



ATHS

CDU UNIT
Chemistry Informal Diagnostics

Grade Level: 10

Stream: Advance

10 ADV

Topic 1: Electrons in atoms

1.1 Electrons in Atoms: Quantum Theory and the Atom

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

- DOK 2 - Describe the main idea of Bohr's model of the hydrogen atom.

Answer: Bohr proposed that electrons orbit the nucleus in fixed energy levels and only change levels by absorbing or emitting energy as photons.

- DOK 3 - How does Bohr's model explain the line spectrum of hydrogen?

Answer: Bohr explained that the emission lines are due to electrons transitioning between energy levels, releasing photons of specific energies corresponding to the spectral lines.

- DOK 3 - How did the quantum mechanical model improve upon Bohr's model?

Answer: It replaced fixed orbits with probability-based orbitals and incorporated the uncertainty principle, providing more accurate predictions for multi-electron systems.

1.1.2 Explain what energy levels and energy sublevels mean

- DOK 1 - What are the energy sublevels found in the fourth energy level?

Answer: The fourth energy level contains the s, p, d, and f sublevels.

- DOK 2 - Differentiate between energy levels and energy sublevels.

Answer: Energy levels (n) are main electron shells, while sublevels (s, p, d, f) are subdivisions within those levels that define the shape and energy of orbitals.

- DOK 3 - Explain how energy sublevels influence the electron configuration of atoms.

Answer: Sublevels determine how electrons are arranged; for example, filling order follows the Aufbau principle, affecting chemical properties and periodic trends.

1.1.3 Differentiate between the ground and excited states of an atom

- DOK 1 - What is meant by the ground state of an atom?

Answer: It is the lowest energy state where all electrons occupy the lowest possible energy levels.

- DOK 2 - How does an atom become excited?

Answer: By absorbing energy, one or more electrons jump to higher energy levels, placing the atom in an excited state.

- DOK 3 - Explain how emission spectra provide evidence of excited states.

Answer: Emission spectra show specific wavelengths emitted when electrons fall from excited to lower energy levels, proving the existence of quantized energy states.

1.1.4 Describe the atomic orbitals and their shapes

- DOK 1 - What is the shape of an s orbital?

Answer: The s orbital is spherical in shape.

- DOK 2 - Compare the shapes of p and d orbitals.

Answer: p orbitals are dumbbell-shaped and oriented along axes, while d orbitals are cloverleaf-shaped or have a doughnut structure around a dumbbell.

- DOK 3 - Explain how the shape of orbitals affects chemical bonding.

Answer: Orbital shapes influence how electrons are shared or transferred during bonding; for example, p orbitals overlap directionally in covalent bonds, affecting molecule geometry.

1.1.5 Analyze the relationship between the principal quantum number (n) and the distance between an atom's electron and the nucleus

- DOK 1 - What does the principal quantum number (n) indicate?

Answer: It indicates the energy level and average distance of electrons from the nucleus.

- DOK 2 - How does increasing the value of n affect atomic size?

Answer: As n increases, electrons occupy orbitals farther from the nucleus, leading to a larger atomic radius.

- DOK 3 - Analyze how the distance from the nucleus influences the energy and reactivity of an atom.

Answer: Electrons farther from the nucleus are less tightly held, increasing reactivity (especially in metals) and lowering ionization energy.

1.1.6 Apply the concept of the principal quantum number to determine the energy state of an electron in an atom

- DOK 1 - Which principal quantum number represents the ground state?

Answer: $n = 1$ represents the lowest energy level or ground state.

- DOK 2 - What energy state does an electron with $n = 4$ occupy?

Answer: It occupies the fourth energy level, which is a higher, more energetic state than the ground state.

- DOK 3 - Given an electron configuration, identify the principal energy level of the outermost electron and explain its significance.

Answer: For example, in $1s^2 2s^2 2p^6 3s^2 3p^1$, the outermost electron is in $n = 3$, indicating a higher energy level with lower nuclear attraction and higher potential energy.

1.1.7 Evaluate the process of absorption and emission of energy by electrons in terms of changes in the principal quantum number

- DOK 2 - What happens to an electron when it absorbs energy?

Answer: It moves from a lower energy level to a higher energy level (increase in n).

- DOK 3 - Explain the relationship between the color of light emitted and the change in n during electron transitions.

Answer: Larger transitions (e.g., $n=6$ to $n=2$) emit higher energy (shorter wavelength) photons like violet, while smaller transitions (e.g., $n=3$ to $n=2$) emit red light.

- DOK 3 - Evaluate how electron transitions in hydrogen produce UV, visible, and infrared radiation.

Answer: Transitions to $n=1$ (Lyman series) emit UV light; to $n=2$ (Balmer series) emit visible light; and to $n=3$ (Paschen series) emit infrared, based on energy differences between levels.

1.1.8 Calculate the number of orbitals and electrons in the energy levels

- DOK 1 - How many orbitals are in the second energy level?

Answer: The second level ($n = 2$) has 4 orbitals: one 2s and three 2p.

- DOK 2 - How many electrons can the third energy level hold?

Answer: The third level can hold up to 18 electrons (in 3s, 3p, and 3d sublevels).

- DOK 3 - Calculate the total number of orbitals in the fourth energy level and explain their significance.

Answer: The fourth level includes 4s (1), 4p (3), 4d (5), and 4f (7) = 16 orbitals, each holding 2 electrons, allowing for 32 total electrons. This defines electron capacity and bonding behavior.

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

- DOK 1 - How many orbitals are in the p sublevel?

Answer: The p sublevel has 3 orbitals.

- DOK 2 - How is the number of orbitals in a principal energy level determined?

Answer: The number of orbitals in energy level n is n^2 . For example, $n = 3$ has 9 orbitals.

- DOK 3 - Relate the number of sublevel orbitals to the full electron capacity of an atom's energy level.

Answer: Each orbital holds 2 electrons. For example, $n = 3$ has 9 orbitals, hence 18 electrons; this governs the filling order in electron configuration and affects atomic properties.

Previous Years IPQs: (For extra practice/ based on teacher's preference)

1. Which of the following statements is/are **correct**?

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

- I. According to Bohr's model, an electron is found only in specific circular paths around the nucleus
 - II. According to quantum mechanical model, electrons are found in various locations around the nucleus
 - III. Quantum mechanical model describe the electron's path around the nucleus
- A. I only
 - B. II only
 - C. III only
 - D. I and II only

2. An *s*-sublevel can hold a maximum of _____ electrons, whereas *p*- sublevel can hold a maximum of _____ electrons.

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

- | | | |
|----|----|----|
| A. | 2 | 6 |
| B. | 6 | 10 |
| C. | 10 | 14 |
| D. | 14 | 10 |

3. The maximum number of **electrons** that could be found in the **first** energy level ($n = 1$) is _____.

- ✓ A. 2
- B. 8
- C. 18

D. 32

4. The maximum number of **orbitals** that can be found in the **fourth** energy level is _____.

A. 4

B. 8

✓ C. 16

D. 24

5. The _____ spectrum is a spectrum of frequencies of electromagnetic radiation emitted due to an atom or a molecules making a transition from a high energy state to a low energy state.

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.

A. linear

B. emission

C. absorption

D. continuous

4- What is the primary difference between the 1s and the 2s orbitals?

A)number of neutrons

B)size

C)number of electrons

D)shape

- 5- Explain the reason, according to Bohr's atomic model, why atomic emission spectra contain only certain frequencies of light.

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 .

Because only certain atomic energies are possible, only certain frequencies of radiation can be emitted from an atom.

- 6- What does n represent in the quantum mechanical model of the atom?

KPI 1.1.2 Explain what is meant by an energy levels and energy sublevels

n represents an orbital's principal quantum number, which indicates the relative size and energy of the orbital.

- 7- How does the quantum mechanical model of the atom describe the paths of an atom's electrons?

The quantum mechanical model gives no description of the electrons' paths. .

- 8- Enumerate the sublevels contained in the hydrogen atom's first four energy levels. What orbitals are related to each s sublevel and each p sublevel?

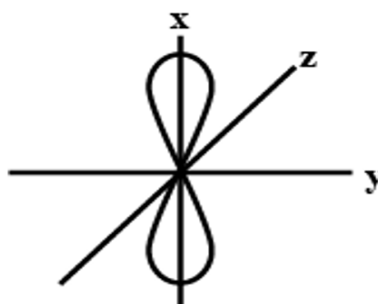
KPI 1.1.4 Describe the atomic orbitals and their shapes

First energy level, s ; second energy level, s and p ; third energy level, s , p , and d ; fourth energy level, s , p , d , and f .

Each s sublevel is related to a spherical s orbital. Each p sublevel is related to three dumbbell-shaped orbitals (p_x , p_y , and p_z).

9. The diagram below represents the _____.

- A. s -orbital
✓ B. p -orbital
C. d -orbital
D. f -orbital



9- Compare and contrast Bohr's model and the quantum mechanical model of the atom.

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

Bohr model: the electron is a particle; the hydrogen atom has only certain allowable energy states.

Quantum mechanical model: the electron is a wave-particle phenomenon; an electron's energy is limited to certain values. Also, the quantum mechanical model makes no assertions regarding the electron's path around the nucleus.

BOHR MODEL VERSUS QUANTUM MODEL

Bohr model is an atomic model that was proposed by Niels Bohr (in 1915) to explain the structure of an atom	Quantum model is an atomic model that is considered as the modern atomic model to explain the structure of an atom accurately
Describes the particle behavior of an electron	Describes the wave-particle duality of an electron
Does not give information about quantum number	Explains quantum numbers
Cannot explain Zeeman effect and Stark effect in line spectra	Explains Zeeman effect and Stark effect
	Visit www.pediaa.com

10. Which of the following statements are **correct**?

- IV. According to Bohr's model, an electron is found only in specific circular paths around the nucleus
- V. According to the quantum mechanical model, electrons are found inside the nucleus
- VI. The quantum mechanical model describes the electron's path around the nucleus

- A. I and II only
- ✓ B. I and III only
- C. II and III only
- D. I, II and III

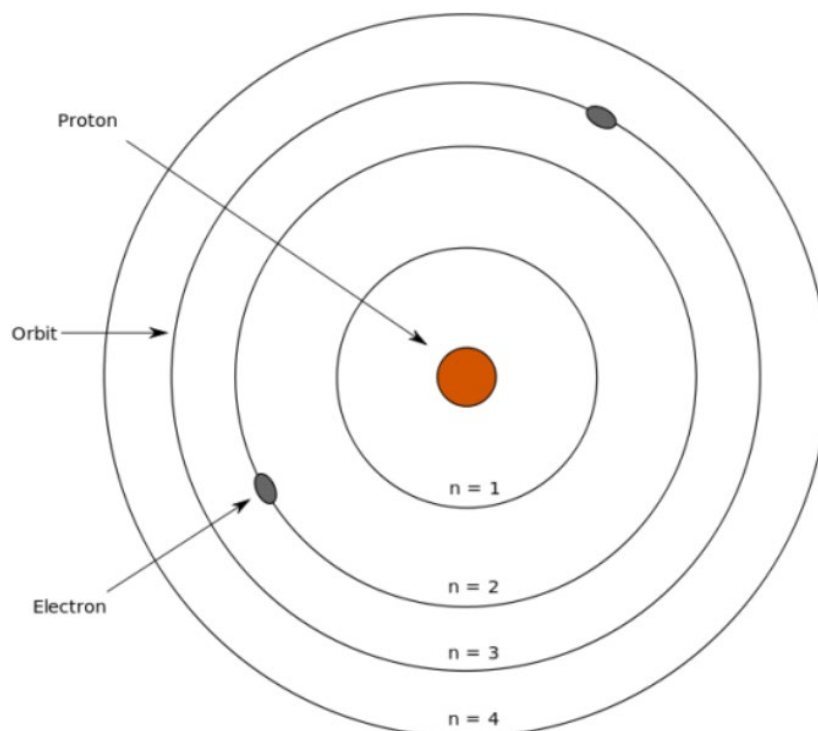


Figure 1: Bohr Model

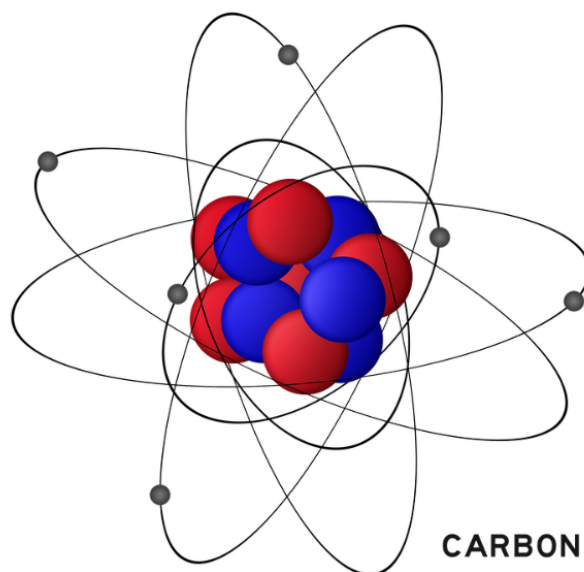


Figure 2: Spatial Structure of Atomic Orbitals

10- What is the maximum number of electrons that can be present in each principal energy level of hydrogen?

KPI 1.1.8 Calculate the number of orbitals and electrons in the energy levels 1

A) $2n$

B) n

C) n^2

D) $2n^2$

1.2. Electrons in Atoms: Electron Configuration

1.2.1 Define electron configuration

- DOK 1 - What is meant by electron configuration?

Answer: Electron configuration is the arrangement of electrons in the orbitals of an atom.

- DOK 2 - Why is electron configuration important in chemistry?

Answer: It determines how atoms interact in chemical bonding and helps predict element properties.

- DOK 3 - Explain how electron configuration relates to the periodic table.

Answer: The periodic table is structured based on increasing atomic number and repeating electron configurations, which influence chemical behavior.

1.2.2 Explain the Aufbau principle, the Pauli exclusion principle, and Hund's rule

- DOK 1 - State the Aufbau principle.

Answer: Electrons occupy the lowest-energy orbitals first.

- DOK 2 - Compare the Pauli exclusion principle and Hund's rule.

Answer: Pauli's principle states that no two electrons in the same orbital can have the same spin, while Hund's rule states that electrons fill orbitals singly before pairing.

- DOK 3 - Explain how these three rules determine the order of orbital filling.

Answer: They govern how electrons fill orbitals: lowest energy first (Aufbau), no identical spins in the same orbital (Pauli), and maximum unpaired electrons (Hund), shaping electron configurations.

1.2.3 Predict the orbital diagrams.

- DOK 1 - What is an orbital diagram?

Answer: An orbital diagram visually represents electrons in orbitals using arrows.

- DOK 2 - Predict the orbital diagram of oxygen (atomic number 8).

Answer: $1s\uparrow\downarrow 2s\uparrow\downarrow 2p\uparrow\downarrow \uparrow \uparrow$

- DOK 3 - Predict and explain the orbital diagram for sulfur.

Answer: $1s^2 2s^2 2p^6 3s^2 3p^4$: 3p orbitals show two paired and two unpaired electrons according to Hund's rule.

1.2.4 Describe the noble-gas notation

- DOK 1 - What is noble-gas notation?

Answer: It is a shorthand notation using the symbol of a noble gas to represent inner electron configurations.

- DOK 2 - Write the noble-gas notation for calcium.

Answer: $[\text{Ar}] 4s^2$

- DOK 3 - Explain how noble-gas notation simplifies electron configuration.

Answer: It avoids rewriting core electron configurations, focusing on valence electrons important in bonding.

1.2.5 Write the electron configuration, orbital diagram, and noble gas notation of different elements

- DOK 2 - Write the full electron configuration and noble-gas notation for chlorine.

Answer: Full: $1s^2 2s^2 2p^6 3s^2 3p^5$; Noble-gas: $[\text{Ne}] 3s^2 3p^5$

- DOK 3 - Construct the orbital diagram of nitrogen.

Answer: $1s\uparrow\downarrow 2s\uparrow\downarrow 2p\uparrow \uparrow \uparrow$

- DOK 3 - Explain the relationship between electron configuration and reactivity using fluorine.

Answer: Fluorine's $2p^5$ configuration shows it needs one more electron to fill its valence shell, making it highly reactive.

1.2.6 Explain the electron configuration in transition metals

- DOK 2 - Why do transition metals often have incomplete d sublevels?

Answer: Because they fill the d sublevel after the s sublevel of the next energy level.

- DOK 3 - Explain the electron configuration of iron (Fe).

Answer: Fe: $[\text{Ar}] 4s^2 3d^6$; Fe^{3+} loses $4s^2$ and one 3d, resulting in $[\text{Ar}] 3d^5$.

- DOK 3 - Discuss why some transition metals have variable oxidation states.

Answer: Because both 4s and 3d electrons can be lost in reactions, creating multiple stable electron configurations.

1.2.7 Investigate and discuss the valence electrons while determining their importance

- DOK 1 - What are valence electrons?

Answer: They are electrons in the outermost energy level of an atom.

- DOK 2 - Why are valence electrons important in chemistry?

Answer: They determine how an atom forms bonds and reacts chemically.

- DOK 3 - Investigate how valence electrons explain the bonding behavior of oxygen and hydrogen in water.

Answer: Oxygen has 6 valence electrons, hydrogen has 1 each; they share electrons to form covalent bonds, filling their valence shells.

1.2.8 Determine the number of valence electrons in atoms

- DOK 1 - How many valence electrons does nitrogen have?

Answer: Nitrogen has 5 valence electrons.

- DOK 2 - Determine the number of valence electrons in elements of Group 2.

Answer: Group 2 elements have 2 valence electrons.

- DOK 3 - Explain the trend in valence electrons across a period.

Answer: Valence electrons increase from left to right across a period, affecting reactivity and chemical properties.

1.2.9 Explore Lewis (electron-dot) structure

- DOK 1 - What is a Lewis dot structure?

Answer: A diagram that shows the valence electrons as dots around the element's symbol.

- DOK 2 - Draw the Lewis structure for nitrogen.

Answer: Nitrogen has 5 valence electrons: one pair and three single electrons around N.

- DOK 3 - Explain how Lewis structures predict bonding.

Answer: They show unpaired electrons available for bonding and help visualize molecule formation.

1.2.10 Represent the electron-dot structure of atoms using simulations, moly-mods, and ball & stick models

- DOK 2 - How can moly-mods be used to represent Lewis structures?

Answer: Moly-mods use colored balls and sticks to represent atoms and bonds, helping visualize valence electrons and bonding.

- DOK 2 - Describe how a simulation can demonstrate electron sharing in covalent bonds.

Answer: Simulations animate electrons being shared between atoms, showing the bond formation process.

- DOK 3 - Construct and explain a 3D model of a water molecule using ball-and-stick representation.

Answer: Use one large oxygen ball and two smaller hydrogen balls connected at an angle with sticks to show covalent bonds and lone pairs on oxygen.

11- Identify the rules for building orbital diagrams listed below.

- a. States that each electron occupies the lowest energy orbital available**

KPI 1.2.2 Explain the Aufbau principle, the Pauli exclusion principle, and Hund's rule

Aufbau principle

- b. States that a maximum of two electrons can occupy a single atomic orbital but only if the electrons have opposite spins**

KPI 1.2.2 Explain the Aufbau principle, the Pauli exclusion principle, and Hund's rule

Pauli exclusion principle

- c. States that single electrons with the same spin must occupy each equal-energy orbital before additional electrons with opposite spins can occupy the same orbitals**

KPI 1.2.2 Explain the Aufbau principle, the Pauli exclusion principle, and Hund's rule

Hund's rule

12. Which of the following principles is **violated** in the diagram below?



- ✓ A. Hund's rule
- B. Dalton's law
- C. Aufbau's principle
- D. Pauli's exclusion principle

13. Define valence electron.

electrons in an atom's outermost orbital

14. Identify the period and group that has the electron configuration [Ar]4s²4p⁴.

KPI 2.1.6 List the different families in the periodic table with the identification of the group number and the elements present

- A) period 3, group 15
- B) period 2, group 4
- C) period 4, group 16
- D) period 4, group 4

15. Which of the following classifications describes the element with the electron configuration [Ar]4s²3d¹⁰4p⁵?

KPI 2.1.6 List the different families in the periodic table with the identification of the group number and the elements present

- A) stable metal
- B) unstable metal
- C) stable nonmetal
- D) unstable nonmetal

16. What is the electron configuration of the element in group 13 and period 3 of the periodic table?

KPI 2.1.6 List the different families in the periodic table with the identification of the group number and the elements present

A) $[\text{Ar}]4s^23d^{10}4p^2$

B) $[\text{Ne}]3s^23p^4$

C) $[\text{Ar}]4s^2$

D) $[\text{Ne}]3s^23p^2$

17. How many electrons are shown in each element's electron-dot structure?

KPI 1.2.8 Determine the number of valence electrons in atoms

a. carbon

4

b. iodine

7

c. calcium

2

d. gallium

3

18. Apply the Pauli exclusion principle, the aufbau principle, and Hund's rule to write out the electron configuration and draw the orbital diagram for each of the following elements.

KPI 1.2.5 Write the electron configuration, orbital diagram, and noble gas notation of different elements

a. Silicon



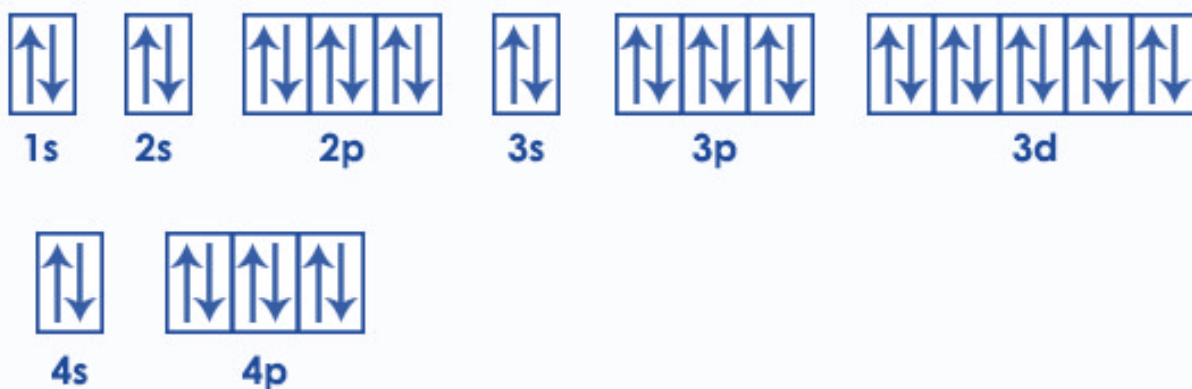
b. Fluorine



c. Calcium



d. krypton



19. Draw an electron-dot structure for an atom of each element.

KPI 1.2.10 Represent the electron-dot structure of atoms

a. Carbon



b. Arsenic



c. Polonium



d. Potassium



e. barium



19. Which of the following electron configurations corresponds to non-metal?

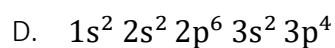
KPI 1.2.5 Write the electron configuration, orbital diagram, and noble gas notation of different elements

- I. $1s^2 2s^2 2p^6 3s^2$
- II. $1s^2 2s^2 2p^6 3s^2 3p^5$
- III. $1s^2 2s^2 2p^6 3s^2 3p^6 4s^2 3d^2$

- A. I only
- B. II only
- C. III only
- D. I and III only

20. The correct electron configuration for **aluminum (Al)** is _____.
(Atomic number of Al=13)

- ✓ A. $1s^2 2s^2 2p^6 3s^2 3p^1$
- B. $1s^2 2s^2 2p^6 3s^2 3p^2$
- C. $1s^2 2s^2 2p^6 3s^2 3p^3$



21. How many valence electrons are present in the orbital notation of element **Y** shown below?

- A. 2
 ✓ B. 4
 C. 6
 D. 8

Y									
$\uparrow\downarrow$	$\uparrow\downarrow$	$\uparrow\downarrow$	$\uparrow\downarrow$	$\uparrow\downarrow$	$\uparrow\downarrow$	$\uparrow$	$\uparrow$		
1s	2s	2p			3s	3p			

22. Which of the following is the correct electron dot structure for **nitrogen**?

- A. $\text{N}:$
 B. $\cdot\text{N}:$
 ✓ C. $\cdot\ddot{\text{N}}:$
 D. $:\ddot{\text{N}}:$

23. Which of the following is the ground state electron configuration of Co?

KPI 1.2.6 Explain the electron configuration in transition metals

- A. $1s^2 2s^2 3s^2 3p^6 4s^2 3d^5$
- B. $1s^2 2s^2 3s^2 3p^8 4s^2 3d^6$
- C. $1s^2 2s^2 2p^6 3s^2 3p^6 4d^8$
- D. $1s^2 2s^2 2p^6 3s^2 3p^6 4s^2 3d^7$

24. The element that corresponds to the electron configuration $1s^2 2s^2 2p^6 3s^2 3p^6 3d^5 4s^1$ is _____.

KPI 1.2.6 Explain the electron configuration in transition metals

- A. chromium
- B. manganese
- C. titanium
- D. vanadium

25. The noble gas notation of chlorine atom is _____.

KPI 1.2.5 Write the electron configuration, orbital diagram, and noble gas notation of different elements

- A. $[\text{Ar}] 3s^2 3p^4$
- B. $[\text{Ar}] 3s^2 3p^5$
- C. $[\text{Ne}] 3s^2 3p^4$
- D. $[\text{Ne}] 3s^2 3p^5$

26. Which of the following electron configurations corresponds to a transition metal?

KPI 1.2.6 Explain the electron configuration in transition metals.

- I. $1s^2 2s^2 2p^6 3s^2$
- II. $1s^2 2s^2 2p^6 3s^2 3p^5$
- III. $1s^2 2s^2 2p^6 3s^2 3p^6 4s^2 3d^2$

- A. I only
- B. II only
- C. III only
- D. I and III only

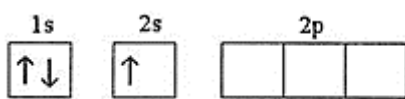
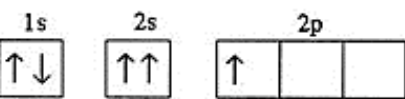
27. Which of the following statements is correct about Hund's principle?

KPI 1.2.5 Write the electron configuration, orbital diagram, and noble gas notation of different elements

- A. No two electrons can have the same quantum numbers
- B. Each electron occupies the lowest energy orbital available
- C. The energy changes that an electron may undergo are quantized
- D. Single electrons will occupy orbitals with equal energies before pairing up

28. Which of the following diagrams does not obey Hund's rule?

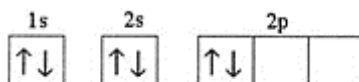
KPI 1.2.5 Write the electron configuration, orbital diagram, and noble gas notation of different elements

- A. 
- B. 
- C. 



29. Which of the following principles is/are violated in the diagram below?

KPI 1.2.5 Write the electron configuration, orbital diagram, and noble gas notation of different elements

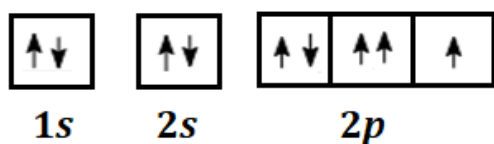


- I. Hund's rule
- II. Pauli Exclusion principle
- III. Aufbau principle

- A. I only
- B. II only
- C. III only
- D. I and II only

30. Which of the following is/are violated in the below orbital notation?

KPI 1.2.5 Write the electron configuration, orbital diagram, and noble gas notation of different elements

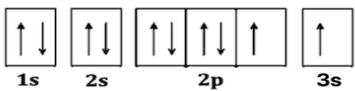


- I. Hund's Rule
- II. Aufbau Principle
- III. Pauli Exclusion principle

- A. I only
- B. II only
- C. III only
- D. I and II only

31. Use the letters (X, Y and Z) in the table below that represent different configurations to match each of the given statements.

(Each letter may be used once, or more than once)

X	Y	Z
	$1s^2 2s^2 2p^6 3s^2 3p^2$	$[\text{Ne}] 3s^2 3p^5$

Statement	Letter (X, Y or Z)
This element is located in the p-block	Z or Y
This element is located in period 3	X or Y or Z
This element is a metal	X, or non (No marks awarded for Z or Y)
This element is located in group 14	Y