

		One Stage (Oxygen)	Two Stages (Air)
Process Water, M gal		1.7	7.2
Deminerlized water, gal		120	—
Cooling tower water, M gal		48	48
Labor, operators/shift		3 to 4	3-4
Natural Gas			
2. Ammonia (2)			Naphtha
Raw materials:			
Gas, process and fuel, MMBtu		32.6	32.7
Catalyst and chemicals, \$		1.13	1.23
Utilities:			
Electricity, kW hr		15	26.6
Makeup water, M gal		2.9	3.0
Labor, operators/shift		5	5
3. Benzene (Houdry Hydrodealkation Processes) (2)			
Detol			Litol
Raw materials:			
Cyclohexane, naphthenes		11.4	4.9
Hydrogen, M scf		0.47	0.32
Catalyst, \$		0.54	0.36
Clay, lb			
Utilities:			
Electricity, kW hr		49	41
Fuel, MMBtu;			
consumed		2.26	3.36
produced		10.0	4.9
net		+ 7.74	+ 1.54
Steam, lb; consumed		88	300
produced		—	1,074
net		- 88	+ 774
Boiler feed water, gal		—	3.91
Cooling water, M gal		4.05	6.86
4. Butadiene (Shell ACN Process) (2)			
Raw materials:			
Butane		98.6% yield	
Acetonitrile, lb		0.296	
Other chemicals, \$		0.44	
Utilities:			
Electricity, kW hr		72	
Steam (600 psig, 600°F), lb		6,460	
Refrigeration (@ 40°F), Btu		71,160	
Process water, gal.		11.8	
Cooling water (30°F rise), M gal		31.4	
Labor, operators/shift		1.5	
By-products, per ton Butadiene			
Butylene, ton 1.335; Light ends, lb 11			
Heavy ends, lb 89			
5. Caprolactum (Stamicarbon Process); 38,500 t/yr plant (2)			
Raw materials:			
Cyclohexane, lb		2,120	
Hydrogen (> 95% 100% basis), lb		192	
Ammonia, lb		632	
Aqua ammonia (20% on 100% NH ₃ basis), lb		962	
Oleum (100% H ₂ SO ₄ basis), lb		2,720	
Sodium hydroxide, lb		200	
Benzene, lb		28	
Toluene, lb		16	
Phosphoric acid		10	
Catalysts, \$		15.10	
Utilities:			
Electricity, kW hr		376	
Fuel (75% furnace efficiency), MMBtu		1.7	
Steam, lb; 440 psig		14,380	
184		3,340	
56		7,260	
Refrigeration (6°C), M Btu		126	
Boiler feedwater, gal (95°C)		295	
Process water, gal		760	
Cooling water, gal		42,400	
By-products:			
Ammonium sulfate, t/t		1.75	
Hydrogen (40% H ₂), lb/t		12	
Hydrogen (95% H ₂), lb/t		28	
6. Chlorine (Hooker Diaphragm Process) (2)			
Raw materials:			
Salt, tons		3.52	
Misc. chemicals, materials, \$		0.12	
Diaphragm asbestos, lb		0.2	
HCl, lb		10	
H ₂ SO ₄ , lb		12	
Utilities:			
Electricity, kW hr: to cells		2,980	
other		250	
Steam, lb: evaporation		5,460	
other		700	
Labor/plant capacity, t/d		200	
Supervision		One man per shift	
Operators, man hours		0.52	
Cell rebuilding, man hours		0.03	
Maintenance, man hours		0.32	
By-products:			
Caustic Soda, t/t		2.14	
Hydrogen, lb/ton		56.32	

7. Cyclohexane (IFP Liquid Phase Hydrogenation Process) (2)

Raw materials:	
Benzene, lb	1,870
Hydrogen, lb	130
Catalyst, \$	11
Utilities:	
Electricity, kW hr	8
Steam (300 psig), lb	370
Boiler feed water, gal	230
Cooling water (10°C rise), gal	4,000
By-products:	
Fuel gas, lb	620
Steam (65 psig), lb	1,900

8. Cyclohexanol (Stamcarbon Process) (2)

Raw materials:	
Cyclohexane, lb	2,200
Caustic soda, lb	180
Catalysts, \$	1.56
Utilities:	
Electricity, kW hr	200
Steam, lbs: 454 psig	7,300
56 psig	700
Refrigeration (0°C), M Btu	66
Process water, gal	101
Cooling water, (8°C rise), M gal	101

9. Ethylene (propylene) (Lummus Naphta Pyrolysis Process) (2)

Raw materials:		
	High Severity: ethane recycle	Moderate severity; no recycle
Medium range naptha, tons (117-308°F; 73° API)	5.95	8
Catalysts, chemicals, \$	1.55	1.55
Utilities:		
Electricity, kW hr	34	34
Fuel, MM Btu	26	26
Boiler feed water, gal	96	96
Cooling water, M gal (25°F rise)	70	70
Labor:		
Operators, foremen/shift	8	8
Maintenance material, % of capital	2	2
By-products, lb/ton ethylene:		
Propylene	991	1,454
Butadiene	272	356
Butylenes/butanes	251	669
Hydrogen	92	77
Methane rich gas (21,630 Bu/lb)	956	1,014
Ethane	--	400
Benzene	401	358

High Severity:
ethane recycle

Moderate
severity; no
recycle

Toluene	199	280
C ₈ aromatics	105	115
C ₄ - 400°F + gasoline	404	1,104
400°F + fuel oil (17,100 Btu/lb)	280	174

10. Formaldehyde (Reichhold Formox Process) (2) (per ton at 35% solution)

Raw Materials:	
Methanol, gal	130
NaOH, lb	2.2
Catalyst, lb	0.08
Ion exchange resin, ft ³	0.0002

Utilities:

Electricity, kW hr	78.5
Steam, startup (168 hr/yr), M lb (150 psig)	300
Fuel, startup (168 hr/yr), M Btu	26.88
Process feedwater, gal	238
Boiler feedwater, gal	94
Cooling water, M gal: 85°F	22.2
60°F	3.72
Instrument air, scf	300

Labor:

Operator/shift	1
Supervisor/shift	1
Laboratory, hr/wk	3
Maintenance: % of capital	3
By-product:	
Steam lb/ton 150 psig	820

11. Liquefied natural gas (TEALARC Process) 1 MMM scfd (2)

Chemicals:

Monoethanol amine, lb	0.154
Antifoamant, lb	0.0006
Caustic soda, lb	0.0112
Hydrazine, lb	0.0052
Tri sodium phosphate, lb	0.0020
Morpholine, lb	0.0024
Chlorohydric acid, lb	0.0084
Chlorine, lb (assumes seawater cooling)	0.56
Molecular sieves, lb	0.016

Utilities:

Electricity, kW hr	29
Fuel, lb (13% of feed)	260
Steam, M lb	4.1
Cooling Water, M gal	36.4

Labor:

Operators, technicians, engineers/3 shifts	40
Maintenance/3 shifts	50

12. Methanol (ICI/Kellogg Process) (2)

Raw materials:	27	
Natural gas, MM Btu	1.40	
Catalyst, \$		
Utilities:		
Electricity, kW hr	4.8	
Fuel, net, MM Btu	5.14	
Boiler feedwater, gal	297	
Cooling water circulation, M gal	44	
Labor: operators/shift	4	
Maintenance: % of capital	3.5	
By-product: steam, lb	271	

13. Phenol (2) Hercules-BPCI Phenol-Acetone

Raw materials:		Hooker
Cumene, lb	2,700	1,855
Hydrogen, lb	0.80	60
NaOH, Na ₂ CO ₃ , H ₂ SO ₄ , lb	24	40
Catalyst, \$	0.84	5.81
		16
Utilities:		
Electricity, kW hr	228	182
Fuel, MM Btu	0.38	6.6
Steam, M lb (450 psig)	10.6	19.5
Cooling water, M gal (30°F rise)	65	74
Labor, operators/shift	4	5
others		2/day shift
Maintenance, % of capital	2	1 supervisor/shift
By-products:		
Acetone, lb/ton	630	
Hydrocarbons, lb (18,500 Btu/lb)	220	

14. Soda ash (Na₂CO₃; Diamond Shamrock Solvey Process) 550 t/d (2)

Raw materials:	
Salt (NaCl; brine), lb	3,060-3,200
Limestone (CaCO ₃), lb	2,080-2,800
Ammonia, lb	4-5
Sodium sulfide, lbs of S	0.6-1.2
Coke, lb (2.2 MM Btu/ton Na ₂ CO ₃)	160-240
Utilities:	
Electricity, kW hr	54-134
Fuel, MM Btu (oil or gas)	7.2
Treated water, gal	240
Cooling water, M gal	30 (once through)
Cooling water, makeup if recycled, Mgal	4.4
Labor, operating man hr/ton	0.6
maintenance,	0.6

Supplies: operating, \$
maintenance, \$0.21
1.05

15. Sodium bicarbonate 150 t/d (2)

Raw materials:	
Caustic soda, lb	965
Natural gas, scf	5,360
Utilities:	
Electricity, kW hr	42
Steam, lb (15 psig)	69
Process water, 85°C, gal	290
Cooling water, M gal (20°F rise)	12.9
Compressed air, 100 psig, scf	590
Labor, operators/shift	2
Maintenance, % of capital	3.5

16. Synthetic natural gas (CRG/Kellogg Naphtha Reforming Process) (2)
Material per MM scf of SNG (993 Btu/scf)

Raw materials:	
Naphtha, M lb (20,263 Btu/lb; Dist. 365°F)	47.95
Chemicals, \$	8.44
Catalysts, \$	63.70
Utilities:	
Electricity, kW hr	850
Fuel, M lb (20,263 Btu/lb)	4.22
Boiler feedwater make up, M gal	4.7
Cooling tower circulation, M gal (25°F rise)	9.6
Cooling tower makeup, gal	380

17. Styrene (Monsanto/Lummus Process) 900 t/d (2)

Raw materials:	
Ethylene, lb	620
Benzene, lb	1,680
Catalysts, chemicals, \$	4.4
Utilities:	
Electricity, kW hr	76
Fuel, MM Btu	4.32
Steam, M lb: 200 psig	4.8
75 psig	2.7
Cooling water, M gal	26.1
Labor, operators/shift	3
supervisors (total)	2
Maintenance, % of capital	2-3
By-products:	
Toluene, lb/ton	126
AlCl ₃ (22% solution), lb/ton	28
Steam condensate, gal	863

18. Sulfuric acid (Monsanto Contact Process) (2)

Raw material:	
Sulfur, lb	674

Utilities:	60	
Process water, gal	324	
Boiler feedwater, gal	7	
Cooling water, circulation (25°F rise), M gal	9	
Power, Kwh (steam turbine)	1	
Labor, operators/shift	5	
Maintenance, % of capital		
By-product:	1.7	
Steam, M lb (225 psig)		
19. Urea (Stamcarbon CO ₂ -Stripping Process; producing prills) (2)		
Raw Materials:		
Ammonia, lb	1140	0.7-0.8%
Carbon dioxide, lb	1510	0.2-0.25%
Utilities:		
Electricity, kW hr	109	127
Steam, M lb (368 psig)	2	2.2
Cooling water, M gal (15°C rise)	11.5	11.5
Labor: operators, supervisors/shift	3	4
Maintenance, % of capital	3	3
By-product:		
Steam, lb (60 psig)	300	700

SECTION 3. SINGLE PLANT SIZE: PERCENT COST BREAKDOWN (3)

Chemical	Plant Capacity, t/d	Mfg Cost, c/lb	Raw Material % as	Depreciation % as	Utilities, % as	Process or Raw Material
Acetaldehyde	70	25	55	29	16	Ethylene
Acetic anhydride	70	25	72	12	16	Ethanol
Acrylic staple	30	175	28	26	46	Acetic acid
Adipic acid	180	38	79	9	12	Dimethyl formamide
Allyl chloride	40	43	47	34	19	Propylene
Aniline	55	32	65	25	10	Nitrobenzene
Benzene	350	14.5	44	38	18	Naphtha
Benzoin acid	7	37	22	39	39	Toluene
Bisphenol A	30	42	63	23	14	Acetone, phenol
Caprolactam	110	62	51	31	18	Cyclohexane
Carbon disulfide	140	14	42	40	18	Methane, S
Carbon tetrachloride	30	21	53	32	15	Propane, Cl ₂
Carboxy methyl cellulose	7	83	45	33	22	Cellulose
Cellulose acetate	70	81	36	26	26	Cellulose, acetic acid
Chloroprene monomer	65	60	34	53	13	Butadiene
Cumene	220	17	80	10	10	Benzene, propylene
Cyclohexanone-cyclohexanol	140	40	68	18	14	Cyclohexane
Dichlorophenoxy acetic acid (2, 4)	15	78	62	24	14	Phenol
DDT	30	57	53	33	14	Chloral, chloro benzene

Chemical	Plant Capacity, t/d	c/lb	Raw Material % as	Depreciation % as	Labor % as	Principal Raw Material
Detergent alkylate	70	25	80	12	8	Propylene, benzene
Diethanolamine	18	23	63	28	9	Ethylene oxide, NH ₃
Dimethyl	70	56	48	32	20	p-xylene, methanol
terephthalate	55	27	84	7	9	Phthalic anhydride
Dioctyl phthalate	55	27	78	11	11	Allyl chloride, Cl ₂
Epichlorohydrin	55	57	73	11	16	Ethylene, benzene
Ethyl benzene	140	14	45	35	20	Propylene, synthesis
Ethyl hexanol	55	23	45	35	20	gas
Acetaldehyde	55	23	68	20	12	Acetaldehyde
Ethylene diamine	20	78	46	27	27	NH ₃
Ethylene dichloride	230	11	88	6	6	Ethylene, Cl ₂
Ethylene glycol	110	22	90	4	6	Ethylene oxide
Fatty alcohol	35	40	82	12	6	Coconut oil
Fluorocarbon	35	35	78	14	8	Carbon tetrachloride, HF
Glycerine	55	60	89	6	5	Epichlorohydrin
Hexamethylene tetramine	7	37	43	17	40	Methanol, NH ₃
Hydrogen cyanide	30	33	19	38	43	Propane, NH ₃
Iso octanol	55	29	45	24	31	Hepiane
Isobutylene	40	21	30	56	14	Butane
Isopropanol	70	14	40	44	16	Propylene
Maleic anhydride	35	37	43	38	19	Benzene
Melamine	28	33	47	33	20	Urea NH ₂
Mercapto- <i>ortho</i> -thiazole	7	83	57	30	13	Aniline
Methyl chloride	30	17	60	19	21	Methanol, HCl
Methyl methacrylate	55	41	75	15	10	Acetone, HCN
Monochloro acetic acid	30	37	67	21	12	Acetic acid, Cl ₂
Naphthol, beta	15	73	67	17	16	Naphthalene
Nylon 6/6 resin	110	73	71	11	18	Adipic acid
Nylon filament	30	320	28	25	47	Dimethyl formamide solution
Olefins, alpha	420	17	73	15	12	Wax
Paraffins, <i>n</i>	70	22	82	14	4	Kerosene
Pentachlorophenol	7	37	41	22	37	Phenol, HCl
Pentaerythritol	14	47	51	35	14	Formaldehyde
Perchloroethylene	40	19	58	29	13	Propane, Cl ₂
Phosgene	35	37	60	30	10	Carbon monoxide, Cl ₂
Polyester staple	30	34	34	29	39	Dimethyl formamide solution
Polystyrene	55	32	69	22	9	Styrene
Propylene oxide	70	32	66	18	16	Propylene, Cl ₂
Rubber (synthetic)	140	38	21	49	30	Isoprene
Sorbitol	15	23	52	18	30	Corn syrup
Terephthalic acid (fiber)	70	53	52	29	19	p-xylene
Tetraethyl lead	55	98	64	26	10	Ethyl chloride, Pb
Toluene diisocyanate	28	67	32	52	16	Phosgene
o-xylene	85	11	0	50	50	Super fractionation

SECTION 4. RAW MATERIAL AND UTILITY REQUIREMENT (3)

Acetaldehyde	Ethylene 0.67 Oxygen 0.29* CW 0.3* DW 0.003* S(L) 1.3 S(H) 0.3 E 0.21 Ethanol 1.15 [Formaldehyde 1.1 Methanol 0.65 Solvents 0.4 Acetone 0.13]
Acetic Acid	Butane 5.53L A 2.5* Acetaldehyde 1.1 Manganous Acetate 0.003 A 0.23* Methanol 0.53 CO 0.47 Catalyst(s) Butane 0.97 A 3.8* [Other acids, alcohols and ketones-] Acetaldehyde 1.2 Catalyst 0.001 Diluent 1.7 A
Acetic Anhydride	Acetic Acid 1.35 Catalyst(s) Isopropyl Alcohol 1.2
Acetone	Calcium Carbide (85%) 3.5 W 29 Natural Gas 8.2* S(H) 29 CW 0.1* PW 0.8L E 0.16 Solvent 0.003 [Tar 0.18 Fuel Gas 11.2*]
Acetylene	Natural Gas 5.9* Oxygen (95%) 5.4 Solvent 0.003 E 1.7 S(L) 5.0 CW 0.03* (Partial Oxidation) [10. * Off Gas C Black 0.03 Acetylene Polymers 0.005]
Acrylate, Ethyl	Acetylene 0.26 Ethanol 0.46 CO 0.06 Ni Carbonyl 0.09 HCl 0.18
Acrylonitrile	Propylene 0.4 Oxygen 0.48 Ethanol 0.46 Catalyst(s) Acrylonitrile 0.53 Ethanol 0.46 W 0.18 Sulphuric acid(s) β-Propiolactone 0.84 Methanol 0.37 Catalyst(s)
Adipic Acid	Propylene 1.18 Ammonia 0.48 A 6.1* Catalyst(s) Cyclohexane feed (95%) 0.8 Nitric Acid (100%), no recycle 1.0 Air 0.6 Cu, CO Naphthenate and Am. Metavandate(s)
Amine, Amyl	Mixed Amyl Chlorides 1.25 Ammonia 0.2 Caustic Soda, solid 0.49 Ethanol(s)
Amines, Methyl (Mixed)	Methanol 1.5 Ammonia 0.43
Alkyl Aryl Sulfonate	Dodecane 0.4 Benzene 0.13 22% Oleum 0.45 NaOH (S, G, 1.21) 0.65 L Alum. Chloride 0.01
Aluminium Chloride	Alum. Scrap 0.25 Chlorine 0.88
Aluminium Sulphate	(17% Alum. Oxide) Bauxite (55% Al ₂ O ₃) 0.34 Sulf. Acid (80%) 0.57 Black ash (70% Bas) 0.007 Flake Gluc(s) Natural Gas 0.8* Catalyst, Shift 0.15, Synthesis 0.25
Ammonia	Natural Gas 0.004 Monoethanolamine 0.15 Fuel Gas for driving Comp. 6.1 m. kcal. E 0.12 W 0.025* Amm. Sulphate 1.3 Sod. Chloride 1.25
Ammonium Chloride	Ammonia 0.22 Nitric Acid (100%) 0.82 E 0.055 W 0.008* S 1.8
Ammonium Nitrate	Nitrobenzene 1.4 Iron borings 1.6 HCl (30%) 0.13 Chlorobenzene 1.35 Amm. Sulphate 3.7 Cuprous Oxide 0.18
Aniline	Nitrobenzene 1.35 Hydrogen 0.08* Copper Carbonate 0.007
Aspirin	Salicylic Acid 0.77 Acetic Anhydride 0.62 [Acetic Acid 0.35]
Barium Carbonate	Black Ash (65% Bas) 1.8 Carbon Dioxide 0.22 Black Ash (65% Bas) 1.3 Soda Ash (58% Na ₂ O) 0.54 [Sod. Sulphate, 60% 0.65]

Benzene	Naphtha 0.88 B Diethylene Glycol 0.02 Clay 0.1 Catalyst 0.003 [Toluene 0.18 B Xylene 0.18 B Raffinate 0.44 B] Toluene 1.23 Hydrogen 0.03 Clay 0.002 [Paraffin HC 0.24] Light Oil 1.98 L Sulphuric Acid (96%) 0.01 Sod. Hydroxide 0.02
Benzoic Acid	Toluene 0.93 Air 1.72* Catalyst(s) Benzotrachloride 1.78 PW 1.25 Catalyst 0.013 Phthalic Anhydride 1.43 Catalyst 0.013 Toluene 0.78 Chlorine 0.64 Phenol 0.88 Acetone 0.27 HCl, Lime, Methyl Mercaptan(s)
Benzyl Chloride	Borax 1.8 Sulphuric Acid (S. G. 1.84) 0.63 Brine (1.000 PPM Bromine) 1.000 Chlorine 0.55 S-(V)
Bisphenol-A	Butylene 1.3 n-Butane 1.93 (Houdry) n-Butanol 0.71 Acetic Acid, Glacial 0.55 Sulphuric Acid (96%) 0.003
Boric Acid	Molasses 5.4L W. 0.08 Nutrients 0.004 [Acetone 0.33 Ethanol 0.05 CO ₂ H ₂]
Bromine	Butyraldehyde 1.03 Hydrogen 0.33* Catalyst(s) Brine or Liquor (9% CaCl ₂) 8.5
Butadiene	Phosphate Rock (70 BPL) 0.6 Sulphuric Acid 0.35 Cyclohexanone 0.9 Ammonia 1.5 CO ₂ 0.5 S 0.7 20% Oleum 1.4 Catalyst(s) A (V)
Butyl Acetate	Oil 1.42.8 L or Natural Gas 5.3-7.0* A 25-38* Methane 0.35* Sulphur 0.9
Butyl Alcohol	Carbon Disulphide 0.55 Chlorine 1.15 Cellulose 0.58 Monochloroacetic Acid 0.3 Caustic Soda 0.25 Water 0.4
Calcium Chloride	Cellulose 0.7 Acetic Anhydride 2.0 Acetic Acid 3.3 Sulphuric Acid 0.1 [Acetic Acid 5.0]
Calcium Phosphate	Salt 1.8 Sod. Carb. 0.03 Sulphuric Acid 0.01 S 11.4 E 3.3 R 1.0 Graphite 0.005 [Sod. Hydrox. 1.13 Hydrogen 0.32*]
Caprolactam	Potassium Chloride 2.1 Nitric Acid 1.8 Oxygen 0.22 [Potassium Nitrate 2.85]
Carbon Black	Hydrogen Chloride 1.0 Oxygen 0.23 Acetic Acid 0.69 Chlorine 0.8
Carbon Disulphide	Benzene 0.95 Chlorine 0.9 Iron Turning(s) Chlorine 1.8 Methane 0.19*
Carbon Tetrachloride	Sod. Dichromate Dihydrate 1.5 Sulphuric Acid (S. G. 1.84) 1.3
Carboxy Methyl Cellulose	Molasses 4.0 Nutrients 0.01 Sulphuric Acid (95%) 0.7 Lime 0.5
Cellulose Acetate	Copper 0.26 Sulphuric Acid (100%) 0.4 Middle Oil (V) Caustic Soda (50%) 0.8 Sulphuric Acid (100%) 0.9
Chlorine	Benzene 0.8 Propylene 0.4 Phosphoric Acid (Solid)(s) Benzene 0.9 Hydrogen 0.07 Catalyst(s) Cyclohexane 1.0 Air (V) Metaboric Acid 0.005 Zinc Oxide 0.001
Chloroacetic Acid	
Chlorobenzene	
Chloroform	
Chromic Acid	
Citric Acid	
Copper Sulphate	
Cresol	
Cumene	
Cyclohexane	
Cyclohexanone	

Decyl Alcohols	Phenol 1.0 Hydrogen 0.07 Catalyst(s)	Hydrofluoric Acid	Fluorspar (98% CaF ₂) 2.25 Sulphuric Acid (100%) 2.85 S 1.75 E 0.22 R (-10°C) 360 kcal Fuel 2.300 kcal PW 0.01* CW 0.12*
Dibutyl Phthalate	C ₉ Olefin 1.15 Synth Gas 0.4* Hydrogen 0.14* Co. Ni Catalyst(s)	Hydrogen (Per*) 99.9%	Propane 0.37 L OR Natural Gas 0.25 S 5.8 Fuel 3.200 kcal CW 90 L F 0.03
Dichlorodifluoromethane	Phthalic Anhydride 0.6 Butyl Alcohol 0.7 Sulphuric Acid (96%) 0.01	97%	Fuel 0.36 Oxygen (95%) 0.36 E 0.07 150 kg-h Coke 0.68 S 7.2 CW 0.27 E 0.11
Dodecylbenzene	Carbon Tetrachloride 1.6 HF 0.4 Antimony Penta- chloride(s)	Hydrogen Peroxide (70%)	Ammonia 0.025 Sulphuric Acid 0.03 PW 1.15L E. 7.1 S 8.4 Platinum (VS)
Epichlorohydrin	Benzene 0.5 Dodecene 0.9 Alum-Chloride or HF Catalyst(s)	25%	Oxygen 0.17* Hydrogen 0.18* W 0.75L Pd, Solvent, Ethylanthraquinone—losses only
Ethanolamines	Propylene 0.8 Chlorine 2.4 Caustic Soda 1.2 (75% Mono, 21% Di and 4% Tri-) Ethylene Oxide 0.8 Ammonia 0.3	25%	Isopropanol 0.5 Oxygen 0.2* [Acetone 0.46] Propylene 0.9 Sulphuric Acid (85%) 0.13 Mineral oil— losses only
Ethyl Ether	Ethanol (95%) 1.4 Sulphuric Acid (96%) 0.02	Lead, Tetraethyl	Sodium 0.33 Lead 0.64 Ethyl Chloride 0.8 Catalyst 0.03 Ferric Chloride Sod. Thio Sulphite(s)
Ethyl Acetate	Ethanol (95%) 0.6 Acetic Acid (100%) 0.7 Sulphuric Acid (96%) 0.04	Lead, Tetramethyl	Mg turnings 0.18 Methyl Chloride 0.75 Lead 0.78 Pig Lead 0.95 A (V)
Ethyl Alcohol (per L)	Molasses 2.4 L Sulphuric Acid (79%) 0.02 Amm. Sulphate 0.0002 S 6 PW 10L CW 42 L E. 0.03	Maleic Anhydride	Benzene 1.34 A 19*
	Benzene 0.7 Ethylene 0.27 CW 17 PW 0.7 E 0.02 Fuel 9.5 kcal	Melamine	Urea 3.1 Ammonia 0.46 Carbon Dioxide 0.03 Catalyst 0.008 Act. C. 0.002 CW 0.65*
Ethyl Benzene	Ethylene 0.49 HCl 0.63 Alum. Chloride(s)	Methyl Alcohol	Carbon Monoxide 1.17* Hydrogen 2.35*
Ethyl Chloride	Ethanol 0.75 HCl 0.6 Catalyst(s)	Methyl Chloride	Chlorine 1.4 Methane 0.45*
Ethylene Diamine	Ethylene Dichloride 1.65 Ammonia 0.57 NaOH—for neutralisation	Methyl Ethyl Ketone	Methanol 0.7 HCl 0.8 Alumina Gel(s)
Ethylene Dibromide	Ethylene 0.15 Bromine 0.86	Methyl Isobutyl-Ketone	Butyl Alcohol (Sec-) 1.18
Ethylene Dichloride	Ethylene 0.32 Chlorine 0.8 Ethylene Dibromide(s)	Methyl Methacrylate	Acetone 1.16 Hydrogen 0.23* Acid, Alkali, Catalyst(s) Acetone 0.38 HCN 0.27 Methanol 0.32 Sulphuric Acid (98%) 0.98
Ethylene Glycol	Ethylene 0.9 Air 9.5 Silver Catalyst(s)	Methyl Parathion	Phosphorous Pentasulphide 0.42 Methanol 0.24 Chlorine 0.27 p-nitrophenol 0.53
Ethylene Diamine Mono- ethyl ether	Ethylene Oxide 0.57 Ethanol 0.6 Catalyst(s)	Nitric Acid (100%)	Ammonia 0.29 Pt 0.00025 mg A 3.6* W 0.13* E 0.39 [Steam 1.0]
Ethylene Oxide	Ethylene 1.1 A 13.1 Ag 0.5 mg. E 1.9 S 0.1 W 0.2*	Nitrobenzene	Benzene 0.65 Mixed Acid (Sulphuric 0.72, Nitric 0.53, Water 0.11) Sod. Carb. 0.01
Ethyl (2-) Hexyl Alcohol	Propylene (92+%) 0.74 Synth. Gas (99%) 0.96 Cocar- bonyl(s) Butyraldehyde	p-Nonylphenol Oxygen (90%)	Phenol 0.62 Nonene 0.45 Catalyst(s) A 3.9* S (H) 1.67 CW 4.2L E 410 kwh
Ferrous Sulphate	Butyraldehyde 1.3 Hydrogen 0.36* Ni Catalyst 0.0001	Pentaerthritol	Formaldehyde (37%) 3.2 Acetaldehyde 0.38 Alkali (50%) 1.05 Acid (as formic) 0.6
Formaldehyde (37%)	Pickling Liquor 2.5 Scrap Iron 0.08	Perchloroethylene	Ethylene Dichloride 1.2 Chlorine 0.64 Oxygen 0.39 Catalyst(s) [Trichloroethylene 0.8]
Glycerine	Methanol 0.47 Air 0.8*	Phenol	Propane 0.2 Chlorine 2.5 [HCl 1.35] Acetylene 0.19 Chlorine 1.5 Lime (hydrate) 0.45 Catalyst(s)
	Spent Lye (5% Glyc.) 22 Sod. Hydrox. 0.1 Ferric Chloride 0.06 Al. Sulph. 0.01 Act. C 0.003 S 4.0 E 0.01 [Salt 2.2]	Phosgene	Cumene 1.38 A 1.4* Sulphuric Acid, Sod. Hydrox.(s)
	Propylene 0.63 Chlorine 2.0 Sod. Hydrox. 0.045 Hydrated Lime 0.045	Phosphoric Acid (100%)	Benzene 1.00 Sulphuric Acid (96%) 1.75 Caustic Soda 1.70 S 2.0 E 0.09
	Propylene 0.93 Oxygen 0.23 Isopropanol 1.1 Hyd. Perox. (100%) 0.49		Chlorobenzene 1.25 Caustic Soda 1.37 HCl (as 100%) 0.5 Toluene 1.25 A 1.06* Catalyst(s)
	Adiponitrile 1.0 Ammonia 0.05 Hydrogen 0.08 Catalyst 0.0008		Co 0.23* Chlorine 0.72 C (Active) 0.0005 Phos. Rock (70 BPL) 2.5 Sand (Silica) 1.0 Coke Breeze 0.44 C Electrode 0.01 A 4.1* E 4.5 W 40* [Slag 2.3]
Hexamethylene Diamene	Formaldehyde (37%) 3.6 Ammonia (100%) 0.55		
Hexamethylene Tetramine	Ammonia 1.33 Sod. Hypochlorite 3.3 Glue(s)		
Hydrazine	Salt 0.5 Sulphuric Acid (100%) 0.48 or Niter Cake 1.3		
Hydrochloric Acid (31.5%)	Coal 0.4 [Salt Cake 0.63 OR 1.42]		
	Chlorine 0.32 Hydrogen 0.01		

(75% H_3PO_4)	Phosphorus 0.32 A 4.1* S.W-(V)	
Phosphorus	Phos. Rock (70 BPL) 1.8 Sulphuric Acid (94%) 1.7 W 0.06* S 1.35* E 3.0	
Phosphorous Oxidechloride	Rock 12.0 Sand (Silica) 2.2 Coke 1.3 C Electrode 0.03 E 14.3	
Phosphorous Pentasulphide	Phosp. Trichloride 0.54 Phosp. Pentoxide 0.20 Chlorine 0.28	
Phosphorous Trichloride	Phosphorus (White) 0.30 Sulphur 0.76	
Phthalic Anhydride	Phosphorus 0.24 Chlorine 0.82	
Potassium Chloride (99%)	Naphthalene (78%) 1.25 A 26*	
(60% K_2O)	o-Xylene 0.98 A 25*	
Potassium Hydroxide	Sylvinit ore 2.5 W 167* S 1.25 E 0.55 (crystallization)	
	Sylvinit 1.15 Flotation Reagent 0.0005 (flotation)	
	Saturated Lake Brine 20.6	
	Pot. Chloride 1.46 Pot. Carbonate 0.025 Sulphuric Acid (SG 1.84) 0.1 S 7.13 E 2.0 [Chlorine 0.63 Hydrogen 0.02]	‡
Potassium Permanganate	Manganese Dioxide 0.55 (0.79-70% ore) Pot. Hydroxide (100%) 0.36	‡
Potassium Pyrophosphate	Caustic Potash (100%) 0.68 Phosphoric Acid (100%) 0.60	‡
Propylene Glycol	Propylene Oxide 0.76 Water 0.24	‡
Propylene Oxide	Propylene (100% Basis) 0.94 Chlorine 1.6 Lime (100% CaO) 1.1	‡
Sodium	Propylene 0.78 Isobutane 2.16 Oxygen 0.90	
Sodium Bicarbonate	Sod. Chloride 3.15 Calcium Chloride 0.006 E 16.5	
Sodium Carbonate	Sod. Carbonate 0.69 Carbon Dioxide 0.30	
(58% Na_2O)	Salt 1.5 Limestone 1.2 Coke 1.0 Coal 0.45, Solvey process;	
	CW 0.07* Ammonia (Make-up) 0.003 Carbon Dioxide 0.35* Sod. Sulphide 0.002	‡
	Trona Ore 1.5 Natural soda ash	‡
Sodium Chlorate	Saturated Seales Lake Brine 21.5	
	Salt 0.57 HCl (100%) 0.014 Sod. Dichromate 0.0005	
Sodium Chloride (99.8%)	Barium Chloride 0.0007 Graphite 0.001 E 5.6	
	Saturated Brine (26.3% NaCl) 3.8 Soda Ash (58%) 0.004	
Sodium Chromate	Caustic Soda (50%) 0.4 S (Triple Effect Evap.) 1.25	‡
	Per 1.6 kg. Sod. Chrom. Decahydrate OR 1.0 kg. Sod. Dichrom. Dihydrate	
Sodium Hydroxide (99%)	Chromite Ore (50% Cr_2O_3) 1.1 Limestone 1.5 Soda Ash 0.8 Sulphuric Acid (S.G. 1.84) 0.5 Fuel Oil 0.54 L S 3.0 E 0.55 [Anhy. Sod. Sulphate 0.5]	
Sodium Phosphate	Salt 1.5 Sod. Carb. (58%) 0.03 Sulphuric Acid (S.G. 1.84) 0.1 S 10 E 2.75 R 0.9 [Chlorine 0.89 Hydrogen 0.28*]	
Sodium Silicate (40° Be)	Phosphoric Acid (45% P_2O_5) 0.44 Sod. Carb. (58% Na_2O) 0.30 Sod. Hydrox. (76% Na_2O) 0.12	
Sodium Sulphate	Sod. Carb. (Dense, 58%) 0.16 Sand 0.29 Gas (250 kcal) 0.02* W 0.67 L E 0.02	
	Natural Brine (10% Sulphate) 10 NaCl (V) Natural Gas 0.16* Salt 0.84 Sulphuric Acid (100%) 0.75 Coal 0.6 [HCl 31.5% 1.58]	

Sodium Thiosulphate	‡	(Pentahydrate) Soda Ash 0.43 Sulphur Dioxide 0.26 Sulphur 0.13
Sorbitol (85%)	‡	Dextrose 0.95 Hydrogen 0.16* Ni Catalyst 0.0001 Ac. C 0.001 Resin (V)
Styrene		Benzene 0.87 Ethylene 0.32 Al Chloride 0.01 Ethyl Chloride(s)
Sulphur		Hydrogen Sulphide (100%) 1.18 Air 1.88*
Sulphuric Acid		Sulphur 0.34 W 16.7 L S (from W. H. Boiler) 0.1 E 0.006 A 7.8* (CONTACT)
Terephthalic Acid (Dimethyl Terephthalate)		p-Xylene 0.68 A (V) Acetic Acid Catalyst(s) Terephthalic Acid (Tech.) 0.87 Methanol 0.34 p-Xylene 0.67 Methanol 0.40 A (V) Catalyst(s)
Titanium Dioxide (98%)		Ilmenite (50% TiO_2) 2.25 Sulphuric Acid (S.G. 1.84) 4.5 Caustic Soda(s) [Ferrous Sulphate, Sulphuric Acid] Rutile (95% TiO_2) 1.13 Chlorine 0.15 Coke 0.25 Oxygen 0.45
Toluene		Naphtha, Sulphuric Acid, Caustic Soda MEK—(V) depending on feedstock.
Toluene Diisocyanate		4-Tolydiamine 0.88 Phosgene 1.4 Solvent(s) Inert Gas (V)
Trichloroethane (1, 1, 1)	‡	Vinyl Chloride 0.47 Chlorine 0.53 Ferric Chloride(s)
Trichloroethylene	‡	Vinylidene Chloride 0.73 HCl 0.27 Ferric Chloride(s)
Tricresyl Phosphate		Ethane 0.39 Chlorine 2 [HCl 1.1 Ethylene 0.07]
Urea (60% Solid, 40% Liquid)		Acetylene 0.22 Chlorine 1.2 Catalyst(s)
Vinyl Acetate		Cresol 1.0 Phosphorous Oxychloride 0.49
Vinyl Chloride		Ammonia 2.0 Carbon Dioxide 0.9
		Ethylene 0.35 Acetic Acid 0.7 Pd. Catalyst(s)
		Acetylene 0.33 Acetic Acid 0.7
		Ethylene Dichloride 1.65
		Acetylene 0.44 HCl (Anhyd.) 0.60 Mercuric Chloride 0.0001
		Mixed Xylenes (15.8% p-) 18.0 R-make up only [Mixed o- and m- 16.9]
		Zinc Metal (Spelter) 0.87 Coal (Anthracite) 0.65
		Franklinite Ore (20% ZnO) 5.3 Coal 4.0 E 0.4
		Zinc Sulphide (100%) 1.3 Coke 0.85 Fluxes (V)

NOTES: 1. Each Line - Different Process. Raw materials indicative of Process 2. All Numbers - Kg. per Kg. of product, except * (Cu.m.(STP), B = Bbl, L = Litre, OR = as noted. 3. ‡ = Theoretical. [J = By-products, m = million, s = small, V = Variable. 4. UTILITIES A = Air, CW = Cooling Water, DW = Demineralised, PW = Process, S(L) = Steam (Low Press), S(H) Steam (High Press), E = Electricity, Kwh. R = Refrigeration.