

©ENTRANCE TRICKS

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Evolution of Atomic Models

This section covers the journey from philosophical ideas to the modern understanding of the atom. You will be asked to identify models, their creators, their key features, and their limitations.

ESSLCE Questions on this Topic: 2014 Q3, Q12, Q13; 2015 Q7, Q16; 2016 Q10; 2017 Q27

Q: What were the foundational ideas of Dalton's Atomic Theory?

A: John Dalton (1803) proposed the first modern atomic theory based on experimental evidence. Its key postulates were:

1. All matter is made of tiny, indivisible particles called **atoms**.
2. Atoms of the same element are **identical** in all respects (mass, size, properties).
3. Atoms of different elements are **different**.
4. Atoms can neither be **created nor destroyed** in chemical reactions.
5. Compounds are formed by the combination of atoms in simple whole-number ratios.

Q: Which part of Dalton's theory was later modified, and why?

A: The postulate that "**atoms are indivisible and indestructible**" was modified.

Why? The discovery of subatomic particles (electrons, protons, and neutrons) proved that atoms are, in fact, divisible into smaller constituents.

✓ *Relevant Question:* **2014 Q12**

Q: What did J.J. Thomson discover, and what was his model of the atom?

A: Through his **cathode ray tube experiment** (late 1800s), Thomson discovered the **electron**, a negatively charged particle.

- **Thomson's Model (Plum Pudding Model):** He proposed that an atom is a sphere of uniform positive charge with negatively charged **electrons embedded within it**, like plums in a pudding or raisins in a cake. The atom as a whole is electrically neutral.
- **Properties of Cathode Rays (Electrons):**
 - They travel in straight lines from the cathode to the anode.
 - They are negatively charged.
 - They are deflected by electric and magnetic fields.
 - They are constituents of all matter, and their charge-to-mass ratio (e/m) is constant for all gases.

✓ *Relevant Question:* **2014 Q3** (The statement "Contain particles, which are positively charged" is NOT true).

Q: What did Rutherford discover, and what conclusions did he draw from his gold foil experiment?

A: Ernest Rutherford (1911) conducted the **gold foil experiment**, firing alpha particles (positive) at a thin sheet of gold.

- **Observations and Conclusions:**
 1. **Most alpha particles passed straight through.** → **Conclusion:** The atom is mostly **empty space**.
 2. **Some alpha particles were deflected by small angles.** → **Conclusion:** There is a small, dense, **positively charged center** (which he named the **nucleus**).
 3. **A very few alpha particles bounced back.** → **Conclusion:** The nucleus is extremely small and dense.
- **Rutherford's Nuclear Model:** The atom consists of a tiny, positive nucleus containing most of the mass, with electrons orbiting the empty space around it.

Q: What are the postulates and limitations of Bohr's atomic model?

A: Niels Bohr (1913) improved upon Rutherford's model to explain the hydrogen spectrum.

➤ **Postulates of Bohr's Model:**

1. Electrons revolve around the nucleus in specific, **fixed circular paths** called **orbits or shells** (K, L, M, N...).
2. These orbits are associated with **definite (quantized) energy levels**. The principal quantum number (**n**) designates these levels (n=1, 2, 3...).
3. As long as an electron revolves in a particular orbit, it does not radiate energy.
4. An electron can **jump** from a lower energy level to a higher one by **absorbing** energy, and from a higher to a lower level by **emitting** energy in the form of a photon.

➤ **Limitations of Bohr's Model:**

- It could not explain the spectra of atoms with more than one electron.
 - It failed to explain the **Zeeman effect** (splitting of spectral lines in a magnetic field).
 - It failed to explain the **Stark effect** (splitting of spectral lines in an electric field).
 - It violated the **Heisenberg Uncertainty Principle** by proposing fixed paths for electrons.
- ✓ *Relevant Questions:* **2016 Q10** (Definition of Bohr's theory), **2017 Q27** (Correct description of Bohr's model).

Q: What is the Quantum Mechanical Model of the atom?

A: This is the most modern and accurate model, developed in the 1920s.

➤ **Key Concepts:**

- It incorporates the **dual nature of matter** (electrons behave as both particles and waves).
 - It is based on the **Heisenberg Uncertainty Principle**, which states that it is impossible to know both the exact position and exact momentum of an electron simultaneously.
 - Therefore, electrons do not have fixed paths. Instead, their location is described in terms of **probability**.
 - The region in space where there is a high probability (>90%) of finding an electron is called an **orbital**.
- ✓ *Relevant Questions:* **2015 Q16** (Describes locations in terms of probability), **2015 Q7** (Light has dual nature).

 Subatomic Particles, Isotopes, and Basic Laws

This section deals with the fundamental particles of the atom, variations of elements, and the historical laws that led to atomic theory.

ESSLCE Questions on this Topic: 2014 Q11; 2015 Q15, Q18; 2016 Q19, Q20; 2017 Q26, Q29, Q30

Q: What are the three main subatomic particles, and what are their properties?

A:

Particle	Symbol	Location	Relative Charge	Absolute Mass (g)	Relative Mass (u)
Electron	e ⁻	Outside nucleus	-1	9.11×10^{-28}	~0 (0.00055)
Proton	p ⁺	Inside nucleus	+1	1.67×10^{-24}	~1 (1.0073)
Neutron	n ⁰	Inside nucleus	0	1.67×10^{-24}	~1 (1.0087)

- **Mass Comparison:** Mass of e⁻ < Mass of p⁺ < Mass of n⁰ (Neutron is slightly heavier than a proton).
- **Charge Comparison:** Electron = -1, Proton = +1, Neutron = 0.
- ✓ *Relevant Questions:* **2016 Q19** (Mass comparison), **2017 Q26** (Charge comparison)

Q: What is the difference between atomic number (Z) and mass number (A)?

A:

- **Atomic Number (Z):** The number of **protons** in the nucleus of an atom. It uniquely identifies an element.

- **Mass Number (A):** The total number of **protons and neutrons** in the nucleus of an atom.

Q: What are isotopes? Which statement about them is true?

- **A:** Isotopes are atoms of the **same element** (same Z) that have a **different number of neutrons** (different A).
- **True Statement:** Because they have the same number of protons and electrons (and thus the same electron configuration), **they have identical chemical properties.**
- ✓ *Relevant Question: 2015 Q15*

Q: What are the fundamental laws of chemical combination?

A: These laws provided the experimental basis for Dalton's Atomic Theory.

1. **Law of Conservation of Mass (Lavoisier):** Mass is neither created nor destroyed in a chemical reaction. The total mass of the reactants equals the total mass of the products.
 - *Experiment:* Mixing two solutions in beakers and weighing before and after shows total mass remains constant. (See **2016 Q20**).
 - ✓ *Relevant Questions: 2017 Q30, 2016 Q20*
2. **Law of Definite Proportions / Constant Composition (Proust):** A given chemical compound always contains its component elements in a fixed ratio by mass.
 - *Example:* Water (H_2O) is always 11.19% hydrogen and 88.81% oxygen by mass, whether it's from a lake or a raindrop.
 - ✓ *Relevant Questions: 2017 Q29*
3. **Law of Multiple Proportions (Dalton):** When two elements form more than one compound, the masses of one element that combine with a fixed mass of the other element are in a ratio of small whole numbers.
 - *Example:* Carbon and oxygen form CO and CO_2 . For a fixed mass of carbon (e.g., 1g), the mass of oxygen in CO is 1.33g and in CO_2 is 2.66g. The ratio of oxygen masses is 1.33 : 2.66, which simplifies to **1:2**.
 - ✓ *Relevant Question: 2015 Q18*

Q: What is a fundamental SI unit?

A: Fundamental SI units are base units that are not derived from other units. Of the options given, **Length (meter)** is a fundamental unit. Force, speed, and pressure are all derived units.

- ✓ *Relevant Question: 2014 Q11*

Quantum Numbers and Electron Configuration

This is a high-weightage topic. You must be able to assign quantum numbers and write electron configurations.

ESSLCE Questions on this Topic: 2014 Q2, Q14; 2015 Q6; 2017 Q33, Q34, Q35

Q: What are the four quantum numbers and what information do they provide?

A: They are like an "address" for an electron, completely describing its location and energy.

1. **Principal Quantum Number (n):** Describes the main **energy level/shell** and the average distance from the nucleus.
 - a. Values: positive integers (1, 2, 3, 4...). Higher n = higher energy and larger size.
2. **Azimuthal / Angular Momentum Quantum Number (l):** Describes the **shape of the subshell/orbital**.
 - a. Values: integers from **0 to (n-1)**.
 - b. $l = 0 \rightarrow$ **s-subshell** (sharp)
 - c. $l = 1 \rightarrow$ **p-subshell** (principal)
 - d. $l = 2 \rightarrow$ **d-subshell** (diffuse)
 - e. $l = 3 \rightarrow$ **f-subshell** (fundamental)

3. **Magnetic Quantum Number (m_l):** Describes the **orientation of the orbital in space**.
 - a. Values: integers from **-l to +l, including 0**.
 - b. Number of orbitals in a subshell = $(2l + 1)$.
 - c. s ($l=0$): $m_l = 0 \rightarrow 1$ orbital.
 - d. p ($l=1$): $m_l = -1, 0, +1 \rightarrow 3$ orbitals.
 - e. d ($l=2$): $m_l = -2, -1, 0, +1, +2 \rightarrow 5$ orbitals.
4. **Spin Quantum Number (m_s):** Describes the intrinsic angular momentum ("spin") of the electron.
 - a. Values: **$+\frac{1}{2}$ or $-\frac{1}{2}$** . An orbital can hold a maximum of two electrons, and they must have opposite spins.

n	l	m_l	Subshell Notation	Number of Orbitals in Subshell
1	0	0	1s	1
2	0	0	2s	1
	1	-1, 0, +1	2p	3
3	0	0	3s	1
	1	-1, 0, +1	3p	3
	2	-2, -1, 0, +1, +2	3d	5
4	0	0	4s	1
	1	-1, 0, +1	4p	3
	2	-2, -1, 0, +1, +2	4d	5
	3	-3, -2, -1, 0, +1, +2, +3	4f	7
5	0	0	5s	1
	1	-1, 0, +1	5p	3
	2	-2, -1, 0, +1, +2	5d	5
	3	-3, -2, -1, 0, +1, +2, +3	5f	7
	4	-4, -3, -2, -1, 0, +1, +2, +3, +4	5g	9

	l = 0	l = 1	l = 2	l = 3	l = 4	l = 5
n = 1	1s					
n = 2	2s	2p				
n = 3	3s	3p	3d			
n = 4	4s	4p	4d	4f		
n = 5	5s	5p	5d	5f	5g	
n = 6	6s	6p	6d	6f	6g	6h
n = 7	7s	7p	7d	7f	7g	7h ...
n = 8	8s	8p	8d	8f	8g	8h ...

Forbidden combinations of quantum numbers (shaded blue area above diagonal)

Allowed combinations of quantum numbers (yellow area below diagonal)

Quantum Number & Orbital

Principal quantum number	Azimuthal quantum number	Magnetic quantum number	Spin quantum number	Total number of electrons in s, p, d orbital
n = 1 (K shell)	l = 0 (1S)	$m_l = 0$ (1S)	$+\frac{1}{2}, -\frac{1}{2}$	2
	l = 0 (2S)	$m_l = 0$ (2S)	$+\frac{1}{2}, -\frac{1}{2}$	2
n = 2 (K shell)	l = 1 (2P)	$m_l = 0$ (2P _x) $m_l = +1$ (2P _y) $m_l = -1$ (2P _z)	$+\frac{1}{2}, -\frac{1}{2}$ $+\frac{1}{2}, -\frac{1}{2}$ $+\frac{1}{2}, -\frac{1}{2}$	$\left. \begin{matrix} 2 \\ 2 \\ 2 \end{matrix} \right\} 6$
	l = 0 (3S)	$m_l = 0$ (3S)	$+\frac{1}{2}, -\frac{1}{2}$	2
	l = 1 (3P)	$m_l = 0$ (3P _x) $m_l = +1$ (3P _y) $m_l = -1$ (3P _z)	$+\frac{1}{2}, -\frac{1}{2}$ $+\frac{1}{2}, -\frac{1}{2}$ $+\frac{1}{2}, -\frac{1}{2}$	$\left. \begin{matrix} 2 \\ 2 \\ 2 \end{matrix} \right\} 6$
n = 3 (K shell)	l = 1 (3d)	$m_l = 0$ (3d _{xy}) $m_l = +1$ (3d _{yz}) $m_l = -1$ (3d _{xz}) $m_l = +2$ (3d _{x²-y²) $m_l = -2$ (3d_{z²})}	$+\frac{1}{2}, -\frac{1}{2}$ $+\frac{1}{2}, -\frac{1}{2}$ $+\frac{1}{2}, -\frac{1}{2}$ $+\frac{1}{2}, -\frac{1}{2}$ $+\frac{1}{2}, -\frac{1}{2}$	$\left. \begin{matrix} 2 \\ 2 \\ 2 \\ 2 \\ 2 \end{matrix} \right\} 10$

Q: How do you write the quantum numbers for an electron in a specific orbital?

A:

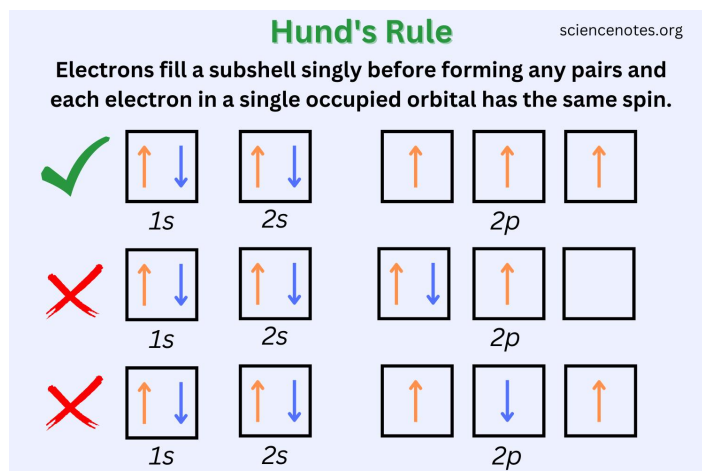
- For a 2s electron (2015 Q6):
 - = 2 (it's in the 2nd shell)
 - l = 0 (it's in an s-subshell)
 - m = 0 (the only orientation for an s orbital)
 - $m_l = +\frac{1}{2}$ or $-\frac{1}{2}$
 - **Correct set: (2, 0, 0, $+\frac{1}{2}$) or (2, 0, 0, $-\frac{1}{2}$)**
- For a 5s electron (2017 Q33):
 - n = 5, l = 0, m = 0, $m_s = \pm\frac{1}{2}$

- Correct set: (5, 0, 0, $\pm\frac{1}{2}$)

Q: What are the rules for filling electrons in an atom?

A:

1. **Aufbau Principle:** Electrons fill orbitals in order of **increasing energy**. The sequence is: 1s, 2s, 2p, 3s, 3p, 4s, 3d, 4p, 5s, 4d, 5p, 6s, 4f, 5d, 6p, 7s...
(Note: 4s is lower in energy than 3d, so it fills first).
2. **Pauli Exclusion Principle:** No two electrons in an atom can have the same set of all four quantum numbers. Consequently, an orbital can hold a maximum of **two electrons**, and they must have **opposite spins**.
 - a. *Application to Helium (2017 Q34):* In a helium atom, both electrons are in the 1s orbital. They must have the same n, l, and m<l but **opposite spins**.
3. **Hund's Rule:** Within a subshell (like p, d, or f), electrons will first **singly occupy each orbital** with their spins parallel (all same spin) before any orbital gets a second electron. This is the most stable arrangement.



Q: How do you write electron configurations?

A:

- **Standard Notation:** List subshells with the number of electrons as a superscript.
- Example (Sodium, Z=11): $1s^2 2s^2 2p^6 3s^1$
- **Noble Gas (Abbreviated) Notation:** Use the preceding noble gas in brackets to represent core electrons.
Example (Sodium): [Ne] $3s^1$ (Neon's configuration is $1s^2 2s^2 2p^6$)

Q: What are some important electron configurations?

A:

- **Group Identification:**
 - Elements ending in $ns^2 np^1$ are in **Group IIIA/13** (e.g., Boron). (Relevant Question: 2014 Q2)
 - **Transition Elements (2017 Q35):**
 - Scandium (Sc, Z=21) has the configuration [Ar] $4s^2 3d^1$. Because its last electron enters a **d-orbital**, it is classified as a **transition element**.
 - **Exceptions (due to stability of half-filled/filled subshells):**
 - **Copper (Cu, Z=29):** Expected [Ar] $4s^2 3d^9$, but actual is [Ar] $4s^1 3d^{10}$. A filled d^{10} is more stable.
 - **Chromium (Cr, Z=24):** Expected [Ar] $4s^2 3d^4$, but actual is [Ar] $4s^1 3d^5$. A half-filled d^5 is more stable.
- ✓ Relevant Questions: 2014 Q14 (Cu), 2017 Q35 (Sc)

Electromagnetic Radiation and Atomic Spectra

This section connects the behavior of electrons to the light they emit or absorb.

ESSLCE Questions on this Topic: 2014 Q4, Q5; 2015 Q7; 2016 Q9; 2017 Q31, Q32, Q36

Q: What are the key properties of electromagnetic radiation (EMR)?

A: EMR has both wave and particle properties. Key relationships:

- **Wavelength (λ) and Frequency (ν) are inversely proportional:** $c = \lambda\nu$ (where c is the speed of light, $\sim 3.00 \times 10^8$ m/s).
 - As wavelength increases, frequency decreases, and vice versa. (*Relevant Question: 2017 Q36*)
- **Speed of EMR:** In a vacuum, the speed of light (c) is constant and independent of frequency and wavelength. (*Relevant Question: 2016 Q9* - "The speed of an electromagnetic wave is independent of the nature of the medium it travels through" is the correct statement, though speed is technically slower in a medium).
- **Energy of a Photon (Particle Nature):** Energy is directly proportional to frequency and inversely proportional to wavelength.
 - $E = h\nu$ (where h is Planck's constant, 6.63×10^{-34} J·s)
 - $E = hc/\lambda$

✓ *Relevant Questions:* **2014 Q4** ($E \propto \nu$), **2015 Q7** (Dual nature of light), **2017 Q36** ($\lambda \propto 1/\nu$)

Q: How do you calculate the wavelength of light from its frequency?

A: Use the formula $\lambda = c / \nu$.

Example (2017 Q31): A mineral absorbs light with $\nu = 7.11 \times 10^{14}$ Hz.

$$\lambda = (3.00 \times 10^8 \text{ m/s}) / (7.11 \times 10^{14} \text{ s}^{-1})$$

$$\lambda = 4.219 \times 10^{-7} \text{ m}$$

To convert to nanometers (nm), multiply by 10^9 : $4.219 \times 10^{-7} \text{ m} \times 10^9 \text{ nm/m} = \mathbf{421.9 \text{ nm}}$.

Q: What is the photoelectric effect?

A: The emission of electrons from a metal surface when light of a sufficient frequency shines on it.

➤ **Key Concepts:**

- **Threshold Frequency (ν_0):** The minimum frequency of light required to eject an electron. Light with $\nu < \nu_0$, no matter how intense, will not cause electron emission.
- **Kinetic Energy of Ejected Electron:** The excess energy of the photon beyond the threshold is converted to kinetic energy (KE) of the electron. $KE = h\nu - h\nu_0$.

✓ *Relevant Questions:* Note content is essential for understanding, though not directly asked in the provided ESSLCE set.

Q: Why do atoms produce line spectra instead of a continuous spectrum?

A: Because the energies of electrons in an atom are **quantized** (they can only exist at specific energy levels).

- **Emission:** When an electron falls from a higher energy level to a lower one, it emits a **photon of light**. The energy of that photon ($E = h\nu$) is exactly equal to the **difference between the two energy levels (ΔE)**. Since ΔE can only have specific values, the emitted photons have specific frequencies/wavelengths, appearing as discrete lines in the spectrum.
- **Absorption:** An electron can only absorb a photon if the photon's energy exactly matches the energy gap to a higher level. This is why atoms **absorb energy** to move from a lower to a higher energy level (e.g., from a smaller orbit to a larger one in Bohr's model).

- ✓ *Relevant Questions:* **2014 Q5** (Explains emission spectra), **2017 Q32** (Explains absorption).

Periodic Table and Periodic Trends

This section covers the organization of elements and the predictable patterns in their properties.

ESSLCE Questions on this Topic: 2014 Q2, Q25; 2016 Q21, Q22, Q23, Q24; 2017 Q28, Q35

Q: What is the basis of the modern periodic table?

A: The **Modern Periodic Law**, proposed by Henry Moseley (1913), states: "The physical and chemical properties of elements are a periodic function of their **atomic numbers**."

- This is a refinement of **Mendeleev's Periodic Law**, which was based on **atomic masses**.

✓ *Relevant Question:* **2014 Q25**

Q: What is periodicity?

A: **Periodicity** is the regular repetition of similar chemical and physical properties of elements when they are arranged in order of increasing atomic number.

✓ *Relevant Question:* **2017 Q28**

Q: How is the modern periodic table organized?

A:

- **Groups:** 18 vertical columns. Elements in the same group have the same number of valence electrons and similar chemical properties.
- **Periods:** 7 horizontal rows. Elements in the same period have the same number of electron shells.
- **Blocks:** Based on the subshell being filled.
- **s-block:** Groups 1 & 2. General config: ns^{1-2} .
- **p-block:** Groups 13-18. General config: $ns^2 np^{1-6}$.
- **d-block:** Groups 3-12 (Transition elements). General config: $(n-1)d^{1-10} ns^{1-2}$.
- **f-block:** Lanthanides and Actinides. General config: $(n-2)f^{1-14} (n-1)d^{0-1} ns^2$.

✓ *Relevant Question:* **2017 Q35** (Scandium is a d-block element)

Q: How do we define and describe the trends in periodic properties?

A:

1. **Atomic Radius:** Half the distance between the centers of two identical atoms that are just touching.
 - **Trend across a Period (Left to Right): DECREASES.**
 - **Why?** Electrons are added to the same shell, but the number of protons (nuclear charge) increases. This increases the **effective nuclear charge**, pulling the electron cloud **inward** and making the atom smaller.
 - **Trend down a Group (Top to Bottom): INCREASES.**
 - **Why?** New electron shells are being added. Each new shell is farther from the nucleus, making the atom larger, even though the nuclear charge also increases. The shielding effect of inner electrons outweighs the increased charge.
- ✓ *Relevant Questions:* **2016 Q22** (Identifying the trend of atomic radius from a chart).
2. **Ionization Energy (IE):** The minimum energy required to remove the most loosely bound electron from a neutral, isolated gaseous atom to form a positive ion. (e.g., $X(g) \rightarrow X^+(g) + e^-$).
 - **Trend across a Period (Left to Right): INCREASES.**
 - **Why?** As atomic radius decreases and nuclear charge increases, the valence electrons are held **more tightly** by the nucleus. It requires more energy to remove them.

- **Trend down a Group (Top to Bottom): DECREASES.**
 - **Why?** The atomic radius increases. The valence electrons are farther from the nucleus and are **more shielded** by inner electron shells. They are held less tightly, so less energy is needed to remove them.
 - ✓ *Relevant Questions:* **2016 Q22** (Identifying the trend from a chart).
- 3. **Electron Affinity (EA):** The energy change that occurs when an electron is added to a neutral, isolated gaseous atom to form a negative ion. (e.g., $X(g) + e^- \rightarrow X^-(g)$). A more negative value indicates a greater affinity for an electron.
 - **Trend across a Period (Left to Right):** Generally **INCREASES IN MAGNITUDE** (becomes more negative).
 - **Why?** Atoms become smaller with a greater nuclear charge, so they attract an additional electron more strongly. **Halogens (Group 17)** have the highest (most negative) electron affinities in their periods because adding one electron gives them a stable noble gas configuration.
 - **Trend down a Group (Top to Bottom):** Generally **DECREASES IN MAGNITUDE** (becomes less negative).
 - **Why?** The added electron goes into an orbital that is farther from the nucleus and more shielded, so it is attracted less strongly.
 - ✓ *Relevant Questions:* **2016 Q21** (Element in Group VIIA, like Cl, forms an acidic oxide, has high EA).
- 4. **Electronegativity:** A measure of the tendency of an atom in a chemical bond to attract the shared pair of electrons towards itself.
 - **Trend across a Period (Left to Right): INCREASES.**
 - **Why?** Due to decreasing atomic radius and increasing nuclear charge, the atom's pull on bonding electrons becomes stronger.
 - **Trend down a Group (Top to Bottom): DECREASES.**
 - **Why?** The increasing atomic radius and shielding effect mean the nucleus has less pull on the bonding electrons.
 - **Most Electronegative Group: Halogens (Group VIIA/17)** . Fluorine is the single most electronegative element.
 - ✓ *Relevant Questions:* **2016 Q21** (Group VIIA element), **2016 Q23** (Halogens are most electronegative).
- 5. **Metallic Character:** The extent to which an element exhibits the properties of a metal (luster, malleability, conductivity, tendency to lose electrons and form positive ions).
 - **Trend across a Period (Left to Right): DECREASES.**
 - **Why?** Elements on the left readily lose electrons (metals), while those on the right tend to gain electrons (nonmetals).
 - **Trend down a Group (Top to Bottom): INCREASES.**
 - **Why?** Atoms become larger and lose electrons more easily.
 - Example:** Cesium (Cs, Z=55) is at the bottom of Group I, making it one of the most highly metallic elements.
 - ✓ *Relevant Question:* **2016 Q24** (Element with Z=55, Cs, has high metallic character).

Q: Can you predict the properties of an element from its position in the table?

A: Yes. For example, an element in **Group VIIA and Period 3** is **Chlorine (Cl)** .

- It is a nonmetal.
- It has high ionization energy and electron affinity.
- It is very electronegative.
- It forms an **acidic oxide** (e.g., Cl_2O_7 reacts with water to form perchloric acid, $HClO_4$).
- ✓ *Relevant Question:* **2016 Q21**

Let's Do it (ESSLCE 2014-2017)

1. What is the significance of electron probability distribution? It tells us about (2014)
A) Finding the electron in its orbit at a particular time
B) The uncertainty to assign fixed path for electrons
C) The probability of finding an electron is very far away from the nucleus.
D) Finding the electron very close to the nucleus at all times.
2. Which group in the periodic table contains elements with the valence electron configuration of $ns^2 np^1$? (2014)
A) II B) I C) IV D) III
3. Which of the following is NOT true about cathode rays? (2014)
A) Travel in straight from cathode to the anode.
B) Contain particles, which are negatively charged.
C) Are common constituents of all matter and their m/e is constant for all gases
D) Contain particles, which are positively charged
4. Which of the following is correct about the energy of photon? (2014) A) IT is inversely proportional to the observed frequency of the light
B) It is directly proportional to the observed frequency of the light C) It is directly proportional to the wave length of the light
D) It is directly related to the intensity of the light.
5. Which of the following explains the emission spectra of atoms consisting of a series of fine lines? (2014)
A) An electron undergoes a transition by energy changes corresponding to photon of specific wave length.
B) An electron can have specific energy values in an atom
C) An electron that revolves around the nucleus emits radiation
D) The energy of atom is continuous with discrete frequencies

6. What are the four quantum numbers for an electron in a 2s orbital? (2015)
- A) 2,1,1, $+\frac{1}{2}$
B) 2,1,0, $+\frac{1}{2}$
C) 2,0,1, $+\frac{1}{2}$ D) 2,0,0, $+\frac{1}{2}$
7. Which one of the following explain that light has both wave and particle nature? (2015)
- A) An electron that is bound to the nucleus behaves like a standing wave and its position is given in terms of probability
B) A beam of light a stream of particles of electromagnetic energy, with energy proportional to the observed frequency of the light.
C) Light consists of electromagnetic waves which have an oscillating electric and magnetic disturbance that spreads electromagnetic radiation
D) Microscopic systems, such as atoms and molecules can possess wave properties
8. A nuclear breakdown in which particles or electromagnetic radiation is emitted is.....(2015)
- A) Radioactivity
B) Radioactive isotopes
C) Radioactive decay
D) Radio wave
9. Which of the following characteristics of an electromagnetic radiation is CORRECT? (2016)
- A. The wavelength of an electromagnetic radiation is directly proportional to its frequency.
B. The speed of an electromagnetic wave is independent of the nature of the medium it travels through.
C. The speed of an electromagnetic radiation increases with increase in its frequency.
D. The speed of an electromagnetic radiation decreases with increase in its wavelength.
10. "The hydrogen atom moves in a fixed circular orbit associated with allowable energy states". This is called (2016)
- A) Aufbau's principle
B) Pauli's principle
C) Bohr's theory
D) Plank's theory
11. Which one of the following is fundamental SI unit? (2014)
- A) Force
B) Speed
C) Length
D) Pressure
12. Which of the following postulates of Dalton's atomic theory was modified by the modern atomic theory? (2014)

- A) Atoms are indivisible and indestructible
- B) Atoms are the smallest particles of all element
- C) Compounds are formed when atoms of more than one element combine
- D) Atoms are neither created nor destroyed in chemical reaction

13. Which of the following includes all of the known atomic models? (2014)

- A. Bohr Model, the quantum Mechanical model, THOMSON Model, Rutherford Model
- B. Bohr Model, the Quantum Mechanical Model, Rutherford Model, Thomson Model, Dalton's Atomic Model.
- C. Bohr Model, the Quantum Mechanical Model, Thomson Model, Rutherford Model.
- D. Bohr Model, Quantum Mechanical Model, Dalton's Atomic Model, Valence Bond Model.

14. The electron configuration of Cu(Z=29) is: (2014)

- A. $[\text{Ar}]4s^33d^{10}$
- B. $[\text{Kr}]4s^23d^9$
- C. $[\text{Ar}]4s^24d^9$
- D. $[\text{Ar}]4s^23p^8$

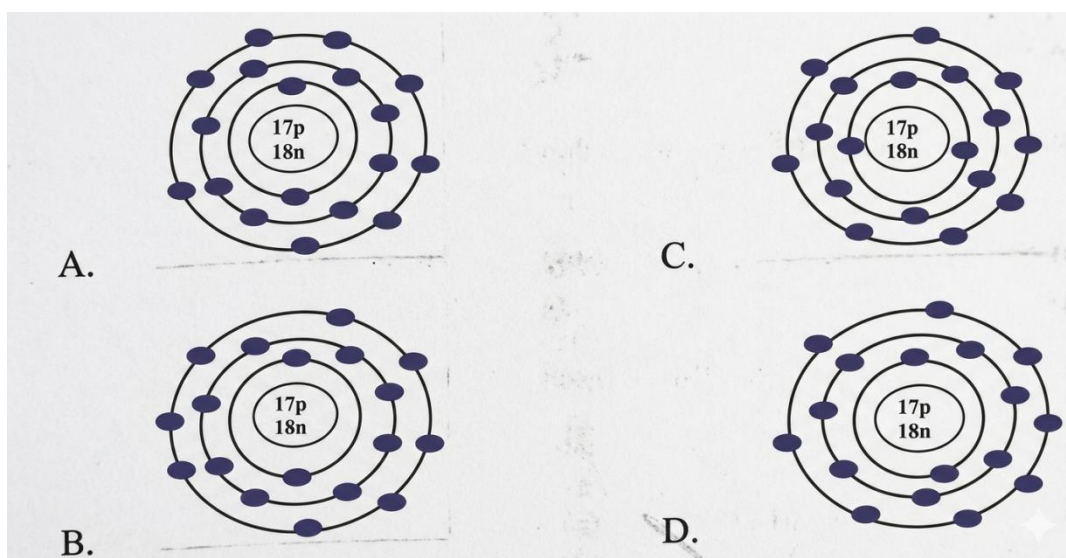
15. Which one of the following is true about isotopes? (2015)

- A) Isotopes of an element are identical in mass number
- B) Isotopes of an element are atoms that have different number of proton and electrons
- C) Isotopes of an element have the same chemical properties
- D) Isotopes of the same elements contain the same number of neutrons

16. Which one of the following describes the quantum mechanical model? (2015)

- A) An atom is represented by a solid indestructible sphere
- B) The locations of electrons in an atom are described in terms of probability
- C) Electrons move around the nucleus of an atom in circular orbitals
- D) An atom is a sphere with a positively charged matter, in which electrons are embedded.

17. Which one of the following is the diagrammatic representation of $^{35}_{17}\text{Cl}$? (2015)



18. Carbon forms two stable compounds with oxygen, namely, carbon monoxide and carbon dioxide. For a fixed mass of carbon, the ratio of oxygen in carbon monoxide to oxygen in carbon dioxide is 1:2. This result is consistent with the law of (2015)

- A. definite proportion.
- B. conservation of mass.
- C. constant composition.
- D. multiple proportion.

19. Given the symbols of the three subatomic particles; electrons (e^-), protons (p^+) and neutrons (n^0), which of the following is the **CORRECT** comparison of the absolute masses of protons, electrons and neutrons? (2016)

- A. Mass of $e^- < \text{mass of } p^+ < \text{mass of } n^0$
- B. Mass of $e^- > \text{mass of } p^+ > \text{mass of } n^0$
- C. Mass of $e^- > \text{mass of } p^+ = \text{mass of } n^0$
- D. Mass of $e^- = \text{mass of } p^+ > \text{mass of } n^0$

20. A student added 25 mL of AgNO_3 solution to a beaker and weighed the mass of the beaker and its content as m_1 . He/she added 50 mL of a saturated solution of NaCl into the second beaker and weighed

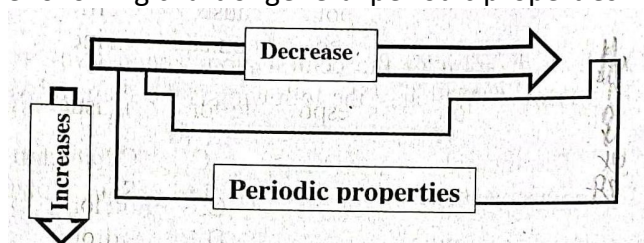
the mass of the beaker and its content as m_2 . Finally, he/she mixed the two solutions and weighed the mass of the resulting solution with the two beakers and recorded as m_3 . If he/she found that $m_3 = m_1 + m_2$, which one of the following laws is investigated by this trial?

- A. Law of definite composition
- B. Law of multiple proportions
- C. Law of conservation of energy
- D. Law of conservation of mass

21. An element is located in Group VIIA and 3rd period of the modern periodic table. On the basis of this the element:

- A) Has very low ionization energy
- B) Generally forms an ion with -2 charges
- C) Has extremely low electron affinity
- D) Forms an acidic oxide

22. Consider the following chart of general periodic properties in the periodic table:



From the given periodic properties, which one **CORRECTLY** agrees with the periodic trend in the chart?

- A) Ionization energy
- B) Atomic radius
- C) Electronegativity
- D) Electron affinity

23. In the modern periodic table, what is the name of the group that contains the most electronegative elements?(2016)

- A) Chalcogens
- B) Noble gases
- C) Alkali
- D) Halogens

24. A given element has atomic number of 55 and mass number of 133. Which of the following describes **CORRECTLY** the property of this element?(2016)

- A. The element has high electron affinity.
- B. The element has high electronegativity.
- C. The non-metallic character of the element is high.
- D. The metallic character of the element is high

25. What does Mendeleev's Periodic Law state? Properties of the elements are periodic functions of their (2014)

- A. Atomic radius.
- B. Electron configurations.
- C. atomic masses
- D. atomic numbers.

26. Which one of the following **CORRECTLY** shows the relative charges of an electron, proton and neutron, respectively? (2017)

- A. 0, +1, -1
 - B. -1, +1, 0
 - C. 0, -1, +1
 - D. -1, 0, +1
27. Which statement below CORRECTLY describes the Bohr's model of an atom? (2017)
- A. Protons and electrons are found in the nucleus.
 - B. Electrons and neutrons are found in the nucleus.
 - C. Protons move in circular orbits around the nucleus.
 - D. Electrons move in circular orbits around the nucleus.
28. Which statement below CORRECTLY describes periodicity? Periodicity is (2017)
- A. A regular repetition of chemical and physical properties in the Periodic table.
 - B. A row in the Periodic Table which contains elements with same number of shells.
 - C. A measure of electronegativity which runs from least electronegative to most electronegative elements.
 - D. A column of the Periodic Table which contains elements with similar chemical properties.
29. Which law governs the fact that the ratio of the amount of hydrogen to oxygen by weight will be the same in a drop of water and a lake of water? (2017)
- A. Law of relative composition
 - B. Law of conservation of mass
 - C. Law of multiple proportions
 - D. Law of definite composition
30. Which of the following statements CORRECTLY describes the law of conservation of mass? (2017)
- A. The total mass of substances varies during a chemical reaction.
 - B. Mass is neither created nor destroyed during a chemical reaction.
 - C. A particular compound is composed of the same elements in the same parts by mass.
 - D. Pure compounds always contain the elements in the same percentage by mass
31. A mineral absorbs purple light of frequency 7.11×10^{14} Hz. What is the wavelength (in nm) of the absorbed light? ($C = 3.00 \times 10^8$ m/s) (2017)
- A. 184.4 nm
 - B. 237.5 nm
 - C. 421.9 nm
 - D. 514.5 nm
32. Why do atoms absorb energy when their electrons undergo transitions from a lower energy to a higher energy level? This is because, (2017)
- A. the electrons of the atoms move from one orbit of lower radius to another one having larger radius.
 - B. the electrons of the atoms move from one orbit of higher radius to another one having lower radius.
 - C. the electrons of the atoms do not have allowable energy levels.
 - D. electrons of the atoms absorb energy when they go from higher to lower energy.
33. What are the quantum numbers for the 5s orbital? (2017)
- A. $n=5, l=0, m_l=-1, m_s=\pm 1/2$
 - B. $n=5, l=1, m_l=-2, m_s=\pm 1/2$
 - C. $n=5, l=2, m_l=-2, m_s=\pm 1/2$

D. $n=5, l=0, m_l=0, m_s=\pm 1/2$

34. Which of the following is CORRECT about the set of quantum numbers assigned to the two electrons of the helium atom? (2017)

- A. Both electrons have the same four quantum numbers.
- B. The second electron occupies the same orbital as the first with the same spin quantum number.
- C. The second electron occupies the same orbital as the first with the opposite spin quantum number.
- D. The magnetic quantum numbers of both electrons are different.

35. Scandium (Sc) has the electron configuration $[\text{Ar}] 4s^2 3d^1$. To which group of elements does it belong to? (2017)

- A. Representative elements
- B. Transition elements
- C. Inner transition elements
- D. Nonmetals

36. Which of the following statements CORRECTLY describes the relationship among wavelength, frequency and speed in an electromagnetic radiation? (2017)

- A. As the wavelength increases, the frequency increases.
- B. As the wavelength decreases, the frequency increases.
- C. As the wavelength decreases, the speed of light increases.
- D. As the frequency increases, the speed of light decreases.

Answer Key

Question No.	Correct Answer
1	B
2	D
3	D
4	B
5	A
6	D
7	B
8	C
9	B
10	C
11	C

Question No.	Correct Answer
12	A
13	B
14	A
15	C
16	B
17	D
18	D
19	A
20	D
21	D
22	B
23	D
24	D
25	C
26	B
27	D
28	A
29	D
30	B
31	C
32	A
33	D
34	C

Question No.	Correct Answer
35	B
36	B

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