

**Chemical Engineering Department  
College of Engineering  
King Saud University**

**Chemical Engineering Principles – I (ChE201)**

**Time: 3 hours**

**Final Examination**

**Date: 20/2/1431 H**

**Instructions:**

- 1- Answer ALL questions
- 2- **Data:** Atomic mass: **H=1, C=12, O=16, N=14**

**Question 1 (10 points):**

A drum contains 3.9 liters of liquid benzene ( $C_6H_6$ ), through which air is bubbled at a rate of 1.8 mol/min. The gas stream leaving the drum contains 10 mol% of benzene vapor. If air is insoluble in benzene estimate the time required to evaporate all of the benzene. The specific gravity of benzene is 0.88

**Question 2 (15 points):**

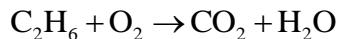
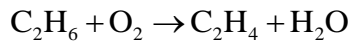
A salt solution flowing at 1000 kg/s and contains 30% salt is mixed with a recycled stream. The mixed stream is fed to an evaporator in which part of the water is evaporated. The concentrated salt solution leaving the evaporator contains 65% salt is fed to a crystallizer equipped with a filter. The solution leaving the filter which contains 52% salt is recycled and mixed with the fresh feed. The solid portion (crystals) contains 90% salt crystals and 10% of a wetting solution having the same composition of the recycled stream. All % are mass % (i.e., weight %).

**Calculate:**

- (i) amount of water evaporated
- (ii) ratio of recycled stream to fresh feed.

**Question 3 (10 points):**

The following simultaneous reactions take place in a continuous reactor:

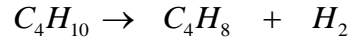


The feed to reactor contains 25 mol% ethane ( $C_2H_6$ ) and the balance is oxygen. The conversion of ethane is 60%. The selectivity of ethylene ( $C_2H_4$ ) to  $CO_2$  is 2. For a feed flow rate of 1000 mol/min:

- (i) The molar flow rate of the reactor's products
- (ii) The molar composition (dry basis) of the products.

**Question 4 (15 points)**

Butane ( $C_4H_{10}$ ) is dehydrogenated to form butylene ( $C_4H_8$ ) in a catalytic reactor according to:



The process is designed for a 90% overall conversion of butane. The reactor products are separated into two streams: the first, which contains  $H_2$ ,  $C_4H_8$  and 1% of the butane that leaves the reactor, is taken off as product; the second stream, which contains the balance of unreacted butane and 2% of the butylene in the first stream, is recycled to the reactor. The fresh feed is pure butane flowing at 200 mol/s. **Calculate:**

- (a) the molar composition of the product
- (b) the ratio (moles recycled)/(moles fresh feed)
- (c) the single pass conversion.

