Rusting

1 Corrosion of metals

- slow reaction of metals (不一定是iron) w/ oxygen, water, and other substances in environment
→ gradual deterioration of metals → X shiny / loses strength

- (at the surface) metal atoms lose e^- → ions ⇒ coating (usu. metal oxide)
- if coating is porous
  > water & air: ✓ trapped inside (ie O_2, H_2O can penetrate coating)
  → coating is not firmly attached to metal surface, flakes off easily (breaks & falls off)
  → new surface of metal exposed → further corrosion
- reactivity ↑ → corrosion rate ↑

2 Rusting

- corrosion of iron → rust (reddish brown solid)
- chemical nature of rust: $Fe_2O_3 \cdot nH_2O_{(s)}$ (hydrated iron (III) oxide)
- water & oxygen: necessary to rusting
- rust is porous (most other metal oxides are usually hard & non-porous)
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$$4Fe + 6H_2O + 3O_2 \rightarrow 4Fe(OH)_3$$

$$2Fe(OH)_3 \xrightarrow{\text{decomposition}} 3H_2O + Fe_2O_3$$

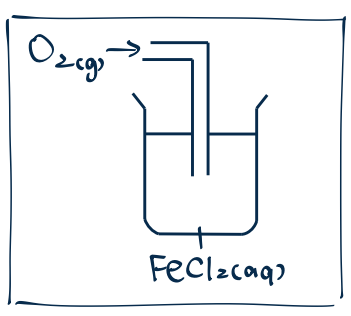
$$\Downarrow$$

$$4Fe + 3O_2 + 2nH_2O \rightarrow 2Fe_2O_3 \cdot nH_2O$$

(much slower process than)

$$Fe \rightarrow Fe^{2+} + 2e^-, \quad Fe^{2+} \rightarrow Fe^{3+} + e^-$$
$$4e^- + 2H_2O + O_2 \rightarrow 4OH^-$$

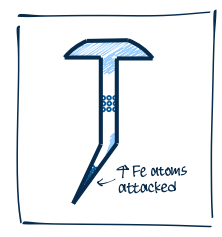
- Exp. to show (☆not "prove both O_2, H_2O are necessary") that rusting occur in environments w/ both O_2, H_2O present:



⇒ soln turns from pale green to yellowish brown

3 Factors affecting rate of rusting

1. amount of reactant
   - piece of iron is exposed to more H_2O & O_2
2. presence of sharp / bent region
   - atoms of Fe packed more densely (surface area ↑) → easier to be attacked by O_2, H_2O.
   - eg. head and tip of nail → ↑ rust



3. heat / high temperature
   - (all chemical rx) temp ↑ → reaction rate ↑
   - eg. car exhaust pipes
4. mobile ion ↑
   - mobile ion ↑ → electrical conductivity ↑ → rate of e^- transfer ↑
   → presence of salts / acids
   - eg. iron objects near the sea rust more easily (sea water: ✓ NaCl)
   - eg. rain / acid rain speeds up rusting (✓ acid)
5. reaction ⇒ Fe^{2+}
   - acidic medium
   - contact w/ less reactive metals (eg. Sn, Cu, Ag)
     > less reaction metals cause Fe to lose e^- ↑ rapidly
   - soln w/ salt (salt里的金属比Fe弱) → displacement ⇒ Fe^{2+}
     > eg. Fe in $AgNO_3$ vs NaCl
   - connection to +ve pole of battery
     > cathode 吸电子