UNIVERSITY OF GHANA

B.Sc SECOND SEMESTER FINAL EXAMINATION, 2014/2015
FPEN 202: FOOD PROCESS ENGINEERING CALCULATIONS (2 Credits)

INSTRUCTIONS **TIME: 2 HRS**

(i) Answer **FOUR** questions
(ii) Psychrometric chart provided
(iii) CO_2 enthalpy chart provided

Question 1

Formaldehyde is used as an intermediary chemical in the manufacture of several commercially important chemicals relevant to the food and other industries like fertilizer, pesticides, resins, etc. It can be made by the oxidation of methanol (CH_3OH).

If stochiometric amounts of CH_3OH (g) and O_2 (g) enter the reactor at 200°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

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

Data

Compound	$\Delta H^{\circ}_{f,298}$ (kJ/gmol)	Mean heat capacities (J/gmol.K)
H_2CO (g)	-120 kJ/g mol	34.85
H_2O (g)	-240 kJ/gmol	33.56
CH_3OH (g)	-200 kJ/gmol	46.11
O_2 (g)	-	29.37

Question 2

The air supply for a dryer has a dry-bulb temperature of 56°C and a wet-bulb temperature of 40°C. It is heated to 100°C by coils and blown into the dryer. In the dryer, it cools along an adiabatic cooling line (which is the same as the wet-bulb temperature 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?

EXAMINER: GEORGE AFRANE

c) What is its percent relative humidity?

d) How much heat is needed to heat 100 m^3 to 100°C?

Question 3

(a) Carbon dioxide is used extensively in the soft drinks processing industry. Two (2) pounds of carbon dioxide is cooled from 120°F in a cylinder of volume 6 ft^3 to saturation. Determine the total enthalpy change in Btu using the CO_2 chart provided.

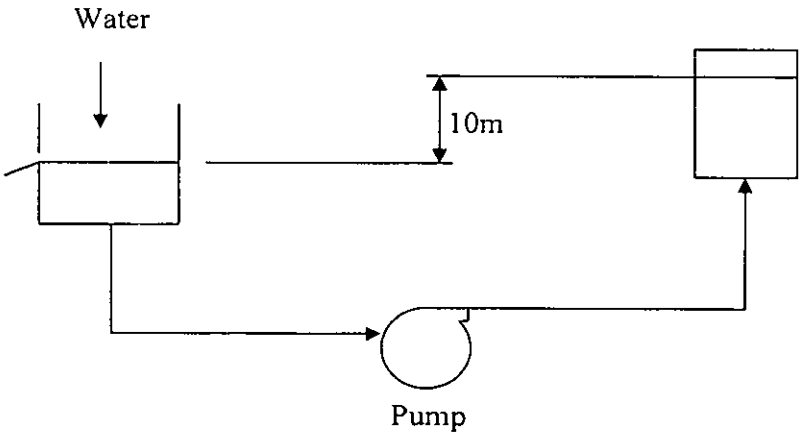
(b) Air is being compressed from 100 kPa and 200K (where it has an enthalpy of 350 kJ/kg) to 900 kPa and 275 K (where it has an enthalpy of 450 kJ/kg). The inlet and exit velocities of the air going through the compressor are 2 and 50 m/s. What is the power required, in kW, for the compressor if the load is 60kg/hr of air?

Question 4

(a) Point out two differences between the General and Mechanical Energy Balance equations.

b) Under what conditions could one equation be derived from the other?

c) Water at 20°C is being pumped from a constant-head tank open to the atmosphere (take atmospheric pressure as 100 kPa) to an elevated tank kept at a constant pressure of 1150 kPa in an experiment as shown in the figure below. If water is flowing in the 4-cm line at a rate of 0.40 m^3/min, find the rating of the pump in joules per kilogram if the energy loss in the line has been determined to be 50.0 J/kg and the pump efficiency is 75%. Take the specific volume of water as 1.268×10^{-4} m^3/kg.



Question 5

A rotary dryer operating at atmospheric pressure dries 10 tonnes/day of wet grain at 20°C, from a moisture content of 10% to 1% moisture. The air flow is counter current to the flow of grain, enters at 110°C dry-bulb and 110°F wet-bulb temperature, and leaves at 50°C dry-bulb. Determine

a) The humidity of the entering and leaving air.

b) The water removal in kg per hour

c) The daily product output in kg per day

d) The heat input to the dryer. Assume that there is no heat loss from the dryer, that the grain is discharged at 45°C, and that its specific heat is 0.753kJ/kg.°C.

(1 tonne =1000 kg)