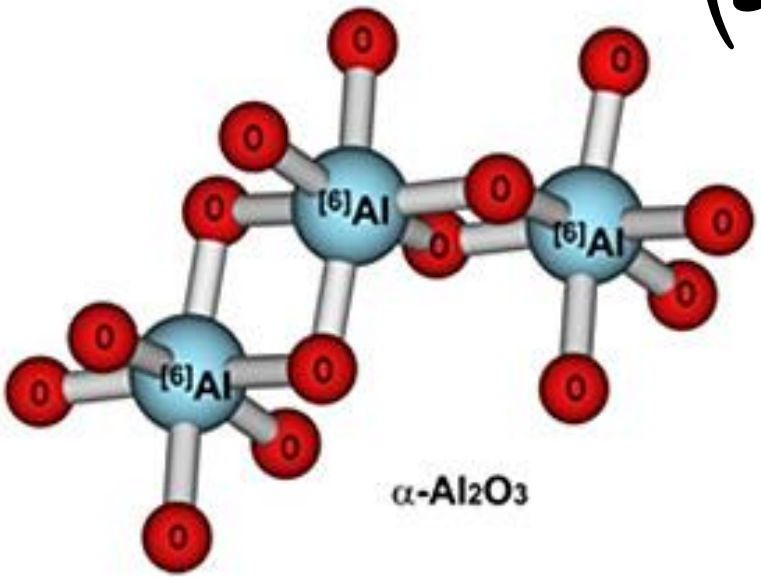


Aluminium *(Aluminum)*

(AD)

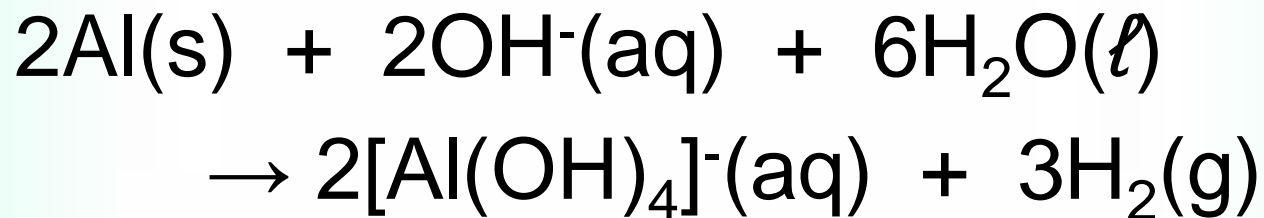
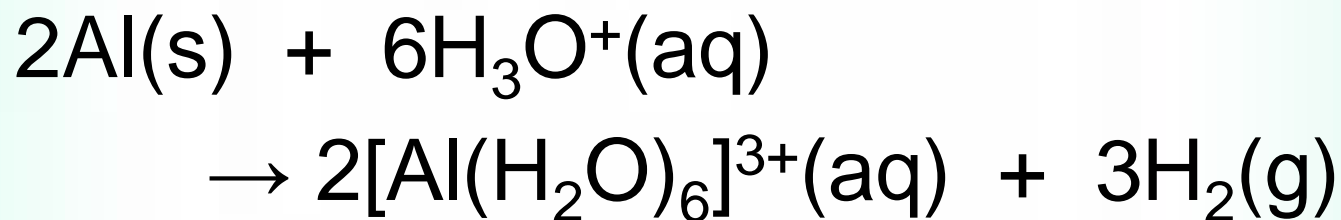


Amphoterism & Hydrolysis

- Hydration energy ($-4665 \text{ kJ.mol}^{-1}$)
- Total ionization energy ($+ 5137 \text{ kJ.mol}^{-1}$)
- Aluminium(III) ion:
 - Written as $[\text{Al}(\text{H}_2\text{O})_6]^{3+}$
 - NOT as Al^{3+}

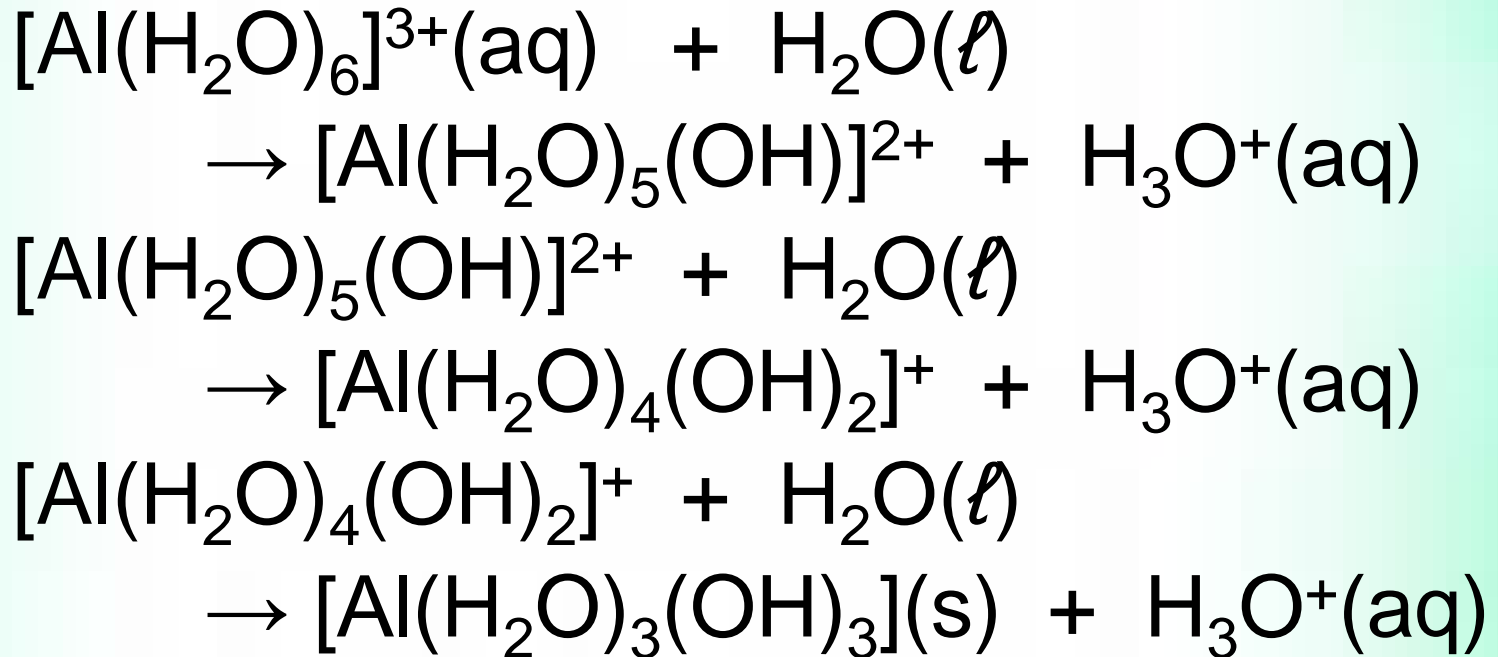
Amphoterism

- Amphoteric



Hydrolysis

- Hydrolysis of aluminum ion (in base condition)



Bauxite

Ore

- bauxite (hydrated aluminum oxide → an impure aluminum oxide)
- cryolite (Na_3AlF_6) → rare and expensive

Bauxite

- Composition of bauxite

Al_2O_3 : 50 – 60%

Fe_2O_3 : 1 – 20%

silicon dioxide : 1 – 10%

water : 20 – 30%

(Ti, Zr, V) – oxide : minor concentration

Aluminum production

- Two processes
 - 1st : Bayer Process
 - convert bauxite into pure aluminum oxide
 - 2nd : Hall- Héroult process
 - electrolysis of aluminum oxide in solution of molten cryolite

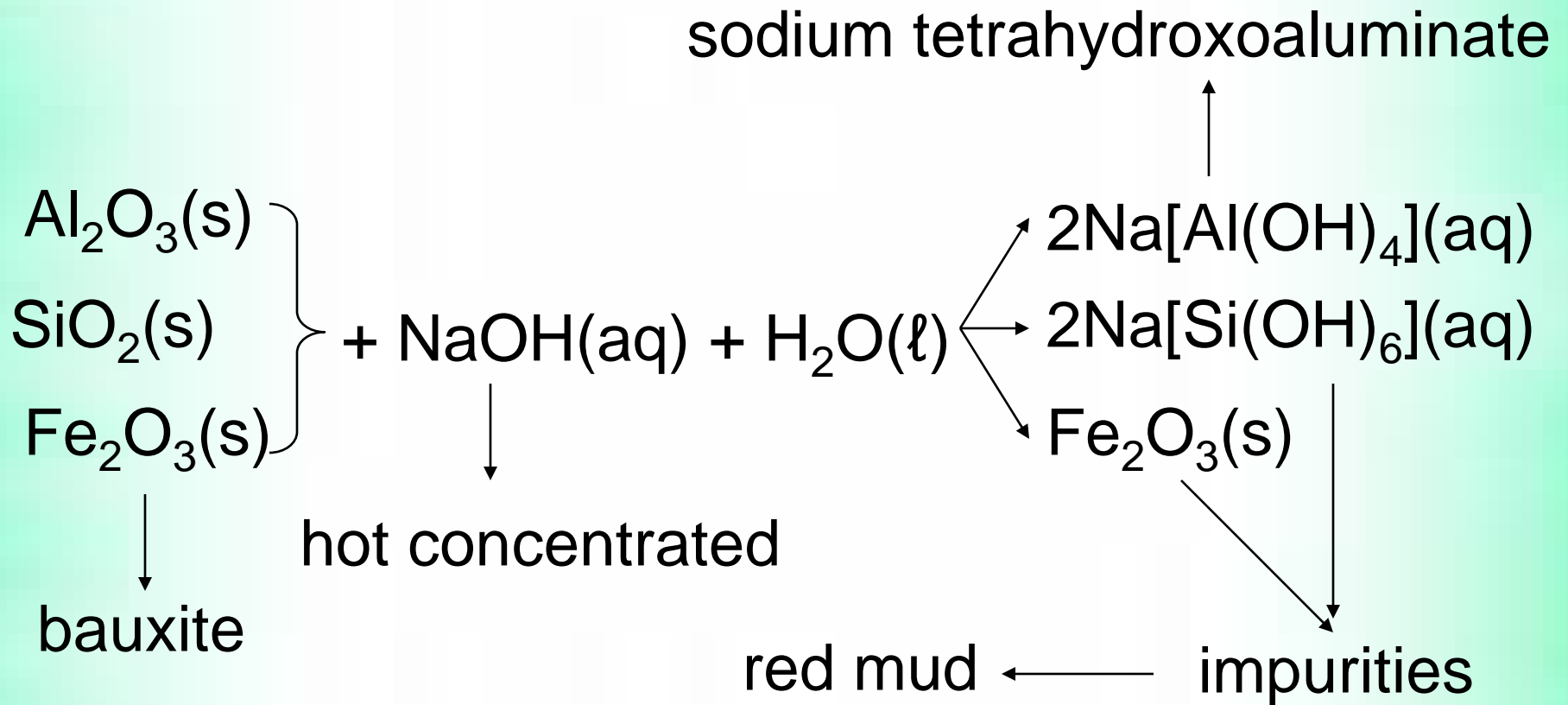
Bayer Process

- Bayer Process: purifying the aluminum oxide
 - Reaction with sodium hydroxide solution
 - Precipitation of hydrated aluminum oxide
 - Calcination

Bayer Process

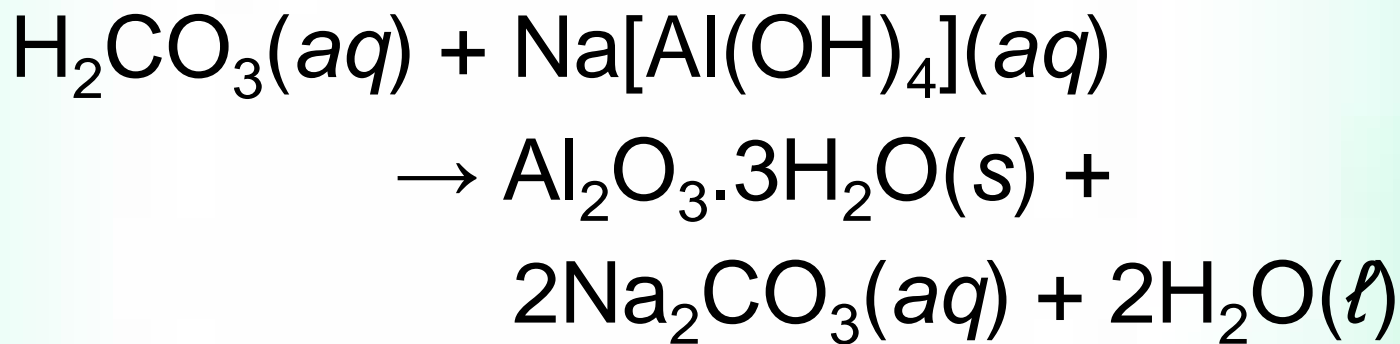
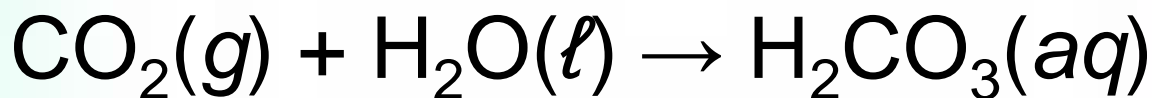
- a. Reaction with sodium hydroxide solution
 - $T \gg$
 - $P \gg$ (to keep the water in the sodium hydroxide solution liquid at $T > 100^\circ\text{C}$)

Bayer Process

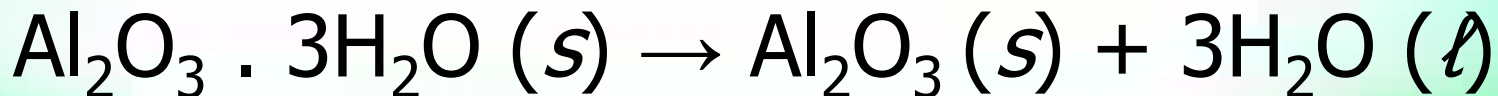


Bayer Process

b. Precipitation of hydrated aluminum oxide



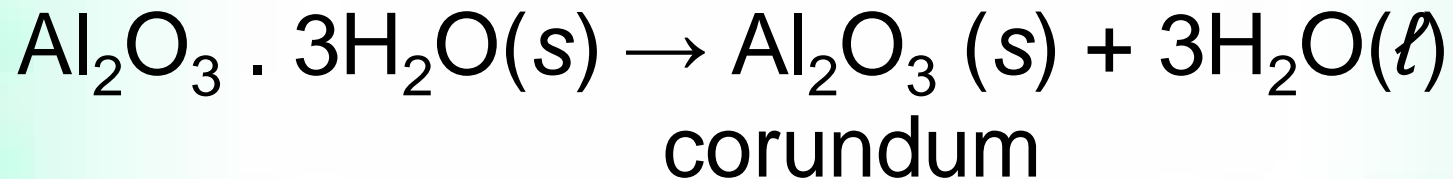
Note $\text{Al}_2\text{O}_3 \cdot 3\text{H}_2\text{O} \approx 2 \text{Al}(\text{OH})_3$



Bayer Process

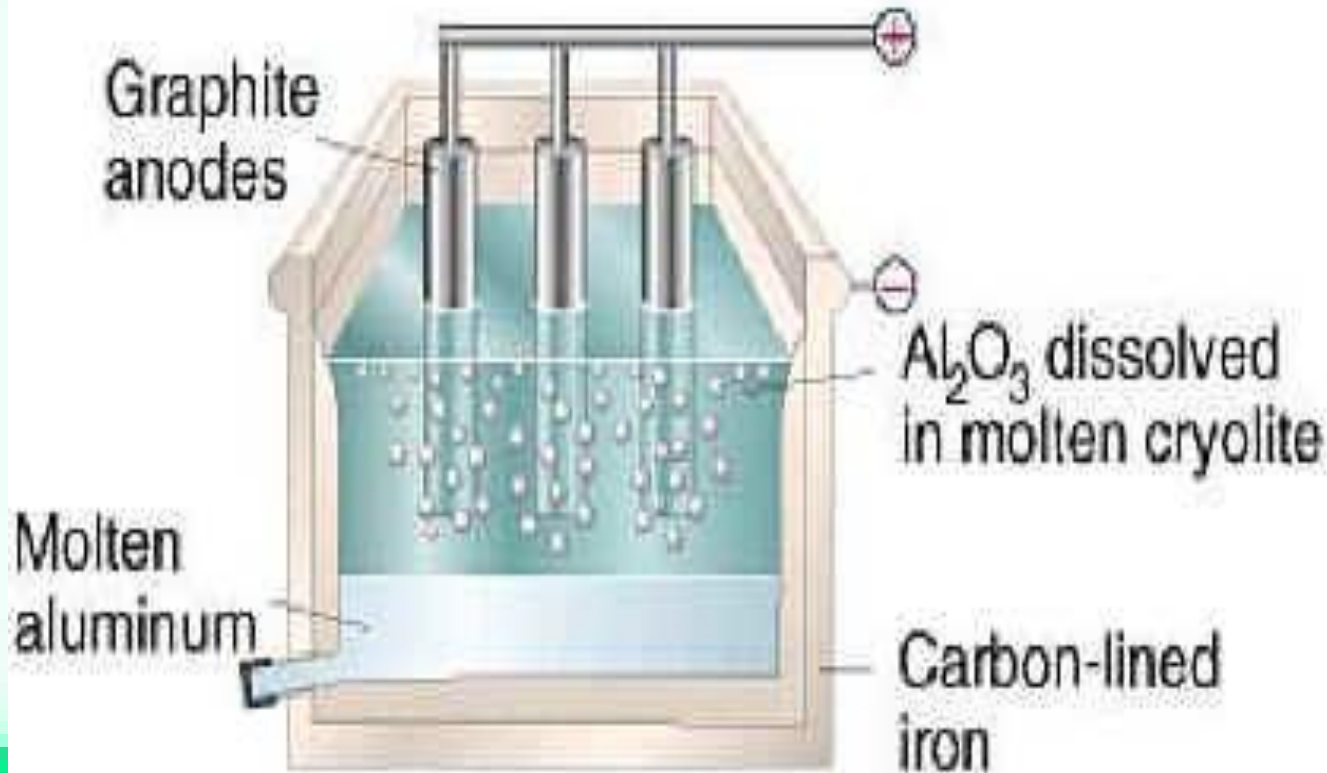
c. Calcination

- Formation of pure aluminum oxide,
- $T = 1100 - 1200^{\circ}\text{C}$



Hall- Héroult process

- electrolysis of aluminum oxide to aluminum



Hall- Héroult process

- Cathode
 - carbon lining (steel) (the effective cathode is molten aluminum)
- Anode
 - carbon (graphite)

Hall- Héroult process

The electrode reactions

- Anode:



- Cathode



- Net



Hall- Héroult process

The electrode reactions

- Aluminium is deposited in cathode
- Oxygen is initially produced at the anode
- Oxygen that produced,
 - Burn the anode yield CO_2 and CO
 - Anode must be placed (major expense)

Hall- Héroult process

- To produce 1 kg aluminum need:
 - 2 kg aluminum oxide
 - 0,6 kg graphite
 - 0,1 kg cryolite
 - 16 kWh electric power

The uses of aluminium

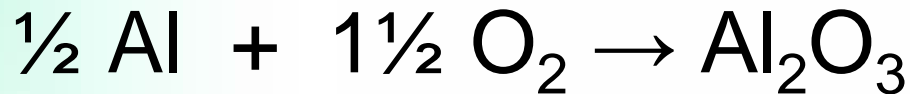
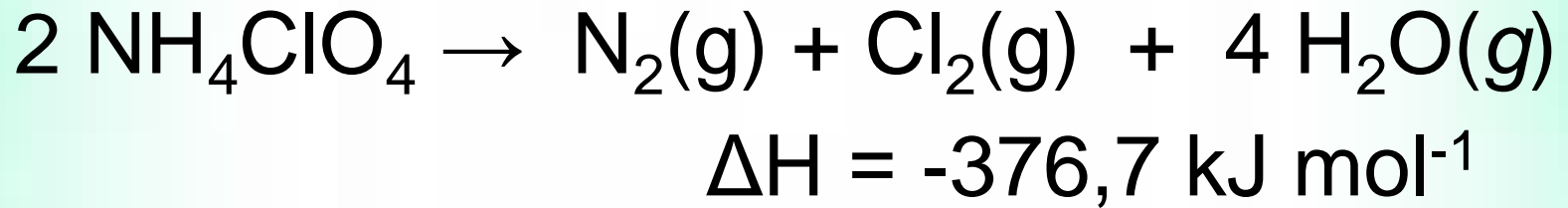
- aluminum is usually alloyed with other elements such as silicon, copper or magnesium. Pure aluminum isn't very strong, and alloying it adds to its strength.
- aluminum is especially useful because it
 - has a low density ($2,73 \text{ g cm}^{-3}$);
 - is a good conductor of electricity (worse than copper)

The uses of aluminium

- aluminum is especially useful because it
 - is strong when alloyed;
 - has a good appearance;
 - resists corrosion because of the strong thin layer of aluminum oxide on its surface. This layer can be strengthened further by anodizing the aluminum.

The uses of aluminium

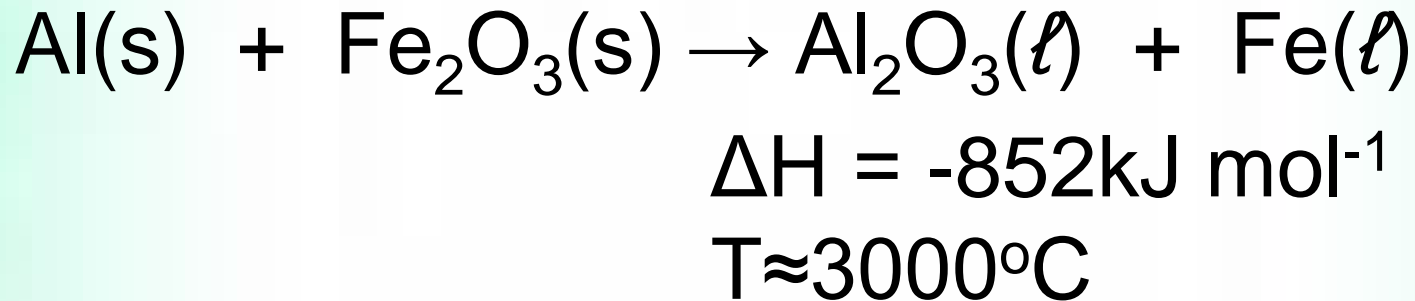
- Mixture of rocket fuel ($\text{NH}_4\text{ClO}_4 + \text{Al}$)



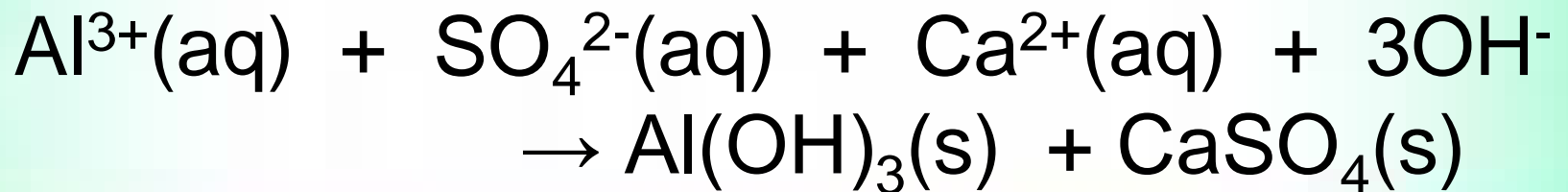
- once gas expanded \rightarrow lift the rocket

The uses of aluminium

- Railway welding (a termite reaction)

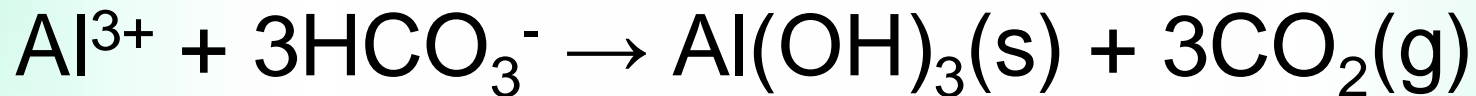
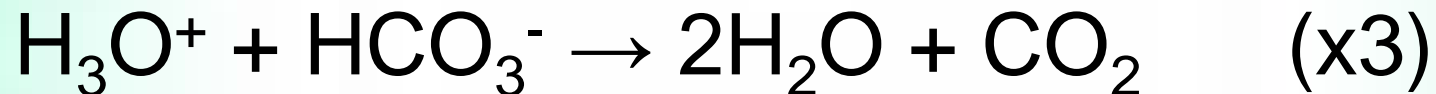


- Water purification (potash aluminum sulfate, $\text{KAl(SO}_4)_2 \cdot 12\text{H}_2\text{O}$) and dyer



The uses of aluminium

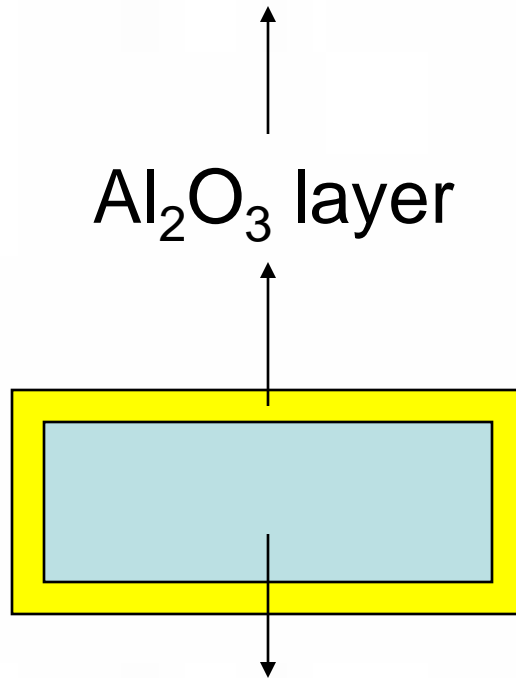
- Extinguisher (+NaHCO₃)



- Al(OH)₃ + CO₂:
 - Foam
 - Cover the fire

Corrosion resistance

non-porous layer ?



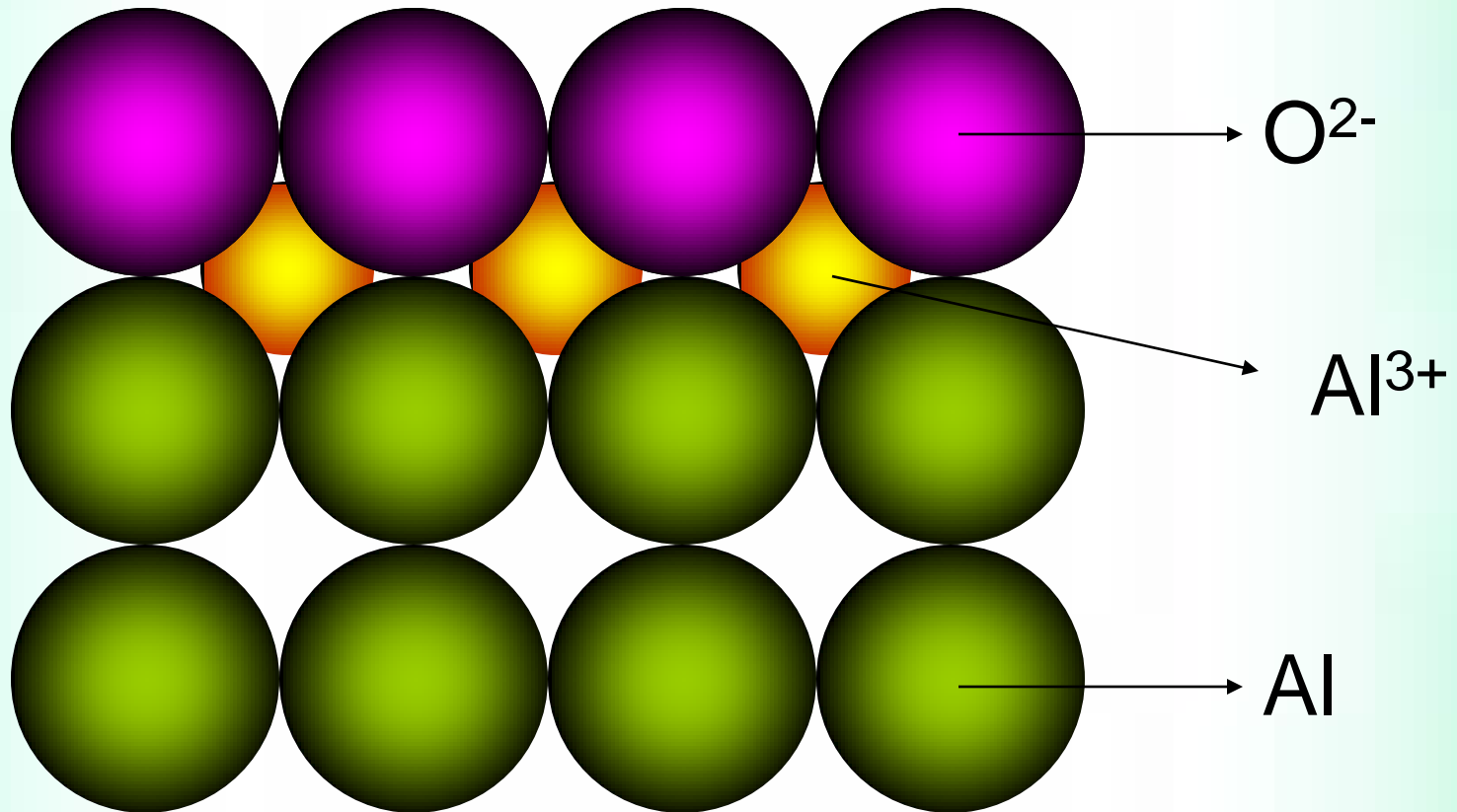
Al₂O₃ layer

Aluminium metal

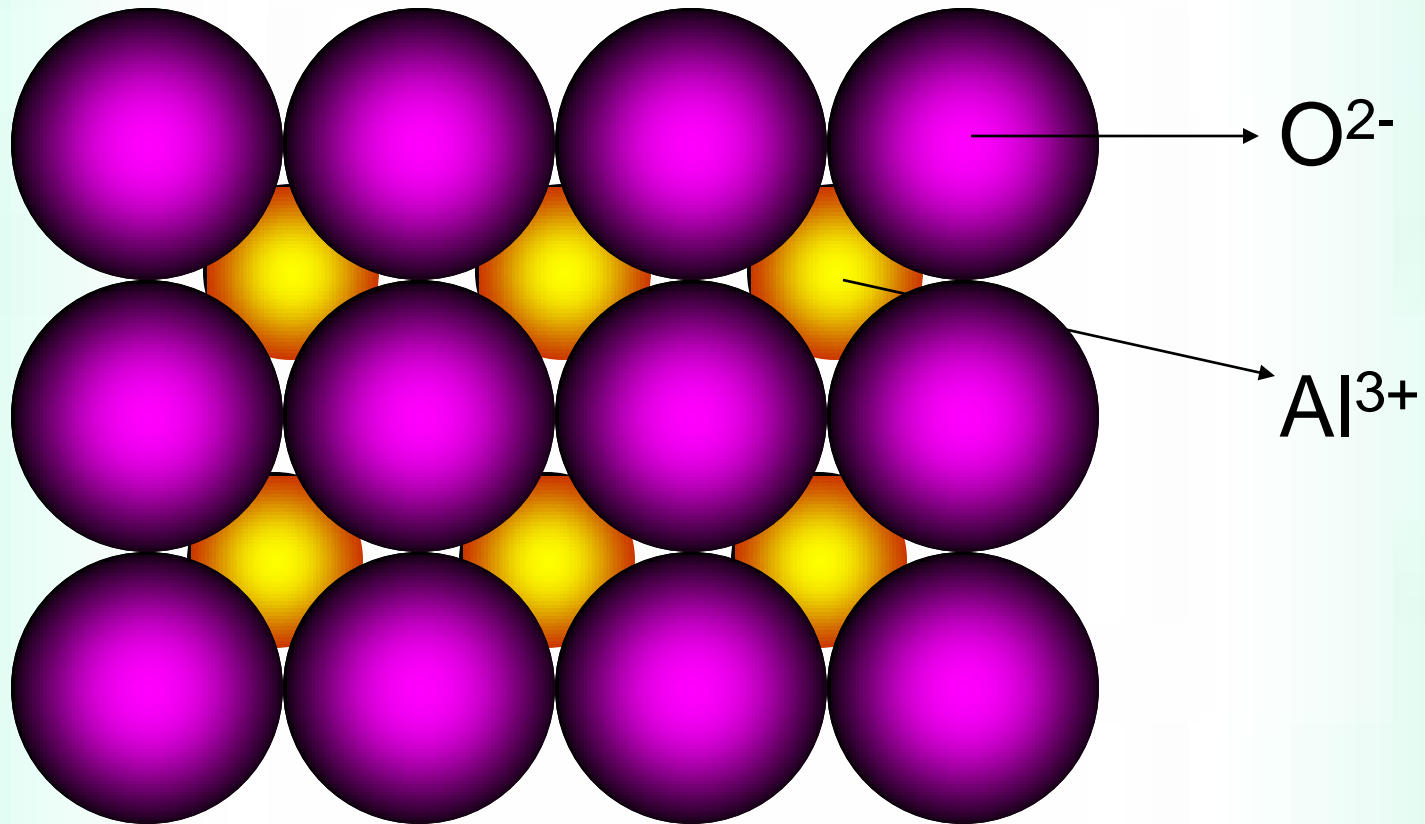
Corrosion resistance

- Ionic radii of O^{2-} ion = 124 pm
- Metallic radii of Al = 143 pm
- Ionic radii of Al^{3+} ion = 68 pm

Corrosion resistance



The formation of monolayer of Al_2O_3 on aluminum surface



The formation of monolayer of Al_2O_3 on aluminum surface

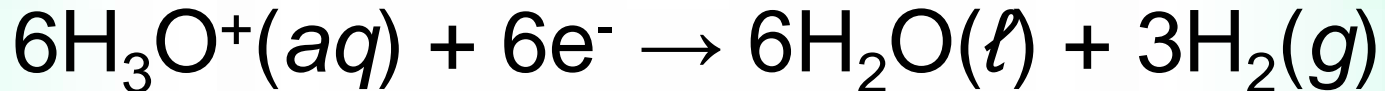
Anodizing of aluminum

- aluminum oxide-coated aluminum by electrolysis
- Cathode : carbon (graphite)
- Anode : aluminum
- Electrolyte : dilute sulfuric acid

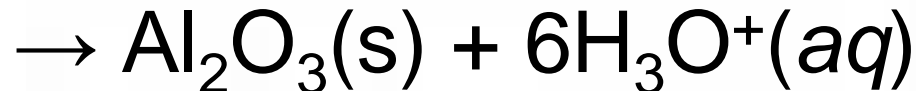
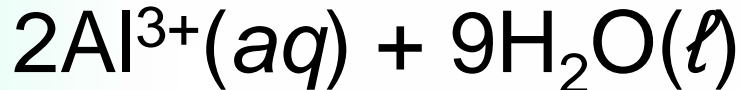
Anodizing of aluminum

Reactions:

- Cathode:

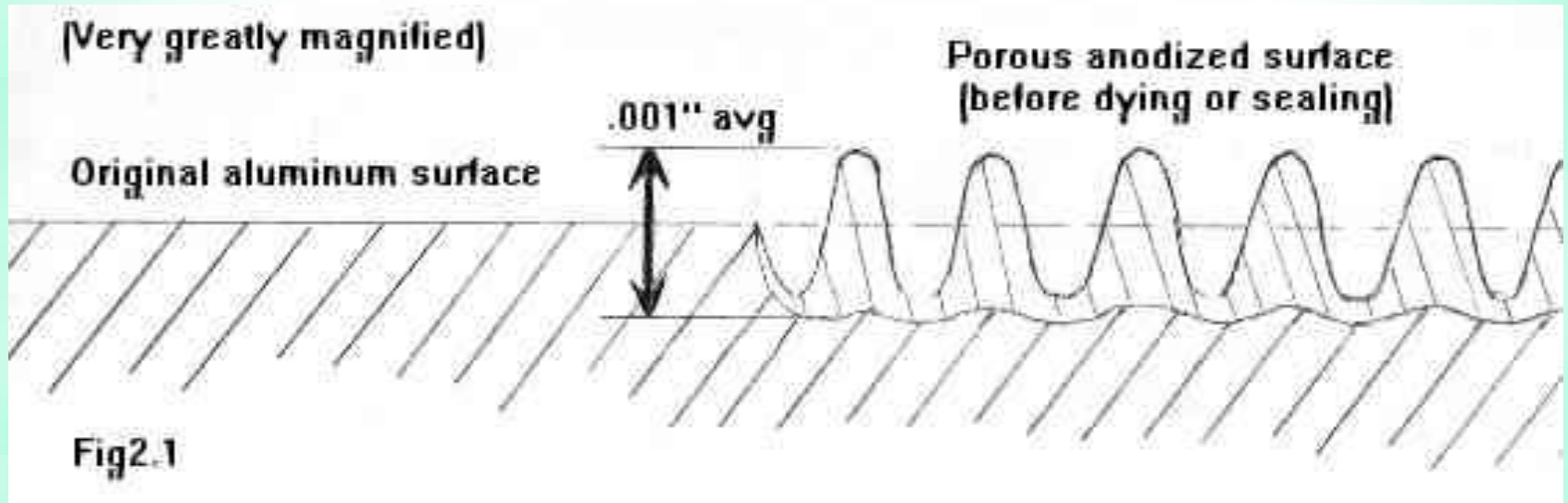


- Anode :

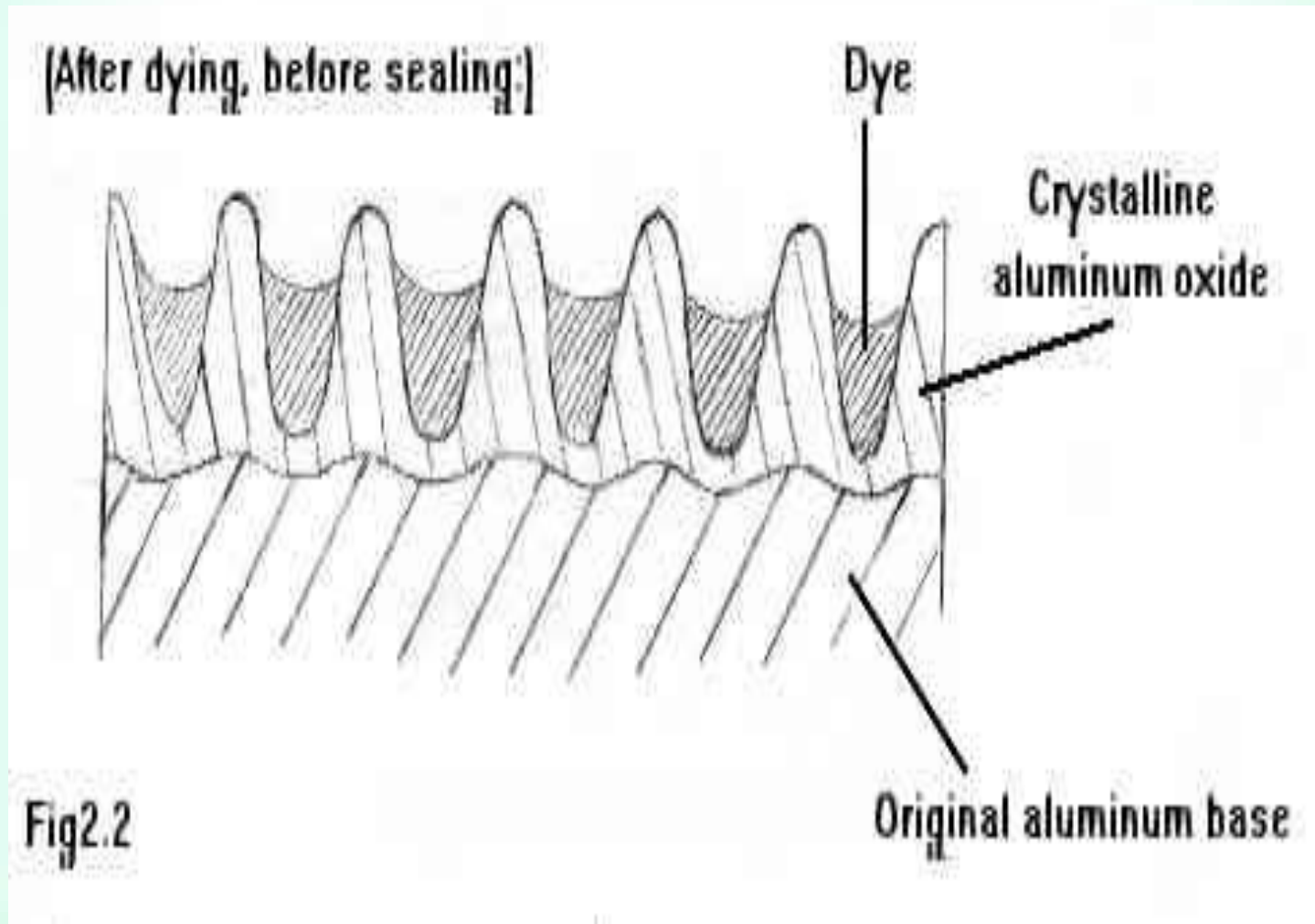


- Net: $2\text{Al}(\text{s}) + 3\text{H}_2\text{O}(\ell) \rightarrow \text{Al}_2\text{O}_3(\text{s}) + 3\text{H}_2(\text{aq})$

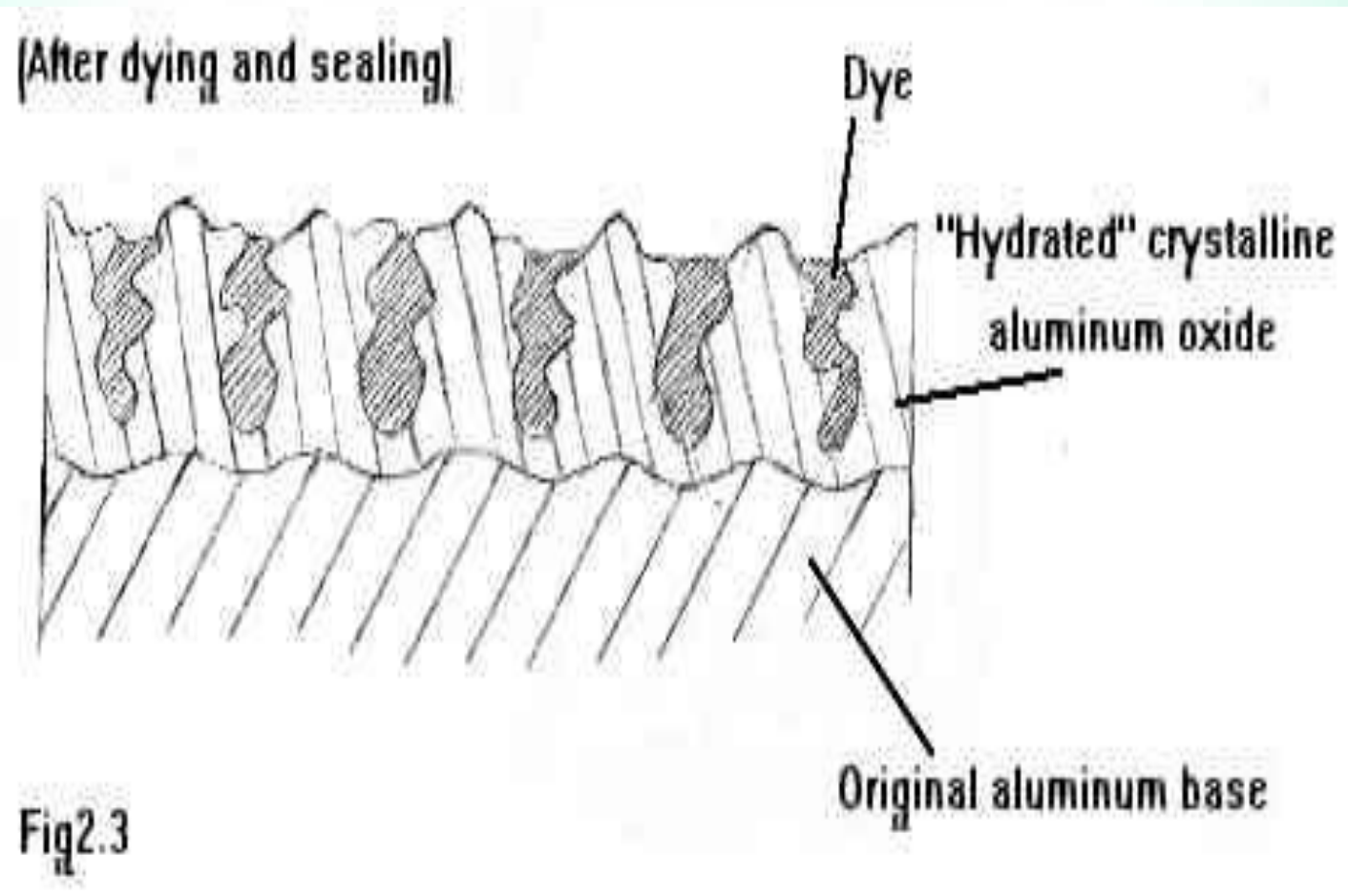
Aluminium coloring by anodizing



Aluminium coloring by anodizing



Aluminium coloring by anodizing



Aluminum production scheme

