Marks scored:

KATHMANDU UNIVERSITY
End Semester Examination [C]
June, 2018

Level : B. Tech.
Year : II
Course : ENVE 204
Semester : I
Exam Roll No. :
Time: 30 mins.
F. M. : 20

Registration No.:
Date JUN 15 2018

SECTION "A"
[20 × 1 = 20 marks]

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

1. Convert 30 mg/s to its equivalent in kg/h.
(a) 0.0018 (b) 0.11 (c) 108 (d) 8333

2. One Rankine increment is equivalent to:
(a) One Fahrenheit increment (b) One Kelvin increment
(c) One Celcius increment (d) 1.8 Fahrenheit increment

3. A liquid stream flowing at 100 g/min contains 0.3 mole fraction benzene (Mw = 78) and the balance 0.7 mole fraction toluene (Mw=92). What is the total molar flow rate of the stream in mol/min?
(a) 0.011 (b) 1.14 (c) 8730 (d) 8780

4. What is the concentration of 3.4 mol% in ppmv?
(a) 0.034 (b) 34 (c) 34000 (d) 3400000

5. In equation $C = 0.03 \exp(-2.00\ t)$, C has the units of kg/L and t has the units of seconds. What is the unit associated with the constant 2.00?
(a) s (b) 1/s (c) kg/L/s (d) s*L/kg

6. A pressure gauge on a tank reads 25 psi. What is the absolute pressure in psi, considering the atmospheric, $P_{atm} = 14.7$ psi?
(a) -10 (b) 1.7 (c) 10 (d) 40

7. What is the unit of specific gravity?
(a) g/cm^3 (b) $(m/s^2)/kg$ (c) cm^3/g (d) $(g/cm^3)/(g/cm^3)$

8. Initially, 100 kg of pressed lemon juice contains 10% of total solids. It is desired to increase the figure to 20% of total solids by evaporation. What is the quantity of water that must be removed?
(a) 10 (b) 20 (c) 50 (d) 80

9. All reactants, other than the limiting species, are termed as:
(a) tie components (b) excess reactants (c) yield (d) auxiliary reactants

10. What is the ratio of the amount reacted to the amount fed to the reactor?
(a) yield (b) conversion (c) excess ratio (d) selectivity

11. In which type of balance is "Input = Output" valid for a steady-state process with chemical reaction?
(a) total moles (b) mass of a chemical compound
(c) moles of a chemical compound (d) moles of an atomic species

12. To ensure good conversion of the expensive fuels, combustion reactions are always conducted with:
(a) stoichiometric air
(b) theoretical air
(c) lean air
(d) excess air

13. For 1 mol of ideal gas when the pressure is in the units of atm, the volume is in cm^3, and the temperature in K, what is the value for the universal gas constant R in $(cm^3)(atm)/((K)(mol))$?
(a) 0.082
(b) 0.089
(c) 8.314
(d) 82.06

14. At low pressure and high temperature, the gases are usually called:
(a) ideal gas
(b) vapor
(c) real gas
(d) supercritical gas

15. Why is compressibility factor used in real gas law?
(a) to consider compression ratio
(b) to compensate for the non-ideality of gas
(c) to consider the temperature anomaly
(d) to compensate for the moisture in gas

16. Which of the following uses pseudoreduced pressure and pseudoreduced temperature?
(a) ideal gas law
(b) single real gas law
(c) Kay's method
(d) van der Waals equation

17. Dry air at 1 atm contains 78% nitrogen, 21% oxygen, and 1.0% argon. What is the partial pressure of nitrogen in atm?
(a) 0.22
(b) 0.78
(c) 1.28
(d) 7800

18. What is the temperature at which saturation occurs in the liquid phase called?
(a) triple point
(b) dew point
(c) bubble point
(d) critical point

19. The sum of the internal energy of fluid volume added to the system plus the flow work is:
(a) total energy
(b) mechanical energy
(c) enthalpy
(d) superheat

20. Which of the following is the enthalpy change for a process in which stoichiometric quantities of reactants at temperature *T* and pressure *P* react completely to form products at the same temperature and pressure.
(a) heat of formation
(b) heat of reaction
(c) standard heat of formation
(d) standard heat of reaction

KATHMANDU UNIVERSITY
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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. Salty water is prepared by mixing salt (NaCl, MW= 58.5) in water (MW = 18). A solution is prepared by adding 20 kg of salt to 100 kg of water, to make a liquid of density 1323 kg/m^3. Calculate the concentration of salt in this solution as:
(a) weight/weight fraction [1]
(b) weight/ volume in kg/L [2]
(c) mole fraction [2]

2. In a reaction, 64 g of methanol (CH_3OH) reacts with 0.5 mol of oxygen (O_2) to form formaldehyde. $CH_3OH + 0.5\ O_2 \rightarrow HCHO + H_2O$
(a) Determine which reactant is limiting. [3]
(b) Determine the percent excess of the excess reactant. [3]

3. A mixture containing 10% ethanol (E) and 90% H_2O (W) by weight is fed into a distillation column at the rate of 100 kg/h. The distillate contains 60% ethanol and the distillate is produced at a rate of one tenth that of the feed. The composition of bottom flow is not known.
(a) Draw and label a flowchart of the process. [2]
(b) Calculate all unknown stream flow rates and compositions. [4]

4. Three input streams are fed into an evaporation chamber to produce an output stream with the desired composition. Liquid water, fed at a rate of 20.0 cm^3/min, air, and pure oxygen, fed at one-fifth of the molar flow rate of air stream. The output gas is analyzed and is found to contain 1.5 mol% water.
(a) Draw and label a mass balance diagram of the process. [2]
(b) Using mass balance method, determine all unknown stream variables. [5]

5. Ammonia is burned to form nitric oxide and water: $4\ NH_3 + 5\ O_2 \rightarrow 4\ NO + 6\ H_2O$. The fractional conversion of oxygen is 0.5. The inlet molar flow rate is 5 mol/h of NH_3 and 5 mol/h of oxygen.
(a) Draw the mass balance diagram of the process. [2]
(b) Calculate the exit component molar flow rates using mass balance method. [6]

6. A fresh feed stream contains liquid mixture containing 35.0 mol% toluene (T), 27.0 mol% xylene (X), and the remainder benzene (B) is fed to a distillation column. The fresh feed molar flow rate is 100 kmol/h. The bottom product contains 97.0 mol% X and no B, and 93.0% of the X in the feed is recovered in this stream. The overhead product is fed to a second column. The overhead product from the second column contains 5.0 mol% T and no X, and 96.0% of the B fed to the system is recovered in this stream.
(a) Draw and completely label a mass balance diagram of the process. [2]
(b) Calculate the composition of the bottoms stream from the second column. [6]

7. Explain the following with their applications: [2×3]
(a) Generalized equation of state
(b) Relative saturation

8. Liquid water is fed to a boiler at 23°C under a pressure of 10 bar, and is converted at constant pressure to saturated steam. Assume that the inlet velocity of liquid entering the boiler is negligible and that the steam is discharged through a 0.15 m ID (inner diameter) pipe. Inlet and exit pipes are at the same level.

(a) Calculate Δh for this process. [3]

(b) Find the heat input required for producing 15000 m^3/h of steam at the exit conditions. [6]

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CONVERSION FACTORS

HEAT, ENERGY, OR WORK EQUIVALENTS

	$(ft)(lb_f)$	kWh	(hp)(hr)	Btu	calorie*	joule
$(ft)(lb_f)$	1	3.766×10^{-7}	5.0505×10^{-7}	1.285×10^{-3}	0.3241	1.356
kWh	2.655×10^{6}	1	1.341	3.4128×10^{3}	8.6057×10^{5}	3.6×10^{6}
(hp)(hr)	1.98×10^{6}	0.7455	1	2.545×10^{3}	6.4162×10^{5}	2.6845×10^{6}
Btu	7.7816×10^{2}	2.930×10^{-4}	3.930×10^{-4}	1	2.52×10^{2}	1.055×10^{3}
calorie*	3.086	1.162×10^{-6}	1.558×10^{-6}	3.97×10^{-3}	1	4.184
joule	0.7376	2.773×10^{-7}	3.725×10^{-7}	9.484×10^{-4}	0.2390	1

*The thermochemical calorie = 4.184 J.

PRESSURE EQUIVALENTS

	mm Hg	in. Hg	bar	atm	kPa	psia
mm Hg	1	3.937×10^{-2}	1.333×10^{-3}	1.316×10^{-3}	0.1333	1.934×10^{-2}
in. Hg	25.40	1	3.386×10^{1}	3.342×10^{-2}	3.386	0.4912
bar	750.06	29.53	1	0.9869	100.0	14.51
atm	760.0	29.92	1.013	1	101.3	14.696
kPa	7.502	0.2954	1.000×10^{-2}	9.872×10^{-3}	1	0.1451
psia	51.71	2.036	6.893×10^{-2}	6.805×10^{-2}	6.893	1

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psia	51.71	2.036	6.893×10^{-2}	6.805×10^{-2}	6.893	1

Table 4. Properties of Saturated Water and Steam (Temperature)

Temp. t (°C)	Pressure MPa	Volume, m³/kg v_L	v_V	Enthalpy, kJ/kg h_L	h_V	Entropy, kJ/(kg•K) s_L	s_V	Temp. t (°C)
0.01	0.0006117	0.0010002	206.00	0.001	2500.9	0.0000	9.1555	**0.01**
5	0.0008726	0.0010001	147.02	21.019	2510.1	0.0763	9.0249	**5**
10	0.001228	0.0010003	106.31	42.021	2519.2	0.1511	8.8998	**10**
15	0.001706	0.0010009	77.881	62.984	2528.4	0.2245	8.7804	**15**
20	0.002339	0.0010018	57.761	83.920	2537.5	0.2965	8.6661	**20**
25	0.003170	0.0010030	43.341	104.84	2546.5	0.3673	8.5568	**25**
30	0.004247	0.0010044	32.882	125.75	2555.6	0.4368	8.4521	**30**
35	0.005629	0.0010060	25.208	146.64	2564.6	0.5052	8.3518	**35**
40	0.007384	0.0010079	19.517	167.54	2573.5	0.5724	8.2557	**40**
45	0.009594	0.0010099	15.253	188.44	2582.5	0.6386	8.1634	**45**
50	0.012351	0.0010121	12.028	209.34	2591.3	0.7038	8.0749	**50**
55	0.015761	0.0010145	9.5649	230.24	2600.1	0.7680	7.9899	**55**
60	0.019946	0.0010171	7.6677	251.15	2608.8	0.8312	7.9082	**60**
65	0.025041	0.0010199	6.1938	272.08	2617.5	0.8935	7.8296	**65**
70	0.031201	0.0010228	5.0397	293.02	2626.1	0.9550	7.7540	**70**
75	0.038595	0.0010258	4.1291	313.97	2634.6	1.0156	7.6812	**75**
80	0.047415	0.0010290	3.4053	334.95	2643.0	1.0754	7.6110	**80**
85	0.057867	0.0010324	2.8259	355.95	2651.3	1.1344	7.5434	**85**
90	0.070182	0.0010359	2.3591	376.97	2659.5	1.1927	7.4781	**90**
95	0.084609	0.0010396	1.9806	398.02	2667.6	1.2502	7.4150	**95**
100	0.10142	0.0010435	1.6719	419.10	2675.6	1.3070	7.3541	**100**
105	0.12090	0.0010474	1.4185	440.21	2683.4	1.3632	7.2951	**105**
110	0.14338	0.0010516	1.2094	461.36	2691.1	1.4187	7.2380	**110**
115	0.16918	0.0010559	1.0359	482.55	2698.6	1.4735	7.1827	**115**
120	0.19867	0.0010603	0.89130	503.78	2705.9	1.5278	7.1291	**120**
125	0.23222	0.0010649	0.77011	525.06	2713.1	1.5815	7.0770	**125**
130	0.27026	0.0010697	0.66808	546.39	2720.1	1.6346	7.0264	**130**
135	0.31320	0.0010747	0.58180	567.77	2726.9	1.6872	6.9772	**135**
140	0.36150	0.0010798	0.50852	589.20	2733.4	1.7393	6.9293	**140**
145	0.41563	0.0010850	0.44602	610.69	2739.8	1.7909	6.8826	**145**
150	0.47610	0.0010905	0.39250	632.25	2745.9	1.8420	6.8370	**150**
155	0.54342	0.0010962	0.34650	653.88	2751.8	1.8926	6.7926	**155**
160	0.61814	0.0011020	0.30682	675.57	2757.4	1.9428	6.7491	**160**
165	0.70082	0.0011080	0.27246	697.35	2762.8	1.9926	6.7066	**165**
170	0.79205	0.0011143	0.24262	719.21	2767.9	2.0419	6.6649	**170**
175	0.89245	0.0011207	0.21660	741.15	2772.7	2.0909	6.6241	**175**
180	1.0026	0.0011274	0.19386	763.19	2777.2	2.1395	6.5841	**180**
185	1.1233	0.0011343	0.17392	785.32	2781.4	2.1878	6.5447	**185**
190	1.2550	0.0011414	0.15638	807.57	2785.3	2.2358	6.5060	**190**
195	1.3986	0.0011488	0.14091	829.92	2788.9	2.2834	6.4679	**195**
200	1.5547	0.0011565	0.12722	852.39	2792.1	2.3308	6.4303	**200**
205	1.7240	0.0011645	0.11509	874.99	2794.9	2.3779	6.3932	**205**
210	1.9074	0.0011727	0.10430	897.73	2797.4	2.4248	6.3565	**210**
215	2.1055	0.0011813	0.094689	920.61	2799.4	2.4714	6.3202	**215**
220	2.3193	0.0011902	0.086101	943.64	2801.1	2.5178	6.2842	**220**

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Table 5. Properties of Saturated Water and Steam (Pressure)

Press. MPa	Temp. t (°C)	Volume, m³/kg v_L	v_V	Enthalpy, kJ/kg h_L	h_V	Entropy, kJ/(kg•K) s_L	s_V	Press. MPa
0.001	6.97	0.0010001	129.18	29.298	2513.7	0.1059	8.9749	**0.001**
0.002	17.50	0.0010014	66.990	73.435	2532.9	0.2606	8.7227	**0.002**
0.003	24.08	0.0010028	45.655	100.99	2544.9	0.3543	8.5766	**0.003**
0.004	28.96	0.0010041	34.792	121.40	2553.7	0.4224	8.4735	**0.004**
0.005	32.88	0.0010053	28.186	137.77	2560.8	0.4763	8.3939	**0.005**
0.006	36.16	0.0010064	23.734	151.49	2566.7	0.5209	8.3291	**0.006**
0.007	39.00	0.0010075	20.525	163.37	2571.8	0.5591	8.2746	**0.007**
0.008	41.51	0.0010085	18.099	173.85	2576.2	0.5925	8.2274	**0.008**
0.009	43.76	0.0010094	16.200	183.26	2580.3	0.6223	8.1859	**0.009**
0.010	45.81	0.0010103	14.671	191.81	2583.9	0.6492	8.1489	**0.010**
0.012	49.42	0.0010119	12.359	206.91	2590.3	0.6963	8.0850	**0.012**
0.014	52.55	0.0010133	10.691	219.99	2595.8	0.7366	8.0312	**0.014**
0.016	55.31	0.0010147	9.4309	231.55	2600.7	0.7720	7.9847	**0.016**
0.018	57.80	0.0010160	8.4433	241.95	2605.0	0.8035	7.9437	**0.018**
0.020	60.06	0.0010171	7.6482	251.40	2608.9	0.8320	7.9072	**0.020**
0.025	64.96	0.0010198	6.2034	271.93	2617.4	0.8931	7.8302	**0.025**
0.030	69.10	0.0010222	5.2286	289.23	2624.6	0.9439	7.7675	**0.030**
0.035	72.68	0.0010244	4.5252	304.25	2630.7	0.9876	7.7146	**0.035**
0.040	75.86	0.0010264	3.9931	317.57	2636.1	1.0259	7.6690	**0.040**
0.045	78.71	0.0010282	3.5761	329.55	2640.9	1.0601	7.6288	**0.045**
0.05	81.32	0.0010299	3.2401	340.48	2645.2	1.0910	7.5930	**0.05**
0.06	85.93	0.0010331	2.7318	359.84	2652.9	1.1452	7.5311	**0.06**
0.07	89.93	0.0010359	2.3649	376.68	2659.4	1.1919	7.4790	**0.07**
0.08	93.49	0.0010385	2.0872	391.64	2665.2	1.2328	7.4339	**0.08**
0.09	96.69	0.0010409	1.8695	405.13	2670.3	1.2694	7.3942	**0.09**
0.10	99.61	0.0010431	1.6940	417.44	2674.9	1.3026	7.3588	**0.10**
0.12	104.78	0.0010473	1.4284	439.30	2683.1	1.3608	7.2976	**0.12**
0.14	109.29	0.0010510	1.2366	458.37	2690.0	1.4109	7.2460	**0.14**
0.16	113.30	0.0010544	1.0914	475.34	2696.0	1.4549	7.2014	**0.16**
0.18	116.91	0.0010576	0.97753	490.67	2701.4	1.4944	7.1620	**0.18**
0.20	120.21	0.0010605	0.88574	504.68	2706.2	1.5301	7.1269	**0.20**
0.25	127.41	0.0010672	0.71870	535.35	2716.5	1.6072	7.0524	**0.25**
0.30	133.53	0.0010732	0.60579	561.46	2724.9	1.6718	6.9916	**0.30**
0.35	138.86	0.0010786	0.52420	584.31	2732.0	1.7275	6.9401	**0.35**
0.40	143.61	0.0010836	0.46239	604.72	2738.1	1.7766	6.8954	**0.40**
0.45	147.91	0.0010882	0.41390	623.22	2743.4	1.8206	6.8560	**0.45**
0.50	151.84	0.0010926	0.37480	640.19	2748.1	1.8606	6.8206	**0.50**
0.55	155.46	0.0010967	0.34259	655.88	2752.3	1.8972	6.7885	**0.55**
0.60	158.83	0.0011006	0.31558	670.50	2756.1	1.9311	6.7592	**0.60**
0.65	161.99	0.0011044	0.29258	684.22	2759.6	1.9626	6.7321	**0.65**
0.70	164.95	0.0011080	0.27276	697.14	2762.7	1.9921	6.7070	**0.70**
0.80	170.41	0.0011148	0.24033	721.02	2768.3	2.0460	6.6615	**0.80**
0.90	175.36	0.0011212	0.21487	742.72	2773.0	2.0944	6.6212	**0.90**
1.00	179.89	0.0011272	0.19435	762.68	2777.1	2.1384	6.5850	**1.00**
1.10	184.07	0.0011330	0.17744	781.20	2780.7	2.1789	6.5520	**1.10**