

Uva Wellassa University, Sri Lanka
End Semester Examination – June 2009
ENG 324-2 Chemical Engineering Science



Time: Two (02) hour

Total 04 questions

Answer all questions

Clearly state any assumptions made

You can assume any missing data

Tables of properties are provided in the exam hall

- 01) The volumetric analysis (on dry basis) of flue gases produced from the combustion of a sample of coal (nitrogen free) containing 81% (w/w) carbon is as given below:

Carbon dioxide	= 11%
Carbon monoxide	= 2%
Oxygen	= 4%
Nitrogen	= 83%

Determine,

- I. mass of air supplied per kg of coal burnt

(08 marks)

- II. excess air supplied per kg of coal burnt.

(08 marks)

- III. air supplied per kg of fuel if the dry flue gas analysis (% by weight) is
 $\text{CO}_2 = 17.36$, $\text{O}_2 = 7.44$ and $\text{N}_2 = 75.2$

(09 marks)

- 02) A saturated liquid mixture containing 60 mole % benzene and 40 mole % toluene is to be distilled continuously into a distillate product containing 90 mole % benzene and the bottom product containing 5 mole % benzene. The fractional distillation column will operate at approximately constant pressure of 1 atm. The reflux ratio is 2. How many theoretical plates must the column have if the feed is introduced into the eighth plate?

Equilibrium data are:

x	0	0.017	0.075	0.13	0.211	0.288	0.37	0.411	0.581	0.78	1
y	0	0.039	0.161	0.261	0.393	0.496	0.591	0.632	0.777	0.9	1

(25 marks)

03)

- I. List out the typical steps in heat transfer equipment design procedure.

(10 marks)

- II. An experimental double pipe heat exchanger consists of a horizontal copper pipe (ID = 15.06 mm, OD = 19.05 mm, length = 2.75 m) inside (tube) and concentric with a 0.1 m OD steel pipe (Shell). The outside of the 0.1 m pipe is well insulated with 85 percent magnesia. The temperature of the outer surface of the copper pipe is measured by means of fine copper – constantan thermocouples attached to the surface. Condensing steam is used on the outside surface of the copper pipe, while the fluid under investigation flows through the copper pipe. The results from a run in which water was flowing through the copper pipe are given below:

Inlet water temperature	= 73.4°C
Outlet water temperature	= 91.8°C
Temperature of condensing steam	= 105.8°C
Heat given up by steam	= 13.98 kW
Mean temperature of outer surface of copper pipe	= 99.5°C

Calculate the heat transfer coefficient (h_i) between water and the inside of copper pipe. Thermal conductivity of copper = 379 W/mK.

Hint: Use mean temperature of outer surface of copper pipe to calculate the heat transfer coefficient (h_o) between steam and the outside of copper.

(15 marks)

04)

- I. List out the main factors to be considered when selecting equipment and operating conditions for liquid filtration.

(10 marks)

- II. A filtration test was carried out, with particular product slurry, on a laboratory filter press under a constant pressure of 340 kPa and volumes of filtrate were collected as follows:

Filtrate volume (kg)	20	40	60	80
Time (min)	8	26	54.5	93

The area of the laboratory filter was 0.186 m². In a plant scale filter, it is desired to filter a slurry containing the same material, but at 50% greater concentration than that used for the test, and under a pressure of 270 kPa. Estimate the quantity of filtrate that would pass through in 1 hour if the area of the filter is 12 m².

(15 marks)