

December 2019

FUNDAMENTALS OF CHEMICAL ENGINEERING*Time Allowed: 3 Hours**Full Marks: 70*

Answer to Question No.1 is compulsory and to be answered first.

This answer is to be made in separate loose script(s) provided for the purpose.

Maximum time allowed is 45 minutes, after which the loose answer scripts will be collected and fresh answer scripts for answering the remaining part of the question will be provided.

On early submission of answer scripts of Question No.1, a student will get the remaining script earlier.

Answer any five questions from the rest.

1. Answer the following questions (any twenty): 1x20

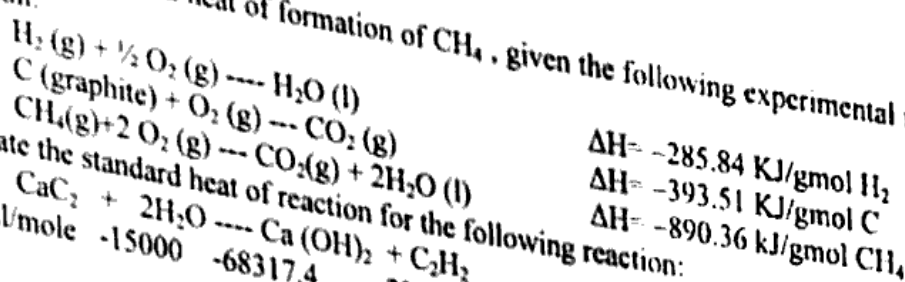
Choose the correct answer from the alternatives:

- i) Dimension of kinematic viscosity is – (a) MLT^{-1} , (b) L^2T^{-1} , (c) L^2T^{-2} .
- ii) Which of the following is not a dimensionless parameter? – (a) pressure co-efficient, (b) froude number, (c) kinematic viscosity, (d) weber number.
- iii) The effect of temperature on the vapour pressure of a liquid is given by – (a) Clausius-clapeyran, (b) Antoin's, (c) Rayleigh equation.
- iv) Poise is converted into stoke by a) multiplying with density b) dividing with density c) multiply with specific gravity d) dividing with specific gravity.
- v) The heat change for the reaction, $C(s) + 2S(s) \rightarrow CS_2(l)$, is 104.2 kJ, it represents the heat of – (a) formation (b) solution (c) combustion (d) fusion.
- vi) What is the unit of kinematic viscosity in SI unit ? a) m^2/sec b) $N/m^2,sec$ c) $kg sec/m$ d) none
- vii) Ideal gas law is applicable at – (a) low temperature low pressure, (b) high temperature low pressure, (c) low temperature high pressure.
- viii) Dry saturated steam can be converted to suspended steam by – (a) increasing cross sectional area of flow, (b) forcing it downwards through a vertical tube, (c) passing it through a pressure reducing valve.
- ix) Which of the following has the form of Reynolds number a) $DV \rho / \mu$ b) DV / μ c) $DV \mu / \rho$ d) $D \mu / \rho V$.
- x) Thermocouple is suitable for measuring a) liquid temperature only b) very high temperature only c) very low temperature only d) both high and low temperature.
- xi) One torr is equal to – (a) 1mm Hg, (b) 1 pascal, (c) 1 atm, (d) 1 mm water column.
- xii) A gas behaves most like an ideal gas under condition of (a) high pressure & low temperature (b) high temperature & high pressure (c) low pressure & high temperature (d) low pressure & low temperature.
- xiii) At 300K & 2 atm pressure gaseous HF has density 4.87 g/l . What is the molecular weight of HF? Assume Ideal gas equation. (a) 20 (b) 59.97 (c) 40 (d) 10.

- xiv) At standard condition: $N_2 + 2O_2 \rightleftharpoons 2NO_2$; $\Delta G^\circ = 100$ KJ/mole, $NO + \frac{1}{2}O_2 \rightleftharpoons 2NO_2$; $\Delta G^\circ = -35$ KJ/mole. The standard free energy of formation of NO in kJ/mole is - (a) 15 (b) 30 (c) 85 (d) 170.
- xv) 40 gms each of the methane and oxygen are mixed in an empty container maintained at 40°C. The fraction of the total pressure exerted by oxygen is (a) 1/2 (b) 1/3 (c) 1/4 (d) 2/3.
- xvi) In petroleum industry, which of the following flow meters is normally used for heavy liquids characterised by high viscosity? (a) nutating disc meter (b) orifice meter (c) nozzle (d) rotating vane/lobe mete.
- xvii) Reynolds number may be defined as the ratio of inertial forces to a) gravity forces b) elastic forces c) pressure force d) viscous force.
- xviii) Unit of mass velocity is a) kg/m.hr b)kg/m².hr c)kg/hr d) kg/m²
- xix) Psychrometer determines - a) humidity of gases b) moisture content of solids c) water of crystallization d) hygroscopic nature of solids.
- xx) 2 litres of nitrogen at N.T.P. weighs _____ gms. (a) 14 (b) 2.5 (c) 28 (d) 1.25.
- xxi) The value of gas constant R is _____ kcal/kg mole.°C. (a) 8.314 (b) 1.987 (c) 0.082 (d) 4.76.
- xxii) The heat evolved in the combustion of benzene is represented by the equation: $C_6H_6 + 7.5 O_2 = 6 CO_2 + 3H_2O$; $\Delta H = 3264.6$ KJ/kg.mole. The heat energy change, when 39gm of C_6H_6 is burnt in an open container, will be _____ KJ/kg.mole - (a) +816.15 (b) +1632.3 (c) -1632.3 (d) -2448.45.
- xxiii) The valve used for very remote and accurate control of fluid is - a) needle valve b) globe valve c) gate valve d) butterfly valve.
- xxiv) Pirani guage is used for a) measurement of very high pressure - b) measurement of high vacuum c) liquid level under pressure d) liquid level at atmospheric pressure.
- xxv) The dew point of an unsaturated mixture of vapour and gas does not depend on a) the temperature of the mixture b) the total pressure of the mixture c) the composition of the mixture d) all of the above.

2. a) What do you mean by unit process and unit operation?, give one example of each.
 b) What is the difference between unit and dimension?
 c) What are the significance of Reynolds number & Prandtle number mentioning the variables used.
 d) Convert 1 kcal/(hr)(ft²)(°C) to W/m²K. 3+2+3+2
3. a) State Henry's law and Amagat's law.
 b) State the difference between density and specific gravity.
 c) What is mole fraction and how is it related to partial pressure of a gas in a mixture? 4+2+4
4. a) State and explain Dalton's law of partial pressure.
 b) 6 liters of a gas mixture contains 2.0 gm of CO₂, 4.0 gm of O₂ and 1.5 gm of CH₄ at 0°C, Calculate the composition of the mixture by volume and the partial pressure of each gas. 3+7
5. a) What is dew point & percentage humidity?
 b) The weather bureau reports the following conditions of air, Temperature of air: 35°C, relative humidity 60%, barometric pressure: 750 mm of Hg. Calculate humidity, molal humidity, percentage humidity at the condition mentioned above. Vapour pressure of water at 35°C is 42 mm of Hg. 4+6

6. a) Calculate the standard heat of formation of CH_4 , given the following experimental results at 25°C and 1 atm:



b) Calculate the standard heat of reaction for the following reaction:
 $\text{CaC}_2 + 2\text{H}_2\text{O} \rightarrow \text{Ca}(\text{OH})_2 + \text{C}_2\text{H}_2$
 ΔH_f cal/mole -15000 -68317.4 -235800 54194

7. a) The analysis of a gas sample is given below on volume basis: $\text{CH}_4 = 66\%$, $\text{CO}_2 = 30\%$, $\text{NH}_3 = 4\%$. Find - (a) the average molecular weight of the gas, and (b) density of the gas at 303.075 kPa & 303K . 6+4

b) How many g moles of nitrogen will occupy 1000 m^3 at $112 \times 10^3 \text{ N/m}^2$ & 400 K . 6+4

8. a) What do you mean by material balance? 2+8

b) It is required to make 2500 kg mixed acid containing $55\% \text{ H}_2\text{SO}_4$, $36\% \text{ HNO}_3$ and $9\% \text{ water}$ by blending (i) the spent acid containing $11.3\% \text{ HNO}_3$, $44.4\% \text{ H}_2\text{SO}_4$ and $44.3\% \text{ water}$, (ii) aqueous $90\% \text{ HNO}_3$ and (iii) aqueous $98\% \text{ H}_2\text{SO}_4$. All percentages are by weight. Calculate the quantities of each of the three acids required for blending.

9. a) Name four modern instruments used in chemical industries with their applications.

b) Name four different types of valves with their specific characteristics.

c) Name four different pipe fittings.

4+4+2