▶ Video explanation (YouTube Short)

# Electronic Configurations of the d-Block Elements

Chromium "should" be $3d^4\ 4s^2$, but it is $3d^5\ 4s^1$. Copper "should" be $3d^9\ 4s^2$, but it is $3d^{10}\ 4s^1$. The reason is the **extra stability of half-filled and completely filled d subshells**.

## 1. General configuration (NCERT 4.2)

**$(n-1)d^{1\text{-}10}\ ns^{1\text{-}2}$**: the inner (n−1)d holds 1–10 electrons and the outer ns holds 1–2. The 4s orbital fills before 3d. (Exception in the 4d series: Pd is $4d^{10}\ 5s^0$.)

## 2. The 3d series

| Sc | Ti | V | Cr | Mn | Fe | Co | Ni | Cu | Zn |
|---|---|---|---|---|---|---|---|---|---|
| $3d^14s^2$ | $3d^24s^2$ | $3d^34s^2$ | **$3d^54s^1$** | $3d^54s^2$ | $3d^64s^2$ | $3d^74s^2$ | $3d^84s^2$ | **$3d^{10}4s^1$** | $3d^{10}4s^2$ |

## 3. Why Cr and Cu are different

- The 3d and 4s orbitals are **very close in energy**, so a small extra stability decides the arrangement.
- **Half-filled ($d^5$)** and **completely filled ($d^{10}$)** sets are extra stable (more exchange energy, symmetrical distribution).
- So one 4s electron goes into 3d: Cr becomes $3d^54s^1$, Cu becomes $3d^{10}4s^1$.

## Solved example

**Q.** Write the configurations of $Mn^{2+}$ and $Cr^{3+}$.
**A.** Mn [Ar]$3d^54s^2$ loses both 4s electrons: $Mn^{2+}$ = [Ar]$3d^5$. Cr [Ar]$3d^54s^1$ loses $4s^1$ and two 3d: $Cr^{3+}$ = [Ar]$3d^3$.

## Key takeaways

- General: $(n-1)d^{1\text{-}10}\ ns^{1\text{-}2}$.
- Cr $3d^54s^1$ (half-filled d), Cu $3d^{10}4s^1$ (full d).
- Reason: 3d and 4s nearly equal in energy + extra stability of $d^5$ and $d^{10}$.

## Practice questions

1. (MCQ) The configuration of Cr (Z = 24) is: (a) [Ar]$3d^4 4s^2$ (b) [Ar]$3d^5 4s^1$ (c) [Ar]$3d^6$ (d) [Ar]$3d^3 4s^2 4p^1$
2. (MCQ) The configuration of Cu (Z = 29) is: (a) [Ar]$3d^9 4s^2$ (b) [Ar]$3d^{10} 4s^1$ (c) [Ar]$3d^{10}$ (d) [Ar]$3d^8 4s^2 4p^1$
3. (MCQ) The general outer configuration of d-block elements is: (a) $ns^{1\text{-}2}$ (b) $ns^2np^{1\text{-}6}$ (c) $(n-1)d^{1\text{-}10}ns^{1\text{-}2}$ (d) $(n-2)f^{1\text{-}14}$
4. (Very short) Which fills first, 4s or 3d?
5. (Very short) Write the configuration of $Fe^{2+}$.
6. (Short) Why is the configuration of chromium $3d^54s^1$ and not $3d^4 4s^2$?
7. (Short) Which two configurations of a d subshell are extra stable? Why?
8. (Application) Write the configuration of Mo (Z = 42), which lies below Cr.

## Answer key

1. (b).
2. (b).
3. (c).
4. 4s.
5. [Ar]$3d^6$ (both 4s electrons leave).
6. 3d and 4s are very close in energy, and a half-filled $3d^5$ set has extra stability (exchange energy), so one 4s electron moves to 3d.
7. $d^5$ (half-filled) and $d^{10}$ (completely filled): symmetrical distribution and maximum exchange energy.
8. [Kr]$4d^5 5s^1$.

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