

**Chemical Engineering Department**

**CLL 111 (Material and Energy Balances) Minor Exam**

**19/9/2021 (9:30-10:30 am)**

**Time: 1 Hour**

**M. Marks: 30**

1. Methanol is synthesized from carbon monoxide and hydrogen in a catalytic reactor. The fresh feed to the process contains 32 mole % CO, 64.0 % H<sub>2</sub>, and 4.0 % N<sub>2</sub>. This stream is mixed with a recycle stream in a ratio 5 mol recycle/1mol fresh feed to produce the feed to the reactor, which contains 13.0 mole % N<sub>2</sub>. A low single-pass conversion is attained in the reactor. The reactor effluent goes to a condenser from which two streams emerge: a liquid product stream containing essentially all the methanol formed in the reactor, and a gas stream containing all the CO, H<sub>2</sub>, and N<sub>2</sub> leaving the reactor. The gas stream is split into two fractions: one is removed from the process as a purge stream, and the other is the recycle stream that combines with the fresh feed to the reactor. Calculate the production rate of methanol (mol/h), the molar flow rate and composition of the purge gas, and the overall and single-pass conversion. **(3x5)**
2. A gas contains 80.0 wt. % propane, 15.0 wt. % n-butane, and the balance water.
  - a. Calculate the molar composition of this gas on both a wet and a dry basis and the ratio (mol H<sub>2</sub>O/mol dry gas). **(3,3)**
  - b. If 100 kg/h of this fuel is to be burned with 30 % excess air, what is the required air feed rate (kmol/h). **(9)**