Time: 2 hours **M. Marks: 40**

1. The emissive power of a black body depends on the fourth power of temperature and is given by

$$W = A.\ T^4$$

where W = emission power, Btu/ (ft^2)(hr)

A = Stefan-Boltzman constant, 0.171×10^{-8} Btu/ $(ft^2)(hr)(^0R)^4$

T = temperature, ^0R

What is the value of A in the units $J/(m^2)(s)(K^4)$. **(6)**

2. Examine Figure A. What is the quantity of the recycle stream in kg/hr. In stream C the composition is 4 % water and 96 % KNO_3. **(8)**

3. The chlorination of methane occurs by the following reaction:

$$CH_4 + Cl_2 \longrightarrow CH_3Cl + HCl$$

Determine the product composition if the conversion of the limiting reactant is 67 % and the feed composition in mole % is 40 % CH_4, 50 % Cl_2 and 10 % N_2. **(8)**

4. A natural gas contains 85 % methane and 15 % ethane by volume. The heats of combustion of methane and ethane at 25^0C and 1 atm with water vapor as the assumed product are given below:

$$CH_4\,(g) + 2\,O_2\,(g) \longrightarrow CO_2\,(g) + 2\,H_2O\,(v);\ \Delta H_C^o = -802\ kJ/mol$$

$$C_2H_6\,(g) + (7/2)\,O_2\,(g) \longrightarrow 2\,CO_2\,(g) + 3\,H_2O\,(v);\ \Delta H_C^o = -1428\ kJ/mol$$

Calculate the higher heating value (kJ/g) of the natural gas.

The heat of vaporization of water is 44.013 kJ/mol. **(6)**

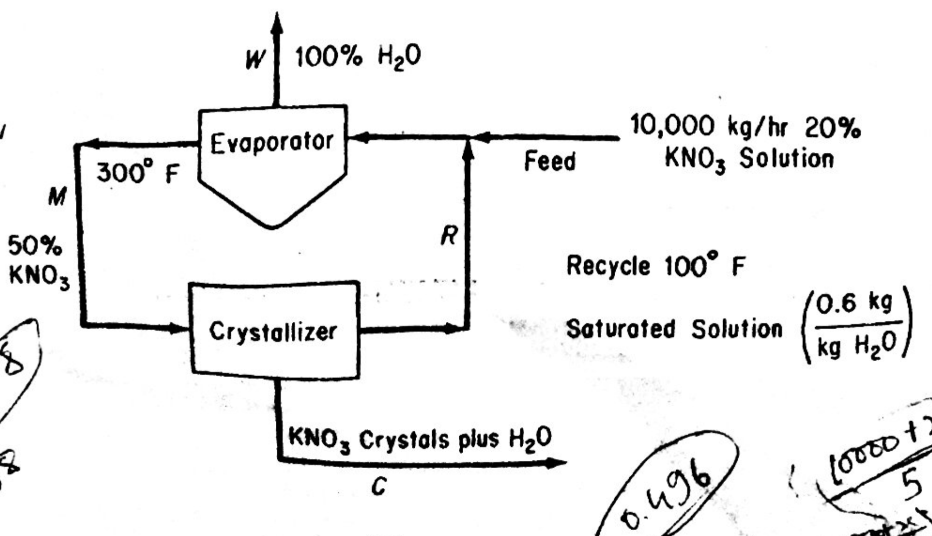
5. The standard heat of the reaction

$$C_2H_4\,(g) + 2\,Cl_2\,(g) \longrightarrow C_2HCl_3\,(l) + H_2\,(g) + HCl\,(g)$$

is $\Delta H_r^o = -420.8$ kJ/mol. Calculate ΔU_r^o for this reaction. **(6)**

6. Assuming ideal gas behaviour, calculate the heat that must be transferred when nitrogen contained in a 5 liter flask at an initial pressure of 3 bar is cooled from 90^0C to 30^0C. The heat capacity data for nitrogen is as follows:

$C_P\ (kJ/mol^0C) = 0.021 + 0.022 \times 10^{-5}\,T + 0.058 \times 10^{-8}\,T^2$ (T in °C) **(6)**



Figure