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Give Short Answers of the Following Questions

1. According to Moseley, the atomic number Z was a fundamental property of an element. How?

Ans. In 1913, Moseley v observed that when different elements were bombarded with cathode rays, the X-rays of some characteristic frequencies were produced. It was found that the square root of the frequency of the X-rays was directly proportional to the atomic number of an elements Z.

$$\sqrt{\text{frequency}} \quad (\nu) \propto Z$$

He concluded that this number, i.e. the atomic number Z was a fundamental property of an element.

2. What is the effect of electric field on the fundamental particles?

Ans. The behavior of particles in an electric field depends upon their mass and charge. They show their behavior as follows.

- Neutrons being neutral are not deflected but travel in a straight path perpendicular to the direction of electric field.
- Protons being positively charged are deflected towards the negative plate.
- Electrons being negatively charged are deflected towards the positive plate.

3. Differentiate between atomic spectra and atomic absorption spectrum.

Ans.	<table border="1"> <thead> <tr> <th>Atomic emission spectrum</th><th>Atomic absorption spectrum</th></tr> </thead> <tbody> <tr> <td>When an element in its gaseous state is heated to high temperatures or subjected to electrical discharge, radiation of certain wavelengths is emitted. The spectrum of this radiation contains coloured lines and is called atomic emission spectrum.</td><td>When a beam of white light is passed through a gaseous sample of an element in cold state, certain wavelengths are absorbed. The wavelengths of the white light that has been absorbed by the atoms show up as dark lines on the spectrum. The spectrum of this radiation is called an atomic absorption spectrum.</td></tr> </tbody> </table>	Atomic emission spectrum	Atomic absorption spectrum	When an element in its gaseous state is heated to high temperatures or subjected to electrical discharge, radiation of certain wavelengths is emitted. The spectrum of this radiation contains coloured lines and is called atomic emission spectrum.	When a beam of white light is passed through a gaseous sample of an element in cold state, certain wavelengths are absorbed. The wavelengths of the white light that has been absorbed by the atoms show up as dark lines on the spectrum. The spectrum of this radiation is called an atomic absorption spectrum.
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4. What is the trend of ionization energy in the periodic table?

Ans. • As we go down a particular group, ionization energies decrease. The larger the atom, the easier is to separate an electron from it. Actually, down the group, number of shells increases, hold of nucleus on the valence electrons decreases, hence removal of electrons becomes easier.

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- The ionization energies generally increase on going across a period. It is due to the reason that across the period shell number remains same. As the proton number increases, electrons are added in the same shell. Therefore, nucleus attracts the valence electrons more strongly. As a result, ionization energy increases across the period.

5. Differentiate between shell and subshell.

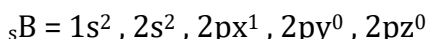
Ans.

Shell	Subshell
- The collection of orbitals with same values of n is called an electron shell. - It is denoted by n.	- The set of orbitals that have the same n and l values is called a subshell. - They are denoted by s, p, d and f.

6. Define electronic configuration and give example.

Ans. Electronic configuration is the distribution of electrons among available shells, subshells, or orbitals of an atom or ion.

Example: the electronic configuration beryllium is given below,



7. State Hund's rule and Puali's exclusion principle.

Ans. Hund's rule: when degenerate orbitals are available and more than two electrons are to be placed in them, they should be placed in separate orbitals with the same spin rather than in the same orbital with opposite spins.

Puali's exclusion principle: According to this principle. No two electrons in an atom can have the same values for all the four quantum numbers or, "Two electrons in an orbital will always have opposite spins".

8. Write the classification of the periodic table on the basis of electronic configuration.

Ans. The classification of elements of periodic table has been done into metals, non-metals, representative, transition elements, periods, groups and blocks (s, p, d, f). This division is done on the basis of electronic configuration and their valence electrons. The chemical properties of various categories of elements discussed above can be easily assessed.

9. Write the electronic configuration of ions with examples.

Ans. Positive ions are formed when electrons are removed from atoms. The sodium ion, Na^+ (proton number = 11), has 10 electrons. So, its electronic configuration is $1s^2 2s^2 2p^6$.

Negative ions are formed when atoms gain electrons. The sulfide ion, S^{2-} (proton number = 16), has 18 electrons. Its electronic configuration is $1s^2 2s^2 2p^6 3s^2 3p^6$, which is the same as argon, the element with 18 electrons in each atom.

10. What is the trend of ionization energy in the periodic table?

Ans. "A free radical is a species that has one or more unpaired electrons".

An example of a simple free radical is free chlorine atom $\cdot\text{Cl}$. The electron configuration of this radical is $1s^2 2s^2 2p^6 3s^2 3p^5$. In the $2p$ subshell, two orbitals have paired electrons whereas,

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the third one contains a single unpaired electron. The unpaired electron is shown by a single dot as in Cl.

11. What is the trend of ionization energy in the periodic table?

Ans.

Property	P-type Semiconductor	n-type Semiconductor
Doping Element	Trivalent (like, boron, Aluminum)	Pentavalent (like, phosphorus, Arsenic).
Charge Carriers	Holes	Electrons
Type of Conduction	Mainly due to holes.	Mainly due to electrons.
Electrons in Conduction Band	Few	Many
Effect of Doping	It creates more holes.	Increases free electrons
Example	Positive side of a diode (anode).	Negative side of a diode (cathode).

12. There are three orientations of p-orbital due to three values of magnetic quantum number. Justify it.

Ans. It is correct. There are three orientations of the p-orbital due to the three values of the magnetic quantum number (m_l). Here's the justification in simple scientific terms:

Quantum Numbers:

Each electron in an atom is described by four quantum numbers:

1. **Principal quantum number (n)** _ energy level
2. **Azimuthal / angular quantum number (l)** _ shape of orbital
3. **Magnetic quantum number (m_l)** – orientation of orbital
4. **Spin quantum number (m_s)** _ spin direction of electron

For a p-orbital:

- The azimuthal quantum number (l) = 1
- (Because p-orbitals correspond to $l = 1$)
- The magnetic quantum number (m_l) can have three values:
 $m_l = -1, 0, +1$

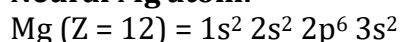
13. ' I_3 ' of Mg is much bigger than its ' I_2 '. Justify.

Ans. The third ionization energy (I_3) of magnesium (Mg) is much bigger than its second ionization energy (I_2). Here's the scientific justification:

- **Ionization energy** is the energy needed to remove one electron from an atom or ion.
- **I_1 :** Remove 1st electron
- **I_2 :** Remove 2nd electron
- **I_3 :** Remove 3rd electron

Electronic Configuration of Magnesium:

Neural Mg atom:

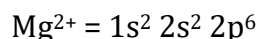


- **First ionization (I_1)** remove one electron from $3s^2 \rightarrow$ becomes Mg^+
- **Second ionization (I_2)** removes second 3s electron $\rightarrow$ become Mg^{2+}

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- **Third ionization (I_3)** would now try to remove an electron from the $2p^6$ (inner, noble gas core)

After removing two outermost 3s electrons, Mg^{2+} has the stable configuration of Neon (Ne):



Now, the third electron to be removed is from a completely filled inner shell (2p) which:

- Is very stable (noble gas configuration)
- Is closer to the nucleus
- Is more strongly attracted by nuclear charge

Hence, much more energy is needed to remove this tightly bound electron.

14. Among the elements Li, K, Ca, S and Kr which one has the lowest first ionization energy? Which has the highest first ionization energy?

Ans. Ionization Energy Trend Recap:

- **Increases across a period** (left → right) due to increasing nuclear charge.
- **Decreases down a group** (top → bottom) as outer electrons are farther from the nucleus and more shielded.

Lowest first ionization energy = potassium (K)

Reason: It's a group 1 element in period 4 → outermost electron is loosely held and easily removed.

Highest first ionization energy = Krypton (Kr)

Reason: Noble gas with a full outer shell → very stable → requires lots of energy to remove an electron.

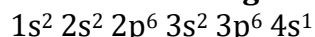
15. Consider the electronic configuration of the potassium atom (atomic number 19).

Ans. Element: Potassium (K)

Atomic Number: 19

So it has 19 electrons.

Electronic Configuration:



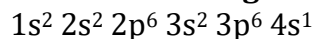
16. Write the full electronic configuration of potassium using s, p, d, f notation.

Ans. Element: Potassium (K)

Atomic Number: 19

So it has 19 electrons.

Electronic Configuration:



17. Explain why the 4s subshell is filled before the 3d subshell in potassium, even though the principal quantum number of the 3d subshell is lower.

Ans. Even though:

- 3d has a lower principal quantum number ($n = 3$)
 - 4d has a lower principal quantum number ($n = 4$)
- The 4s subshell has lower energy than 3d at the time potassium's electrons are being placed.

Key Principle:

1. Aufbau principle

Electrons fill orbitals in order of increasing energy, not just by n value. According to the

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Aufbau (building-up) principle.

$$1s < 2s < 2p < 3s < 3p < 4s < 3d < 4p$$

As you can see, 4s comes before 3d.

2. Energy Level Overlap

- 4s orbital is farther from the nucleus but has less electron-electron repulsion, making it lower in energy than 3d.
- So, the first 19 electrons (in potassium) go into the 4s before starting to fill 3d.

Potassium (Z = 19):

- **Configuration:** $1s^2 2s^2 2p^6 3s^2 3p^6 4s^1$
- The 3d subshell remains empty in potassium because it's higher in energy at this point.

Conclusion:

The 4s subshell is filled before 3d in potassium because, despite having a higher principal quantum number, it is lower in energy at the point when electrons are added, following the Aufbau principle.

18. An atom of element X has an atomic number of 17 and a mass number of 35. Determine the number of protons, neutrons, and electrons in this atom.

Ans. Number of protons = Atomic number

Protons = 17

Number of neutrons = Mass number – Atomic number

Neutron = 18

Number of electrons = Number of protons (in a neutral atom)

Electrons = 17

19. If this element forms an ion with a charge of -1, how many protons, neutrons, and electrons will be present in the ion?

Ans. X element has:

- Atomic number = 17
- Mass number = 35

We previously identified it as chlorine (Cl).

Now, let's consider the Cl^- ion (chloride ion), which has a – 1 charge.

Protons

- The number of protons never changes, even when forming ions.

Protons = 17

Neutrons

- Mass number = 35, Atomic number = 17

Neutrons = 18

Electrons (for Cl^- ion)

- Neutral chlorine atom has 17 electrons
- A – 1 charge means it has gained one extra electron

Electron = $17 + 1 = 18$

20. In the ground state of mercury $_{80}\text{Hg}$:

Ans. In the ground state of mercury (Hg), which has an atomic number of 80, we can determine several important features of the atom, such as its electron configuration, and the number of protons, neutrons, and electrons.

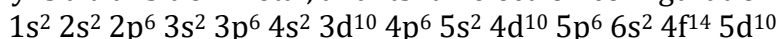
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Basic information for Mercury (Hg):

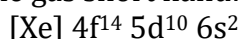
- **Symbol:** Hg
- **Atomic number (Z):** 80 → Protons = 80, Electrons = 80 (in a neutral atom)
- **Mass number (most common isotope):** 200 → So, Neutrons = 200 – 80 = 120

Ground- State Electron Configuration:

Mercury is a transition metal, and its full electron configuration is:



In noble gas short hand:



21. How many electrons occupy atomic orbitals with $n = 3$?

Ans. Electrons can occupy atomic orbitals where the principal quantum number $n = 3n = 3n = 3$

For $n = 3n = 3n = 3$, the possible **subshells** (values of l) are:

- $L = 0 \setminus \ell = 0 \rightarrow 3s$
- $L = 1 \setminus \ell = 1 \rightarrow 3p$
- $L = 2 \setminus \ell = 2 \rightarrow 3d$

Each subshell has a certain number of orbital, and each orbital holds **2 electrons**:

Subshell	Orbitals	Electrons
3s	1	2
3p	3	6
3d	5	10

Total electrons when $n = 3n = 3n = 3$:

$$2 (3s) + 6 (3p) + 10 (3d) = 18 \text{ electrons}$$

So, **18 electrons** can occupy atomic orbitals with **principal quantum number $n = 3n = 3n = 3$**

22. How many electrons occupy 4d atomic orbitals?

Ans. The 4d atomic orbitals can hold a maximum of 10 electrons. This is because the 4d subshell consists of 5 orbitals (each orbital can hold a maximum of 2 electron), so 5 orbitals x 2 electrons = 10 electrons in total.

23. How many electrons occupy 4p_z atomic orbitals?

Ans. The 4p_z atomic orbital can hold a maximum of 2 electrons. Each atomic orbital, including the 4p_z orbital, can accommodate up to 2 electrons, with each electron having opposite spins.

24. How many electrons in the valence shell have spin “up” ($s = -\frac{1}{2}$)?

Ans. In an atomic orbital, each electron can have one of two possible spins: “up” {donated as $s = +\frac{1}{2}$ } or “down” (donated as $s = -\frac{1}{2}$).

If you are asking how many electrons have a spin of $s = -\frac{1}{2}$ in a particular orbital, it depends on how many electrons are present in that orbital. For example.

In a single atomic orbital (such as the 4p_z orbital), a maximum of 2 electrons can occupy it one with spin $+\frac{1}{2}$ and one with spin $-\frac{1}{2}$.

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If there are multiple orbitals (such as in a subshell like the 4d or 4p), the electrons will fill the orbitals according to the Pauli exclusion principle, with one electron having spin $+\frac{1}{2}$ and the other having spin $-\frac{1}{2}$ in each orbital.

So, in general, half of the electrons in any set of orbitals would have spin $s = -\frac{1}{2}$, assuming the electrons are paired and fill orbitals according to Hund's rule and the Pauli exclusion principle. Conclusion: 80 electrons in total and thus 40 orbital in Hg.

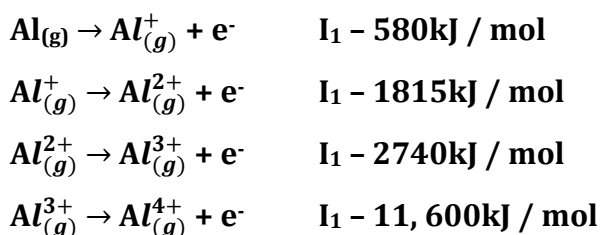
25. The successive ionization energies for an unknown element are

$$\begin{array}{ll} I_1 = 896 \text{ kJ / mol} & I_2 = 1752 \text{ kJ / mol} \\ I_3 = 14,807 \text{ kJ / mol} & I_4 = 17,948 \text{ kJ / mol} \end{array}$$

To which family in the periodic table, does the unknown element most likely belong?

Ans. As there is greatest difference between 2nd and 3rd ionization energies, it means this element belongs to group 2A (Alkaline Earth's metal).

i. Consider the following ionization energies for aluminum:

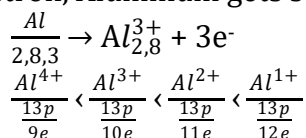


- Account for the trend in the values of the ionization energies.
- Explain the large increase between I_3 and I_4 .
- List the four aluminum ions given in order of increasing size, and explain your ordering.

(i) $I_4 > I_3 > I_2 > I_1$

(ii) As there is greatest difference between 3rd and 4th ionization energies, it means this element belongs to group 3A (Boron family).

(iii) After losing 3rd electron, Aluminum gets stable electronic configuration of noble gas.



In Al^{+1} there are 13 protons and 12 electrons so, control of nucleus is lesser on outer electrons so its size greatest among above.

In Al^{+4} there are 13 protons and 9 electrons, there is more imbalance between proton to electron ratio so, control of nucleus is greatest and its size is the least among above.

- 26. (i) State the general order of filling orbitals up to the 4p subshell.**
(ii) Explain why the 4s subshell is filled before the 3d subshell, according to the Aufbau principle.

Ans. (i) $1s^2 2s^2 2p^6 3s^2 3p^6 4s^2 3d^{10} 4p^6$

(ii) The 4s subshell is filled before the 3d subshell according to the Aufbau principle because

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the 4s orbital is lower in energy than the 3d orbital when these orbitals are empty or partially filled neutral atoms.

1. Energy considerations:

- Even though 4s has a higher principal quantum number ($n = 4$) than 3d ($n = 3$), the energy of an orbital depends on both the principal quantum number n and the azimuthal quantum number l .
- For 4s: $n = 4, l = 0$, so $n + l = 4$
- For 3d: $n = 3, l = 2$, so $n + l = 5$
- According to the $(n + l)$ rule (used in the Aufbau principle), orbitals with a lower $n + l$ value are filled first.

2. Electron Shielding and Penetration:

- The 4s orbital penetrates closer to the nucleus and experiences less shielding than the 3d orbital.
- As a result, electrons in the 4s orbital are more tightly held and thus occupy a lower energy level initially.

However, once electrons are added to the 3d subshell, the energy level shift slightly. In ions of transition metals, for example, the 4s electrons are usually lost before the 3d electrons, because the 4s orbital becomes higher in energy after the 3d subshell is filled or partially filled.

27. Draw the orbital box diagram for the valence electrons of a phosphorus atom (atomic number 15), ensuring that your diagram adheres the Hund's rule and the Pauli exclusion principle.

Ans.

