Aalto University
School of Chemical Technology

Dec, 12th 2016

PO

CHEM-E7105 – Process Development

Name: _____ Student nr: _____

- Be short, but precise in your answers.
- Avoid telling stories!
- Calculator can be used.

1a) Why and by which chemical sectors batch processes are used in chemical industry [3]

1b) Describe shortly the batch process of figure A [3]

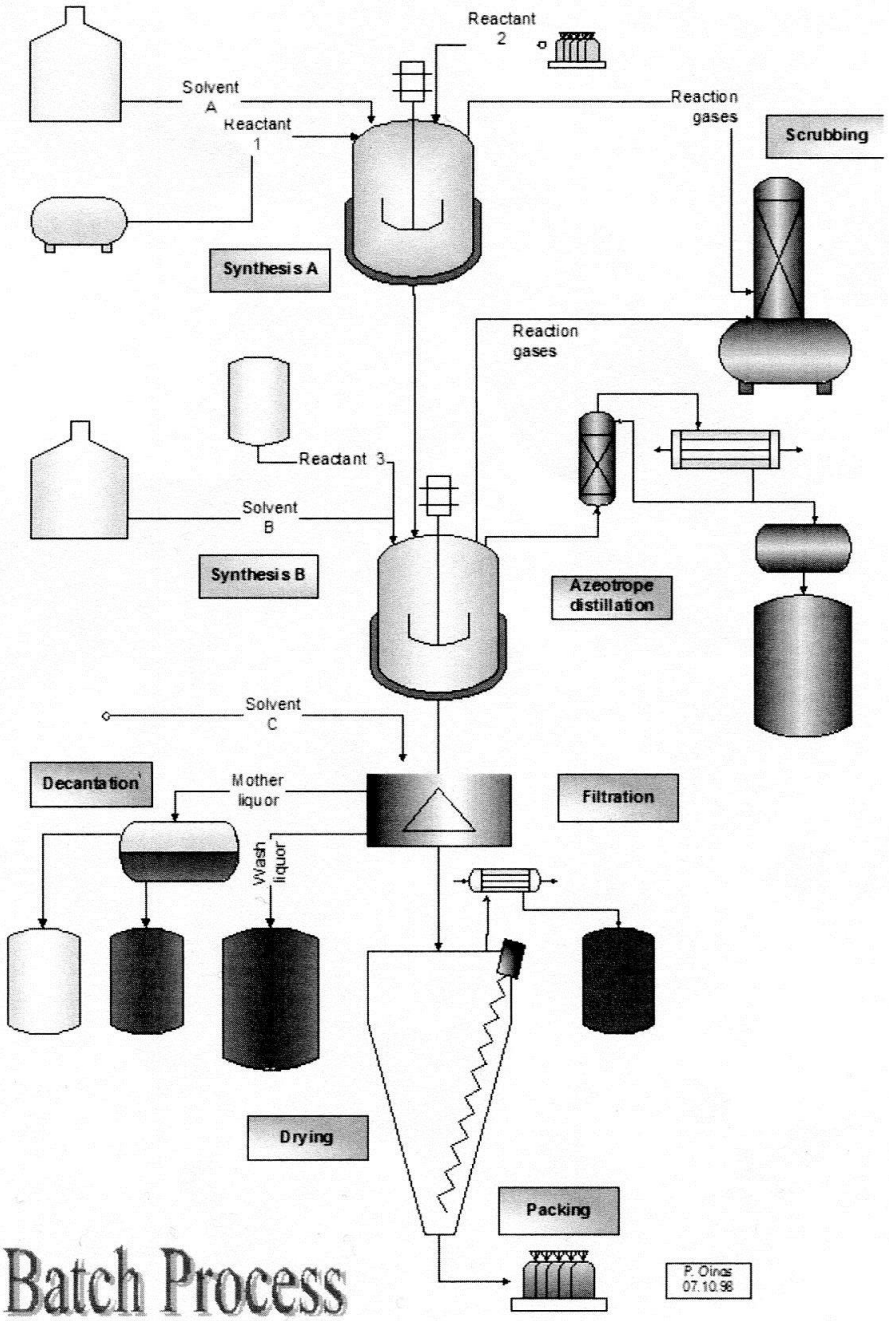

Figure A. Batch process

2) Mechanistic models in chemical engineering [6]

3a) What information is needed for thermal safety [2]

3b) Methods for preventing corrosion [2]

3c) Selection criteria for the safe manufacturing [2]

4) Principles of process intensification [6]

5. Balance calculation [12]

Sulphuric acid can be produced by two absorption routes. In the first route, sulphur trioxide is contacted with water by chemical absorption

Route 1: $H_2O + SO_3(g) \rightarrow H_2SO_4(l)$

Another way is to use so-called contact process by absorbing sulphur trioxide to sulphuric acid and forming firt fuming sulphuric acid (oleum, $H_2SO_4 \cdot SO_3$)

Route 2: $H_2SO_4 + SO_3(g) \rightarrow H_2SO_4 \cdot SO_3(l)$

Oleum is then reacted with water to form concentrated sulphuric acid.

$H_2SO_4 \cdot SO_3(l) + H_2O(l) \rightarrow 2\ H_2SO_4(l)$

a) Which route is more appropriate by inspecting the heats of formation of the components?

b) Calculate mass balance for the route 2 (products; moles, masses, volumes weight percentages) for an absorption where 20 kmol/h of H_2SO_4 (99 wt.% acid, rest is water) is scrubbed with equimolar amount of SO_3 gas at 50 °C and 1 bar pressure (R=8.314 $\frac{J}{mol/K}$). Note that water in feed H_2SO_4 also reacts to H_2SO_4 according route 1 reaction scheme.

c) If the absorber diameter of route 2 process is 500 mm, what is the superficial velocity of SO_3 gas?

INFORMATION

Substance	MW	ρ_L	ΔH_f
	g/mol	kg/m^3	kJ/mol
H_2SO_4	98.08	1842	-814.0
SO_3	80.06	1850	-395.7
H_2O	18.01	1000	-285.8
Oleum	178.14	see fig. B	-683.92

ΔH_f, heat of formation

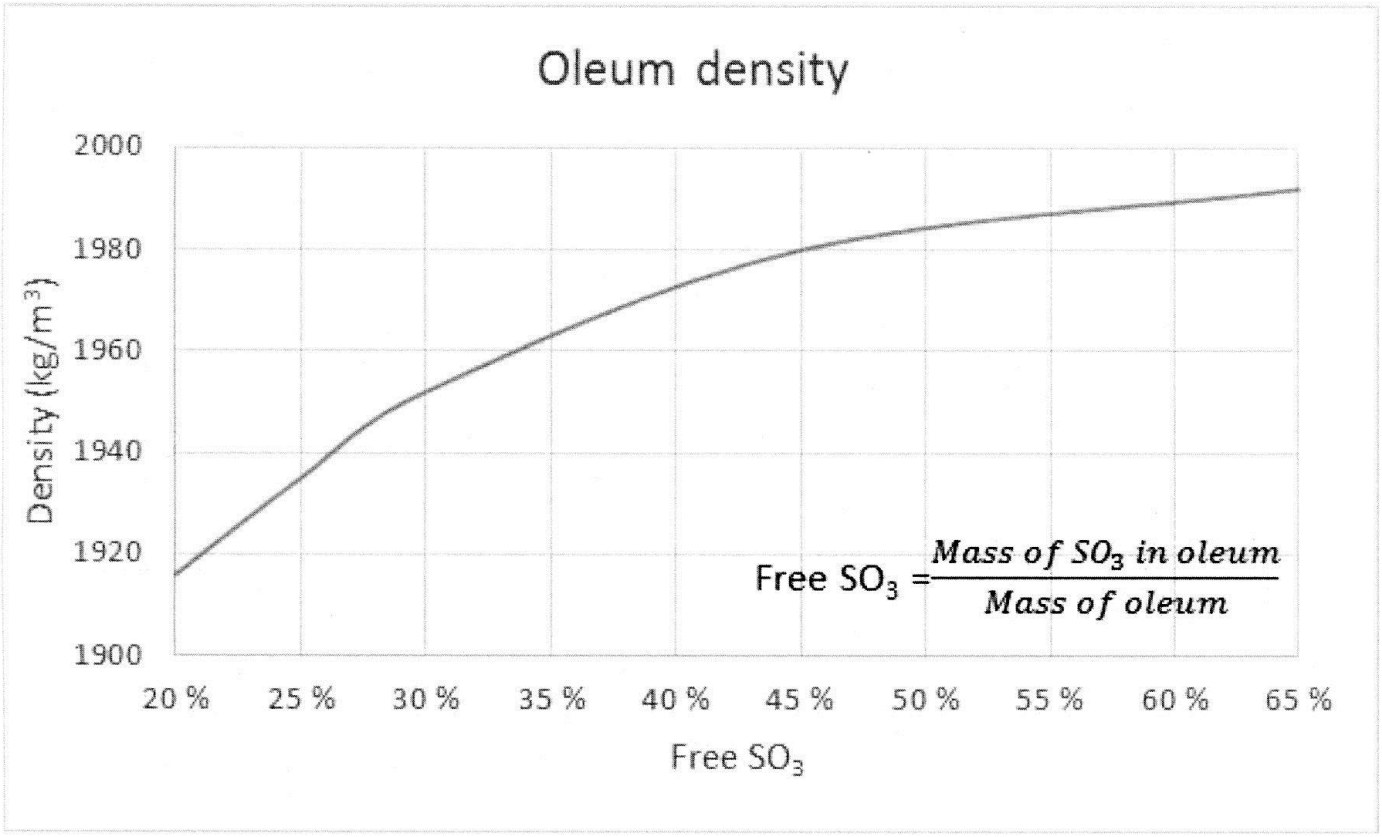

Figure B. Oleum density

Grading:

Total points: 36 5 ≥ 31 points