Annexure-I

List of Products

Sr. No.	Name of Products	Quantity	
		(MT/Year)	(MT/month)
1	**Bromination and Chlorination of Alcohols**		
1.1.	Ethyl Bromide	3500	291.67
1.2.	n-Propyl Bromide		
1.3.	Iso Propyl Bromide		
1.4.	n-Butyl Bromide		
1.5.	Iso Butyl Bromide		
1.6.	Sec-Butyl Bromide		
1.7.	n-Hexyl Bromide		
1.8.	n-Heptyl Bromide		
1.9.	n-Octyl Bromide		
1.10.	n-Decyl Bromide		
1.11.	Lauryl Bromide		
1.12.	Cetyl Bromide		
1.13.	Myristyl Bromide		
1.14.	Stearyl Bromide		
1.15.	1,2 Dibromo Ethane		
1.16.	1,3 Dibromo Propane		
1.17.	1,4 Dibromo Butane		
1.18.	1,5 Dibromo pentane		
1.19.	1,6 Dibromo Hexane		
1.20.	1 Chloro 2 Ethyl Hexane		
1.21.	6 Chloro 1 Hexanol		
1.22.	3 Chloro Propanol		
1.23.	1,6 Dichloro Hexane		
1.24.	Cyclo Propyl Methyl Bromide		
1.25.	Cyclo Pentyl Bromide		
1.26.	Cyclo Pentyl Chloride		

Sr. No.	Name of Products	Quantity	
		(MT/Year)	(MT/month)
2.	**Bromination of Organic Acids and Esterification thereof**		
2.1.	2 Bromo propionic Acid	3500	291.67
2.2.	2 Bromo Propionyl Bromide		
2.3.	5 Bromo Valeric Acid		
2.4.	2 Bromo Hexanoic Acid		
2.5.	Sodium 2 Bromo Propionate		
2.6.	Ethyl 3 Bromo Propionate		
2.7.	Methyl 2 Bromo Butyrate		
2.8.	Ethyl 2 Bromo Butyrate		
2.9.	Ethyl 4 Bromo Butyrate		
2.10.	Methyl 2 Bromo Iso Butyrate		
2.11.	Ethyl 2 Bromo Iso Butyrate		
2.12.	Iso Propyl 2 Bromo Iso Butyrate		
2.13.	Ethyl 2 Bromo Valerate		
2.14.	Methyl 2 Bromo valerate		
2.15.	Ethyl 5 Bromo Valerate		
2.16.	Tert-Butyl 2 Bromo Iso Butyrate		
2.17.	Methyl 2 Bromo Caproate		
3.	**Grignards Formation from Organic Halides**		
3.1.	Methyl Magnesium Chloride 3M in THF	1000	83.33
3.2.	Methyl Magnesium Bromide 1.5M in THF		
3.3.	Ethyl Magnesium Chloride 2M in THF		
3.4.	Ethyl Magnesium Bromide 2M in THF		
3.5.	Vinyl Magnesium Bromide in 1M in THF		
3.6.	Isopropyl Magnesium Chloride 1M in THF		
3.7.	Phenyl Magnesium Bromide 2M in THF		
3.8.	n-Butyl Magnesium Chloride 1M in THF		
3.9.	Iso Propyl Magnesium Chloride–Li Cl Complex 1.3M in THF		

Sr. No.	Name of Products	Quantity	
		(MT/Year)	(MT/month)
3.10.	Iso Propyl Magnesium Bromide 1M in THF		
4.	**Halogen Exchange Reactions**		
4.1.	1 Bromo 2 Chloro Ethane	2000	166.67
4.2.	1 Bromo 4 Chloro Butane		
4.3.	1 Bromo 5 Chloro Pentane		
4.4.	1 Bromo 6 Chloro Hexane		
4.5.	1 Bromo 1 Fluoro Methane		
4.6.	Dibromo Methane		
4.7.	Bromo Chloro Methane		
4.8.	Ethyl 5 Iodo Valerate		
4.9.	2 Bromo Hepta Fluoro Propane		
5.	**Addition of Halogen and Halogen Acids across Double Bonds**		
5.1.	1,2 Di Bromo Ethane	2500	208.33
5.2.	Phenyl Ethyl Bromide		
5.3.	1 Bromo 3 Chloro Propane		
5.4.	n-Hexyl Bromide		
5.5.	n-Octyl Bromide		
5.6.	n-Decyl Bromide		
5.7.	Cyclo Pentyl Bromide		
5.8.	Cyclo Pentyl Chloride		
5.9.	1,2 Dibromo 3 Chloro Propane		
5.10.	1,2 Dibromo Hexa Fluoro Propane		
6	**Bromination or Chlorination of Cyclic and Aromatic Compounds with or Without Functional Groups**		
6.1.	Bromo Benzene	2500	208.33
6.2.	Di Bromo Benzene		
6.3.	Ethyl 4 Bromo Methyl Benzoate		
6.4.	1 Bromo 4 Chloro Benzene		
6.5.	p- Bromo Toluene		

Sr. No.	Name of Products	Quantity	
		(MT/Year)	(MT/month)
6.6.	4 Bromo O Xylene		
6.7.	2 Chloro 1,4 Naphthaquinone		
6.8.	1 Bromo 4 Fluoro Benzene		
6.9.	4 Bromo Methyl 2 Cyano Biphenyl (Bromo OTBN)		
6.10.	1 Bromo 3,4 Dichloro Benzene		
7	**Dehydrohalogenation of Organic Halides Optionally with or without functional Group**		
7.1.	Vinyl Bromide	1000	83.33
7.2.	Vinyl Bromide in THF 25%		
7.3.	Vinyl Chloride		
7.4.	4 Bromo 1 Butene		
7.5.	6 Bromo 1 Hexene		
7.6.	7 Bromo 1 Heptene		
7.7.	8 Bromo 1 Octene		
8	**Advance Intermediates from Category 1 to 7**		
8.1.	6 Methoxy Naphthaldehyde	2000	166.67
8.2.	2 Fluoro 5 Bromo Benzonitrile		
8.3.	Ethyl 4- (dimethyl amino) Butyrate		
8.4.	Bromo Acetal		
8.5.	6 Bromo Hexyl Trimethyl Ammonium bromide		
8.6.	1 Bromo 3 Phenoxy Propane		
8.7.	6 Chloro 2 Hexanone		
8.8.	n-Octyl Amine		
8.9.	Bifenthrin Alcohol		
8.10.	Ethyl 7 Chloro 2 Oxo Heptanoate		
8.11.	1 Bromo 6 Methyl Heptane		
8.12.	Methyl 3 Oxo Pentanoate		
9	**Lithium Carbonate or Hydroxide reaction with Inorganic or Organic Acids**		

Sr. No.	Name of Products	Quantity	
		(MT/Year)	(MT/month)
9.1.	Lithium Bromide 55%	2000	166.67
9.2.	Lithium Bromide Anhydrous		
9.3.	Lithium Chloride 40%		
9.4.	Lithium Chloride Anhydrous		
9.5.	Lithium Nitrate		
9.6.	Lithium Sulphate		
9.7.	Lithium Molybdate 20%		
9.8.	Lithium Acetate		
9.9.	Lithium Iodide		
9.10.	Lithium Fluoride		
10	**Hydrobromic Acid from Bromine**		
10.1.	Hydrogen Bromide 48% to 62%	5000	416.67
10.2.	Hydrogen Bromide 20% in IPA		
10.3.	Hydrogen Bromide 30% in Acetic Acid		
10.4.	Hydrogen Bromide Anhydrous		
	R & D products	120	10
	Total	**20120**	**1676.7**
11	**Co-Products:**		
11.1.	Sodium Bromide	5000	416.67
11.2.	Zinc Bromide		
11.3.	Potassium Bromide		
11.4.	Calcium Bromide		
11.5.	Magnesium Bromide		
11.6.	$NaHSO_3$		
11.7.	HCl		
11.8.	Spent HBr		
	And/or		
	Liquid Bromine (Recovered from above co-product)	700	58.4

List of Raw Materials

Sr. No.	Name of Raw Materials	Quantity (MT/MT)
1. Bromination and Chlorination of Alcohols		
1.1.	**Ethyl Bromide**	
	Ethyl Alcohol	0.465
	Hydrobromic Acid (48%)	2.790
1.2.	**n Propyl Bromide**	
	n- Propyl Alcohol	0.568
	Hydrobromic Acid (48%)	2.099
1.3.	**Iso Propyl Bromide**	
	Iso - Propyl Alcohol	0.530
	Hydrobromic Acid (48%)	2.370
1.4.	**n Butyl Bromide**	
	n- Butyl Alcohol	0.642
	Hydrobromic Acid (48%)	2.155
1.5.	**Iso Butyl Bromide**	
	Iso - Butyl Alcohol	0.584
	Hydrobromic Acid (48%)	2.175
1.6.	**Sec-Butyl Bromide**	
	sec-Butyl Alcohol	0.581
	Hydrobromic Acid (48%)	1.913
1.7.	**n-Hexyl Bromide**	
	n-Hexyl Alcohol	0.687
	Hydrobromic Acid (48%)	2.154
1.8.	**n-Heptyl Bromide**	
	n-Heptyl Alcohol	0.710
	Hydrobromic Acid (48%)	2.139
1.9.	**n-Octyl Bromide**	
	n Octyl Alcohol	0.736
	Hydrobromic Acid	1.765

Sr. No.	Name of Raw Materials	Quantity (MT/MT)
1.10.	**n-Decyl Bromide**	
	n- Decyl Alcohol	0.796
	Hydrobromic Acid (48%)	1.305
1.11.	**Lauryl Bromide**	
	Lauryl Alcohol	0.809
	Hydrobromic Acid (48%)	1.121
1.12.	**Cetyl Bromide**	
	Cetyl Alcohol	0.841
	Hydrobromic Acid (48%)	0.927
1.13.	**Myristyl Bromide**	
	Myristyl Alcohol	0.832
	Hydrobromic Acid (48%)	1.231
1.14.	**Stearyl Bromide**	
	Stearyl Alcohol	0.927
	Hydrobromic Acid (48%)	0.899
1.15.	**1,2 Dibromo Ethane**	
	Ethylene Glycol	0.360
	Hydrobromic Acid (48%)	2.951
1.16.	**1,3 Dibromo Propane**	
	1,3 Propanediol	0.412
	Hydrobromic Acid (48%)	2.693
1.17.	**1,4 Dibromo Butane**	
	1,4 Butanediol	0.458
	Hydrobromic Acid (48%)	2.541
1.18.	**1,5 Dibromo pentane**	
	1,5 Pentanediol	0.488
	Hydrobromic Acid (48%)	2.402
1.19.	**1,6 Dibromo Hexane**	
	1,6 Hexanediol	0.546

Sr. No.	Name of Raw Materials	Quantity (MT/MT)
	Bromine	0.732
1.20.	**1 Chloro 2 Ethyl Hexane**	
	2 Ethyl Hexanol	0.956
	Thionyl Chloride	0.985
1.21.	**6 Chloro 1 Hexanol**	
	1,6 Hexanediol	0.946
	HCl (20%)	5.138
1.22.	**3 Chloro Propanol**	
	1,3 Propanediol	0.892
	Thionyl Chloride	1.396
1.23.	**1,6 Dichloro Hexane**	
	1,6 Hexanediol	0.864
	Thionyl Chloride	1.742
1.24.	**Cyclo Propyl Methyl Bromide**	
	Cyclo Propyl Methyl Alcohol	0.584
	Hydrobromic Acid (48%)	2.281
1.25.	**Cyclo Pentyl Bromide**	
	Cyclo Pentyl Alcohol	0.626
	Hydrobromic Acid (48%)	2.003
1.26.	**Cyclo Pentyl Chloride**	
	Cyclo Pentyl Alcohol	0.907
	Hydrochloric Acid (20%)	5.783
2. Bromination of Organic Acids and Esterification thereof		
2.1.	**2 Bromo propionic Acid**	
	Propionic Acid	0.520
	Bromine	1.125
2.2.	**2 Bromo Propionyl Bromide**	
	Propionyl Bromide	0.696
	Bromine	0.813

Sr. No.	Name of Raw Materials	Quantity (MT/MT)
2.3.	**5 Bromo Valeric Acid**	
	Valerolactone	0.606
	Hydrobromic Acid	1.332
2.4.	**2 Bromo Hexanoic Acid**	
	n- Hexanoic Acid	0.611
	Bromine	0.843
2.5.	**Sodium 2 Bromo Propionate**	
	Propionic Acid	0.456
	Bromine	0.986
	Sodium Methoxide	1.109
2.6.	**Ethyl 3 Bromo Propionate**	
	Propiolactone	0.640
	Hydrogen Bromide (48%)	1.825
	Ethanol	0.785
2.7.	**Methyl 2 Bromo Butyrate**	
	n-Butyric Acid	0.484
	Bromine	0.880
	Methanol	0.413
2.8.	**Ethyl 2 Bromo Butyrate**	
	n-Butyric Acid	0.472
	Bromine	0.859
	Ethanol	0.568
2.9.	**Ethyl 4 Bromo Butyrate**	
	Butryolactone	0.450
	Hydrogen Bromide (48%)	1.235
	Ethanol	0.541
2.10.	**Methyl 2 Bromo Iso Butyrate**	
	Iso-Butyric Acid	0.514
	Bromine	0.935

Sr. No.	Name of Raw Materials	Quantity (MT/MT)
	Methanol	0.382
2.11.	**Ethyl 2 Bromo Iso Butyrate**	
	Iso-Butyric Acid	0.472
	Bromine	0.859
	Ethanol	0.568
2.12.	**Iso Propyl 2 Bromo Iso Butyrate**	
	Iso - Butyric Acid	0.469
	Bromine	0.852
	Iso Propyl Alcohol	0.514
2.13.	**Ethyl 2 Bromo Valerate**	
	Valeric Acid	0.489
	Bromine	0.768
	Ethanol	0.511
2.14.	**Methyl 2 Bromo Valerate**	
	Valeric Acid	0.553
	Bromine	0.868
	Methanol	0.381
2.15.	**Ethyl 5 Bromo Valerate**	
	Valerolactone	0.506
	Hydrobromic Acid	1.113
	Ethanol	0.484
2.16.	**Tert-Butyl 2 Bromo Iso Butyrate**	
	Iso Butyric Acid	0.407
	Bromine	0.739
	t Butyl Alcohol	1.062
2.17.	**Methyl 2 Bromo Caproate**	
	n- Hexanoic Acid	0.616
	Bromine	0.849
	Methanol	0.357

Sr. No.	Name of Raw Materials	Quantity (MT/MT)
3. Grignards Formation from Organic Halides		
3.1.	**Methyl Magnesium Chloride 3M in THF**	
	n-Octyl Bromide	0.193
	Magnesium	0.024
	THF Solution	0.783
3.2.	**Methyl Magnesium Bromide 1.5M in THF**	
	Methyl Bromide	0.146
	Magnesium	0.037
	THF Solution	0.818
3.3.	**Ethyl Magnesium Chloride 2M in THF**	
	Ethyl Chloride	0.141
	Magnesium	0.053
	THF Solution	0.806
3.4.	**Ethyl Magnesium Bromide 2M in THF**	
	Ethyl Bromide	0.218
	Magnesium	0.048
	THF Solution	0.734
3.5.	**Vinyl Magnesium Bromide in 1M in THF**	
	Vinyl Bromide	0.113
	Magnesium	0.024
	THF Solution	0.863
3.6.	**Isopropyl Magnesium Chloride 1M in THF**	
	Iso Propyl Chloride	0.087
	Magnesium	0.027
	THF Solution	0.886
3.7.	**Phenyl Magnesium Bromide 2M in THF**	
	Phenyl Bromide	0.302
	Magnesium	0.045
	THF Solution	0.653

Sr. No.	Name of Raw Materials	Quantity (MT/MT)
3.8.	**n-Butyl Magnesium Chloride 1M in THF**	
	n-Butyl Chloride	0.103
	Magnesium	0.026
	THF Solution	0.870
3.9.	**Iso Propyl Magnesium Chloride–LiCl Complex 1.3M in THF**	
	Iso Propyl Chloride	0.085
	Magnesium	0.026
	Lithium Chloride	0.046
	THF Solution	0.843
3.10.	**Iso Propyl Magnesium Bromide 1M in THF**	
	Iso Propyl Bromide	0.130
	Magnesium	0.025
	THF Solution	0.845
4. Halogen Exchange Reactions		
4.1.	**1 Bromo 2 Chloro Ethane**	
	1,2 - Di Bromo Ethane	1.480
	Sodium Chloride	0.461
4.2.	**1 Bromo 4 Chloro Butane**	
	1,4 - Di Bromo Butane	1.452
	Sodium Chloride	0.393
4.3.	**1 Bromo 5 Chloro Pentane**	
	1,5 - Di Bromo Pentane	1.144
	Sodium Chloride	0.292
4.4.	**1 Bromo 6 Chloro Hexane**	
	1,6 - Di Bromo Hexane	1.405
	Sodium Chloride	0.338
4.5.	**1 Bromo 1 Fluoro Methane**	
	1,1 - Di Bromo Methane	1.649
	Sodium Fluoride	0.399

Sr. No.	Name of Raw Materials	Quantity (MT/MT)
4.6.	**Dibromo Methane**	
	Methylene Di Chloride	0.525
	Sodium Bromide	1.271
4.7.	**Bromo Chloro Methane**	
	1,1 - Di Bromo Methane	1.456
	Sodium Chloride	0.490
4.8.	**Ethyl 5 Iodo Valerate**	
	5 Bromo Valeric Acid Ethyl Ester	0.906
	Sodium Iodide	0.650
4.9.	**2 Bromo Hepta Fluoro Propane**	
	1,2 Dibromo Hexa Fluoro Propane	1.377
	Potassium Fluoride (30%)	0.858
5. Addition of Halogen and Halogen Acids across Double Bonds		
5.1.	**1,2 Di Bromo Ethane**	
	Vinyl Bromide	0.616
	Hydrogen Bromide	0.466
5.2.	**Phenyl Ethyl Bromide**	
	Phenyl Ethene	0.652
	Hydrobromic Acid	0.433
5.3.	**1 Bromo 3 Chloro Propane**	
	Allyl Chloride	0.533
	Hydrogen Bromide	0.564
5.4.	**n-Hexyl Bromide**	
	n- Hexene	0.561
	Hydrogen Bromide	0.541
5.5.	**n-Octyl Bromide**	
	n- Octene	0.638
	Hydrogen Bromide	0.462
5.6.	**n-Decyl Bromide**	

Sr. No.	Name of Raw Materials	Quantity (MT/MT)
	n- Decene	0.692
	Hydrogen Bromide	0.401
5.7.	**Cyclo Pentyl Bromide**	
	Cyclo Pentene	0.915
	Hydrobromic Acid	0.591
5.8.	**Cyclo Pentyl Chloride**	
	Cyclo Pentene	1.322
	Hydrobromic Acid	0.381
5.9.	**1,2 Dibromo 3 Chloro Propane**	
	2,3 Di Brome Propene	0.926
	Hydrochloric Acid	0.169
5.10.	**1,2 Dibromo Hexa Fluoro Propane**	
	Hexa Fluoro Propane	0.520
	Bromine	0.555
6. Bromination or Chlorination of Cyclic and Aromatic Compounds with or Without Functional Groups		
6.1.	**Bromo Benzene**	
	Benzene	0.546
	Bromine	1.118
6.2.	**Di Bromo Benzene**	
	Benzene	0.364
	Bromine	1.488
6.3.	**Ethyl 4 Bromo Methyl Benzoate**	
	4 Methyl Benzoic Acid	0.617
	Bromine	0.725
	Ethanol	0.209
6.4.	**1 Bromo 4 Chloro Benzene**	
	Chloro Benzene	0.640
	Bromine	0.911
6.5.	**p- Bromo Toluene**	

Sr. No.	Name of Raw Materials	Quantity (MT/MT)
	Toluene	1.312
	Bromine	0.940
6.6.	**4 Bromo O Xylene**	
	O - Xylene	0.627
	Bromine	0.946
6.7.	**2 Chloro 1,4 Naphthaquinone**	
	1,4 Naphthaquinone	0.897
	Chlorine	0.403
6.8.	**1 Bromo 4 Fluoro Benzene**	
	Fluoro Benzene	0.597
	Bromine	0.995
6.9.	**4 Bromo Methyl 2 Cyano Biphenyl (Bromo OTBN)**	
	OTBN	0.909
	Bromine	0.455
	Methylene Dichloride	5.909
	Hydrogen peroxide (30%)	0.745
	Ethyl Acetate	2.273
6.10.	**1 Bromo 3,4 Dichloro Benzene**	
	1,2 Dichloro Benzene	0.717
	Bromine	0.780
7. Dehydro-halogenation of Organic Halides Optionally with or without functional Group		
7.1.	**Vinyl Bromide**	
	1,2 Dibromo Ethane	1.861
	NaOH	0.396
	Methanol	0.198
7.2.	**Vinyl Bromide in THF 25%**	
	1,2 Dibromo Ethane	1.422
	NaOH	0.304
	Methanol	0.152

Sr. No.	Name of Raw Materials	Quantity (MT/MT)
	THF	0.270
7.3.	**Vinyl Chloride**	
	1,2 Dichloro Ethane	1.715
	NaOH	0.692
	Methanol	0.304
7.4.	**4 Bromo 1 Butene**	
	1,4 Dibromo Butane	1.699
	NaOH	0.314
	Methanol	0.175
7.5.	**6 Bromo 1 Hexene**	
	1,6 Dibromo Hexane	1.562
	NaOH	0.256
	Methanol	0.160
7.6.	**7 Bromo 1 Heptene**	
	1,7 Dibromo Heptane	1.527
	NaOH	0.237
	Methanol	0.158
7.7.	**8 Bromo 1 Octene**	
	1,8 Dibromo Octane	1.479
	NaOH	0.217
	Methanol	0.132
8. Advance Intermediates from Category 1 to 7		
8.1.	**6 Methoxy Naphthaldehyde**	
	Naphthaldehyde	0.777
	Bromine	0.874
	Sodium Methoxide	0.295
	Oxygen	0.174
	Methanol	0.689
8.2.	**2 Fluoro 5 Bromo Benzonitrile**	

Sr. No.	Name of Raw Materials	Quantity (MT/MT)
	2 Chloro Benzonitrile	0.762
	Potassium Fluoride (30%)	1.072
	Bromine	0.888
8.3.	**Ethyl 4- (dimethyl amino) Butyrate**	
	Ethyl 4 Bromo Butyrate	1.235
	Dimethyl Amine	0.570
	Ethyl Acetate	1.332
8.4.	**Bromo Acetal**	
	Vinyl Acetate	0.644
	Methanol	1.246
	Bromine	1.198
	Soda solution	0.599
8.5.	**6 Bromo Hexyl Trimethyl Ammonium bromide**	
	1,6-Dibromohexane	1.411
	Trimethyl amine Gas	0.194
	Ethyl Acetate	2.106
8.6.	**1 Bromo 3 Phenoxy Propane**	
	1,3 Dibromo Propane	1.029
	Phenol	0.479
	Sodium Hydroxide (40%)	0.509
8.7.	**6 Chloro 2 Hexanone**	
	Methyl Acetoacetate	0.862
	1 Bromo 3 Chloro Propane	1.171
	Potassium Carbonate (30%)	3.421
	IPA	3.309
	HCl (40%)	0.691
8.8.	**n-Octyl Amine**	
	n Octyl Bromide	1.650
	Ammonia (20%)	0.726

Sr. No.	Name of Raw Materials	Quantity (MT/MT)
8.9.	**Bifenthrin Alcohol**	
	Dichloro Toluene	0.898
	Magnesium	0.266
	Bromo Benzene	0.871
	Formaldehyde (60%)	0.266
	THF	0.818
8.10.	**Ethyl 7 Chloro 2 Oxo Heptanoate**	
	Ethyl Acetoacetate	1.261
	1 Bromo 5 Chloro Pentane	1.797
	Potassium Carbonate	0.670
	Nitrosyl Sulphuric Acid	0.703
	Toluene	2.424
	Formaldehyde (35%)	0.415
8.11.	**1 Bromo 6 Methyl Heptane**	
	1,5 Di Bromo Pentane	1.210
	Iso Propyl Magnesium	4.980
8.12.	**Methyl 3 Oxo Pentanoate**	
	Butyl methyl ketone	0.608
	Chlorine	0.600
	Sodium Cyanide	0.413
	Sulphuric Acid (65%)	1.269
	Methanol	0.270
9. Lithium Carbonate or Hydroxide reaction with Inorganic or Organic Acids		
9.1.	**Lithium Bromide 55%**	
	Lithium Carbonate	0.234
	Hydrobromic Acid (48%)	1.067
9.2.	**Lithium Bromide Anhydrous**	
	Lithium Carbonate	0.425
	Hydrobromic Acid (48%)	1.940

Sr. No.	Name of Raw Materials	Quantity (MT/MT)
9.3.	**Lithium Chloride 40%**	
	Lithium Carbonate	0.348
	Hydrobromic Acid (30%)	1.144
9.4.	**Lithium Chloride Anhydrous**	
	Lithium Carbonate	0.870
	Hydrobromic Acid (30%)	2.862
9.5.	**Lithium Nitrate**	
	Lithium Carbonate	0.526
	Nitric Acid (68%)	1.315
9.6.	**Lithium Sulphate**	
	Lithium Carbonate	0.659
	Sulphuric Acid	0.873
9.7.	**Lithium Molybdate 20%**	
	Lithium Hydroxide Monohydrate	0.193
	Molybdenum Trioxide	0.165
9.8.	**Lithium Acetate**	
	Lithium Carbonate	0.503
	Acetic acid	0.816
9.9.	**Lithium Iodide**	
	Lithium Carbonate	0.152
	Hydro Iodic Acid (48 %)	1.095
9.10.	**Lithium Fluoride**	
	Lithium Carbonate	0.783
	Hydrofluoric Acid (48%)	0.882
10. Hydrobromic Acid from Bromine		
10.1.	**Hydrogen Bromide 48% to 62%**	
	Bromine	0.474
	Hydrogen	0.006
10.2.	**Hydrogen Bromide 20% in IPA**	

Sr. No.	Name of Raw Materials	Quantity (MT/MT)
	Bromine	0.198
	Hydrogen	0.002
	Iso propyl alcohol	0.800
10.3.	**Hydrogen Bromide 30% in Acetic Acid**	
	Bromine	0.296
	Hydrogen	0.004
	Acetic acid	0.700
10.4.	**Hydrogen Bromide Anhydrous**	
	Bromine	0.988
	Hydrogen	0.012
11. Co - Products		
11.1.	**Sodium Bromide**	
	Sodium Hydroxide (50%)	0.777
	Hydrobromic Acid (48%)	1.638
11.2.	**Zinc Bromide**	
	Zinc Hydroxide (45%)	0.981
	Hydrobromic Acid (48%)	1.497
11.3.	**Potassium Bromide**	
	Potassium Hydroxide (45%)	1.046
	Hydrobromic Acid (48%)	1.418
11.4.	**Calcium Bromide**	
	Calcium Hydroxide (45%)	0.825
	Hydrobromic Acid (48%)	1.686
11.5	**Magnesium Bromide**	
	Magnesium Hydroxide (40%)	0.548
	Hydrobromic Acid (48%)	1.829
11.6	**Liquid Bromine (Recovered from above co-products)**	

Hazardous Chemicals Storage Facilities

Sr. No.	Name of Chemicals	MOC	Numbers of Tank	Storage Capacity (M^3)
RM 1	Bromine storage	MSGL	4	6
RM 2	n Butryc acid	SS 316	1	40
RM 3	Iso Butryc acid	SS316	1	40
RM 4	Iso propanol	MS	2	40
RM 5	Ethyl Alcohol	MS	1	40
RM 6	Methanol	MS	1	20
RM 7	Xylene	MS	1	20
RM 8	Toluene	MS	1	20
RM 9	Ethylene Di Chloride	MS	1	20
RM 10	Hexene	MS	1	20
RM 11	Octene	MS	1	20
RM 12	Decene	MS	1	20
RM 13	Ethyl acetate	SS	1	40
RM 14	HBr 48%	HDPE	2	40
FP 1	Ethyl 2 Bromo Butyrate	SS 316	1	20
FP 2	Iso-Propyl 2-Bromo iso butyrate	SS 316	1	30
FP 3	Iso Propyl Bromide	HDPE	1	30
FP 4	Decyl Bromide	HDPE	1	20
FP 5	n Propylbromide	HDPE	1	20
FP 6	Iso Butyl Bromide	HDPE	1	20
FP 7	Lithium Bromide 55%	HDPE	2	20

Annexure-II

Manufacturing Process

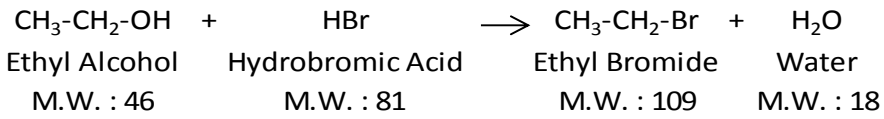
1) Bromination and Chlorination of Alcohols

1.1) Ethyl Bromide

Manufacturing Process:

- Ethyl Alcohol is taken in Aqueous Hydro bromic Acid. To this Gaseous HBr is passed, after passing required amount of HBr acid over a given period of time the mass is analyzed for completion of reaction on GC.
- When unreacted Ethyl alcohol is less than 1% HBr acid addition is stopped and taken for Water washing.
- The Organic is taken in to the Glass lined reactor and water is added. This mass was stirred at room temperature. Organic layer taken for Purification and Aqueous layer containing HBr is recycled to next Batch.
- Organic Layer is then taken for Fractionation after removal of Low Boiler Impurities under Vacuum, the Product is fractionated. Pure Ethyl Bromide thus obtained is packed in 200 lit Drums.

Chemical reaction:



Mass Balance:

Input	Kg				Output	Kg
Ethyl Alcohol	1815		**Reaction**		Ethyl Bromide	4300
Hydrobromic Acid (48%)	10880	→		→	Recovered HBr (24%)	8395
Total	12695				Total	12695
Ethyl Bromide	4300		**Water Wash**		Ethyl Bromide	4280
Water	2000	→		→	Water to ETP	2020
Total	6300				Total	6300
Ethyl Bromide	4280		**Vacuum Distillation**		Main Product	3900
		→		→	Residue	380
Total	4280				Total	4280

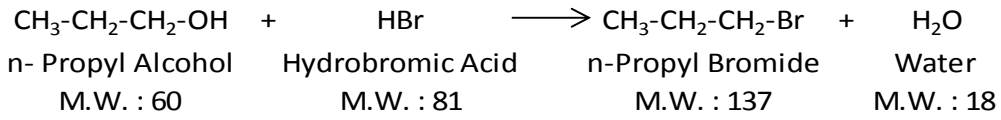
1.2) n Propyl Bromide

Manufacturing Process:

- n-Propyl Alcohol is taken in Aqueous Hydro bromic Acid. To this Gaseous HBr is passed, after passing required amount of HBr acid over a given period of time the mass is analyzed for completion of reaction on GC.
- When unreacted n-Propyl Alcohol is less than 1% HBr acid addition is stopped and taken for Water washing.

- The Organic is taken in to the Glass lined reactor and water is added. This mass was stirred at room temperature for about 30 mins. Organic layer taken for Purification and Aqueous layer containing HBr is recycled to next Batch.
- Organic Layer is then taken for Fractionation after removal of Low Boiler impurities under Vacuum, the Product is fractionated. Pure n-Propyl Bromide thus obtained is packed in 200 lit Drums.

Chemical reaction:



Mass Balance:

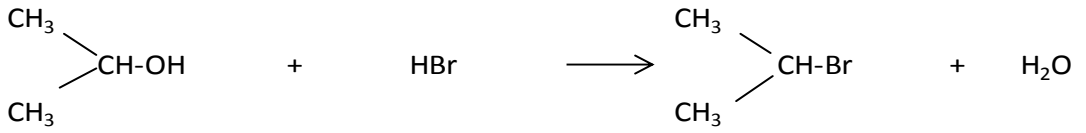
Input	Kg				Output	Kg
n- Propyl Alcohol	2410		**Reaction**		n - Propyl Bromide	4935
Hydrobromic Acid (48%)	8900				Recovered HBr (16%)	6375
Total	11310				Total	11310
n-Propyl Bromide	4935		**Water Wash**		n-Propyl Bromide	4900
Water	2000				Water to ETP	2035
Total	6935				Total	6935
n-Propyl Bromide	4900		**Vacuum Distillation**		Main Product	4240
					Residue	660
Total	4900				Total	4900

1.3) Iso Propyl Bromide

Manufacturing Process:

- Isopropyl Alcohol is taken in Aqueous Hydro bromic Acid. To this Gaseous HBr is passed, after passing required amount of HBr acid over a given period of time the mass is analyzed for completion of reaction on GC.
- When unreacted iso Propyl alcohol is less than 1% HBr acid addition is stopped and taken for Water washing.
- The Organic is taken in to the Glass lined reactor and water is added. This mass was stirred at room temperature. Organic layer taken for Purification and Aqueous layer containing HBr is recycled to next Batch.
- Organic Layer is then taken for Fractionation after removal of Low Boiler impurities under Vacuum, the Product is fractionated. Pure Iso-Propyl Bromide thus obtained is packed in 200 lit Drums.

Chemical reaction:



Iso Propyl Alcohol	Hydrobromic Acid	Iso-Propyl Bromide	Water
M.W. : 60	M.W. : 81	M.W. : 123	M.W. : 18

Mass Balance:

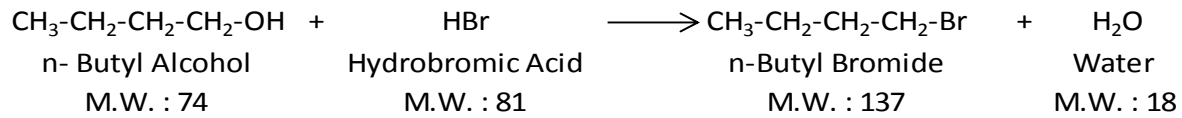
Input	Kg				Output	Kg
Iso - Propyl Alcohol	2200		**Reaction**		Iso - Propyl Bromide	4510
Hydrobromic Acid (48%)	9835				Recovered HBr (23%)	7525
Total	12035				Total	12035
Iso-Propyl Bromide	4510		**Water Wash**		Iso-Propyl Bromide	4490
Water	2000				Water to ETP	2020
Total	6510				Total	6510
Iso-Propyl Bromide	4490		**Vacuum Distillation**		Main Product	4150
					Residue	340
Total	4490				Total	4490

1.4) n Butyl Bromide

Manufacturing Process:

- n-Butyl Alcohol is taken in Aqueous Hydro bromic Acid. To this Gaseous HBr is passed at, after passing required amount of HBr acid over a given period of time the mass is analyzed for completion of reaction on GC.
- When unreacted n-Butyl Alcohol is less than 1% HBr acid addition is stopped and taken for Water washing.
- The Organic is taken in to the Glass lined reactor and water is added. This mass was stirred at room temperature. Organic layer taken for Purification and Aqueous layer containing HBr is recycled to next Batch.
- Organic Layer is then taken for Fractionation after removal of Low Boiler impurities under Vacuum, the Product is fractionated. Pure n-Butyl Bromide thus obtained is packed in 200 lit Drums.

Chemical reaction:



n- Butyl Alcohol	Hydrobromic Acid	n-Butyl Bromide	Water
M.W. : 74	M.W. : 81	M.W. : 137	M.W. : 18

Mass Balance:

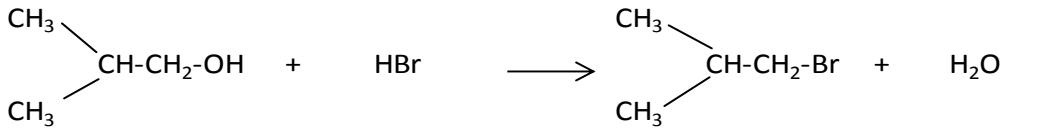
Input	Kg				Output	Kg
n- Butyl Alcohol	2665		**Reaction**		n - Butyl Bromide	4935
Hydrobromic Acid (48%)	8945				Recovered HBr (21%)	6675
Total	11610				Total	11610
n-Butyl Bromide	4813		**Water Wash**		n-Butyl Bromide	4790
Water	2000				Water to ETP	2023
Total	6813				Total	6813
n-Butyl Bromide	4790		**Vacuum Distillation**		Main Product	4150
					Residue	640
Total	4790				Total	4790

1.5) Iso Butyl Bromide

Manufacturing Process:

- Isobutyl Alcohol is taken in Aqueous Hydro bromic Acid. To this Gaseous HBr is passed, after passing required amount of HBr acid over a given period of time the mass is analyzed for completion of reaction on GC.
- When unreacted Iso Butyl alcohol is less than 1% HBr acid addition is stopped and taken for Water washing.
- The Organic is taken in to the Glass lined reactor and water is added. This mass was stirred at room temp. Organic layer taken for Purification and Aqueous layer containing HBr is recycled to next Batch.
- Organic Layer is then taken for Fractionation after removal of Low Boiler impurities under Vacuum, the Product is fractionated. Pure Iso-Butyl Bromide thus obtained is packed in 200 lit Drums.

Chemical reaction:



Iso Butyl Alcohol	Hydrobromic Acid	Iso-Butyl Bromide	Water
M.W. : 74	M.W. : 81	M.W. : 137	M.W. : 18

Mass Balance:

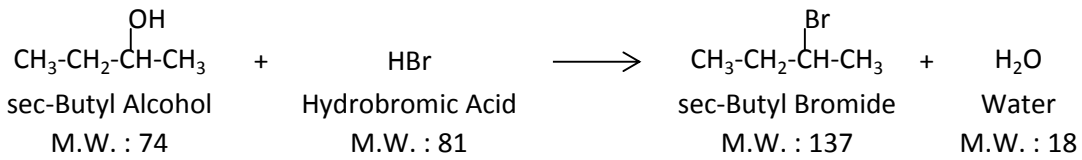
Input	Kg				Output	Kg
Iso - Butyl Alcohol	2565		Reaction		Iso - Butyl Bromide	4748
Hydrobromic Acid (48%)	9550				Recovered HBr (24%)	7367
Total	12115				Total	12115
Iso Butyl Bromide	4748		Water Wash		Iso Butyl Bromide	4720
Water	2000				Water to ETP	2028
Total	6748				Total	6748
Iso Butyl Bromide	4720		Vacuum Distillation		Main Product	4390
					Residue	330
Total	4720				Total	4720

1.6) sec Butyl Bromide

Manufacturing Process:

- Sec-Butyl Alcohol is taken in Aqueous Hydro bromic Acid. To this Gaseous HBr is passed, after passing required amount of HBr acid over a given period of time the mass is analyzed for completion of reaction on GC.
- When unreacted sec-butyl alcohol is less than 1% HBr acid addition is stopped and taken for Water washing.
- The Organic is taken in to the Glass lined reactor and water is added. This mass was stirred at room temperature. Organic layer taken for Purification and Aqueous layer containing HBr is recycled to next Batch.
- Organic Layer is then taken for Fractionation after removal of Low Boiler impurities under Vacuum, the Product is fractionated. Pure Sec-Amyl Bromide thus obtained is packed in 200 lit Drums.

Chemical reaction:



sec-Butyl Alcohol	Hydrobromic Acid		sec-Butyl Bromide	Water
M.W. : 74	M.W. : 81		M.W. : 137	M.W. : 18

Mass Balance:

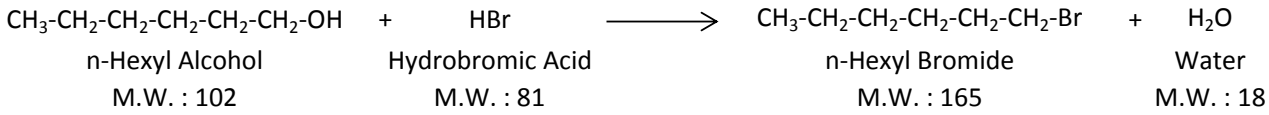
Input	Kg				Output	Kg
sec-Butyl Alcohol	2785	→	**Reaction**	→	sec - Butyl Bromide	5155
Hydrobromic Acid (48%)	9165				Recovered HBr (20%)	6795
Total	11950				Total	11950
Sec - Butyl Bromide	5155	→	**Water Wash**	→	Sec-Butyl Bromide	5140
Water	2000				Water to ETP	2015
Total	7155				Total	7155
Sec - Butyl Bromide	5140	→	**Vacuum Distillation**	→	Main Product	4790
					Residue	350
Total	5140				Total	5140

1.7) n Hexyl Bromide

Manufacturing Process:

- n-Hexyl Alcohol is taken in aqueous Hydro bromic Acid. To this Gaseous HBr is passed, after passing required amount of HBr acid over a given period of time the mass is analyzed for completion of reaction on GC.
- When unreacted n-Hexyl alcohol is less than 1% HBr acid addition is stopped and taken for Water washing.
- The Organic is taken in to the Glass lined reactor and water is added. This mass was stirred at room temperature. Organic layer taken for Purification and Aqueous layer containing HBr is recycled to next Batch.
- Organic Layer is then taken for Fractionation after removal of Low Boiler impurities under Vacuum, the Product is fractionated. Pure n-Hexyl Bromide thus obtained is packed in 200 lit Drums.

Chemical reaction:



Mass Balance:

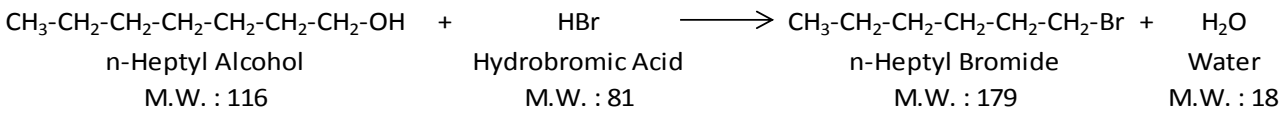
Input	Kg				Output	Kg
n-Hexyl Alcohol	2850	→	**Reaction**	→	n - Hexyl Bromide	4610
Hydrobromic Acid (48%)	8940				Recovered HBr (28%)	7180
Total	11790				Total	11790
n-Hexyl Bromide	4610	→	**Water Wash**	→	n-Hexyl Bromide	4590
Water	2000				Water to ETP	2020
Total	6610				Total	6610
n-Hexyl Bromide	4590	→	**Vacuum Distillation**	→	Main Product	4150
					Residue	440
Total	4590				Total	4590

1.8) n Heptyl Bromide

Manufacturing Process:

- n-Heptyl Alcohol is taken in Aqueous Hydrobromic Acid. To this Gaseous HBr is passed, after passing required amount of HBr acid over a given period of time the mass is analyzed for completion of reaction on GC.
- When unreacted n-Heptyl alcohol is less than 1% HBr acid addition is stopped and taken for Water washing.
- The Organic is taken in to the Glass lined reactor and water is added. This mass was stirred at room temperature for about 30 mins. Organic layer taken for Purification and Aqueous layer containing HBr is recycled to next Batch.
- Organic Layer is then taken for Fractionation after removal of Low Boiler impurities under Vacuum, the Product is fractionated. Pure n-Heptyl Bromide thus obtained is packed in 200 lit Drums.

Chemical reaction:



Mass Balance:

Input	Kg				Output	Kg
n-Heptyl Alcohol	2870	→	**Reaction**	→	n - Heptyl Bromide	4430
Hydrobromic Acid (48%)	8640				Recovered HBr (30%)	7080
Total	11510				Total	11510
n-Heptyl Bromide	4430	→	**Water Wash**	→	n-Heptyl Bromide	4400
Water	2000				Water to ETP	2030
Total	6430				Total	6430
n-Heptyl Bromide	4400	→	**Vacuum Distillation**	→	Main Product	4040
					Residue	360
Total	4400				Total	4400

1.9) n Octyl Bromide

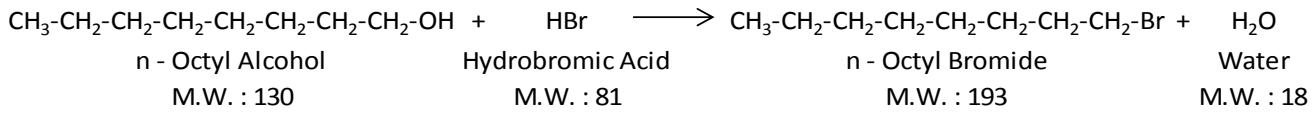
Manufacturing Process:

- n-Octyl Alcohol is taken in Aqueous Hydro bromic Acid. To this Gaseous HBr is passed, after passing required amount of HBr acid over a given period of time the mass is analyzed for completion of reaction on GC.
- When unreacted n-Octyl Alcohol is less than 1% HBr acid addition is stopped and taken for Water washing.
- The Organic is taken in to the Glass lined reactor and water is added. This mass was stirred at room temperature for about 30 mins. Organic layer

taken for Purification and Aqueous layer containing HBr is recycled to next Batch.

- Organic Layer is then taken for Fractionation after removal of Low Boiler impurities under Vacuum, the Product is fractionated. Pure n-Octyl Bromide thus obtained is packed in 200 lit Drums.

Chemical reaction:



Mass Balance:

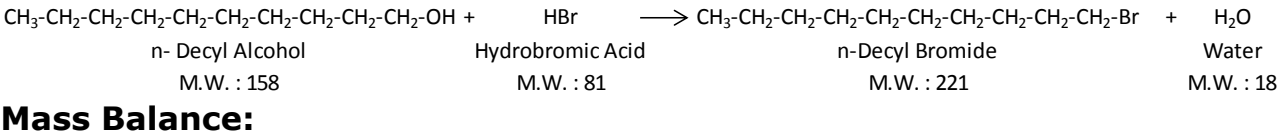
Input	Kg				Output	Kg
n Octyl Alcohol	3400	→	**Reaction**	→	n Octyl Bromide	5048
Hydrobromic Acid	8155				Hydrobromic Acid (27.5%)	6507
Total	11555				Total	11555
n Octyl Bromide	5048	→	**Water Wash**	→	n Octyl Bromide	5030
Water	2000				Water to ETP	2018
Total	7048				Total	7048
n Octyl Bromide	5030	→	**Vacuum Distillation**	→	Main Product	4620
					Residue	410
Total	5030				Total	5030

1.10) n Decyl Bromide

Manufacturing Process:

- n-Decyl Alcohol is taken in Aqueous Hydrobromic Acid. To this Gaseous HBr is passed, after passing required amount of HBr acid over a given period of time the mass is analyzed for completion of reaction on GC.
- When unreacted n-Decyl alcohol is less than 1% HBr acid addition is stopped and taken for Water washing.
- The Organic is taken in to the Glass lined reactor and water is added. This mass was stirred at room temperature for about 30 mins. Organic layer taken for Purification and Aqueous layer containing HBr is recycled to next Batch.
- Organic Layer is then taken for Fractionation after removal of Low Boiler impurities under Vacuum, the Product is fractionated. Pure n-Decyl Bromide thus obtained is packed in 200 lit Drums.

Chemical reaction:



Mass Balance:

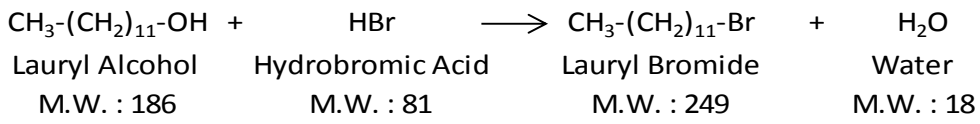
Input	Kg				Output	Kg
n- Decyl Alcohol	4300	→	**Reaction**	→	n - Decyl Bromide	6015
Hydrobromic Acid (48%)	7045				Recovered HBr (20%)	5330
Total	11345				Total	11345
n-Decyl Bromide	6015	→	**Water Wash**	→	n-Decyl Bromide	6000
Water	2000				Water to ETP	2015
Total	8015				Total	8015
n-Decyl Bromide	6000	→	**Vacuum Distillation**	→	Main Product	5400
					Residue	600
Total	6000				Total	6000

1.11) Lauryl Bromide

Manufacturing Process:

- Lauryl Alcohol is taken in Aqueous Hydrobromic Acid. To this Gaseous HBr is passed, after passing required amount of HBr acid over a given period of time the mass is analyzed for completion of reaction on GC.
- When unreacted Lauryl Alcohol is less than 1% HBr acid addition is stopped and taken for Water washing.
- The Organic is taken in to the Glass lined reactor and water is added. This mass was stirred at room temperature for about 30 mins. Organic layer taken for Purification and Aqueous layer containing HBr is recycled to next Batch.
- Organic Layer is then taken for Fractionation after removal of Low Boiler impurities under Vacuum, the Product is fractionated. Pure Lauryl Bromide thus obtained is packed in 200 lit Drums.

Chemical reaction:



Mass Balance:

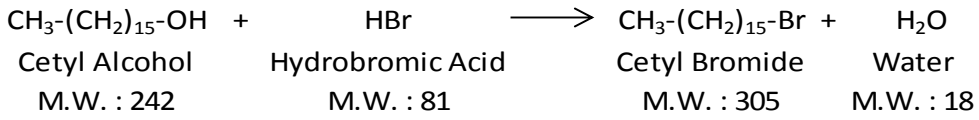
Input	Kg				Output	Kg
Lauryl Alcohol	4500	→	**Reaction**	→	Lauryl Bromide	6025
Hydrobromic Acid (48%)	6235				Recovered HBr (22%)	4710
Total	10735				Total	10735
Lauryl Bromide	6025	→	**Water Wash**	→	Lauryl Bromide	6000
Water	2000				Water to ETP	2025
Total	8025				Total	8025
Lauryl Bromide	6000	→	**Vacuum Distillation**	→	Main Product	5560
					Residue	440
Total	6000				Total	6000

1.12) Cetyl Bromide

Manufacturing Process:

- Cetyl Alcohol is taken in Aqueous Hydrobromic Acid. To this Gaseous HBr is passed, after passing required amount of HBr acid over a given period of time the mass is analyzed for completion of reaction on GC.
- When unreacted Cetyl Alcohol is less than 1% HBr acid addition is stopped and taken for Water washing.
- The Organic is taken in to the Glass lined reactor and water is added. This mass was stirred at room temperature for about 30 mins. Organic layer taken for Purification and Aqueous layer containing HBr is recycled to next Batch.
- Organic Layer is then taken for Fractionation after removal of Low Boiler Impurities under Vacuum, the Product is fractionated. Pure Cetyl Bromide thus obtained is packed in 200 lit Drums.

Chemical reaction:



Mass Balance:

Input	Kg				Output	Kg
Cetyl Alcohol	4865	→	**Reaction**	→	Cetyl Bromide	6132
Hydrobromic Acid (48%)	5365				Recovered HBr (23%)	4098
Total	10230				Total	10230
Cetyl Bromide	6132	→	**Water Wash**	→	Cetyl Bromide	6120
Water	2000				Water to ETP	2012
Total	8132				Total	8132
Cetyl Bromide	6120	→	**Vacuum Distillation**	→	Main Product	5785
					Residue	335
Total	6120				Total	6120

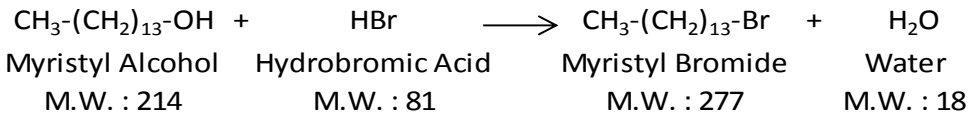
1.13) Meristyl Bromide

Manufacturing Process:

- Myristyl Alcohol is taken in Aqueous Hydrobromic Acid. To this Gaseous HBr is passed, after passing required amount of HBr acid over a given period of time the mass is analyzed for completion of reaction on GC.
- When unreacted Myristyl Alcohol is less than 1% HBr acid addition is stopped and taken for Water washing.

- The Organic is taken in to the Glass lined reactor and water is added. This mass was stirred at room temperature for about 30 mins. Organic layer taken for Purification and Aqueous layer containing HBr is recycled to next Batch.
- Organic Layer is then taken for Fractionation after removal of Low Boiler Impurities under Vacuum, the Product is fractionated. Pure Myristyl Bromide thus obtained is packed in 200 lit Drums.

Chemical reaction:



Mass Balance:

Input	Kg				Output	Kg
Myristyl Alcohol	4350	→	**Reaction**	→	Myristyl Bromide	5630
Hydrobromic Acid (48%)	6440				Recovered HBr (28%)	5160
Total	10790				Total	10790
Myristyl Bromide	5630	→	**Water Wash**	→	Myristyl Bromide	5605
Water	2000				Water to ETP	2025
Total	7630				Total	7630
Myristyl Bromide	5605	→	**Vacuum Distillation**	→	Main Product	5230
					Residue	375
Total	5605				Total	5605

1.14) Stearyl Bromide

Manufacturing Process:

- Stearyl Alcohol is taken in Aqueous Hydrobromic Acid. To this Gaseous HBr is passed, after passing required amount of HBr acid over a given period of time the mass is analyzed for completion of reaction on GC.
- When unreacted Stearyl Alcohol is less than 1% HBr acid addition is stopped and taken for Water washing.
- The Organic is taken in to the Glass lined reactor and water is added. This mass was stirred at room temperature for about 30 mins. Organic layer taken for Purification and Aqueous layer containing HBr is recycled to next Batch.
- Organic Layer is then taken for Fractionation after removal of Low Boiler Impurities under Vacuum, the Product is fractionated. Pure Stearyl Bromide thus obtained is packed in 200 lit Drums.

Chemical reaction:

$CH_3\text{-}(CH_2)_{17}\text{-}OH$ + HBr ⟶ $CH_3\text{-}(CH_2)_{17}\text{-}Br$ + H_2O

Stearyl Alcohol	Hydrobromic Acid	Stearyl Bromide	Water
M.W. : 270	M.W. : 81	M.W. : 333	M.W. : 18

Mass Balance:

Input	Kg				Output	Kg
Stearyl Alcohol	5100	⟹	**Reaction**	⟹	Stearyl Bromide	6290
Hydrobromic Acid (48%)	4945				Recovered HBr (22.5%)	3755
Total	10045				Total	10045
Stearyl Bromide	6290	⟹	**Water Wash**	⟹	Stearyl Bromide	6200
Water	2000				Water to ETP	2090
Total	8290				Total	8290
Stearyl Bromide	6200	⟹	**Vacuum Distillation**	⟹	Main Product	5500
					Residue	700
Total	6200				Total	6200

1.15) 1,2 Dibromo Ethane

Manufacturing Process:

- Ethylene Glycol is taken in Aqueous Hydrobromic Acid. To this Gaseous HBr is passed, after passing required amount of HBr acid over a given period of time the mass is analyzed for completion of reaction on GC.
- When unreacted Ethylene Glycol is less than 1% HBr acid addition is stopped and taken for Water washing.
- The Organic is taken in to the Glass lined reactor and water is added. This mass was stirred at room temperature for about 30 mins. Organic layer taken for Purification and Aqueous layer containing HBr is recycled to next Batch.
- Organic Layer is then taken for Fractionation after removal of Low Boiler impurities under Vacuum, the Product is fractionated. Pure 1,2 Dibromo Ethane thus obtained is packed in 200 lit Drums.

Chemical reaction:

$OH\text{-}(CH_2)_2\text{-}OH$ + 2 HBr ⟶ $Br\text{-}(CH_2)_2\text{-}Br$ + $2\,H_2O$

Ethylene glycol	Hydrobromic Acid	1,2 Dibromo Ethane	Water
M.W. : 62	M.W. : 162	M.W. : 188	M.W. : 18 X 2 = 36

Mass Balance:

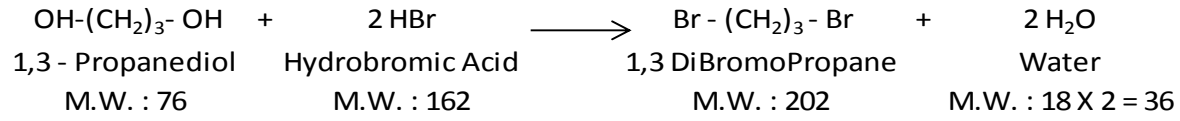
Input	Kg				Output	Kg
Ethylene Glycol	1500	→	**Reaction**	→	1,2 Dibromo Ethane	4550
Hydrobromic Acid (48%)	12305				Recovered HBr(21%)	9255
Total	13805				Total	13805
1,2 Dibromo Ethane	4550	→	**Water Wash**	→	1,2 Dibrpmo Ethane	4530
Water	2000				Water to ETP	2020
Total	6550				Total	6550
1,2 Dibromo Ethane	4530	→	**Vacuum Distillation**	→	Main Product	4170
					Residue	360
Total	4530				Total	4530

1.16) 1,3 Dibromo Propane

Manufacturing Process:

- 1,3 Propanediol is taken in Aqueous Hydrobromic Acid. To this Gaseous HBr is passed, after passing required amount of HBr acid over a given period of time the mass is analyzed for completion of reaction on GC.
- When unreacted 1,3 Propanediol is less than 1% HBr acid addition is stopped and taken for Water washing.
- The Organic is taken in to the Glass lined reactor and water is added. This mass was stirred at room temperature for about 30 mins. Organic layer taken for Purification and Aqueous layer containing HBr is recycled to next Batch.
- Organic Layer is then taken for Fractionation after removal of Low Boiler Impurities under Vacuum, the Product is fractionated. Pure 1,3 Dibromo Propane thus obtained is packed in 200 lit Drums.

Chemical reaction:



Mass Balance:

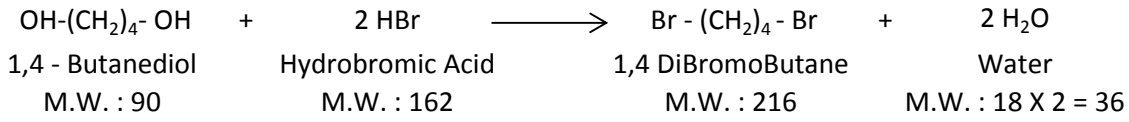
Input	Kg				Output	Kg
1,3 Propanediol	1800	→	**Reaction**	→	1,3 DiBromoPropane	4785
Hydrobromic Acid (48%)	11770				Recovered HBr(20%)	8785
Total	13570				Total	13570
1,3 DiBromoPropane	4785	→	**Water Wash**	→	1,3 DiBromoPropane	4750
Water	2000				Water to ETP	2035
Total	6785				Total	6785
1,3 DiBromoPropane	4750	→	**Vacuum Distillation**	→	Main Product	4370
					Residue	380
Total	4750				Total	4750

1.17) 1,4 Dibromo Butane

Manufacturing Process:

- 1,4 Butanediol is taken in Aqueous Hydrobromic Acid. To this Gaseous HBr is passed, after passing required amount of HBr acid over a given period of time the mass is analyzed for completion of reaction on GC.
- When unreacted 1,4 Butanediol is less than 1% HBr acid addition is stopped and taken for Water washing.
- The Organic is taken in to the Glass lined reactor and water is added. This mass was stirred at room temperature for about 30 mins. Organic layer taken for Purification and Aqueous layer containing HBr is recycled to next Batch.
- Organic Layer is then taken for Fractionation after removal of Low Boiler Impurities under Vacuum, the Product is fractionated. Pure 1,4 Dibromo Butane thus obtained is packed in 200 lit Drums.

Chemical reaction:



Mass Balance:

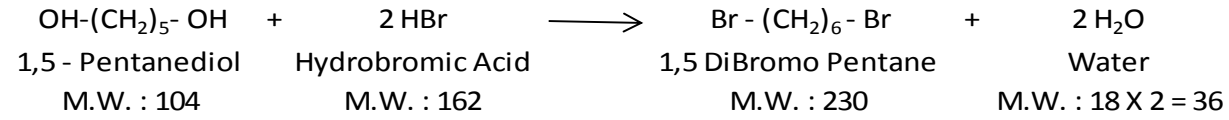
Input	Kg				Output	Kg
1,4 Butanediol	2040	→	**Reaction**	→	1,4 DiBromodecane	4895
Hydrobromic Acid (48%)	11320				Recovered HBr (21%)	8465
Total	13360				Total	13360
1,4 DiBromoButane	4895	→	**Water Wash**	→	1,4 DiBromoButane	4850
Water	2000				Water to ETP	2045
Total	6895				Total	6895
1,4 DiBromoButane	4850	→	**Vacuum Distillation**	→	Main Product	4455
					Residue	395
Total	4850				Total	4850

1.18) 1,5 Dibromo Pentane

Manufacturing Process:

- 1,5 Pentanediol is taken in Aqueous Hydrobromic Acid. To this Gaseous HBr is passed at 25°C - 30°C, after passing required amount of HBr acid over a given period of time the mass is analyzed for completion of reaction on GC.
- When unreacted 1,5 Pentanediol is less than 1% HBr acid addition is stopped and taken for Water washing.
- The Organic is taken in to the Glass lined reactor and water is added. This mass was stirred at room temperature for about 30 mins. Organic layer taken for Purification and Aqueous layer containing HBr is recycled to next Batch.
- Organic Layer is then taken for Fractionation after removal of Low Boiler Impurities under Vacuum, the Product is fractionated. Pure 1,5 Dibromo Pentane thus obtained is packed in 200 lit Drums.

Chemical reaction:



Mass Balance:

Input	Kg				Output	Kg
1,5 Pentanediol	2200		Reaction		1,5 Dibromo Pentane	4865
Hydrobromic Acid (48%)	10835				Recovered HBr (21%)	8170
Total	13035				Total	13035
1,5 Dibromo Pentane	4865		Water Wash		1,5 Dibromo Pentane	4850
Water	2000				Water to ETP	2015
Total	6865				Total	6865
1,5 Dibromo Pentane	4850		Vacuum Distillation		Main Product	4510
					Residue	340
Total	4850				Total	4850

1.19) 1,6 Dibromo Hexane

Manufacturing Process:

- 1,6 Hexanediol is taken in a reactor to that Sulphur is added and Bromine addition is done over a period of time to get 1,6 Dibromo Hexane to which water washing is given.
- The Organic Layer is taken for Fractionation to get Pure 1,6 Dibromo Hexane and Aqueous layer is recycled or sold as a By Product.

Chemical reaction:

$$3\,Br_2 + S + 4\,H_2O \longrightarrow 6\,HBr + H_2SO_4$$

$$3\,OH\text{-}(CH_2)_6\text{-}OH + 6\,HBr \longrightarrow 3\,Br\text{-}(CH_2)_6\text{-}Br + 6\,H_2O$$

$$3\,OH\text{-}(CH_2)_6\text{-}OH + 3\,Br_2 + S \longrightarrow 3\,Br\text{-}(CH_2)_6\text{-}Br + H_2SO_4 + 2\,H_2O$$

1,6 - Hexanediol	Bromine	Sulphur	1,6 DiBromohexane	Sulphuric Acid	Water
M.W. : 354	M.W. : 480	M.W. : 32	M.W. : 732	M.W.: 98	M.W. : 36

Mass Balance:

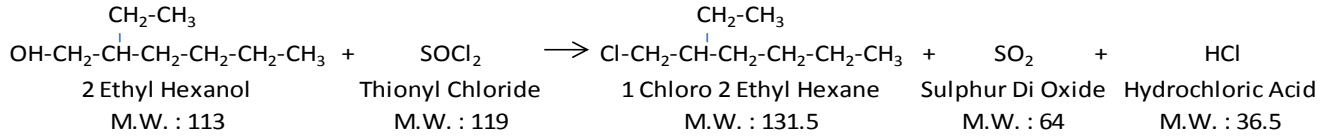
Input	Kg				Output	Kg
1,6 Hexanediol	6945		Reaction		1,6 DiBromoHexane	14190
Bromine	9305				Sulphuric Acid	1900
Sulphur	620				Water	780
Total	16870				Total	16870
1,6 DiBromoHexane	14190		Water Wash		1,6 DiBromoHexane	14150
Water	5000				Water to ETP	5040
Total	19190				Total	19190
1,6 DiBromoHexane	14150		Vacuum Distillation		Main Product	12720
					Residue	1430
Total	14150				Total	14150

1.20) 1 Chloro 2 Ethyl Hexane

Manufacturing Process:

- 2 Ethyl Hexanol is taken in reactor. To this Thionyl Chloride is added, after addition of required amount of Thionyl Chloride over a given period of time the mass is analyzed for completion of reaction on GC.
- When unreacted 2 Ethyl Hexanol is less than 1% thionyl Chloride addition is stopped and taken for Water washing.
- The Organic is taken in to the Glass lined reactor and water is added. This mass was stirred at room temperature for about 30 mins. Organic layer taken for Purification and aqueous layer containing is recycled to next Batch.
- Organic Layer is then taken for Fractionation after removal of Low Boiler Impurities under Vacuum, the Product is fractionated. Pure 1 Chloro 2 Ethyl Hexane thus obtained is packed in 200 lit Drums.

Chemical reaction:



Mass Balance:

Input	Kg				Output	Kg
2 Ethyl Hexanol	5250	→	**Reaction**	→	1 Chloro 2 Ethyl Hexane	5980
Thionyl Chloride	5410				Sulphur Di Oxide	2975
Water	3955				HCl (30%)	5660
Total	14615				Total	14615
1 Chloro 2 Ethyl Hexane	5980	→	**Water Wash**	→	1 Chloro 2 Ethyl Hexane	5950
Water	2000				Water to ETP	2030
Total	7980				Total	7980
1 Chloro 2 Ethyl Hexane	5950	→	**Vacuum Distillation**	→	Main Fraction	5490
					Residue	460
Total	5950				Total	5950

1.21) 6 Chloro 1 Hexanol

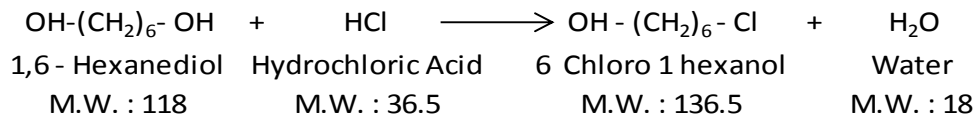
Manufacturing Process:

- 1,6 Hexanediol is taken in Aqueous Hydrochloric Acid. To this Gaseous HCl is passed, after passing required amount of HCl acid over a given period of time the mass is analyzed for completion of reaction on GC.
- When unreacted 1,6 Hexanediol is less than 1% HCl acid addition is stopped and taken for Water washing.
- The Organic is taken in to the Glass lined reactor and water is added. This mass was stirred at room temperature for about 30 mins. Organic layer

taken for Purification and Aqueous layer containing HCl is recycled to next Batch.

- Organic Layer is then taken for Fractionation after removal of Low Boiler Impurities under Vacuum, the Product is fractionated. Pure 6 Chloro 1 Hexanol thus obtained is packed in 200 lit Drums.

Chemical reaction:



Mass Balance:

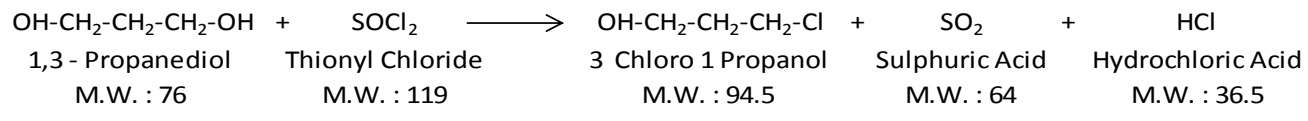
Input	Kg				Output	Kg
1,6 Hexanediol	1920		**Reaction**		6 Chloro 1 Hexanol	2221
HCl (20%)	10430				HCl (15%)	10129
Total	12350				Total	12350
6 Chloro 1 Hexanol	2221		**Water Wash**		6 Chloro 1 Hexanol	2200
Water	500				Water to ETP	521
Total	2721				Total	2721
6 Chloro 1 Hexanol	2200		**Vacuum Distillation**		Main Product	2030
					Residue	170
Total	2200				Total	2200

1.22) 3 Chloro Propanol

Manufacturing Process:

- 1,3 Propanediol is taken in reactor. To this Thionyl Chloride is added over a given period of time, after addition of required amount of Thionyl Chloride the mass is analyzed for completion of reaction on GC.
- When unreacted 1,3 Propanediol is less than 1% Thionyl Chloride addition is stopped and taken for Water washing.
- The Organic is taken in to the Glass lined reactor and water is added. This mass was stirred at room temperature for about 30 mins. Organic layer taken for Purification and Aqueous layer is recycled to next Batch.
- Organic Layer is then taken for Fractionation after removal of Low Boiler Impurities under Vacuum, the Product is fractionated. Pure 3 Chloro 1 Propanol thus obtained is packed in 200 lit Drums.

Chemical reaction:



Mass Balance:

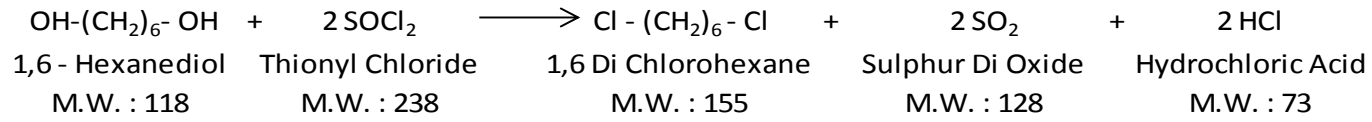
Input	Kg				Output	Kg
1,3 Propanediol	4770		**Reaction**		3 Chloro 1 Propanol	5931
Thionyl Chloride	7470	→		→	Sulphur Di Oxide	4019
Water	5350				Hydrochloric Acid (30%	7640
Total	17590				Total	17590
3 Chloro Propanol	5931		**Water Wash**		3 Chloro 1 Propanol	5900
Water	2000	→		→	Water to ETP	2031
Total	7931				Total	7931
3 Chloro 1 Propanol	5900		**Vacuum Distillation**		Main Product	5350
		→		→	Residue	550
Total	5900				Total	5900

1.23) 1,6 Dichloro Hexane

Manufacturing Process:

- 1,6 Hexanediol is taken in a reactor. To this Thionyl Chloride is added over a given period of time, after adding required amount of Thionyl Chloride the mass is analyzed for completion of reaction on GC.
- When unreacted 1,6 Hexanediol is less than 1% Thionyl Chloride addition is stopped and taken for Water washing.
- The Organic is taken in to the Glass lined reactor and water is added. This mass was stirred at room temperature Organic layer taken for Purification and Aqueous layer containing HCl is recycled to next Batch.
- Organic Layer is then taken for Fractionation after removal of Low Boiler impurities under Vacuum, the Product is fractionated. Pure 1,6 Dichlorohexane thus obtained is packed in 200 lit Drums.

Chemical reaction:



Mass Balance:

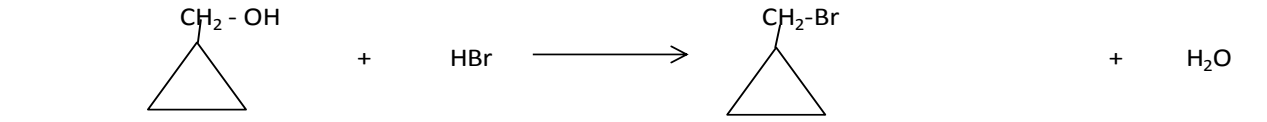
Input	Kg				Output	Kg
1,6 Hexanediol	4580		**Reaction**		1,6 DiChloroHexane	6015
Thionyl Chloride	9235	→		→	Sulphur Di Oxide	4965
Water	995				HCl (35%)	3830
Total	14810				Total	14810
1,6 DiChloroHexane	6015		**Water Wash**		1,6 DiChloroHexane	6000
Water	2000	→		→	Water to ETP	2015
Total	8015				Total	8015
1,6 DiChloroHexane	6000		**Vacuum Distillation**		Main Product	5300
		→		→	Residue	700
Total	6000				Total	6000

1.24) Cyclo Propyl Methyl Bromide

Manufacturing Process:

- Cyclo Propyl Methyl Alcohol is taken in Aqueous Hydrobromic Acid. To this Gaseous HBr is passed in it, after passing required amount of HBr acid over a given period of time the mass is analyzed for completion of reaction on GC.
- When unreacted Cyclo Propyl Methyl alcohol is less than 1% HBr acid addition is stopped and taken for Water washing.
- The Organic is taken in to the Glass lined reactor and water is added. This mass was stirred at room temperature Organic layer taken for Purification and Aqueous layer containing HBr is recycled to next Batch.
- Organic Layer is then taken for Fractionation after removal of Low Boiler impurities under Vacuum, the Product is fractionated. Pure Cyclo Propyl Methyl Bromide thus obtained is packed in 200 lit Drums.

Chemical reaction:



Cyclo Propyl Methyl Alcohol	Hydrobromic Acid	Cyclo Propyl Methyl Bromide	Water
M.W. : 72	M.W. : 81	M.W. : 135	M.W. : 18

Mass Balance:

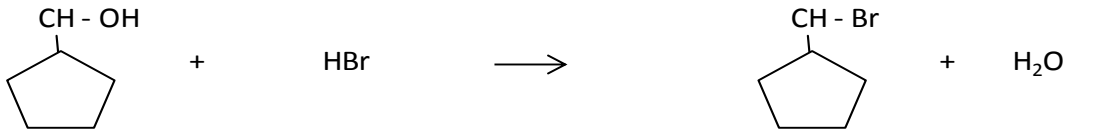
Input	Kg				Output	Kg
Cyclo Propyl Methyl Alcohol	2400	→	**Reaction**	→	Cyclo Propyl Methyl Bromide	4500
Hydrobromic Acid (48%)	9375				Recovered HBr (24%)	7275
Total	11775				Total	11775
Cyclo Propyl Methyl Bromide	4500	→	**Water Wash**	→	Cyclo Propyl Methyl Bromide	4470
Water	2000				Water to ETP	2030
Total	6500				Total	6500
Cyclo Propyl Methyl Bromide	4470	→	**Vacuum Distillation**	→	Main Product	4110
					Residue	360
Total	4470				Total	4470

1.25) Cyclo Pentyl Bromide

Manufacturing Process:

- Cyclo Pentyl Alcohol is taken in Aqueous Hydrobromic Acid. To this Gaseous HBr is passed in it, after passing required amount of HBr acid over a given period of time the mass is analyzed for completion of reaction on GC.
- When unreacted Cyclo Pentyl alcohol is less than 1% HBr acid addition is stopped and taken for Water washing.
- The Organic is taken in to the Glass lined reactor and water is added. This mass was stirred at room temperature Organic layer taken for Purification and Aqueous layer containing HBr is recycled to next Batch.
- Organic Layer is then taken for Fractionation after removal of Low Boiler impurities under Vacuum, the Product is fractionated. Pure Cyclo Pentyl Bromide thus obtained is packed in 200 lit Drums.

Chemical reaction:



Cyclo Pentyl Alcohol	Hydrobromic Acid	Cyclo Pentyl Bromide	Water
M.W. : 86	M.W. : 81	M.W. : 149	M.W. : 18

Mass Balance:

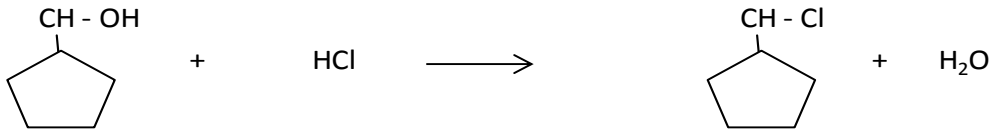
Input	Kg				Output	Kg
Cyclo Pentyl Alcohol	3000		**Reaction**		Cyclo Pentyl Bromide	5195
Hydrobromic Acid (48%)	9595				Recovered HBr (24%)	7400
Total	12595				Total	12595
Cyclo Pentyl Bromide	5195		**Water Wash**		Cyclo Pentyl Bromide	5170
Water	2000				Water to ETP	2025
Total	7195				Total	7195
Cyclo Pentyl Bromide	5170		**Vacuum Distillation**		Main Product	4790
					Residue	380
Total	5170				Total	5170

1.26) Cyclo Pentyl Chloride

Manufacturing Process:

- Cyclo Pentyl Alcohol is taken in Aqueous Hydrochloric Acid. To this Gaseous HCl is passed to it, after passing required amount of Hydrochloric acid over a given Period of time the mass is analyzed for completion of reaction on GC.
- When unreacted Cyclo Pentyl alcohol is less than 1% Hydrochloric acid addition is stopped and taken for Water washing.
- The Organic is taken in to the Glass lined reactor and water is added. This mass was stirred at room temp. Organic layer taken for Purification and Aqueous layer containing HCl is recycled to next Batch.
- Organic Layer is then taken for Fractionation after removal of Low Boiler impurities under Vacuum, the Product is fractionated. Pure Cyclo Pentyl Chloride thus obtained is packed in 200 lit Drums.

Chemical reaction:



Cyclo Pentyl Alcohol	Hydrochloric Acid	Cyclo Pentyl Chloride	Water
M.W. : 86	M.W. : 36.5	M.W. : 104.5	M.W. : 18

Mass Balance:

Input	Kg				Output	Kg
Cyclo Pentyl Alcohol	1800	→	**Reaction**	→	Cyclo Pentyl Chloride	2190
Hydrochloric Acid (20%)	11480				Recovered HCl (15%)	11090
Total	13280				Total	13280
Cyclo Pentyl Chloride	2190	→	**Water Wash**	→	Cyclo Pentyl Chloride	2170
Water	1000				Water to ETP	1020
Total	3190				Total	3190
Cyclo Pentyl Chloride	2170	→	**Vacuum Distillation**	→	Main Product	1985
					Residue	185
Total	2170				Total	2170

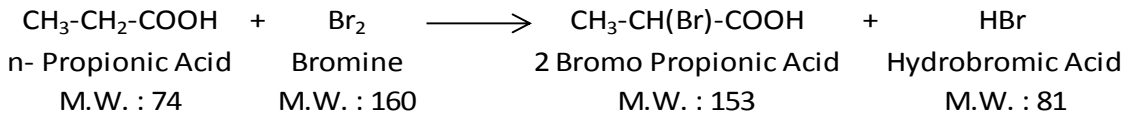
2) Bromination of Organic Acids and Esterification thereof

2.1) 2-Bromo Propionic Acid

Manufacturing Process:

- Propionic Acid is taken in a Reactor to that the Bromine addition is done over a given Period of time. The progress of Reaction is monitored on GC.
- When the Propionic Acid Content is 1% the Bromine addition is stopped to get 2-Bromo Propionic Acid. The Hydrobromic acid thus generated is recycled.
- The Crude 2-Bromo Propionic Acid so obtained is subjected to Fractionation to get pure 2-Bromo Propionic Acid.

Chemical reaction:



Mass Balance:

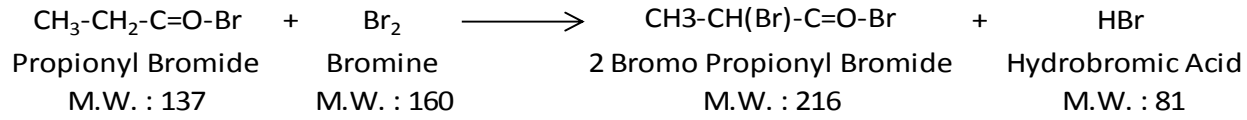
Input	Kg				Output	Kg
Propionic Acid	3300		**Bromination**		2 Bromo Propionic Acid	6825
Bromine	7135	→		→	Hydrobromic Acid (48%)	7525
Water	3915					
Total	14350				Total	14350
2 Bromo Propionic Acid	6825	→	**Fractionation**	→	Main Product	6345
					Residue	480
Total	6825				Total	6825

2.2) 2-Bromo Propionyl Bromide

Manufacturing Process:

- Propionyl Bromide is taken in a Reactor to that the Bromine addition is done over a given Period of time. The progress of Reaction is monitored on GC.
- When the Propionyl Bromide Content is 1% the Bromine addition is stopped to get the 2-Bromo Propionyl Bromide. The Hydrobromic acid thus generated is recycled.
- The Crude 2-Bromo Propionyl Bromide so obtained is subjected to Fractionation to get pure 2-Bromo Propionyl Bromide.

Chemical reaction:



Mass Balance:

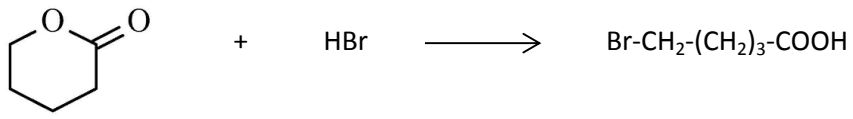
Input	Kg				Output	Kg
Propionyl Bromide	5705		**Brominati on**		2 Bromo Propionyl Bromide	8995
Bromine	6660				Hydrobromic Acid 48%	7025
Water	3655					
Total	16020				Total	16020
2 Bromo Propionyl Bromide	8995		**Fractionati on**		Main Product	8195
					Residue	800
Total	8995				Total	8995

2.3) 5-Bromo Valeric Acid

Manufacturing Process:

- Valerolactone is taken in a Reactor to that the Bromine addition is done over a given Period of time. The progress of Reaction is monitored on GC.
- When the Valerolactone Content is 1% the Bromine addition is stopped to get 5-Bromo Valeric Acid. The Hydrobromic acid thus generated is recycled.
- The Crude 5-Bromo Valeric Acid so obtained is subjected to fractionation to get pure 5-Bromo Valeric Acid.

Chemical reaction:



Valerolactone
M.W. : 100

Hydrobromic Acid
M.W. : 81

5 Bromo Valeric Acid
M.W. : 181

Mass Balance:

Input	Kg				Output	Kg
Valerolactone	4000		**Brominatio n**		5 Bromo Valeric Acid	7240
Hydrobromic Acid	8790				Hydrobromic Acid (18%)	5550
Total	12790				Total	12790
5 Bromo Valeric Acid	7240		**Fractionatio n**		Main Product	6600
					Residue	640
Total	7240				Total	7240

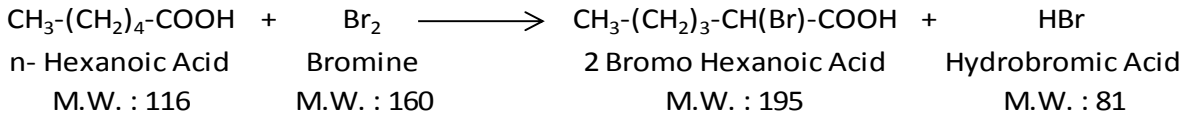
2.4) 2-Bromo Hexanoic Acid

Manufacturing Process:

- Hexanoic Acid is taken in a Reactor to that the Bromine addition is done over a given Period of time. The progress of Reaction is monitored on GC.

- When the Hexanoic Acid Content is 1% the Bromine addition is stopped to get the 2-Bromo Hexanoic Acid. The Hydrobromic acid thus generated is recycled.
- The Crude 2-Bromo Hexanoic Acid so obtained is subjected to fractionation to get pure 2-Bromo Hexanoic Acid.

Chemical reaction:



Mass Balance:

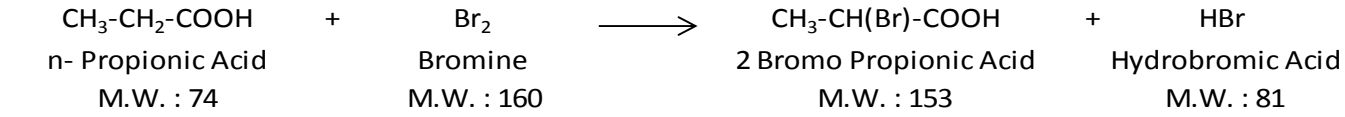
Input	Kg				Output	Kg
n- Hexanoic Acid	4210		**Brominati on**		2 Bromo Hexanoic Acid	7080
Bromine	5805				Hydrobromic Acid (48%)	6210
Water	3275					
Total	13290				Total	13290
2 Bromo Hexanoic Acid	7080		**Fractiona tion**		Main Product	6890
					Residue	190
Total	7080				Total	7080

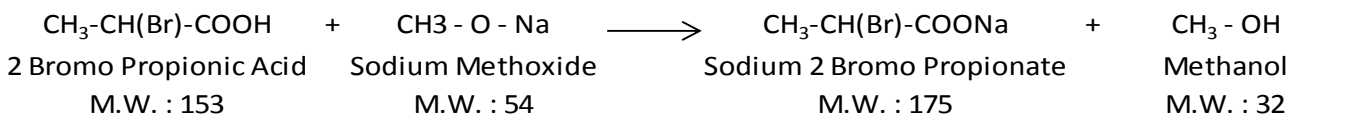
2.5) Sodium 2 Bromo Propionate

Manufacturing Process:

- Propionic Acid is taken in a Reactor to that the Bromine addition is done over a given Period of time. The progress of Reaction is monitored on GC.
- When the Propionic Acid Content is 1% the Bromine addition is stopped to get 2-Bromo Propionic Acid. The Hydrobromic acid thus generated is recycled.
- Sodium Methoxide addition is done to the 2-Bromo Propionic Acid so formed. The addition of Sodium Methoxide is carried out over a given period of time; the progress of reaction is monitored on GC.
- When the 2-Bromo Propionic acid content is 1% the Sodium Methoxide addition is stopped. The Sodium 2-Bromo Propionate so obtained is taken for fractionation to get the Pure Sodium 2-Bromo Propionate.

Chemical reaction:





Mass Balance:

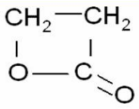
Input	Kg				Output	Kg
Propionic Acid	2575		**Brominati on**		2 Bromo Propionic Acid	5325
Bromine	5570	→		→	Hydrobromic Acid (48%)	5875
Water	3055					
Total	11200				Total	11200
2 Bromo Propionic Acid	5325		**Reaction**		Sodium 2 Bromo Propionate	6090
Sodium Methoxide	6265	→		→	Recovered Methanol	5500
Total	11590				Total	11590
Sodium 2 Bromo Propionate	6090		**Distillatio n**		Main Product	5650
		→		→	Residue	440
Total	6090				Total	6090

2.6) Ethyl 3 Bromo Propionate

Manufacturing Process:

- Propiolactone is taken in a Reactor to that the Hydrobromic Acid addition is done over a given Period of time. The progress of Reaction is monitored on GC.
- When the Propiolactone Content is 1% the Hydrogen Bromide addition is stopped to get 3-Bromo Propionic Acid. The Hydrobromic acid thus generated is recycled.
- The Ethanol addition is done to 3-Bromo Propionic Acid so formed. The addition of Ethanol is carried out over a given period of time; the progress of reaction is monitored on GC.
- When the 3-Bromo Propionic acid content is 1% the Ethanol addition is stopped. The Crude Bromo Acid ester obtained is taken for fractionation to get the Pure Ethyl 3-Bromo Propionate.

Chemical reaction:



Propiolactone + HBr ⟶ $Br\text{-}CH_2\text{-}CH_2\text{-}COOH$

Propiolactone	Hydrobromic Acid	3 Bromo Propionic Acid
M.W. : 72	M.W. : 81	M.W. : 153

$Br\text{-}CH_2\text{-}CH_2\text{-}COOH + CH_3\text{-}CH_2\text{-}OH \longrightarrow Br\text{-}CH_2\text{-}CH_2\text{-}COO\text{-}CH_2\text{-}CH_3 + H_2O$

3 Bromo Propionic Acid	Ethanol	3 Bromo Propionic Acid Ethyl Ester	Water
M.W. : 153	M.W. : 46	M.W: 181	M.W: 18

Mass Balance:

Input	Kg				Output	Kg
Propiolactone	3450		**Brominati on and Esterificat**		Crude Ester	8675
Hydrogen Bromide (48%)	9835				Recovered Ethanol	2025
Ethanol	4230				Hydrogen Bromide (12%)	6815
Total	17515				Total	17515
Crude Ester	8675		**Fractionat ion**		Main Product	7985
					Residue	690
Total	8675				Total	8675
Recovered Ethanol	2025		**Ethanol Recovery**		Ethanol	1400
					Residue	275
					Water fraction	350
Total	2025				Total	2025
Residue	965		**Residue Recovery**		Main Fraction	405
					Residue	560
Total	965				Total	965

2.7) Methyl 2 Bromo Butyrate

Manufacturing Process:

- n-Butyric Acid is taken in a Reactor to that the Bromine addition is done over a given Period of time. The progress of Reaction is monitored on GC.
- When the Butyric Acid Content is 1% the Bromine addition is stopped to get 2-Bromo Butyric Acid. The Hydrobromic acid thus generated is recycled.
- The Methanol addition is done to 2-Bromo Butyric Acid so formed. The addition of Methanol is carried out over a given period of time; the progress of reaction is monitored on GC.
- When the 2-Bromo Butyric acid content is 1% the Methanol addition is stopped. The Crude Bromo Acid ester obtained is taken for fractionation to get the Pure Methyl 2-Bromo Butyrate.

Chemical reaction:

CH_3-CH_2-CH_2-COOH + Br_2 ⟶ CH_3-CH_2-CH-(Br)-COOH + HBr

n- Butyric Acid M.W. : 88 | Bromine M.W. : 160 | 2 Bromo Butyric Acid M.W. : 167 | Hydrobromic Acid M.W. : 81

CH_3-CH_2-CH-(Br)-COOH + CH_3-OH ⟶ CH3-CH2-CH-(Br)-COO-CH3 + H_2O

2 Bromo Butyric Acid M.W. : 167 | Methanol M.W. : 32 | 2 Bromo Butyric Acid Methyl Ester M.W: 181 | Water M.W: 18

Mass Balance:

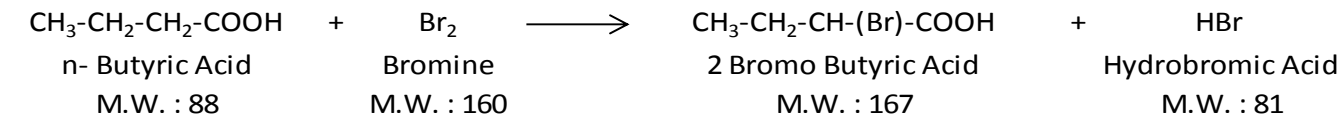
Input	Kg				Output	Kg
n-Butyric Acid	3520		**Brominatio n and Esterificati on**		Crude Ester	7240
Bromine	6400				Recovered Methanol	1720
Methanol	3000	→		→	Hydrobromic Acid (48%)	6750
Water	2790					
Total	15710				Total	15710
Crude Ester	7240		**Fractionati on**		Main Product	6720
		→		→	Residue	520
Total	7240				Total	7240
Recovered Methanol	2390		**Methanol Recovery**		Dist.Methanol	1440
					Water Fraction	450
		→		→	Residue	500
Total	2390				Total	2390
Residue	1400		**Residue Recovery**		Main Product	550
		→		→	Residue	850
Total	1400				Total	1400

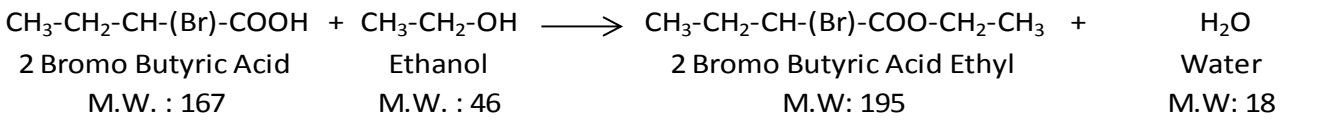
2.8) Ethyl 2 Bromo Butyrate

Manufacturing Process:

- n-Butyric Acid is taken in a Reactor to that the Bromine addition is done over a given Period of time. The progress of Reaction is monitored on GC.
- When the Butyric Acid Content is 1% the Bromine addition is stopped to get 2-Bromo Butyric Acid. The Hydrobromic acid thus generated is recycled.
- The Ethanol addition is done to 2-Bromo Butyric Acid so formed. The addition of Ethanol is carried out over a given period of time; the progress of reaction is monitored on GC.
- When the 2-Bromo Butyric acid content is 1% the Ethanol addition is stopped. The Crude Bromo Acid ester obtained is taken for fractionation to get the Pure Ethyl 2-Bromo Butyrate.

Chemical reaction:





Mass Balance:

Input	Kg				Output	Kg
n-Butyric Acid	3520		**Bromination and Esterification**		Crude Ester	7800
Bromine	6400				Recovered Ethanol	2390
Ethanol	4230	→		→	Hydrobromic Acid (48%)	6750
Water	2790					
Total	16940				Total	16940
Crude Ester	7800		**Fractionation**		Main Product	6900
		→		→	Residue	900
Total	7800				Total	7800
Recovered Ethanol	2390		**Ethanol Recovery**		Ethanol	1440
		→		→	Water Fraction	450
					Residue	500
Total	2390				Total	2390
Residue	1400		**Residue Recovery**		Main Product	550
		→		→	Residue	850
Total	1400				Total	1400

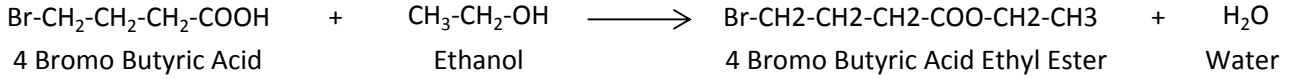
2.9) Ethyl 4 Bromo Butyrate

Manufacturing Process:

- Butyrolactone is taken in a Reactor to that the Hydrogen Bromide addition is done over a given Period of time. The progress of Reaction is monitored on GC.
- When the Butyrolactone Content is 1% the Hydrogen Bromide addition is stopped to get 4-Bromo Butyric Acid. The Hydrobromic acid thus generated is recycled.
- The Ethanol addition is done to 4-Bromo Butyric Acid so formed. The addition of Ethanol is carried out over a given period of time; the progress of reaction is monitored on GC.
- When the 4-Bromo Butyric acid content is 1% the Ethanol addition is stopped. The Crude Bromo Acid ester obtained is taken for fractionation to get the Pure Ethyl 4 Bromo Butyrate.

Chemical reaction:

Butyrolactone	Hydrobromic Acid	4 Bromo Butyric Acid
M.W. : 86	M.W. : 81	M.W. : 167



4 Bromo Butyric Acid	Ethanol	4 Bromo Butyric Acid Ethyl Ester	Water
M.W. : 167	M.W. : 46	M.W: 195	M.W: 18

Mass Balance:

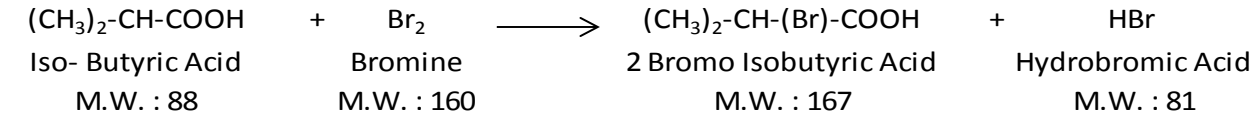
Input	Kg				Output	Kg
Butyrolactone	3520		**Brominati on and Esterificat**		Crude Ester	7980
Hydrogen Bromide (48%)	9655				Recovered Ethanol	2350
Ethanol	4230				Hydrobromic Acid (18%)	7075
Total	17405				Total	17405
Crude Ester	7980		**Fractionat ion**		Main Product	7320
					Residue	660
Total	7980				Total	7980
Recovered Ethanol	2350		**Ethanol Recovery**		Ethanol	1420
					Water Fraction	430
					Residue	500
Total	2350				Total	2350
Residue	1160		**Residue Recovery**		Main Product	500
					Residue	660
Total	1160				Total	1160

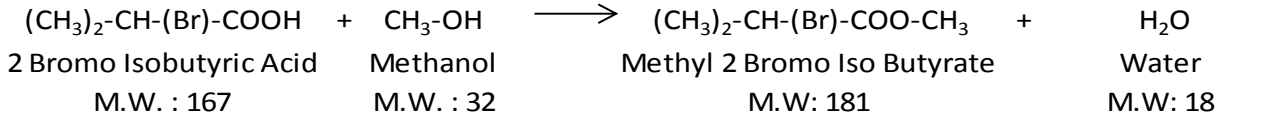
2.10) Methyl 2 Bromo Iso Butyrate

Manufacturing Process:

- Iso-Butyric Acid is taken in a Reactor to that the Bromine addition is done over a given Period of time. The progress of Reaction is monitored on GC.
- When the Iso Butyric Acid Content is 1% the Bromine addition is stopped to get the 2-Bromo Iso-Butyric Acid. The Hydrobromic acid thus generated is recycled.
- The Methanol addition is done to 2-Bromo Iso-Butyric Acid so formed. The addition of Methanol is carried out over a given period of time; the progress of reaction is monitored on GC.
- When the 2-Bromo Iso Butyric acid content is 1% the Methanol addition is stopped. The Crude Bromo Acid ester obtained is taken for fractionation to get the Pure Methyl 2 Bromo Iso Butyrate.

Chemical reaction:





Mass Balance:

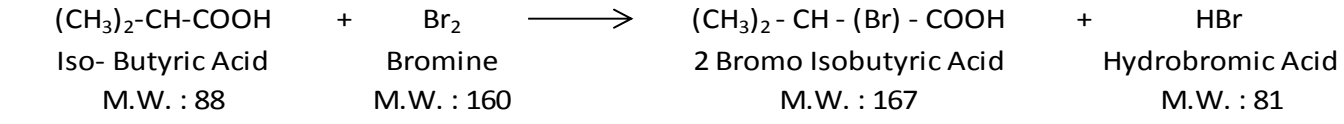
Input	Kg				Output	Kg
Iso-Butyric Acid	4400		**Brominat ion and Esterifica tion**		Crude Ester	9050
Bromine	8000				Recovered Methanol	1665
Methanol	3265				Hydrobromic Acid (48%)	8435
Water	3485					
Total	19150				Total	19150
Crude Ester	9050		**Fractiona tion**		Main Product	8000
					Residue	1050
Total	9050				Total	9050
Recovered Methanol	1665		**Methanol Recovery**		Methanol	970
					Water Fraction	350
					Residue	345
Total	1665				Total	1665
Residue	1395		**Residue Recovery**		Main Product	555
					Residue	840
Total	1395				Total	1395

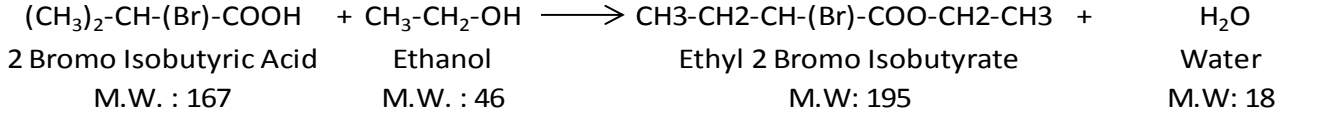
2.11) Ethyl 2 Bromo Iso Butyrate

Manufacturing Process:

- Iso-Butyric Acid is taken in a Reactor to that the Bromine addition is done over a given Period of time. The progress of Reaction is monitored on GC.
- When the Iso Butyric Acid Content is 1% the Bromine addition is stopped to get the 2-Bromo Iso-Butyric Acid. The Hydrobromic acid thus generated is recycled.
- The Ethanol addition is done to 2-Bromo Iso-Butyric Acid so formed. The addition of Ethanol is carried out over a given period of time; the progress of reaction is monitored on GC.
- When the 2-Bromo iso Butyric acid content is 1% the Ethanol addition is stopped. The Crude Bromo Acid ester obtained is taken for fractionation to get the Pure Ethyl 2 Bromo Iso Butyrate.

Chemical reaction:





Mass Balance:

Input	Kg				Output	Kg
Iso-Butyric Acid	3520		**Bromination and Esterification**		Crude Ester	7800
Bromine	6400				Recovered Ethanol	2390
Ethanol	4230	→		→	Hydrobromic Acid (48%)	6750
Water	2790					
Total	16940				Total	16940
Crude Ester	7800		**Fractionation**		Main Product	6900
		→		→	Residue	900
Total	7800				Total	7800
Recovered Ethanol	2390		**Ethanol Recovery**		Ethanol	1440
		→		→	Water Fraction	450
					Residue	500
Total	2390				Total	2390
Residue	1400		**Residue Recovery**		Main Product	550
		→		→	Residue	850
Total	1400				Total	1400

2.12) Iso Propyl 2 Bromo Iso Butyrate

Manufacturing Process:

- Iso-Butyric Acid is taken in a Reactor to that the Bromine addition is done over a given Period of time. The progress of Reaction is monitored on GC.
- When the Iso Butyric Acid Content is 1% the Bromine addition is stopped to get the 2-Bromo Iso-Butyric Acid. The Hydrobromic acid thus generated is recycled.
- The Iso propyl alcohol addition is done to 2-Bromo Iso-Butyric Acid so formed. The addition of Iso Propyl Alcohol is carried out over a given period of time; the progress of reaction is monitored on GC.
- When the 2-Bromo Iso Butyric acid content is 1% the Iso propyl Alcohol addition is stopped. The Crude Bromo Acid ester obtained is taken for fractionation to get the Pure Iso Propyl 2 Bromo Iso Butyrate.

Chemical reaction:

$(CH_3)_2$-CH-COOH + Br_2 ⟶ $(CH_3)_2$-C-Br-COOH + HBr

Iso-Butryic Acid M.W. : 88 | Bromine M.W. : 160 | 2 Bromo iso butryic Acid M.W. : 167 | Hydrobromic Acid M.W. : 81

$(CH_3)_2$-C-Br-COOH + $(CH_3)_2$-CH-OH ⟶ $(CH_3)_2$-C-Br-COO-CH-$(CH_3)_2$ + H_2O

2 Bromo iso butryic Acid M.W. : 167 | Iso Propyl Alcohol M.W. : 60 | Iso Propyl 2 Bromo Iso Butyrate M.W: 209 | Water M.W: 18

Mass Balance:

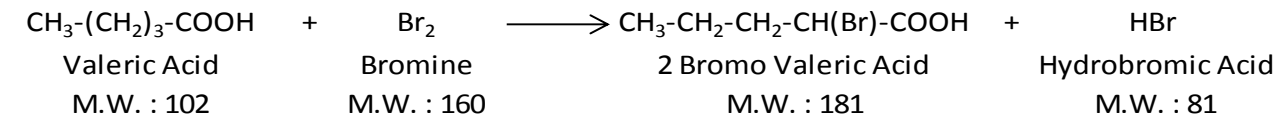
Input	Kg				Output	Kg
Iso - Butyric Acid	6000		**Brominat ion and Esterifica tion**		Crude Ester	14250
Bromine	10910				Rec Iso Propyl Alcohol	2500
Iso Propyl Alcohol	6585	→		→	HBr Gas (49%)	11500
Water	4755					
Total	28250				Total	28250
Crude Ester	14250		**Fractiona tion**		Main Product	11825
		→		→	Residue	2425
Total	14250				Total	14250
Recovered Iso Propanol	2500		**Iso Propyl Alcohol Recovery**		Iso Propanol	2000
		→		→	Water Fraction	400
					Residue	100
Total	2500				Total	2500
Residue	2525		**Residue Recovery**		Main Product	975
		→		→	Residue	1550
Total	2525				Total	2525

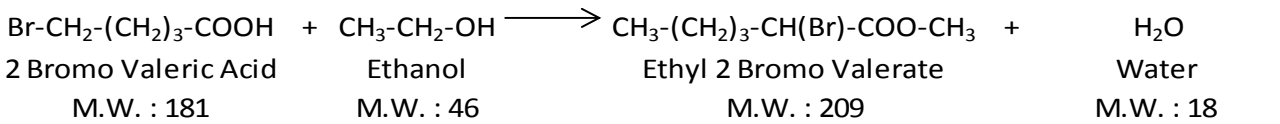
2.13) Ethyl 2 Bromo Valerate

Manufacturing Process:

- Valeric Acid is taken in a Reactor to that the Bromine addition is done over a given Period of time. The progress of Reaction is monitored on GC.
- When the Valeric Acid Content is 1% the Bromine addition is stopped to get 2-Bromo Valeric Acid. The Hydrobromic acid thus generated is recycled.
- The Ethyl alcohol addition is done to 2-Bromo Valeric Acid so formed. The addition of Ethyl Alcohol is carried out over a given period of time; the progress of reaction is monitored on GC.
- When the 2-Bromo Valeric acid content is 1% the Ethyl Alcohol addition is stopped. The Crude Bromo Acid ester obtained is taken for fractionation to get the Pure Ethyl 2 Bromo Valerate.

Chemical reaction:





Mass Balance:

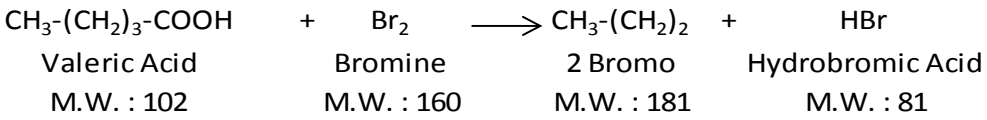
Input	Kg				Output	Kg
Valeric Acid	3855		**Brominatio n and Esterificati on**		Crude Ester	7900
Bromine	6050				Rec. Ethanol	2290
Ethanol	4025				Hydrobromic Acid (48%)	6375
Water	2635					
Total	16565				Total	16565
Crude Ester	7900		**Fractionati on**		Main Product	7430
					Residue	470
Total	7900				Total	7900
Rec. Ethanol	2290		**Ethanol Recovery**		Dist. Ethanol	1440
					Water Fraction	170
					Residue	680
Total	2290				Total	2290
Residue	1150		**Residue Recovery**		Main Product	450
					Residue	700
Total	1150				Total	1150

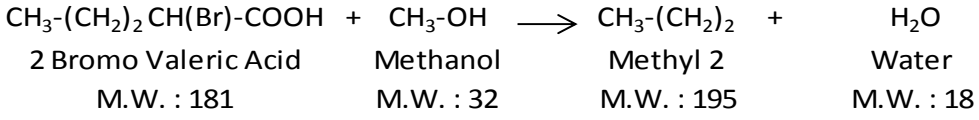
2.14) Methyl 2 Bromo Valerate

Manufacturing Process:

- Valeric Acid is taken in a Reactor to that the Bromine addition is done over a given Period of time. The progress of Reaction is monitored on GC.
- When the Valeric Acid Content is 1% the Bromine addition is stopped to get 2-Bromo Valeric Acid. The Hydrobromic acid thus generated is recycled.
- The Methanol addition is done to 2-Bromo Valeric Acid so formed. The addition of Methanol is carried out over a given period of time; the progress of reaction is monitored on GC.
- When the 2-Bromo Valeric acid content is 1% the Methanol addition is stopped. The Crude Bromo Acid ester obtained is taken for fractionation to get the Pure Methyl 2 Bromo Valerate.

Chemical reaction:





Mass Balance:

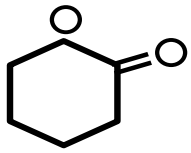
Input	Kg				Output	Kg
Valeric Acid	4365		**Brominati on and Esterificat ion**		Crude Ester	8350
Bromine	6850				Rec. Methanol	1640
Methanol	3010	→		→	Hydrobromic Acid (48%)	7225
Water	2990					
Total	17215				Total	17215
Crude Ester	8350		**Fractionat ion**		Main Product	7760
		→		→	Residue	590
Total	8350				Total	8350
Rec. Methanol	1640		**Methanol Recovery**		Dist. Methanol	1340
		→		→	Water Fraction	180
					Residue	120
Total	1640				Total	1640
Residue	710		**Residue Recovery**		Main Product	135
		→		→	Residue	575
Total	710				Total	710

2.15) Ethyl 5 Bromo Valerate

Manufacturing Process:

- Valerolactone is taken in a Reactor to that the Bromine addition is done over a given Period of time. The progress of Reaction is monitored on GC.
- When the Valerolactone Content is 1% the Bromine addition is stopped to get 5-Bromo Valeric Acid. The Hydrobromic acid thus generated is recycled.
- The Ethanol addition is done to 5-Bromo Valeric Acid so formed. The addition of Ethanol is carried out over a given period of time; the progress of reaction is monitored on GC.
- When the 5-Bromo Valeric acid content is 1% the Ethanol addition is stopped. The Crude Bromo Acid ester obtained is taken for fractionation to get the Pure Ethyl 5 Bromo Valerate.

Chemical reaction:



+ HBr ⟶ $Br\text{-}CH_2\text{-}(CH_2)_3\text{-}COOH$

Valerolactone	Hydrobromic Acid	5 Bromo Valeric Acid
M.W. : 100	M.W. : 81	M.W. : 181

$Br\text{-}CH_2\text{-}(CH_2)_3\text{-}COOH + CH_3\text{-}CH_2\text{-}OH \longrightarrow Br\text{-}CH_2\text{-}(CH_2)_3\text{-}COO\text{-}CH_2\text{-}CH_3 + H_2O$

5 Bromo Valeric Acid	Ethanol	Ethyl 5 Bromo Valerate	Water
M.W. : 181	M.W. : 46	M.W. : 209	M.W. : 18

Mass Balance:

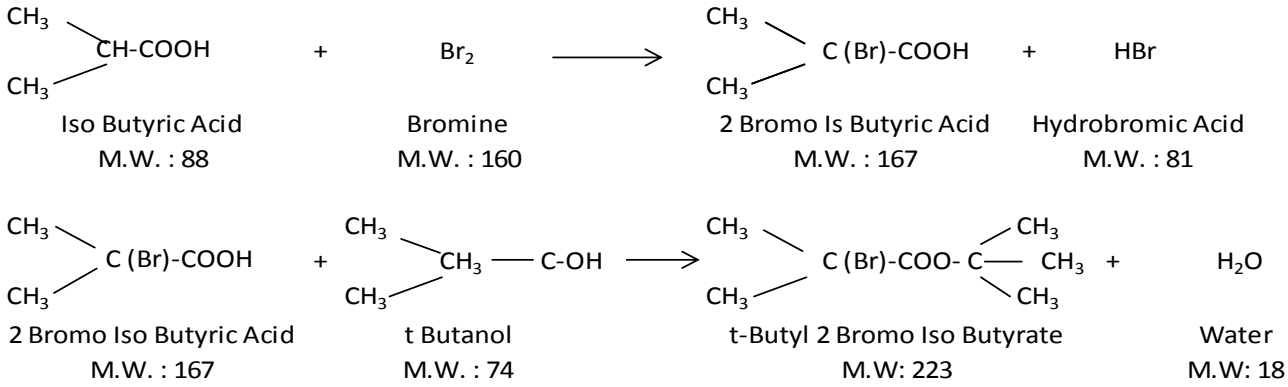
Input	Kg				Output	Kg
Valerolactone	4000		**Brominati on and Esterificati**		5 Bromo Valeric Acid	8360
Hydrobromic Acid	8790				Hydrobromic Acid (16%)	6270
Ethanol	3825				Recovered Ethanol	1985
Total	16615				Total	16615
Crude Ester	8360		**Fractionat ion**		Main Product	7775
					Residue	585
Total	8360				Total	8360
Rec. Ethanol	1985		**Ethanol Recovery**		Dist. Ethanol	1585
					Water Fraction	235
					Residue	165
Total	1985				Total	1985
Residue	750		**Residue Recovery**		Main Product	125
					Residue	625
Total	750				Total	750

2.16) t-Butyl 2 Bromo Iso Butyrate

Manufacturing Process:

- Iso Butyric Acid is taken in a Reactor to that the Bromine addition is done over a given Period of time. The progress of Reaction is monitored on GC.
- When the Iso Butyric Acid Content is 1% the Bromine addition is stopped to get the 2-Bromo Iso Butyric Acid. The Hydrobromic acid thus generated is recycled.
- The T-Butyl Alcohol addition is done to 2-Bromo Iso butyric Acid so formed. The addition of t-Butyl alcohol is carried out over a given period of time; the progress of reaction is monitored on GC.
- When the 2-Bromo Iso butyric acid content is 1% the t-Butyl addition is stopped. The Crude Bromo Acid ester obtained is taken for fractionation to get the Pure Iso Propyl 2 Bromo Iso Butyrate.

Chemical reaction:



Mass Balance:

Input	Kg				Output	Kg
Iso Butyric Acid	2110		**Bromination and Esterification**		Crude Ester	5340
Bromine	3830				Recovered t-Butanol	3730
t Butyl Alcohol	5500	→		→	Hydrobromic Acid (48%)	4040
Water	1670					
Total	13110				Total	13110
Crude Ester	5340		**Fractionation**		Main Product	4890
		→		→	Residue	450
Total	5340				Total	5340
Recovered t-Butanol	3730		**t - Butanol Recovery**		Ethanol	2830
		→		→	Water Fraction	350
					Residue	550
Total	3730				Total	3730
Residue	1000		**Residue Recovery**		Main Product	290
		→		→	Residue	710
Total	1000				Total	1000

2.17) Methyl 2 Bromo Caproate

Manufacturing Process:

- Caproic Acid is taken in a Reactor to that the Bromine addition is done over a given Period of time. The progress of Reaction is monitored on GC.
- When the caproic Acid Content is 1% the Bromine addition is stopped to get 2-Bromo Caproic Acid. The Hydrobromic acid thus generated is recycled.
- The Methanol addition is done to 2-Bromo Caproic Acid so formed. The addition of Methanol is carried out over a given period of time; the progress of reaction is monitored on GC.
- When the 2-Bromo Caproic acid content is 1% the Methanol addition is stopped. The Crude Bromo Acid ester obtained is taken for fractionation to get the Pure Methyl 2 Bromo Caproate.

Chemical reaction:

$CH_3-(CH_2)_4-COOH$ + Br_2 ⟶ $CH_3-(CH_2)_3-CH(Br)-COOH$ + HBr

Caproic Acid	Bromine	2 Bromo Caproic Acid	Hydrobromic Acid
M.W. : 116	M.W. : 160	M.W. : 195	M.W. : 81

$CH_3-(CH_2)_3-CH(Br)-COOH$ + CH_3-OH ⟶ $CH_3-(CH_2)_3-CH(Br)-COO-CH_3$ + H_2O

2 Bromo Caproic Acid	Methanol	Methyl 2 Bromo Caproate	Water
M.W. : 195	M.W. : 32	M.W. : 209	M.W. : 18

Mass Balance:

Input	Kg				Output	Kg
n- Hexanoic Acid	6000		**Bromination and Esterification**		Crude Ester	10810
Bromine	8275				Rec. Methanol	1825
Methanol	3475	→		→	Hydrobromic Acid (48%)	9480
Water	4365					
Total	22115				Total	22115
Crude Ester	10810		**Fractionation**		Main Product	8975
		→		→	Residue	1835
Total	10810				Total	10810
Rec. Methanol	1825		**Methanol Recovery**		Dist. Methanol	1135
					Water Fraction	600
		→		→	Residue	90
Total	1825				Total	1825
Residue	1925		**Residue Recovery**		Main Product	770
		→		→	Residue	1155
Total	1925				Total	1925

3) Grignards Formation from Organic Halides

3.1) Methyl Magnesium Chloride 3M in THF

Manufacturing Process:

- Take in a clean reactor under Nitrogen Blanketing required amount of THF. To THF add clean Magnesium turnings. Start stirring and raise the temperature to 55°C – 60°C.
- Add required amount of catalyst and add Methyl Chloride in 4 to 5 hours maintaining the temperature 55°C – 60°C.
- Maintain for 2 hours check the quality if OK cool to 30°C and pack in 200 Lit MS PP lined barrels.

Chemical reaction:

CH_3 - Cl + Mg ⟶ CH_3- Mg -Cl

Methyl Chloride + Magnesuim ⟶ Methyl Magnesium Chloride

M.W. : 50.5 M.W. : 24 M.W. : 74.5

Mass Balance:

Input	Kg				Output	Kg
Methyl Chloride	726		**Reaction**		Methyl Magnesuim Chloride	4882
Magnesium	345	⟶		⟶	in THF	
THF Solution	3811					
Total	4882				Total	4882

3.2) Methyl Magnesium Bromide 1.5 M in THF

Manufacturing Process:

- Take in a clean reactor under Nitrogen Blanketing required amount of THF. To THF add clean Magnesium turnings. Start stirring and raise the temperature to 55°C – 60°C.
- Add required amount of catalyst and add Methyl Bromide in 4 to 5 hours maintaining the temperature 55°C – 60°C.
- Maintain for 2 hours check the quality if OK cool to 30°C and pack in 200 Lit MS PP lined barrels.

Chemical reaction:

CH_3 - Br + Mg ⟶ CH_3- Mg -Br

Methyl Bromide + Magnesium ⟶ Methyl Magnesium Bromid

M.W. : 95 M.W. : 24 M.W. : 119

Mass Balance:

Input	Kg				Output	Kg
Methyl Bromide	683		Reaction		Methyl Magnesuim Bromide	4685
Magnesium	172				in THF	
THF Solution	3830					
Total	4685				Total	4685

3.3) Ethyl Magnesium Chloride 2 M in THF

Manufacturing Process:

- Take in a clean reactor under Nitrogen Blanketing required amount of THF. To THF add clean Magnesium turnings. Start stirring and raise the temperature to 55°C – 60°C.
- Add required amount of catalyst and add Ethyl Chloride in 4 to 5 hours maintaining the temperature 55°C – 60°C.
- Maintain for 2 hours check the quality if OK cool to 30°C and pack in 200 Lit MS PP lined barrels.

Chemical reaction:

$CH_3 - CH_2 - Cl$ + Mg $\longrightarrow$ $CH_3 - CH_2 - Mg - Cl$

Ethyl Chloride M.W. : 64.5 | Magnesium M.W. : 24 | Ethyl Magnesium Chloride M.W. : 88.5

Mass Balance:

Input	Kg				Output	Kg
Ethyl Chloride	618		Reaction		Ethyl Magnesuim Chloride	4380
Magnesium	230				in THF	
THF Solution	3532					
Total	4380				Total	4380

3.4) Ethyl Magnesium Bromide 2 M in THF

Manufacturing Process:

- Take in a clean reactor under Nitrogen Blanketing required amount of THF. To THF add clean Magnesium turnings. Start stirring and raise the temperature to 55°C – 60°C.
- Add required amount of catalyst and add Ethyl Bromide in 4 to 5 hours maintaining the temperature 55°C – 60°C.
- Maintain for 2 hours check the quality if OK cool to 30°C and pack in 200 Lit MS PP lined barrels.

Chemical reaction:

$CH_3 - CH_2 - Br$ + Mg $\longrightarrow$ $CH_3 - CH_2 - Mg - Br$

Ethyl Bromide M.W. : 109 | Magnesium M.W. : 24 | Ethyl Magnesium Bromide M.W. : 133

Mass Balance:

Input	Kg				Output	Kg
Ethyl Bromide	1045		Reaction		Ethyl Magnesuim Bromide	4785
Magnesium	230	→		→	in THF	
THF Solution	3510					
Total	4785				Total	4785

3.5) Vinyl Magnesium Bromide 1M in THF

Manufacturing Process:

- Take in a clean reactor under Nitrogen Blanketing required amount of THF. To THF add clean Magnesium turnings. Start stirring and raise the temperature to 55°C – 60°C.
- Add required amount of catalyst and add Vinyl Bromide in 4 to 5 hours maintaining the temperature 55°C – 60°C.
- Maintain for 2 hours check the quality if OK cool to 30°C and pack in 200 Lit MS PP lined barrels.

Chemical reaction:

$CH_2 = CH - Br$ + Mg ⟶ $CH_2 = CH - Mg - Br$

Vinyl Bromide	Magnesium	Vinyl Magnesium Bromide
M.W. : 107	M.W. : 24	M.W. : 131

Mass Balance:

Input	Kg				Output	Kg
Vinyl Bromide	513		Reaction		Vinyl Magnesuim Bromide	4533
Magnesium	109	→		→	in THF	
THF Solution	3911					
Total	4533				Total	4533

3.6) Iso Propyl Magnesium Chloride 1M in THF

Manufacturing Process:

- Take in a clean reactor under Nitrogen Blanketing required amount of THF. To THF add clean Magnesium turnings. Start stirring and raise the temperature to 55°C – 60°C.
- Add required amount of catalyst and add Iso Propyl Chloride in 4 to 5 hours maintaining the temperature 55°C – 60°C.
- Maintain for 2 hours check the quality if OK cool to 30°C and pack in 200 Lit MS PP lined barrels.

Chemical reaction:

$(CH_3)_2CH - Cl$ + Mg ⟶ $(CH_3)_2CH - Mg - Cl$

Iso Propyl Chloride	Magnesuim	Iso Propyl Magnesium Chloride
M.W. : 78.5	M.W. : 24	M.W. : 102.5

Mass Balance:

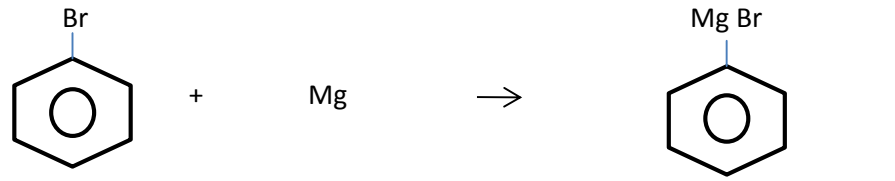
Input	Kg				Output	Kg
Iso Propyl Chloride	377				Iso Propyl Magnesuim Chloride	4312
Magnesium	115	→	**Reaction**	→	in THF	
THF Solution	3820					
Total	4312				Total	4312

3.7) Phenyl Magnesium Bromide 2M in THF

Manufacturing Process:

- Take in a clean reactor under Nitrogen Blanketing required amount of THF. To THF add clean Magnesium turnings. Start stirring and raise the temperature to 55°C – 60°C.
- Add required amount of catalyst and add Phenyl Bromide in 4 to 5 hours maintaining the temperature 55°C – 60°C.
- Maintain for 2 hours check the quality if OK cool to 30°C and pack in 200 Lit MS PP lined barrels.

Chemical reaction:



Phenyl Bromide
M.W. : 157

Magnesuim
M.W. : 24

Phenyl Magnesuim Bromide
M.W. : 181

Mass Balance:

Input	Kg				Output	Kg
Phenyl Bromide	1504				Phenyl Magnesuim Bromide	4988
Magnesuim	225	→	**Reaction**	→	in THF	
THF Solution	3256					
Total	4985				Total	4988

3.8) n Butyl Magnesium Chloride 1M in THF

Manufacturing Process:

- Take in a clean reactor under Nitrogen Blanketing required amount of THF. To THF add clean Magnesium turnings. Start stirring and raise the temperature to 55°C – 60°C.
- Add required amount of catalyst and add n-Butyl Chloride in 4 to 5 hours maintaining the temperature 55°C – 60°C.
- Maintain for 2 hours check the quality if OK cool to 30°C and pack in 200 Lit MS PP lined barrels.

Chemical reaction:

CH_3-$(CH_2)_3$-Cl + Mg ⟶ CH_3-$(CH_2)_3$- Mg -Cl

n-Butyl Chloride — Magnesium — n- Butyl Magnesium Chloride

M.W. : 92.5 — M.W. : 24 — M.W. : 116.5

Mass Balance:

Input	Kg				Output	Kg
n-Butyl Chloride	444				n-Butyl Magnesuim Chloride	4303
Magnesium	114	⟹	**Reaction**	⟹	in THF	
THF Solution	3745					
Total	4303				Total	4303

3.9) Iso Propyl Magnesium Chloride -LiCl Complex 1.3M in THF

Manufacturing Process:

- Take in a clean reactor under Nitrogen Blanketing required amount of THF. To THF add clean Magnesium turnings. Start stirring and raise the temperature to 55°C – 60°C.
- Add required amount of catalyst and add Iso Propyl Bromide in 4 to 5 hours and add Lithium Chloride maintaining the temperature 55°C – 60°C.
- Maintain for 2 hours check the quality if OK cool to 30°C and pack in 200 Lit MS PP lined barrels.

Chemical reaction:

$(CH_3)_2$-(CH)-Cl + Mg + Li.Cl ⟶ $(CH_3)_2$-(CH)- Mg -Br . LiCl

Iso Propyl Chloride — Magnesuim — Lithium Chloride — Iso Propyl Magnesium Chloride Li Cl

M.W. : 78.5 — M.W. : 24 — M.W. : 42.5 — M.W. : 145

Mass Balance:

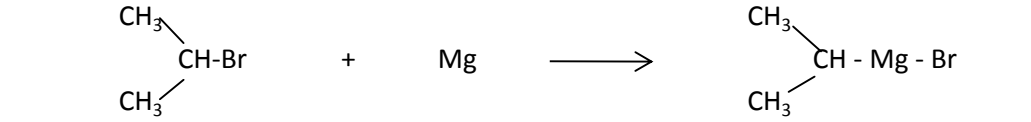
Input	Kg				Output	Kg
Iso Propyl Chloride	377				Iso Propyl Magnesuim Chloride	4428
Magnesium	115	⟹	**Reaction**	⟹	Li Cl complex in THF	
Lithium Chloride	204					
THF Solution	3732					
Total	4428				Total	4428

3.10) Iso Propyl Magnesium Bromide 1M in THF

Manufacturing Process:

- Take in a clean reactor under Nitrogen Blanketing required amount of THF. To THF add clean Magnesium turnings. Start stirring and raise the temperature to 55°C – 60°C.
- Add required amount of catalyst and add Iso propyl Bromide in 4 to 5 hours maintaining the temperature 55°C – 60°C.
- Maintain for 2 hours check the quality if OK cool to 30°C and pack in 200 Lit MS PP lined barrels.

Chemical reaction:



Iso Propyl Bromide	Magnesuim	Iso Propyl Magnesium Bromide
M.W. : 123	M.W. : 24	M.W. : 147

Mass Balance:

Input	Kg				Output	Kg
Iso Propyl Bromide	585		**Reaction**		Iso Propyl Magnesuim Bromide	4510
Magnesium	114				in THF	
THF Solution	3811					
Total	4510				Total	4510

4) Halogen Exchange Reactions

4.1) 1 Bromo 2 Chloro Ethane

Manufacturing Process:

- 1,2-Dibromo Ethane is taken in water containing (salt) Sodium Chloride. The mass is stirred for a given stipulated time. Progress of reaction is monitored by GC, on achieving the desired result the reaction mass is taken for Phase separation.
- Organic Phase containing desired halide is taken for fractionation under reduced pressure.
- Pure 1 Bromo 2 Chloro Ethane thus obtained is packed in 200 Kg HDPE Barrels; Intermediate fractions obtained from fractional distillation are again taken for Halide Exchange reaction for next batch.

Chemical reaction:

$Br\text{-}C_2H_4\text{-}Br$	+	NaCl	⟶	$Br\text{-}C_2H_4\text{-}Cl$	+	NaBr
1,2- Di Bromo Ethane		Soduim Chloride		1 Bromo 2 Chloro Ethane		Sodium Bromide
M.W. : 188		M.W. : 58.5		M.W. : 143.5		M.W. : 103

Mass Balance:

Input	Kg				Output	Kg
1,2 - Di Bromo Ethane	3760		**Reaction**		1 Bromo 2 Chloro-Ethane	2870
Soduim Chloride	1170	⟹		⟹	NaBr Solution (43%)	4790
Water	2730					
Total	7660				Total	7660
1 Bromo 2 Chloro Ethane	2870		**Water Wash**		1 Bromo 2 Chloro Ethane	2850
Water	1000	⟹		⟹	Water to ETP	1020
Total	3870				Total	3870
1 Bromo 2 Chloro Ethane	2850		**Vacuum Distillation**		Final Product	2540
(Washed)		⟹		⟹	Residue	310
Total	2850				Total	2850

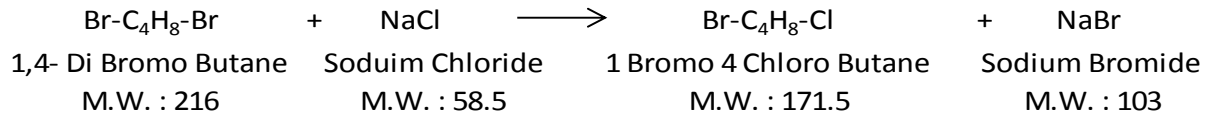
4.2) 1 Bromo 4 Chloro Butane

Manufacturing Process:

- 1,4 Dibromo Butane is taken in water containing (salt) Sodium Chloride. The mass is stirred for a given stipulated time. Progress of reaction is monitored by GC, on achieving the desired result the reaction mass is taken for Phase separation.
- Organic Phase containing desired halide is taken for fractionation under reduced pressure.

- Pure 1 Bromo 4 Chloro Butane thus obtained is packed in 200 Kg HDPE Barrels; Intermediate fractions obtained from fractional distillation are again taken for Halogen Exchange reaction for next batch.

Chemical reaction:



Mass Balance:

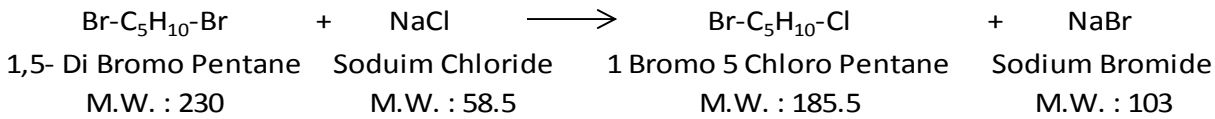
Input	Kg				Output	Kg
1,4 - Di Bromo Butane	3455		**Reaction**		1 Bromo 4 Chloro-Butane	2740
Soduim Chloride	935				NaBr Solution (43%)	3830
Water	2180					
Total	6570				Total	6570
1 Bromo 4 Chloro Butane	2740		**Water Wash**		1 Bromo 4 Chloro Butane	2700
Water	1000				Water to ETP	1040
Total	3740				Total	3740
1 Bromo 4 Chloro Butane	2700		**Vacuum Distillation**		Final Product	2380
(Washed)					Residue	320
Total	2700				Total	2700

4.3) 1 Bromo 5 Chloro Pentane

Manufacturing Process:

- 1,5 Dibromo Pentane is taken in water containing (salt) Sodium Chloride. The mass is stirred for a give Stipulated time. Progress of reaction is monitored by GC, on achieving the desired result the reaction mass is taken for Phase separation.
- Organic Phase containing desired halide is taken for fractionation under reduced pressure.
- Pure 1 Bromo 5 Chloro Pentane thus obtained is packed in 200 Kg HDPE Barrels; Intermediate fractions obtained from fractional distillation are again taken for Halogen Exchange reaction for next batch.

Chemical reaction:



Mass Balance:

Input	Kg				Output	Kg
1,5 - Di Bromo Pentane	3450		**Reaction**		1 Bromo 5 Chloro - Pentane	2785
Soduim Chloride	880				NaBr Solution (43%)	3600
Water	2055					
Total	6385				Total	6385
1 Bromo 5 Chloro Pentane	3385		**Water Wash**		1 Bromo 5 Chloro Pentane	3350
Water	1000				Water to ETP	1035
Total	4385				Total	4385
1 Bromo 5 Chloro Pentane	3350		**Vacuum Distillation**		Final Product	3015
(Washed)					Residue	335
Total	3350				Total	3350

4.4) 1 Bromo 6 Chloro Hexane

Manufacturing Process:

- 1,6 Dibromo Hexane is taken in water containing (salt) Sodium Chloride. The mass is stirred for a given stipulated time. Progress of reaction is monitored by GC, on achieving the desired result the reaction mass is taken for Phase separation.
- Organic Phase containing desired halide is taken for fractionation under reduced pressure.
- Pure 1 Bromo 6 Chloro Hexane thus obtained is packed in 200 Kg HDPE Barrels; Intermediate fractions obtained from fractional distillation are again taken for Halogen Exchange reaction for next batch.

Chemical reaction:

$$Br\text{-}C_6H_{12}\text{-}Br + NaCl \longrightarrow Br\text{-}C_6H_{12}\text{-}Cl + NaBr$$

1,6- Di Bromo Hexane	Sodium Chloride	1 Bromo 6 Chloro Hexane	Sodium Bromide
M.W. : 244	M.W. : 58.5	M.W. : 199.5	M.W. : 103

Mass Balance:

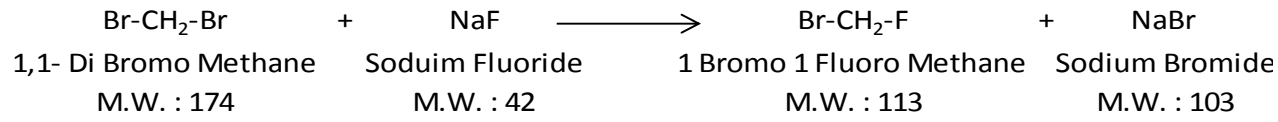
Input	Kg				Output	Kg
1,6 - Di Bromo Hexane	3660		**Reaction**		1 Bromo 6 Chloro -Hexane	2995
Soduim Chloride	880				NaBr Solution (43%)	3600
Water	2055					
Total	6595				Total	6595
1 Bromo 6 Chloro Hexane	2995		**Water Wash**		1 Bromo 6 Chloro Hexane	2950
Water	1000				Water to ETP	1045
Total	3995				Total	3995
1 Bromo 6 Chloro Hexane	2950		**Vacuum Distillation**		Final Product	2605
(Washed)					Residue	345
Total	2950				Total	2950

4.5) 1 Bromo 1 Fluoro Methane

Manufacturing Process:

- 1,1 Dibromo Methane is taken in water containing (salt) Sodium Fluoride. The mass is stirred for a given stipulated time. Progress of reaction is monitored by GC, on achieving the desired result the reaction mass is taken for Phase separation.
- Organic Phase containing desired halide is taken for fractionation under reduced pressure.
- Pure 1 Bromo 1 Fluoro Methane thus obtained is packed in 200 Kg HDPE Barrels; Intermediate fractions obtained from fractional distillation are again taken for Halogen Exchange reaction for next batch.

Chemical reaction:



Mass Balance:

Input	Kg				Output	Kg
1,1 - Di Bromo Methane	6660		**Reaction**		1 Bromo 1 Fluoro Methane	4325
Soduim Fluoride	1610				NaBr Solution (51 %)	7695
Water	3750					
Total	12020				Total	12020
1 Bromo 1 Fluoro Methane	4325		**Water Wash**		1 Bromo 1 Fluoro Methane	4300
Water	1000				Water to ETP	1025
Total	5325				Total	5325
1 Bromo 1 Fluoro Methane	4300		**Vacuum Distillation**		Main Product	4040
(Washed)					Residue	260
Total	4300				Total	4300

4.6) Dibromo Methane

Manufacturing Process:

- Methylene Dichloride is taken in water containing (salt) Sodium Bromide. The mass is stirred for a given stipulated time. Progress of reaction is monitored by GC, on achieving the desired result the reaction mass is taken for Phase separation.
- Organic Phase containing desired halide is taken for fractionation under reduced pressure.
- Pure Methylene Dibromide thus obtained is packed in 200 Kg HDPE Barrels; Intermediate fractions obtained from fractional distillation are again taken for Halogen Exchange reaction for next batch.

Chemical reaction:

$Cl\text{-}CH_2\text{-}Cl$ + 2 NaBr ⟶ $Br\text{-}CH_2\text{-}Br$ + 2 NaCl

Methylene Di Chloride	Sodium Bromide	Methylene Di Bromide	Soduim Chloride
M.W. : 85	M.W. : 206	M.W. : 174	M.W. : 117

Mass Balance:

Input	Kg				Output	Kg
Methylene Di Chloride	1470	⟹	**Reaction**	⟹	Methylene Di Bromide	3007
Sodium Bromide	3560				NaCl Solution (20%)	10328
Water	8305					
Total	13335				Total	13335
Methylene Di Bromide	3007	⟹	**Water Wash**	⟹	Methylene Di Bromide	2990
Water	1000				Water to ETP	1017
Total	4007				Total	4007
Methylene Di Bromide	2990	⟹	**Vacuum Distillation**	⟹	Main Product	2800
(Washed)					Residue	190
Total	2990				Total	2990

4.7) Bromo Chloro Methane

Manufacturing Process:

- 1,1, Dibromo methane is taken in water containing salt (Sodium Chloride). The mass is stirred for a given Stipulated Time. Progress of reaction is monitored by GC, on achieving the desired result the mass is taken for Phase separation.
- Organic Phase containing desired halide is taken for fractionation under reduced pressure.
- Pure 1 Bromo 1 Chloro Methane thus obtained is packed in 200 Kg HDPE Barrels; Intermediate fractions obtained from fractional distillation are again taken for Halogen Exchange reaction for next batch.

Chemical reaction:

$Br\text{-}CH_2\text{-}Br$ + NaCl ⟶ $Br\text{-}CH_2\text{-}Cl$ + NaBr

1,1- Di Bromo Methane	Soduim Chloride	1 Bromo 1 Chloro Methane	Sodium Bromide
M.W. : 174	M.W. : 58.5	M.W. : 129.5	M.W. : 103

Mass Balance:

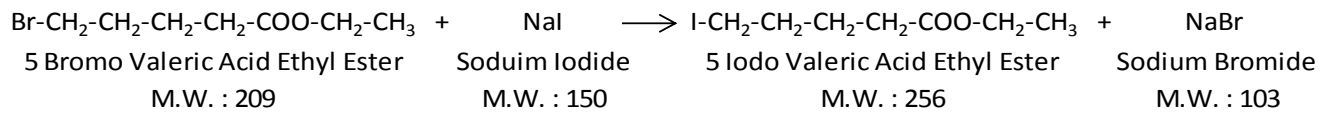
Input	Kg				Output	Kg
1,1 - Di Bromo Methane	5220		**Reaction**		1 Bromo 1 Chloro Methane	3885
Soduim Chloride	1755				NaBr Solution (43%)	7185
Water	4095					
Total	11070				Total	11070
1 Bromo 1 Chloro Methane	3885		**Water Wash**		1 Bromo 1 Chloro Methane	3870
Water	1000				Water to ETP	1015
Total	4885				Total	4885
1 Bromo 1 Chloro Methane	3870		**Vacuum Distillation**		Main Fraction	3585
(Washed)					Residue	285
Total	3870				Total	3870

4.8) Ethyl 5 Iodo Valerate

Manufacturing Process:

- 5-Bromo Valeric Acid Ethyl ester is taken in water containing (salt) Sodium Iodide. The mass is stirred at around 40°C to 55°C for 8 to 9 hours. Progress of reaction is monitored by GC, on achieving the desired result the reaction mass is taken for Phase separation.
- Organic Phase containing desired halide is taken for fractionation under reduced pressure.
- Pure 5-Iodo Valeric Acid Ethyl Ester thus obtained is packed in 200 Kg HDPE Barrels; Intermediate fractions obtained from fractional distillation are again taken for Halogen Exchange reaction for next batch.

Chemical reaction:



Mass Balance:

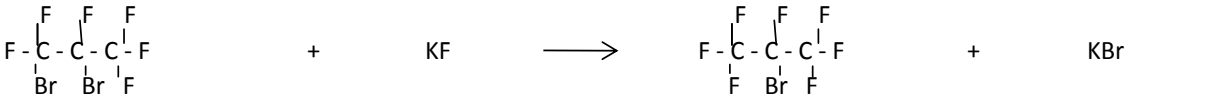
Input	Kg				Output	Kg
5 Bromo Valeric Acid Ethyl Ester	3405		**Reaction**		5 Iodo Valeric Acid Ethyl Ester	4170
Sodium Iodide	2445				NaBr Solution (23%)	7380
Water	5700					
Total	11550				Total	11550
5 Iodo Valeric Acid Ethyl Ester	4170		**Water Wash**		5 Iodo Valeric Acid Ethyl Ester	4150
Water	2000				Water to ETP	2020
Total	6170				Total	6170
5 Iodo Valeric Acid Ethyl Ester	4150		**Vacuum Distillation**		Main Fraction	3760
(Washed)					Residue	390
Total	4150				Total	4150

4.9) 2 Bromo Hepta Fluoro Propane

Manufacturing Process:

- 1,2 Dibromo Hexa Fluoro Propane is taken in water containing salt (Potassium Fluoride). The mass is stirred for a given stipulated time. Progress of reaction is monitored by GC, on achieving the desired result the reaction mass is taken for Phase separation.
- Organic Phase containing desired halide is taken for fractionation under reduced pressure.
- Pure 2-Bromo Hepta Fluoro Propane thus obtained is packed in 200 Kg HDPE Barrels; Intermediate fractions obtained from fractional distillation are again taken for Halogen Exchange reaction for next batch.

Chemical reaction:



1,2 Dibromo Hexa Fluoro Propane	Potassium Fluoride	2 Bromo Hepta Fluoro Propane	Potassium Bromide
M.W. : 310	M.W. : 58	M.W, : 249	M.W. : 119

Mass Balance:

Input	Kg				Output	Kg
1,2 Dibromo Hexa Fluoro Propane	9085	→	**Reaction**	→	2 Bromo Hepta Fluoro Propane	7300
Potassium Fluoride (30%)	5665				Potassium Bromide (46%)	7450
Total	14750				Total	14750
2 Bromo Hepta Fluoro Propane	7300	→	**Water Wash**	→	2 Bromo Hepta Fluoro Propane	7285
Water	4000				Water to ETP	4015
Total	11300				Total	11300
2 Bromo Hepta Fluoro Propane	7285	→	**Vacuum Distillation**	→	Main Product	6600
					Residue	685
Total	7285				Total	7285

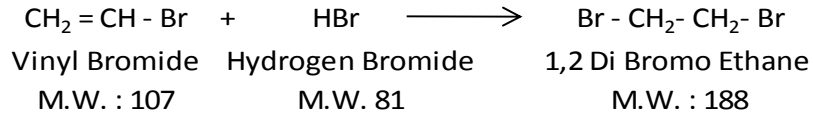
5) Addition of Halogen and Halogen Acids across Double Bonds

5.1) 1,2 Di Bromo Ethane

Manufacturing Process:

- Unsaturated Hydrocarbon such as Vinyl Bromide is taken in a Glass lined reactor. To this mass concentrated Hydro Bromic Acid is added over a given period of time.
- On Completion of addition of Hydro bromic Acid to the mass is maintained for a given stipulated time. The progress of reaction is monitored on GC.
- On Completion of reaction Organic and aqueous layers are separated. Organic phase is taken for fractionation. Pure Ethylene Dibromide thus obtained is packed in 200 Lit HDPE Barrels.
- Alternatively this material can be packed in smaller packing such as 50 lit / 100 Lit carboys or drums. Aqueous layer is taken for next batch to recycle the Hydrobromic Acid.

Chemical reaction:



Mass Balance:

Input	Kg				Output	Kg
Vinyl Bromide	11020		**Reaction**		1,2 Di Bromo Ethane	19365
Hydrogen Bromide	8345					
Total	19365				Total	19365
1,2 Di Bromo Ethane	19365		**Water Wash**		1,2 Di Bromo Ethane	19300
Water	4000				Water to ETP	4065
Total	23365				Total	23365
			Vacuum Distillation		Final Product	17900
1,2 Di Bromo Ethane	19300				Residue	1400
Total	19300				Total	19300

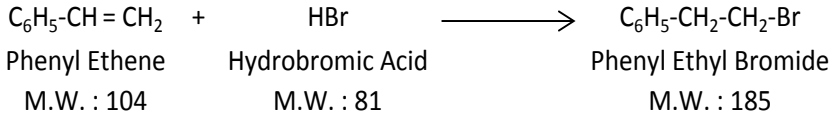
5.2) Phenyl Ethyl Bromide

Manufacturing Process:

- Unsaturated Hydrocarbon such as Phenyl Ethene is taken in a Glass lined reactor. To this mass concentrated Hydro Bromic Acid is added over a given period of time.
- On Completion of addition of Hydrobromic Acid the mass is maintained for a stipulated time. The progress of reaction is monitored on GC.

- On Completion of reaction Organic and aqueous layers are separated. Organic phase is taken for fractionation. Pure Phenyl Ethyl Bromide thus obtained is packed in 200 Lit HDPE Barrels.
- Alternatively this material can be packed in smaller packing such as 50 lit / 100 Lit carboys or drums. Aqueous layer is taken for next batch to recycle the Hydrobromic Acid.

Chemical reaction:



Mass Balance:

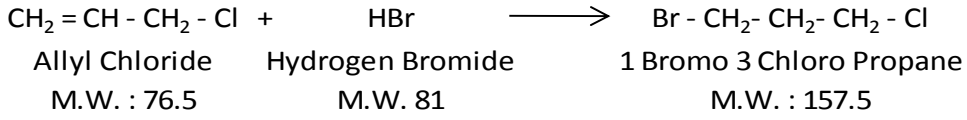
Input	Kg				Output	Kg
Phenyl Ethene	7500	→	**Reaction**	→	Phenyl Ethyl Bromide	12480
Hydrobromic Acid	4980					
Total	12480				Total	12480
Phenyl Ethyl Bromide	12480	→	**Water Wash**	→	Phenyl Ethyl Bromide	12450
Water	4000				Water to ETP	4030
Total	16480				Total	16480
Phenyl Ethyl Bromide	12450	→	**Vacuum Distillation**	→	Main Fraction	11500
					Residue	950
Total	12450				Total	12450

5.3) 1 Bromo 3 Chloro Propane

Manufacturing Process:

- Unsaturated Hydrocarbon such as Allyl Chloride is taken in a Glass lined reactor. To this mass concentrated Hydrobromic Acid is added over a given period of time.
- On Completion of addition of concentrated Hydrobromic Acid the mass is maintained for a stipulated time. The progress of reaction is monitored on GC.
- On Completion of reaction Organic and aqueous layers are separated. Organic phase is taken for fractionation. Pure 1 Bromo 3 Chloro Propane thus obtained is packed in 200 Lit HDPE Barrels.
- Alternatively this material can be packed in smaller packing such as 50 lit / 100 Lit carboys or drums. Aqueous layer is taken for next batch to recycle the Hydrobromic Acid.

Chemical reaction:



Mass Balance:

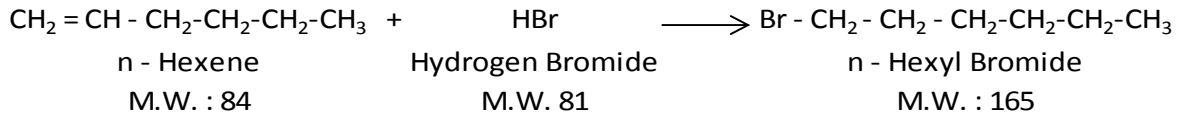
Input	Kg				Output	Kg
Allyl Chloride	7050		**Reaction**		1 Bromo 3 Chloro propane	14515
Hydrogen Bromide	7465					
Total	14515				Total	14515
1 Bromo 3 Chloro propane	14515		**Water Wash**		1 Bromo 3 Chloro propane	14480
Water	4000				Water to ETP	4035
Total	18515				Total	18515
			Vacuum Distillation		Final Product	13235
1 Bromo 3 Chloro propane	14480				Residue	1245
Total	14480				Total	14480

5.4) n-Hexyl Bromide

Manufacturing Process:

- Unsaturated Hydrocarbon such as n-Hexene is taken in a Glass lined reactor. To this mass concentrated Hydro Bromic Acid is added over a given period of time.
- On completion of addition of Hydrobromic Acid the mass is maintained for a stipulated time. The progress of reaction is monitored on GC.
- On completion of reaction Organic and aqueous layers are separated. Organic phase is taken for fractionation. Pure n-Hexyl Bromide thus obtained is packed in 200 Lit HDPE Barrels.
- Alternatively this material can be packed in smaller packing such as 50 lit / 100 Lit carboys or drums. Aqueous layer is taken for next batch to recycle the Hydrobromic Acid.

Chemical reaction:



Mass Balance:

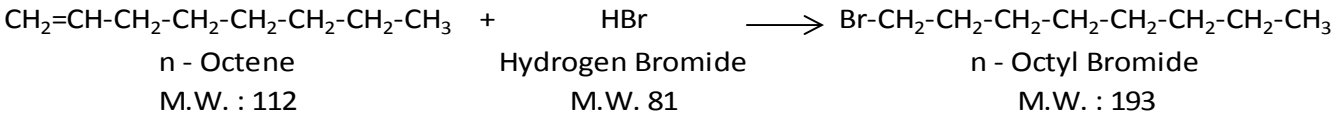
Input	Kg				Output	Kg
n- Hexene	5385	→	**Reaction**	→	n-Hexyl Bromide	10575
Hydrogen Bromide	5190					
Total	10575				Total	10575
n - Hexyl Bromide	10575	→	**Water Wash**	→	n - Hexyl Bromide	10500
Water	4000				Water to ETP	4075
Total	14575				Total	14575
n - Hexyl Bromide	10500	→	**Vacuum Distillation**	→	Main Product	9600
					Residue	900
Total	10500				Total	10500

5.5) n-Octyl Bromide

Manufacturing Process:

- Unsaturated Hydrocarbon such as n-Octene is taken in a Glass lined reactor. To this mass concentrated Hydro Bromic Acid is added over a given period of time.
- On completion of addition of Hydrobromic Acid the mass is maintained for a stipulated time. The progress of reaction is monitored on GC.
- On completion of reaction Organic and aqueous layers are separated. Organic phase is taken for fractionation. Pure n-Octyl Bromide thus obtained is packed in 200 Lit HDPE Barrels.
- Alternatively this material can be packed in smaller packing such as 50 lit / 100 Lit carboys or drums. Aqueous layer is taken for next batch to recycle the Hydrobromic Acid.

Chemical reaction:



Mass Balance:

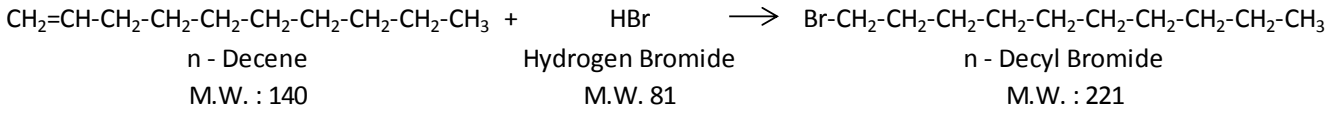
Input	Kg				Output	Kg
n- Octene	6000	→	**Reaction**	→	n-Octyl Bromide	10340
Hydrogen Bromide	4340					
Total	10340				Total	10340
n - Octyl Bromide	10340	→	**Water Wash**	→	n - Octyl Bromide	10300
Water	4000				Water to ETP	4040
Total	14340				Total	14340
n - Octyl Bromide	10300	→	**Vacuum Distillation**	→	Main Product	9400
					Residue	900
Total	10300				Total	10300

5.6) n-Decyl Bromide

Manufacturing Process:

- Unsaturated Hydrocarbon such as n-Decene is taken in a Glass lined reactor. To this mass concentrated Hydro Bromic Acid is added for a given period of time.
- On completion of addition of Hydrobromic Acid the mass is maintained for a stipulated time. The progress of reaction is monitored on GC.
- On completion of reaction Organic and aqueous layers are separated. Organic phase is taken for fractionation. Pure n-Decyl Bromide thus obtained is packed in 200 Lit HDPE Barrels.
- Alternatively this material can be packed in smaller packing such as 50 lit / 100 Lit carboys or drums. Aqueous layer is taken for next batch to recycle the Hydrobromic Acid.

Chemical reaction:



Mass Balance:

Input	Kg				Output	Kg
n- Decene	6300		**Reaction**		n-Decyl Bromide	9945
Hydrogen Bromide	3645					
Total	9945				Total	9945
n - Decyl Bromide	9945		**Water Wash**		n - Decyl Bromide	9930
Water	4000				Water to ETP	4015
Total	13945				Total	13945
n - Decyl Bromide	9930		**Vacuum Distillation**		Main Product	9100
					Residue	830
Total	9930				Total	9930

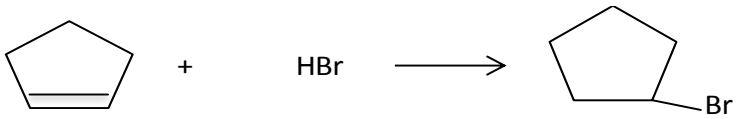
5.7) Cyclo Pentyl Bromide

Manufacturing Process:

- Unsaturated Hydrocarbon such as Cyclo Pentene is taken in a Glass lined reactor. To this mass concentrated Hydrobromic Acid is added over a given period of time.
- On completion of addition of concentrated Hydrobromic Acid the mass is maintained for a stipulated time. The progress of reaction is monitored on GC.
- On completion of reaction Organic and aqueous layers are separated. Organic phase is taken for fractionation. Pure Cyclo pentyl Bromide thus obtained is packed in 200 Lit HDPE Barrels.

- Alternatively this material can be packed in smaller packing such as 50 lit / 100 Lit carboys or drums. Aqueous layer is taken for next batch to recycle the Hydrobromic Acid.

Chemical reaction:



Cyclo Pentene M.W. : 68 | Hydrobromic Acid M.W. : 81 | Cyclo Pentyl Bromide M.W. : 149

Mass Balance:

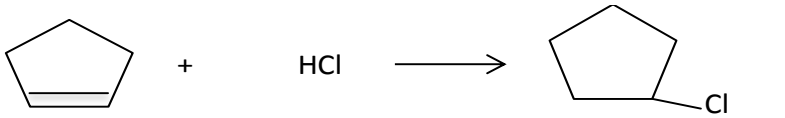
Input	Kg				Output	Kg
Cyclo Pentene	3500		**Reaction**		Cyclo Pentyl Bromide	7670
Hydrobromic Acid	4170				Cyclo Pentane	2950
Cyclo Pentane	2950					
Total	10620				Total	10620
Cyclo Pentyl Bromide	7670		**Water Wash**		Cyclo Pentyl Bromide	7650
Water	3000				Water to ETP	3020
Total	10670				Total	10670
Cyclo Pentyl Bromide	7650		**Vacuum Distillation**		Main Product	7050
					Residue	600
Total	7650				Total	7650

5.8) Cyclo Pentyl Chloride

Manufacturing Process:

- Unsaturated Hydrocarbon such as Cyclo Pentene is taken in a Glass lined reactor. To this mass concentrated Hydrochloric Acid is added over a given period of time.
- On completion of addition of concentrated Hydrochloric Acid the mass is maintained for a stipulated time. The progress of reaction is monitored on GC.
- On completion of reaction Organic and aqueous layers are separated. Organic phase is taken for fractionation. Pure Cyclo pentyl Chloride thus obtained is packed in 200 Lit HDPE Barrels.
- Alternatively this material can be packed in smaller packing such as 50 lit / 100 Lit carboys or drums. Aqueous layer is taken for next batch to recycle the Hydrochloric Acid.

Chemical reaction:



Cyclo Pentene M.W. : 68 | Hydrochloric Acid M.W. : 36.5 | Cyclo Pentyl Chloride M.W. : 104.5

Mass Balance:

Input	Kg				Output	Kg
Cyclo Pentene	3500		**Reaction**		Cyclo Pentyl Chloride	5375
Hydrobromic Acid	1875				Cyclo Pentane	3000
Cyclo Pentane	3000					
Total	8375				Total	8375
Cyclo Pentyl Chloride	5375		**Water Wash**		Cyclo pentyl Chloride	5355
Water	2000				Water to ETP	2020
Total	7375				Total	7375
Cyclo Pentyl Chloride	5355		**Vacuum Distillation**		Main Product	4915
					Residue	440
Total	5355				Total	5355

5.9) 1,2 Dibromo 3 Chloro propane

Manufacturing Process:

- Unsaturated Hydrocarbon such as 2,3 Dibromo Propene is taken in a Glass lined reactor. To this mass concentrated Hydrochloric Acid is added for a given Period of time.
- On completion of addition of Hydrochloric Acid the mass is maintained for a given stipulated time. The progress of reaction is monitored on GC.
- On completion of reaction Organic and aqueous layers are separated. Organic phase is taken for fractionation. Pure 1,2 Dibromo 3 Chloro propane thus obtained is packed in 200 Lit HDPE Barrels.
- Alternatively this material can be packed in smaller packing such as 50 Lit / 100 Lit carboys or drums. Aqueous layer is taken for next batch to recycle the Hydrochloric Acid.

Chemical reaction:

$CH_2=C(Br)-CH_2-Br$ + HCl ⟶ $Cl-CH_2-CH(Br)-CH_2-Br$

2,3 DiBromo Propene M.W. : 200 | Hydrochloric Acid M.W. 36.5 | 1,2 Di Bromo 3 Chloro Propane M.W. : 236.5

Mass Balance:

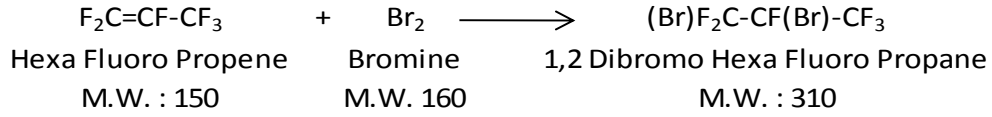
Input	Kg				Output	Kg
2,3 Di Brome Propene	15840		**Reaction**		1,2 Di Bromo 3 Chloro Propane	18730
Hydrochloric Acid	2890					
Total	18730				Total	18730
1,2 Di Bromo 3 Chloro Propane	18730		**Water Wash**		1,2 Di Bromo 3 Chloro Propane	18700
Water	4500				Water to ETP	4530
Total	23230				Total	23230
			Vacuum Distillation		Final Product	17100
1,2 Di Bromo 3 Chloro Propane	18700				Residue	1600
Total	18700				Total	18700

5.10) 1,2 Dibromo Hexa Fluoro Propane

Manufacturing Process:

- Unsaturated Hydrocarbon such as Hexa Fluoro Propane is taken in a Glass lined reactor. To this mass Liquid Bromine is added for a given Period of time.
- On completion of addition of Bromine the mass is maintained for a given stipulated time. The progress of reaction is monitored on GC.
- On completion of reaction Organic and aqueous layers are separated. Organic phase is taken for fractionation. Pure 1,2 Dibromo Hexa Fluoro propane thus obtained is packed in 200 Lit HDPE Barrels.

Chemical reaction:



Mass Balance:

Input	Kg				Output	Kg
Hexa Fluoro Propane	8770		**Reaction**		1,2 Dibromo Hexa Fluoro Propane	18125
Bromine	9355					
Total	18125				Total	18125
1,2 Dibromo hexa Fluoro Propane	18125		**Water Wash**		1,2 Di Bromo Hexa Fluoro Propane	18100
Water	5000				Water to ETP	2025
Total	23125				Total	20125
1,2 Di Bromo Hexa Fluoro Propane	18100		**Vacuum Distillation**		Main Product	16850
					Residue	1250
Total	18100				Total	18100

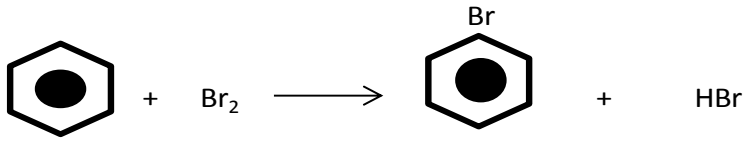
6) Bromination or Chlorination of Cyclic and Aromatic Compounds with or Without Functional Groups

6.1) Bromo Benzene

Manufacturing Process:

- Benzene is taken in a Reactor. To this Liquid Bromine is added or a given period of time after addition of required amount of Bromine the mass is analyzed for completion of reaction on GC.
- When unreacted Benzene content is less than 1% Bromine addition is stopped and taken for Water washing.
- The Organic is taken in to the Glass lined reactor and water is added. This mass was stirred at room temperature for about 30 mins. Organic layer taken for Purification and Aqueous layer is recycled to next Batch.
- Organic Layer is then taken for Fractionation after removal of Low Boiler Impurities under Vacuum, the Product is fractionated. Pure Bromo Benzene thus obtained is packed in 200 lit Drums.

Chemical reaction:



Benzene	Bromine	Bromo Benzene	Hydrobromic Acid
M.W. : 78	M.W. : 160	M.W. : 157	M.W. : 81

Mass Balance:

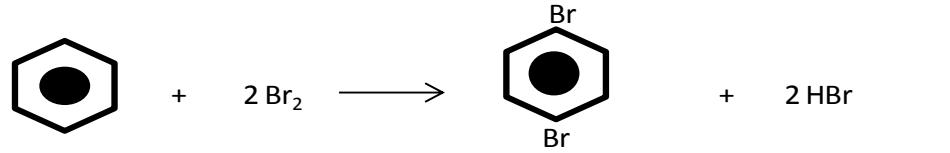
Input	Kg				Output	Kg
Benzene	3285		**Reaction**		Bromo Benzene	6610
Bromine	6730				HBr (48%)	7085
Water	3680					
Total	13695				Total	13695
Bromo Benzene	6610		**Washing**		Bromo Benzene	6550
Water	2000				Water Washings to ETP	2060
Total	8610				Total	8610
Bromo Benzene	6550		**Vacuum Distillation**		Final Product	6020
(Washed)					Residue	530
Total	6550				Total	6550

6.2) Di Bromo Benzene

Manufacturing Process:

- Benzene is taken in a Reactor. To this Liquid Bromine is added or a given period of time after addition of required amount of Bromine the mass is analyzed for completion of reaction on GC.
- When unreacted Benzene content is less than 1% Bromine addition is stopped and taken for Water washing.
- The Organic is taken in to the Glass lined reactor and water is added. This mass was stirred at room temperature for about 30 mins. Organic layer taken for Purification and Aqueous layer is recycled to next Batch.
- Organic Layer is then taken for Fractionation after removal of Low Boiler Impurities under Vacuum, the Product is fractionated. Pure Di Bromo Benzene thus obtained is packed in 200 lit Drums.

Chemical reaction:



Benzene	Bromine	p Di Bromo Benzene	Hydrobromic Acid
M.W. : 78	M.W. : 320	M.W. : 236	M.W. : 162

Mass Balance:

Input	Kg				Output	Kg
Benzene	1950		**Reaction**		p DiBromo Benzene	5870
Bromine	7960	→		→	HBr (48%)	8440
Water	4400					
Total	14310				Total	14310
p Di Bromo Benzene	5870		**Washing**		p Di Bromo Benzene	5850
Water	3000	→		→	Water Washings-ETP	3020
Total	8870				Total	8870
p Di Bromo Benzene	5850		**Vacuum Distillation**		Main Product	5350
(Washed)		→		→	Residue	500
Total	5850				Total	5850

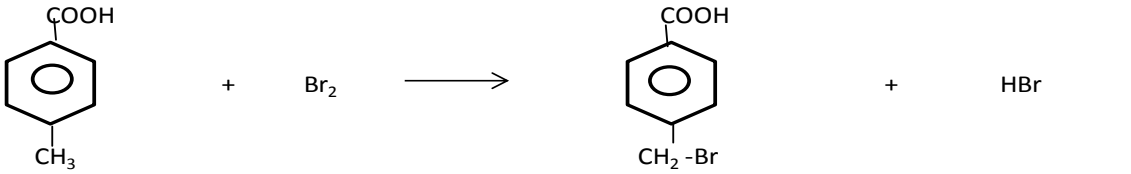
6.3) Ethyl (4 Bromo methyl) Benzoate

Manufacturing Process:

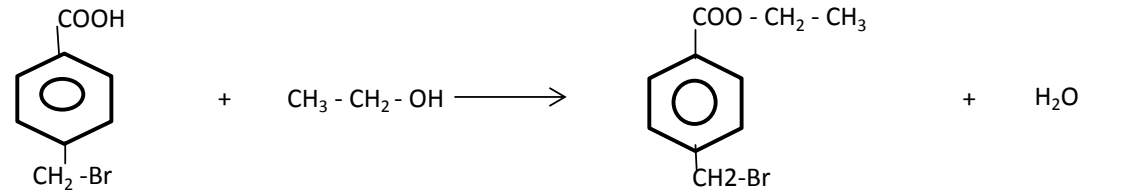
- 4-Methyl Benzoic acid is taken in a Reactor. To this Liquid Bromine is added or a given period of time after addition of required amount of Bromine the mass is analyzed for completion of reaction on GC.
- When unreacted 4-Methyl Benzoic acid content is less than 1% Bromine addition is stopped and reacted with Ethanol to get Ethyl 4 Bromo Methyl Benzoate.

- The Organic is taken in to the Glass lined reactor and water is added. This mass was stirred at room temperature for about 30 mins. Organic layer taken for Purification and Aqueous layer is recycled to next Batch.
- Organic Layer is then taken for Fractionation after removal of Low Boiler Impurities under Vacuum, the Product is fractionated. Pure Ethyl 4 Bromo Methyl Benzoate thus obtained is packed in 200 lit Drums.

Chemical reaction:



4 Methyl Benzoic Acid M.W. : 136 | Bromine M.W. : 160 | 4 Bromo Methyl Benzoic Acid M.W. : 215 | Hydrogen Bromide M.W. : 81



4 Bromo Methyl Benzoic Acid M.W. : 215 | Ethanol M.W. : 46 | Ethyl 4 Bromo Methyl Benzoate M.W. : 243 | Water M.W. : 18

Mass Balance:

Input	Kg				Output	Kg
4 Methyl Benzoic Acid	7500		**Reaction**		Ethyl 4 Bromo Methyl Benzoate	13400
Bromine	8825				HBr (48%)	9310
Ethanol	2540					
Water	3845					
Total	22710				Total	22710
Ethyl 4 Bromo Methyl Benzoate	13400		**Washing**		Ethyl 4 Bromo Methyl Benzoate	13350
Water	4000				Water Washings to ETP	4050
Total	17400				Total	17400
Ethyl 4 Bromo Methyl Benzoate	13350		**Vacuum Distillation**		Main Product	12165
(Washed)					Residue	1185
Total	13350				Total	13350

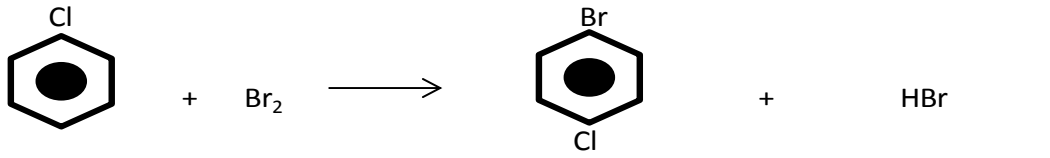
6.4) 1 Bromo 4 Chloro Benzene

Manufacturing Process:

- Chloro Benzene is taken in a Reactor. To this Liquid Bromine is added or a given period of time after addition of required amount of Bromine the mass is analyzed for completion of reaction on GC.

- When unreacted Chloro Benzene content is less than 1% Bromine addition is stopped and taken for Water washing.
- The Organic is taken in to the Glass lined reactor and water is added. This mass was stirred at room temperature for about 30 mins. Organic layer taken for Purification and Aqueous layer is recycled to next Batch.
- Organic Layer is then taken for Fractionation after removal of Low Boiler Impurities under Vacuum, the Product is fractionated. Pure 1 Bromo 4 Chloro Benzene thus obtained is packed in 200 lit Drums.

Chemical reaction:



Chloro Benzene	Bromine	1 Bromo 4 Chloro Benzene	Hydrobromic Acid
M.W. : 112.5	M.W. : 160	M.W. : 191.5	M.W. : 81

Mass Balance:

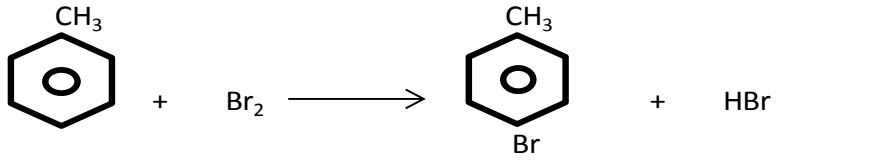
Input	Kg				Output	Kg
Chloro Benzene	4450		**Reaction**		1 Bromo 4 Chloro Benzene	7575
Bromine	6330				HBr (48%)	6675
Water	3470					
Total	14250				Total	14250
1 Bromo 4 Chloro Benzene	7575		**Washing**		1 Bromo 4 Chloro Benzene	7550
Water	3000				Water Washings to ETP	3025
Total	10575				Total	10575
1 Bromo 4 Chloro Benzene	7550		**Vacuum Distillation**		Final Product	6950
(Washed)					Residue	600
Total	7550				Total	7550

6.5) p Bromo Toluene

Manufacturing Process:

- Toluene is taken in a Reactor. To this Liquid Bromine is added or a given period of time after addition of required amount of Bromine the mass is analyzed for completion of reaction on GC.
- When unreacted Toluene content is less than 1% Bromine addition is stopped and taken for Water washing.
- The Organic is taken in to the Glass lined reactor and water is added. This mass was stirred at room temperature for about 30 mins. Organic layer taken for Purification and Aqueous layer is recycled to next Batch.
- Organic Layer is then taken for Fractionation after removal of Low Boiler Impurities under Vacuum, the Product is fractionated. Pure 4 Bromo Toluene thus obtained is packed in 200 lit Drums.

Chemical reaction:



Toluene	Bromine	4 -Bromo Toluene	Hydrobromic Acid
M.W. : 92	M.W. : 160	M.W. : 171	M.W. : 81

Mass Balance:

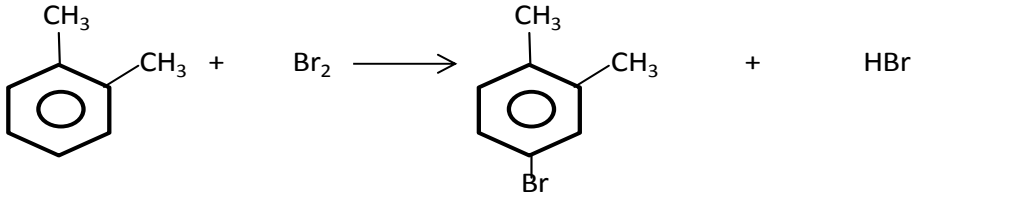
Input	Kg				Output	Kg
Toluene	6940		**Reaction**		4 Bromo Toluene	5310
Bromine	4970				Unreacted Toluene	4085
Water	2725				HBr (48%)	5240
Total	14635				Total	14635
4 Bromo Toluene	9395		**Washing**		4 Bromo Toluene	9350
Water	3000				Water Washings to ETP	3045
Total	12395				Total	12395
			Vacuum Distillation		Dist Toluene	3900
4 Bromo Toluene	9350				Final Product	5290
(Washed)					Residue	160
Total	9350				Total	9350

6.6) 4 Bromo O-Xylene

Manufacturing Process:

- O-Xylene is taken in a Reactor. To this Liquid Bromine is added or a given period of time after addition of required amount of Bromine the mass is analyzed for completion of reaction on GC.
- When unreacted O-Xylene content is less than 1% Bromine addition is stopped and taken for Water washing.
- The Organic is taken in to the Glass lined reactor and water is added. This mass was stirred at room temperature for about 30 mins. Organic layer taken for Purification and Aqueous layer is recycled to next Batch.
- Organic Layer is then taken for Fractionation after removal of Low Boiler Impurities under Vacuum, the Product is fractionated. Pure 4 Bromo O-Xylene thus obtained is packed in 200 lit Drums.

Chemical reaction:



O - Xylene	Bromine	4 -Bromo O - Xylene	Hydrobromic Acid
M.W. : 106	M.W. : 160	M.W. : 185	M.W. : 81

Mass Balance:

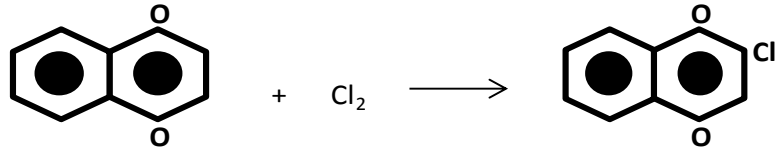
Input	Kg				Output	Kg
O - Xylene	5900		**Reaction**		4 Bromo O Xylene	10295
Bromine	8905				HBr (48%)	9390
Water	4880					
Total	19685				Total	19685
4 Bromo O Xylene	10295		**Washing**		4 Bromo O Xylene	10250
Water	3000				Water Washings	3045
Total	13295				Total	13295
4 Bromo O Xylene	10250		**Vacuum Distillation**		Main Product	9410
(Washed)					Residue	840
Total	10250				Total	10250

6.7) 2 Chloro 1,4 Naphthaquinone

Manufacturing Process:

- 1,4 Naphthaquinone is taken in a Reactor. To this Liquid Chlorine is added or a given period of time after addition of required amount of Bromine the mass is analyzed for completion of reaction on GC.
- When unreacted 1,4 Naphthaquinone content is less than 1% Chlorine addition is stopped and taken for Water washing.
- The Organic is taken in to the Glass lined reactor and water is added. This mass was stirred at room temperature for about 30 mins. Organic layer taken for Purification and Aqueous layer is recycled to next Batch.
- Organic Layer is then taken for Fractionation after removal of Low Boiler Impurities under Vacuum, the Product is fractionated. Pure 2 Chloro 1,4 naphthaquinone thus obtained is packed in 200 lit Drums.

Chemical reaction:



1,4 Naphthoquinone	Chlorine	2 Chloro 1,4 Naphthoquinone	Hydrochloric Acid
M.W. : 158	M.W. : 71	M.W. : 192.5	M.W. : 36.5

Mass Balance:

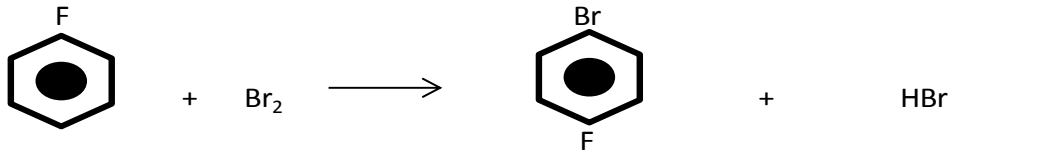
Input	Kg				Output	Kg
1,4 Naphthaquinone	8745		**Reaction**		2 Chloro 1,4 Naphthoquinone	10655
Chlorine	3930	→		→	HCl (48%)	4210
Water	2190					
Total	14865				Total	14865
2 Chloro 1,4 Naphthoquinone	10655		**Washing**		2 Chloro 1,4 Naphthoquinone	10600
Water	4000	→		→	Water Washings to ETP	4055
Total	14655				Total	14655
2 Chloro 1,4 Naphthoquinone	10600		**Vacuum Distillation**		Final Product	9750
(Washed)		→		→	Residue	850
Total	10600				Total	10600

6.8) 1 Bromo 4 Fluoro Benzene

Manufacturing Process:

- Fluoro Benzene is taken in a Reactor. To this Liquid Bromine is added or a given period of time after addition of required amount of Bromine the mass is analyzed for completion of reaction on GC.
- When unreacted Fluoro Benzene content is less than 1% Bromine addition is stopped and taken for Water washing.
- The Organic is taken in to the Glass lined reactor and water is added. This mass was stirred at room temperature for about 30 mins. Organic layer taken for Purification and Aqueous layer is recycled to next Batch.
- Organic Layer is then taken for Fractionation after removal of Low Boiler Impurities under Vacuum, the Product is fractionated. Pure 1 Bromo 4 Fluoro benzene thus obtained is packed in 200 lit Drums.

Chemical reaction:



Fluoro Benzene	Bromine	1 Bromo 4 Fluoro Benzene	Hydrobromic Acid
M.W. : 96	M.W. : 160	M.W. : 175	M.W. : 81

Mass Balance:

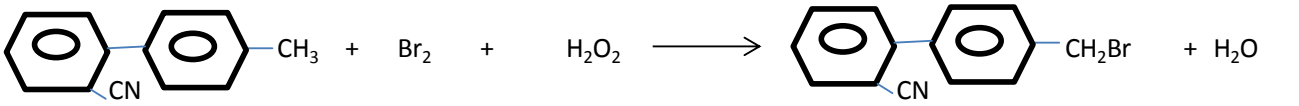
Input	Kg				Output	Kg
Fluoro Benzene	3850		**Reaction**		1 Bromo 4 Fluoro Benzene	7020
Bromine	6415				HBr (48%)	6765
Water	3520					
Total	13785				Total	13785
1 Bromo 4 Fluoro Benzene	7020		**Washing**		1 Bromo 4 Fluoro Benzene	7000
Water	3000				Water Washings to ETP	3020
Total	10020				Total	10020
1 Bromo 4 Fluoro Benzene	7000		**Vacuum Distillation**		Final Product	6450
(Washed)					Residue	550
Total	7000				Total	7000

6.9) 4 Bromo methyl 2 Cyano biphenyl (Bromo OTBN)

Manufacturing Process:

- 4 Methyl 2 Cyanobiphenyl is Brominated in Presence of Hydrogen Peroxide to get 4 Bromo Methyl 2 Cyanobiphenyl.
- The 4-Bromo Methyl Biphenyl is given Ethyl Acetate washings and subjected to Drying.
- 4 Bromo Methyl Biphenyl is then packed in 50 Kg PPE Bags.

Chemical reaction:



OTBN	Bromine	Hydrogen Peroxide	4 bromomethyl 2 Cyanobiphenyl	Water
M.W. : 193	M.W. : 160	M.W. : 34	M.W. : 272	M.W. : 18

Mass Balance:

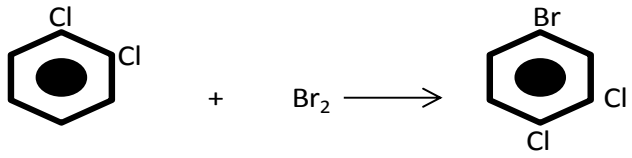
Input	Kg				Output	Kg
OTBN	500		**Reaction**		4 Bromomethyl 2 Cyanobiphenyl	825
Bromine	250				(Bromo OTBN)	
Methylene Dichloride	3250				Methylene Dichloride	3250
Hydrogen peroxide (30%)	410				Water	1335
Water	1000					
Total	5410				Total	5410
4 Bromomethyl 2 Cyanobiphenyl	4075		**Solvent Recovery**		4 Bromomethyl 2 Cyanobiphenyl	650
(Bromo OTBN) + MDC					Methylene Dichloride	3240
					Residue	185
Total	4075				Total	4075
4 Bromomethyl 2 Cyanobiphenyl	650		**Ethyl Acetate Washings**		4 Bromomethyl 2 Cyanobiphenyl	600
(Bromo OTBN)					Rec. Ethyl Acetate	1240
Ethyl Acetate	1250				Residue	60
Total	1900				Total	1900
4 Bromomethyl 2 Cyanobiphenyl	600		**Drying**		4 Bromomethyl 2 Cyanobiphenyl	550
(Bromo OTBN)					(Bromo OTBN)	
					Moisture	50
Total	600				Total	600
Ethyl Acetate	1240		**Ethyl Acetate Recovery**		Ethyl Acetate	1210
					Residue	30
Total	1240				Total	1240

6.10) 1 Bromo 3,4 Dichloro Benzene

Manufacturing Process:

- 1,2 Dichloro Benzene is taken in a Reactor. To this Liquid Bromine is added or a given period of time after addition of required amount of Bromine the mass is analyzed for completion of reaction on GC.
- When unreacted 1,2 Dichloro Benzene content is less than 1% Bromine addition is stopped and taken for Water washing.
- The Organic is taken in to the Glass lined reactor and water is added. This mass was stirred at room temperature for about 30 mins. Organic layer taken for Purification and Aqueous layer is recycled to next Batch.
- Organic Layer is then taken for Fractionation after removal of Low Boiler Impurities under Vacuum, the Product is fractionated. Pure 1 Bromo 3,4 Dichloro Benzene thus obtained is packed in 200 lit Drums.

Chemical reaction:



1,2 Dichloro Benzene	Bromine	1 Bromo 3,4 Dichloro Benzene	Hydrobromic Acid
M.W. : 147	M.W. : 160	M.W. : 226	M.W. : 81

Mass Balance:

Input	Kg				Output	Kg
1,2 Dichloro Benzene	5720		**Reaction**		1 Bromo 3,4 Dichloro Benzene	8795
Bromine	6225				HBr (48%)	6565
Water	3415					
Total	15360				Total	15360
1 Bromo 3,4 Dichloro Benzene	8795		**Washing**		1 Bromo 3,4 Dichloro Benzene	8750
Water	3000				Water Washings to ETP	3045
Total	11795				Total	11795
1 Bromo 3,4 Dichloro Benzene	8750		**Vacuum Distillation**		Final Product	7980
(Washed)					Residue	770
Total	8750				Total	8750

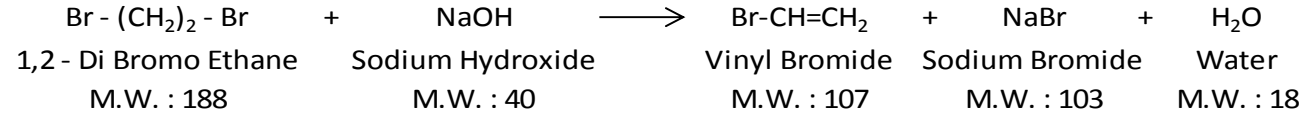
7) Dehydro-halogenation of Organic Halides Optionally with or without functional Group

7.1) Vinyl Bromide

Manufacturing Process:

- Take 1,2 Dibromo Ethane in a Reactor add dilute Methanolic Caustic over a given period of time. On completion of NaOH addition stir the mass for a stipulated time.
- Reaction completion is monitored on GC, if found Ok add water. Settle the mass and separate lower Organic layer and Top aqueous layer.
- Aqueous layer is taken for Sodium Bromide recovery and Organic layer for Product Purification. Distilled Unsaturated Vinyl Bromide is packed in 200 Lit HDPE Barrels.

Chemical reaction:



Mass Balance:

Input	Kg				Output	Kg
1,2 DiBromo Ethane	3760		**Reaction**		Vinyl Bromide	2140
NaOH	800	→		→	Sodium Bromide (48%)	4285
Water	1865				Methanol	400
Methanol	400					
Total	6825				Total	6825
Vinyl Bromide	2140		**Water Wash**		Vinyl Bromide	2100
Water	1000	→		→	Water to ETP	1040
Total	3140				Total	3140
Vinyl Bromide	2100				Main Product	2020
(Washed)		→	**Distillation**	→	Residue	80
Total	2100				Total	2100

7.2) Vinyl Bromide in THF 25%

Manufacturing Process:

- Take 1,2 Dibromo Ethane in a Reactor add dilute Methanolic Caustic over a given period of time. On completion of NaOH addition stir the mass for a stipulated time.
- Reaction completion is monitored on GC, if found Ok add water. Settle the mass and separate lower Organic layer and Top aqueous layer.

- Aqueous layer is taken for Sodium Bromide recovery and Organic layer for Product Purification. Distilled Unsaturated Vinyl Bromide is packed in 200 Lit HDPE Barrels.

Chemical reaction:

$Br - (CH_2)_2 - Br$	+	NaOH	$\longrightarrow$	$Br-CH=CH_2$	+	NaBr	+	H_2O
1,2 - Di Bromo Ethane		Sodium Hydroxide		Vinyl Bromide		Sodium Bromide		Water
M.W. : 188		M.W. : 40		M.W. : 107		M.W. : 103		M.W. : 18

Mass Balance:

Input	Kg				Output	Kg
1,2 DiBromo Ethane	3420		**Reaction**		Vinyl Bromide in THF 25%	2597
NaOH	730				Sodium Bromide (48%)	3903
Water	1700				Methanol	365
Methanol	365					
THF	650					
Total	6865				Total	6865
Vinyl Bromide in THF 25%	2597		**Water Wash**		Vinyl Bromide in THF 25%	2580
Water	1000				Water to ETP	1017
Total	3597				Total	3597
Vinyl Bromide in THF 25%	2580		**Distillation**		Vinyl Bromide in THF 25%	2405
(Washed)					Residue	175
Total	2580				Total	2580

7.3) Vinyl Chloride

Manufacturing Process:

- Take 1,2 Dichloro Ethane in a Reactor add dilute Methanolic Caustic over a given period of time. On completion of NaOH addition stir the mass for a stipulated time.
- Reaction completion is monitored on GC, if found Ok add water. Settle the mass and separate lower Organic layer and Top aqueous layer.
- Aqueous layer is taken for Sodium Bromide recovery and Organic layer for Product Purification. Distilled Unsaturated Vinyl Chloride is packed in 200 Lit HDPE Barrels.

Chemical reaction:

$Cl - (CH_2)_2 - Cl$	+	NaOH	$\longrightarrow$	$Cl-CH=CH_2$	+	NaCl	+	H_2O
1,2 - Di Chloro Ethane		Sodium Hydroxide		Vinyl Chloride		Sodium Chloride		Water
M.W. : 99		M.W. : 40		M.W. : 62.5		M.W. : 58.5		M.W. : 18

Mass Balance:

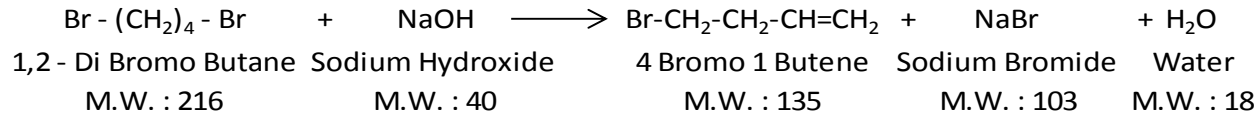
Input	Kg				Output	Kg
1,2 Dichloro Ethane	2255		Reaction		Vinyl Chloride	1425
NaOH	910				Sodium Chloride (35%)	3860
Water	2120				Methanol	400
Methanol	400					
Total	5685				Total	5685
Vinyl Chloride	1425		Water Wash		Vinyl Chloride	1410
Water	1000				Water to ETP	1015
Total	2425				Total	2425
Vinyl Chloride	1410		Distillation		Main Product	1315
(Washed)					Residue	95
Total	1410				Total	1410

7.4) 4 Bromo 1 Butene

Manufacturing Process:

- Take 1,4 Dibromo Butane in a Reactor add dilute Methanolic Caustic over a given period of time. On completion of NaOH addition stir the mass for a stipulated time.
- Reaction completion is monitored on GC, if found Ok add water. Settle the mass and separate lower Organic layer and Top aqueous layer.
- Aqueous layer is taken for Sodium Bromide recovery and Organic layer for Product Purification. Distilled Unsaturated 4 Bromo 1 Butene is packed in 200 Lit HDPE Barrels.

Chemical reaction:



Mass Balance:

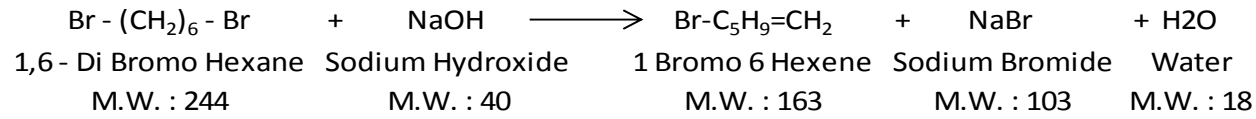
Input	Kg				Output	Kg
1,4 DiBromo Butane	3890		Reaction		4 Bromo 1 Butene	2430
NaOH	720				Sodium Bromide	1855
Water	1680				Water	2005
Methanol	400				Methanol	400
Total	6690				Total	6690
4 Bromo 1 Butene	2430		Water Wash		4 Bromo 1 Butene	2400
Water	1000				Water to ETP	1030
Total	3430				Total	3430
4 Bromo 1 Butene	2400		Distillation		4 Bromo 1 Butene	2290
(Washed)					Residue	110
Total	2400				Total	2400

7.5) 6 Bromo 1 Hexene

Manufacturing Process:

- Take 1,6 Dibromo Hexane in a Reactor add dilute Methanolic Caustic over a given period of time. On completion of NaOH addition stir the mass for a stipulated time.
- Reaction completion is monitored on GC, if found Ok add water. Settle the mass and separate lower Organic layer and Top aqueous layer.
- Aqueous layer is taken for Sodium Bromide recovery and Organic layer for Product Purification. Distilled Unsaturated 6 Bromo 1 Hexene is packed in 200 Lit HDPE Barrels.

Chemical reaction:



Mass Balance:

Input	Kg				Output	Kg
1,6 DiBromo Hexane	3905		**Reaction**		1 Bromo 6 Hexene	2610
NaOH	640				Sodium Bromide	1650
Water	1495				Water	1780
Methanol	400				Methanol	400
Total	6440				Total	6440
1 Bromo 6 Hexene	2610		**Water Wash**		1 Bromo 6 Hexene	2600
Water	1500				Water to ETP	1510
Total	4110				Total	4110
1 Bromo 6 Hexene	2600		**Distillation**		1 Bromo 6 Hexene	2500
(Washed)					Residue	100
Total	2600				Total	2600

7.6) 7 Bromo 1 Heptene

Manufacturing Process:

- Take 1,7 Dibromo Heptane in a Reactor add dilute Methanolic Caustic over a given period of time. On completion of NaOH addition stir the mass for a stipulated time.
- Reaction completion is monitored on GC, if found Ok add water. Settle the mass and separate lower Organic layer and Top aqueous layer.
- Aqueous layer is taken for Sodium Bromide recovery and Organic layer for Product Purification. Distilled Unsaturated 7 Bromo 1 Heptene is packed in 200 Lit HDPE Barrels.

Chemical reaction:

$Br - (CH_2)_7 - Br$ + NaOH ⟶ $Br\text{-}CH_2\text{-}CH_2\text{-}CH_2\text{-}CH_2\text{-}CH_2\text{-}CH{=}CH_2$ + NaBr + H_20

1,7 - Di Bromo Heptane	Sodium Hydroxide	7 Bromo 1 Heptene	Sodium Bromide	Water
M.W. : 258	M.W. : 40	M.W. : 177	M.W. : 103	M.W. : 18

Mass Balance:

Input	Kg				Output	Kg
1,7 DiBromo Heptane	3870		**Reaction**		7 Bromo 1 Heptene	2655
NaOH	600				Sodium Bromide (48%)	3215
Water	1400				Methanol	400
Methanol	400					
Total	6270				Total	6270
7 Bromo 1 Heptene	2655		**Water Wash**		7 Bromo 1 Heptene	2640
Water	1500				Water to ETP	1515
Total	4155				Total	4155
7 Bromo 1 Heptene	2640		**Distillation**		7 Bromo 1 Heptene	2535
(Washed)					Residue	105
Total	2640				Total	2640

7.7) 8 Bromo 1 Octene

Manufacturing Process:

- Take 1,8 Dibromo Octane in a Reactor add dilute Methanolic Caustic over a given period of time. On completion of NaOH addition stir the mass for a stipulated time.
- Reaction completion is monitored on GC, if found Ok add water. Settle the mass and separate lower Organic layer and Top aqueous layer.
- Aqueous layer is taken for Sodium Bromide recovery and Organic layer for Product Purification. Distilled Unsaturated 8 Bromo 1 Octene is packed in 200 Lit HDPE Barrels.

Chemical reaction:

$Br - (CH_2)_8 - Br$ + NaOH ⟶ $Br\text{-}C_7H_{13}{=}CH_2$ + NaBr + H2O

1,8 - Di Bromide Octane	Sodium Hydroxide	1 Bromo 8 Octene	Sodium Bromide	Water
M.W. : 272	M.W. : 40	M.W. : 191	M.W. : 103	M.W. : 18

Mass Balance:

Input	Kg				Output	Kg
1,8 DiBromo Octane	4488		**Reaction**		1 Bromo 8 Octene	3152
NaOH	660				Sodium Bromide (48%)	3656
Water	1660				Methanol	402
Methanol	402					
Total	7210				Total	7210
1 Bromo 8 Octene	3152		**Water Wash**		1 Bromo 8 Octene	3100
Water	2000				Water to ETP	2052
Total	5152				Total	5152
1 Bromo 8 Octene	3100		**Distillation**		1 Bromo 8 Octene	3035
(Washed)					Residue	65
Total	3100				Total	3100

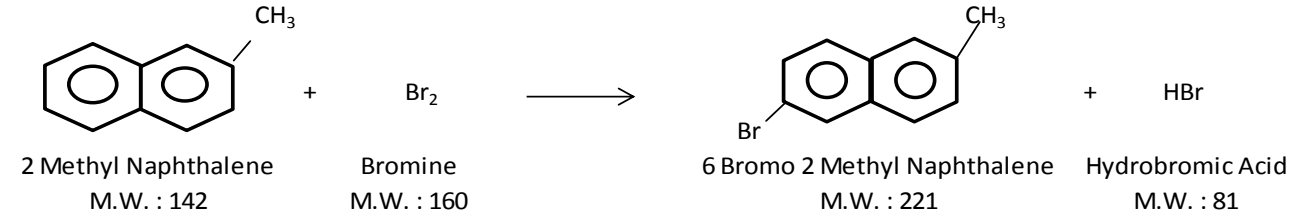
8) Advance Intermediates from Category 1 to 7

8.1) 6 Methoxy 2 Naphthaldehyde

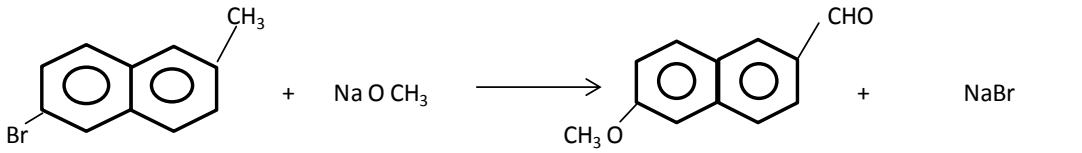
Manufacturing Process:

- 2 Methyl Naphthalene is Brominated to get 6 Bromo 2 Methyl Naphthalene. This on reaction with Sodium Methoxide will give 6 Methoxy 2 Methyl Naphthalene.
- This on Controlled Oxidation will give 6 Methoxy 2 Naphthaldehyde.

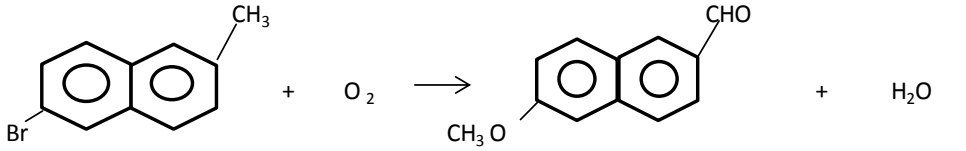
Chemical reaction:



2 Methyl Naphthalene M.W. : 142 | Bromine M.W. : 160 | 6 Bromo 2 Methyl Naphthalene M.W. : 221 | Hydrobromic Acid M.W. : 81



6 Bromo 2 Naphthalene M.W. : 221 | Sodium Methoxic M.W. : 54 | 6 Methoxy Naphthaldehyde M.W. : 186 | Sodium Bromide M.W. : 103



6 Bromo 2 Naphthalene M.W. : 221 | Oxygen M.W. : 32 | 6 Methoxy Naphthaldehyde M.W. : 186 | Water M.W. : 18

Mass Balance:

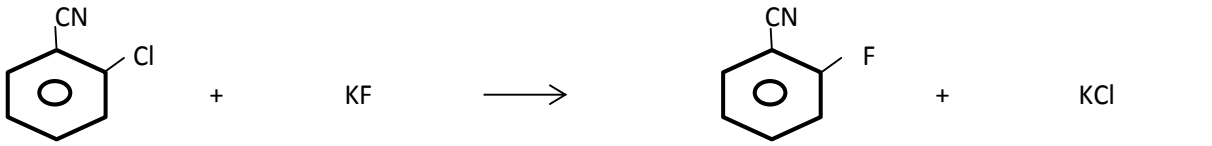
Input	Kg				Output	Kg
Naphthaldehyde	3805				6 Bromo Naphthaldehyde	5920
Bromine	4285	→	**Reaction**	→	HBr (48%)	4520
Water	2350					
Total	10440				Total	10440
6 Bromo Naphthaldehyde	5920				6 Methoxy Naphthaldehyde	4605
Sodium Methoxide	1445	→	**Reaction**	→	Sodium Bromide	2760
Methanol	3375				Methanol	3375
Total	10740				Total	10740
6 Bromo Naphthaldehyde	4605				6 Methoxy Naphthaldehyde	4980
Oxygen	855	→	**Reaction**	→	Water	480
Total	5460				Total	5460
6 Methoxy Naphthaldehyde	4980				Main Product	4900
		→	**Drying**	→	Moisture	80
Total	4980				Total	4980

8.2) 2 Fluoro 5 Bromo Benzonitrile

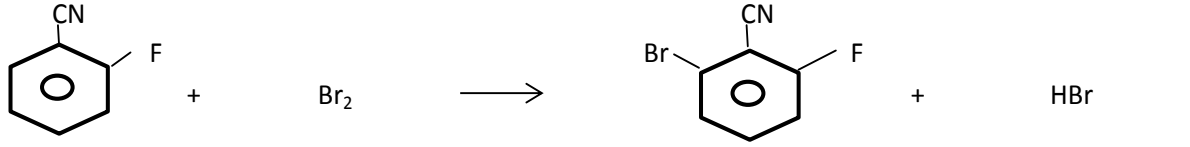
Manufacturing Process:

- 2 Chloro benzonitrile is reacted with Potassium Fluoride Solution (30%) to get 2 Fluoro Benzonitrile which is then brominated to get 2 Fluoro 5 Bromo Benzonitrile.
- 2 Fluoro 5 Bromo Benzonitrile is then washed and then Fractionated to get Pure Product which is then packed in 200 Lit HDPE Barrels.

Chemical reaction:



2 Chloro Benzonitrile M.W. : 137.5 + Potassium Fluoride M.W. : 58 → 2 Fluoro Benzonitrile M.W. : 121 + Potassium Chloride M.W. : 74.5



2 Fluoro Benzonitrile M.W. : 121 + Bromine M.W. : 160 → 2 Fluoro 5 Bromo Benzonitrile M.W. : 200 + Hydrogen Bromide M.W. : 81

Mass Balance:

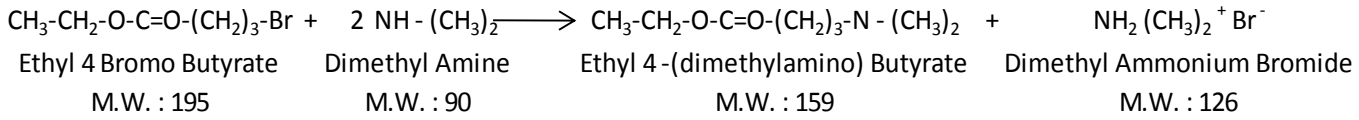
Input	Kg				Output	Kg
2 Chloro Benzonitrile	3445		**Reaction**		2 Fluoro 5 Bromo Benzonitrile	5010
Potassium Fluoride (30%)	4845				Potassium Chloride (35%)	5255
Bromine	4015				HBr (48 %)	4240
Water	2200					
Total	14505				Total	14505
2 Fluoro 5 Bromo Benzonitrile	5010		**Washing**		2 Fluoro 5 Bromo Benzonitrile	5000
Water	2000				Water Washings	2010
Total	7010				Total	7010
2 Fluoro 5 Bromo Benzonitrile	5000		**Vacuum Distillation**		Main Fraction	4520
(Washed)					Residue	480
Total	5000				Total	5000

8.3) Ethyl 4 -(dimethylamino) Butyrate

Manufacturing Process:

- Ethyl 4 Bromo Butyrate is reacted with Dimethyl amine 30% in Presence of Ethyl Acetate to get Ethyl 4 (dimethylamino) Butyrate and Dimethyl ammonium Bromide salt.
- Ethyl 4 (dimethylamino) Butyrate is the given Ethyl Acetate washings and then Packed in 200 Lit HDPE Barrels.
- Ethyl acetate washings are the fractionated to get Dist. Ethyl Acetate.

Chemical reaction:



Mass Balance:

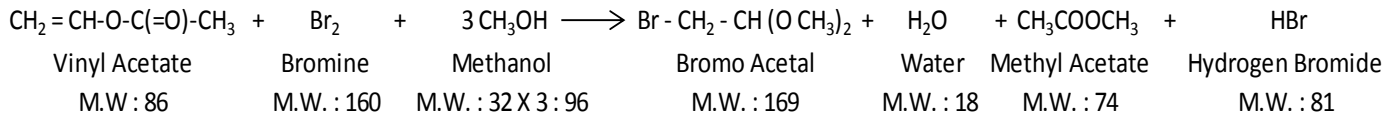
Input	Kg				Output	Kg
Ethyl 4 Bromo Butyrate	1840		**Reaction**		Ethyl 4 dimethylamino Butyrate	1500
Dimethyl Amine	850				Dimethyl Ammonium Bromide	1190
Ethyl Acetate	1985				Ethyl Acetate	1985
Total	4675				Total	4675
Ethyl 4 dimethylamino Butyrate	1500		**Filtration**		Ethyl 4 dimethylamino Butyrate	1490
Ethyl Acetate	1000				Washings	1010
Total	2500				Total	2500
Ethyl Acetate Washings	2995		**Ethyl Acetate Recovery**		Ethyl Acetate	2865
					Residue	130
Total	2995				Total	2995

8.4) Bromo Acetal

Manufacturing Process:

- Vinyl Acetate is reacted with Bromine and Methanol to get Bromo Acetal and Methyl Acetate Mixture, which is then given Soda washing.
- Then the mixture is then fractionated to get Bromo Acetal and Methyl Acetoacetate; Bromo Acetal is then packed in 200 HDPE Barrels.

Chemical reaction:



Mass Balance:

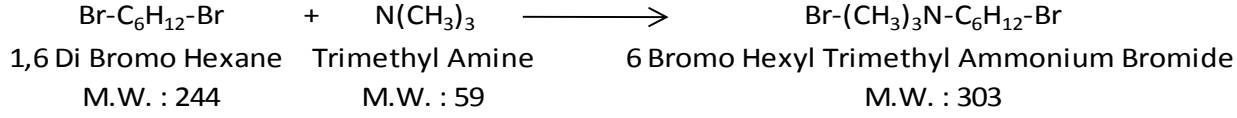
Input	Kg				Output	Kg
Vinyl Acetate	430				Bromo Acetal & Methyl Acetate	1140
Methanol	832				HBr (16%)	2622
Bromine	800	→	**Reaction**	→		
Water	1700					
Total	3762				Total	3762
Bromo Acetal & methyl Acetate	1140				Bromo Acetal & Methyl Acetate	1060
Soda solution	400	→	**Water Washing**	→	Washings to ETP	480
Total	1540				Total	1540
Bromo Acetal & Methyl Acetate	1060				Bromo Acetal	668
		→	**Vacuum Distillation**	→	Methyl Acetoacetate	342
					Residue	50
Total	1060				Total	1060

8.5) 6 Bromo Hexyl Trimethyl Ammonium bromide

Manufacturing Process:

- Aqueous Trimethyl Amine is reacted with 1,6 Dibromo Hexane to get 6 Bromo Hexyl Trimethyl Ammonium Bromide.
- The Material is then Filtered and Dried to get the Final Product which is then packed in 50 Kg HDPE Drums.

Chemical reaction:



Mass Balance:

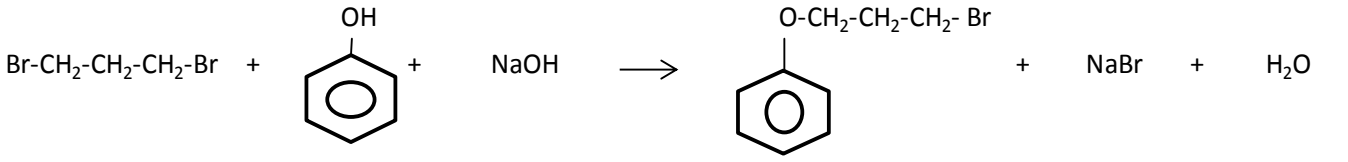
Input	Kg				Output	Kg
1,6-Dibromohexane	2540		**Reaction**		DBH crude	1070
Trimethyl amine Gas	350				6BHTMAB	1820
Total	2890				Total	2890
6BHTMAB	1820		**Filtration**		6BHTMAB	1800
DBH crude	1070				DBH crude	1090
Total	2890				Total	2890
DBH crude	1090		**Distillation**		1,6 Dibromohexane	950
					Residue	140
Total	1090				Total	1090

8.6) 1 Bromo 3 Phenoxy Propane

Manufacturing Process:

- 1,3 Dibromo Propane is taken in a reactor to that Phenol is added and then Sodium Hydroxide solution (40%) is added to get 1 Bromo 3 Phenoxy Propane.
- The Product is then given the Water washing Layer separation is done. Organic Layer is taken for Fractionation and Aqueous Layer is separated to get Sodium Bromide Solution.
- Organic Layer is fractionated to get Pure 1 Bromo 3 Phenoxy Propane.

Chemical reaction:



Mass Balance:

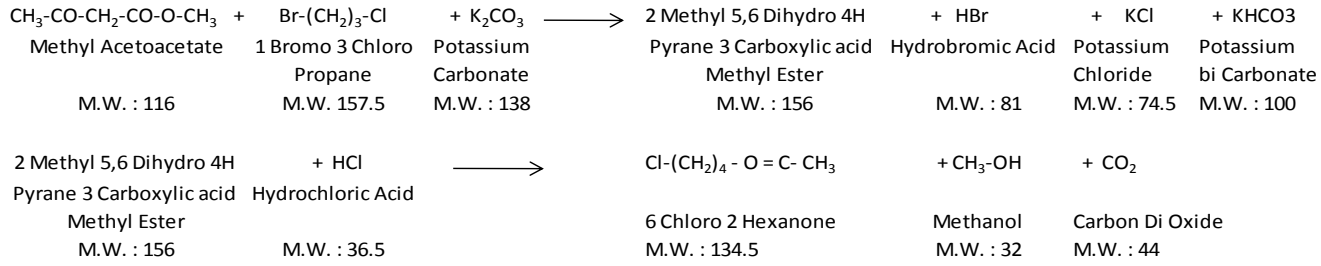
Input	Kg				Output	Kg
1,3 Dibromo Propane	3780		Reaction		1 Bromo 3 Phenoxy Propane	4022
Phenol	1760				Sodium Bromide (55%)	3390
Sodium Hydroxide (40%)	1872					
Total	7412				Total	7412
1 Bromo 3 Phenoxy Propane	4022		Water Wash		1 Bromo 3 Phenoxy Propane	4010
Water	1000				Water to ETP	1012
Total	5022				Total	5022
1 Bromo 3 Phenoxy Propane	4010		Vacuum Distillation		Main Product	3675
					Residue	335
Total	4010				Total	4010

8.7) 6 Chloro 2 Hexanone

Manufacturing Process:

- Methyl Acetoacetate is reacted with 1 Bromo 3 Chloro Propane to get Potassium Carbonate to get an Intermediate stage which is then further reacted with Hydrochloric Acid to get 6 Chloro 2 Hexanone.

Chemical reaction:



Mass Balance:

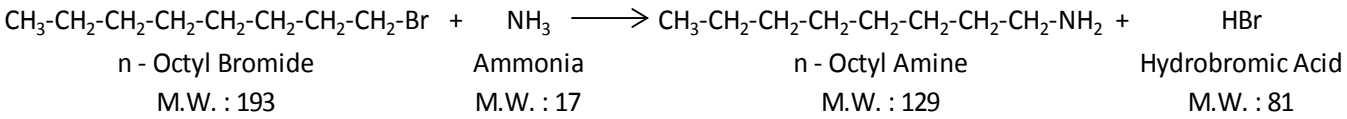
Input	Kg				Output	Kg
Methyl Acetoacetate	655		Reaction		Intermediate Stage	881
1 Bromo 3 Choro Propane	890				HBr	458
Potassium Carbonate (30%)	2600				KCl	421
IPA	2515				KHCO3	2385
					IPA	2515
Total	6660				Total	6660
Input	Kg				Output	Kg
Intermediate Stage	881		Reaction		6 Chloro 2 Hexanone	760
HCl (40%)	525				CH3-OH and Water	398
					CO2	248
Total	1406				Total	1406

8.8) n Octyl Amine

Manufacturing Process:

- n-Octyl Bromide in reacted with Liquor Ammonia to get n-Octyl Amine.

Chemical reaction:



Mass Balance:

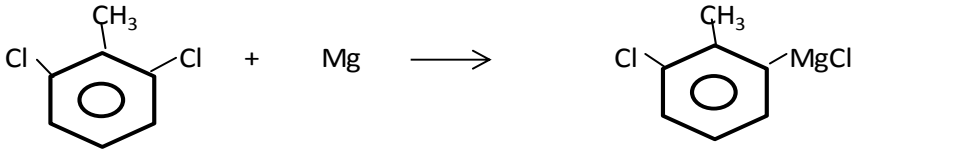
Input	Kg				Output	Kg
n Octyl Bromide	6435	→	**Reaction**	→	n Octyl Amine	4300
Ammonia (20%)	2830				Hydrobromic Acid (48%)	5625
Water	660					
Total	9925				Total	9925
n Octyl Amine	4300	→	**Water Wash**	→	n Octyl Amine	4250
Water	2000				Water to ETP	2050
Total	6300				Total	6300
n Octyl Amine	4250	→	**Vacuum Distillation**	→	Main Product	3900
					Residue	350
Total	4250				Total	4250

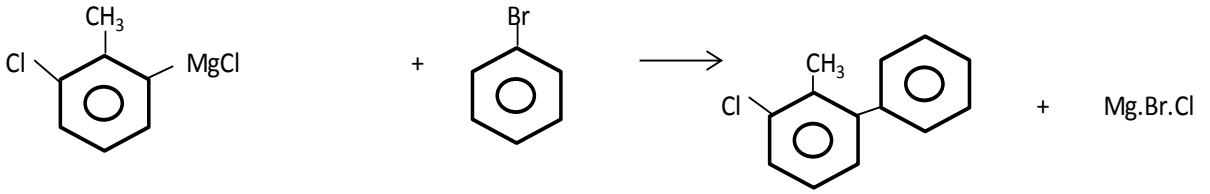
8.9) Bifenthrin Alcohol

Manufacturing Process:

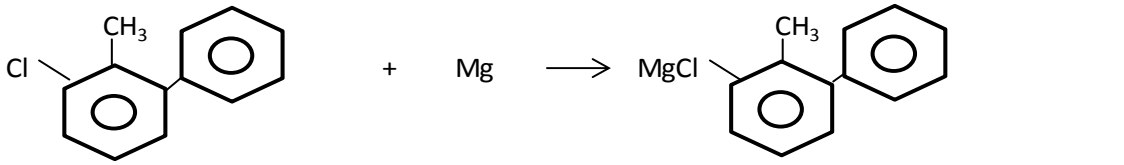
- Charge 2,6 Dichloro toluene in reactors and slowly add Mg metal. Stir entire mass for completion of the reaction.
- After completion of the reaction 2 MgCl 6 chloro toluene will be obtained. This mass is further react with Bromo benzene. During the reaction Mg is replaced and 2 benzene 6 chloro benzene will be obtained and MgBrCl is obtained as byproduct.
- 2 benzene 6 chloro benzene is further react with Mg and convert in to 2 benzene 6 magnesium chloride benzene. This mass is further react with formaldehyde and get final product.

Chemical reaction:

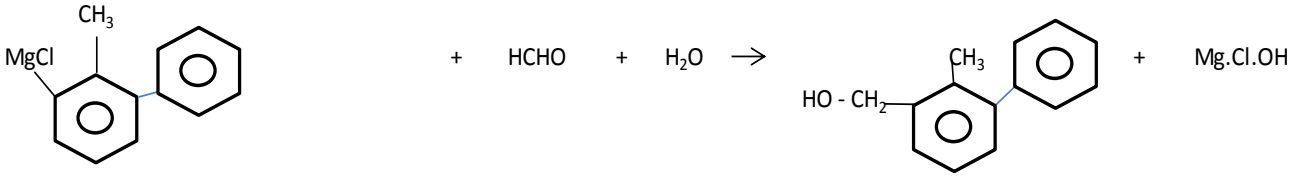




2 Magnesium Chloro,6 Chloro Toluene	Bromo Benzene	2 Benzene 6 Chloro Benzene	Magnesium Bromo Chloride
M.W. : 186	M.W. : 157	M.W. : 203.5	M.W. : 139.5



2 Benzene 6 Chloro Benzene	Magnesium	2 Benzene 6 Magnesium Chloride Benzene
M.W. : 203.5	M.W. : 24	M.W. : 227.5



2 Benzene 6 Magnesium Chloride Benzene	Formaldehyde	Water	Bifenthrin Alcohol	Magnesium Chloro Oxide
M.W. : 227.5	M.W. : 30	M.W. : 18	M.W. : 199	M.W. : 76.5

Mass Balance:

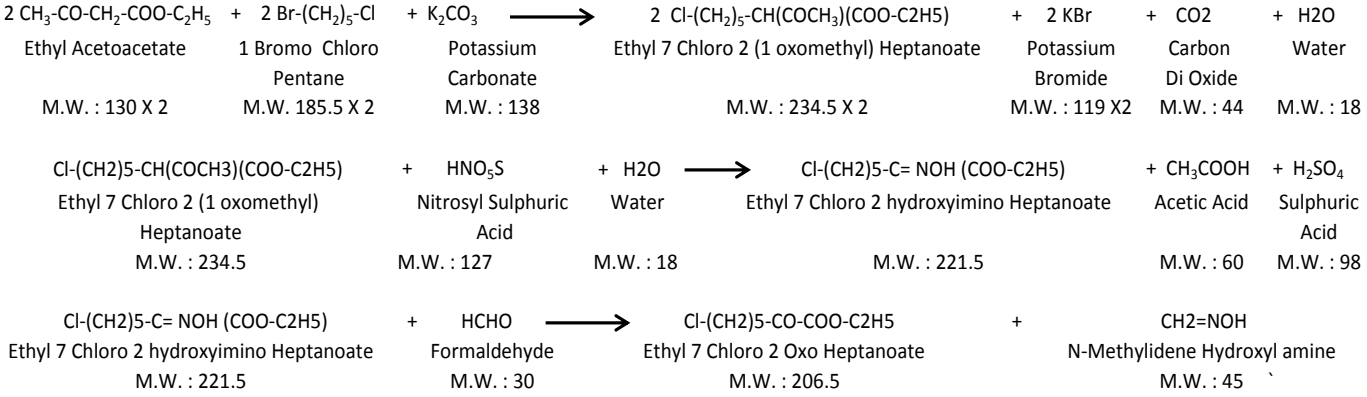
Input	Kg				Output	Kg
Dichloro Toluene	5000				Bifenthrin Alcohol	6140
Magnesium	1480				Mg.Br.Cl	4305
Bromo Benzene	4845	→	**Reaction**	→	Mg.Cl.OH	2360
Formaldehyde (60%)	1480				Rec. THF	4550
THF	4550					
Total	17355				Total	17355
Bifenthrin Alcohol	6140				Bifenthrin Alcohol	6115
Water	2000	→	**Washing**	→	Water to ETP	2025
Total	8140				Total	8140
Bifenthrin Alcohol	6115				Main Product	5565
		→	**Vacuum Distillation**	→	Residue	550
Total	6115				Total	6115

8.10) Ethyl 7 Chloro 2 Oxo Heptanoate

Manufacturing Process:

- Ethyl Acetoacetate is reacted with 1 Bromo 5 Chloro pentane in Presence of Potassium carbonate to get Ethyl 7 Chloro Heptanoate which is then reacted with Nitrosyl Sulphuric acid and Formaldehyde to get Ethyl 7 Chloro 2 hydroamino Heptanoate.
- This is then purified with Formaldehyde to get Ethyl 7 Chloro 2 Oxo Heptanoate.

Chemical reaction:



Mass Balance:

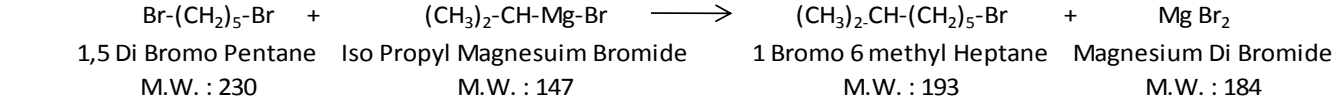
Input	Kg				Output	Kg
Ethyl Acetoacetate	2080				Ethyl 7 Chloro 2(1-oxomethyl)-Heptanoate	3750
1 Bromo 5 Choro Pentane	2965					
Potassium Carbonate	1105	→	**Reaction**	→	Potassium Bromide	1905
					Carbon Di Oxide	352
					Water	143
Total	6150				Total	6150
Ethyl 7 Chloro 2(1-oxomethyl)-Heptanoate	1875				Ethyl 7 Chloro 2(Hydroxyamino)-Heptanoate	1770
Nitrosyl Sulphuric Acid	1160	→	**Reaction**	→	Acetic Acid	480
Toluene	2000				Sulphuric Acid	785
					Toluene	2000
Total	5035				Total	5035
Ethyl 7 Chloro 2(Hydroxyamino)-Heptanoate	1770				Ethyl 7 Chloro 2 oxo Heptanoate	1650
		→	**Reaction**	→	N-Methylidene Hydroxyl amine	360
Formaldehyde (35%)	685				Water	445
Toluene	2000				Toluene	2000
Total	4455				Total	4455

8.11) 1 Bromo 6 Methyl Heptane

Manufacturing Process:

- 1,5 Dibromo Pentane is reacted with Iso Propyl Magnesium Bromide over a Period of time. The Progress of reaction is monitored by GC.
- The Product is then packed in 200 Lit HDPE Barrels.

Chemical reaction:



Mass Balance:

Input	Kg				Output	Kg
1,5 Di Bromo Pentane	4052		Reaction		1 Bromo 6 Methyl Heptane	3400
Iso Propyl Magnesium	16683				Magnesium Bromide	17335
-Bromide in THF						
Total	20735				Total	20735
1 Bromo 6 Methyl Heptane	3400		Water Washing		1 Bromo 6 Methyl Heptane	3350
Water	1000				Washings to ETP	1050
Total	4400				Total	4400
Magnesium Bromide in THF	17335		Distillation		Magnesium Bromide	3200
					THF	14000
					Residue	135
Total	17335				Total	17335

8.12) Methyl 3 Oxo Pentanoate

Manufacturing Process:

- Chlorination of Butyl Methyl Ketone is carried out to get Chloro Derivative. This on Cynation gives Cyano Compound.
- The Cyano Compound on Hydrolysis and Esterification gives Methyl 3 Oxo pentanoate.

Chemical reaction:

$CH_3\text{-}CH_2\text{-}C(=O)\text{-}CH_3$ + Cl_2 $\longrightarrow$ $CH_3\text{-}CH_2\text{-}C(=O)\text{-}CH_2Cl$ + HCl

Ethyl Methyl Ketone M.W : 72 | Chlorine M.W. : 71 | Ethyl Chloro Methyl Ketone M.W. : 106.5 | Hydrochloric Acid M.W. : 36.5

$CH_3\text{-}CH_2\text{-}C(=O)\text{-}CH_2Cl$ + NaCN $\longrightarrow$ $CH_3\text{-}CH_2\text{-}C(=O)\text{-}CH_2CN$ + NaCl

Ethyl Chloro Methyl Ketone M.W. : 106.5 | Sodium Cyanide M.W. : 49 | Ethyl Cyano Methyl Ketone M.W. : 97 | Sodium Chloride M.W. : 58.5

$CH_3\text{-}CH_2\text{-}C(=O)\text{-}CH_2CN$ + H_2SO_4 + $2\,H_2O$ $\longrightarrow$ $CH_3\text{-}CH_2\text{-}C(=O)\text{-}CH_2COOH$ + NH_4HSO_4

Ethyl Cyano Methyl Ketone M.W. : 97 | Sulphuric Acid M.W. : 98 | Water M.W. : 36 | 3 Oxo Pentanoic Acid M.W. : 116 | Ammonium Bisulphite M.W. : 115

$CH_3\text{-}CH_2\text{-}C(=O)\text{-}CH_2COOH$ + $CH_3\text{-}OH$ $\longrightarrow$ $CH_3\text{-}CH_2\text{-}C(=O)\text{-}CH_2COOCH_3$ + H_2O

3 Oxo Pentanoic Acid M.W. : 116 | Methanol M.W. : 32 | Methyl 3 Oxo Pentanoate M.W. : 130 | Water M.W. : 18

Mass Balance:

Input	Kg				Output	Kg
Butyl methyl ketone	3055		**Reaction**		Methyl 2 oxo Pentanoate	5515
Chlorine	3015				Hydrochloric Acid	1545
Sodium Cyanide	2075				Sodium Chloride	2475
Sulphuric Acid (65%)	6375				Ammonium Bisulphite	4860
Methanol	1355				Water	1480
Total	15875				Total	15875
Methyl 3 Oxo Pentanoate	5515		**Water Washing**		Methyl 3 Oxo Pentanoate	5500
Water	2000				Washings to ETP	2015
Total	7515				Total	7515
Methyl 3 Oxo Pentanoate	5500		**Vacuum Distillation**		Main Product	5025
					Residue	475
Total	5500				Total	5500

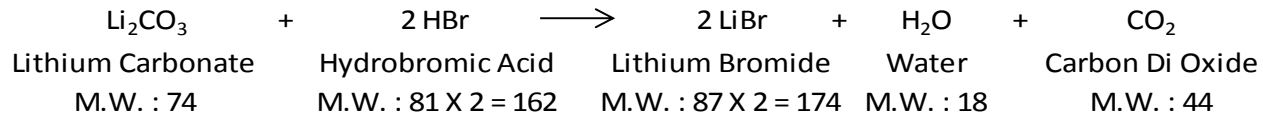
9) Lithium Carbonate or Hydroxide reaction with Inorganic or Organic Acids

9.1) Lithium Bromide 55%

Manufacturing Process:

- Hydrobromic Acid 48% is reacted with Lithium Carbonate Powder to get Lithium Bromide.
- Lithium Bromide is then subjected to heating to get desired Concentration of Lithium Bromide 55% which is then packed in 200 Lit HDPE Barrels.

Chemical reaction:



Mass Balance:

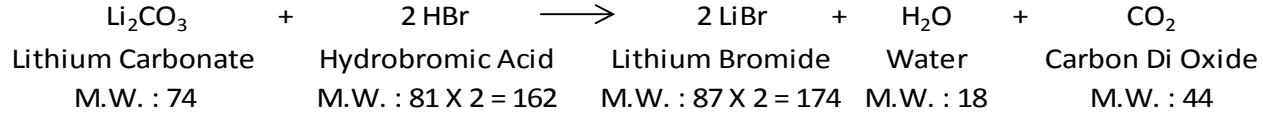
Input	Kg				Output	Kg
Lithium Carbonate	3000				Lithium Bromide	7055
Hydrobromic Acid (48%)	13685				Carbon Di Oxide	1785
		→	**Reaction**	→	Water from Reaction	730
					Water from HBr	7115
Total	16685				Total	16685
Lithium Bromide as is (45%)	14900				Lithium Bromide as is (55%)	12830
		→	**Concentration**	→	Distilled Water	2070
Total	14900				Total	14900

9.2) Lithium Bromide anhydrous

Manufacturing Process:

- Hydrobromic Acid 48% is reacted with Lithium Carbonate Powder is added to get Lithium Bromide.
- Lithium Bromide is then subjected to heating to get desired Concentration and then Drying to get Lithium Bromide anhydrous.
- The Product is then packed in 50 Kg PPE Bag.

Chemical reaction:



Mass Balance:

Input	Kg				Output	Kg
Lithium Carbonate	3000				Lithium Bromide	7055
Hydrobromic Acid (48%)	13685				Carbon Di Oxide	1785
		→	**Reaction**	→	Water from Reaction	730
					Water from HBr	7115
Total	16685				Total	16685
Lithium Bromide as is (45%)	14900				Lithium Bromide as is (55%)	12830
		→	**Concentration**	→	Distilled Water	2070
Total	14900				Total	14900
Lithium Bromide as is (55%)	12830				Lithium Bromide as is (98%)	7055
		→	**Drying**	→	Moisture	5775
Total	12830				Total	12830

9.3) Lithium Chloride 40%

Manufacturing Process:

- Hydrochloric Acid 30% is reacted with Lithium Carbonate Powder is added to get Lithium Chloride.
- Lithium Chloride is then subjected to heating to get desired Concentration of Lithium Chloride 40% which is then packed in 200 Lit HDPE Barrels.

Chemical reaction:

$$Li_2CO_3 + 2\,HCl \longrightarrow 2\,LiCl + H_2O + CO_2$$

Lithium Carbonate	Hydrochloric Acid	Lithium Chloride	Water	Carbon Di Oxide
M.W. : 74	M.W. : 36.5 X 2 = 73	M.W. : 42.5 X 2 = 85	M.W. : 18	M.W. : 44

Mass Balance:

Input	Kg				Output	Kg
Lithium Carbonate	2650				Lithium Chloride	3045
Hydrochloric Acid (30%)	8715				Carbon Di Oxide	1575
		→	**Reaction**	→	Water from Reaction	645
					Water from HCl	6100
Total	11365				Total	11365
Lithium Chloride as is (31%)	9790				Lithium Chloride as is (40%)	7615
		→	**Concentration**	→	Distilled Water	2175
Total	9790				Total	9790

9.4) Lithium Chloride anhydrous

Manufacturing Process:

- Hydrochloric Acid 30% is reactor to with Lithium Carbonate Powder is added to get Lithium Chloride.
- Lithium Chloride is then subjected to heating to get desired Concentration of Lithium Chloride.
- The Product is then dried then packed in 50 Kg PPE Bag.

Chemical reaction:

Li_2CO_3 + 2 HCl ⟶ 2 LiCl + H_2O + CO_2

Lithium Carbonate	Hydrochloric Acid	Lithium Chloride	Water	Carbon Di Oxide
M.W. : 74	M.W. : 36.5 X 2 = 73	M.W. : 42.5 X 2 = 85	M.W. : 18	M.W. : 44

Mass Balance:

Input	Kg				Output	Kg
Lithium Carbonate	2650				Lithium Chloride	3045
Hydrochloric Acid (30%)	8715				Carbon Di Oxide	1575
		→	**Reaction**	→	Water from Reaction	645
					Water from HCl	6100
Total	11365				Total	11365
Lithium Chloride as is (31%)	9790				Lithium Chloride as is (40%)	7615
		→	**Concentration**	→	Distilled Water	2175
Total	9790				Total	9790
Lithium Chloride as is (95%)	3205				Lithium Chloride anhydrous	3045
		→	**Drying**	→	Distilled Water	160
Total	3205				Total	3205

9.5) Lithium Nitrate

Manufacturing Process:

- Nitric Acid 68% is reacted with Lithium Carbonate Powder to get Lithium Nitrate.
- Lithium Nitrate is then subjected to heating to get desired Concentration of Lithium Nitrate 98% which is then packed in 50 Kg PPE Bags.

Chemical reaction:

Li_2CO_3 + 2 HNO_3 ⟶ 2 $LiNO_3$ + H_2O + CO_2

Lithium Carbonate	Nitric Acid	Lithium Nitrate	Water	Carbon Di Oxide
M.W. : 74	M.W. : 63 X 2 = 126	M.W. : 69 X 2 = 138	M.W. : 18	M.W. : 44

Mass Balance:

Input	Kg				Output	Kg
Lithium Carbonate	4515				Lithium Nitrate	8420
Nitric Acid (68%)	11300				Carbon Di Oxide	2685
		→	**Reaction**	→	Water from Reaction	1100
					Water from Nitric Acid	3610
Total	15815				Total	15815
Lithium Nitrate as is (65%)	13130				Lithium Nitrate as is (98%)	8590
		→	**Concentration**	→	Distilled Water	4540
Total	13130				Total	13130

9.6) Lithium Sulfate

Manufacturing Process:

- Sulphuric Acid 98% is reacted with Lithium Carbonate to get Lithium Sulphate 85%.

- Lithium Sulphate is then subjected to heating to get Dry Lithium Sulphate Powder which is then packed in 50 Kg PPE Bags.

Chemical reaction:

Li_2CO_3	+	H_2SO_4	⟶	Li_2SO_4	+	H_2O	+	CO_2
Lithium Carbonate		Sulphuric Acid		Lithium Sulfate		Water		Carbon Di Oxide
M.W. : 74		M.W. : 98		M.W. : 110		M.W. : 18		M.W. : 44

Mass Balance:

Input	Kg				Output	Kg
Lithium Carbonate	7930				Lithium Sulfate	11785
Sulphuric Acid	10500				Carbon Di Oxide	4715
		⟶	**Reaction**	⟶	Water from Reaction	1930
Total	18430				Total	18430
Lithium Sulfate as is (85%)	13715				Lithium Sulfate as is (98%)	12025
		⟶	**Drying**	⟶	Moisture	1690
Total	13715				Total	13715

9.7) Lithium Molybdate 20%

Manufacturing Process:

- Lithium Hydroxide Monohydrate is reacted with Molybdenum Trioxide to get Lithium Molybdate.
- Lithium Molybdate is then subjected to heating to get desired Lithium Molybdate 20% which is then packed in 200 Lit HDPE Barrels.

Chemical reaction:

2 LiOH . H2O	+	Mo.O3	⟶	Li2 Mo.O4	+	3 H_2O
Lithium Hydroxide Monohydrate		Molybdenum Trioxide		Lithium Molybdate		Water
M.W. : 84		M.W. : 144		M.W. : 174		M.W. : 54

Mass Balance:

Input	Kg				Output	Kg
Lithiun Hydroxide Monohydrate	1060				Lithium Molybdate 19.4 %	5670
Molybdenum Trioxide	910					
Water	3700	⟶	**Reaction**	⟶		
Total	5670				Total	5670
Lithium Molybdate 19.4%	5670				Lithium Acetate 20%	5500
		⟶	**Concentration**	⟶	Moisture removed	170
Total	5670				Total	5670

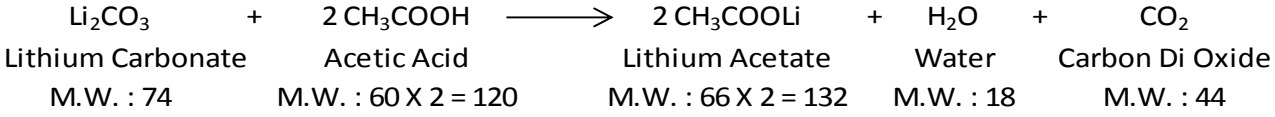
9.8) Lithium Acetate

Manufacturing Process:

- Acetic Acid 98% is taken in a Reactor to this the Lithium Carbonate Powder is added to get Lithium Acetate 88%.

- Lithium Acetate is then subjected to heating to get desired Dry Lithium Acetate Powder which is then packed in 50 Kg PPE Bags.

Chemical reaction:



Mass Balance:

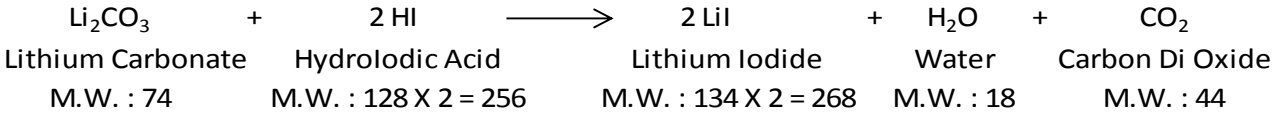
Input	Kg				Output	Kg
Lithium Carbonate	4810				Lithium Acetate	8580
Acetic Acid	7800	→	**Reaction**	→	Carbon Di Oxide	2860
					Water from Reaction	1170
Total	12610				Total	12610
Lithium Acetate as is (88%)	9750				Lithium Acetate as is (97%)	9555
		→	**Drying**	→	Moisture removed	195
Total	9750				Total	9750

9.9) Lithium Iodide

Manufacturing Process:

- Hydroiodic Acid 30% is taken in a Reactor to this the Lithium Carbonate Powder is added to get Lithium Iodide.
- Lithium Iodide is then subjected to heating to get desired Concentration of Lithium Iodide 55 % which is then packed in 200 Lit HDPE Barrels.

Chemical reaction:



Mass Balance:

Input	Kg				Output	Kg
Lithium Carbonate	3610				Lithium Iodide	13075
Hydro Iodic Acid (48 %)	26020				Carbon Di Oxide	2145
		→	**Reaction**	→	Water from Reaction	880
					Water from HBr	13530
Total	29630				Total	29630
Lithium Iodide as is (45%)	27485				Lithium Iodide as is (55%)	23770
		→	**Concentration**	→	Distilled Water	3715
Total	27485				Total	27485

9.10) Lithium Fluoride

Manufacturing Process:

- HydroFluoric Acid 30% is taken in a Reactor to this the Lithium Carbonate Powder is added to get Lithium Iodide.
- Lithium Fluoride is then subjected to heating to get desired Concentration of Lithium Chloride 55% which is then packed in 200 Lit HDPE Barrels.

Chemical reaction:

Li_2CO_3	+	2 HF	⟶	2 LiF	+	H_2O	+	CO_2
Lithium Carbonate		HydroFluoric Acid		Lithium Fluoride		Water		Carbon Di Oxide
M.W. : 74		M.W. : 20 X 2 = 40		M.W. : 26 X 2 = 52		M.W. : 18		M.W. : 44

Mass Balance:

Input	Kg				Output	Kg
Lithium Carbonate	6290				Lithium Fluoride	4420
Hydrofluoric Acid (48%)	7085		**Reaction**		Carbon Di Oxide	3740
					Water from Reaction	1530
					Water from HBr	3685
Total	13375				Total	13375
Lithium Fluoride as is (45%)	9635		**Concentration**		Lithium Fluoride as is (55%)	8035
					Distilled Water	1600
Total	9635				Total	9635

10) Hydrobromic Acid from Bromine

10.1) Hydrogen Bromide 48% to 62%

Manufacturing Process:

- Bromine is reacted with the Hydrogen gas to get Hydrobromic Acid. The Hydrobromic Acid is then absorbed in Water to get Hydrogen Bromide 48% to 62% concentration by controlling the amount of water.

Chemical reaction:

Br_2 + H_2 ⟶ 2 HBr

Bromine (M.W. : 160) + Hydrogen (M.W. : 2) ⟶ Hydrogen Bromide (M.W. : 162)

Mass Balance:

Input	Kg				Output	Kg
Bromine	1600				Hydrogen Bromide (48%)	3375
Hydrogen	20	⟹	**Reaction**	⟹		
Water	1755					
Total	3375				Total	3375

10.2) Hydrogen Bromide 20% in IPA

Manufacturing Process:

- The Hydrogen Bromide gas is absorbed in Iso Propyl Alcohol to get Hydrogen Bromide 20% in IPA.
- The Hydrogen Bromide 20% in IPA is then packed in 200 Liters HDPE Barrels.

Chemical reaction:

Br_2 + H_2 ⟶ 2 HBr

Bromine (M.W. : 160) + Hydrogen (M.W. : 2) ⟶ Hydrogen Bromide (M.W. : 162)

Mass Balance:

Input	Kg				Output	Kg
Bromine	1600				Hydrogen Bromide (20%)	8100
Hydrogen	20	⟹	**Reaction**	⟹	in IPA	
Iso Propyl Alcohol	6480					
Total	8100				Total	8100

10.3) Hydrogen Bromide 30% in Acetic Acid

Manufacturing Process:

- The Hydrogen Bromide gas is absorbed in Acetic Acid to get Hydrogen Bromide 30% in Acetic Acid.

- The Hydrogen Bromide 30% in Acetic Acid is then packed in 200 Liters HDPE Barrels.

Chemical reaction:

Br_2 + H_2 ⟶ 2 HBr

Bromine — Hydrogen — Hydrogen Bromide

M.W. : 160 — M.W. : 2 — M.W. : 162

Mass Balance:

Input	Kg				Output	Kg
Bromine	1600				Hydrogen Bromide (30%)	5400
Hydrogen	20	⟹	**Reaction**	⟹	in Acetic Acid	
Acetic Acid	3780					
Total	5400				Total	5400

10.4) Hydrogen Bromide Anhydrous

Manufacturing Process:

- Bromine is reacted with the Hydrogen gas. The Hydrogen Bromide gas thus obtained is then compressed to get Hydrogen Bromide Anhydrous.
- The Hydrogen Bromide Anhydrous is then packed in Cylinder.

Chemical reaction:

Br_2 + H_2 ⟶ 2 HBr

Bromine — Hydrogen — Hydrogen Bromide

M.W. : 160 — M.W. : 2 — M.W. : 162

Mass Balance:

Input	Kg				Output	Kg
Bromine	1600				Hydrogen Bromide	1620
Hydrogen	20	⟹	**Reaction**	⟹		
Total	1620				Total	1620

11) Co - Products

11.1) Sodium Bromide

Manufacturing Process:

- Sodium Hydroxide solution 50% is taken in a Reactor, to that Hydrobromic Acid 48% is added over a period of time to get Sodium Bromide solution 40% solution.
- The Sodium Bromide Solution is then packed in 200 Lit HDPE Barrels.

Chemical reaction:

$$NaOH + HBr \longrightarrow NaBr + H_2O$$

Sodium Hydroxide	Hydrobromic Acid	Sodium Bromide	Water
M.W. : 40	M.W. : 81	M.W. : 103	M.W. : 18

Mass Balance:

Input	Kg				Output	Kg
Sodium Hydroxide (50%)	4775				Sodium Bromide	6145
Hydrobromic Acid (48%)	10065	⇒	**Reaction**	⇒	Water from Reaction	1075
					Water from Raw Material	7620
Total	14840				Total	14840

11.2) Zinc Bromide

Manufacturing Process:

- Zinc Hydroxide slurry 45% is taken in a Reactor, to that Hydrobromic Acid 48% is added over a period of time to get Zinc Bromide solution 40% solution.
- The Sodium Bromide Solution is then packed in 200 Lit HDPE Barrels.

Chemical reaction:

$$Zn(OH)_2 + 2\ HBr \longrightarrow ZnBr_2 + 2\ H_2O$$

Zinc Hydroxide	Hydrobromic Acid	Zinc Bromide	Water
M.W. : 99.5	M.W. : 162	M.W. : 225.5	M.W. : 36

Mass Balance:

Input	Kg				Output	Kg
Zinc Hydroxide (45%)	7055				Zinc Bromide	7190
Hydrobromic Acid (48%)	10760	⇒	**Reaction**	⇒	Water from Reaction	1150
					Water from Raw Material	9475
Total	17815				Total	17815

11.3) Potassium Bromide

Manufacturing Process:

- Potassium Hydroxide solution 45% is taken in a Reactor, to that Hydrobromic Acid 48% is added over a period of time to get Potassium Bromide solution 40% solution.
- The Potassium Bromide Solution is then packed in 200 Lit HDPE Barrels.

Chemical reaction:

$$KOH + HBr \longrightarrow KBr + H_2O$$

Potassium Hydroxide	Hydrobromic Acid	Potassium Bromide	Water
M.W. : 56	M.W. : 81	M.W. : 119	M.W. : 18

Mass Balance:

Input	Kg				Output	Kg
Potassium Hydroxide (45%)	6360				Potassium Bromide	6082
Hydrobromic Acid (48%)	8625	⇒	**Reaction**	⇒	Water from Reaction	920
					Water from Raw Material	7983
Total	14985				Total	14985

11.4) Calcium Bromide

Manufacturing Process:

- Calcium Hydroxide slurry 45% is taken in a Reactor, to that Hydrobromic Acid 48% is added over a period of time to get Calcium Bromide solution 40% solution.
- The Calcium Bromide Solution is then packed in 200 Lit HDPE Barrels.

Chemical reaction:

$$Ca(OH)_2 + 2\ HBr \longrightarrow CaBr_2 + 2\ H_2O$$

Calcium Hydroxide	Hydrobromic Acid	Calcium Bromide	Water
M.W. : 74	M.W. : 162	M.W. : 200	M.W. : 36

Mass Balance:

Input	Kg				Output	Kg
Calcium Hydroxide (45%)	5105				Calcium Bromide	6185
Hydrobromic Acid (48%)	10430	⇒	**Reaction**	⇒	Water from Reaction	1120
					Water from Raw Material	8230
Total	15535				Total	15535

11.5) Magnesium Bromide

Manufacturing Process:

- Magnesium Hydroxide 40% Slurry is taken in a Reactor, to that Hydrobromic Acid 48% is added over a period of time to get Magnesium Bromide solution 42% solution.
- The Magnesium Bromide Solution is then packed in 200 Lit HDPE Barrels.

Chemical reaction:

$$MgO + 2\ HBr \longrightarrow MgBr2 + H_2O$$

Magnesium Oxide	Hydrobromic Acid	Magnesium Bromide	Water
M.W. : 40.5	M.W. : 162	M.W. : 184.5	M.W. : 18

Mass Balance:

Input	Kg				Output	Kg
Magnesium Oxide (40%)	3600				Magnesium Bromide	6560
Hydrobromic Acid (48%)	12000	⇒	**Reaction**	⇒	Water from Reaction	640
					Water from Raw Material	8400
Total	15600				Total	15600

11.6) Liquid Bromine from Sodium Bromide

Manufacturing Process:

- Sodium Bromide is first acidified and then taken in a stripping Column where it is reacted with Chlorine gas to get Pure Liquid Bromine and Sodium Chloride solution.
- The Liquid Bromine thus obtained is then packed in Glass Lined Tank or PVDF Lined tank for internal use.

Chemical reaction:

$$2\ NaBr + Cl_2 \longrightarrow Br_2 + 2\ NaCl$$

Sodium Bromide	Chlorine	Bromine	Sodium Chloride
M.W. :206	M.W. : 71	M.W. : 160	M.W. : 117

Mass Balance:

Input	Kg				Output	Kg
Sodium Bromide (2	12875				Bromine	2000
Chlorine	890	⇒	**Reaction**	⇒	Sodium Chloride (12.5%)	11765
Total	13765				Total	13765

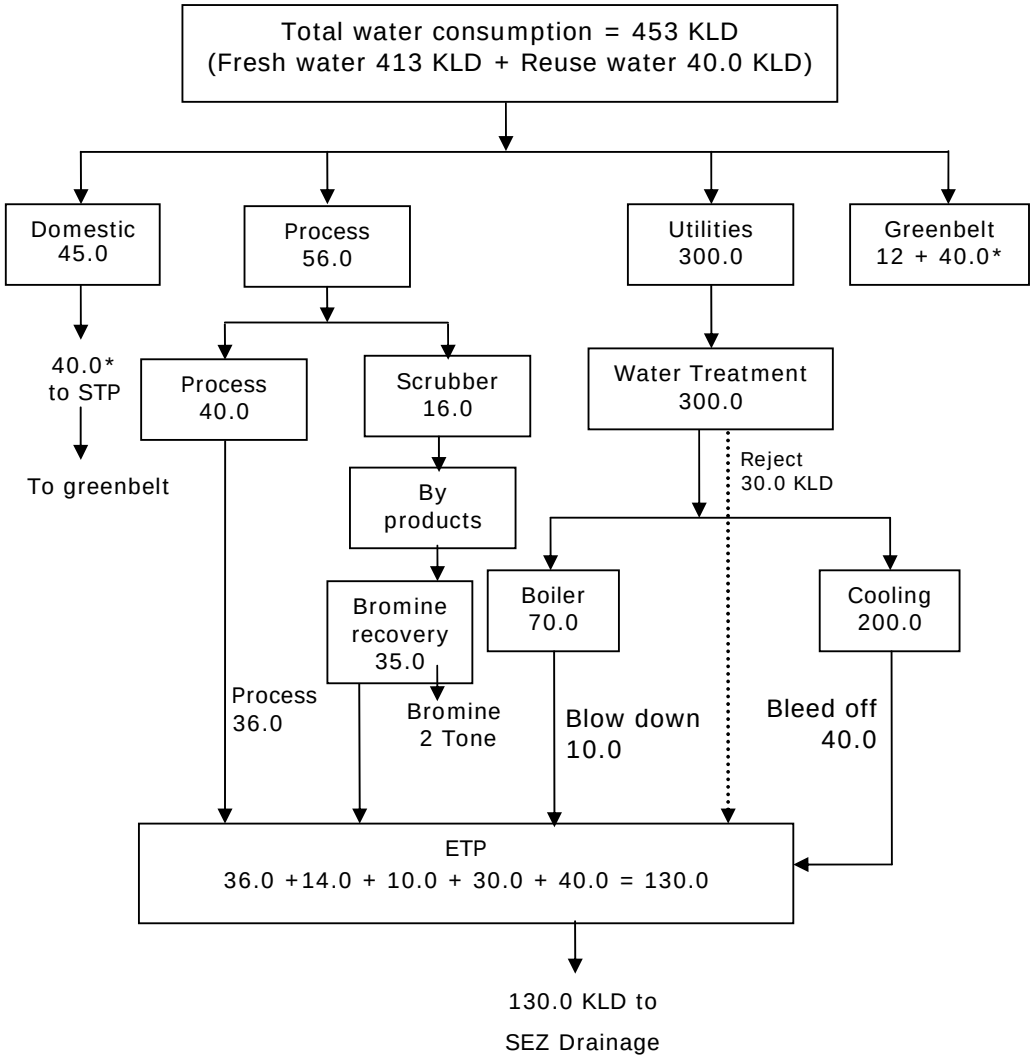
Annexure-III (A)

Water Balance

Sr. No.	Source	Water Consumption (KLD)	Wastewater Generation (KLD)
1.	**Domestic**	45	40*
2.	**Green Belt**	12+40*	00
3.	**Industrial**		
A	Water treatment	30	30
B	Process	40	36
C	Scrubber	16	14
D	Boiler	70	10
E	Cooling Tower	200	40
	Total Industrial	**356**	**130**
	TOTAL (1 +2 + 3)	**453**	**170**
	Reuse water	**40***	**-**
	Fresh water requirements	**413**	**-**

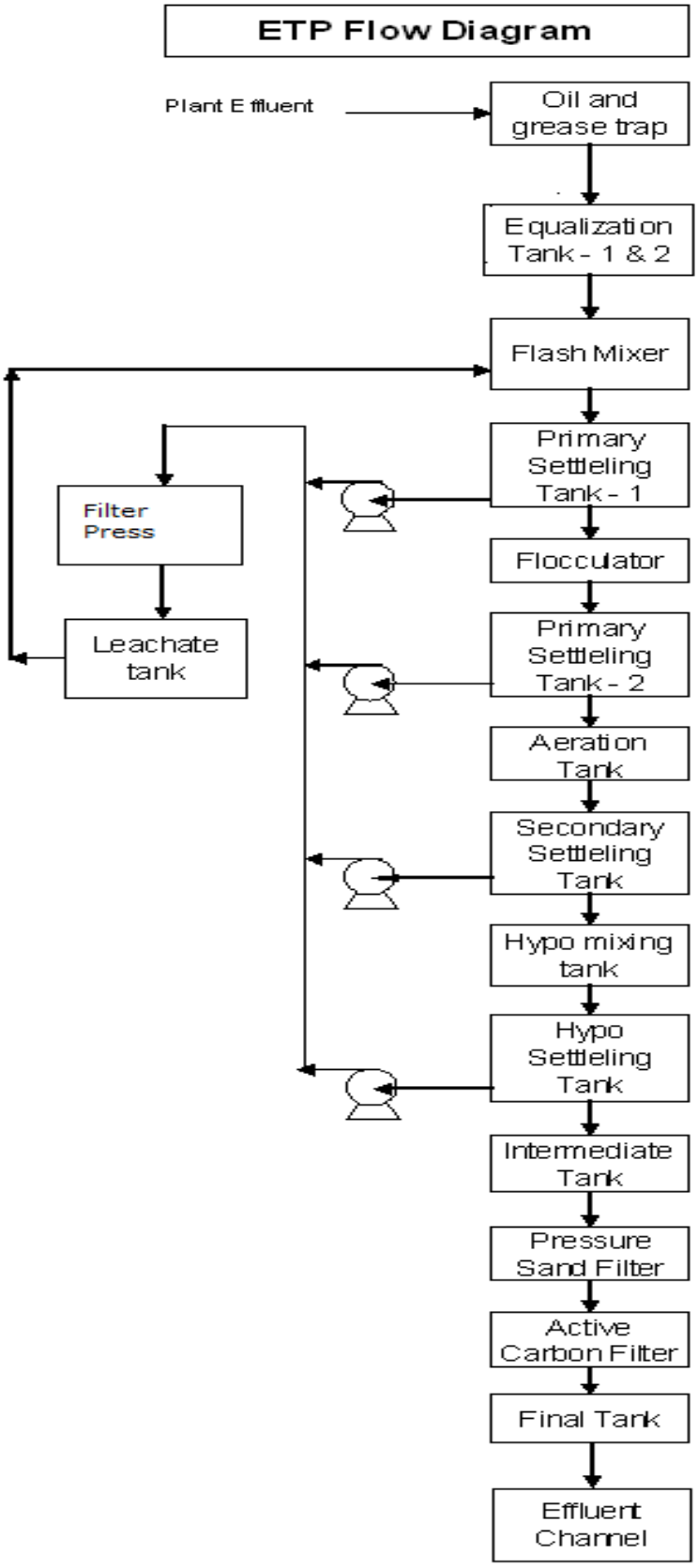
* Treated Sewage

Water Balance Diagram



Annexure-III (B)

Schematic Flow Diagram of ETP



Note: Above is tentative ETP scheme and subject to revised based on the detailed study.

Annexure-IV

Hazardous waste details

Sr. No.	Type of Waste	Category No. as per HWM rules, 2008	Quantity	Method of Disposal
1.	ETP waste	34.3	30 MT/month	Collection, storage & disposal at TSDF site approved by GPCB.
2.	Process/distillation residue	29.1 / 20.3	137 MT/month	Collection, storage & disposal at CHWIF or co-processing.
3.	Discarded containers/ barrels/ liners	33.3	Barrels-5000 nos./month Liner-500 kg/month	Collection, storage and reuse for packing of products or disposal by selling to approved recycler or traders.
4.	Used Lubricating Oil	5.1	1.0 Kl/year	Collection, storage & use within premises as lubricant/sell to registered recycler.

Annexure-V

Details of Air Pollution

Sr. No.	Stack attached to	Stack Height in m	Fuel Used	Fuel Consumption Rate	APC measure	Pollutant
➢ **Flue gas stacks**						
01	Boiler (3 nos.) (2 TPH each)	30 (common stack)	PNG	10000 SCM/day	**--**	SPM<150 mg/Nm^3 SO_2<100 ppm NO_X<50 ppm
02	D G set (250 KVA x 3)	21	HSD	60 Lit/hrs. each	--	
➢ **Process vent**						
01	Halogen Specific Reaction Plant	21	-	-	Caustic Scrubber	HBr<20 mg/Nm^3 HCl<20 mg/Nm^3 Br_2<2 mg/Nm^3 Cl_2<9 mg/Nm^3
02	Bromine recovery	21	-	-	Caustic Scrubber	
03	Common Reaction & Multi-purpose Plant	21	-	-	Caustic Scrubber	
04	Distillation/ Rectification Plant	21	-	-	Caustic Scrubber	
05	Ejector vents from Distillation / Rectification Plant	21	-	-	Caustic Scrubber	
06	Drying, Packing & Finishing Plant	21	-	-	Caustic Scrubber	
07	Common stack attached to suction of work place area	21	-	-	Caustic Scrubber	