



- (ix) In the exothermic reaction enthalpy change of the reaction is  
 (a) positive (b) negative (c) zero (d) not possible to predict
- (x) Refluxing of part of the distillate in a fractionating column is a recycling operation, aimed primarily at  
 (a) heat conservation (b) yield enhancement  
 (c) product enrichment (d) all the above

*Fill in the blanks with the correct word*

- (xi) 1° Brix is equivalent to a \_\_\_\_\_ % sugar solution.
- (xii) If mole ratio of N<sub>2</sub> to CO in a gas mixture is 1:1 then mass ratio of N<sub>2</sub> to CO is \_\_\_\_\_.
- (xiii) For unsaturated humid air relative humidity is always \_\_\_\_\_ than percentage humidity.
- (xiv) With rise in pressure, the solubility of gases in solvent at fixed temperature \_\_\_\_\_.
- (xv) Calorific value of a fuel at constant pressure is \_\_\_\_\_ than the calorific value at constant volume for the same fuel.

### Group - B

2. (a) Convert 23 lb<sub>m</sub>.ft/min<sup>2</sup> to its equivalent in kg.cm/s<sup>2</sup> [[CO1](Remember/LOCQ)]  
 (b) The equation for the heat transfer from a stream of gas flowing in turbulent motion is as follows:

$$h = \alpha \frac{C_p G^{0.8}}{D^{0.2}} = 16.2 \frac{C_p G^{0.8}}{D^{0.2}}$$

Where, h = Heat transfer coefficient, Btu/hr.ft<sup>2</sup>. °F

D = internal diameter, in

G = superficial mass velocity, lb. /ft<sup>2</sup>. s

C<sub>p</sub> = heat capacity, Btu/lb. °F

Transform this equation in a new form

$$h' = \alpha' \frac{C_p' G'^{0.8}}{D'^{0.2}}$$

Where, h' = Heat transfer coefficient, Kcal/hr.m<sup>2</sup>. °C

D' = internal diameter, cm

G' = superficial mass velocity, Kg. /m<sup>2</sup>. s

C' <sub>p</sub> = heat capacity, Kcal/Kg. °C

[[CO1](Remember/IOCQ)]

**4 + 8 = 12**

3. (a) 1000 Kg/hr of a mixture of benzene(B) and toluene(T) containing 50% benzene by mass is separated by distillation into two fractions. The mass flow rate of benzene in the top stream is 450 Kg B/h and that of toluene in the bottom stream is 475 Kg T/h. The operation is at steady state. Make balances on benzene and toluene to calculate the unknown component flow rates in the output stream.

[[CO2](Apply/LOCQ)]

- (b) A direct contact counter current rotary drier is to be used for drying a crystalline organic solid. Wet solid enters the drier at 303 K containing 25% moisture. Atmospheric air entering at the rate of 4.25 kg/s is heated to 393K. The solid

leaves the drier at 353K with moisture content of 2%. Dried product output is 1000 Kg/ h. Air leaves at 323 K from the drier. Calculate the humidity of air leaving the drier. At inlet of air heater, the humidity of 100 % saturated air at 308 K is 0.036 Kg moisture / Kg dry air.

[[CO2](Apply/HOCQ)]

**6 + 6 = 12**

### Group - C

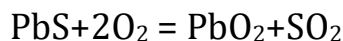
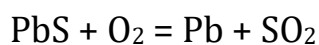
4. (a) A fuel gas contains 60% CH<sub>4</sub> and 40% CO<sub>2</sub> by volume. The gas is burned in a furnace with 20% excess air. 80% of the CH<sub>4</sub> reacted is converted to CO<sub>2</sub> and rest to CO. During combustion, 75% CH<sub>4</sub> is converted. Determine the flue gas composition. [[CO1](Analyse/HOCQ)]
- (b) Ethylene Oxide is produced by oxidation of ethylene. 100 kmol of ethylene are fed to a reactor and the product is found to contain 80 kmol ethylene oxide and 10 kmol CO<sub>2</sub>. Calculate the percentage conversion of ethylene and percent yield to ethylene oxide. [[CO1](Apply/IOCQ)]

**8 + 4 = 12**

5. (a) A sample of coal has the following ultimate analysis: carbon 52.22%, hydrogen 2.8%, sulfur 0.41%, nitrogen 2.1%, ash 18.5%, oxygen 18.05% and rest is moisture. Predict the Orsat analysis of the flue gas produced from the coal taking 100% excess air. [[CO1](Analyse/IOCQ)]

[[CO1](Analyse/IOCQ)]

- (b) 10 kg of PbS and 3 kgs of O<sub>2</sub> react to yield 6 kgs of Pb and 1 kg of PbO<sub>2</sub> according to the reaction:



Calculate (i) the amount of PbS that does not react, (ii) percentage excess O<sub>2</sub> based on the amount of PbS that actually reacts, (iii) amounts of SO<sub>2</sub> formed (iv) percentage conversion of PbS to Pb. (Atomic weight of Pb = 207.2) [[CO1](Understand/LOCQ)]

[[CO1](Understand/LOCQ)]

**6 + 6 = 12**

### Group - D

6. (a) The vapour pressure of chloroform is given by Antoine equation

$$\ln P^s = 13.9582 - \frac{2696.8}{T - 46.16}$$

where, pressure is in kPa and temperature in K. Determine the boiling point of chloroform at 0.5 bar pressure. Also determine the vapour pressure of chloroform at 27°C. [[CO3](Apply/IOCQ)]

[[CO3](Apply/IOCQ)]

- (b) The vapour pressure of acetone at 273 K is 8.52 kPa and that at 353 K is 195 kPa. Dry air initially at 101.3 kPa and 300 K is allowed to get saturated with the vapours of acetone at constant temperature and volume. Assuming that the Clausius-Clapeyron equation is applicable determine the final pressure of the mixture and the mole fraction of acetone in the final mixture. [[CO3](Apply/IOCQ)]

[[CO3](Apply/IOCQ)]

**4 + 8 = 12**

7. A mixture of n-hexane and n-heptane containing 25% n-hexane is vaporized at a pressure of 100 kPa. Determine the following assuming ideal vapour-liquid equilibrium:

- (i) The composition of vapour phase in equilibrium with the liquid phase.  
(ii) The bubble point temperature.

The vapour pressure are given by the Antoine equation

$$\ln P^s = A - \frac{B}{T - C}$$

Where  $P^s$  is in kPa and  $T$  in K. The Antoine constants are given as follows:

	A	B	C
n-heptane	13.8587	2911.32	56.51
n-hexane	13.8216	2697.55	48.78

[[CO3](Apply/IOCQ)]

**(4 + 8) = 12**

### Group - E

8. (a) Define the following term: (i) The standard heat of reaction, (ii) The standard heat of combustion, (iii) The standard heat of formation. [[CO5](Remember/LOCQ)]
- (b) Calculate the maximum flame temperature attained when methane is burned with theoretical amount of air. Methane and air are initially at 298 K. The mean heat capacities in J/mol K are 62.75 for CO<sub>2</sub>, 52.96 for H<sub>2</sub>O, 38.67 for O<sub>2</sub> and 37.13 for N<sub>2</sub>. The standard heat of combustion of methane at 298 K is -802.625 kJ/mol. [[CO6](Apply/IOCQ)]
- 6 + 6 = 12**
9. (a) Methanol is synthesised according to the following reaction:  

$$\text{CO (g)} + 2\text{H}_2\text{(g)} = \text{CH}_3\text{OH(g)}$$
The standard heat of formation at 298 K are -110.125 kJ/mol for CO and -200.66 kJ/mol for methanol. The specific heat in J/mol K are given by  

$$C_P (\text{CH}_3\text{OH}) = 19.382 + 101.564 \times 10^{-3} T - 28.683 \times 10^{-6} T^2$$

$$C_P (\text{CO}) = 28.068 + 4.631 \times 10^{-3} T - 2.5773 \times 10^{-6} T^2$$

$$C_P (\text{H}_2) = 27.012 + 3.509 \times 10^{-3} T - 6.9006 \times 10^{-6} T^2$$
Calculate the standard heat of reaction at 1073 K. [[CO5](Evaluate/IOCQ)]
- (b) A well stirred batch reactor wrapped in an electrical heating mantle is charged with a liquid reaction mixture. The reactant must be heated from an initial temperature of 25°C to 250°C before the reaction can take place at a measurable rate. Using the data given below determine the time required for this heating to take place.  
Reactant: mass = 1.5 Kg,  $C_V = 0.90$  Kcal / Kg. °C  
Reactor: mass = 3.0 Kg,  $C_V = 0.12$  Kcal / Kg. °C  
Heating rate(Q) = 500 W  
Negligible reaction and no phase change during heating. Negligible energy added to the system by the stirrer. [[CO6](Analyze/LOCQ)]
- 8 + 4 = 12**

Cognition Level	LOCQ	IOCQ	HOCQ
Percentage distribution	27	58	15