

Invigilator's Signature :

# CS / B.Tech / (FT / BJ / NEW) / SEM-4 / CH-401 / 2013 2013 <br> INDUSTRIAL STOICHIOMETRY 

Time Allotted : 3 Hours
Full Marks : 70

The figures in the margin indicate full marks.
Candidates are required to give their answers in their own words as far as practicable.

## GROUP - A <br> ( Multiple Choice Type Guestions )

1. Choose the correct alternatives for any ten of the following :

$$
10 \times 1=10
$$

i) Dimension of viscosity is
a) $\quad M^{2} L^{-1} T$
b) $\quad M L^{-1} T^{-1}$
c) $M L T^{-1}$
d) $\quad M L^{-1} T^{-2}$.
ii) The temperature at which the first drop of vapour formed is
a) Bubble point
b) Boiling point
c) Dew point
d) Melting point.
a) $1.5 \mathrm{~kg} / \mathrm{m}^{3}$
b) $1.4 \mathrm{~kg} / \mathrm{m}^{3}$
c) $1.35 \mathrm{~kg} / \mathrm{m}^{3}$
d) $1.3 \mathrm{~kg} / \mathrm{m}^{3}$.
iv) Unit of humidity is
a) $\%$
b) kg moisture / kg dry air
c) kg moisture per $\mathrm{m}^{3}$ of dry air
d) none of these.
v) How many moles of $\mathrm{K}_{2} \mathrm{CO}_{3}$ will contain 117 kg potassium ?
a) 1.5 k mol
b) $2 \cdot 0 \mathrm{k} \mathrm{mol}$
c) $\quad 1.75 \mathrm{k} \mathrm{mol}$
d) 2.25 k mol .
vi) Graphical Integration is more accurate when done by
a) Rectangular rule
b) Trapezoidal rule
c) Simpson's rule
d) none of these.
vii) If 50 kg of dry solid containing $6 \%$ water is obtained by drying 65 kg of wet material, what was the initial moisture content?
a) $27 \cdot 7 \%$
b) $77 \%$
c) $23 \%$
d) $21 \%$.

a) decreases
b) increases
c) remains unchanged
d) may increase or decrease
ix) Exponential equations are solved by plotting on
a) rectangular graph
b) semi-log graph
c) $\log -\log$ graph
d) triangular graph.
x) Nusselt number is defined as
a) $\frac{h k}{\mathrm{~d}}$
b) $\frac{k \mathrm{~d}}{\mathrm{~h}}$
c) $\frac{h d}{k}$
d) none of these.
xi) Ideal solution obeys
a) Boyle's law
b) Fick's law
c) Raoult's law
d) none of these.

CS/B.Tech/(FT/BJ/NEW)/SEM-4/CH-401/2013 (Short Answer Type Questions)
Answer any three of the following.

2. Stainless steel has a thermal conductivity $k$ of $16 \cdot 2 \mathrm{Btu} /(\mathrm{hr})(\mathrm{ft})\left({ }^{\circ} \mathrm{F}\right)$. Convert this value into $\mathrm{cal} /(\mathrm{sec})(\mathrm{cm})$ $\left({ }^{\circ} \mathrm{R}\right)$. Write an example of dimensionless group and show how it becomes unitless.
3. A natural gas has the following composition by volume \% :
$\mathrm{CH}_{4}-83 \cdot 5 \%, \mathrm{C}_{2} \mathrm{H}_{6}-12 \cdot 5 \%$ and $\mathrm{N}_{2}-4 \%$.
Find the following :
(i) Composition in weight percent
(ii) Average molecular weight.
4. Write a short note on any one of the following topics :
(i) Effect of temperature on heat of reaction
(ii) Buckingham Pi-theorem.
5. Write a short note on Trapizoid rule.
6. Briefly describe the steps of material balance.
7. An evaporator has a rated evaporation capacity of 500 kg water/hr. Calculate the rate of production of concentrated juice containing $45 \%$ total solid from raw juice containing $12 \%$ solid.

8. a) Determine the quantity of sucrose crystals that will crystallize out of 100 kg of a $75 \%$ sucrose solution after cooling to $15^{\circ} \mathrm{C}$. The mother liquor contains $66 \%$ sucrose.
b) Pure $\mathrm{Na}_{2} \mathrm{CO}_{3} \cdot 10 \mathrm{H}_{2} \mathrm{O}$ was crystallized from a solution containing $25 \% \quad \mathrm{Na}_{2} \mathrm{CO}_{3}$ by evaporating $15 \%$ of the water at a temperature of $25^{\circ} \mathrm{C}$. Calculate the yield of crystals produced per 100 kg of original solution. Solubility of $\mathrm{Na}_{2} \mathrm{CO}_{3}$ at $25^{\circ} \mathrm{C}$ is $27.5 \mathrm{~kg} / 100 \mathrm{~kg}$ of water.

$$
7 \frac{1}{2}+7 \frac{1}{2}
$$

9. a) The spent acid from a Nitrating process contains $35 \%$ $\mathrm{H}_{2} \mathrm{SO}_{4}, 35 \% \mathrm{HNO}_{3}$ and $30 \% \mathrm{H}_{2} \mathrm{O}$ by weight. This acid is to be strengthened by the addition of conc. $\mathrm{H}_{2} \mathrm{SO}_{4}$ containing $95 \% \mathrm{H}_{2} \mathrm{SO}_{4}$ and conc. $\mathrm{HNO}_{3}$ containing $76 \% \mathrm{HNO}_{3}$. The strengthened mixed acid is to contain $40 \% \mathrm{H}_{2} \mathrm{SO}_{4}$ and $42 \% \mathrm{HNO}_{3}$. Calculate the quantity of spent acid and the concentrated acids that should be mixed together to yield 1000 kg of the desired mixed acid.
b) Alcohol manufacturing company produces it with a distillation column in a continuous fashion. 1000 kg of ethanol water mixture ( $10 \%$ ethanol and $90 \%$ water) is entering in the distillation column and after the completion of the process major product as distillate ( $60 \%$ ethanol and $40 \%$ water) and bottom product as waste are obtained. It was also given that the weight of the product is one tenth of feed and some distillate undergoes reflux operation. Now from these datas calculate the composition of the bottom and the mass of the alcohol lost in the bottom.

$$
7 \frac{1}{2}+7 \frac{1}{2}
$$

10. a) How much of water is required to raise the moisture content of a 100 kg material from $30 \%$ to $75 \%$ ?
b) Determine the amount of apple juice concentrate containing $65 \%$ solid and single strength juice containing $15 \%$ solid that must be mixed to produce 100 kg of an apple juice concentrate containing $45 \%$ solids.
$5+10$
11. A distillation column separates out $10000 \mathrm{~kg} / \mathrm{hr}$ of a $50 \%$ benzene, $50 \%$ toluene mixture. The product $(D)$ recovered from the condenser at the top of the column contains $95 \%$ benzene, and the bottom (W) from the column contains $96 \%$ toluene. The vapour stream $(V)$ entering the condenser from the top of the column is $8000 \mathrm{~kg} / \mathrm{hr}$. A portion of the product from the condenser is returned to the column as reflux and the rest is withdrawn for use. Assume that the composition of the stream at the top of the column $(V)$, the product withdrawn $(D)$ and the reflux $(R)$ are identical because the $(V)$ stream is condensed completely. Find the ratio of the amount refluxed $R$ to the product withdrawn ( $D$ ).

12. a) The Arrhenius equation relates the rate ofreaction with temperature as follows :

$K=A e^{-E a / R T}$

| $T\left({ }^{\circ} \mathrm{C}\right)$ | 100 | 110 | 120 | 130 |
| :---: | :---: | :---: | :---: | :---: |
| $K$ | $1 \cdot 005 \times 10^{-16}$ | $1 \cdot 07 \times 10^{-15}$ | $9 \cdot 25 \times 10^{-15}$ | $6.96 \times 10^{-14}$ |


| 140 | 150 |
| :---: | :---: |
| $4.58 \times 10^{-12}$ | $3.19 \times 10^{-12}$ |

Using these data evaluate the values of $E$ and $K$.
b) For heat transfer to a fluid in turbulent flow through a pipe, the heat transfer coefficient $h$, is a function of the pipe diameter $D$, thermal conductivity of the fluid $K$, velocity of the fluid $V$, density of the fluid $\rho$, heat capacity $C_{p}$, and viscosity $\mu$. Evaluate the dimensionless groups in this case. $8+7$

