# Zinc Fizzes, Copper Stays Silent: Electrode Potentials of the 3d Metals

Copper is the only 3d metal with a positive $E°(M^{2+}/M)$ (+0.34 V), so it gives no $H_2$ with dilute acids. Turning Cu(s) into $Cu^{2+}(aq)$ costs more (atomisation + two ionisations) than hydration pays back: 921 against zinc's 711 kJ/mol. Stable $d^5$ and $d^{10}$ bend the trend: Mn and Zn dip, $Mn^{3+}$ is a strong oxidant, $Fe^{3+}$ is stable.

Name: Date: Score: ____ / 15

## A. Fill in the blanks

**1.** The only 3d metal with a positive $E°(M^{2+}/M)$ is ____.

**2.** $E°(Cu^{2+}/Cu)$ = +____ V.

**3.** Energy released when water surrounds an ion is the ____ enthalpy.

**4.** $E°(Mn^{3+}/Mn^{2+})$ is high because $Mn^{2+}$ has the stable $d^{____}$ configuration.

## B. True or False

**5.** Zinc liberates $H_2$ from dilute HCl. True / False

**6.** Copper dissolves in nitric acid with evolution of $H_2$. True / False

**7.** $Fe^{3+}$ is $d^5$. True / False

## C. Assertion and reason

**8. Assertion (A):** Copper does not liberate $H_2$ from dilute acids.
**Reason (R):** $E°(Cu^{2+}/Cu)$ is positive.

(a) Both A and R are true, and R explains A
(b) Both A and R are true, but R does not explain A
(c) A is true, R is false
(d) A is false, R is true

Answer: _____

**9. Assertion (A):** E° of Zn is more negative than the trend.
**Reason (R):** $Zn^{2+}$ has a stable $d^{10}$ configuration.

(a) Both A and R are true, and R explains A
(b) Both A and R are true, but R does not explain A
(c) A is true, R is false
(d) A is false, R is true

Answer: _____

## D. Choose the correct option

**10.** The only positive $E°(M^{2+}/M)$ in the 3d series:

(a) Zn
(b) Ni
(c) Cu
(d) Fe

Answer: _____

**11.** Net enthalpy for $Zn(s) \rightarrow Zn^{2+}(aq)$:

(a) 711 kJ/mol
(b) 921 kJ/mol
(c) 130 kJ/mol
(d) 2059 kJ/mol

Answer: _____

**12.** A strong oxidising agent:

(a) $Mn^{3+}$ (b) $Fe^{2+}$

(c) $Zn^{2+}$ (d) $Sc^{3+}$

Answer: _____

## E. Numerical problems

**13.** Find the net enthalpy (kJ/mol) for Ni(s) → $Ni^{2+}$(aq): $\Delta_a H$ 431, $IE_1$ 736, $IE_2$ 1752, $\Delta_{hyd} H$ −2121.

## F. Short answer questions

**14.** Why is $Cr^{2+}$ reducing while $Mn^{3+}$ is oxidising, though both are $d^4$?

## G. Match the columns

**15. Match each item in Column A with the correct item in Column B.**

| Column A | Column B | Your answer |
|---|---|---|
| 1. Cu | (a) −0.76 V | 1 → ____ |
| 2. Zn | (b) +1.57 V | 2 → ____ |
| 3. $Mn^{3+}/Mn^{2+}$ | (c) +0.77 V | 3 → ____ |
| 4. $Fe^{3+}/Fe^{2+}$ | (d) +0.34 V | 4 → ____ |

## Detailed solutions

**1.** copper

**2.** 0.34

**3.** hydration

**4.** 5

**5.** True. Its E° is −0.76 V.

**6.** False. It dissolves, but the acid is reduced; no $H_2$.

**7.** True. So E°($Fe^{3+}/Fe^{2+}$) is comparatively low.

**8.** (a) R explains A.

**9.** (a) R explains A.

**10.** (c) Cu. +0.34 V.

**11.** (a) 711 kJ/mol. 130 + 906 + 1734 − 2059.

**12.** (a) $Mn^{3+}$. It becomes $d^5$ $Mn^{2+}$.

**13.** 431 + 736 + 1752 − 2121. **Answer: 798**

**14.** $Cr^{2+} \rightarrow Cr^{3+}$ gives $d^3$ (half-filled $t_2g$, more stable), so it loses an electron easily; $Mn^{3+} \rightarrow Mn^{2+}$ gives the half-filled $d^5$, so it gains one easily.

**15.** 1 → (d), 2 → (a), 3 → (b), 4 → (c). Each item matches its E°.