



iv) The temperature at which the first drop of vapour is formed is

- a) bubble point
- b) dew point
- c) boiling point
- d) melting point.

v) Heat of formation of carbon is

- a) 0 kJ/mol
- b) - 393 kJ/mol
- c) - 241.82 kJ/mol
- d) none of these.

vi) Volume per cent of a gas in a mixture is equal to

- a) pressure per cent
- b) mole per cent
- c) weight per cent
- d) mole per cent only for ideal gas.

vii) Standard atmospheric pressure is equal to

- a) 10 psia
- b) 1.033 kg/cm²
- c) 760 mm Hg
- d) both (b) and (c).

viii) Dimension of viscosity is

- a) $ML^{-1}T^{-1}$
- b) ML^2T^{-1}
- c) MLT^{-1}
- d) ML^2T .

ix) Prandtl number is

- a) $\mu C_p / K$ b) V^2 / gD
c) hD / K d) μ / KC_p .

x) In a biochemical process, the recycle stream is purged for

- a) increasing the yield b) enriching the product
c) limiting the inerts d) heat conservation.

GROUP – B

(Short Answer Type Questions)

Answer any *three* of the following. 3 × 5 = 15

2. A natural gas has following composition by volume :

CO₂ - 0.8%, N₂ - 3.2% and CH₄ - 96%.

Calculate : (a) the composition in weight percentage (b) the average molecular weight.

3. Mass flow through a nozzle as a function of gas pressure and temperature is given by $m = 0.0549 (P/T^{0.5})$, where m is in lb/min, P is in psi and T is in °R. Obtain an expression of mass flow rate in kg/sec with P in atmospheres and T in Kelvin. Given $T^{\circ R} = T^{\circ F} + 460$;

14.7 psi = 1 atm.



4. An heat exchanger for cooling a hot hydrocarbon liquid uses 10,000 kg/hr of cooling water, which enters the exchanger at 294 K. The hot oil at the rate of 5000 kg/hr enters at 423 K and leaves at 338 K and has an average heat capacity of 2.51 kJ/KgK. Calculate the outlet temperature of water.
5. Define or state the following :
- Heat capacity
 - First law of thermodynamics
 - Heat of formation
 - Degree of reduction
 - Ideal solution.
6. A continuous distillation column is used to regenerate solvent for use in a solvent extraction unit. The column treats 200 kmol/hr of a feed containing 10% (mol) ethyl alcohol and the rest is water. The overhead product is 89% (mol) alcohol and the bottom product is 0.3% (mol) alcohol. The overhead is sent to the extraction unit and the bottom is wasted. What is the daily requirement of make-up alcohol in the solvent extraction unit ?



GROUP – C

(Long Answer Type Questions)

Answer any *three* of the following.

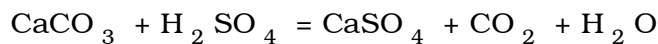
3 × 15 = 45

7. Consider the convective mass transfer of a fluid flowing in by forced convection through a pipe. The fluid is flowing at a velocity v , through a pipe of diameter D and has the density ρ , viscosity μ and the diffusivity D_{AB} . Relate the mass transfer coefficient K_c to the variables D , ρ , μ , v and D_{AB} using the Buckingham pi theorem.
8. Pure CO_2 may be prepared by treating limestone with aqueous H_2SO_4 . The limestone contains CaCO_3 and MgCO_3 and the remaining is insoluble matter. The acid is 12% H_2SO_4 . The residue from the process has the following composition :

CaSO_4	8.56%
MgSO_4	5.23%
H_2SO_4	1.05%
Inert	0.53%
CO_2	0.12%
Water	84.51%

Calculate :

- a) Composition of limestone used
 b) % excess acid used.



8 + 7



9. Wet solid is fed to a drier to reduce the moisture content from 80% to 15%. The product leaving the drier again passed through an oven and further moisture is reduced to 2%. If the drier can handle 1000 kg of wet solid per day, Calculate :

- a) The weight of products leaving the drier and oven per day,
- b) The percentage of the original water that is removed in the drier and oven.

8 + 7

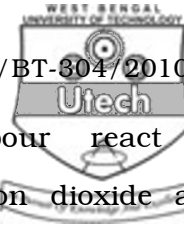
10. Flue gases leaving the stack of a boiler at 533 K have the following molar composition :

$\text{CO}_2 = 11.31\%$, $\text{H}_2\text{O} = 13.04\%$, $\text{O}_2 = 2.17\%$ and $\text{N}_2 = 73.48\%$. Calculate the heat loss in kJ of gas mixture above 298 K. Also calculate the average heat capacity of dry flue gas.

C_p in kJ/kmolK is given in the following table,

$$C_p = a + bT + cT^2$$

	a	$b \times 10^3$	$c \times 10^6$
CO_2	21.3655	64.284	- 41.0506
H_2O	18.56	33.23	- 52.16
O_2	26.0257	11.7551	- 2.3426
N_2	19.2494	52.1135	11.973



11. a) Carbon monoxide and water vapour react in stoichiometric amounts to form carbon dioxide and hydrogen. The feed enters at 25°C and the product leaves at 540°C with a carbon monoxide conversion of 75%. Determine the total amount of heat which must be added or removed in the reactor per 100 kg of hydrogen product. The following data may be used :

Component	Heat of formation at 25°C, kJ/kmol	Heat capacity 25°C, kJ/(kmol K)
CO	- 110600	30.35
H ₂ O	- 241980	36.00
CO ₂	- 393770	45.64
H ₂	0	29.30

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- b) Define adiabatic flame temperature.

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