Name: **Enrolment No:**	

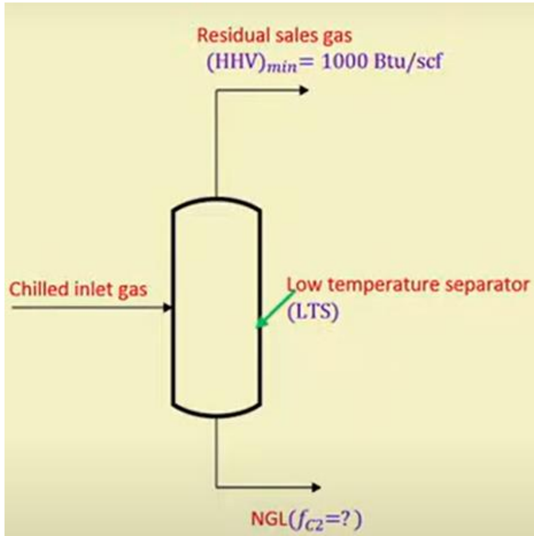
UNIVERSITY OF PETROLEUM AND ENERGY STUDIES

End Semester Examination, May 2023

Program Name: B. Tech APE UP **Semester: VI**
Course Name : Natural Gas Processing **Time: 3 hr**
Course Code : CHGS3022P **Max. Marks: 100**
Nos. of page(s) : 06
Instructions: Answer the questions in sequence.

S. No.		Marks	CO
	SECTION A **(Attempt all 5 questions and each carries 4 marks) (5 X 4=20Marks)**		
Q1.	List the design variables for the Glycol dehydration process.	**4M**	**CO1**
Q2.	Compare the alkanol and hot carbonate processes.	**4M**	**CO2**
Q3.	Sketch a typical water wash process for the removal of H_2S from natural gas.	**4M**	**CO2**
Q4.	Describe the field operations to control the dew point and fuel conditioning to knock out heavy hydrocarbons from the gas stream.	**4M**	**CO3**
Q5.	Identify the possible routes for the utilization of natural gas.	**4M**	**CO4**
	SECTION B **(Attempt all 4 questions and each carries 10 marks) (4 X 10 = 40Marks)**		
Q6.	Design an adsorber for dehydrating 20 MMscfd of a 0.7 gravity gas at 1000 psia and 100°F. Assume a two-tower plant using an 8-hr cycle with a 15 ft long silica bed. Compressibility factor=0.88, Gas velocity=1800 ft/hr.	**10M**	**CO1**
Q7.	With a sketch of the process flow scheme, explain the chemical absorption process for the sweetening of natural gas.	**10M**	**CO2**
Q8.	A propane refrigeration system with an evaporator duty of 12.7 MJ/hr operates between temperatures -40°C (evaporator) and 40°C (Condenser). Determine the flow rate of Propane.	**10M**	**CO3**
Q9.	Hydrogen can be made from natural gas with capture and storage or utilization of carbon (“clean”), or via water electrolysis using renewable energy to give “green” hydrogen. Explain.	**10M**	**CO4**
	SECTION C **(Attempt all 2 questions and each carries 20 marks) (2X 20 = 40Marks)**		

Q10. Consider the fractionator of an ethane-recovery system, as shown in the figure. **20M** **CO3**



If the residue sales gas must have a minimum higher heating value (HHV) of 1000 Btu/scf (37.3 MJ/Nm^3). Assume 0% recovery of nitrogen and methane and 100% recovery of propane in the recovered liquid stream. Determine:

a) The maximum ethane recovery (f_{C2}) obtainable from an inlet gas containing nitrogen, methane, ethane and propane.
b) Gas concentration (mol%) for each component in the residue.

The inlet compositions and HHV are given in the following table.

Component	Inlet gas concentration (mol%)	HHV (BTU/scf)
Nitrogen	3.5	0
Methane	87.0	1010
Ethane	7.0	1770
Propane	2.5	2516

Q11. Natural gas can compete and be a far more profitable alternative with all other sources like coal, fuel oil, and naphtha to produce ammonia. Justify by explaining the reactions, kinetics, thermodynamics, and various processes involved. **20M** **CO4**

Table 1 (a): Properties of Saturated Propane

TABLE B.27 (Continued)
Properties of Saturated Propane in Engineering Units

Temp (°F)	Pressure (psia)	Liquid Density (lb/ft³)	Vapor Volume (ft³/lb)	Enthalpy (Btu/lb)		Entropy (Btu/lb-°F)		Temp (°F)
				Liquid	Vapor	Liquid	Vapor	
15.00	51.012	33.80	2.0605	30.900	197.620	0.06872	0.41994	15.00
20.00	55.844	33.57	1.8899	33.836	198.970	0.07482	0.41908	20.00
25.00	61.011	33.34	1.7362	36.796	200.310	0.08090	0.41827	25.00
30.00	66.527	33.10	1.5975	39.781	201.640	0.08696	0.41751	30.00
35.00	72.406	32.86	1.4719	42.791	202.960	0.09301	0.41680	35.00
40.00	78.662	32.62	1.3581	45.827	204.270	0.09905	0.41613	40.00
45.00	85.310	32.38	1.2548	48.889	205.560	0.10507	0.41550	45.00
50.00	92.365	32.13	1.1607	51.979	206.830	0.11108	0.41491	50.00
55.00	99.841	31.88	1.0749	55.097	208.090	0.11708	0.41435	55.00
60.00	107.750	31.62	0.99652	58.245	209.330	0.12308	0.41382	60.00
65.00	116.120	31.36	0.92479	61.422	210.560	0.12907	0.41332	65.00
70.00	124.950	31.10	0.85903	64.630	211.760	0.13506	0.41283	70.00
75.00	134.260	30.83	0.79865	67.870	212.940	0.14104	0.41237	75.00
80.00	144.080	30.56	0.74310	71.144	214.090	0.14703	0.41191	80.00
85.00	154.410	30.28	0.69192	74.452	215.220	0.15301	0.41146	85.00
90.00	165.270	29.99	0.64468	77.797	216.320	0.15900	0.41102	90.00
95.00	176.680	29.70	0.60102	81.178	217.390	0.16500	0.41058	95.00
100.00	188.650	29.40	0.56059	84.600	218.430	0.17100	0.41013	100.00
105.00	201.200	29.10	0.52310	88.062	219.430	0.17702	0.40966	105.00
110.00	214.360	28.79	0.48828	91.568	220.390	0.18305	0.40918	110.00
115.00	228.140	28.47	0.45588	95.120	221.300	0.18911	0.40868	115.00
120.00	242.550	28.14	0.42569	98.721	222.170	0.19518	0.40814	120.00
125.00	257.620	27.80	0.39751	102.370	222.980	0.20129	0.40756	125.00
130.00	273.370	27.45	0.37116	106.080	223.730	0.20743	0.40694	130.00
135.00	289.820	27.08	0.34648	109.860	224.420	0.21361	0.40625	135.00
140.00	306.980	26.71	0.32331	113.690	225.030	0.21984	0.40549	140.00
145.00	324.900	26.32	0.30152	117.610	225.550	0.22613	0.40464	145.00
150.00	343.580	25.91	0.28098	121.600	225.980	0.23249	0.40369	150.00

Source: Lemmon et al. (2005).

Table 1 (b): Properties of Saturated Propane

Properties of Saturated Propane in Engineering Units

Temp (°F)	Pressure (psia)	Liquid Density (lb/ft³)	Vapor Volume (ft³/lb)	Enthalpy (Btu/lb) Liquid	Enthalpy (Btu/lb) Vapor	Entropy (Btu/lb-°F) Liquid	Entropy (Btu/lb-°F) Vapor	Temp (°F)
−200.00	0.0202	42.05	3133.5	−80.216	137.530	−0.23924	0.59932	−200.00
−190.00	0.0401	41.70	1637.0	−75.457	140.150	−0.22126	0.57825	−190.00
−180.00	0.0754	41.35	902.43	−70.677	142.800	−0.20386	0.55945	−180.00
−170.00	0.135	40.99	521.84	−65.873	145.480	−0.18698	0.54266	−170.00
−160.00	0.231	40.64	314.91	−61.043	148.200	−0.17059	0.52765	−160.00
−150.00	0.381	40.28	197.42	−56.184	150.950	−0.15464	0.51424	−150.00
−145.00	0.482	40.11	158.36	−53.743	152.330	−0.14683	0.50807	−145.00
−140.00	0.605	39.93	128.06	−51.294	153.720	−0.13911	0.50224	−140.00
−135.00	0.754	39.75	104.36	−48.836	155.120	−0.13148	0.49672	−135.00
−130.00	0.932	39.57	85.666	−46.370	156.520	−0.12394	0.49150	−130.00
−125.00	1.143	39.38	70.808	−43.894	157.930	−0.11649	0.48657	−125.00
−120.00	1.394	39.20	58.912	−41.409	159.350	−0.10912	0.48190	−120.00
−115.00	1.687	39.02	49.321	−38.913	160.760	−0.10184	0.47749	−115.00
−110.00	2.030	38.84	41.537	−36.407	162.180	−0.09462	0.47332	−110.00
−105.00	2.428	38.65	35.179	−33.891	163.610	−0.08748	0.46937	−105.00
−100.00	2.888	38.47	29.954	−31.363	165.040	−0.08041	0.46564	−100.00
−95.00	3.416	38.28	25.636	−28.824	166.470	−0.07341	0.46212	−95.00
−90.00	4.020	38.09	22.047	−26.272	167.900	−0.06647	0.45879	−90.00
−85.00	4.707	37.90	19.048	−23.708	169.330	−0.05959	0.45565	−85.00
−80.00	5.485	37.71	16.530	−21.132	170.770	−0.05276	0.45268	−80.00
−75.00	6.364	37.52	14.404	−18.542	172.210	−0.04600	0.44988	−75.00
−70.00	7.351	37.33	12.603	−15.938	173.640	−0.03929	0.44723	−70.00
−65.00	8.456	37.14	11.068	−13.320	175.080	−0.03262	0.44473	−65.00
−60.00	9.689	36.94	9.7563	−10.687	176.510	−0.02601	0.44238	−60.00
−55.00	11.059	36.75	8.6295	−8.039	177.950	−0.01944	0.44016	−55.00
−50.00	12.577	36.55	7.6580	−5.376	179.380	−0.01292	0.43807	−50.00
−45.00	14.254	36.35	6.8174	−2.696	180.810	−0.00644	0.43610	−45.00
−43.75	14.700	36.30	6.6252	−2.024	181.170	−0.00483	0.43562	−43.75
−40.00	16.101	36.15	6.0872	0.000	182.240	0.00000	0.43424	−40.00
−35.00	18.128	35.94	5.4509	2.713	183.660	0.00640	0.43250	−35.00
−30.00	20.348	35.74	4.8944	5.444	185.080	0.01277	0.43085	−30.00
−25.00	22.772	35.53	4.4062	8.193	186.500	0.01910	0.42931	−25.00
−20.00	25.412	35.32	3.9766	10.960	187.910	0.02540	0.42786	−20.00
−15.00	28.281	35.11	3.5974	13.747	189.320	0.03167	0.42650	−15.00
−10.00	31.390	34.90	3.2618	16.553	190.720	0.03791	0.42522	−10.00
−5.00	34.754	34.68	2.9638	19.380	192.110	0.04412	0.42403	−5.00
0.00	38.385	34.46	2.6987	22.227	193.500	0.05030	0.42290	0.00
5.00	42.296	34.24	2.4620	25.096	194.880	0.05646	0.42185	5.00
10.00	46.500	34.02	2.2503	27.987	196.250	0.06260	0.42087	10.00

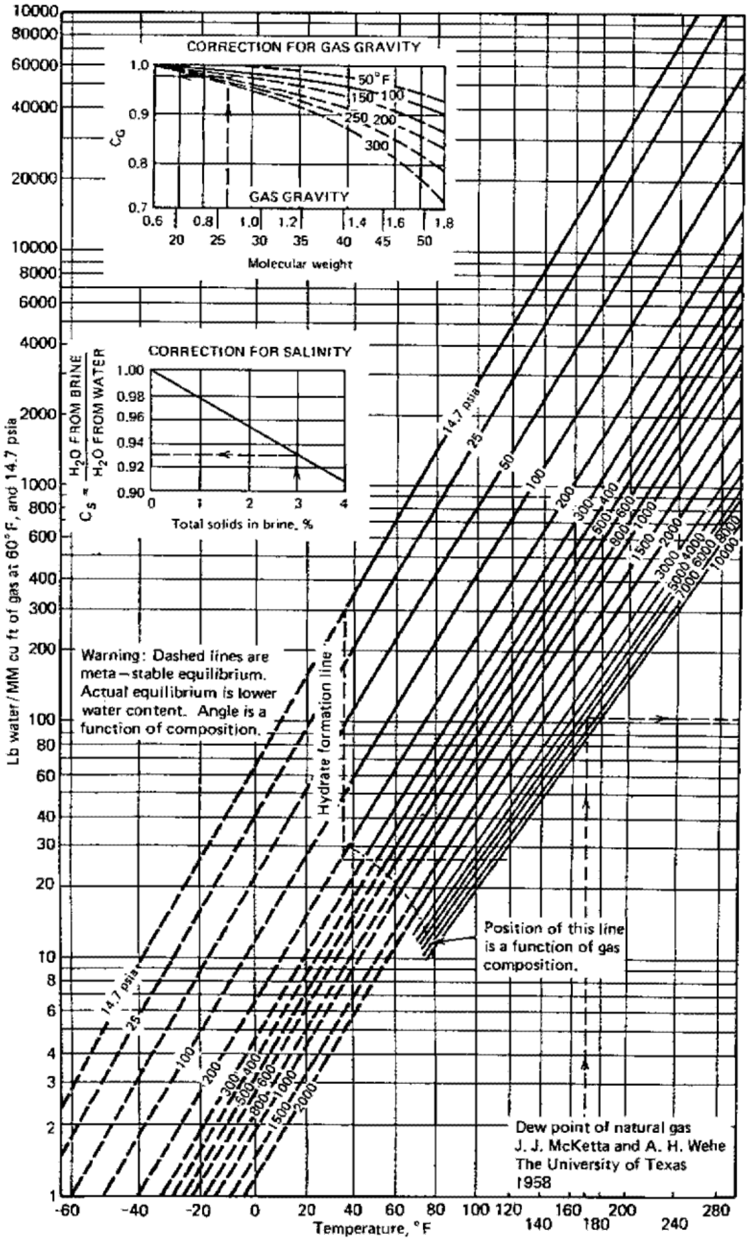


Fig. 2.13 Water contents of natural gases with corrections for salinity and gravity. (Courtesy Gas Processors Suppliers Assoc.)

Fig 1: Mc Ketta Graph for water content estimation

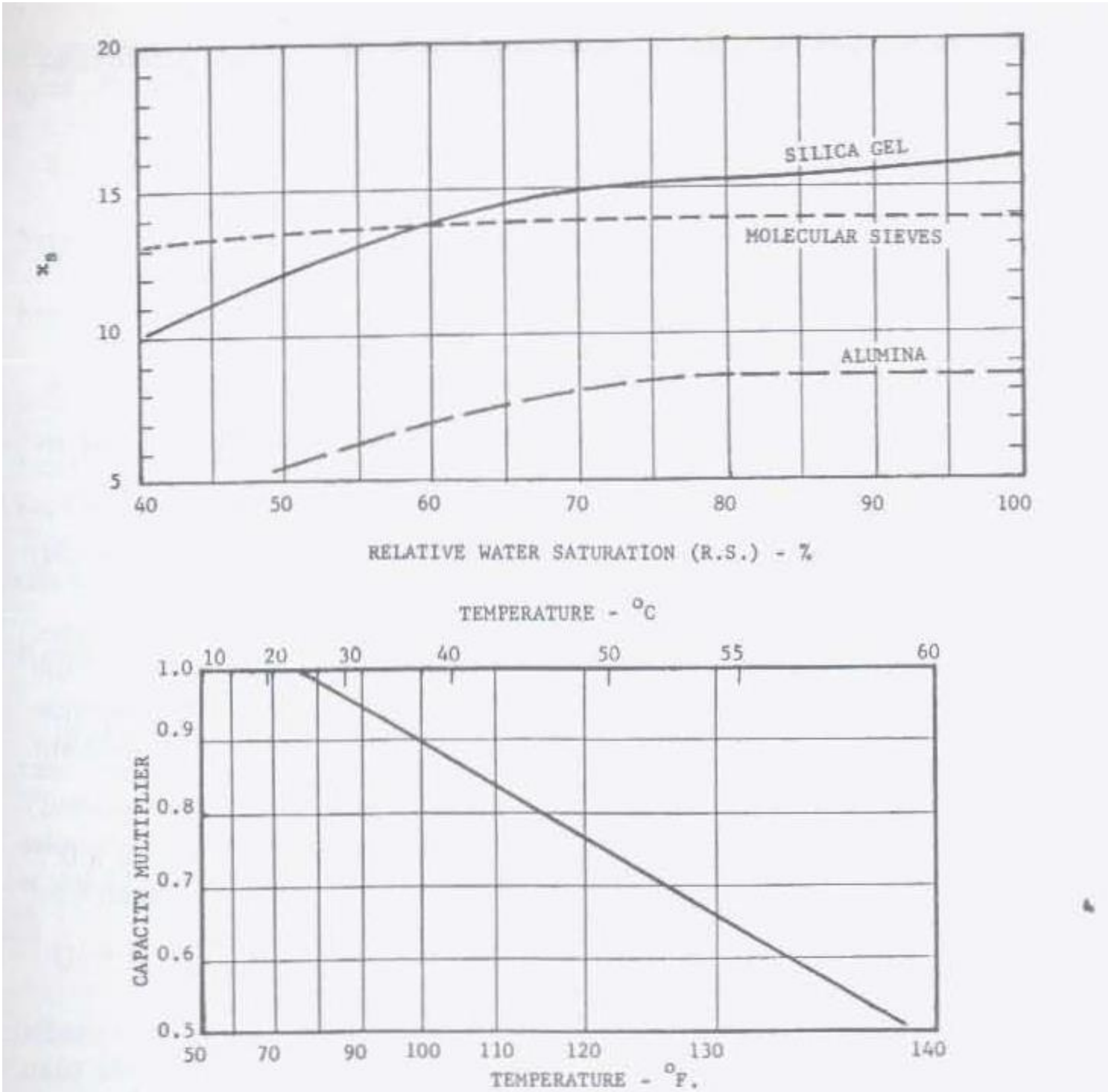


Fig 2: The effect of (a) relative water saturation and (b) temperature on the dynamic capacity of desiccants.