1/ Which of the three principle types of flowsheet would one use to:

i) give a new employee an overview of the plant process?
ii) trace down a fault in a control loop?
iii) make a preliminary capital cost estimate to construct a plant?
iv) indicate whether a controller is to be located in the control room or in the plant?
v) indicate which pipe lines need insulation?
vi) represent major pieces of equipment as rectangles rather than icons?
vii) In what type of flowsheet would one expect to find pipe diameters and materials of construction?

2/ 500kg of a 5% slurry of calcium hydroxide in water is to be prepared by diluting a 20% slurry. Calculate the quantities required.

[125kg of 20% $Ca(OH)_2$ and 375kg of H_2O]

3/ 20% excess air is supplied to a furnace burning 100m^3/hr of natural gas (95% methane, 5% ethane by volume). Calculate the air flow of air (21% O_2) required. The reactions are:

$$CH_4 + 2O_2 \rightarrow CO_2 + 2H_2O$$
$$C_2H_6 + 7/2\ O_2 \rightarrow 2CO_2 + 3H_2O$$

[1185.7m^3/hr]

4/ In the production of ethanol by the hydrolysis of ethylene, diethyl ether is produced as a by-product. The feed stream composition is 55% ethylene, 5% inerts, 40% water. The composition of the product stream is 52.26% ethylene, 5.49% ethanol, 0.16% ether, 36.81% water, 5.28% inerts. All percentages are by mole. Calculate the selectivity of ethylene for ethanol and for ether and also the conversion of ethylene. The reactions are:

$$C_2H_4 + H_2O \rightarrow C_2H_5OH$$
$$2C_2H_5OH \rightarrow (C_2H_5)_2O + H_2O$$

[selectivity for ethanol = 94.4%, for ether = 5.44%, conversion = 10%]

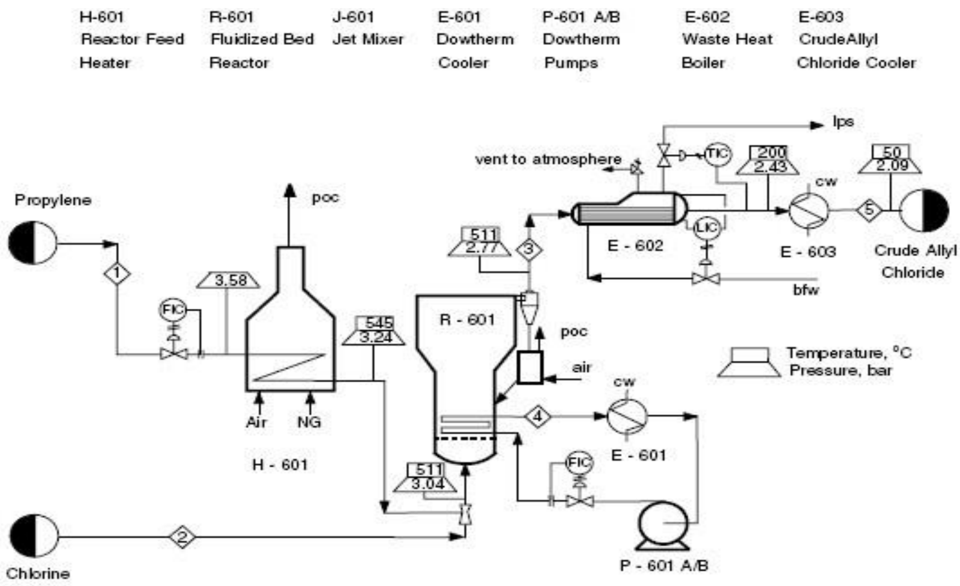
5/ A train of two distillation columns is being used to separate a mixture of hexane, heptane and octane. The feed to the first column contains 40 mole% hexane, 30 mole% heptane and 30 mole% octane and enters at a rate of 2500 kmol/h. In the first column 98% of the octane fed is recovered in the bottom product. Essentially no hexane goes with the bottom product and the mole fraction of octane in the bottom is 99.5%. The overhead product flows to a second column. The overhead product from the second column contains 98 mole% hexane and no octane. In addition, 98% of the hexane fed to this column is recovered in the overhead.

a) Draw a diagram of the process, labeling all of the streams.
b) Calculate the molar flow rates and mole fractions for each stream in the process.

6/ In ammonia production from H_2 and N_2, unreacted material is recycled. The feed stream to the process is at 200mols/hr and contains 0.2% argon as an inert. To avoid a build up of the inert there is a purge stream. Calculate the required flow rate in the purge stream to maintain the argon level in the recycle stream below 5%.

[8 mols/hr]

7/ Examine the process flow diagram below and answer the following questions:



i) What is the pressure (in bar) in stream 5?
ii) What is the temperature change in the product caused by E-603?
iii) What is the role of the LIC between E-603 and the boiler feed water (bfw)?
iv) What differences (composition, pressure, temperature, flowrate, vapour fraction) are there between streams 3 and 5?
v) What is the overall conversion of this process?

Stream No.	1	2	3	4	5
Temperature (°C)	25	25	511	400	50
Pressure (bar)	11.7	6.44	2.77	11.34	2.09
Vapor fraction	1.0	1.0	1.0	0.0	1.0
Mass flowrate (tonne/h)	3.19	1.40	4.59	16.63	4.59
Molar flowrate (kmol/h)					
Propylene	75.89	—	58.08	—	58.08
Chlorine	—	19.70	—	—	—
Allyl chloride	—	—	15.56	—	15.56
2-Chloro propene	—	—	0.46	—	0.46
Di chloro propene	—	—	1.81	—	1.81
Hydrogen chloride	—	—	19.70	—	19.70
Carbon	—	—	—[1]	—	—
Dowtherm™ A	—	—	—	4.62 kg/s	—
Total mole flow (kmol/h)	75.89	19.70	95.61	4.62 kg/s	95.61

$$Conversion = \frac{moles\ of\ reagent\ consumed}{moles\ of\ reagent\ supplied}$$

$$Selectivity = \frac{moles\ of\ product\ formed}{moles\ of\ product\ that\ could\ have\ been\ formed\ had\ all\ reagent\ been\ used\ to\ make\ product}$$

$$Yield = \frac{moles\ of\ product\ formed}{moles\ of\ reagent\ supplied\ x\ stoichiometry}$$

$$Yield = conversion * selectivity$$