(35.5)	
4	K(39)	Ca(40)	_(44)	Ti(48)	V(51)	Cr(52)	Mn(55)	Fe(56), Co(59) Ni(59), Cu(63)
5	[Cu(63)]	Zn(65)	_(68)	_(72)	As(75)	Se(78)	Br(80)	
6	Rb(85)	Sr(87)	?Yt(88)	Zr(90)	Nb(94)	Mo(96)	_(100)	Ru(104), Rh(104) Pd(105), Ag(108)
7	Ag[(108)]	Cd(112)	In(113)	Sn(118)	Sb(122)	Te(125)	I(127)	
8	Cs(133)	Ba(137)	?Di(138)	?Ce(140)				
9								
10			?Er(178)	?La(180)	Ta(182)	W(184)		Os(195), Ir(197) Pt(198), Au(199)
11	[Au(199)]	Hg(200)	Tl(204)	Pb(207)	Bi(208)			
12				Th(231)		U(240)		

Check your understanding of this segment by completing the following. Use the back of the sheet if necessary.

1. Copper, silver and gold have been used by most cultures for jewelry and ornaments. What properties make them suitable for these purposes?

2. How would Mendeleev's periodic table have predicted that these elements (copper, silver and gold) would have similar properties?

EARLY NUCLEAR THEORY

Describe Dalton's model of the atom.

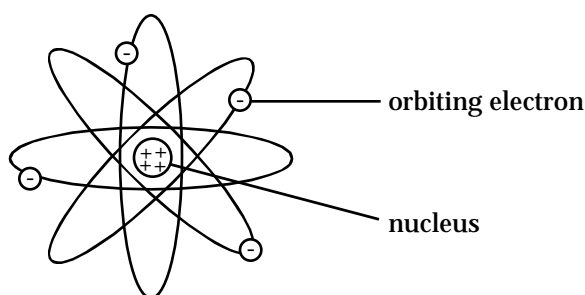
Dalton described the atom as solid and indivisible.

What were the raisins in Thomson's raisin-bun model of the atom?

Electrons are the raisins in Thomson's raisin-bun model.

Rutherford's Model of the Atom – The Nuclear Model

The positive charges (protons) and the mass of the atom are concentrated in the nucleus. The negative charges (electrons) are orbiting the nucleus. Most of the atom is empty space.



Isotopes

Isotopes are atoms of the same element with different masses. They have the same number of protons, but a different number of neutrons, that is, they have the same atomic number but different mass numbers.

The atomic mass of an element, as reported on the periodic table, is the weighted average of all its isotope masses, e.g., carbon = 12.01.

The atomic number is equal to the number of protons in the nucleus of an atom of the element.

The mass number is a whole number equal to the sum of the number of protons and the number of neutrons in the nucleus of an atom of a particular isotope of an element. For most isotopes of an element the rounded off atomic mass equals the mass number.

We can find the number of neutrons in any isotope by subtracting the atomic number from the mass number.

neutrons = mass number - atomic number

Example

Three of more than 10 reported isotopes of the element of carbon are:

carbon-12 (C-12), carbon-13 (C-13) and carbon-14 (C-14)

	C-12	C-13	C-14
atomic mass	12.0000	13.00335	14.0032
mass number	12	13	14
atomic number	6	6	6
number of protons	6	6	6
number of neutrons	6	7	8

EARLY NUCLEAR THEORY

Chromoly, the material used for bicycle frames, is an alloy consisting of chromium and molybdenum. Alloys are a chemical or physical combination of two or more elements with metallic characteristics.

Check your understanding of this segment by completing the following. Use the back of the sheet if necessary.

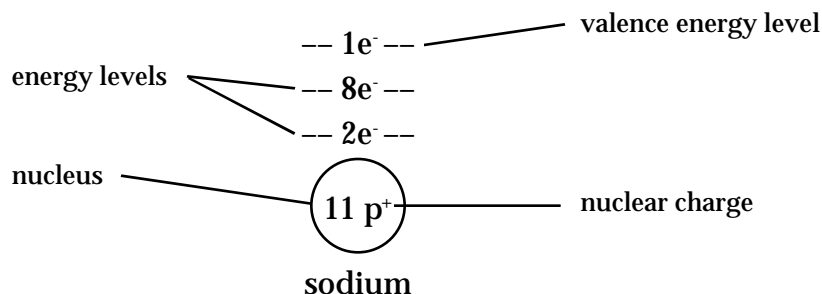
3. What does the atomic number tell us?
4. What does the mass number tell us?
5. Where are neutrons and protons found in an atom?
6. How many protons and neutrons are there in a carbon-14 atom?
7. How many protons and neutrons are there in a potassium-39 atom?
8. Which element has atomic number 13?
9. What is an atomic mass unit?
10. What is the ratio of the mass of a proton to the mass of a neutron?
11. Complete this chart:

Element Name	Symbol	Atomic Number	Number of Protons	Number of Neutrons
lithium	Li	3	3	4
	Al			
		17		
			7	
	Ca			

BOHR'S MODEL OF THE ATOM

The Bohr Model

Energy level diagrams of an atom show the number of protons in the nucleus and electrons in energy levels around it.



When drawing energy level diagrams for neutral atoms:

- The atomic number is the number of protons in the nucleus.
- The atomic number is also equal to the number of electrons.
- Energy levels for the representative elements are filled in order from closest to the nucleus.
- The maximum number of electrons that can occupy the first three energy levels are:

8 e⁻

8 e⁻

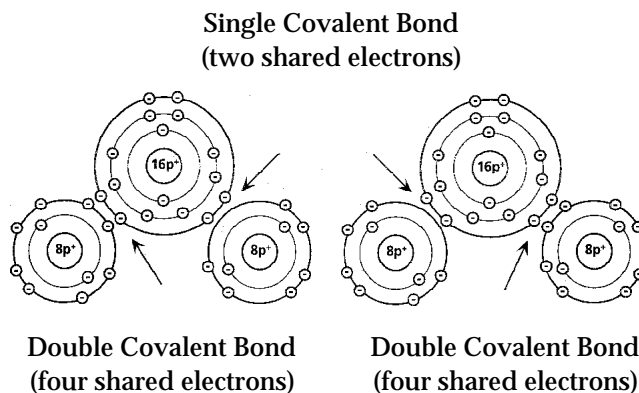
2 e⁻

18p⁺

Sulfur Dioxide

Sulfur dioxide is a product of the combustion of sulfur-containing fossil fuels and the roasting of iron ore. Volcanic eruptions are a natural source of SO_{2(g)}. Once released into the atmosphere, SO_{2(g)} becomes a contributing factor to acid rain. Today, flue gases are treated before they are released into the atmosphere to remove most of the SO_{2(g)}. The remaining products are used to produce sulfuric acid.

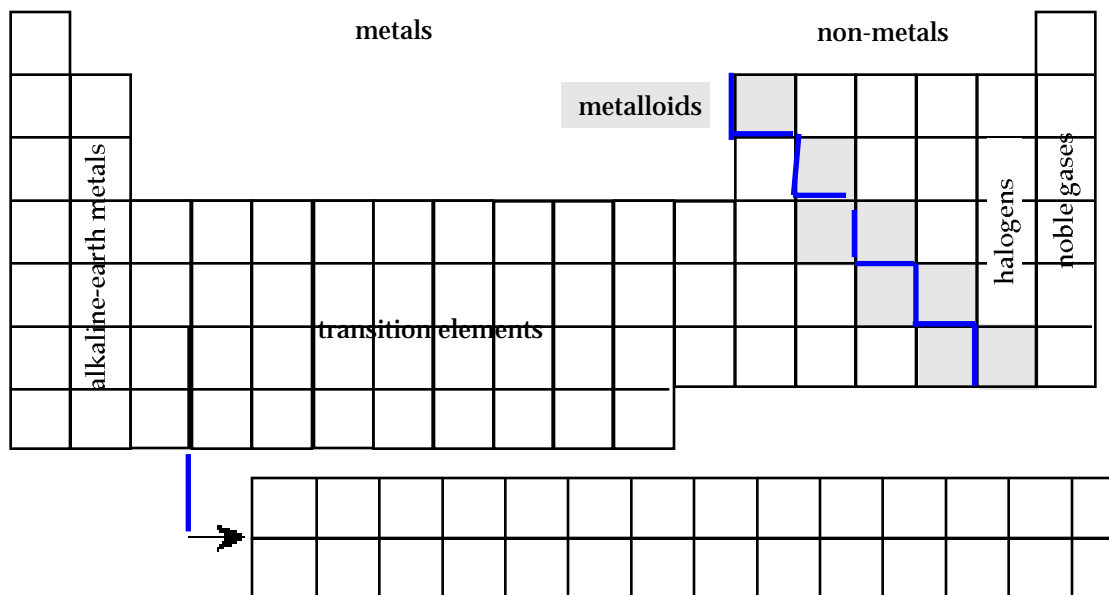
Sulfur dioxide is an important industrial, commercial and research chemical. It also illustrates a peculiar bonding structure called resonance. Scientists believe that a sulfur dioxide molecule would alternate between the two molecular arrangements shown in the following diagram:



EXPLORING THE MODERN PERIODIC TABLE

Have a copy of the periodic table available.

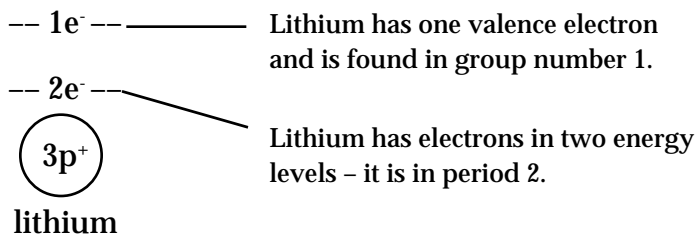
Review the meaning of groups and periods on the periodic table.



The period number and group number on the periodic table give information about the structure of atoms. Group numbers indicate the number of valence electrons*, and period numbers indicate the number of occupied energy levels.

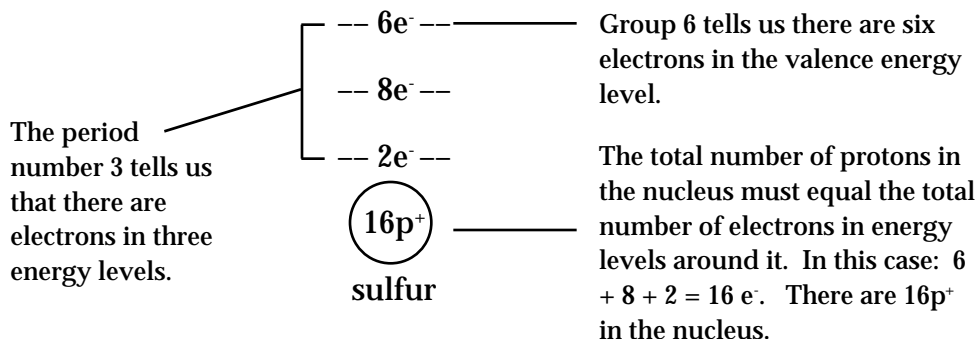
Example

This is the energy level diagram for lithium, which has atomic number 3. In which group and in which period would you expect to find lithium?



EXPLORING THE MODERN PERIODIC TABLE

Sulfur is found in group number 6 and period 3. Draw the energy level diagram for sulfur.



* Note: For elements in the first three periods (except helium) the last digit of the group number indicates the number of valence electrons.

Check your understanding of this segment by completing the following. Use the back of the sheet if necessary.

15. Draw energy level diagrams for boron, carbon, aluminum and silicon atoms.

16. How many energy levels are occupied for atoms of the following elements: phosphorus, arsenic and antimony?

17. How many valence electrons do each of the following atoms have: hydrogen, calcium, chlorine?

18. Name the element in period 2 which has six valence electrons.

USING THE MODERN PERIODIC TABLE

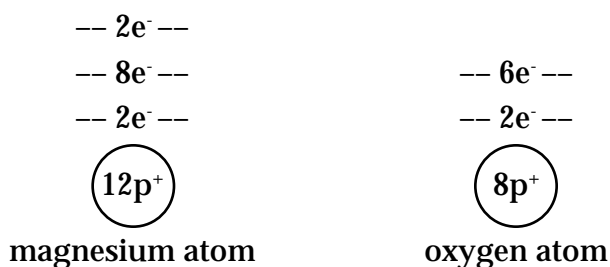
4a

When elements react, they combine in various fixed proportions. Generally atoms will react until the valence energy levels are filled or emptied. That allows us to predict the products of a chemical reaction.

Examples

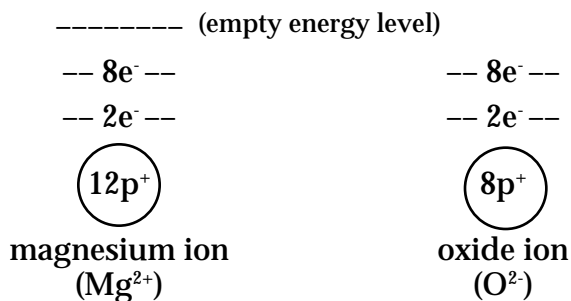
- When magnesium ribbon is burned it reacts with oxygen from the air, producing a bright flash of light and white ash.

Predict the product when magnesium and oxygen react.



From the diagrams we can see magnesium has two valence electrons. Oxygen has six valence electrons.

When a metal reacts with a non-metal, electrons are transferred. Magnesium will transfer its two valence electrons to a single oxygen atom. When electrons are transferred atoms become charged – they become ions.

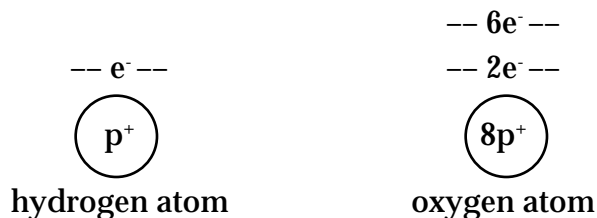


Both species now have filled valence energy levels. The product, the ionic compound magnesium oxide, MgO_(s), contains magnesium ions and oxide ions in a ratio of 1:1.

USING THE MODERN PERIODIC TABLE

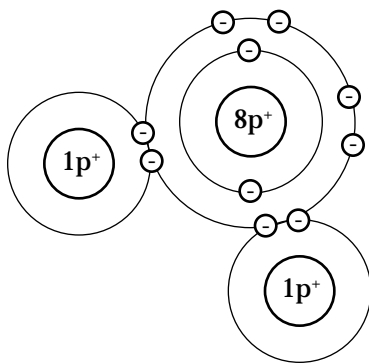
2. Hydrogen fuel cells are considered a potential source of energy in the future. In these cells hydrogen reacts with oxygen from the air.

Predict the product when hydrogen and oxygen react.



When non-metals react they share electrons. Oxygen must share two electrons to fill its valence energy level. Hydrogen atoms have only one electron. So, for oxygen to fill its valence energy level, it must combine with two hydrogen atoms.

The product of oxygen and hydrogen, the molecular compound $\text{H}_2\text{O}_{(g)}$, will include two hydrogen atoms and one oxygen atom.



Check your understanding of this segment by completing the following. Use the back of the sheet if necessary.

19. In general, what kinds of elements will form alloys?
20. If the following pairs of elements react, would an ionic or a covalent bond form?
 - a. hydrogen + sulfur
 - b. potassium + chlorine
 - c. iron + fluorine
 - d. nitrogen + oxygen
21. Predict the product when lithium and chlorine react.
22. Predict the product when beryllium and chlorine react.
23. Predict the product when nitrogen and fluorine react.
24. Explain why aluminum will not react with magnesium.
25. Explain why hydrogen fuel cells might be less harsh on the environment than burning gasoline in a car engine.

POST-TEST

MULTIPLE CHOICE

Directions: Decide which of the choices best completes the statement or answers the question, then circle the letter that corresponds to your choice. (3 marks each)

1. The periodic law was first stated by
 - a. John Dalton
 - b. John Newlands
 - c. Dmitry Mendeleev
 - d. Julius Lothar Meyer

2. Mendeleev predicted that an unknown element, which he called eka-silicon, will fill one of the gaps in his periodic table. The element which took eka-silicon's place is
 - a. carbon
 - b. aluminum
 - c. phosphorus
 - d. germanium

3. The existence of the neutron was confirmed by
 - a. J.J. Thomson
 - b. Henry Moseley
 - c. James Chadwick
 - d. Ernest Rutherford

4. The bond formed between non-metallic elements is a(n)
 - a. ionic bond
 - b. covalent bond
 - c. hydrogen bond
 - d. polar covalent bond

POST-TEST

LONG ANSWER

Directions: Answer the following questions in the spaces provided. Use the back of the sheet if necessary.

1. Rutherford found that the mass of an atom was concentrated in the _____ charged _____ . (6 marks)
2. The atomic number of an element is equal to the number of _____ in the _____ . (6 marks)
3. On the modern periodic table the elements are ordered according to their _____ . (3 marks)
4. The Rutherford model of the atom contributed a great deal to our understanding of matter but it failed to explain why elements had _____ . (4 marks)
5. Neils Bohr modified Rutherford's model of the atom. Describe these modification and the physical theory he used to support his atomic model. (6 marks)
6. In chemical reactions metals are considered electron _____ because they tend to _____ . (6 marks)
7. Compounds consisting of non-metallic atoms are formed when the atoms _____ electrons forming _____ . (6 marks)
8. An neutral atom of carbon-14, an isotope of carbon, has _____ electrons, _____ protons and _____ neutrons. (6 marks)
9. The "Group A" elements on the modern periodic table are referred to as the representative elements because they _____ .
Of the specially named groups, they include _____ , _____ , and the _____ . (11 marks)
10. Based on its position on the periodic table, a neutral selenium atom has _____ occupied electron energy levels and _____ valence electrons. (4 marks)

POST-TEST

11. One strontium atom and one oxygen atom react to form a compound. Describe how these atoms are bonded into one entity and give the name of the type of compound formed. (6 marks)
12. Draw an electron energy-level diagram of the following: (8 marks)
- magnesium atom
- fluorine atom
13. During a chemical reaction atoms rearrange their _____ electrons in order to become _____. (6 marks)
14. The group of elements that titanium, manganese, iron and mercury belong to are called the _____. (3 marks)
15. Cesium-133, a naturally occurring isotope of cesium has _____ protons and _____ neutrons in its nucleus. (4 marks)
16. Chlorine and iodine belong to the _____ family of elements. (3 marks)