



# ENGINEERING CHEMISTRY

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Department of Science and Humanities

# ENGINEERING CHEMISTRY

## Corrosion Chemistry

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### *Module content:*

- *Electrochemical Theory of corrosion*
- *Types of corrosion*
- *Factors affecting rates of corrosion*
- *Corrosion control*

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## Corrosion Chemistry

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### *Class content:*

- *Corrosion*
- *Types of corrosion*
- *Electrochemical Theory of corrosion*
- *Corrosion of Iron*

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## Corrosion Chemistry

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### Corrosion

- The destruction or deterioration & consequent loss of metal through **direct chemical or electrochemical attack** by the environment
- Most metals except very noble ones, corrode on contact with water (and moisture in the air), acids, bases, salts, oils, aggressive metal polishes, and other solid and liquid chemicals
- **Spontaneous process**
- Causes **indirect losses**

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## Corrosion Chemistry

### Pure metal → undesirable products

- **Rusting of iron** - a reddish brown scale formation on iron and steel objects
- Due to formation of **hydrated ferric oxide** ( $\text{Fe}_2\text{O}_3 \cdot x\text{H}_2\text{O}$ )
- **Scaling of Copper** - Green scales formed on copper articles
- Due to formation of **basic cupric carbonate** ( $\text{CuCO}_3 + \text{Cu}(\text{OH})_2$ )



The Statue of Liberty is covered with a copper skin, and was originally brown, as shown in this painting



Exposure to the elements has resulted in the formation of the blue-green patina seen today

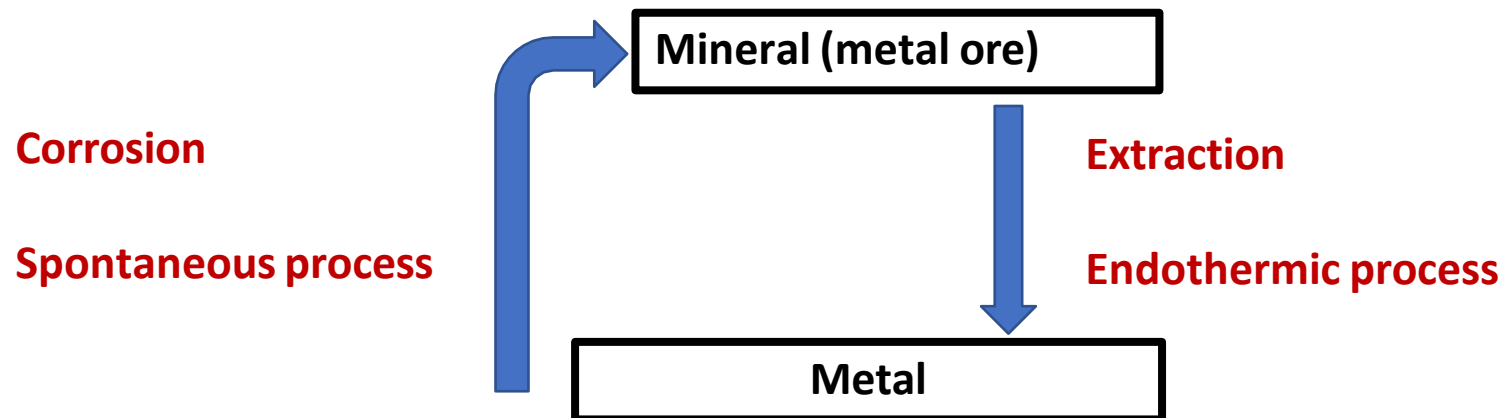
Source: <https://opentextbc.ca/chemistry/chapter/17-6-corrosion/>

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## Corrosion Chemistry

### Why do metals undergo corrosion?

- Most metals occur in nature in the **form of their compounds** such as oxides, sulfides, carbonates, chlorides
- Metals are extracted from these ores by reduction which is an **endothermic process**, energy being supplied in the form of heat or electrical energy
- Pure metals are relatively at **higher energy state** compared to their corresponding ores, and they have a natural tendency to revert back to their combined state



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## Corrosion Chemistry

### Types of corrosion

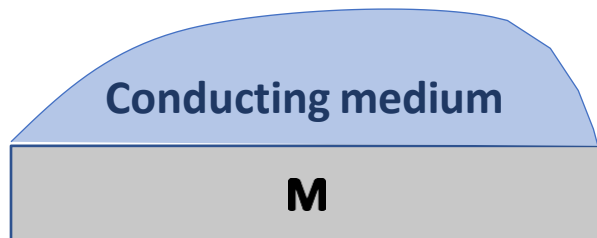
- **Dry corrosion :**

- **Direct chemical attack** due to affinity of the metal to certain gases
- In the **absence of the electrolytic medium**



- **Wet corrosion :**

- **Electrochemical attack** on the metal
- in the **presence of moisture or conducting medium**

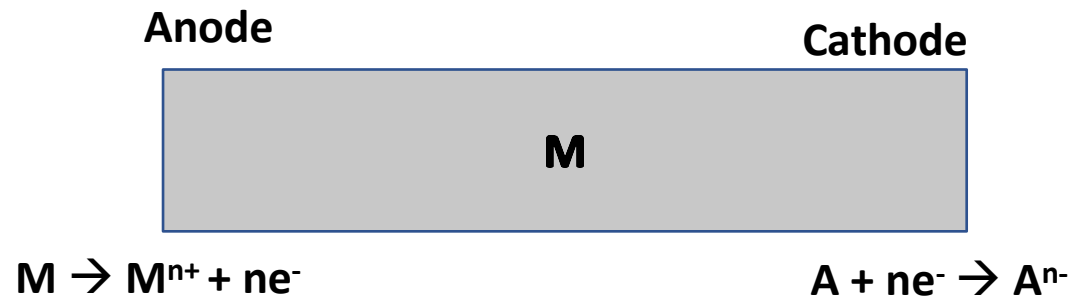


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## Corrosion Chemistry

### Electrochemical theory of corrosion

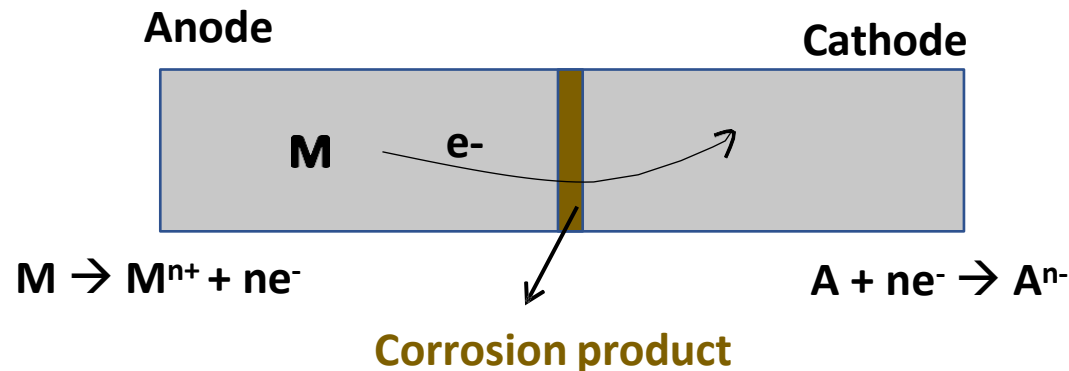
- A large number of **tiny galvanic cells** are formed due to the formation of separate anodic and cathodic regions on the metal surface
- **At the anodic region**, metal undergoes oxidation and gets converted into its ions, liberating electrons and the **metal undergoes corrosion**
- **At the cathodic region**, reduction takes place but since the metal cannot be reduced further, metal atoms are **unaffected by corrosion**



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- The electrons liberated at the anodic region **migrate** to the cathodic region constituting a **small corrosion current**
- The **metal ions** formed at the anode and **some anions** formed at the cathode diffuse towards each other through the conducting medium and form a **corrosion product** somewhere between anode and the cathode
- Corrosion of metal continues as long as both **anodic and cathodic reactions take place simultaneously**



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### Reactions:

- Anode:



e.g., when iron undergoes corrosion,



- Cathode:

- Liberation of hydrogen
- Absorption of oxygen

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## Corrosion Chemistry

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- Liberation of hydrogen

- In acidic medium



- In neutral or alkaline medium



- Absorption of oxygen

- In acidic medium



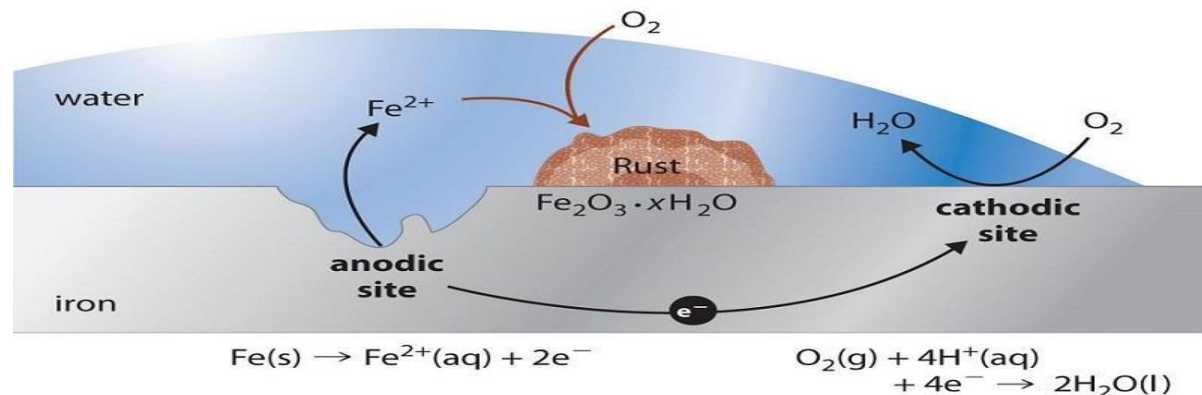
- In neutral or alkaline medium



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## Corrosion Chemistry

### Corrosion of Iron:



Source: [https://chem.libretexts.org/Bookshelves/General\\_Chemistry/Book%3A\\_Chem1\\_\(Lower\)/16%3A\\_Electrochemistry/16.08%3A\\_Electrochemical\\_Corrosion](https://chem.libretexts.org/Bookshelves/General_Chemistry/Book%3A_Chem1_(Lower)/16%3A_Electrochemistry/16.08%3A_Electrochemical_Corrosion)

Anode :  $\text{Fe} \rightarrow \text{Fe}^{2+} + 2\text{e}^{-}$

Cathode :  $2\text{H}_2\text{O} + \text{O}_2 + 4\text{e}^{-} \rightarrow 4\text{OH}^{-}$

$\text{Fe}^{2+}$  and  $\text{OH}^{-}$  ions move towards one another and  $\text{Fe(OH)}_2$  is formed somewhere between anode and cathode regions



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- In an **oxidizing environment**,  $\text{Fe(OH)}_2$  is oxidized to hydrated ferric oxide and is known as **yellow rust**



Yellow rust

- In the **presence of limited oxygen**,  $4\text{Fe(OH)}_2$  is converted into magnetic oxide of iron ( $\text{Fe}_3\text{O}_4$ ) and is known as **black rust**



Black rust



# THANK YOU

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