A **Reg. No. :** | | | | | | | | | | |

Question Paper Code: 54902

B.E. / B.Tech. DEGREE EXAMINATION, APRIL 20119

Fourth Semester

Chemical Engineering

15UCH402 - CHEMICAL PROCESS CALCULATIONS

(Regulation 2015)

(Psychometric chat and Necessary Data book must be provided)

(Any missing data maybe assumed suitably)

Duration: Three hours Maximum: 100 Marks

Answer ALL Questions

PART A - (10 x 1 = 10 Marks)

1. 1 atmospheric pressure is equal to____ N/m^2 CO1- R

   (a) 101325 (b) 10^5 (c) 100 (d) 1

2. The number gram moles of the solute dissolved in one litre of solution CO1- R

   (a) atomic weight (b) molarity (c) molality (d) normality

3. The reactant that would disappear first if a reaction goes to completion is ___ CO2- R

   (a) initial reactant (b) limiting reactant (c) final reactant (d) product

4. The basis for material balance is the law of conservation of _____ CO2- R

   (a) steady state (b) mass (c) momentum (d) unsteady state

5. The temperature of the vapour- gas mixture recorded by a thermometer is CO3- R

   (a) WBT (b) DBT (c) dew point (d) humidity

6. The ratio of partial pressure of vapour in gas phase to vapour pressure of pure liquid at DBT is CO3- R

   (a) humidity (b) dew point (c) relative humidity (d) absolute humidity

7. When the standard heat of combustion is negative then the calorific value is CO4- R

   (a) positive (b) zero (c) negative (d) one

8. Determination of moisture and volatile matter is done by CO4- R

(a) moisture content (b) proximate analysis (c) ultimate analysis (d) combustion

9. 1 Calorie is equal to_____J CO5- R

(a) 4.184 (b) 3.18 (c) 6.628 (d) 0

10. The heat of formation of hydrocarbons is calculated by CO5- R

(a) Raoults law (b) Amagats law (c) Henry's law (d) Hess's law

PART – B (5 x 2= 10 Marks)

11. A mixture of methane and ethane contains 20 weight percent ethane. Find the composition of mixture on mole basis. CO1- U

12. Differentiate purging and recycle CO2- R

13. Write down the energy balance equation during phase change operation under the condition that the condensed liquid is sub cooled. CO3- U

14. Compute mass of water produced during combustion. CO4- E

Data: NCV=39696 kJ/kg, GCV=41785 kJ/kg, λ=2442.5 kJ/kg.

15. Distinguish between heat of solution and mixing CO5- R

PART – C (5 x 16= 80 Marks)

16. (a) (i) A saturated solution of salicylic acid in methanol contains 64 kg of salicylic acid per 100 kg of methanol at 298 K. Find the composition of solution in CO1- App (8)

(i) weight % and

(ii) mole %.

(ii) A mixture of H_2 and O_2 contains 11.1% H_2 by weight. Calculate CO1- App (8)

(a) average molecular weight of gas mixture and

(b) partial pressure of O_2 and H_2 at 100 kPa and 303 K.

Or

(b) A flue gas has the following composition: CO_2 -14%; SO_2 -0.5%; CO -2%; O_2 – 2.5% and N_2 - 81%. Determine
(a) Its weight percentage.
(b) Average molecular weight of the gas.
(c) Density of the gas at 320 K and 1.5 bar. CO1- App (16)

17. (a) A single effect evaporator is fed with 10,000 kg/hr of weak liquor containing 15% caustic by weight and is concentrated to get thick liquor containing 40% by weight caustic. Calculate
(i) kg/hr of water evaporated and
(ii) kg/hr of thick liquor obtained. CO2- App (16)

Or

(b) The producer gas made from the coke has the following composition by volume: CO – 28%, CO_2 – 3.5%, O_2 – 0.5% and N_2 – 68%. The gas is burned with such a quantity of air that the oxygen from air is 20% in excess of the net oxygen required for complete combustion. If the combustion is 98% complete, calculate the weight of the gaseous product formed per 100 kg of gas burned. CO2 -App (16)

18. (a) The dry bulb temperature and dew point of ambient air were found to be 302 K and 291 K respectively. Barometer reads 100 kPa. Calculate:
(a) Absolute molal humidity,
(b) Absolute humidity,
(c) % RH,
(d) The % saturation,
(e) The humid heat and
(f) The humid volume.
Data: Vapor pressure of water at 291 K = 2.0624 kPa
Vapor pressure of water at 302 K = 4.004 kPa CO3- Ana (16)

Or

(b) An air-water mixture has relative humidity of 80% at 293 K temperature and 100 kPa pressure. Calculate: CO3- Ana (16)

(a) Molal humidity of air,

(b) Molal humidity of air if its temperature is reduced to 283 K and the pressure is increased to 174.65 kPa condensing out some water ,

(c) The weight of water condensed from 500 kg of original wet air in the process of part (b).

(d) The final volume of the wet air of the part (c)

Data: Vapor pressure of water at 293 K = 2.40 kPa
Vapor pressure of water at 283 K = 1.266 kPa

19. (a) Calculate the GHV and NHV at 298 K (25^0c) of the gas having following composition by volume: CO4- App (16)

CH_4 : 74.4%, C_2H_6 : 8.4%, C_3H_8 : 7.4%, i-C_4H_{10} : 1.7%, n-C_4H_{10} : 2.0%, i-C_5H_{12} : 0.5%, n-C_5H_{12} : 0.4%, N_2 : 4.3%, and CO_2 : 0.9%

Data:

Component	$-\Delta H^0_c$=(gross),kJ/mol	$-\Delta H^0_c$=(net),kJ/mol
H_2	890.65	802.62
CH_4	1560.69	1428.64
C_2H_6	2219.17	2043.11
n-C_4H_{10}	2877.40	2657.32
n-C_5H_{12}	3535.77	3271.67
i-C_5H_{12}	3528.83	3264.73
i-C_4H_{10}	3535.77	3271.67

Or

(b) Calculate the theoretical number of moles of oxygen that must be supplied for combustion of one mol of a gas and the heating value in kJ/mol of the gas having the following composition by volume: CO4- Ana (16)

CO_2 : 5.4%,H_2 : 39.9%,CO : 32.9%, N_2 : 2.6%, O_2 :0.7%, $C_{2.73}H_{4.22\ (UNSATURATES)}$: 8.4%, $C_{1.14}H_{4.28\ (PARAFFINS)}$:10.1%.

Data:

Heating value of H_2 : 285.83 kJ/mol

Heating value of CO: 283.18 kJ/mol

Heating value of unsaturates : 411.14 A + 118.06 B + 120.6

Heating value of paraffins : 661.93 N +229

Where A and N are the number of carbon atoms and B is the number of hydrogen atoms.

20. (a) From the following data compute the enthalpy change of formation for NH_3 at 480 ^{0}C CO5- E (16)

DATA:

ΔH_f at 25 ºC for = -10.96kcal/kmol

C_P for N_2 = $6.76 +(6.06 \times 10^{-4}T) +(13 \times 10^{-8}T^2)$

C_P O_2 = $6.85 +(2.8 \times 10^{-4}T) +(22 \times 10^{-8}T^2)$

C_P NH_3 = 6.703 +(0.0063 T) where T is in K.

Or

(b) A natural gas has the following composition on mole basis: CH_4 =84%, C_2H_6 = 13% and N_2 = 3%. Calculate the heat to be added to heat 10Kmol of natural gas from 98 K 25ºC) to 523 K(250 ºC) using heat capacity data given below. DATA: CO5- E (16)

$C^o_P = a+bT+cT^2+dT^3$ KJ/ (kmol.K)

GAS	a	$b\times10^{-3}$	$c\times10^{-6}$	$d\times10^{-9}$
CH_4	19.2494	52.1135	11.973	-11.3173
C_2H_6	5.4129	178.0872	-67.3749	8.7147
N_2	29.5909	-5.141	13.1829	-4.968