مدارس التكنولوجيا التطبيقية
Applied Technology Schools

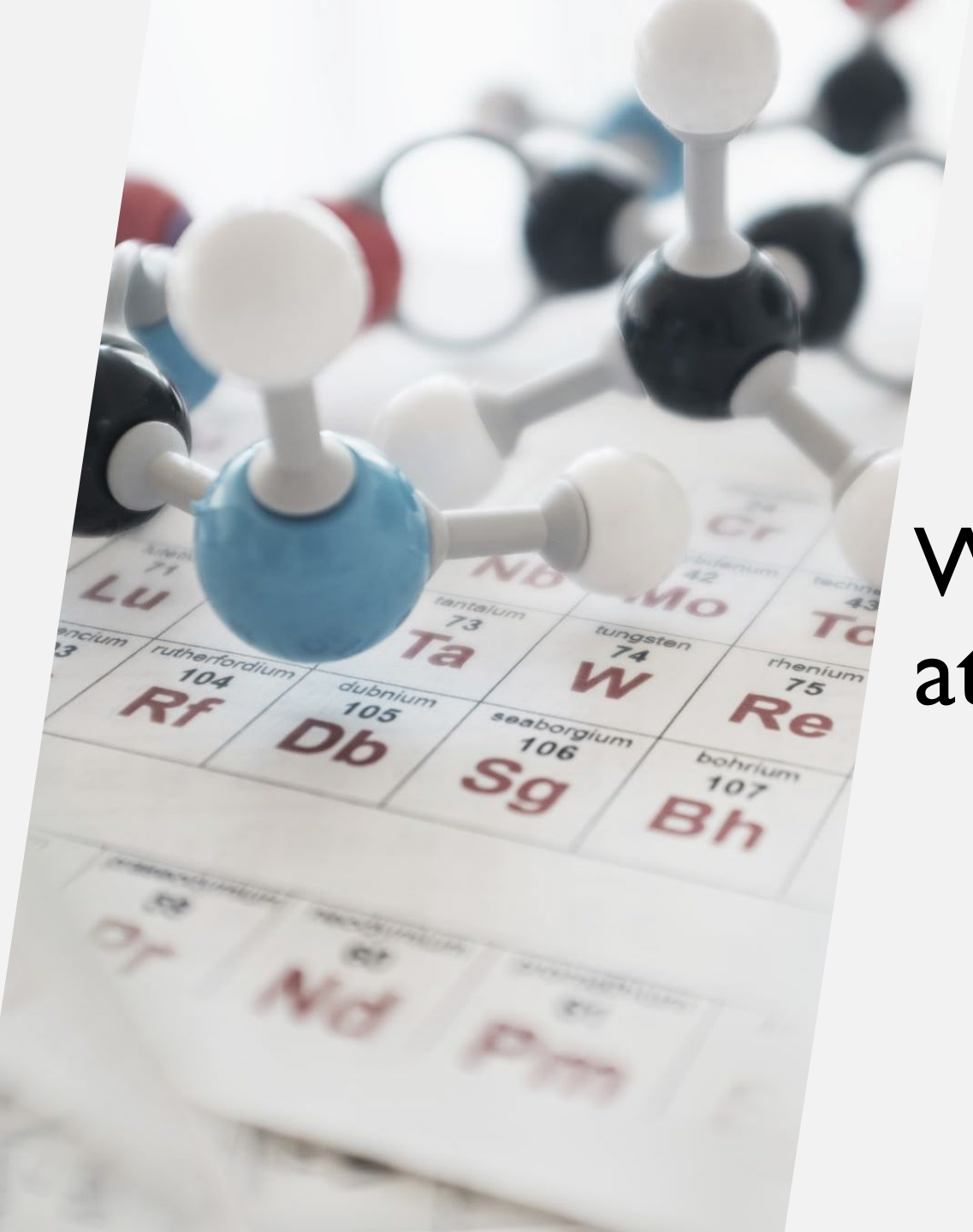
TOPIC 1: ELECTRONS IN ATOMS

LESSON 1.1: QUANTUM THEORY AND ATOMS

Week 1:
Grade 10 ADV

Time: 50 minutes

Period 1

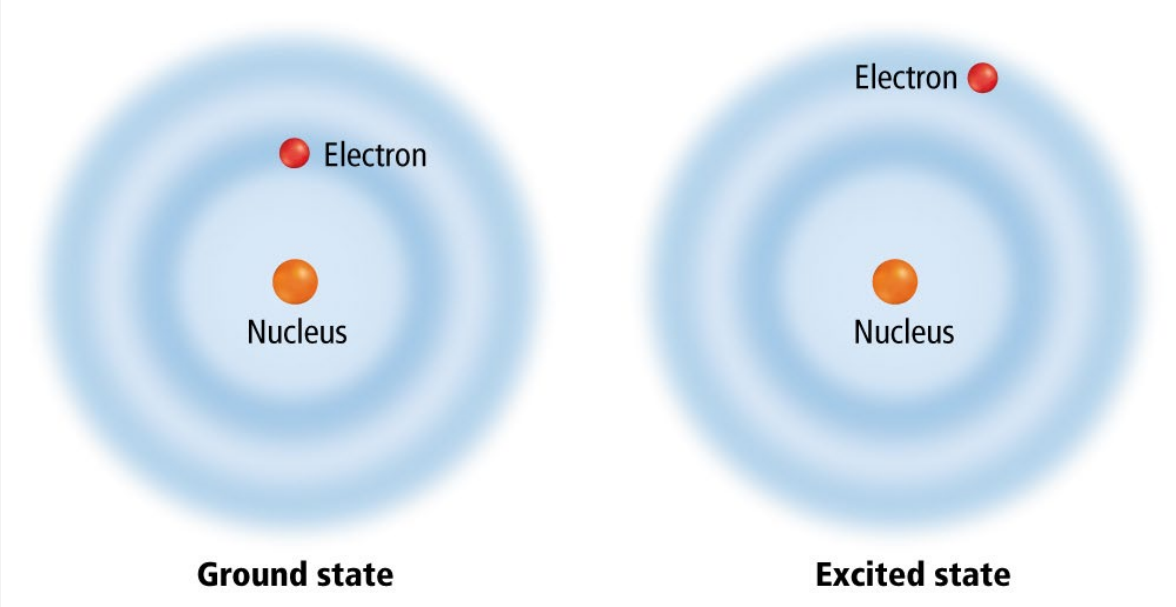


What do you know about atoms?

LET`S WATCH THE FOLLOWING VIDEO TOGETHER

KPI 1.1.1: Describe Bohr's model of the hydrogen atom according to the quantum mechanical theory.

- Niels Bohr, a physicist correctly predicted the frequency lines in hydrogen's atomic emission spectrum.
- The lowest allowable energy state of an atom is called its **ground state**.
- When an atom gains energy, it is in an **excited state.**
- Bohr suggested that an electron moves around the nucleus only in certain allowed circular orbits.



KPI 1.1.1: Describe Bohr's model of the hydrogen atom according to the quantum mechanical theory.

- **Bohr** suggested that the electron in a hydrogen atom moves around the nucleus in only certain allowed circular orbits.

  The larger the electron's orbit, the higher the atom's energy state, or energy level.

  Bohr assigned a number, **n, called a quantum number**, to each orbit.
  He also calculated the radius of each orbit.

Table 1 Bohr's Description of the Hydrogen Atom

Bohr's Atomic Orbit	Quantum Number	Orbit Radius (nm)	Corresponding Atomic Energy Level	Relative Energy
First	$n = 1$	0.0529	1	E_1
Second	$n = 2$	0.212	2	$E_2 = 4E_1$
Third	$n = 3$	0.476	3	$E_3 = 9E_1$
Fourth	$n = 4$	0.846	4	$E_4 = 16E_1$
Fifth	$n = 5$	1.32	5	$E_5 = 25E_1$
Sixth	$n = 6$	1.90	6	$E_6 = 36E_1$
Seventh	$n = 7$	2.59	7	$E_7 = 49E_1$

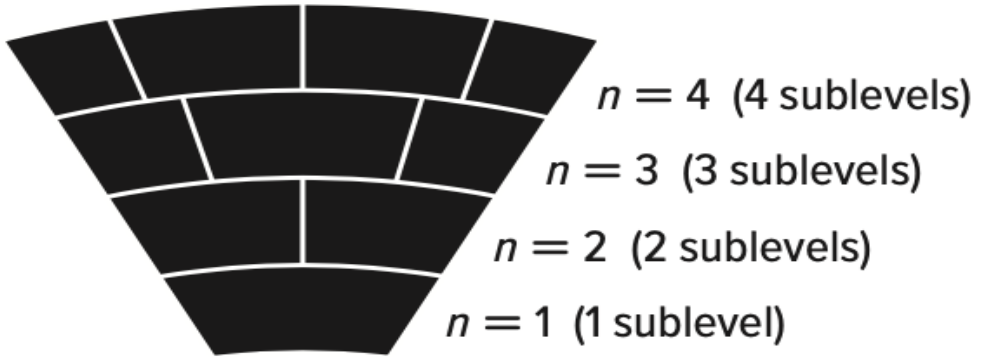
KPI 1.1.2: Explain what energy levels and energy sublevels mean.

- **Energy levels:** The Bohr atomic model assigns quantum numbers to electron orbits that indicate the relative size and energy of atomic orbitals.

Therefore, n specifies the atom's Principal energy levels.

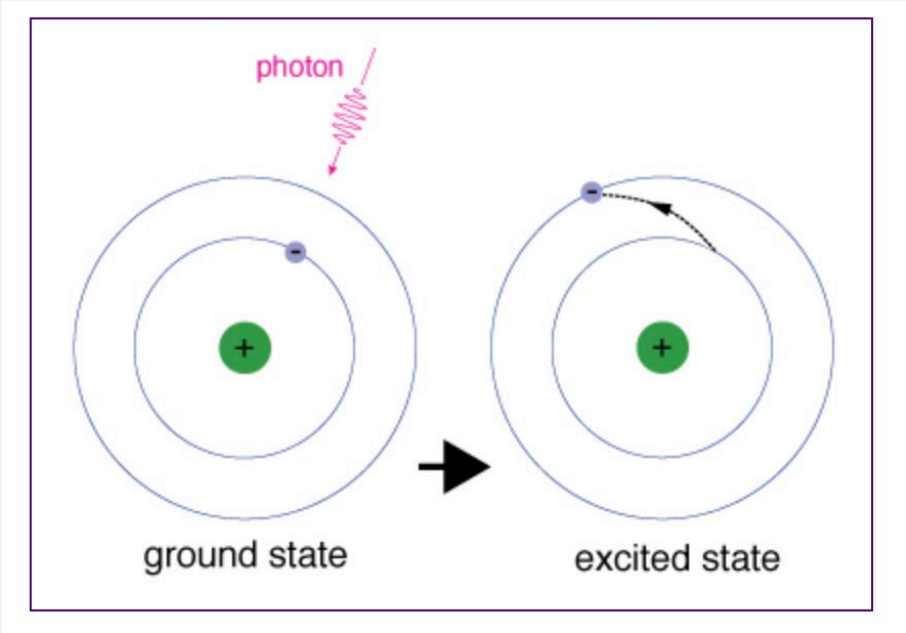
- **Energy sublevels** are contained within the principal energy levels, designated by letters **(s,p,d,f).**

- **Principal energy level 1 consists of a single sublevel (s)**
- **principal energy level 2 consists of two sublevels (s, p)**
- **principal energy level 3 consists of three sublevels (s, p, d)**
- **principal energy level 4 consists of four sublevels (s, p, d, f)**



KPI 1.1.3: Differentiate between the ground and excited states of an atom.

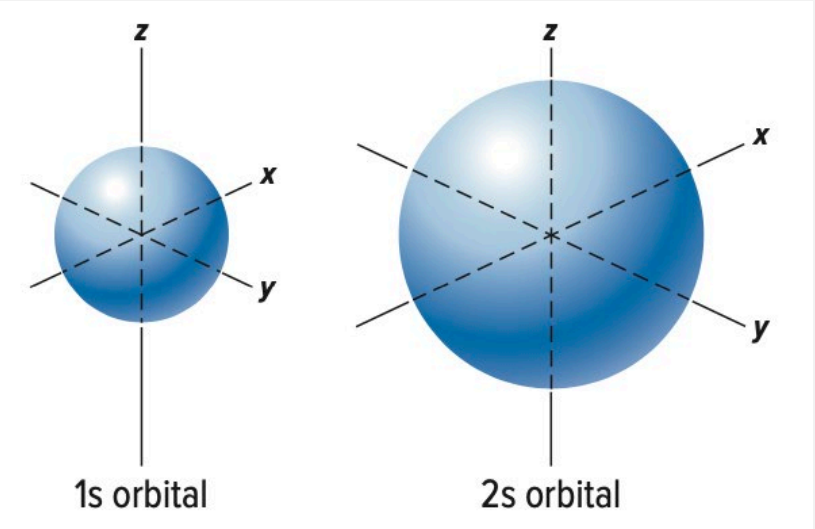
- Hydrogen with the lowest energy possible has a single electron in the *n* = 1 orbit in **the ground state.**
- When energy is added, the electron moves to the *n* = 2 orbit to be in the **excited state.**



KPI 1.1.4: Describe the atomic orbitals and their shapes.

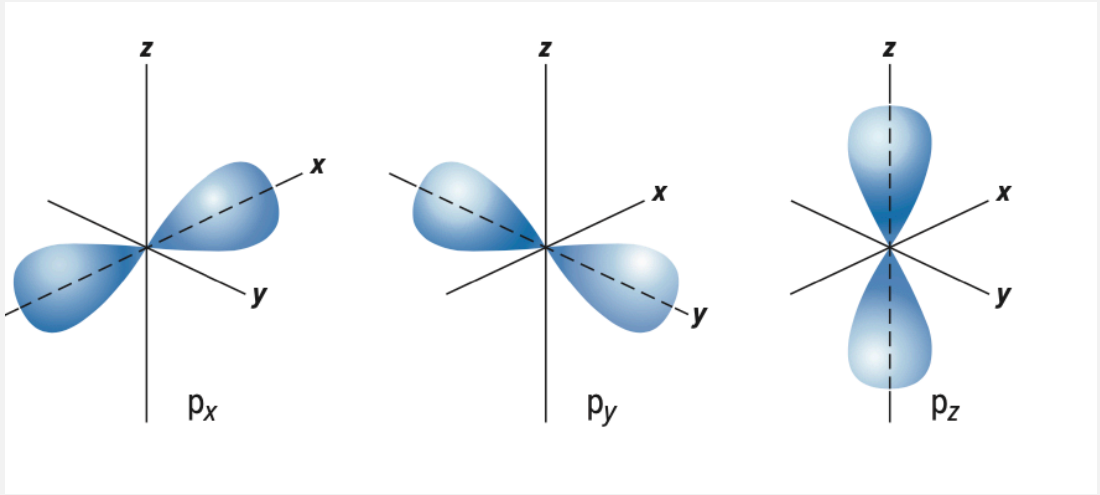
Sublevels s, p, d, or f are labeled according to the shapes of the atom's orbitals.

All s orbitals are spherical. and their size increases with increasing principal quantum number.



All p orbitals are dumbbell-shaped.

- The p sublevel corresponds to three dumbbell-shaped p orbitals designated p_x , p_y , and p_z .



KPI 1.1.5: Analyze the relationship between the principal quantum number (n) and the distance between an atom's electron and the nucleus. Explain how an increase in the value of n corresponds to a larger atomic size.

(n) indicates the relative size and energy of atomic orbitals.

As n increases, the orbital becomes larger, the electron spends more time farther from the nucleus, and **the atom's energy and radius increase.**

Bohr's Atomic Orbit	Quantum Number	Orbit Radius (nm)
First	$n = 1$	0.0529
Second	$n = 2$	0.212
Third	$n = 3$	0.476
Fourth	$n = 4$	0.846
Fifth	$n = 5$	1.32
Sixth	$n = 6$	1.90
Seventh	$n = 7$	2.59

KPI 1.1.6: Apply the concept of the principal quantum number to determine the energy state of an electron in an atom. Describe how n=1 represents the innermost electron shell, corresponding to the ground state of an electron.

- **Principal Quantum Number (n):** The value of n determines:
- **Energy of the electron** → larger n, higher energy.
- **The distance of the electron from the nucleus** → larger n, farther from the nucleus.
- Maximum number of **orbitals** in that energy level →n^2.
- Maximum number of **electrons** that can occupy that level → $2n^2$.
- **In Case of n=1**
  The electron is in the first energy level, also called the **innermost shell.**
  closest to the nucleus.
- Electrons here have the lowest possible energy.
  This corresponds to the ground state of an electron — the most stable arrangement.

KPI 1.1.7: Evaluate the process of absorption and emission of energy by electrons in terms of changes in the principal quantum number. Explain how electrons transition between energy levels by absorbing or emitting photons, resulting in changes in the value of n.

1- Absorption of Energy: When an atom absorbs energy (from a photon, light, or heat). An electron can move from a lower energy level to a higher energy level. (n=1 to n=3)

2- Emission of Energy: When an excited electron falls back to a lower energy level, it loses energy.

This lost energy is released as a photon of light with energy equal to the difference between the two levels. (n=3→n=1)

•**Summary:**
Absorption: n increases → electron moves farther from nucleus → photon absorbed.

•**Emission:** n decreases → electron moves closer to nucleus → photon emitted.

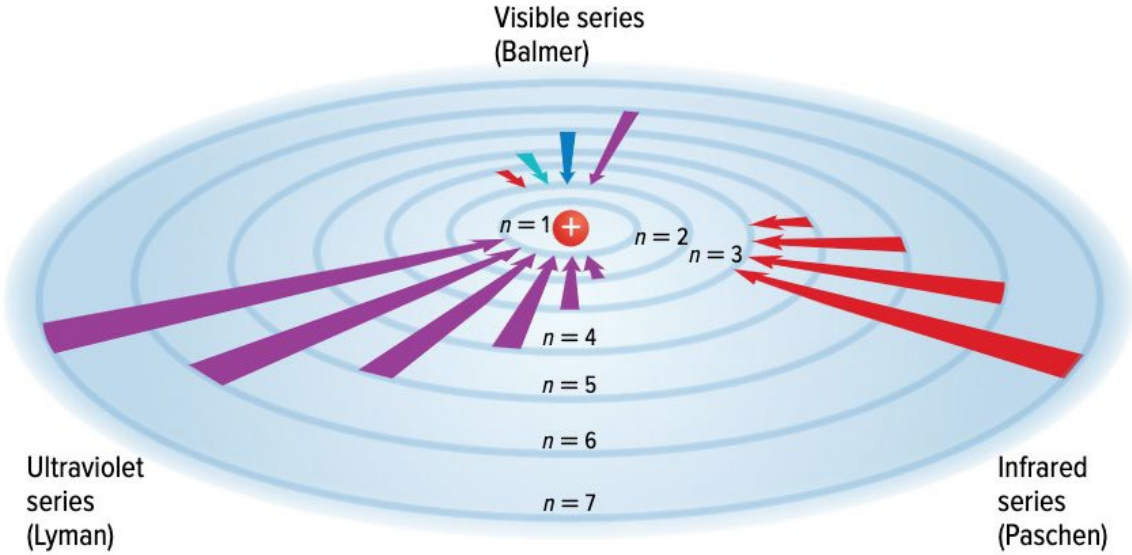


Figure 11 When an electron drops from a higher-energy orbit to a lower-energy orbit, a photon is emitted. The ultraviolet (Lyman), visible (Balmer), and infrared (Paschen) series correspond to electrons dropping to $n = 1$, $n = 2$, and $n = 3$, respectively.

- **KPI 1.1.7: Evaluate the process of absorption and emission of energy by electrons in terms of changes in the principal quantum number.**

Explain how electrons transition between energy levels by absorbing or emitting photons, resulting in changes in the value of n.

GROUP WORK:

DETERMINE THE NUMBER OF ORBITALS AND THE MAXIMUM NUMBER OF ELECTRONS IN THE FIRST FIVE ENERGY LEVELS OF AN ATOM.

Energy Level	Number of orbitals	Number of Electrons	Sublevels

GROUP WORK:

DETERMINE THE NUMBER OF ORBITALS AND THE MAXIMUM NUMBER OF ELECTRONS IN THE FIRST FIVE ENERGY LEVELS OF AN ATOM.

- **KPI 1.1.7: Evaluate the process of absorption and emission of energy by electrons in terms of changes in the principal quantum number. Explain how electrons transition between energy levels by absorbing or emitting photons, resulting in changes in the value of n.**

KPI 1.1.8: Calculate the number of orbitals and electrons in the energy levels.

Number of orbitals: use the formula n^2

Number of electrons: use the formula $2n^2$

Where n is the number of energy levels

Energy level, n	Number of orbitals, n^2	Number of electrons, $2n^2$
1	1	2
2	4	8
3	9	18
4	16	32
5	25	50
6	36	72

How many orbitals and electrons are in the fourth energy level?

KPI 1.1.9: Relate the principal quantum number to the total number of orbitals of the principal energy levels and the number of orbitals in sub-energy levels

- The number of orbitals related to each sublevel is always an odd number.
- The maximum number of orbitals related to each principal energy level is n^2.

Summary of Principle Energy Levels and Sublevels			
Principle Quantum Number *(n)*	**Sublevels (Types of Orbital Present)**	**Number of orbitals related to sublevel**	**Total number of orbitals related to Principle Energy Level *(n^2)***
$n = 1$	*s*	1 orbital (1*s*)	1
$n = 2$	*s* *p*	1 orbital (2*s*) 3 orbitals (2*p*)	4
$n = 3$	*s* *p* *d*	1 orbital (3*s*) 3 orbitals (3*p*) 5 orbitals (3*d*)	9
$n = 4$	*s* *p* *d* *f*	1 orbital (4*s*) 3 orbitals (4*p*) 5 orbitals (4*d*) 7 orbitals (4*f*)	16

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Bronze: Compare the ground state and the excited state.

Silver: Differentiate and draw the shape of s and p orbitals

Gold: Describe how the photon is going to be emitted during the electron transition.

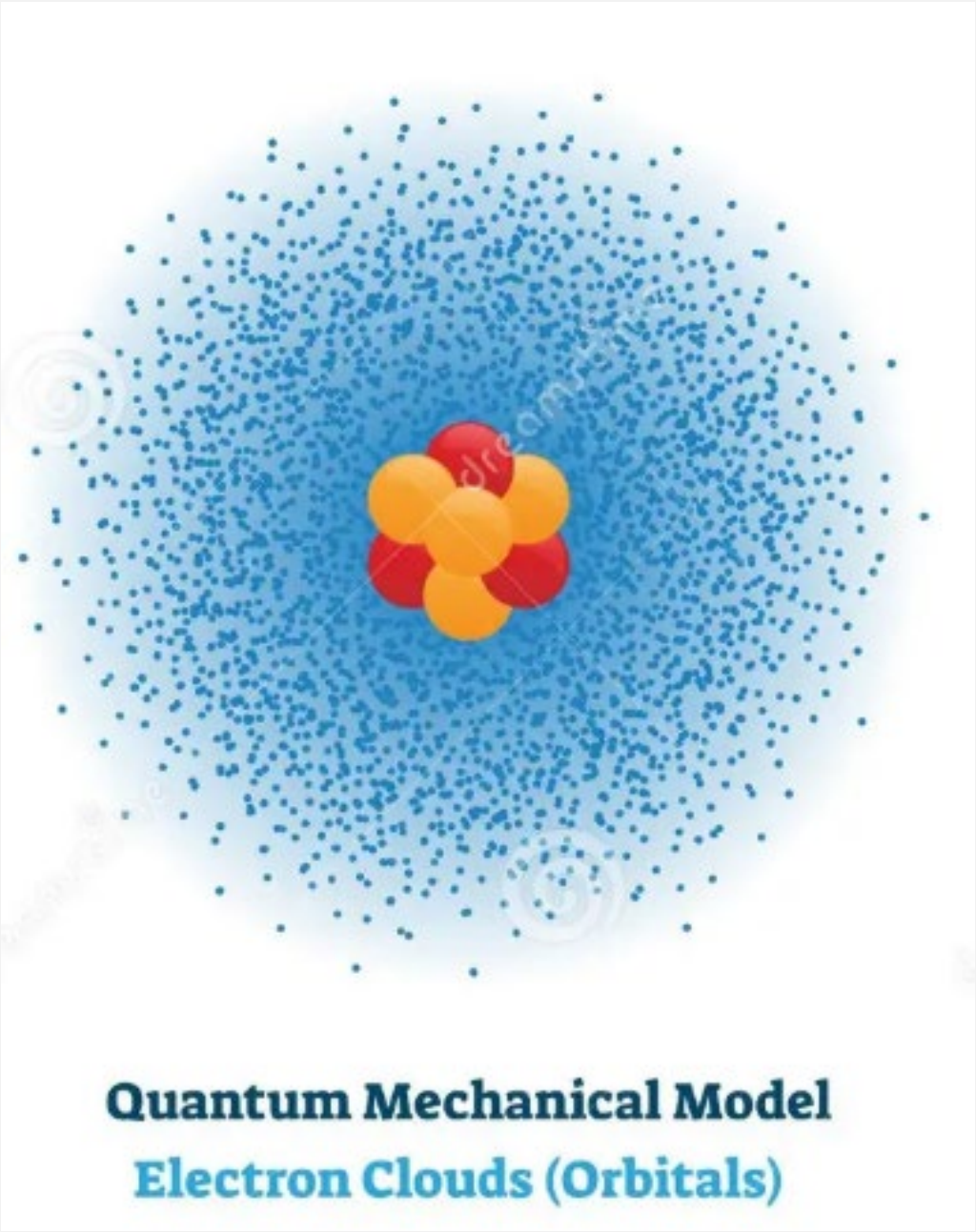
Complete the following table:

Principal Quantum Number	Type of Orbitals	Number of Orbitals Related to Principle Energy Level
1	___	___
___	s, p	___
3	___	9
4	___	___

Quantum atomic model

Electrons are located in orbitals

Orbital: region around an atom's nucleus where an electron is most likely to be found.



- End Of Lesson