Marks Scored:

KATHMANDU UNIVERSITY
End Semester Examination
March/April, 2017

Level : B. Tech.
Year : II

Course : ENVE 204
Semester : I

Exam Roll No. :

Time : 30 mins.

F. M. : 10

Registration No. :

Date : APR 13 2017

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SECTION "A"
[20 Q. × 1 = 20 marks]

Select the correct answer from the given choices. Attempt *ALL* the questions.

1. If 1ft is equivalent to 30.48 cm, convert 100.0 m/s^2 to ft/min^2.
   a) 1.181×10^2
   b) 1.097×10^9
   c) 1.181×10^6
   d) 1.969×10^4

2. If the specific gravity of a substance is 1.203, what is the density in g/cm^3?
   a) 0.0012 b) 0.831 c) 1.203 d) 1203.0

3. What is the volume occupied by 120.0 g of a pollutant in cm^3 if the specific gravity is 0.90?
   a) 7.5 b) 108.0 c) 1200 d) 133.3

4. If 0.110 lb_m of a pollutant is held in a cylinder container with a base of 1 in. in diameter, what is the absolute pressure at the base in psia?
   a) 0.0043 b) 0.14 c) 0.086 d) 14.56

5. Convert 20°C to °R.
   a) 0.006 b) 36.0 c) 93.6 d) 527.4

6. If 1 lb_m is 454 g and 1 Btu is 252 cal, convert 0.61 cal/(g · °C) to Btu/(lb_m · °F).
   a) 0.61 b) 0.188 c) 1.97 d) 33.98

7. The composition of a flue gas is given as: 79% N_2, 5% O_2, 10% CO_2 and 6% CO. What is the average molecular weight of the mixture? Take molecular weights of N_2, O_2, CO_2 and CO as 28, 32, 44 and 28 respectively.
   a) 0.298 b) 29.8 c) 44.2 d) 44.92

8. If 72 g of HCl is in 128 cm^3 of water, express the concentration of HCl in fraction by weight.
   a) 0.36 b) 0.56 c) 0.09 d) 36.0

9. Which method is generally preferred to solve mass balance problems with complex reaction equations?
   a) species balance
   b) mole balance
   c) tie balance
   d) element balance

10. Which of the following considers only the reactor unit for calculation?
   a) single-pass conversion
   b) recycle ratio
   c) single-pass recycle
   d) reflux ratio

11. What is the value of the common standard pressure in psia?

a) 0 b) 760 c) 14.7 d) 460

12. When do you use Kay's method?

a) to calculate compressibility factor of gaseous mixture
b) to calculate compressibility factor of ideal gases
c) to calculate compressibility factor of a supercritical fluid
d) to calculate compressibility factor of a real gas

13. The largest value of the quality of vapor and liquid mixture is:

a) 0 b) 1 c) 100 d) infinity

14. The condition at which the partial pressure of the vapor is equal to the vapor pressure of the volatile liquid is called:

a) triple point
b) saturated expansion
c) dew point
d) saturated compression

15. Which of the following is the mass of water vapor per unit mass of bone-dry air?

a) humidity
b) saturation mass
c) relative humidity
d) saturated water

16. A boiler converts liquid water to steam by letting the water flow through tubes that are heated by hot gases. The pressure and flow rate of water are maintained by a regulator. If the boiler is the system under consideration, what is the simplest equation of energy balance after deleting as many terms as feasible?

a) $0 = Q + W - \Delta(H + KE)$
b) $0 = Q - \Delta(H)$
c) $\Delta E = Q + W - \Delta(H)$
d) $0 = W - \Delta(H + KE)$

17. For the energy transfer to a closed system, which of the following is true?

a) heat is the only possible mechanism
b) work is the only possible mechanism
c) heat and work are the only possible mechanisms
d) heat and mass transfer are the only possible mechanisms

18. Choose the extensive property from the following

a) pressure
b) mass
c) density
d) specific heat capacity

19. An ideal gas in a tank at 100 kPa is compressed isothermally to 900 kPa by doing 15900 J/gmol of work on the gas. How much heat in J/gmol has to be transferred to or from the compression equipment to keep it isothermal?

a) 15900 b) –5900 c) 19.875 d) 0

20. What assumption can you make to simplify the general energy balance when the temperatures of the system and its surroundings are the same?

a) $Q = 0$ b) $\Delta KE = 0$ c) $W = 0$ d) $\Delta U = 0$

KATHMANDU UNIVERSITY
End Semester Examination
March/April, 2017

APR 1 3 2017

Level : B. Tech.
Year : II
Time : 2 hrs. 30 mins.

Course : ENVE 204
Semester : I
F. M. : 55

SECTION "B"

Answer *ALL* the questions. The data or information not given in the questions should be assumed properly.

1. A mixture contains 20 lb of oxygen, 2 lb of sulfur dioxide, and 3 lb of sulfur trioxide. Take the molecular weight of sulfur trioxide as 80.
   a) Determine the weight fraction of each component. [1]
   b) Determine the mole fraction of each component. [2]
   c) If the exhaust to the atmosphere from an incinerator has a sulfur dioxide concentration of 0.12 mm Hg partial pressure, calculate the parts per million of sulfur dioxide in the exhaust. [2]

2. When ammonia is burned, the products are nitric oxide and water. $4NH_3 + 5O_2 \rightarrow 4NO + 6H_2O$. Ammonia is fed to a combustion device at the rate of 150 kgmol/h and oxygen at a rate of 200 kgmol/h.
   a) Which is the limiting reactant? [2]
   b) What is the percent excess of the excess reactant? [2]
   c) If 85 kgmol/h of nitric oxide is produced, at what rate in kg/h is water produced? [1]
   d) What is the fractional conversion of the ammonia? [2]
   e) What is the fractional conversion of the oxygen? [1]

3. A cement factory is emitting CO_2 from the stack. There are two streams containing CO_2 that enter the stack. The first stream is the waste stream that contains 3.4% CO_2. The second stream is pure CO_2 with the flow rate of 3.5 kg/min. The concentration of CO_2 in the stack discharge is found to be 3.2%. Calculate the rate of flow of the waste stream by following all the steps of the mass balance. [6]

4. Hydrocracking is the process of converting heavy hydrocarbons to lower-molecular-weight hydrocarbons at high temperature and pressure by reacting with hydrogen (H_2). In the hydrocracking of octane (C_8H_{18}), the cracked products had the following composition in mole percent: 19.5% C_3H_8, 59.4% C_4H_{10}, and 21.1% C_5H_{12}. Determine the molar ratio of hydrogen consumed to octane reacted in the given process. You must show all the steps of the mass balance. [7]

5. A synthesis gas analyzing CO_2 : 4.5%; CO: 26%; H_2 : 13%; CH_4 : 0.5%; and N_2 : 56%, is burned in a furnace with 10 percent excess air. Calculate the Orsat analysis of the flue gas. [6]

6. In the process shown in the following figure, calculate the fraction of sugar in the cane (*F*) that is recovered in *M*. [7]

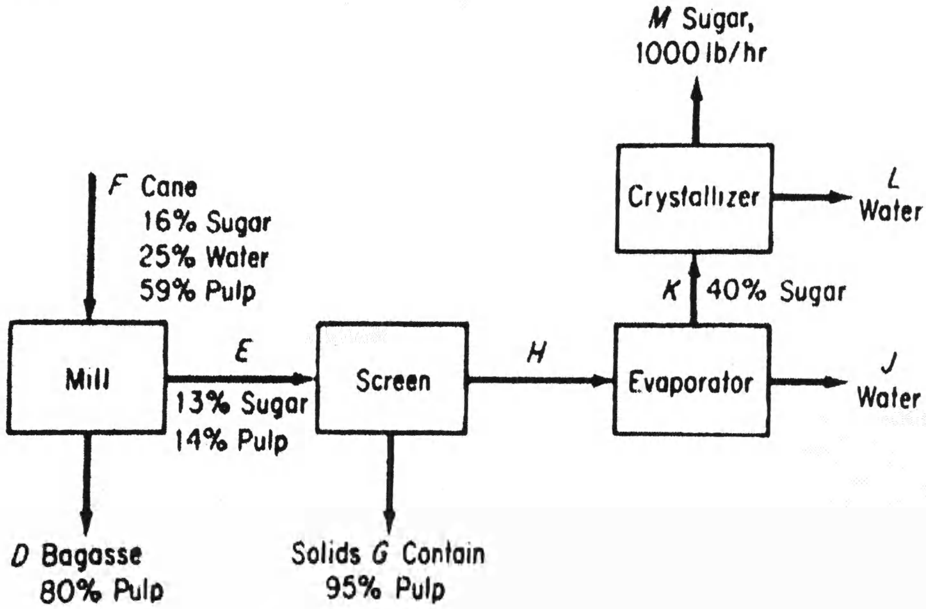

Figure for Q.6.

7. What mass (in lb_m) of ethane is contained in a gas cylinder of 1.0 ft^3 in volume if the gas is at 100 °F and 2000 psig? Use the following methods:
a) Ideal gas law. The universal gas constant is 0.7302 $ft^3 \cdot atm / (lbmol \cdot °R)$. [2]
b) The compressibility factor method. Take the critical pressure as 48.2 atm and critical temperature as 305.4 K. [4]

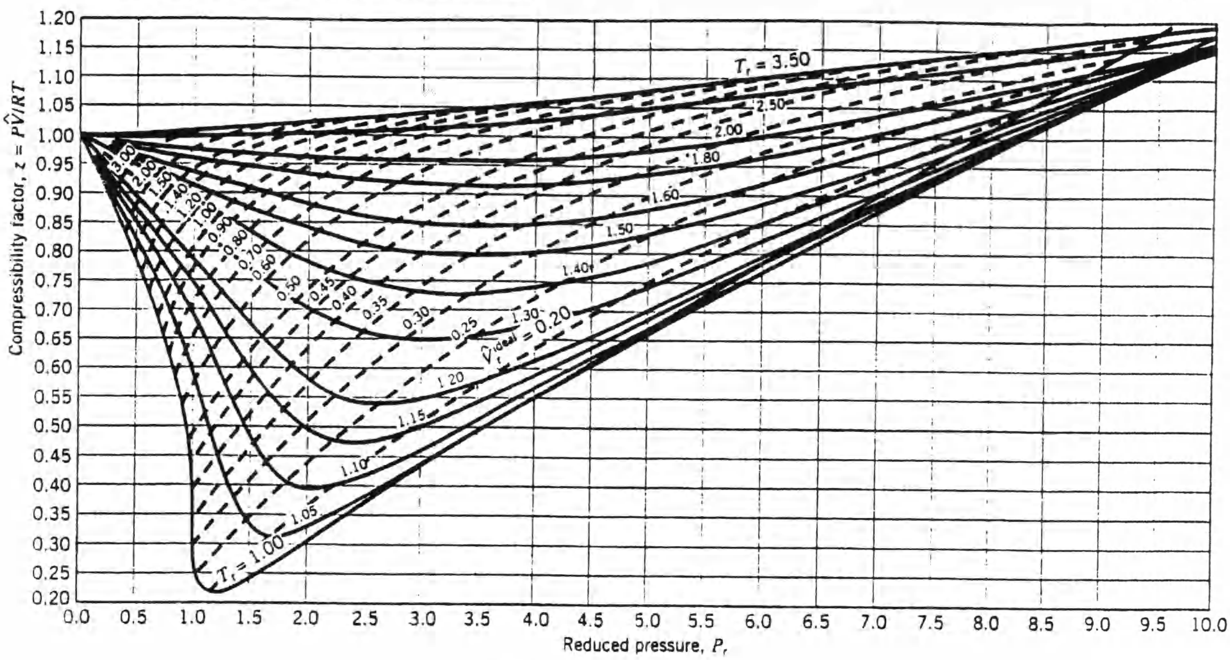

Figure for Q.7.

8. If a gas has a molal humidity of 0.10 at temperature of 200 °F and 30 in. Hg abs., calculate the following:
a) relative humidity. Take 1 in. = 25.4 mm. [2]
b) percentage humidity. [2]
c) dew point of the gas in °F. [1]

9. Calculate the quality of 15 lb of wet steam at 120 psia when the enthalpy of the wet steam has been calculated to be 12,000 Btu (relative to liquid water at 32 °F which has a value of 0 Btu). [5]

Table

Table C.1a Saturated Water, Temperature Table (English Units)

T, °F	p, psia	Volume, ft³/lbm v_f	v_g	Energy, Btu/lbm u_f	u_g	Enthalpy, Btu/lbm h_f	h_{fg}	h_g	Entropy, Btu/(lbm·R) s_f	s_{fg}	s_g
32.018	0.08866	0.01602	3302	0.0	1021.2	0.0	1075.4	1075.4	0.0000	2.1871	2.1871
35	0.09992	0.01602	2948	3.0	1022.2	3.0	1073.7	1076.7	0.0061	2.1705	2.1766
40	0.1217	0.01602	2445	8.0	1023.8	8.0	1070.9	1078.9	0.0162	2.1432	2.1594
45	0.1475	0.01602	2037	13.0	1025.5	13.0	1068.1	1081.1	0.0262	2.1163	2.1425
50	0.1780	0.01602	1704	18.1	1027.2	18.1	1065.2	1083.3	0.0361	2.0900	2.1261
55	0.2140	0.01603	1431	23.1	1028.8	23.1	1062.4	1085.5	0.0458	2.0643	2.1101
60	0.2563	0.01603	1207	28.1	1030.4	28.1	1059.6	1087.7	0.0555	2.0390	2.0945
65	0.3057	0.01604	1021	33.1	1032.1	33.1	1056.8	1089.9	0.0651	2.0142	2.0793
70	0.3632	0.01605	867.6	38.1	1033.7	38.1	1053.9	1092.0	0.0746	1.9898	2.0644
75	0.4300	0.01606	739.7	43.1	1035.4	43.1	1051.1	1094.2	0.0840	1.9659	2.0499
80	0.5073	0.01607	632.7	48.1	1037.0	48.1	1048.3	1096.4	0.0933	1.9425	2.0358
85	0.5964	0.01609	543.1	53.1	1038.6	53.1	1045.5	1098.6	0.1025	1.9195	2.0220
90	0.6989	0.01610	467.6	58.1	1040.2	58.1	1042.6	1100.7	0.1116	1.8969	2.0085
95	0.8162	0.01611	403.9	63.0	1041.9	63.1	1039.8	1102.9	0.1206	1.8747	1.9953
100	0.9503	0.01613	350.0	68.0	1043.5	68.0	1037.0	1105.0	0.1296	1.8528	1.9824
110	1.276	0.01617	265.1	78.0	1046.7	78.0	1031.3	1109.3	0.1473	1.8103	1.9576
120	1.695	0.01621	203.0	88.0	1049.9	88.0	1025.5	1113.5	0.1646	1.7692	1.9338
130	2.225	0.01625	157.2	98.0	1053.0	98.0	1019.7	1117.7	0.1817	1.7294	1.9111
140	2.892	0.01629	122.9	107.9	1056.2	108.0	1013.9	1121.9	0.1985	1.6909	1.8894
150	3.722	0.01634	96.98	117.9	1059.3	117.9	1008.2	1126.1	0.2150	1.6535	1.8685
160	4.745	0.01640	77.23	127.9	1062.3	128.0	1002.1	1130.1	0.2313	1.6173	1.8486
180	7.515	0.01651	50.20	148.0	1068.3	148.0	990.2	1138.2	0.2631	1.5480	1.8111
200	11.53	0.01663	33.63	168.0	1074.2	168.1	977.8	1145.9	0.2941	1.4823	1.7764
212	14.696	0.01672	26.80	180.1	1077.6	180.1	970.4	1150.5	0.3122	1.4447	1.7569
220	17.19	0.01677	23.15	188.2	1079.8	188.2	965.3	1153.5	0.3241	1.4202	1.7443
240	24.97	0.01692	16.33	208.4	1085.3	208.4	952.3	1160.7	0.3534	1.3611	1.7145
260	35.42	0.01708	11.77	228.6	1090.5	228.7	938.9	1167.6	0.3820	1.3046	1.6866

Table C.2a Saturated Water, Pressure Table (English Units)

p, psia	T, °F	Volume, ft³/lbm		Energy, Btu/lbm		Enthalpy, Btu/lbm			Entropy, Btu/(lbm·R)		
		v_f	v_g	u_f	u_g	h_f	h_{fg}	h_g	s_f	s_{fg}	s_g
0.0887	32.018	0.01602	3302.0	0.0	1021.2	0.0	1075.4	1075.4	0.0000	2.1871	2.1871
0.1	35.0	0.01602	2946.0	3.0	1022.2	3.0	1073.7	1076.7	0.0061	2.1705	2.1768
0.12	39.6	0.01602	2477.0	7.7	1023.7	7.7	1071.0	1078.7	0.0155	2.1451	2.1606
0.14	43.6	0.01602	2140.0	11.7	1025.0	11.7	1068.8	1080.5	0.0234	2.1237	2.1471
0.16	47.1	0.01602	1886.0	15.2	1026.2	15.2	1066.8	1082.0	0.0304	2.1050	2.1354
0.18	50.3	0.01602	1686.0	18.3	1027.2	18.3	1065.1	1083.4	0.0366	2.0886	2.1252
0.2	53.1	0.01603	1526.0	21.2	1028.2	21.2	1063.5	1084.7	0.0422	2.0738	2.1160
0.25	59.3	0.01603	1235.0	27.4	1030.2	27.4	1060.0	1087.4	0.0542	2.0425	2.0967
0.3	64.5	0.01604	1040.0	32.5	1031.9	32.5	1057.1	1089.6	0.0641	2.0168	2.0809
0.4	72.8	0.01606	792.0	40.9	1034.7	40.9	1052.4	1093.3	0.0799	1.9762	2.0561
0.6	85.2	0.01609	540.0	53.3	1038.7	53.3	1045.3	1098.6	0.1028	1.9187	2.0215
0.8	94.3	0.01611	411.7	62.4	1041.6	62.4	1040.2	1102.6	0.1195	1.8775	1.9970
1	101.7	0.01614	333.6	69.7	1044.0	69.7	1036.0	1105.7	0.1326	1.8455	1.9781
1.2	107.9	0.01616	280.9	75.9	1046.0	75.9	1032.5	1108.4	0.1435	1.8193	1.9628
1.4	113.2	0.01618	243.0	81.2	1047.7	81.2	1029.5	1110.7	0.1529	1.7969	1.9498
1.6	117.9	0.01620	214.3	85.9	1049.2	85.9	1026.8	1112.7	0.1611	1.7775	1.9386
1.8	122.2	0.01621	191.8	90.2	1050.6	90.2	1024.3	1114.5	0.1684	1.7604	1.9288
2	126.0	0.01623	173.8	94.0	1051.8	94.0	1022.1	1116.1	0.1750	1.7450	1.9200
3	141.4	0.01630	118.7	109.4	1056.6	109.4	1013.1	1122.5	0.2009	1.6854	1.8863
4	152.9	0.01636	90.64	120.9	1060.2	120.9	1006.4	1127.3	0.2198	1.6428	1.8626
6	170.0	0.01645	61.98	138.0	1065.4	138.0	996.2	1134.2	0.2474	1.5820	1.8294
8	182.8	0.01653	47.35	150.8	1069.2	150.8	988.5	1139.3	0.2676	1.5384	1.8060
10	193.2	0.01659	38.42	161.2	1072.2	161.2	982.1	1143.3	0.2836	1.5043	1.7879
12	201.9	0.01665	32.40	170.0	1074.7	170.0	976.7	1146.7	0.2970	1.4762	1.7732
14	209.6	0.01670	28.05	177.6	1076.9	177.7	971.9	1149.6	0.3085	1.4523	1.7608
14.696	212.0	0.01672	26.80	180.1	1077.6	180.1	970.4	1150.5	0.3122	1.4447	1.7569
16	216.3	0.01675	24.75	184.4	1078.8	184.5	967.6	1152.1	0.3186	1.4315	1.7501

p, psia	T, °F	Volume, ft³/lbm		Energy, Btu/lbm		Enthalpy, Btu/lbm			Entropy, Btu/(lbm·R)		
		v_f	v_g	u_f	u_g	h_f	h_{fg}	h_g	s_f	s_{fg}	s_g
18	222.4	0.01679	22.17	190.6	1080.5	190.6	963.8	1154.4	0.3277	1.4129	1.7406
20	228.0	0.01683	20.09	196.2	1082.0	196.2	960.2	1156.4	0.3359	1.3963	1.7322
30	250.3	0.01700	13.75	218.8	1088.0	218.9	945.4	1164.3	0.3683	1.3315	1.6998
40	267.3	0.01715	10.50	236.0	1092.3	236.2	933.8	1170.0	0.3922	1.2847	1.6769
60	292.7	0.01738	7.177	262.0	1098.3	262.2	915.8	1178.0	0.4274	1.2172	1.6446
80	312.1	0.01757	5.474	281.9	1102.6	282.2	901.4	1183.6	0.4535	1.1681	1.6216
100	327.9	0.01774	4.434	298.3	1105.8	298.6	889.2	1187.8	0.4745	1.1291	1.6036
120	341.3	0.01789	3.730	312.3	1108.3	312.7	878.4	1191.1	0.4921	1.0967	1.5888
140	353.1	0.01802	3.221	324.6	1110.3	325.0	868.8	1193.8	0.5074	1.0688	1.5762
160	363.6	0.01815	2.836	335.6	1112.0	336.2	859.8	1196.0	0.5209	1.0443	1.5652
180	373.1	0.01827	2.533	345.7	1113.4	346.3	851.5	1197.8	0.5330	1.0225	1.5555
200	381.9	0.01839	2.289	354.9	1114.6	355.6	843.7	1199.3	0.5441	1.0025	1.5466
300	417.4	0.01890	1.544	393.0	1118.1	394.1	809.8	1203.9	0.5885	0.9232	1.5117
400	444.7	0.01934	1.162	422.8	1119.4	424.2	781.3	1205.5	0.6219	0.8639	1.4858
600	486.3	0.02013	0.7702	469.4	1118.5	471.6	732.5	1204.1	0.6724	0.7742	1.4466
800	518.4	0.02087	0.5691	506.6	1115.0	509.7	689.6	1199.3	0.7112	0.7050	1.4162
1000	544.8	0.02159	0.4459	538.4	1109.9	542.4	650.0	1192.4	0.7434	0.6471	1.3905
1200	567.4	0.02232	0.3623	566.7	1103.5	571.7	612.2	1183.9	0.7714	0.5961	1.3675
1400	587.3	0.02307	0.3016	592.6	1096.0	598.6	575.5	1174.1	0.7966	0.5497	1.3463
1600	605.1	0.02386	0.2552	616.9	1087.4	624.0	538.9	1162.9	0.8198	0.5062	1.3260
2000	636.0	0.02565	0.1881	662.4	1066.6	671.9	464.4	1136.3	0.8624	0.4239	1.2863
2600	674.1	0.02938	0.1210	729.2	1021.8	743.3	336.8	1080.1	0.9237	0.2971	1.2208
3203.8	705.445	0.05053	0.05053	872.6	872.6	902.5	0.0	902.5	1.0582	0.0000	1.0582

Note: Saturated liquid entropies have been adjusted to make the Gibbs functions of the liquid and vapor phases exactly equal. For this reason, there are some small differences between values presented here and the original tables.

Sources: Reprinted by permission from Reynolds, W. C., Perkins, H. C. Engineering Thermodynamics, second ed., 1977, McGraw-Hill, New York. Recalculated from equations given in Keenan, J. H., Keyes, F. G., Hill, P. G., Moore, J. G. Steam Tables. Wiley, New York, 1969. Reprinted by permission of John Wiley & Sons, Inc.