

IEQB - Ficha 3

Balanços Materiais sem Reacção Química

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Questão 1

(i) m_{final}

$$= (150 + 200) \text{ kg h}^{-1} = 350 \text{ kg h}^{-1}$$

(ii) $[\text{met}]$

$$= \frac{40\% * 200 + 70\% * 150}{350} \frac{\text{kg}_{\text{met}}}{\text{kg}_{\text{total}}} \cong 52.9 \frac{\text{kg}_{\text{met}}}{\text{kg}_{\text{total}}}$$

Questão 2

mol	i		o1		o2	
Total:	100.0	1250.0	50.0	650.0	50.0	650.0
$X_A :$	0.60	0.60	0.95	0.95	0.25	0.25
$X_B :$	0.40	0.40	0.05	0.05	0.75	0.75

Questão 3

(i) m_1

$$= (100 - 40) \text{ kg h}^{-1} = 60 \text{ kg h}^{-1}$$

(ii) A_1

$$= \left(\frac{0.5 * 100 - 0.9 * 40}{60} \right) \frac{\text{kg}_A}{\text{kg}} \cong 0.23 \frac{\text{kg}_A}{\text{kg}}$$

(iii) B_1

$$= \left(\frac{0.5 * 100 - 0.1 * 40}{60} \right) \frac{\text{kg}_B}{\text{kg}} \cong 0.77 \frac{\text{kg}_A}{\text{kg}}$$

(iv) m_2

$$= (60 + 30) \text{ kg h}^{-1} = 90 \text{ kg h}^{-1}$$

(v) A_2

$$\cong \left(\frac{0.23 * 60 + 0.3 * 30}{90} \right) \frac{\text{kg}_A}{\text{kg}} \cong 0.26 \frac{\text{kg}_A}{\text{kg}}$$

(vi) B_2

$$\cong \left(\frac{0.77 * 60 + 0.7 * 30}{90} \right) \frac{\text{kg}_B}{\text{kg}} \cong 0.74 \frac{\text{kg}_B}{\text{kg}}$$

(vii) m_3

$$= (90 - 30) \text{ kg h}^{-1} = 60 \text{ kg h}^{-1}$$

(viii) A_3

$$\cong \left(\frac{0.26 * 90 - 0.6 * 30}{60} \right) \frac{\text{kg}_A}{\text{kg}} \cong 0.08 \frac{\text{kg}_A}{\text{kg}}$$

(ix) B_3

$$\cong \left(\frac{0.74 * 90 - 0.4 * 30}{60} \right) \frac{\text{kg}_B}{\text{kg}} \cong 0.92 \frac{\text{kg}_B}{\text{kg}}$$

Questão 4

(i) m_{o1}

$$= \frac{1000 * 50 \% - m_{o2} 9.5 \%}{95 \%} \frac{\text{kg}}{\text{h}};$$

$$m_{o2} = 1000 - m_{o1} \implies$$

$$\implies m_{o1} = \frac{1000 * 50 \% - 1000 * 9.5 \%}{95 \% - 9.5 \%} \cong$$

$$\cong 474 \text{ kg h}^{-1}$$

(ii) m_{o2}

$$\cong 1000 - 474 \cong 526 \text{ kg h}^{-1}$$

Questão 5

% kg	i1	i2	i3	o
Açucar	2.5	1	-	2
H ₂ O	50.0	18	100	
Sucrose	-	50	-	12.6
Solidos	47.7	31	-	
Total (kg)	125	45	8.8	178.8

5 - a) m_{i3}

$$= m_o - m_{i1} - m_{i2}; m_o = \frac{m_{i1} 2.5 \% + m_{i2} 1 \%}{2 \%} \implies m_{i3} = \frac{125 (2.5 - 2) \% + 45 (1 - 2) \%}{2 \%} \cong 8.8$$

5 - b) $[\text{Sucrose}]_o$

$$= \frac{m_{i2} * 50 \%}{m_o}; m_o = m_{i1} + m_{i2} + m_{i3} = 125 + 45 + 8.8 \cong 178.8 \implies [\text{Sucrose}]_o \cong \frac{45 * 50 \%}{178.8} \cong 12.6 \%$$

Questão 6

% kg/kg	i	o1	o2
et	10	60	4.4
H ₂ O	90	40	95.6
Total (kg h ⁻¹)	1000	100	900

(i) m_{o2}

$$= m_i - m_{o1} = (1000 - 100) \text{ kg/h} = 900 \text{ kg/h}$$

(iii) $[\text{H}_2\text{O}]_{o2}$

$$= 1 - 4.4 \% \cong 95.6 \%$$

(ii) $[\text{et}]_{o2}$

$$= \frac{1000 * 10 \% - 100 * 60 \%}{900} \text{ kg kg}^{-1} \cong 4.4 \% \text{ kg/kg}$$

Questão 7

- 1 = 1i.1
- 2 = 1i
- 3 = 1o1
- 4 = 1o2 = 2i
- 5 = 2o1
- 6 = 2o2 = 1i.2

% kg/kg	1i.1	1i	1o1	1o2	2i	2o1	2o2	1i.2
K ₂ Cr ₂ O ₇	33	34.8	-	49.4		95		36.36
H ₂ O	67	65.2	100	50.6		5		63.64
Total (kg h ⁻¹)	4500	9966.3	2936.8	7029.4		1563.2		5466.3

(i) m_{2o1}

$$= \frac{m_{1i.1} [\text{K}_2\text{Cr}_2\text{O}_7]_{1i.1}}{[\text{K}_2\text{Cr}_2\text{O}_7]_{2o1}} = \frac{4500 * 33 \%}{95 \%} \text{kg h}^{-1} \cong$$

$$\cong 1563.2 \text{ kg h}^{-1}$$

(ii) m_{1o1}

$$= m_{1i.1} - m_{2o1} = (4500 - 1563.2) \text{kg h}^{-1} \cong$$

$$\cong 2936.8 \text{ kg h}^{-1}$$

(iii) m_{2i}

$$= m_{2o1} + m_{2o2};$$

$$m_{2o2} = \frac{m_{2i} [\text{H}_2\text{O}]_{2i} - m_{2o1} [\text{H}_2\text{O}]_{2o1}}{[\text{H}_2\text{O}]_{2o2}} \implies$$

$$\implies m_{2i} = m_{2o1} \frac{[\text{H}_2\text{O}]_{2o2} - [\text{H}_2\text{O}]_{2o1}}{[\text{H}_2\text{O}]_{2o2} - [\text{H}_2\text{O}]_{2i}} =$$

$$1563.2 \frac{63.64 \% - 5 \%}{63.64 \% - 50.6 \%} \text{kg h}^{-1} \cong 7029.4 \text{ kg h}^{-1}$$

(iv) m_{2o2}

$$= m_{2i} - m_{2o1} = (7029.4 - 1563.2) \text{kg h}^{-1} \cong$$

$$\cong 5466.3 \text{ kg h}^{-1}$$

(v) m_{1i}

$$= m_{1i.1} + m_{1i.2} = (4500 + 5466.3) \text{kg h}^{-1} \cong$$

$$\cong 9966.3 \text{ kg h}^{-1}$$

(vi) $[\text{K}_2\text{Cr}_2\text{O}_7]_{1i}$

$$= \frac{m_{1i.1} [\text{K}_2\text{Cr}_2\text{O}_7]_{1i.1} + m_{1i.2} [\text{K}_2\text{Cr}_2\text{O}_7]_{1i.2}}{m_{1i}} =$$

$$= \frac{4500 * 33 \% + 5466.3 * 36.36 \%}{9966.3} \text{kg/kg} \cong$$

$$\cong 34.8 \% \text{ kg/kg}$$

(vii) $[\text{H}_2\text{O}]_{1i}$

$$= (100 \% - [\text{K}_2\text{Cr}_2\text{O}_7]_{1i}) \text{kg kg}^{-1} =$$

$$= (100 \% - 34.8 \%) \text{kg kg}^{-1} \cong 65.2 \% \text{ kg/kg}$$

Questão 8

- 1 = i1
- 2 = o1
- 3 = i2.1
- 4 = i2
- 5 = o2
- 6 = o2.1
- 7 = o2.2 = i2.2

% kg/kg	i1	o1	i2.1	i2	o2	o2.1	<u>o2.2</u>	<u>i2.2</u>
Solidos	85	93	-	-	-	-	-	-
Agua	15	7	0.99	2.91	9.09	9.09		9.09
Ar Seco	-	-	99.01	97.09	90.91	90.91		90.91
Total (kg)	100	91.4	96.5					

(i) $[\text{Agua}]_{i2.1}$

$$= \frac{1\%}{0.01 + 1} \text{kg kg}^{-1} \cong 0.99\% \text{ kg/kg}$$

(ii) $[\text{Agua}]_{i2.2}$

$$= \frac{10\%}{0.10 + 1} \text{kg kg}^{-1} \cong 9.09\% \text{ kg/kg}$$

(iii) $[\text{Agua}]_{i2}$

$$= \frac{3\%}{0.3 + 1} \text{kg kg}^{-1} \cong 2.91\% \text{ kg/kg}$$

(iv) $[\text{Agua}]_{o2.1}$

$$= [\text{Agua}]_{o2.2} = 9.09\% \text{ kg/kg}$$

(v) $[\text{Agua}]_{o2}$

$$= [\text{Agua}]_{o2.2} = 9.09\% \text{ kg/kg}$$

8 - a) $m_{i2.1}$

$$\begin{aligned}
 &= m_{o1} + m_{o2.1} - m_{i1}; \quad m_{o2.1} = \frac{m_{i1} [\text{Agua}]_{i1} + m_{i2.1} [\text{Agua}]_{i2.1} - m_{o1} [\text{Agua}]_{o1}}{[\text{Agua}]_{o2.1}} \implies \\
 &\implies m_{i2.1} = \frac{m_{o1} ([\text{Agua}]_{o2.1} - [\text{Agua}]_{o1}) + m_{i1} ([\text{Agua}]_{i1} - [\text{Agua}]_{o2.1})}{[\text{Agua}]_{o2.1} - [\text{Agua}]_{i2.1}} = \\
 &= \frac{91.4 * (9.09\% - 7\%) + 100 * (15\% - 9.09\%)}{9.09\% - 0.99\%} \text{kg h}^{-1} \cong 96.5 \text{ kg}
 \end{aligned}$$

8 - b) $m_{i2.2}/m_{i2.1}$

$$\begin{aligned}
 &= \frac{m_{i2} - m_{i2.1}}{m_{i2.1}}; \quad m_{i2} = \frac{m_{i2.1} [\text{Agua}]_{i2.1} + m_{i2.2} [\text{Agua}]_{i2.2}}{[\text{Agua}]_{i2}} \implies \\
 &\implies \frac{m_{i2.2}}{m_{i2.1}} = \frac{[\text{Agua}]_{i2.1} - [\text{Agua}]_{i2}}{[\text{Agua}]_{i2} - [\text{Agua}]_{i2.2}} = \frac{0.99 - 2.91}{2.91 - 9.09} \cong 0.31
 \end{aligned}$$

Questão 9

- 1 = i.1
- 2 = i = i.1.1
- 3 = i.1.2 = o2.1.2
- 4 = o1
- 5 = o2 = o2.1.1
- 6 = o2.1

% kg/kg	i.1	i	i.1.1	i.1.2	o2.1.1	o1	o2	o2.1.2	o2.1
Crómio	5.15		5.15		5.15	100			0.27
Agua						-			
Total (kg h ⁻¹)	6000		4500		1500	220.2		4279.8	5779.8

(i) m_{o1}

$$\begin{aligned}
 &= \frac{95 \% m_i [\text{Crómio}]_i}{[\text{Crómio}]_{o1}} = \\
 &= \frac{95 \% * 4500 * 5.15 \%}{100 \%} \text{kg h}^{-1} \cong 220.2 \text{kg h}^{-1}
 \end{aligned}$$

(ii) m_i

$$\begin{aligned}
 &= 4500 + (m_{i.1} - 4500) * \\
 &* \left(\frac{1 + \left(\frac{4500 - m_{i1}}{|4500 - m_{i1}|} \right)}{2} \right) = \\
 &= \frac{13500 - m_{i1} + |4500 - m_{i1}|}{2} = \\
 &= \frac{13500 - 6000 + |4500 - 6000|}{2} \text{kg h}^{-1} = \\
 &= 4500 \text{kg h}^{-1}
 \end{aligned}$$

(iii) $m_{i1.2}$

$$= m_{i1} - m_{i1.1} = (6000 - 4500) \text{kg h}^{-1} = 1500 \text{kg h}^{-1}$$

(iv) m_{o2}

$$= m_i - m_{o1} \cong (4500 - 220.2) \text{kg h}^{-1} \cong 4279.8 \text{kg h}^{-1}$$

(v) $m_{o2.1}$

$$\begin{aligned}
 &= m_{o2.1.1} + m_{o2.1.2} \cong (1500 + 4279.8) \text{kg h}^{-1} \cong \\
 &\cong 5779.8 \text{kg h}^{-1}
 \end{aligned}$$

(vi) $[\text{Crómio}]_{o2.1}$

$$\begin{aligned}
 &= \frac{m_{i.1} [\text{Crómio}]_{i.1} - m_{o1} [\text{Crómio}]_{o1}}{m_{o2.1}} \cong \\
 &\cong \frac{6000 * 5.15 \% - 220.2 * 100 \%}{5779.8} \cong 1.54 \% \text{kg/kg}
 \end{aligned}$$

Questão 10

- 1 = 1i
- 2 = 1o1
- 3 = 1o2 = 2i
- 4 = 2o1
- 5 = 2o2

% mol/mol	1i	1o1	1o2	2i	2o1	2o2
B	20	90		2.5	8	-
T	30	10		35	72	18.18
X	50	-		62.5	20	81.82
Total (mol h ⁻¹)	1000	200		800	250	550

(i) m_{1o2}

$$\begin{aligned}
 &= \frac{m_{1i} [X]_{1i} - m_{1o1} [X]_{1o1}}{[X]_{1o2}} = \\
 &= \frac{1000 * 50 \% - m_{1o1} * 0}{62.5 \%} \text{mol h}^{-1} = \\
 &= 800 \text{mol h}^{-1}
 \end{aligned}$$

(ii) m_{1o1}

$$\begin{aligned}
 &= m_{1i} - m_{1o2} = (1000 - 800) \text{mol h}^{-1} = \\
 &= 200 \text{mol h}^{-1}
 \end{aligned}$$

(iii) $[B]_{1o1}$

$$\begin{aligned}
 &= \frac{m_{1i} [B]_{1i} - m_{1o2} [B]_{1o2}}{m_{1o1}} = \\
 &= \frac{1000 * 20 \% - 800 * 2.5 \%}{200} \text{mol mol}^{-1} = \\
 &= 90 \% \text{mol/mol}
 \end{aligned}$$

(iv) $[T]_{1o1}$

$$= 100 \% - [B]_{1o1} = 10 \% \text{mol/mol}$$

(v) m_{2o1}

$$\begin{aligned}
 &= \frac{m_{1i} [B]_{1i} - m_{1o1} [B]_{1o1} - m_{2o2} [B]_{2o2}}{[B]_{2o1}} = \\
 &= \frac{1000 * 20 \% - 200 * 90 \% - m_{2o2} * 0 \%}{8 \%} \text{mol h}^{-1} = \\
 &= 250 \text{mol h}^{-1}
 \end{aligned}$$

(vi) m_{2o2}

$$\begin{aligned}
 &= m_{2i} - m_{2o1} = (800 - 250) \text{mol h}^{-1} = \\
 &= 550 \text{mol h}^{-1}
 \end{aligned}$$

(vii) $[T]_{2o2}$

$$\begin{aligned}
 &= \frac{m_{2i} [T]_{2i} - m_{2o1} [T]_{2o1}}{m_{2o2}} = \\
 &= \frac{800 * 35 \% - 250 * 72 \%}{550} \text{mol mol}^{-1} \cong \\
 &\cong 18.18 \% \text{mol/mol}
 \end{aligned}$$

(viii) $[X]_{2o2}$

$$\begin{aligned}
 &= 100 \% - [T]_{2o2} = (100 \% - 18.18 \%) \text{mol mol}^{-1} \cong \\
 &\cong 81.82 \% \text{mol/mol}
 \end{aligned}$$

Questão 11

- 1 = 1i1
- 2 = 1o1
- 3 = 1i2
- 4 = 1o2 = 2i
- 5 = 2o1
- 6 = 2o2

% kg/kg	1i1	1o1	1i2	1o2	2i	2o1	2o2
Glic	-	1	10	69.51	25	-	-
NaCl	-	5	3	-	-	-	-
Álcool	98	1	-	6.71	-	95	-
Água	2	93	87	23.78	75	5	-
Total (kg h ⁻¹)	1000	598.7	1000	1401.3			

(i) m_{1o1}

$$\begin{aligned}
 &= m_{1i1} + m_{1i2} - m_{2o1} - m_{2o2}; \quad m_{2o1} = \frac{m_{1i1} [\text{Glic}]_{1i1} + m_{1i2} [\text{Glic}]_{1i2} - m_{1o1} [\text{Glic}]_{1o1} - m_{2o2} [\text{Glic}]_{2o2}}{[\text{Glic}]_{2o2}}; \\
 m_{2o2} &= \frac{m_{1i1} [\text{Álcool}]_{1i1} + m_{1i2} [\text{Álcool}]_{1i2} - m_{1o1} [\text{Álcool}]_{1o1} - m_{2o1} [\text{Álcool}]_{2o2}}{[\text{Álcool}]_{2o2}} \implies \\
 \implies m_{1o1} &= \frac{m_{1i1} [\text{Glic}]_{2o1} ([\text{Álcool}]_{2o2} - [\text{Álcool}]_{1i1}) + m_{1i2} [\text{Álcool}]_{2o2} ([\text{Glic}]_{2o1} - [\text{Glic}]_{1i2})}{[\text{Glic}]_{2o1} [\text{Álcool}]_{2o2} - [\text{Glic}]_{1o1} [\text{Álcool}]_{2o2} - [\text{Álcool}]_{1o1} [\text{Glic}]_{2o1}} = \\
 &= \frac{1000 * 25 \% (95 \% - 98 \%) + 1000 * 95 \% (25 \% - 10 \%) }{25 \% * 95 \% - 1 \% * 95 \% - 1 \% * 25 \%} \text{ kg h}^{-1} \cong 598.7 \text{ kg h}^{-1}
 \end{aligned}$$

(ii) $[\text{NaCl}]_{1o1}$

$$\begin{aligned}
 &= \frac{m_{1i2} [\text{NaCl}]_{1i2}}{m_{1o1}} \cong \frac{1000 * 3 \%}{598.7} \text{ kg kg}^{-1} \cong \\
 &\cong 5.01 \% \text{ kg/kg}
 \end{aligned}$$

(iii) $[\text{Água}]_{1o1}$

$$\begin{aligned}
 &= 100 \% - [\text{Glic}]_{1o1} - [\text{Álcool}]_{1o1} - [\text{NaCl}]_{1o1} \cong \\
 &\cong (100 \% - 1 \% - 1 \% - 5.01 \%) \text{ kg kg}^{-1} \cong \\
 &\cong 92.99 \% \text{ kg/kg}
 \end{aligned}$$

(iv) m_{1o2}

$$\begin{aligned}
 &= m_{1i1} + m_{1i2} - m_{1o1} \cong \\
 &\cong (1000 + 1000 - 598.7) \text{ kg h}^{-1} \cong 1401.3 \text{ kg h}^{-1}
 \end{aligned}$$

11 - a) $m_{2o1} [\text{Glic}]_{2o1}$

$$\begin{aligned}
 &= m_{1i1} [\text{Glic}]_{1i1} + m_{1i2} [\text{Glic}]_{1i2} - m_{1o1} [\text{Glic}]_{1o1} - m_{2o2} [\text{Glic}]_{2o2} = \\
 &= (1000 * 0 \% + 1000 * 10 \% - 598.7 * 1 \% - m_{2o2} * 0 \%) \text{ kg h}^{-1} \cong 94.0 \text{ kg h}^{-1}
 \end{aligned}$$

