



### Electron Configurations of Elements

Each **element** has a characteristic electron **configuration**.

The simplest elements are hydrogen and helium:

- Hydrogen (H):  $1s^1$
- Helium (He):  $1s^2$



### Lesson Objectives

By the end of this lesson, you should be able to:

- Relate the **position** of an element in the periodic table to its electron configuration.
- Use the periodic table to determine the number of valence electrons available for bonding.

**Science Practice:** Analyze the relationship between electron configurations and the **structure** of the periodic table.

**Words to Know**

Write the letter of the definition next to the matching word as you work through the lesson. You may use the glossary to help you.

- |                             |  |
|-----------------------------|--|
| <u>C</u> noble-gas notation | A. the electrons that are found in the inner shells or lowest energy levels of an atom and not involved in reactions with other atoms  |
| <u>A</u> core electrons     | B. the electrons that are found in the outermost shell or highest energy levels of an atom and are responsible for determining the reactivity of the atom                    |
| <u>B</u> valence electrons  | C. a shorthand notation for writing the electron configuration for an element; substitutes the symbol of a noble gas to represent the configuration of inner shell electrons |
| <u>F</u> s-block elements   | D. the elements in which the final electron used to fill orbitals occupies a <i>d</i> orbital; transition elements in Groups 3 to 12   |
| <u>G</u> p-block elements   | E. the elements in which the final electron used to fill orbitals occupies an <i>f</i> orbital; inner transition elements  |
| <u>D</u> d-block elements   | F. the elements in which the final electron used to fill orbitals occupies an <i>s</i> orbital; elements in Groups 1 and 2   |
| <u>E</u> f-block elements   | G. the elements in which the final electron used to fill orbitals occupies a <i>p</i> orbital; elements in Groups 13 to 18   |

## Instruction

## Electrons and the Periodic Table

Slide

1

## Lesson Question

How can the periodic table be used to understand the arrangement of electrons in an atom?

2

## The First Ten Elements and Noble-Gas Configuration

## Noble-gas notation

- Substitutes the **symbol** of a noble gas to represent the configuration of inner shell electrons
- Shorthand **notation** for writing the electron configuration for an element

Element	Electron Configuration
Hydrogen (H)	$1s^1$
Helium (He)	$1s^2$
Lithium (Li)	$1s^2 2s^1$
Beryllium (Be)	$1s^2 2s^2$
Boron (B)	$1s^2 2s^2 2p^1$
Carbon (C)	$1s^2 2s^2 2p^2$
Nitrogen (N)	$1s^2 2s^2 2p^3$
Oxygen (O)	$1s^2 2s^2 2p^4$
Fluorine (F)	$1s^2 2s^2 2p^5$
Neon (Ne)	$1s^2 2s^2 2p^6$

## Instruction

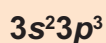
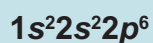
## Electrons and the Periodic Table

Slide

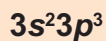
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## Core and Valence Electrons in Periods 1-3

Example:

Phosphorus ( P )

[Ne]



core

valence

Periods 1, 2, and 3

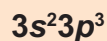
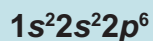
- Highest  $n$  orbitals = **valence**

**electrons**

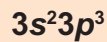
- Electrons found in the outermost shell or highest energy levels of an atom and responsible for determining the reactivity of the atom
- Most reactive and participate in bonding

Example:

Phosphorus (P)



[Ne]



core

valence

Periods 1, 2, and 3

- All interior orbitals/non valence = **core electrons**

- Electrons found in the inner shells or lowest energy levels of an atom and not involved in reactions with other atoms
- Stable and nonreactive
- Group number related to number of valence electrons
- Noble gases : full valence shell
- Stable configuration (2 or 8)

## Instruction

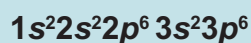
## Electrons and the Periodic Table

Slide

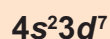
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## Core and Valence Electrons in Periods 4+

Example:

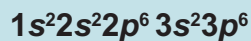
Cobalt (  $\text{Co}$  )

core



valence

Arsenic (As)



core



valence

Periods 4 and higher

- $s$  and  $p$  orbitals with highest  $n$  = valence electrons
- Partially filled  $d$  and  $f$  orbitals = valence electrons
- Full  $d$  and  $f$  orbitals = core electrons

9

## Pathway of Filling Orbitals with Electrons

The order of filling orbitals is determined by the  $\text{energies}$  of the orbitals.

- Electrons always fill in order of increasing orbital energy.
- Trace the pathway of electron filling from left to  $\text{right}$  in the periodic table.

Pathway of Filling Orbitals with Electrons

1 H Hydrogen 1.01																	2 He Helium 4.00																
3 Li Lithium 6.94	4 Be Beryllium 9.01	s-block										p-block						10 Ne Neon 20.18															
11 Na Sodium 22.99	12 Mg Magnesium 24.31	d-block										f-block						18 Ar Argon 39.95															
19 K Potassium 39.10	20 Ca Calcium 40.08	21 Sc Scandium 44.96	22 Ti Titanium 47.87	23 V Vanadium 50.94	24 Cr Chromium 52.00	25 Mn Manganese 54.94	26 Fe Iron 55.85	27 Co Cobalt 58.93	28 Ni Nickel 58.69	29 Cu Copper 63.55	30 Zn Zinc 65.39	31 Ga Gallium 69.72	32 Ge Germanium 72.61	33 As Arsenic 74.92	34 Se Selenium 78.96	35 Br Bromine 79.90	36 Kr Krypton 83.80																
37 Rb Rubidium 85.47	38 Sr Strontium 87.62	39 Y Yttrium 88.91	40 Zr Zirconium 91.22	41 Nb Niobium 92.91	42 Mo Molybdenum 95.94	43 Tc Technetium 98.00	44 Ru Ruthenium 101.07	45 Rh Rhodium 102.91	46 Pd Palladium 106.42	47 Ag Silver 107.87	48 Cd Cadmium 112.41	49 In Indium 114.82	50 Sn Tin 118.71	51 Sb Antimony 121.76	52 Te Tellurium 127.60	53 I Iodine 126.90	54 Xe Xenon 131.29																
55 Cs Cesium 132.91	56 Ba Barium 137.33	57-71 Lanthanides		72 Hf Hafnium 178.49	73 Ta Tantalum 180.95	74 W Tungsten 183.84	75 Re Rhenium 186.21	76 Os Osmium 190.23	77 Ir Iridium 192.22	78 Pt Platinum 195.08	79 Au Gold 196.97	80 Hg Mercury 200.59	81 Tl Thallium 204.38	82 Pb Lead 207.20	83 Bi Bismuth 208.98	84 Po Polonium 209	85 At Astatine 209	86 Rn Radon 222.02															
87 Fr Francium 223.00	88 Ra Radium 226.00	89-103 Actinides		104 Rf Rutherfordium 261.00	105 Db Dubnium 262.00	106 Sg Seaborgium 266.00	107 Bh Bohrium 264.00	108 Hs Hassium 277.00	109 Mt Meitnerium 268.00	110 Ds Darmstadtium 281.00	111 Rg Roentgenium 272.00	112 Cn Copernicium 285.00	113 Uut Ununtrium 284.00	114 Fl Flerovium 289.00	115 Uup Ununpentium 288.00	116 Lv Livermorium 291.00	117 Uus Ununseptium Unknown	118 Uuo Ununoctium 294.00															
																			57 La Lanthanum 138.91	58 Ce Cerium 140.12	59 Pr Praseodymium 140.91	60 Nd Neodymium 144.24	61 Pm Promethium 144.91	62 Sm Samarium 150.36	63 Eu Europium 151.97	64 Gd Gadolinium 157.25	65 Tb Terbium 158.93	66 Dy Dysprosium 162.50	67 Ho Holmium 164.93	68 Er Erbium 167.26	69 Tm Thulium 168.93	70 Yb Ytterbium 173.04	71 Lu Lutetium 174.97
																			89 Ac Actinium 227.00	90 Th Thorium 232.04	91 Pa Protactinium 231.04	92 U Uranium 238.03	93 Np Neptunium 237.00	94 Pu Plutonium 244.00	95 Am Americium 243.00	96 Cm Curium 247.00	97 Bk Berkelium 247.00	98 Cf Californium 251.00	99 Es Einsteinium 252.00	100 Fm Fermium 257.00	101 Md Mendelevium 258.00	102 No Nobelium 259.00	103 Lr Lawrencium 262.00

Hydrogen has one electron in the **1s** orbital. Then you go to the right to continue adding the next electron to make **helium** ( $1s^2$ ). Moving from **left** to right along each row, the pattern of filling **atomic** orbitals is provided by the labels shown on the periodic table.

s-Block, p-Block, d-Block, and f-Block Elements

Notice the **different** colors used to make this periodic table image. These colors designate different regions of the periodic table that correspond to atomic **orbitals**. The regions include the s-block elements, **p**-block elements, d-block elements, and f-block elements.

Each **element** has an identity as an s-block, p-block, d-block, or f-block element.

## Instruction

## Electrons and the Periodic Table

Slide

9

**s-Block Elements**

The elements in the **blue** region are known as the s-block elements.

The s-block elements are groups in which the final electron used to fill the orbitals occupies an s orbital, and these are elements in **Groups** 1 and 2.

**Valence** electrons in these elements, which are the electrons in the highest energy levels and most **reactive** electrons, are located in the s orbitals.

The last electron to be added to an **s-block element** goes into an s orbital.

12

**p-Block Elements**

The p-block elements are elements in which the final electron used to **fill** orbitals occupies a p orbital. And these are elements in Groups 13 through 18.

Valence electrons in the p-block elements are located in both the **s** and p orbitals.

The **last** electron to be added to a **p-block element** goes into a p orbital.

**p-Block Elements Beyond Period 3**

p-Block elements in periods **4** or higher have valence electrons in **d** orbitals as well as s and p orbitals.

The p-block elements in the first three **rows** are very straightforward to analyze, because their valence electrons occupy s and p orbitals only.

## Instruction

## Electrons and the Periodic Table

Slide

14

**d-Block Elements**

The elements in the **green** region are known as the *d*-block elements. The *d*-block elements are elements in which the final electron used to fill **orbitals** occupies a *d* orbital. **Transition** elements in Groups 3 through 12 are *d* block.

The last electron to be added to a ***d*-block element** goes into an *d* orbital.

16

**f-Block Elements**

These are **inner** transition elements. **Valence** electrons in *f*-block elements are located in the *s* and *f* orbitals.

The **last** electron to be added to an ***f*-block element** goes into an *f* orbital.

18

**Exceptions**

Chromium

- Predicted:  $[\text{Ar}]4s^23d^4$
- Actual:  $[\text{Ar}]$   **$4s^1$**   $3d^5$ 
  - The *s* and *d* that are exactly **half-filled** seems to be more stable.
- Mainly **transition** metals

As in many situations in chemistry, there are exceptions to the general pattern of **filling** orbitals.

## Summary

## Electrons and the Periodic Table

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## Lesson Question

How can the periodic table be used to understand the arrangement of electrons in an atom?

✓

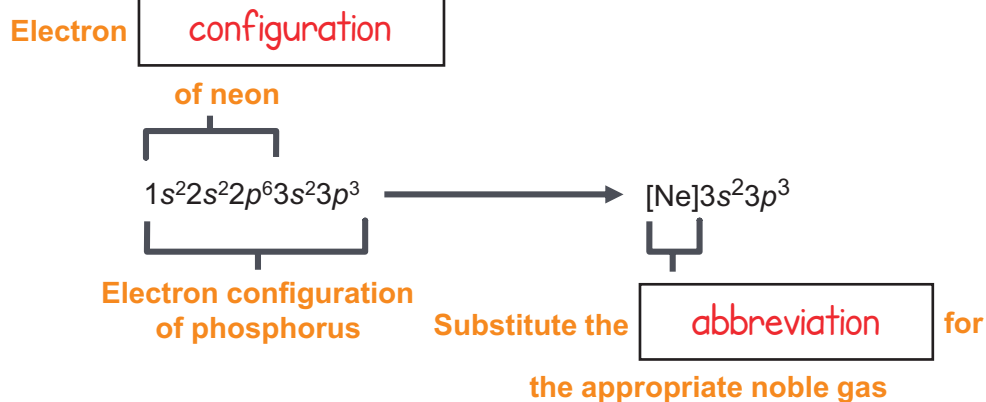
## Answer

(Sample answer) The periodic table is divided into four different blocks: *s*-block, *p*-block, *d*-block, and *f*-block elements. The elements in these blocks are classified on the basis of electron arrangement in an atom.

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2

## Noble-Gas Notation



# Summary

## Electrons and the Periodic Table

Slide

2

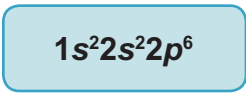
### Core Electrons and Valence Electrons

Core electrons

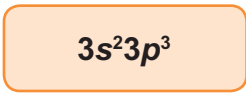
- Found in the lowest energy levels of an atom
- Correspond to those of a

noble

gas and are generally nonreactive



core



valence

Valence electrons

- Found in the highest energy levels of an atom
- **Outermost** electrons; responsible for the atom's reactivity

### Using the Periodic Table to Determine Electron Configuration

Any element's electron configuration can be determined by keeping in mind that electrons fill orbitals in order of their increasing **energy**.

The sequence of orbital filling follows a left to **right** pattern across each row on the periodic table.



# Summary

## Electrons and the Periodic Table

*Use this space to write any questions or thoughts about this lesson.*