**BIRLA INSTITUTE OF TECHNOLOGY AND SCIENCE, PILANI**
**First Semester 2022-2023**
**CHE F211: Chemical Process Calculations**
**Mid-Semester Examination**

**Date: 31.10.2022** **Time: 2:00-3:30 PM** **Maximum Marks: 90**

***Note*:** The question paper consists of two parts. Answer **Part A** and **Part B** in separate answer books. Collect answer book for **Part B** after submitting **Part A** answer book.

**PART – A (Closed Book)**

**Time: 2:00 - 2.45 P.M.** **Marks: 45**

1. **(15 Marks)** Explain the following terms/phrases briefly in a sentence or two:
(i) Limiting reactant (ii) Excess reactant and % excess reactant (iii) Selectivity (iv) Conversion (v) Yield (vi) Degrees of freedom analysis (vii) Degree of completion (viii) Extent of reaction (ix) Orsat analysis (x) Theoretical air (xi) Closed- and open system (xii) Steady-state- and Unsteady-state process (xiii) Batch- and semi-batch process (xiv) Continuous process (xv) Unit processes and unit operations.

2. **(15 Marks)** Oxalic acid ($H_2C_2O_4$) is to be crystallized from a saturated aqueous solution by cooling from 100$^o$C, where the solubility is 84.4 g $H_2C_2O_4$/100 g of water. Find the amount of crystals and the final solubility in g $H_2C_2O_4$/100 g of water if 95% of the acid is crystallized as dihydrate ($H_2C_2O_4.2H_2O$)? Neglect the amount of water vaporized.

3. (**15 Marks**) Acrylonitrile is produced in the reaction of propylene, ammonia and oxygen:

$$C_3H_6 + NH_3 + 1.5\ O_2 \rightarrow C_3H_3N + 3H_2O$$

The feed contains10 mol% propylene, 12 mol% ammonia and 78 mol% air. A conversion of 30% of the limiting reactant is achieved. Determine:
   a) Which reactant is limiting,
   b) The percentage by which each of the other reactants is in excess, and
   c) The analysis by wt% of all product gas constituents for 30 mol% conversion of the limiting reactant.

[Atomic weights: C-12, H-1, O-16, N-14]

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**PART – B (Open Book)**

**Time: 2:45 – 3:30 P.M.** **Marks: 45**

***Note*:** Only Text book (Himmelblau and Riggs, 8th ed.) and hand written class notes are allowed. Photocopies of class notes are not allowed.

1. (**15 *Marks***). A manufacturer of briquettes has a contract to make briquettes for barbecuing that are guaranteed to not contain over 10% moisture or 10% ash. The basic material used has this analysis: moisture 12.4%, volatile material 16.6%, carbon 57.5%, and ash 13.5%. To meet the specifications (at their limits) the manufacturer plans to mix with the base material a certain amount of petroleum coke that has this analysis: volatile material 8.2%, carbon 88.7%, and moisture 3.1%. How much petroleum coke must be added per 100 kg of the base material?

2. (**15 *Marks***) Hydrogen can be produced by the shift reaction:

   $$CO + H_2O \rightarrow CO_2 + H_2$$

   In the reactor system shown in Figure Q2, the conditions of conversion have been adjusted so that the $H_2$ content of the effluent from the reactor is 3 mol %. Based on the data in Figure Q2:

   a) Perform the degrees of freedom analysis.

   b) Calculate the amount of reactants in the fresh feed per 100 mole of product.

   c) Calculate the moles of recycle per mole of hydrogen produced.

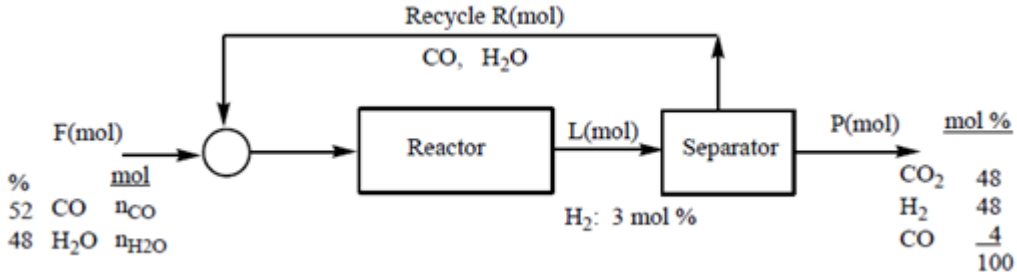


Figure Q2

3. (**15 *Marks***) Pure carbon is burned in oxygen. The flue gas analysis is:

   $CO_2$ 75 mol%

   CO 14 mol%

   $O_2$ 11 mol%

   What was the percent excess oxygen used?

**[All the best]**

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