**RECORD YOUR RESPONSE IN THE SPACE PROVIDED UNDER EACH SUBQUESTION**

**AQ1: Gas absorption 20 Marks**

A gas absorption tower is expected to remove 90% of CO2 present in a flue gas stream by contacting counter-currently with a water-amine solution. The inlet flue gas has a flow rate of 20 kmol/s and contains 11 mol% CO2. The absorption process is carried out in a packed absorption column at 60 °C and 1.2 bar. The water-amine feed solution contains 2.0 mol% CO2, since it comes from a stripping column used for regeneration. The enriched solution leaving the bottom contains 4.8 mol% CO2. The equilibrium data for this system is provided in Table 1.

**Table 1: Equilibrium data for CO2 and water-amine at 1.2 bar and 60 °C (inert air present).**

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| **CO2 mol fraction in water-amine** | **CO2 mol fraction in gas** |
| 0 | 0 |
| 0.01121 | 0.00525 |
| 0.02227 | 0.01162 |
| 0.03001 | 0.02917 |
| 0.03339 | 0.03783 |
| 0.04101 | 0.06057 |
| 0.047 | 0.08448 |
| 0.05324 | 0.116 |

Based on this description, answer questions given below.

a) Conduct a mole balance and calculate the values of all the unknown flow rates and compositions of the terminal streams. **3 Marks**

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| Response: |

b) Calculate the minimum solvent flow rate and the *L/Lmin* ratio. **5 Marks**

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| Response: |

c) Based on a design superficial gas velocity (i.e. neglecting the volume taken by the packings and liquid) of 5.2 m/s, determine the inner diameter (m) of the column. Note that CO2 can be assumed as an ideal gas. **2 Marks**

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| Response: |

d) Calculate the value for a 1½ inch Rashig Rings with an estimated value of 82.6 kmol/m2.h.bar. **3 Marks**

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| Response: |

e) Briefly discuss if this system can be considered a dilute case for the purpose of solving for the number of transfer units. What should be form of the equation for this problem and how would you solve it? (100 words maximum) **4 Marks**

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| Response: |

f) A chemical engineering student calculated the height of packing materials for the above absorption process and obtained 5.2 m. The student would like to use this knowledge to understand operational difficulties in a new Carbon Capture and Storage (CCS) project, which he saw in a news article – “In 2014, Norway planned a CCS project at the Mongstad oil refinery, though it has been delayed several times due to technological challenges and health and safety concerns. This project employs water-amine to absorb CO2 from flue gas that contains 11 mol% CO2.”

Discuss the potential technological challenges in terms of flooding and loading points in the proposed project using the given equilibrium data and 11% CO2 content in flue gas based on your calculation (100 words maximum, graphical methods are not required). **3 Marks**

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| Response: |

**END OF QUESTION AQ1 (Go to next page)**