KIBABII UNIVERSITY

UNIVERSITY EXAMINATIONS
2017/2018 ACADEMIC YEAR

THIRD YEAR FIRST SEMESTER
MAIN EXAMINATIONS

FOR THE BACHELOR OF RENEWABLE ENERGY AND BIOFUELS TECHNOLOGY

COURSE CODE: IPT 320

COURSE TITLE: ENERGY AND MASS BALANCE

DURATION: 2 HOURS

DATE: FRIDAY 19TH JANUARY 2018 **TIME:** 8 – 10 AM

INSTRUCTIONS TO CANDIDATES

- Answer **QUESTION ONE** (Compulsory) and any other two (3) Questions.
- Indicate **answered questions** on the front cover.
- Start every question on a new page and make sure question's number is written on each page.

This paper consists of **4** printed pages. Please Turn Over

Question 1

a. Calculate the density of mercury in lb_m/ft^3 from a tabulated specific gravity, and calculate the volume in ft^3 occupied by 215 kg of mercury.

4 Marks

b. How many of each of the following are contained in 100.0 g of CO_2 = (M = 44:01)?

(i) mol CO_2
(ii) lb-moles CO_2
(iii) mol C
(iv) mol O
(v) mol O_2
(vi) g O
(vii) g O_2
(viii) molecules of CO_2.

16 *Marks*

Question 2

a. Define the following terms related to a Thermodynamic Systems.

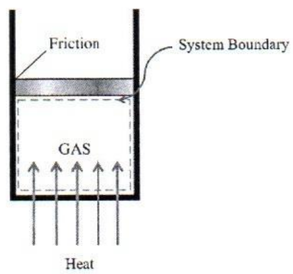
(i) Thermodynamic equilibrium **2 *Marks***
(ii) Entropy **2 *Marks***
(iii) Universe, system, surroundings, and boundary ***3 Marks***
(iv) Open system, closed system, and isolated system***3 Marks***

b. Use equations to describe how energy balance of a closed system, relates heat and work based on the first law of thermodynamics.

2 Marks

c. The expansion of gas in a cylinder occurs due to heat. Consider the Potential Energy, Kinetic Energy, and the frictional losses, to derive an equation below.

8 *Marks*



$$H2 - H1 = Q + Ef + \int Pd_v$$

Question 3

Water (Cp= 4180 J/kg · °C) enters the 2.5-cminternal- diameter tube of a double-pipe counter-flow heat exchanger at 17°C at a rate of 3 kg/s. It is heated by steam condensing at 120°C (hfg= 2203 kJ/kg) in the shell. If the overall heat transfer coefficient of the heat exchanger is 1500 W/m^2 · °C, determine the length of the tube required in order to
heat the water to 80°C.

20 Marks

Question 4

a. A mixture containing 45% benzene (B) and 55% toluene (T) by mass is fed to a distillation column. An overhead stream of 95 wt% B is produced, and 8% of the benzene fed to the column leaves in the bottom stream. The feed rate is 2000 kg/h. Determine the overhead flow rate and the mass flow rates of benzene and toluene in the bottom stream.

10 Marks

b. An aqueous solution of sodium hydroxide contains 20% NaOH by mass. It is desired to produce an 8% NaOH solution by diluting a stream of the 20% solution with a stream of pure water.
   (i) Calculate the ratios (g H2O/g feed solution) and (g product solution/g feed solution).
   (ii) Determine the feed rates of 20% solution and diluting water needed to produce 2310 lbm/min of the 8% solution.

10 Marks

Question 5

Consider a 1.2-m-high and 2-m-wide glass window whose thickness is 6 mm and thermal conductivity is k = 0.78 W/m · °C. Determine the steady rate of heat transfer through this glass window and the temperature of its inner surface for a day during which the room is maintained at 24°C while the temperature of the outdoors is -5°C. Take the convection heat transfer coefficients on the inner and outer surfaces of the window to be h_1 = 10 W/m^2 · °C and h_2 = 25 W/m^2 · °C, and disregard any heat transfer by radiation.

20 Marks

Conversion Factors

Mass	1 lb_m= 5 × 10^{-4} t = 0.453593 kg = 453.593 g = 16 oz
	1 kg = 1000 g = 2.20462 lb_m= 0.001 t
	1 t = 2000 lb_m; 1 t = 1000 kg
Length	1 ft = 12 in.; 1 ft = 0.3048 m = 30.48 cm; 1 in. = 2.54 cm; 1 mile = 5280 ft
	1 m = 10^{10} Å= 39.37 in. = 3.2808 ft = 1.0936 yd = 0.0006214 mi
Volume	1 ft^3 = 7.481 gal = 1728 $in.^3$ = 28.317 L= 28,317 cm^3
	1 gal = 231 $in.^3$; 1 $in.^3$ = 16.387 cm^3
	1 cc = 1 cm^3 = 1 mL; 1000 mL= L
	1000L=1m^3=35.3145ft^3=220.83imperialgallons=264.17gal=1056.68qt
	8 floz = 1 cup; 4 cup = 1 quart; 4 quart = 1 gal = 128 floz
Density	1 g/cm^3 = 1 kg/L= 1000 kg/m^3 = 62.428 lb/ft^3 = 8.345 lb_m/gal
Force	1 lb_f= 32.174 lb_m-ft/s^2 = 4.448222 N = 4.4482 × 10^5 dynes
	1 N = 1 kg-m/s^2 = 10^5 dynes = 10^5 g-cm/s^2 = 0.22481 lb_f
Pressure	1 bar = 10^5 Pa = 100 kPa = 10^5 N/m^2
	Pascal (Pa) is defined as 1 N/m^2 = 1 kg/m-s^2
	1atm=1.01325bar=14.696lb_f/$in.^2$=760mmHgat0°C(torr)=29.92 in Hg at 0°C
	1 psi = 1 lb_f/$in.^2$; psia (absolute) = psig (gauge) + 14.696
Temperature	1 K = 1.8°R (absolute temperature)
	T (°C) = T (K) − 273.15
	T (°F) = T (°R) − 459.67
	T (°F) = 1.8T (°C) + 32
Energy	1 J = 1 N-m = 1 kg-m^2/s^2 = 10^7 ergs = 10^7 dyne-cm = 2.778 × 10^{-7} kW-h
	= 0.23901 cal = 0.7376 ft-lb_f= 9.486 × 10^{-4} Btu
	1 cal = 4.1868 J; 1 Btu = 778.17 ft-lb_f= 252.0 cal
	1 Btu/lb_m-F = 1 cal/g-°C
Power	1 hp = 550 ft-lb/s = 0.74570 kW
	1 W = 1 J/s = 0.23901 cal/s = 0.7376 ft-lb_f/s = 9.486 × 10^{-4} Btu/s
	1 kW = 1000 J/s = 3412.1 Btu/h = 1.341 hp