Preparing gases in lab		
Gas	Method(s)	Reaction(s)
H_2S	Treat FeS with acid	$FeS + 2H^+ \rightarrow Fe^{2+} + H_2S$
CO_2	Treat marble stone or limestone ($CaCO_3$) with HCl	$CaO + 2HCl \rightarrow CaCl_2 + CO_2 + H_2O$
SO_2	Heat Cu with conc. H_2SO_4	$Cu + 2H_2SO_4 \rightarrow CuSO_4 + SO_2 + 2H_2O$
	Treat Na_2SO_3 or $NaHSO_3$ with diluted H_2SO_4	$Na_2SO_3 + H_2SO_4 \rightarrow Na_2SO_4 + SO_2 + H_2O$ / $2NaHSO_3 + H_2SO_4 \rightarrow Na_2SO_4 + 2SO_2 + 2H_2O$
NH_3	Heat NH_4Cl with NaOH or $Ca(OH)_2$	$NH_4^+ + OH^- \rightarrow NH_3 + H_2O$
H_2	Treat Zn with acid	$Zn + 2H^+ \rightarrow Zn^{2+} + H_2$
	Electrolysis of water	$2H_2O \rightarrow 2H_2 + O_2$
O_2	Catalytic decomposition of H_2O_2 with MnO_2 catalyst	$2H_2O_2 \rightarrow 2H_2O + O_2$
	Thermal decomposition of $KClO_3$ with MnO_2 catalyst	$2KClO_3 \rightarrow 2KCl + 3O_2$
	Electrolysis of water	$2H_2O \rightarrow 2H_2 + O_2$
NO_2	Treat Cu with diluted HNO_3	$Cu + 4HNO_3 \rightarrow Cu(NO_3)_2 + 2H_2O + 2NO_2$
NO	Treat Cu with conc. HNO_3	$3Cu + 8HNO_3 \rightarrow 3Cu(NO_3)_2 + 4H_2O + 2NO$
Cl_2	Treat bleaching powder (ClO^- ion) with HCl	$ClO^- + 2HCl \rightarrow Cl^- + Cl_2 + H_2O$
	Heat conc. HCl with MnO_2	$MnO_2 + 4HCl \rightarrow MnCl_2 + Cl_2 + 2H_2O$
N_2	Thermal decomposition of NH_4NO_2	$NH_4NO_2 \rightarrow 2H_2O + N_2$
HCl	Heat table salt (NaCl) with conc. H_2SO_4	$2NaCl + H_2SO_4 \rightarrow Na_2SO_4 + 2\ HCl$
HF	Heat fluorite (CaF_2) with conc. H_2SO_4	$CaF_2 + H_2SO_4 \rightarrow CaSO_4 + 2HF$
CO	Dehydration of formic acid	$HCOOH \rightarrow H_2O + CO$

Industrial processes

-Ammonia-soda process (Solvay process): $2NaCl + CaCO_3 \rightarrow Na_2CO_3 + CaCl_2$

Step 1: $NaCl + H_2O + CO_2 + NH_3 \rightarrow NaHCO_3 + NH_4Cl$ (neutralisation + precipitation)

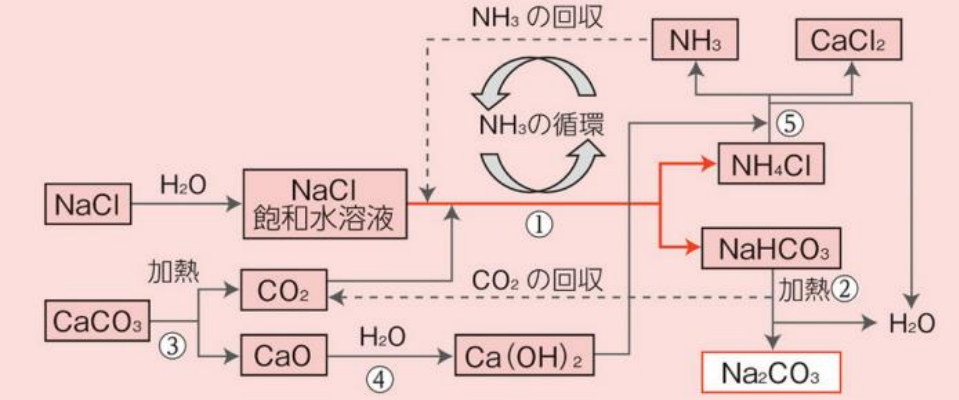
Step 2: $2NaHCO_3 \rightarrow Na_2CO_3 + H_2O + CO_2$ (thermal decomposition)

Step 3: $CaCO_3 \rightarrow CaO + CO_2$ (thermal decomposition)

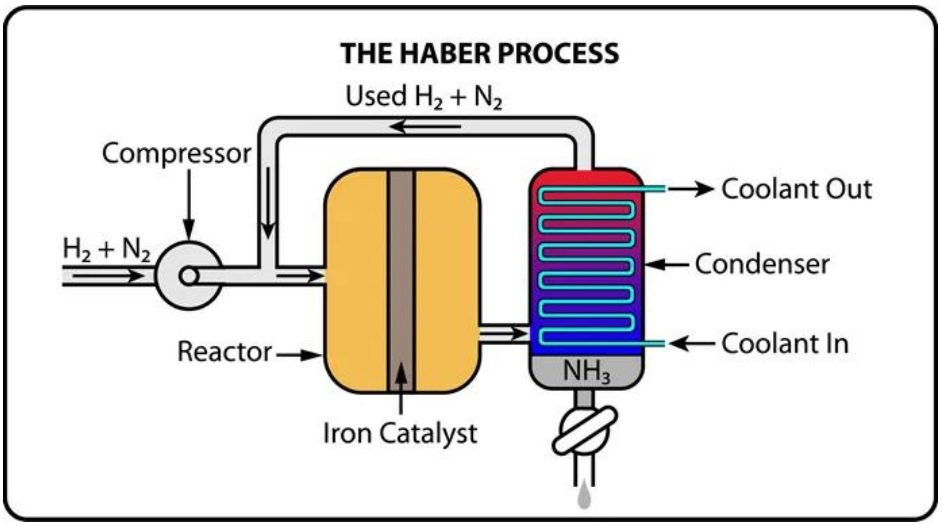
Step 4: $CaO + H_2O \rightarrow Ca(OH)_2$ (combination reaction)

Step 5: $2NH_4Cl + Ca(OH)_2 \rightarrow 2NH_3 + 2H_2O + CaCl_2$ (double displacement)

Flowchart:



-Haber process (Haber–Bosch process): $N_2 + 3\ H_2 \rightleftharpoons 2NH_3$



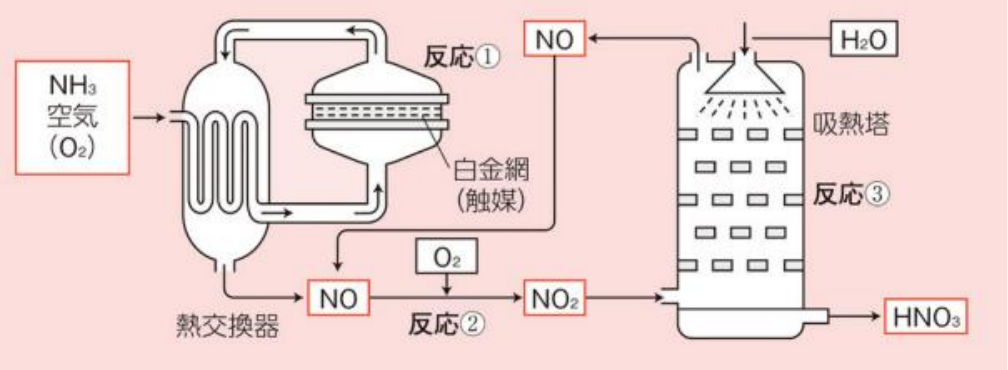
Optimum condition: 400°C, 200 atm (Note: Coefficients in the reactant and product sides)

-Ostwald process: $NH_3 + 2O_2 \rightarrow HNO_3 + H_2O$

Step 1: $4NH_3 + 5O_2 \rightarrow 4NO + 6H_2O$ (Pt catalyst)

Step 2: $2NO + O_2 \rightarrow 2NO_2$

Step 3: $3NO_2 + H_2O \rightarrow 2HNO_3 + NO$

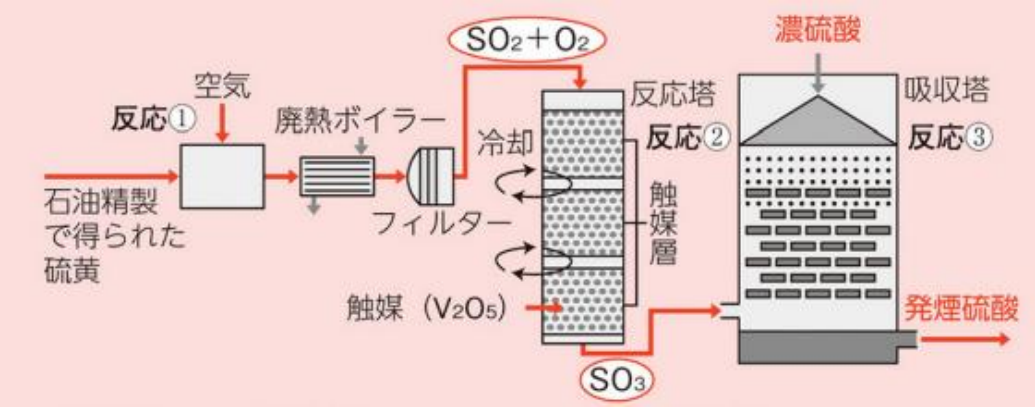


-Contact method:

Step 1: $S + O_2 \rightarrow SO_2$

Step 2: $2SO_2 + O_2 \rightarrow 2SO_3$ (V_2O_5 catalyst)

Step 3: Absorb SO_3 with conc. H_2SO_4 to produce oleum (fuming sulphuric acid) and then dilute it to conc. H_2SO_4 (Overall equation: $SO_3 + H_2O \rightarrow H_2SO_4$)

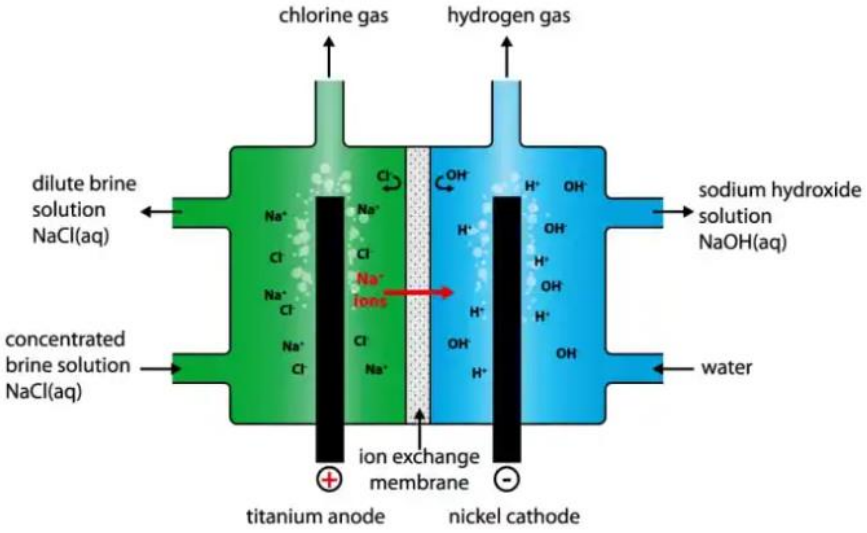


-Membrane cell: $2NaCl + 2H_2O \rightarrow 2NaOH + H_2 + Cl_2$

Anode: $2H_2O + 2e^- \rightarrow 2OH^- + H_2$ (Ni electrode)

Cathode: $2NaCl \rightarrow 2Na^{+} + Cl_2 + 2e^{-}$ (Ti electrode)

Setting:

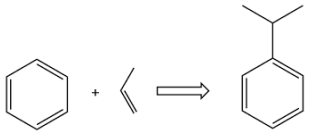


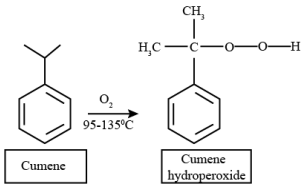
-Ethanol production:

Step 1: $CH_4 + H_2O \rightarrow 3H_2 + CO$ (steaming forming to produce syngas)

Step 2: $2H_2 + CO \rightarrow CH_3OH$ (High pressure temperature, $CuO+ZnO+Al_2O_3$ catalyst)

-Cumene process (Hock process):

Step 1:  (Addition)

Step 2: 

(Aerobic oxidation)

Step 3: