Iron makes ammonia possible



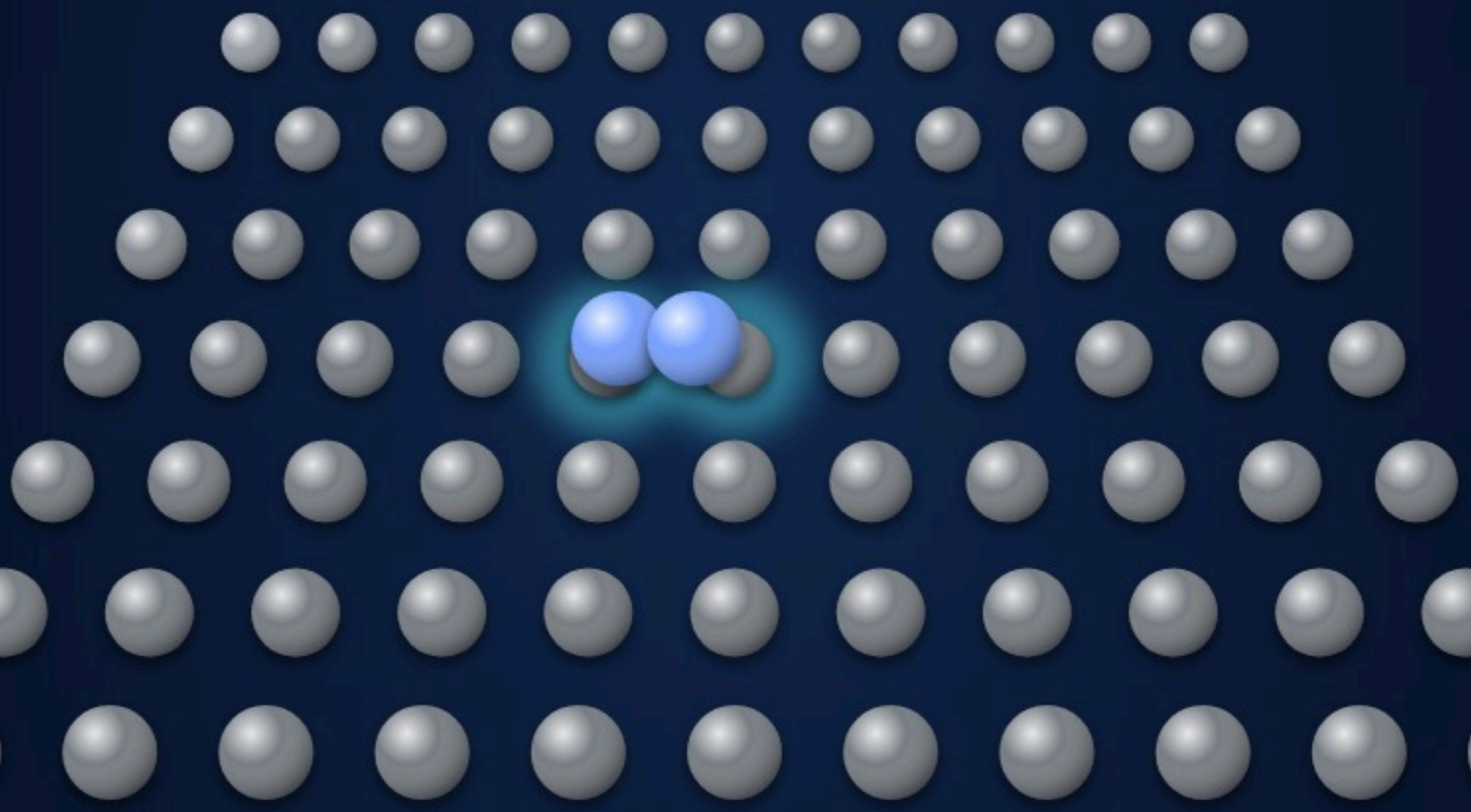
iron powder, ≈ 450 °C, 200 atm

N≡N is very strong: without a catalyst, almost no NH_3

A **catalyst** speeds up a reaction and is **not used up**.

Transition metals and their compounds are **very good catalysts**.

Reason 1: bonding at the surface



uses 3d + 4s electrons

Reactant molecules **form bonds** with atoms on the metal surface.

First-row transition metals use their **3d and 4s electrons** for this bonding.

Two effects of surface bonding

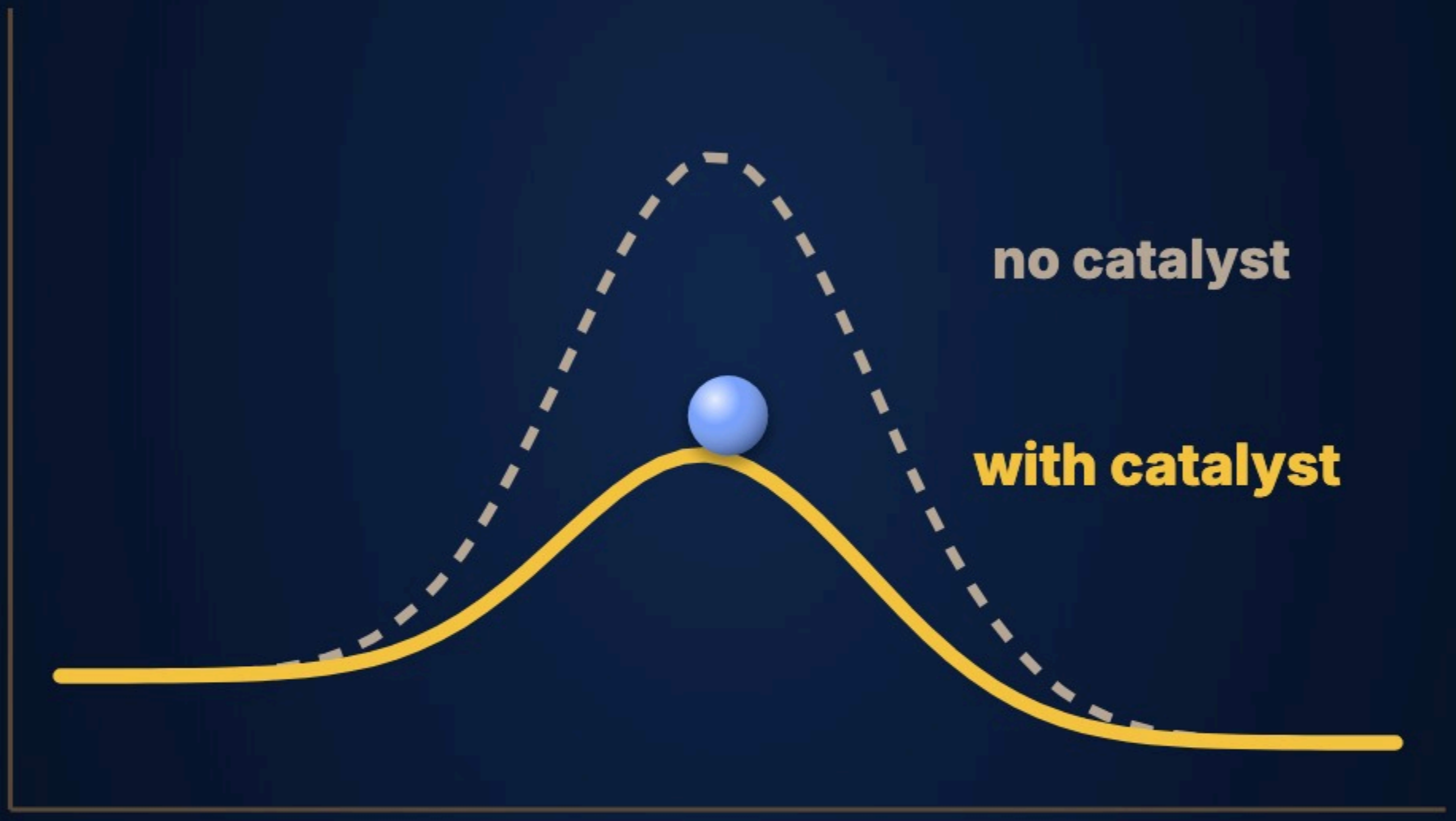


1 · crowded **2 · bonds weaker**

1 Concentration of reactants at the surface **increases**.

2 Bonds in the reacting molecules **weaken** → activation energy is **lowered**.

A lower hill, a faster reaction



A catalyst **lowers the activation energy** (E_a).

It adds no energy: it gives the reaction an **easier path**.

Catalysts in industry

Fe — Haber: $N_2 + 3H_2 \rightleftharpoons 2NH_3$

V_2O_5 — Contact: $2SO_2 + O_2 \rightleftharpoons 2SO_3$

Ni — Hydrogenation: oil → vanaspati

Fe: Haber process (ammonia). **V_2O_5**: Contact process (H_2SO_4).

Ni: catalytic hydrogenation of vegetable oils (**vanaspati ghee**).

Reason 2: changing oxidation state

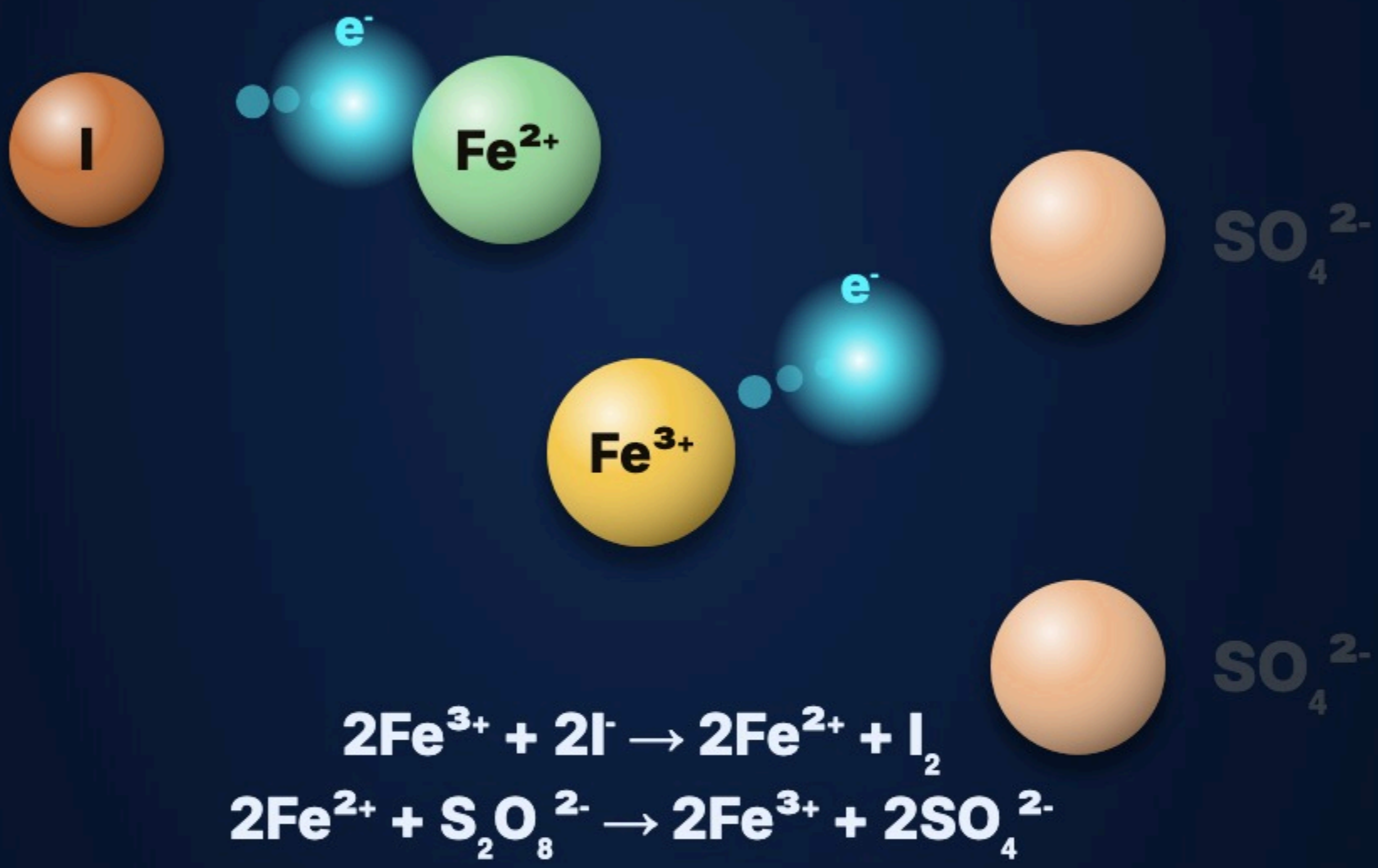


both negative → they repel → slow

$2I^- + S_2O_8^{2-} \rightarrow I_2 + 2SO_4^{2-}$ is slow: two **negative ions repel**.

Fe^{3+} can switch between **+3 and +2**, so it can carry electrons across.

The Fe^{3+} / Fe^{2+} ferry



$$2Fe^{3+} + 2I^- \rightarrow 2Fe^{2+} + I_2$$

$$2Fe^{2+} + S_2O_8^{2-} \rightarrow 2Fe^{3+} + 2SO_4^{2-}$$

Fe^{3+} takes an electron from I^- ($\rightarrow Fe^{2+}$); Fe^{2+} gives it to $S_2O_8^{2-}$ ($\rightarrow Fe^{3+}$).

Iron comes back **unchanged**: it is a catalyst.

Remember

1 · surface bonding (3d + 4s)

crowding + weaker bonds → lower E_a

2 · changing oxidation state

takes and gives electrons, comes back unchanged



Transition metals are good catalysts for **two reasons**.

Your turn: why is Zn^{2+} (only +2) a poor catalyst for the iodide–persulphate reaction?