



## Group G, Task A: Stream table of each area

### Area 1

Line number	1.1	1.2	1.3	1.4	1.5	1.6	1.7	1.8	1.9	1.10	1.11	1.12	1.13
Flow (t/h)	117.3	117.3	117.3	117.3	8.5	125.8	37.0	97.1	28.7	0.15	97.3	97.1	0.15
Composition (wt%)													
Starch	0.6490	0.6490	0.6490	0.6490	0	0.6054	0.6054	0.7360	0.1619	0	0.7349	0.7360	0
Water	0.0887	0.0887	0.0887	0.0887	1.000	0.1500	0.1500	0.1200	0.2519	0	0.1198	0.1200	0
Protein	0.1300	0.1300	0.1300	0.1300	0	0.1213	0.1213	0.1190	0.1291	0	0.1188	0.1190	0
Lipid	0.0158	0.0158	0.0158	0.0158	0	0.0147	0.0147	0.0110	0.0273	0	0.0110	0.0110	0
Glucose	0.0035	0.0035	0.0035	0.0035	0	0.0033	0.0033	0.0040	0.0009	0	0.0040	0.0040	0
Fibre	0.1130	0.1130	0.1130	0.1130	0	0.1053	0.1053	0.0100	0.4293	0	0.0100	0.0100	0
Air	0	0	0	0	0	0	0	0	0	1.000	0.0016	0	1.000
$\alpha$ -amylase	0	0	0	0	0	0	0	0	0	0	0	0	0
Phase	Solid	Solid	Solid	Solid	Liquid	Solid	Solid	Solid	Solid	Gas	Solid, Gas	Solid	Gas
Pressure (bar)	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Temperature (K)	298	298	298	298	298	298	298	298	298	298	298	298	298

## Area 2

Line number	2.1	2.2	2.3	2.4	2.5	2.6
<b>Flow (t/h)</b>	122.6	219.7	219.7	18.6	238.3	238.3
<b>Composition (wt%)</b>						
<b>Starch</b>		0.3254	0.3254		0.3000	0.3000
<b>Water</b>	0.9999	0.6109	0.6109	1.0000	0.6413	0.6413
<b>Protein</b>		0.05261	0.05261		0.04851	0.04851
<b>Lipid</b>		0.004863	0.004863		0.004484	0.004484
<b>Glucose</b>		0.001768	0.001768		0.001630	0.001630
<b>Fibre</b>		0.004421	0.004421		0.004076	0.004076
<b>Air</b>						
<b>α-amylase</b>	0.00005833	0.00003254	0.00003254		0.00003000	0.00003000
<b>Phase</b>	Liquid	Solid, Liquid	Solid, Liquid	Vapour	Liquid	Liquid
<b>Pressure (bar)</b>	1.00	1.00	2.77	2.77	2.50	2.00
<b>Temperature (K)</b>	298	298	298	446	373	328

### Area 3

Line Number	3.1	3.2	3.3	3.4	3.5	3.6	3.7	3.8	3.9	3.10	3.11	3.12
Mass Flow (t)	2383.3	2383.3	12636.0	12636.0	15015.9	15015.9	15019.3	15019.3	3050.0	3050.0	11969.3	11969.3
Batch cycle time (h)	10	10	10	10	10	10	10	10	10	10	10	10
Composition (wt%)												
Starch (gelatinised)	0.3000	0.3000	0	0	0	0	0	0	0	0	0	0
Water	0.6413	0.6413	1.000	1.000	0.9433	0.9433	0.9430	0.9430	0	1.000	0.9285	0.9285
Trace impurities	0.0571	0.0571	0	0	0.0091	0.0091	0.0091	0.0091	0	0	0.0114	0.0114
$\alpha$ -amylase	Trace	Trace	0	0	Trace	Trace	0	0	0	0	0	0
Glucose	0.0016	0.0016	0	0	0.0061	0.0061	0.0479	0.0479	0	0	0.0601	0.0601
Maltose	0	0	0	0	0.0048	0.0048	0	0	0	0	0	0
Maltotriose	0	0	0	0	0.0002	0.0002	0	0	0	0	0	0
Maltotetraose	0	0	0	0	0.0009	0.0009	0	0	0	0	0	0
Maltopentaose	0	0	0	0	0.0004	0.0004	0	0	0	0	0	0
Maltohexaose	0	0	0	0	0.0016	0.0016	0	0	0	0	0	0
Maltoheptaose	0	0	0	0	0.0006	0.0006	0	0	0	0	0	0
Oligosaccharides (DP>7)	0	0	0	0	0.0330	0.0330	0	0	0	0	0	0
Steam	0	0	0	0	0	0	0	0	1.000	0	0	0
Phase	Solid, Liquid	Solid, Liquid	Liquid	Liquid	Solid, Liquid	Solid, Liquid	Liquid	Liquid	Gas	Liquid	Liquid	Liquid
Pressure (bar)	2.10	1.60	5.00	4.50	1.60	1.10	1.10	2.00	1.50	1.00	1.50	1.00
Temperature (K)	328	363	293	363	363	328	328	328	393	373	393	308

#### Area 4

Line Number	4.1	4.2	4.3	4.4	4.5	4.6	4.7	4.8
<b>Mass Flow (t)</b>	14363.2	2891.8	2891.8		434.0	16821.0	15970.2	850.8
<b>Batch cycle time (h)</b>	12	12	12	12	12	12	12	12
<b>Composition (wt %)</b>								
<b>Water</b>	0.9285	0.2403	0.2403	0	0	0	0	0.7000
<b>Trace impurities</b>	0.0114	0	0	0	0	0	0	0
<b>Glucose</b>	0.0601	0	0	0	0	0	0	0
<b>Biomass</b>	0	0.0597	0.0597	0	0	0.0102	0.0107	0
<b>Nutrients</b>	0	0.7000	0.7000	0	0	0	0	0
<b>Carbon dioxide</b>	0	0	0	0	0.9660	0	0	0
<b>Hydrogen</b>	0	0	0	0	0.0340	0	0	0
<b>Fermentation broth</b>	0	0	0	0	0	0.9709	0.9853	0
<b>Acetone</b>	0	0	0	0	0	0.00536	0.000574	0.0952
<b>Butanol</b>	0	0	0	0	0	0.01050	0.00114	0.1862
<b>Ethanol</b>	0	0	0	0	0	0.00105	0.000114	0.01862
<b>Acetic acid</b>	0	0	0	0	0	0.00203	0.00214	0
<b>Butyric acid</b>	0	0	0	0	0	Trace	Trace	0
<b>Nitrogen</b>	0	0	0	1.0000		0	0	0
<b>Phase</b>	Liquid	Liquid	Liquid	Gas	Gas	Liquid	Liquid	Liquid
<b>Pressure (bar)</b>	1.0	1.0	1.0		1.0	1.0	1.0	1.0
<b>Temperature (K)</b>	308	308	308	308	308	308	308	308

## Area 5

Line Number	5.1	5.2	5.3	5.4	5.5	5.6	5.7	5.8	5.9	5.10
<b>Mass Flowrate (t/h)</b>	70.9	111.4	39.5	71.9	13.0	26.5	26.5	26.5	48.1	23.8
<b>Molar flowrate (kmol/h)</b>	3078	4557	1364	3194	177	1187	1187	1187	2658	536
<b>Composition (wt%)</b>										
<b>Water</b>	0.7000	0.6376	0.4824	0.7230	0.002201	0.7175	0.7175	0.7175	0.9935	0.1750
<b>Acetone</b>	0.09521	0.1027	0.1185	0.09394	0	0.1766	0.1766	0.1766	0.001403	0.2814
<b>Butanol</b>	0.1862	0.2296	0.3644	0.1554	0.9978	0.05430	0.05430	0.05430	0.00464	0.4607
<b>Ethanol</b>	0.01862	0.03016	0.03467	0.02768	0	0.05166	0.05166	0.05166	0.004130	0.08290
<b>Trace impurities</b>	0	0	0	0	0	0	0	0	0	0
<b>Composition (mol%)</b>										
<b>Water</b>	0.8951	0.8651	0.7764	0.9029	0.008993	0.8906	0.8906	0.8906	0.9983	0.4304
<b>Acetone</b>	0.03776	0.04322	0.05918	0.03639	0	0.06798	0.06798	0.06798	0.004370	0.2146
<b>Butanol</b>	0.05786	0.07571	0.1426	0.04717	0.9910	0.01638	0.01638	0.01638	0.001133	0.2753
<b>Ethanol</b>	0.009309	0.01600	0.02183	0.01352	0	0.02507	0.02507	0.02507	0.0001620	0.07971
<b>Trace impurities</b>	0	0	0	0	0	0	0	0	0	0
<b>Phase</b>	Liquid	Liquid	Liquid (Organic)	Liquid (Aqueous)	Liquid	Vapour	Liquid	Liquid	Liquid	Vapour
<b>Pressure (bar)</b>	3.00	3.00	2.50	2.50	2.00	2.00	1.50	3.00	2.00	2.00
<b>Temperature (K)</b>	308	322	384	384	409	390	360	360	392	384

## Area 6

Line Number	6.1	6.2	6.3	6.4	6.5	6.6	6.7	6.8	6.9	6.10	6.11
<b>Mass Flowrate (t/h)</b>	23.8	14.0	14.0	9.8	9.8	9.8	3.1	3.1	6.7	6.7	6.7
<b>Molar flowrate (kmol/h)</b>	536	293	293	243	243	243	128	128	115	115	115
<b>Composition (wt%)</b>											
<b>Water</b>	0.1750	0.1688	0.1688	0.1839	0.1839	0.1839	0.5757	0.5757	0.0000320	0.0000320	0.0000320
<b>Acetone</b>	0.2814	0.000221	0.000221	0.6825	0.6825	0.6825	0.02146	0.02146	0.9918	0.9918	0.9918
<b>Butanol</b>	0.4607	0.7831	0.7831	0.000747	0.000747	0.000747	0.002337	0.002337	0	0	0
<b>Ethanol</b>	0.08290	0.0479	0.0479	0.1328	0.1328	0.1328	0.4005	0.4005	0.008152	0.008152	0.008152
<b>Trace impurities</b>	0	0	0	0	0	0	0	0	0	0	0
<b>Composition (mol%)</b>											
<b>Water</b>	0.4304	0.4466	0.4466	0.4108	0.4108	0.4108	0.7784	0.7784	0.0001040	0.0001040	0.0001040
<b>Acetone</b>	0.2146	0.0001820	0.0001820	0.4728	0.4728	0.4728	0.009001	0.009001	0.9909	0.9909	0.9909
<b>Butanol</b>	0.2753	0.5036	0.5036	0.0004050	0.0004050	0.0004050	0.000768	0.000768	0	0	0
<b>Ethanol</b>	0.07971	0.04956	0.04956	0.1160	0.1160	0.1160	0.2118	0.2118	0.009000	0.009000	0.009000
<b>Trace impurities</b>	0	0	0	0	0	0	0	0	0	0	0
<b>Phase</b>	Vapour	Liquid	Liquid	Liquid	Liquid	Liquid	Liquid	Liquid	Liquid	Liquid	Liquid
<b>Pressure (bar)</b>	1.00	0.50	3.00	2.50	2.00	1.00	0.50	1.01	3.50	3.00	1.01
<b>Temperature (K)</b>	383	349	349	362	334	334	337	337	371	329	329

## Inter-Area summary

Area	1						2			
	IN			OUT			IN			OUT
Line number	1.1	1.5	1.10	1.9	1.12	1.13	1.12	2.1	2.4	2.6
Flow (t/h)	117.3	8.5	0.15	28.7	97.1	0.15	97.1	122.6	18.6	238.3
Composition (wt%)										
Starch	0.6490	0	0	0.1619	0.6490	0	0	0	0	0
Water	0.0887	1.0000	0	0.2519	0.0887	0	0	0.9999	1.0000	1.0000
Protein	0.1300	0	0	0.1291	0.1300	0	0	0	0	0
Lipid	0.0158	0	0	0.0273	0.0158	0	0	0	0	0
Glucose	0.0035	0	0	0.0009	0.0035	0	0	0	0	0
Fibre	0.1130	0	0	0.4293	0.1130	0	0	0	0	0
Air	0	0	1.0000	0	0	1.0000	1.0000	0	0	0
$\alpha$ -amylase	0	0	0	0	0	0	0	0.00005833	0	0
Phase	Solid	Liquid	Gas	Solid	Solid	Gas	Solid	Liquid	Vapour	Liquid
Pressure (bar)	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	2.77	2.00
Temperature (K)	298	298	298	298	298	298	298	298	446	328
Total mass flowrate (t/h)	125.95			125.95			238.3			238.3



Area	3					4				
	IN		OUT			IN		OUT		
Line number	3.1	3.3	3.10	3.12		4.1	4.2	4.5	4.7	4.8
Mass Flow (t)	2383.3	12636.0	3050.0	11969.3		14363.2	2891.8	434.0	15970.2	850.8
Batch cycle time (h)	10	10	10	10		12	12	12	12	12
Composition (wt%)										
Starch (gelatinised)	0.3000	0	0	0	Biomass	0	0.0597	0	0.0107	0
Water	0.6413	1.000	1.000	0.9285	Water	0.9285	0.2403	0	0	0.7000
Trace impurities	0.0571	0	0	0.0114	Trace impurities	0.0114	0	0	0	0
$\alpha$ -amylase	Trace	0	0	0	Nutrients	0	0.7000	0	0	0
Glucose	0.0016	0	0	0.0601	Glucose	0.0601	0	0	0	0
Maltose	0	0	0	0	Carbon dioxide	0	0	0.9660	0	0
Maltotriose	0	0	0	0	Hydrogen	0	0	0.0340	0	0
Maltotetraose	0	0	0	0	Fermentation broth	0	0	0	0.9853	0
Maltopentaose	0	0	0	0	Acetone	0	0	0	0.000574	0.0952
Maltohexaose	0	0	0	0	Butanol	0	0	0	0.00114	0.1862
Maltoheptaose	0	0	0	0	Ethanol	0	0	0	0.000114	0.01862
Oligosaccharides (DP>7)	0	0	0	0	Acetic acid	0	0	0	0.00214	0
Steam	0	0	0	0	Butyric acid	0	0	0	Trace	0
					Nitrogen	0	0		0	0
Phase	Solid, Liquid	Liquid	Liquid	Liquid		Liquid	Liquid	Gas	Liquid	Liquid
Pressure (bar)	2.10	5.00	1.00	1.00		1.0	1.0	1.0	1.0	1.0
Temperature (K)	328	293	373	308		308	308	308	308	308
Total mass of streams (t)	15019.3		15019.3			17255.0		17255.0		

Area	5					6			
	IN		OUT			IN	OUT		
Line Number	5.1	6.3	5.5	5.9	5.10	5.10	6.3	6.8	6.11
Mass Flowrate (t/h)	70.9	14.0	13.0	48.1	23.8	23.8	14.0	3.1	6.7
Molar flowrate (kmol/h)	3078	293	177	2658	536	536	293	128	115
Composition (wt %)									
Water	0.7000	0.1688	0.002201	0.9935	0.1750	0.1750	0.1688	0.5757	0.0000320
Acetone	0.09521	0.000221	0	0.001403	0.2814	0.2814	0.000221	0.02146	0.9918
Butanol	0.1862	0.7831	0.9978	0.00464	0.4607	0.4607	0.7831	0.002337	0
Ethanol	0.01862	0.0479	0	0.004130	0.08290	0.08290	0.0479	0.4005	0.008152
Trace impurities	0	0	0	0	0	0	0	0	0
Composition (mol%)									
Water	0.8951	0.4466	0.008993	0.9983	0.4304	0.4304	0.4466	0.7784	0.0001040
Acetone	0.03776	0.0001820	0	0.004370	0.2146	0.2146	0.0001820	0.009001	0.9909
Butanol	0.05786	0.5036	0.9910	0.001133	0.2753	0.2753	0.5036	0.000768	0
Ethanol	0.009309	0.04956	0	0.0001620	0.07971	0.07971	0.04956	0.2118	0.009000
Trace impurities	0	0	0	0	0	0	0	0	0
Phase	Liquid	Liquid	Liquid	Liquid	Vapour	Vapour	Liquid	Liquid	Liquid
Pressure (bar)	3.00	3.00	2.00	2.00	2.00	2.00	3.00	1.01	1.01
Total mass flowrate (t/h)	84.9		84.9			23.8	23.8		

## Mass balance over entire plant

IN		OUT	
Line number	Mass flowrate (t/h)	Line number	Mass flowrate (t/h)
1.1	117.3	1.9	28.7
1.5	8.5	1.13	0.15
1.10	0.15	3.10*	305.0
2.1	122.6	4.5*	36.2
2.4	18.6	4.7*	1330.8
3.3*	1263.6	5.5	13.0
4.2*	241.0	5.9	48.1
		6.8	3.1
		6.11	6.7
<b>Total mass going in plant (t/h):</b>	<b>1771.75</b>	<b>Total mass going out of plant (t/h):</b>	<b>1771.75</b>

\*Streams from batch areas have been normalised according to the area's total batch time.