

Balances on Multiple Units

(No reaction)

Part 1
PART 2
PART 3

Prof. Faith Morrison

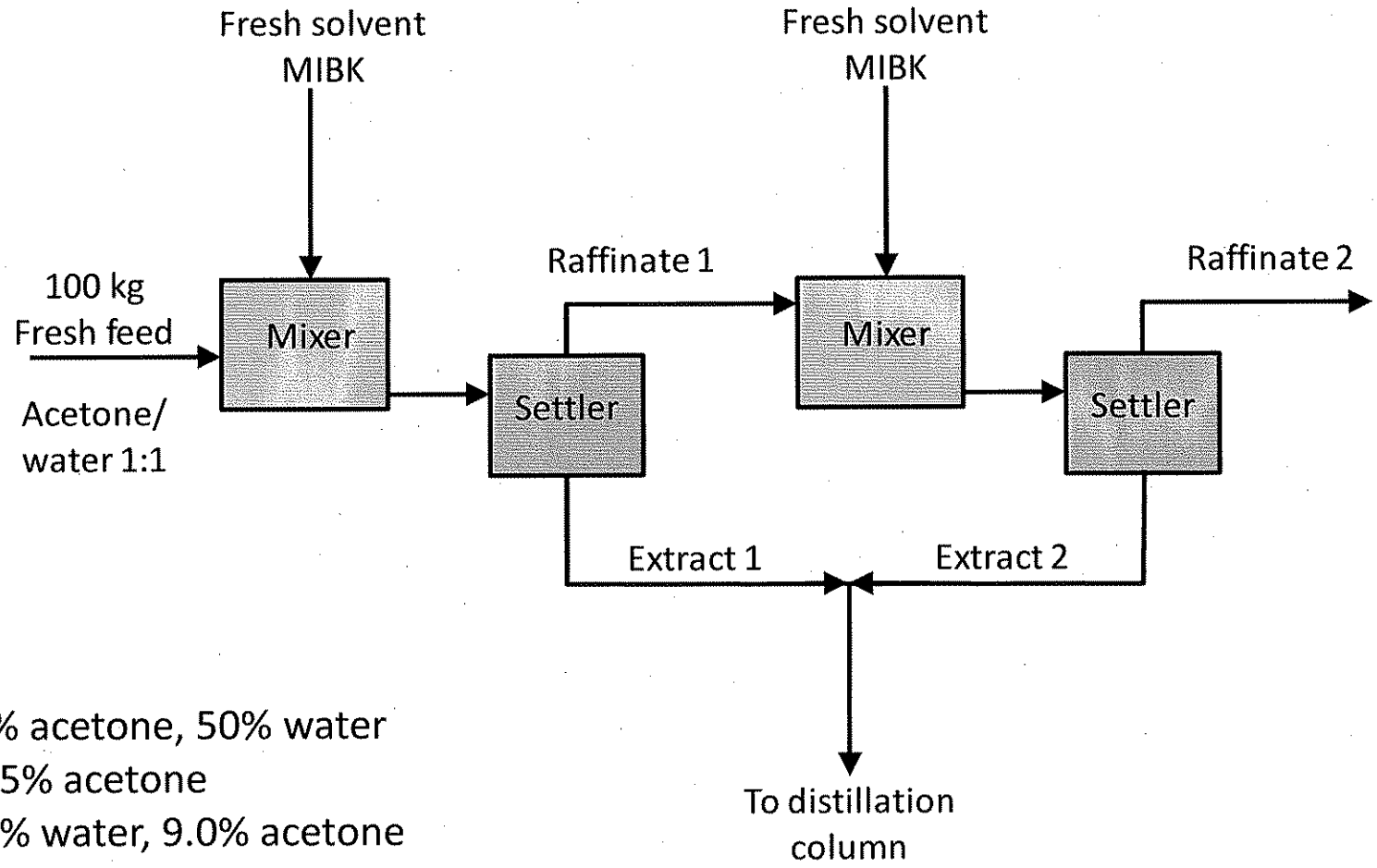
Department of Chemical Engineering
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28 May 2013

YouTube: [DrMorrisonMTU](#)

Reference: Felder and Rousseau, 3rd Edition, 2000

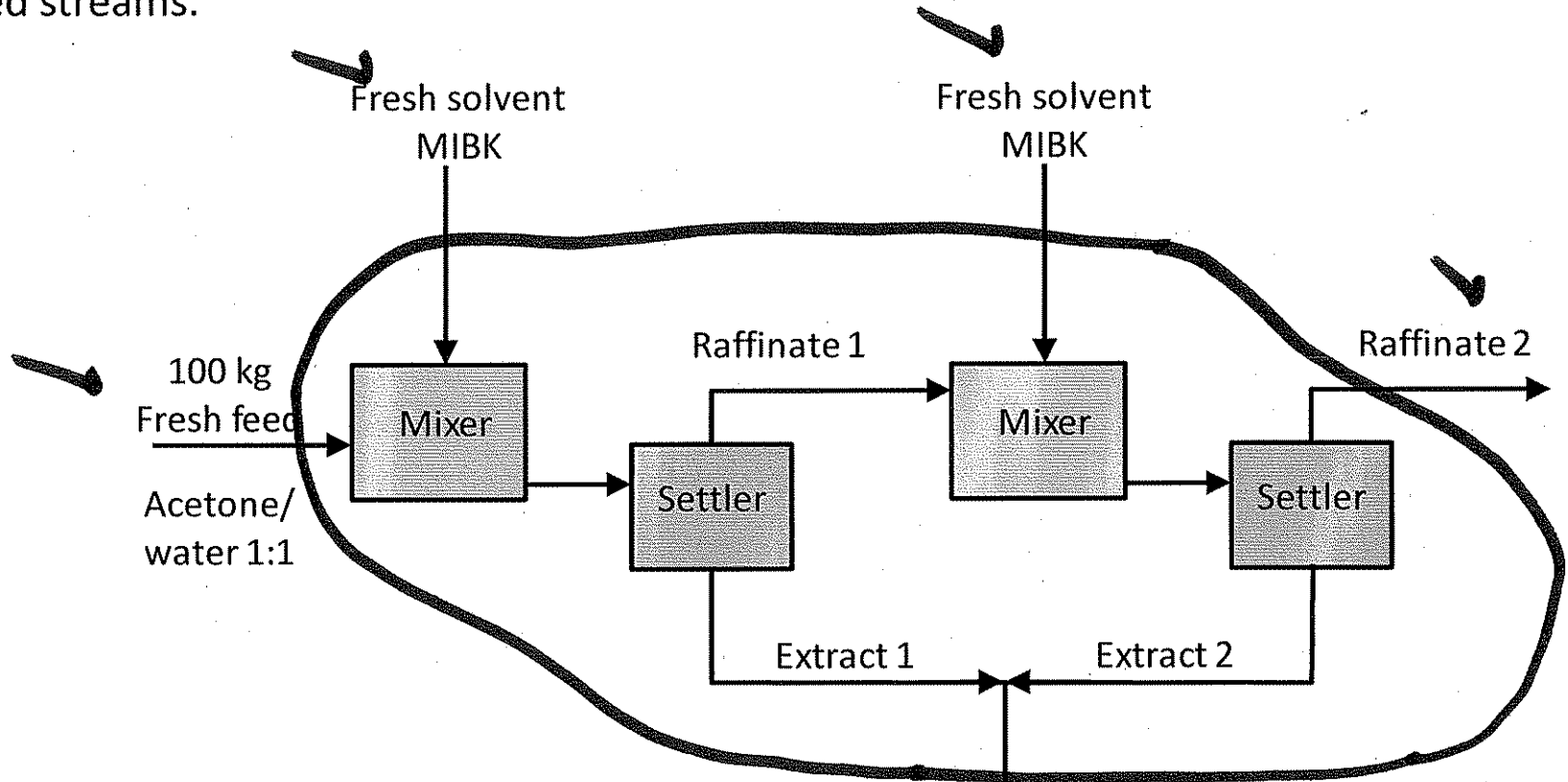
FR Example 4.4-2 (partial): The two-stage extraction process shown below is used to separate a 50/50 wt% mixture of acetone and water. The extraction solvent is methyl isobutyl ketone (MIBK). For every 100 kg of fresh feed, 100 kg MIBK is added to stage 1 and 75 kg MIBK is added to stage 2. Calculate the flow rates and compositions of all named streams.



- Fresh feed: 50% acetone, 50% water
- Extract 1: 27.5% acetone
- Extract 2: 3.0% water, 9.0% acetone
- Raffinate 2: 43.1 kg total, 93.1% water, 5.3% acetone

3

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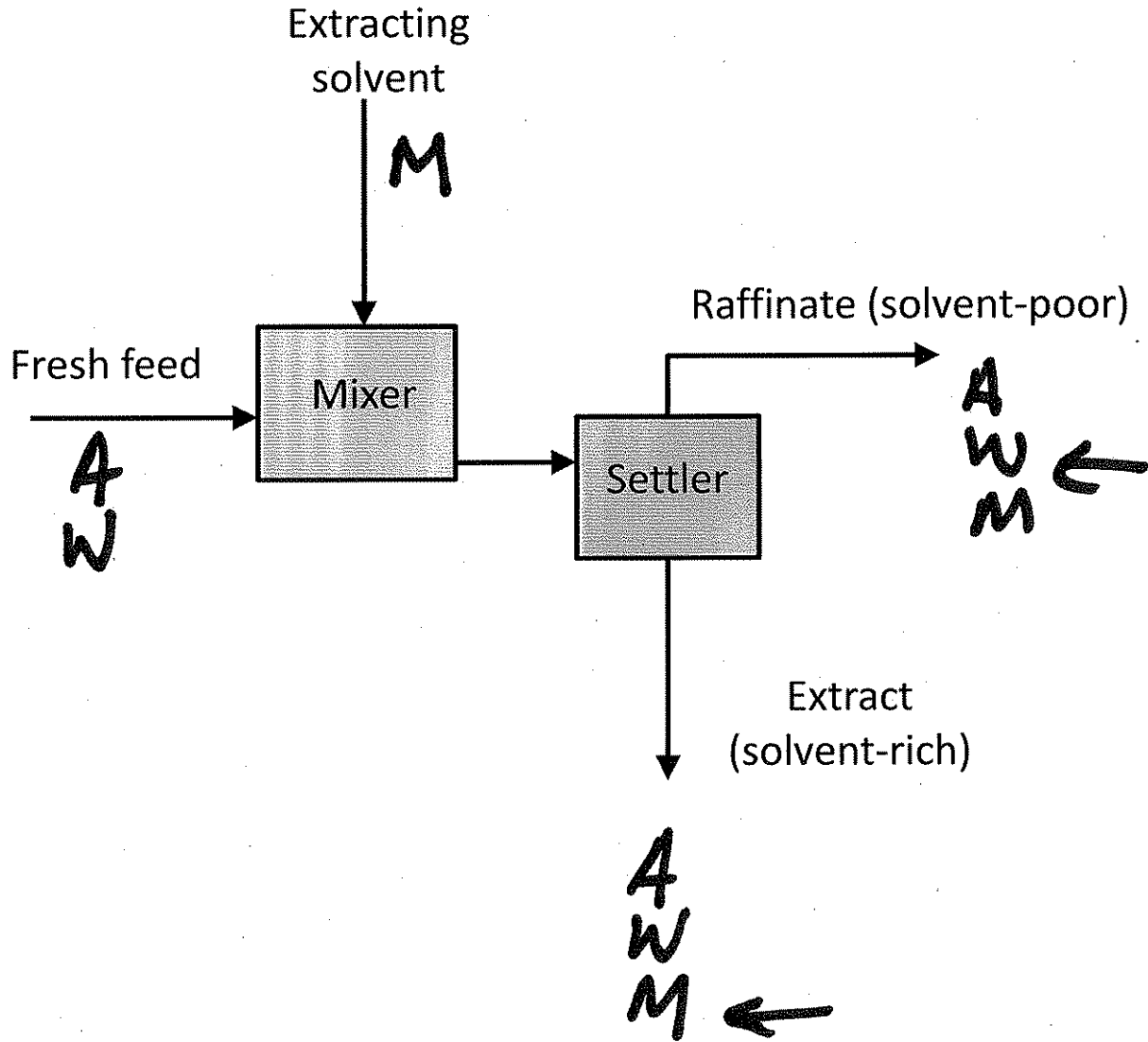
⇒ 1.6% MIBK

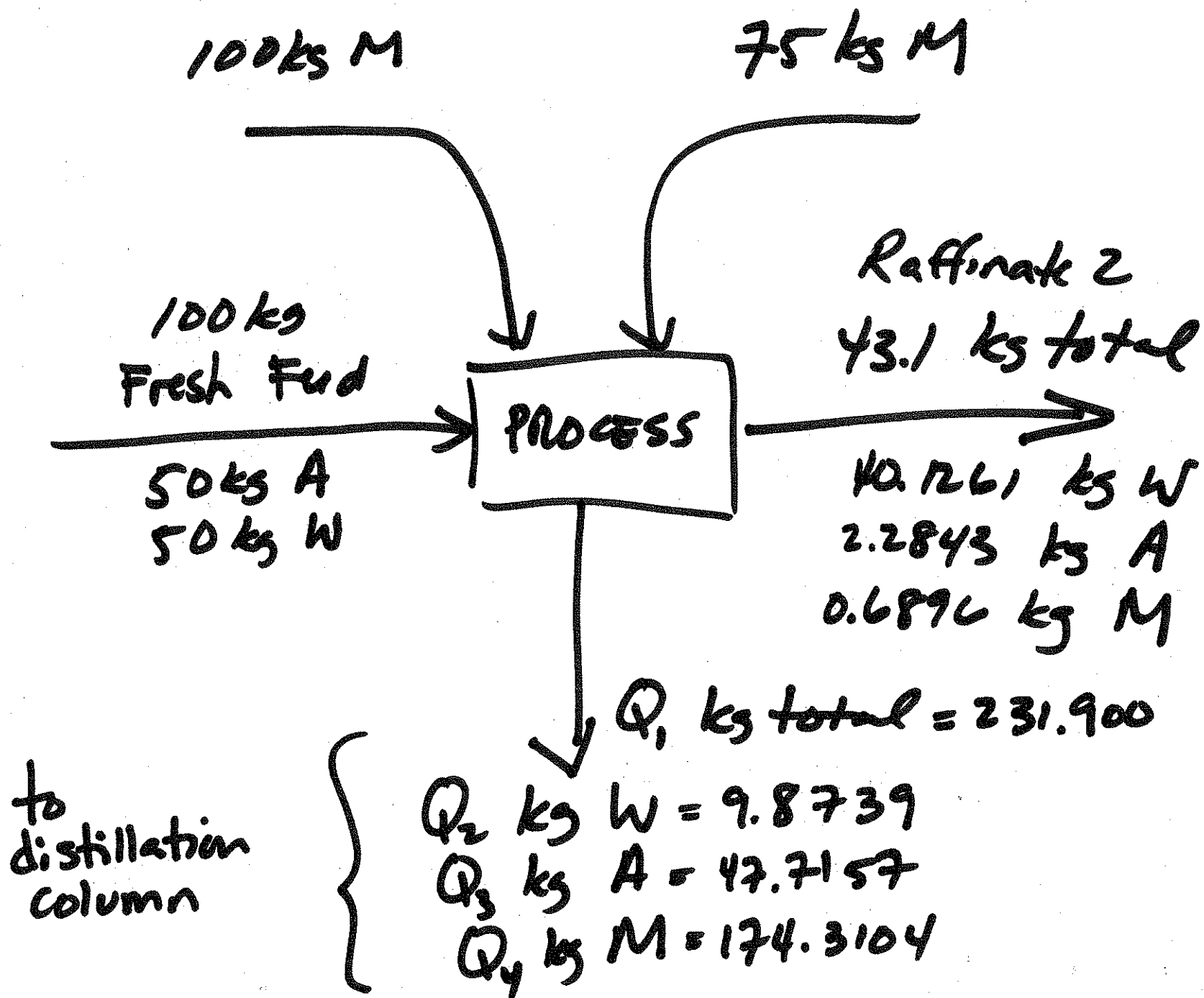
To distillation column

W:

$$\frac{(43.1 \text{ kg}) \cdot (93.1)}{\text{kg Total}} = 40.1261 \text{ kg W}$$

Liquid-Liquid Extraction





Overall MASS Balance

$$100 + 100 + 75 = 43.1 + Q_1$$

$$Q_1 = 231.9 \text{ kg}$$

WATER

$$SD = 40.1261 + Q_2$$

$$Q_2 = 9.8739 \text{ kg}$$

ACETONE

$$SD = 2.2843 + Q_3$$

$$Q_3 = 47.7157 \text{ kg A}$$

MIBK

$$100 + 75 = 0.6896 + Q_4$$

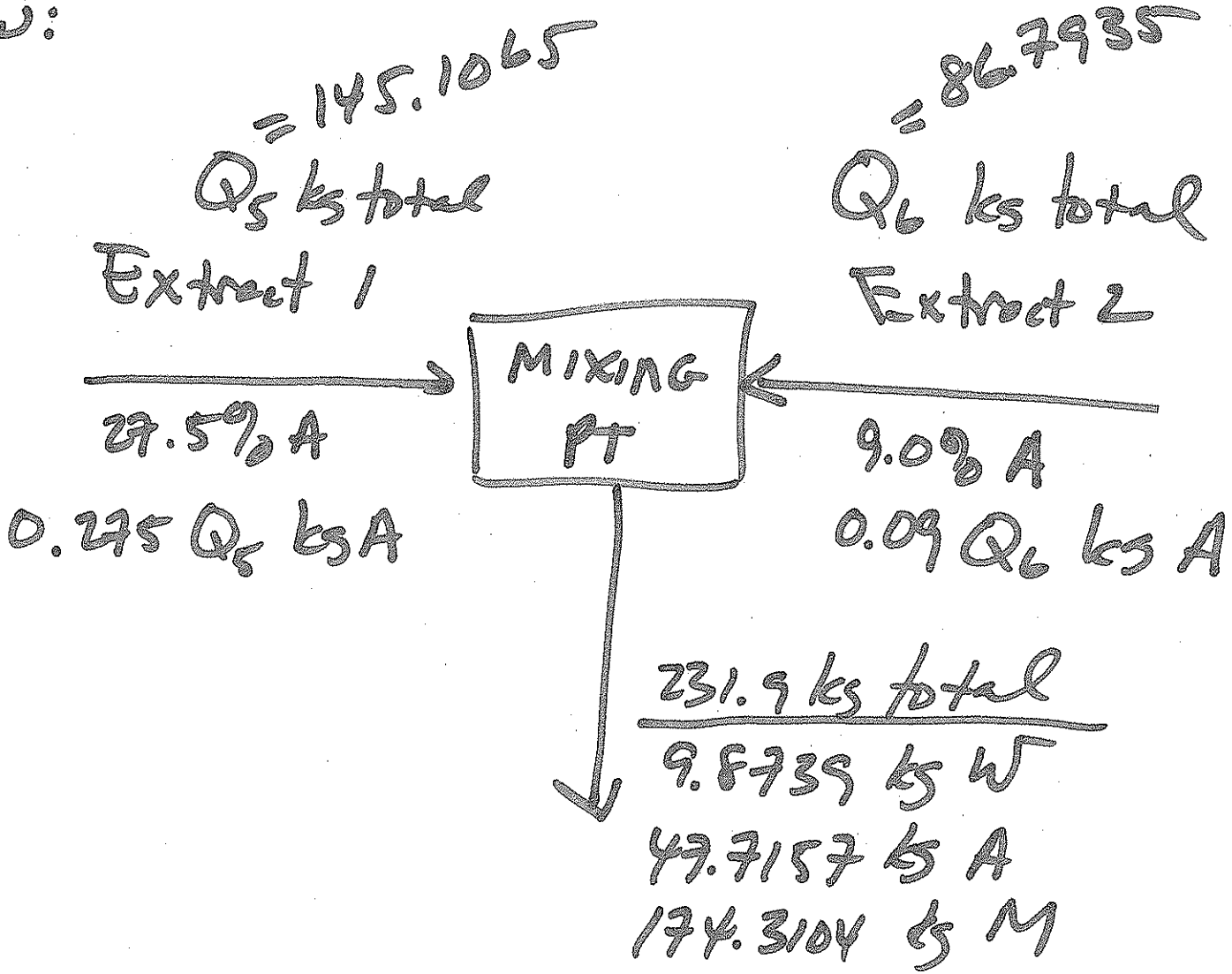
$$Q_4 = 174.3104 \text{ kg}$$

(5)

PART 2: Inside Balances

Choose the mixing point, where we know the most.

Redraw:



MIXING POINT

(7)

MASS BAL OVERALL

$$Q_5 + Q_6 = 231.9 \text{ kg}$$

$$Q_6 = 231.9 - Q_5$$

2 EQUATIONS
2 unknowns

ACETONE BAL

$$0.275 Q_5 + 0.09 Q_6 = 47.7157$$

$$0.275 Q_5 + 0.09 (231.9 - Q_5) = 47.7157$$

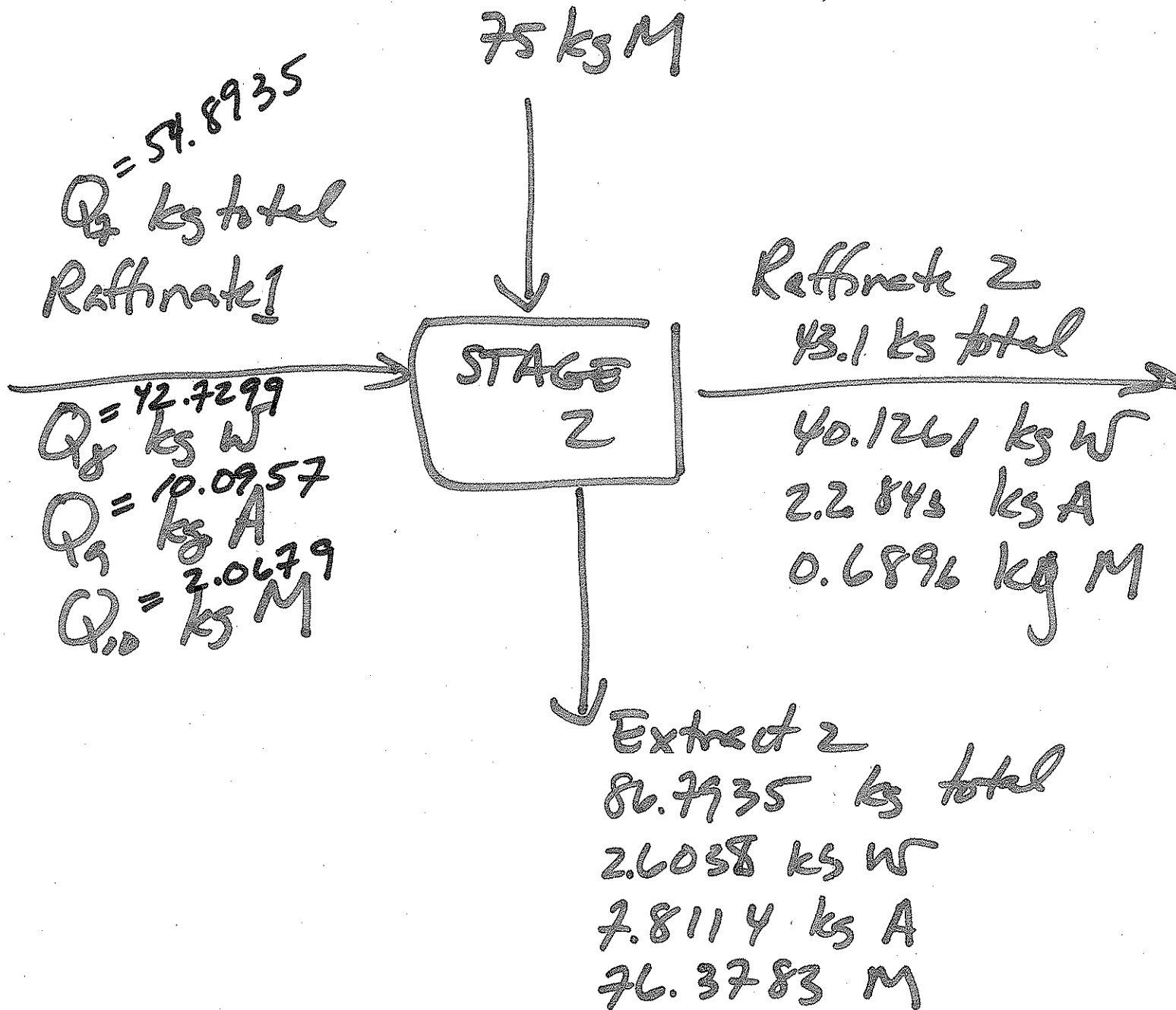
$$0.275 Q_5 + 20.8710 - 0.09 Q_5 = 47.7157$$

$$0.185 Q_5 = 26.8447$$

$Q_5 = 145.1065 \text{ kg}$
$Q_6 = 86.7935 \text{ kg}$

STAGE 2 BALANCES (redraw)

8



STAGE 2

9

OVERALL MASS

$$Q_7 + 75 = 43.1 + 86.7935$$

$$Q_7 = 51.8935 \text{ kg}$$

WATER BAL

$$Q_8 = 40.1261 + 2.6038 = 42.7299 \text{ kg} = Q_8$$

ACETONE BAL

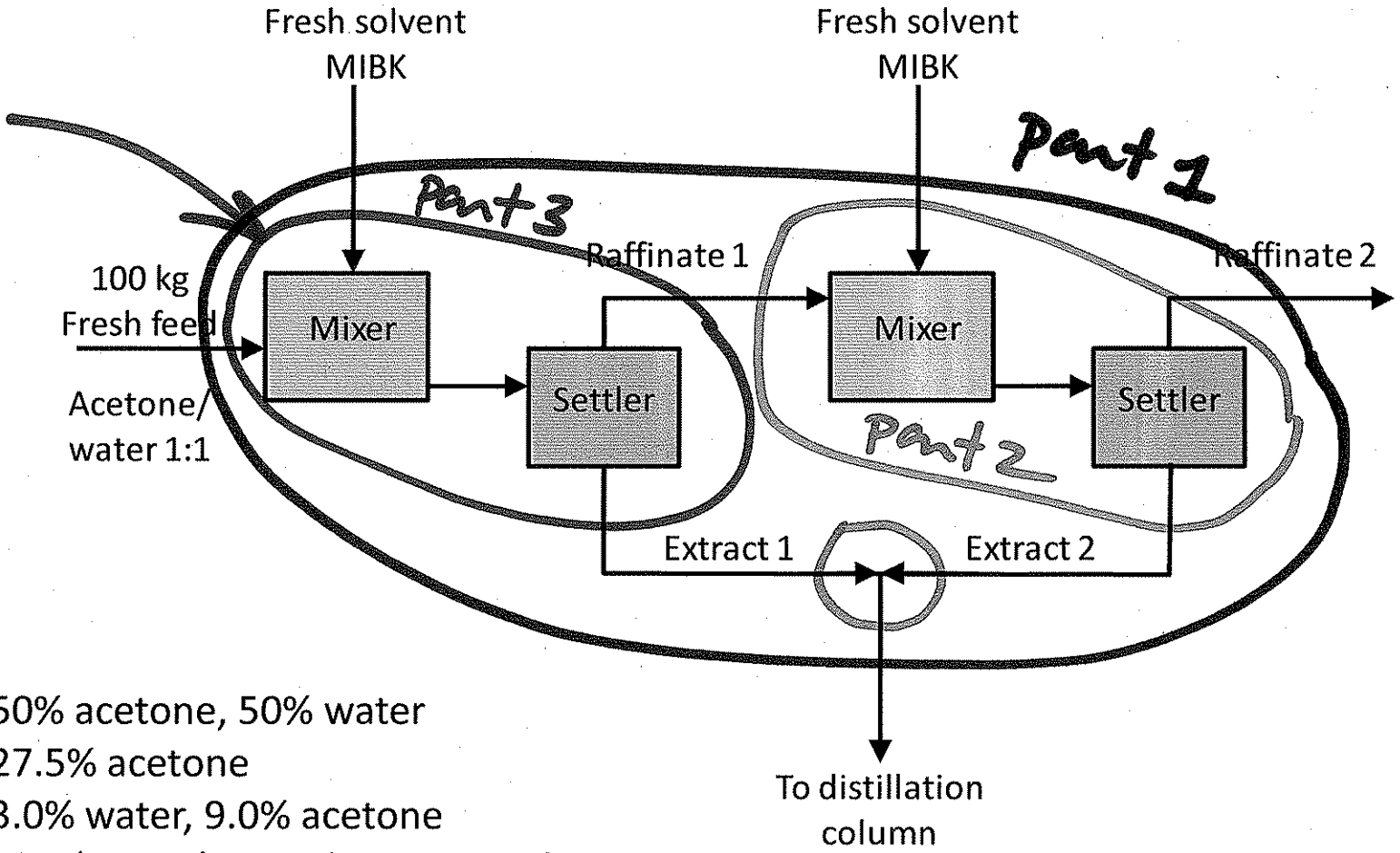
$$Q_9 = 2.2843 + 7.8114 = 10.0957 \text{ kg} = Q_9$$

MIBK Bal

$$Q_{10} + 75 = 0.6896 + 76.3783$$
$$Q_{10} = 2.0679 \text{ kg}$$

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Last step!

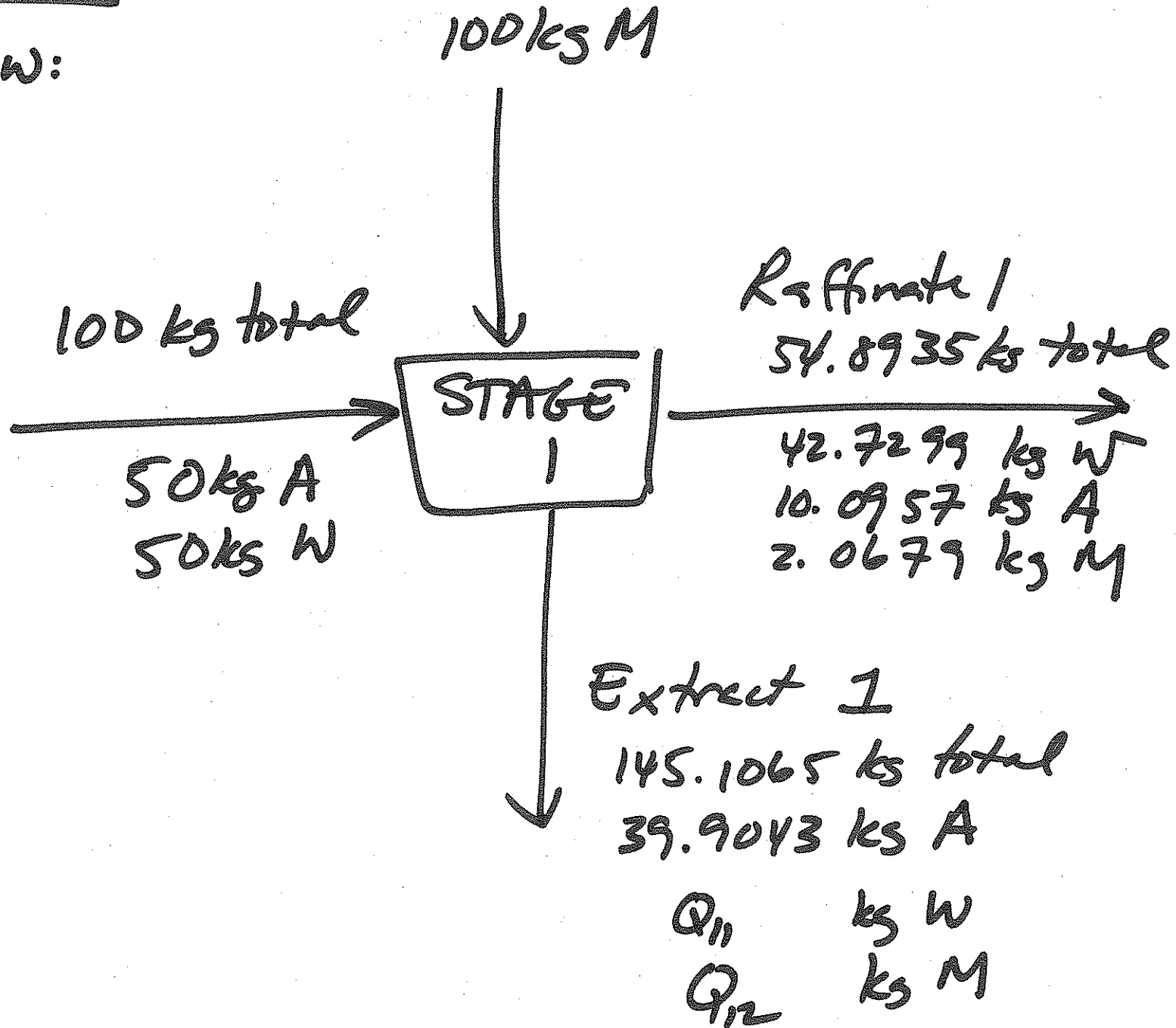


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STAGE 1

(11)

redraw:



STAGE 1

OVERALL MASS BAL (check)

$100 + 100 \stackrel{?}{=} 54.8935 + 145.1065 \checkmark$

ACETONE BAL (check)

$50 \stackrel{?}{=} 10.0957 + 39.9043 \checkmark$

WATER BAL

$50 \text{ kg} = 42.7299 + Q_{11}$

$Q_{11} = 7.2701 \text{ kg}$

MIBK BAL

$100 = 2.0679 + Q_{12}$

$Q_{12} = 97.9321 \text{ kg}$

Remaining:

- sig Figs = 3
- mass % calculations

