

The World's top 10 Chemicals

1) Sulfuric Acid, H_2SO_4 90 billion lbs/yr

Manufacture: Sulfur or H_2S is burned in air to form SO_2 . Very exothermic.

SO_2 is dried & reacted with air over an intercooled - multipass V_2O_5 catalyst reactor. This makes SO_3 . The SO_3 is absorbed in H_2SO_4 in a packed tower. This is exothermic. This H_2SO_4 is then diluted - some recycled to absorber - some sent to product. The SO_3 is absorbed in H_2SO_4 (~98%) as opposed to pure H_2O because it has a lower vapor pressure.

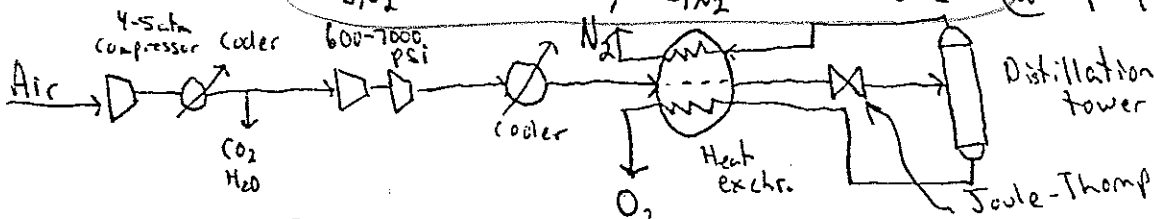
Uses: Alkylation units, Fertilizer, metal processing

2) Nitrogen, N_2

52 billion lbs/yr

Manufacture: Distillation of liquid air (Linde process)

$T_{b,O_2} = -183^\circ C$; $T_{b,N_2} = -195.8^\circ C$ @ $P = 1 \text{ atm}$



note: The modified Linde cycle used in industry divides the column into a low pressure (top) & high pressure section

Pressure swing adsorption on a zeolite. At high P. ~~one~~ of the components of air (N_2 or O_2) will adsorb, but not other. Lower P - adsorbed gas desorbs.

Membrane separation - size exclusion

Magnetic methods - O_2 is strongly paramagnetic

Uses: Enhanced oil recovery, freezing meat, Electronics, inert atmospheres.

3) Oxygen, O_2 37 billion lbs/yr

Manufacture: See N_2 ; Also Electrolytic decomp. of H_2O

Uses: many chemical process - oxidation, Electronics, medical use

4) Ethylene, C_2H_4 36 billion lbs/yr

Manufacture: catalytic cracking of hydrocarbons, or thermal pyrolysis: Endothermic rxn.

Thermal pyrolysis at 1 atm & $1300-1600^\circ F$ of petroleum fractions (largely C_6 's) gives from 6-40% Ethylene

Recovery in low pressure distillation columns - for removal of heavy HC's. low temp, high P. columns for CH_4, H_2 removal & C_3, C_4 's

Uses: Polymers - polyethylene, polyvinyl chloride, polystyrene, polyethylene terephthalate (2 liter coke bottles); Antifreeze

5) Ammonia, NH_3 34 billion lbs/yr

Manufacture: Haber process: H_2 from thermal reforming of natural gas w/ steam. N_2 from air after O_2 removed in furnace.

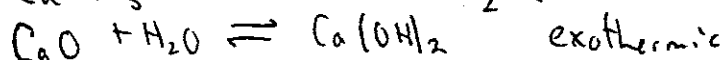
Water gas shift rxn comes in here

N_2 & H_2 in a ratio of 1:3 is sent at $550^\circ C$, 200-350 atm over doubly promoted iron catalyst. recirculation, & bleeding of inerts is required. Need either refrigeration or scrubbing to collect NH_3 Exothermic rxn

Uses: Fertilizer, explosives, refrigeration, paper pulping

6) Lime, CaO 32 billion lbs/yr

Manufacture: calcination ~~(burning in the absence of O_2)~~
of limestone. $\text{CaCO}_3 \rightleftharpoons \text{CaO} + \text{CO}_2 \text{ (a)}$



limestone must be crushed & calcined at $1700-2450^\circ\text{F}$
the CO_2 must be removed quickly as rxn (a) is reversible
rotary kilns are used. 6-12ft in diameter x 60-400ft long

Uses: Metallurgy, soap, waste water treatment

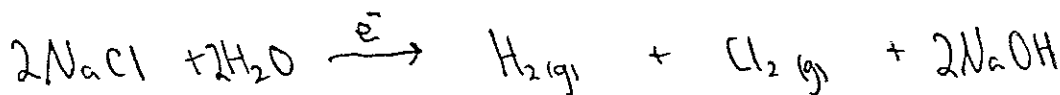
7) Sodium Hydroxide, NaOH 24 billion lbs/yr

Manufacture: produced by electrolysis of NaCl sol'n's

USES: Chemical production, rayon, soap, pulp & paper

8) Chlorine, Cl_2 23 billion lbs/yr

Manufacture: Also made by electrolysis of NaCl
sol'n's



Made in diaphragm cells. Cl_2 made on anode, H_2
(& NaOH) made at cathode.

With graphite anodes some CO_2 is produced.

Cl_2 with water vapor (inevitably released in production) is very
corrosive. It must be dried with H_2SO_4 , then it is
liquefied (100psi, -40°C) & stored.

Uses: Vinyl chloride, pulp & paper bleaching, water treatment,
chlorinated ethanes, bromine production from sea water.

9) Phosphoric Acid, H_3PO_4

23 billion lbs/yr

Manufacture: liquid elemental Phosphorous is burned at $\sim 1000^\circ F$ to form P_2O_5 , this is hydrated in a spray tower & mists

best absorp. are collected in an electrostatic ppt. - this method produces "clean" phosphoric acid for uses other than fertilizer. When the H_3PO_4 doesn't have to be particularly pure, the wet process is used:

Phosphate rock + $H_2SO_4 \rightleftharpoons CaSO_4(s) + H_3PO_4$
Partial purification - removal of F, Ca, Fe, Al, SO₄ - is performed by evaporative concentration.

Uses: Fertilizer, dicalcium phosphate (Animal feed preparation)

10) Propylene, $CH_2=CH-CH_3$

20 billion lbs/yr

Manufacture: produced as side product in manufacture of gasoline, or Ethylene.

Uses: Alkylation with isobutane to raise octane levels in gas.
Polypropylene

In your free time investigate production of HCl, HNO_3 , benzene, p-Xylene, Acetic Acid, The water gas shift rxn.