DEPARTMENT OF CHEMICAL ENGINEERING  
COLLEGE OF SCIENCE AND TECHNOLOGY  
COVENANT UNIVERSITY, CANAANLAND, OTA

2010-2011 ALPHA SEMESTER EXAMINATION

COURSE: CHEMICAL PROCESS ANALYSIS [CHE 310]  
EXAMINER: Prof. S.S. Adefila, Adewale A. Adeosun  
INSTRUCTION: Answer all questions. Time: 2.5 hours

Gas Constant, \( R = 8314 \text{ J/kgmol-K} \), 1 atm = 101325 Pa. Van der Waals parameters, in S.I. units, are:

\[
a = \left( \frac{27}{32} \right)^{\frac{8}{5}} \frac{T_c}{P_c} \quad \quad \quad b = \frac{1}{8} \frac{RT_c}{P_c}
\]

Antoine Equation parameters for pressure in mmHg and temperature in K.

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<th></th>
<th>A</th>
<th>B</th>
<th>C</th>
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<tbody>
<tr>
<td>Ethyl Alcohol</td>
<td>18.5242</td>
<td>3578.91</td>
<td>-50.50</td>
</tr>
<tr>
<td>Water</td>
<td>18.3036</td>
<td>3816.44</td>
<td>-46.13</td>
</tr>
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1. The density in kg/m\(^3\) of an ideal gas that has a molecular weight of 0.123 kg/kgmol at 27°C and 1 bar is:
   A. 0.00202  
   B. 0.00547  
   C. 0.00183  
   D. 0.00493  
   3 MARKS

INSTRUCTION: Use Figure 1. to answer question 2 to 3

![Compressibility Chart](image)

2. The real volume (in m\(^3\)) of 100 kg of ideal hydrogen gas at 200°C under 150 atm is:
   A. 1.423  
   B. 0.1423  
   C. 14.23  
   D. 0.01423  
   3 MARKS

3. Calculate the real volume (in m\(^3\)) of 50 kgmol of methane at 273K at 200 atm:
   A. 7.48  
   B. 5.48  
   C. 4.48  
   D. 3.48  
   3 MARKS
4. Given Van der Waal’s Equation as \((P + \frac{a}{V^2}) \times (V-nb) = nRT\), \(R = 8.314\text{J/mol-K}\), \(P_c = 42.5\text{bar}\) and \(T_c = 96.6^\circ\text{C}\), calculate the temperature of 66g of propane in 5 ft\(^3\) cylinder at 0.4 bar.
   A. 456K  B. 644K  C. 922K  D. 788K

5. Calculate the saturated pressure of ethyl alcohol in (mmHg), using Antoine’s equation, at 300K.
   A. 4.2  B. 2.4  C. 66  D. 11

6. The ethyl alcohol vapour mole percent in a binary mixture with air at 300K temperature and a total pressure of 165mmHg in a 75 mole percent ethyl alcohol liquid feed to a flash distillation still is:
   A. 15  B. 30  C. 45  D. 45

Propylene, an important monomer in packaging industry, has its thermodynamic properties represented in Figure 2. Assuming the gas stream exist under a pressure of 250 psia and specific entropy of 1.42, answer Questions 7 to 11.

7. The inlet temperature of the gas stream is:
   A. 120  B. 140  C. 160  D. 180

8. The inlet enthalpy of the gas stream is:
   A. 515  B. 615  C. 715  D. 415

9. If the inlet stream is expanded at constant enthalpy to a specific volume of 6.0, the specific entropy is:
   A. 1.44  B. 1.46  C. 1.52  D. 1.60

10. The Degree of Saturation of the inlet stream is:
    A. 30  B. 50  C. 60  D. 80

11. If the inlet stream undergoes an isobaric change from inlet enthalpy to 420 BTU/Lb, what is the vapour quality of the resulting stream:
    A. 0.5  B. 0.6  C. 0.7  D. 0.9

Figure 3 is a heat engine working on the Carnot cycle principle. Answer Questions 12 to 14 using information provided.

12. Given that the hot reservoir temperature is 77\(^\circ\text{C}\) and the cold reservoir is at 17\(^\circ\text{C}\) and work at the pump is negligible, the efficiency of the engine is:
    A. 0.78  B. 0.17  C. 0.87  D. 0.37
13. Assuming the work input at the pump is 125 kJ/kg with \( Q_H \) and \( Q_C \) being 450kJ/kg and 150 kJ/kg respectively, the work output in turbine is:
   A. 475   B. 425   C. 175   D. 225  2 MARKS

14. Assuming no work input to the pump, with \( Q_H \), \( T_H \) and \( T_C \) 450kJ/kg, 137°C and 37°C respectively, the cold reservoir heat is:
   A. 340   B. 122   C. 430   D. 212  2 MARKS

Pick True (T) or False (F) for questions 15 to 16

15. At dew point, \( \Sigma x_i = 0 \)  2 MARKS
16. At bubble point, \( \Sigma x_i = 1 \)  2 MARKS

Suppose that a liquid mixture of 4% n-hexane and n-octane is vaporized and using the data given below:

\[ \ln \left( \frac{p^*}{p} \right) = A - \frac{B}{C + T} \]
where \( p^* \) is in mm Hg and \( T \) is in K:

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<tbody>
<tr>
<td>n-hexane (C):</td>
<td>15.8737</td>
<td>2697.53</td>
<td>-48.784</td>
</tr>
<tr>
<td>n-octane (C):</td>
<td>15.9198</td>
<td>3127.60</td>
<td>-63.633</td>
</tr>
</tbody>
</table>

17. If the total pressure is 760mmHg, calculate the bubble point temperature:
   A. 293   B. 493   C. 193   D. 393  4 MARKS
18. The saturated vapour pressure of n-octane in mmHg is:
   A. 661   B. 561   C. 698   D. 654  3 MARKS
19. The n-octane vapour mole fraction is:
   A. 0.536  B. 0.636  C. 0.726  D. 0.826  3 MARKS
20. Show that the equation below is true for flash vaporization:

\[ 1 = \sum_{i=1}^{n} \frac{x_{F,i}}{1 - \frac{L}{F} \left( 1 - \frac{1}{K_{i}} \right)} \]  7 MARKS

21. A heat engine, using water as working fluid, operates between boiler and condenser temperatures of 280°C and 120°C, respectively. The temperature drop is:
   A. 400   B. 160   C. 120   D. 280  1 MARKS
22. The efficiency of the heat engine is:
   A. 0.71   B. 1.41   C. 0.41   D. 0.29  3 MARKS

INSTRUCTION: Use Figure 13.11 to answer Questions 23 to 25

23. Write the material balance equation around the absorber  2 MARKS
24. Write the energy balance equation around the absorber.  3 MARKS
25. The Generator-Absorber Unit serves the same purpose as a turbine. TRUE or FALSE  2 MARKS