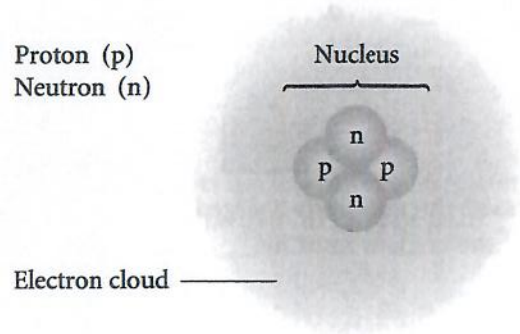
# Atomic Structure 1

## ELEMENTARY PARTICLES

Atoms are made up of several components. Collectively these components are called the *elementary particles*. We will be discussing the three major elementary particles: *protons, neutrons,* and *electrons*.

Here is a diagram of an atom:




**1**

The protons (p) and the neutrons (n) are packed together in an inner core called the _____. The outer part of the atom, which contains electrons, is called the _____.

**nucleus; electron cloud**

**a negative electrical charge, because the electron cloud consists of electrons**

## 2

The electron cloud has a negative electrical charge. What type of charge would you expect the electron to have? _____

_____

**a. repel**
**b. attract**
**c. repel**
**d. attract**

## 3

The electron has a *negative electrical charge* and is symbolized by $e^-$. Remember that *like* electrical charges repel each other and *unlike* charges attract.

Indicate whether the following pairs of charges would attract or repel each other.

a. ⊕ ⊕ _____ b. ⊖ ⊕ _____

c. ⊖ ⊖ _____ d. ⊕ ⊖ _____

**positive**

## 4

The nucleus attracts the negatively charged electrons. Therefore, the overall charge of the nucleus must be _____ (negative/positive).

**proton**

## 5

The neutron was named for its electrical characteristics. It has no electrical charge; it is neutral. In other words, the positive charge of the nucleus must be due to the *second type of particle* it contains. This second type of particle is the _____.

**2**

egative electrical charge. What type of charge
ron to have? _____

_____

**3**

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cal charges repel each other and *unlike*

wing pairs of charges would attract or repel

b. ⊖ ⊕ _____

d. ⊕ ⊖ _____

**4**

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us must be _____ (negative/positive).

**5**

or its electrical characteristics. It has no
ral. In other words, the positive charge of
the *second type of particle* it contains. This
he _____.

**6**

So far, then, we have this picture of atomic structure:

a. An atom consists of an inner part, or _____, that is made up of _____ and _____.

b. The electron has what type of charge? _____

c. The proton has what type of charge? _____

d. The neutron has a charge of _____.

**7**

The charge on the electron balances the charge on the proton. If the electron has a charge of –1, then the proton would have a charge of _____ (−1, +1, ±1).

**8**

An atom with one proton in its nucleus and one electron outside that nucleus would therefore have an overall charge of _____ (+1, −1, 0).

**9**

Atoms are electrically neutral. Therefore, an atom will contain: (check one)

__ more protons than electrons
__ more electrons than protons
__ an equal number of protons and electrons

**a. nucleus; protons; neutrons**
**b. negative**
**c. positive**
**d. zero (0)**

**+1**

**0**

**an equal number of protons and electrons**

12

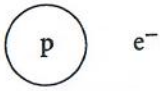
## 10

An atom with 12 protons in the nucleus would have how many electrons outside the nucleus? _____

a. proton
b. electron

## 11

The atom with the simplest atomic structure is hydrogen. For simplicity we shall merely indicate the electron(s) outside the nucleus and omit the electron cloud.




Hydrogen

a. The nucleus of the hydrogen atom consists of one _____.

b. The outer part of the atom, the electron cloud, contains one _____.

2; 2; 2

## 12

The helium atom is a little more complicated.


Helium

It contains: (how many?)

_____ neutrons
_____ protons
_____ electrons

**10**

n the nucleus would have how many electrons

_____

**11**

:t atomic structure is hydrogen. For simplicity
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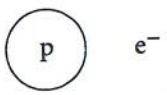


Hydrogen

drogen atom consists of one _____.

atom, the electron cloud, contains one

**12**

: more complicated.


Helium



# ATOMIC NUMBER

There are over 100 known elements. Each element has two numbers associated with it, numbers that give certain facts about the structure of its atoms.

The first number is the *atomic number*. The atomic number is the number of protons in the nucleus of the atom.

**13**

Hydrogen, the simplest atom, contains only one proton, so the atomic number of hydrogen is _____.

**1**

**14**

Uranium is the most complicated of the elements that occur naturally. A uranium atom contains 92 protons, 146 neutrons, and 92 electrons. The atomic number of uranium is _____.

**92**

**15**

An atom of magnesium, atomic number 12, must have a nucleus containing _____ protons.

If the nucleus contains 12 protons, then there must be how many electrons? _____

**12; 12**

**16**

Therefore, the atomic number of an element indicates the number of _____ in the nucleus of the atom and also the number of _____ outside the nucleus.

**protons; electrons**

# MASS NUMBER*

The second number associated with each atom is the *mass number*. The mass number expresses the sum of the masses of the particles in the atom.

A proton has a mass of 1 dalton. An electron is considered to have zero mass, or a mass of 0.

1

**17**

A hydrogen atom has a mass of _____. (If you don't know, see problem 11.)

a. 2
b. 0
c. 2
d. 1

**18**

The helium atom has a mass number of 4.

a. The 2 protons in the helium atom have a total of how many daltons? _____

b. The 2 electrons in the helium atom have a total of how many daltons? _____

c. Therefore, for the helium atom to have a mass number of 4, the 2 neutrons must contain how many daltons? _____

d. If 2 neutrons have a total of 2 daltons, a neutron must have an atomic mass of _____.

* The *atomic mass* of an atom is the weighted average of the masses of its isotopes (see the later section on isotopes). The atomic mass of an atom is a decimal value, as shown in the periodic table on the inside front cover of this book. The *mass number* of an atom is a whole number and is equal to the sum of protons and neutrons in that atom.

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**17**

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**18**

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helium atom have a total of how many

_

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_

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_____.

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**19**

Because the electrons, which have practically no mass, are located outside the nucleus, the entire mass of the atom can be considered to be located:

__ in its electron cloud __ in the nucleus

**20**

The *atomic number* indicates the number of protons (each with atomic mass 1) inside the nucleus of an atom. The *mass number* indicates the number of protons and neutrons (each with atomic mass 1) in the nucleus. Therefore, the number of neutrons can be determined by *subtracting* the atomic number from the mass number.

The sodium atom has a mass number of 23 and an atomic number of 11. The number of neutrons in the nucleus of the sodium atom is _____.

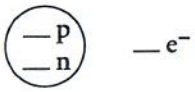
**21**

The carbon atom has an atomic number of 6 and a mass number of 12. The carbon atom contains: (how many?)

_____ protons in its nucleus
_____ neutrons in its nucleus
_____ electrons outside its nucleus

**22**

The element phosphorus has an atomic number of 15 and a mass number of 31. Indicate on the blank lines in the diagram the number of protons, neutrons, and electrons.

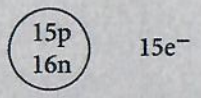



Phosphorus

in the nucleus

12

6; 6; 6



12p
12n

$12e^-$

92; 238

a.

6p
6n

$6e^-$

Carbon-12

## 23

Diagram the structure of the magnesium atom, atomic number 12 and mass number 24.

Magnesium

## 24

The uranium atom has the atomic structure shown here.

92p
146n

$92e^-$

Uranium

Therefore, the uranium atom has an atomic number of _____ and a mass number of _____.

# ISOTOPES

## 25

a. Draw the structure of a carbon atom, atomic number 6 and mass number 12.

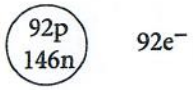
**23**

the magnesium atom, atomic number 12 and

Magnesium

**24**

e atomic structure shown here.




Uranium

om has an atomic number of _____ and _____.

## ISOTOPES

**25**

a carbon atom, atomic number 6 and mass



b. Draw the structure of a carbon atom, atomic number 6 and mass number 13.

**26**

Here are the structures you drew for the two carbon atoms:


Carbon-12 Carbon-13

a. These atoms have _____ (the same/different) atomic number(s).

b. These atoms have _____ (the same/different) mass number(s).

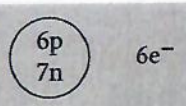
Such atoms are called *isotopes.*

**27**

Isotopes, then, may be defined as atoms that have:

__ the same atomic number and the same mass number
__ different atomic numbers
__ different mass numbers and the same atomic number

**b.**




Carbon-13

**a. the same**
**b. different**

**different mass numbers and the same atomic number**

a. 17p 18n 17e⁻

Chlorine-35

b. 17p 20n 17e⁻

Chlorine-37

a. 1p 1e⁻

Hydrogen-1

b. 1p 1n 1e⁻

Hydrogen-2

c. 1p 2n 1e⁻

Hydrogen-3

**a. same**
**b. different**

## 28

Draw the two isotopes of chlorine, atomic number 17 and mass numbers 35 and 37.

a. chlorine-35 b. chlorine-37

## 29

Draw the three isotopes of hydrogen, atomic number 1 and mass numbers 1, 2, and 3.

a. hydrogen-1 b. hydrogen-2 c. hydrogen-3

## 30

*Radioisotopes*, isotopes that give off radiation, are frequently used in medical applications. I-131 (radioactive iodine, also written as $^{131}I$) is used in the diagnosis and treatment of thyroid conditions. How does I-131, radioactive iodine, compare with I-127, nonradioactive iodine, in:

a. atomic number _____

b. mass number _____

# ELECTRON ENERGY LEVELS

The electrons are located outside of the nucleus of the atom. These electrons make up the electron cloud, which may be subdivided into different energy levels. The first energy level is nearest the nucleus; then comes the second energy level, the third energy level, and so on.

Each energy level can hold a certain maximum number of electrons. This maximum number may be determined by using the formula $X = 2n^2$ ($X$ is the maximum number of electrons in energy level number $n$).

**31**

Using the formula $X = 2n^2$, if $n = 1$, then $X =$ _____. The energy level indicated by $n = 1$ is the first energy level. Therefore, the first energy level can hold a maximum of _____ electrons.

2; 2

**32**

a. Can the first energy level hold fewer than two electrons? _____

b. Can the first energy level hold more than two electrons? _____

a. yes
b. no

**33**

For the second energy level, where $n = 2$, the maximum number of electrons is _____.

8

**34**

a. The maximum number of electrons in the third energy level is _____.

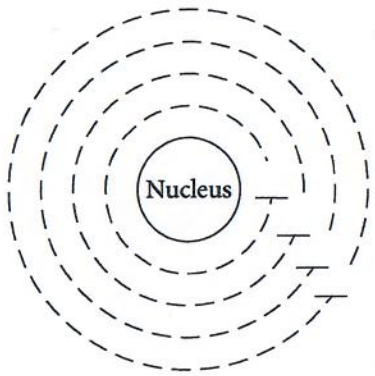
b. The maximum number of electrons in the fourth energy level is _____.

a. 18
b. 32

$2e^-$ in the first energy level; $8e^-$ in the second energy level; $18e^-$ in the third energy level; $32e^-$ in the fourth energy level

## 35

Label the maximum number of electrons possible in each energy level in the diagram.




8

## 36

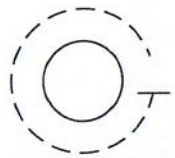
The following rules must be observed when considering the placement of electrons in the various energy levels. The first energy level must be filled with 2 electrons before electrons can go into the second energy level.

The second energy level must be filled with _____ electrons before electrons can go into the third energy level.

For elements having more than three energy levels, the sequence of filling those levels is complex and can be found in a general chemistry text.

## 37

On the diagram, show the structure of the hydrogen atom, atomic number 1 and mass number 1.



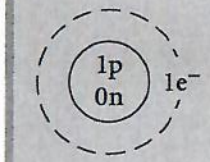
Hydrogen atom

a. The number of protons in the hydrogen atom is _____.

b. The number of neutrons is _____.

c. The number of electrons is _____.

d. The 1 electron in the hydrogen atom must go into which energy level: first, second, or third? _____

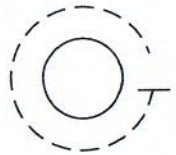



Hydrogen atom

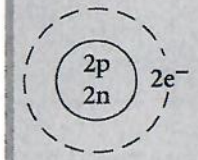
**a. 1**
**b. 0**
**c. 1**
**d. first**

## 38

In the space provided, draw the structure of the helium atom, atomic number 2 and mass number 4.



Helium atom




Helium atom

a. 3
b. 4
c. 3

## 39

Now let's look at the structure for the lithium atom, atomic number 3 and mass number 7.

a. The number of protons in the lithium atom is _____.

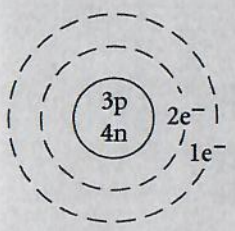
b. The number of neutrons in the lithium atom is _____.

c. The number of electrons in the lithium atom is _____.

2

## 40

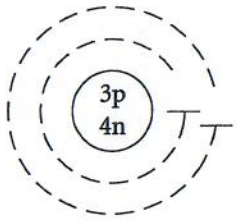
There are 3 electrons in the lithium atom. How many energy levels will the lithium atom have? _____ (If you aren't sure, check problem 36.)




Lithium atom

## 41

Complete the diagram of the lithium atom.




Lithium atom

## 42

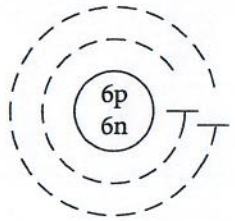
The carbon atom has atomic number 6 and mass number 12.

a. The carbon atom contains _____ protons.

b. The carbon atom contains _____ neutrons.

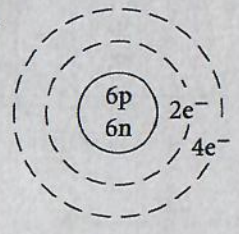
c. The carbon atom contains _____ electrons.

d. Complete the structure of the carbon atom.




Carbon atom

**a. 6**
**b. 6**
**c. 6**
**d.**




Carbon atom

## 43

a. In the element sodium, atomic number 11, there are how many electrons? _____

b. How many energy levels will the sodium atom have? _____

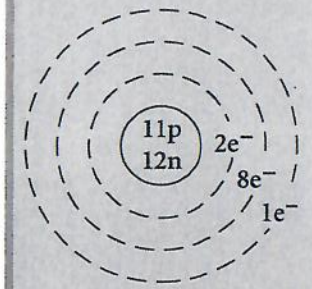
c. How many electrons will each energy level of the sodium atom have?

1st energy level __ 2nd energy level __ 3rd energy level __

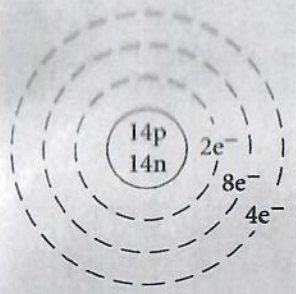
d. Diagram the complete structure of the sodium atom, atomic number 11 and mass number 23.


Sodium atom

**a. 11**
**b. 3**
**c. 2; 8; 1**




Sodium atom




Silicon atom

## 44

Diagram the structure of the silicon atom, atomic number 14 and mass number 28.