UNIVERSITY OF GHANA

B.Sc ENGINEERING SECOND SEMESTER EXAMINATION: 2015/2016
SCHOOL OF ENGINEERING SCIENCES
FPEN 202: FOOD PROCESS ENGINEERING CALCULATIONS (2 Credits)

INSTRUCTIONS:

ANSWER **FOUR** QUESTIONS

PSYCHROMETRIC AND CO_2 CHARTS PROVIDED

TIME ALLOWED: TWO (2) HOURS

1. Carbon dioxide gas enters a water-cooled compressor at conditions P_1=15 psia and T_1=50°F and is discharged at conditions P_2=520 psia and T_2=200°F. The entering CO_2 flows through a 4-in diameter pipe with a velocity of 20 ft/s, and is discharged through a 1-in diameter pipe. The shaft work supplied to the compressor is 5,360 Btu/**mol**. What is the heat-transfer rate from the compressor in Btu/**hr**?

   H_1=307 Btu/lb_m V_1=9.25 ft^3/lb_m
   H_2=330 Btu/lb_m V_2=0.28 ft^3/lb_m
   g_c=32.174 $lb_m.ft/lb_f.s^2$
   MW, CO_2 = 44

2. Formaldehyde can be made by the oxidation of methanol (CH_3OH). If stoichiometric amounts of $CH_3OH(g)$ and $O_2(g)$ enter the reactor at 100°C, the reaction is complete, and the products leave the reactor at 200°C, calculate the heat that is added or removed from the reactor per mole of $CH_3OH(g)$ fed to the reactor. The reaction is

   $$CH_3OH(g)+\tfrac{1}{2}O_2(g) \rightarrow H_2CO(g)+H_2O(g)$$

Compound	Heat of formation (kJ/g mol), $\Delta H^o_{f,298K}$	Mean C_p (J/g mol °C)
CH_3OH	- 201.25	2.75
H_2CO	- 115.89	2.15
H_2O	- 241.83	1.96
O_2	0	1.74

3. The air supply for a dryer has a dry-bulb temperature of 40°C and a wet-bulb temperature of 30°C. It is heated to 80°C by coils and blown into the dryer. In the dryer it cools along an adiabatic cooling line as it picks up moisture from the dehydrating material and leaves the dryer fully saturated.

a) What is the dew point of the initial air?
b) What is its humidity?
c) What is its percent relative humidity?
d) How much heat is needed to heat 100 m^3 of initial air to 80°C?
e) How much water will be evaporated per 100 m^3 of air entering the dryer?

4. In one system, carbon dioxide, which is commonly used in the food industry, is flashed across an insulated throttling valve. The inlet pressure and temperature of the carbon dioxide are 1800 psia and 250°F, and the outlet is set at 60 psia. Indicate on the CO_2 chart the position of the inlet and outlet points as points A and B, respectively. What are

a) the temperature
b) the quality
c) the specific volume of the outlet stream at 60 psia
d) mark as D on the chart an outlet state of 140 psia and -40°F. What is the quality of the CO_2 at state D?
e) What is the difference between the enthalpies at conditions A and B?

5. a) Simplify the general energy balance equation as much as possible for each of the following circumstances (state which terms can be deleted and why):

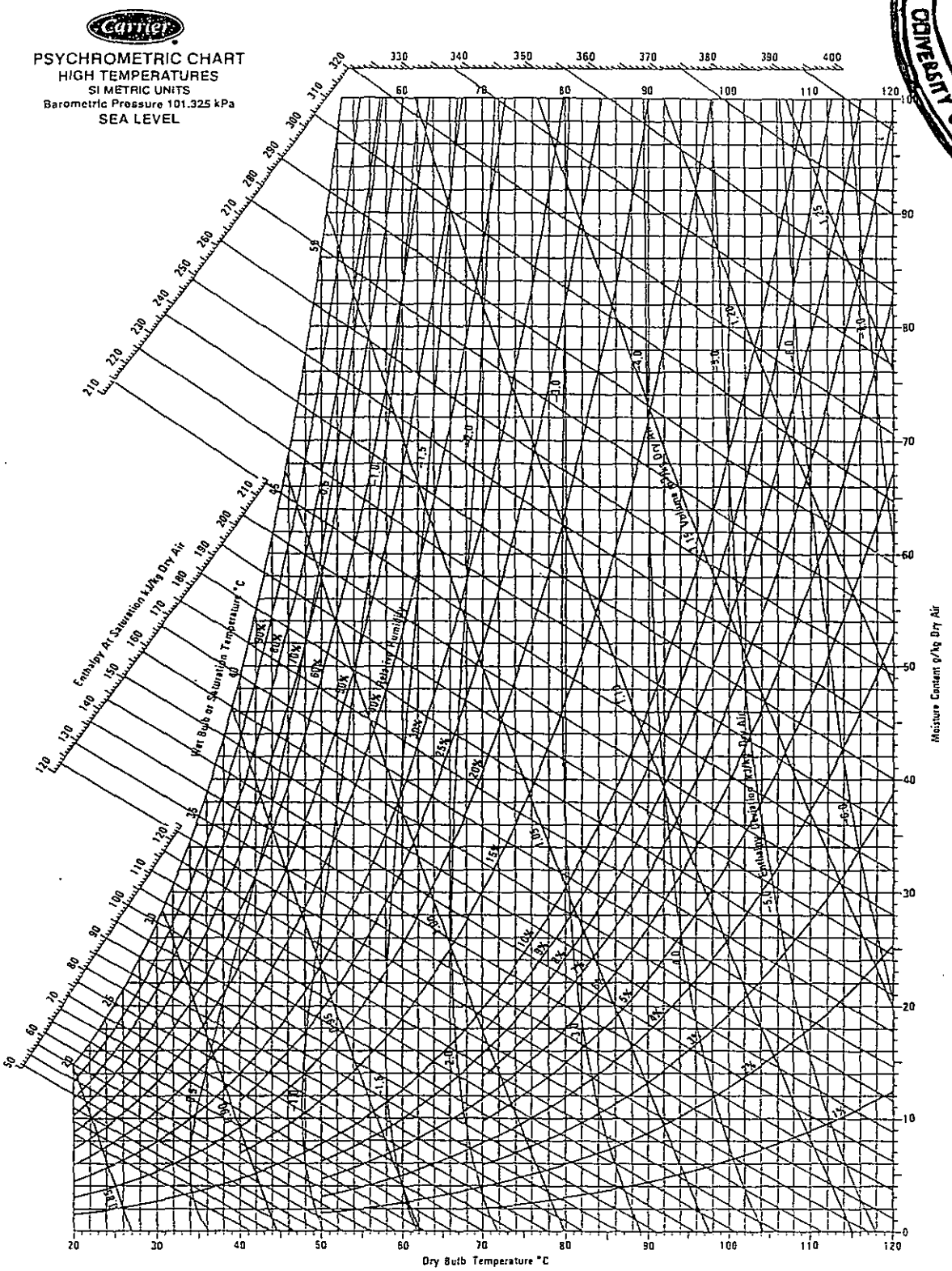
i) The system has no moving parts
ii) The temperature of the system and surroundings is the same
iii) The velocity of the fluid flowing into the system equals the velocity of the fluid leaving the system
iv) The fluid exits the system with sufficient velocity so that it can shoot out 3 meters.

b) A tank at a service station containing air at 100 kPa and 300 K is filled with air from a compressor that discharges air at 300 kPa and 400 K into the tank. After 1 kg of air is pumped into the tank, the pressure in the tank reaches 300 kPa and 400 K. How much heat was added to or removed from the tank during the filling?

Data for air:

Condition	H (kJ/kg)	U (kJ/kg)	V(m^3/kg)
100 kPa/300 K	459.85	337.75	0.8497
300 kPa/400 K	560.51	445.61	0.3830

.5 Psychrometric Charts



A.5.1 Psychrometric chart for high temperature range.

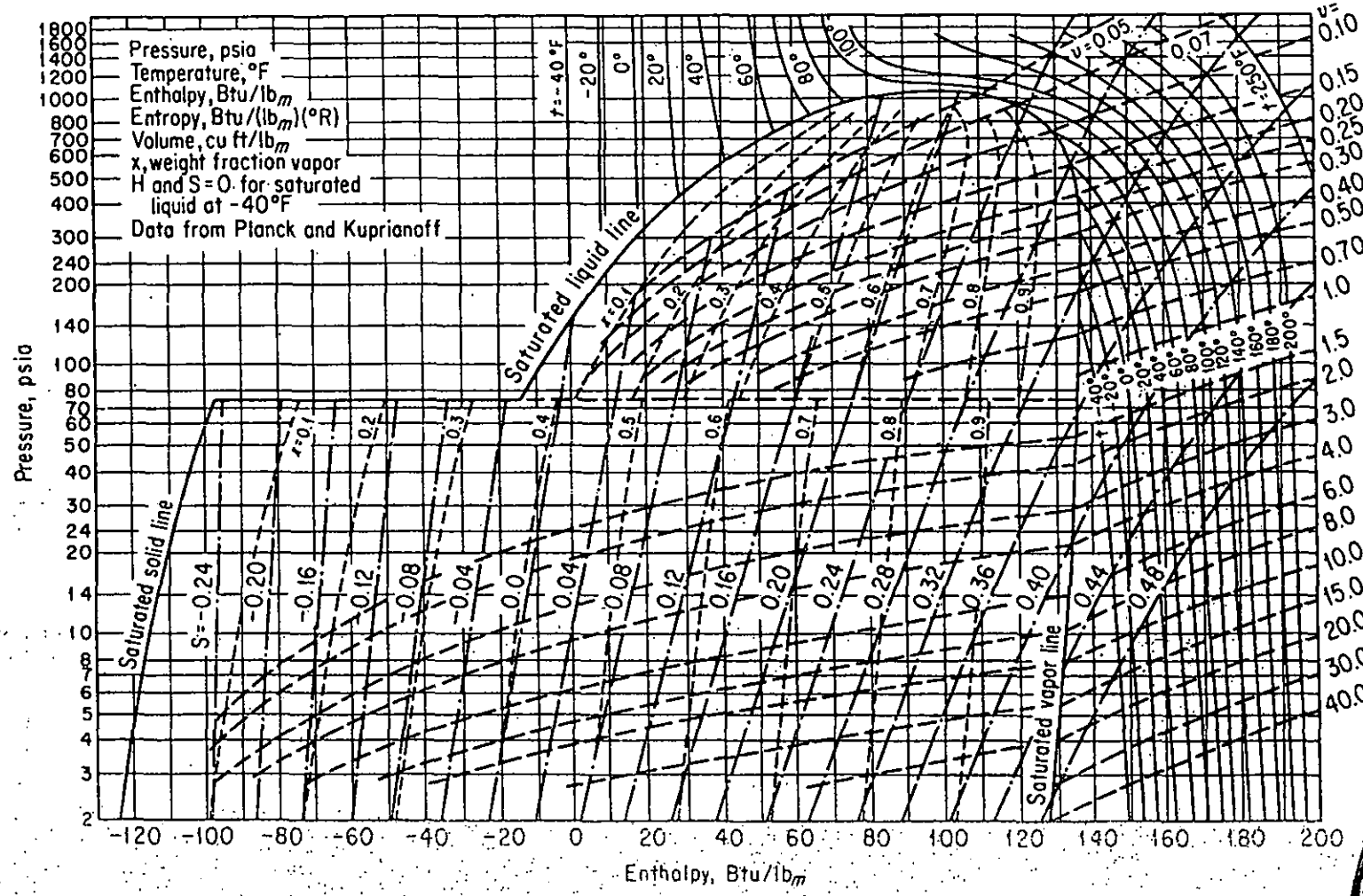


Figure J.2 Pressure-enthalpy chart for carbon dioxide.