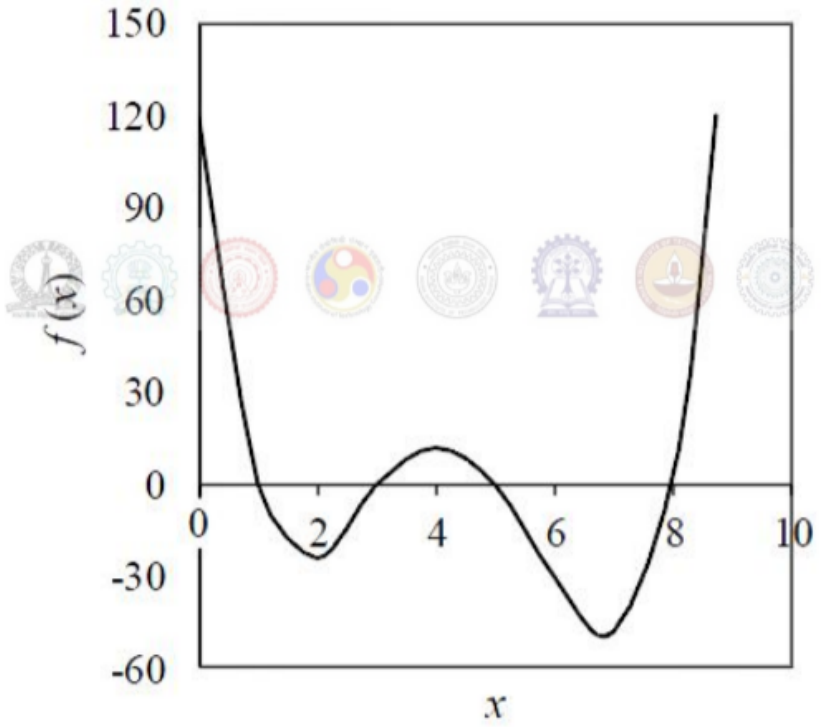
CH: CHEMICAL ENGINEERING

EE25BTECH11042 - Nipun Dasari

1) The value of $\lim_{x\to 0} \frac{tan(x)}{x}$ (GATE CH 2017)

2) The real part of $6e^{i\pi/3}$ (GATE CH 2017)

3) The number of positive roots of the function f(x) shown below in range $0 < x < 6$ is



(GATE CH 2017)

4) Let **i** and **j** be unit vectors in x and y directions respectively. For the function

$$F(x, y) = x^3 + y^2 \tag{1}$$

the gradient of the function, i.e; ΔF is given

a) $3x^2\mathbf{i} - 2y\mathbf{j}$
b) $6x^2y$
c) $3x^2\mathbf{i} + 2y\mathbf{j}$
d) $2y\mathbf{i} - 3x^2\mathbf{j}$

(GATE CH 2017)

5) The marks obtained by a set of students are: 38, 84. 45, 70, 75, 60. 48.
The mean and median marks, respectively, are

a) 45 and 75
b) 55 and 48
c) 60 and 60
d) 60 and 70

(GATE CH 2017)

6) The volumetric properties of two gases M and N are described by the generalized compressibility chart which expresses the compressibility factor (Z) as a function of reduced pressure and reduced temperature only. The operating pressure P and temperature T of two gases M and N along with their critical properties (P_c, T_c) are given in the table below.

Gas	P(bar)	T(K)	$P_c(bar)$	T_c
M	25	300	75	150
N	75	1000	225	500

Z_M and Z_N are the compressibility factor of the gases M and N under the given operating conditions. respectively.
The relation between Z_M and Z_N is

a) $Z_M = 8Z_N$ b) $Z_M = 3Z_N$ c) $Z_M = Z_N$ d) $Z_M = 0.333Z_N$

(GATE CH 2017)

7) Water is heated at atmospheric pressure from $40°C$ to $80°C$ using two different processes. In process L. the heating is done by a source at $80°C$. In process II. the water is first heated from 40°C to 60°C by a source at 60°C, and then from 60°C to 80°C by another source at 80°C.
Identify the correct statement.
a) Enthalpy change of water in process I is greater than enthalpy change in process II
b) Enthalpy change of water in process II is greater than enthalpy change in process I
c) Process I is closer to reversibility
d) Process II is closer to reversibility

(GATE CH 2017)

8) In a venturi meter. ΔP_1 and ΔP_2 are the pressure drops corresponding to volumetric flowrates Q_1 and Q_2. If Q2/Q12. then $\Delta P_2/\Delta P_1$ equals

a) 2 b) 4 c) 0.5 d) 0.25

(GATE CH 2017)

9) The thickness of laminar boundary layer over a flat plate varies along the distance from the leading edge of the plate. As the distance increases, the boundary layer thickness

a) increases
b) decreases
c) initially increases and then decreases
d) initially decreases and then increases

(GATE CH 2017)

10) Which of the following is the correct sequence of equipment for size reduction of solids?

a) Fluid energy mill → Jaw crusher → Hammer mill 0

b) Hammer mill → Jaw crusher → Fluid energy mill

c) Fluid energy mill → Hammer mill → Jaw crusher → Jaw crusher → Hammer mill

d) Fluid energy mill

(GATE CH 2017)

11) A gas bubble $\left(\text{gas density}\rho_g = 2kg/m^3\text{bubble diameter}D = 10^{-4}m\right)$ is rising vertically through water $\left(\text{density}\rho = 1000kg/m^3\text{viscosity}\mu = 0.001Pa.s\right)$. Force balance on the bubble leads to the following

equation, where v is the velocity of the bubble at any given time t. Assume that the volume of the rising bubble does not change. The value of $g = 9.81 m/s^2$

$$\frac{dv}{dt} = -g\frac{\rho_g - \rho}{\rho_g} - \frac{18\mu}{\rho_g D^2}v \tag{2}$$

The terminal rising velocity of the bubble (in cm/s), rounded to 2 decimal places, is cm/s (GATE CH 2017)

12) The one-dimensional unsteady heat conduction equation is

$$\rho C_p \frac{\delta T}{\delta t} = \frac{1}{r^n}\frac{\delta}{\delta r}\left(r^n k \frac{\delta T}{\delta r}\right) \tag{3}$$

where T temperature, t-time, r radial position, k thermal conductivity, ρ density, and C_p - specific heat.

For the cylindrical coordinate system, the value of n in the above equation is

a) 0 b) 1 c) 2 d) 3

(GATE CH 2017)

13) n a heat exchanger, the inner diameter of a tube is 25 mm and its outer diameter is 30 mm. The overall heat transfer coefficient based on the inner area is $360 W/m^{2\circ}C$. Then, the overall heat transfer coefficient based on the outer area, rounded to the nearest integer, is — $W/m^{2\circ}C$

(GATE CH 2017)

14) Which of the following conditions are valid at the plait point?

(P) Density difference between the extract and raffinate phases is zero
(Q) Interfacial tension between the extract and raffinate phases is zero
(R) Composition difference between the extract and raffinate phases is zero

a) P and Q only b) Q and R only c) P and R only d) P, Q and R

(GATE CH 2017)

15) The composition of vapour entering a tray in a distillation column is 0.47. The average composition of the vapour leaving the tray is 0.53. The equilibrium composition of the vapour corresponding to the liquid leaving this tray is 0.52. All the compositions are expressed in mole fraction of the more volatile component.

The Murphree efficiency based on the vapour phase. rounded to the nearest integer, is %. (GATE CH 2017)

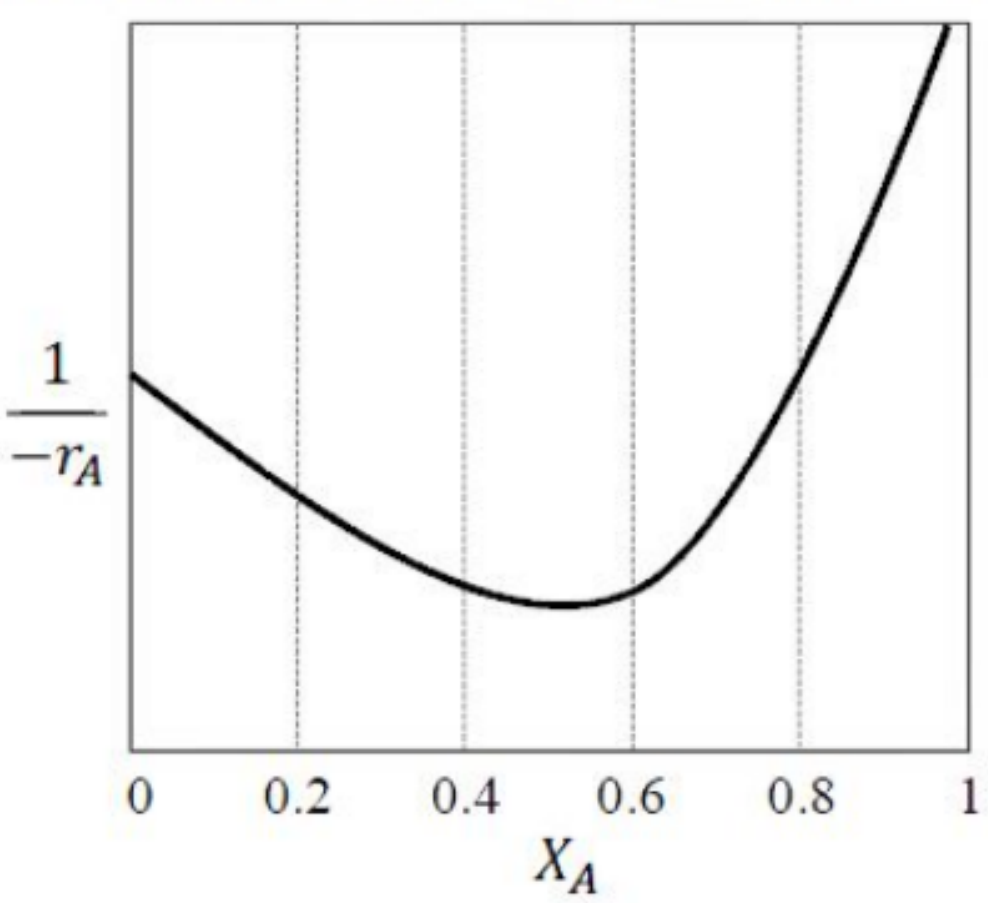
16) Consider steady state mass transfer of a solute A from a gas phase to a liquid phase. The gas phase bulk and interface mole fractions are $y_{A,G}$ and $y_{A,i}$, respectively. The liquid phase bulk and interface mole fractions are $X_{A,L}$ and $X_{A,i}$ respectively. The ratio $\frac{X_{A,i}-X_{A,L}}{Y_{A,G}-Y_{A,i}}$ is very close to zero.

This implies that mass transfer resistance is

a) negligible in gas phase only
b) negligible in liquid phase only
c) negligible in both the phases
d) considerable in both the phases

(GATE CH 2017)

17) The following reaction rate curve is shown for a reaction A P. Here, $(-r_A)$ and X represent reaction rate and conversion, respectively. The feed is pure A and 90% conversion is desired



Which amongst the following reactor configurations gives the lowest total volume of the reactor(s)?

a) CSTR followed by PFR
b) Two CSTRs in series
c) PFR followed by CSTR
d) A single PFR

(GATE CH 2017)

18) Consider a first order catalytic reaction in a porous catalyst pellet.
Given R characteristic length of the pellet: D_e effective diffusivity: ke mass transfer coefficient: k_1 rate constant based on volume of the catalyst pellet; C_s concentration of reactant on the pellet surface. The expression for Thiele modulus is

a) $\frac{k_C R}{D_e}$
b) $R\sqrt{\frac{k_1}{D_e}}$
c) $R\sqrt{\frac{k_1 C_s}{D_e}}$
d) $R\sqrt{\frac{D_e}{k_1}}$

(GATE CH 2017)

19) For a solid-catalyzed gas phase reversible reaction, which of the following statements is ALWAYS TRUE?
a) Adsorption is rate limiting
b) Desorption is rate limiting
c) Solid catalyst does not affect equilibrium conversion
d) Temperature doesn't affect equilibrium conversion

(GATE CH 2017)

20) Match the variables in Group-1 with the instruments in Group-2

Group-1	Group 2
P) Temperature	I) Capacitance probe
Q)Liquid level	II) McLeod gauge
R)Vacuum	III) Chromatograph
S)Concentration	IV) Thermistor

a) P-IV,Q-III,R-II,S-I b) P-I,Q-II,R-IV,S-III c) P-IV,Q-I,R-II,S-III d) P-III,Q-II,R-I,S-IV

(GATE CH 2017)

21) An LVDT (Linear Variable Differential Transformer) is a transducer used for converting

a) displacement to voltage
b) voltage to displacement
c) resistance to voltage
d) voltage to current

(GATE CH 2017)

22) The cost of a new pump (including installation) is 24,000 Rupees. The pump has a useful life of 10 years. Its salvage value is 4000 Rupees. Assuming straight line depreciation, the book value of the pump at the end of 4th year. rounded to the nearest integer. is Rupees. (GATE CH 2017)

23) The DCDA (Double Contact Double Absorption) process is used for the manufacture of

a) urea b) sulphuric acid c) nitric acid d) ammonia

(GATE CH 2017)

24) Match the polymerization processes in Group-1 with the polymers in Group-2.

a) P-I, Q-II, R- III
b) P-III, Q-II, R- I
c) P-I, Q-III, R- II
d) P-II, Q-I, R- III

(GATE CH 2017)

25) The purpose of methanation reaction used in ammonia plants is to

a) remove CO as it is a catalyst poison
b) increase the amount of hydrogen
c) remove sulphur as it is a catalyst poison
d) utilize methane as a catalyst for ammonia synthesis

(GATE CH 2017)

26) For the initial value problem

$$\frac{dx}{dt} = sin\,(t)\,, x\,(0) = 0 \tag{4}$$

the value of x at $t = \pi/3$ (GATE CH 2017)

27) The Laplace transform of a function is $\frac{s+1}{s(s+2)}$ The initial and final values, respectively, of the function are

a) 0 and 1
b) 1 and 1/2
c) 1/2 and 1
d) 1/2 and 0

(GATE CH 2017)

28) Match the problem type in Group-1 with the numerical method in Group-2.

Group 1	Group 2
P)System of linear algebraic equations	I0 Newton-Raphson
Q) Non-linear algebraic equations	II)Gauss-Seidel
R)Ordinary differential equations	III)Simpson's rule
S)Numerical integration	IV) Runge-Kutta

a) P-II, Q-I, R-III, S-IV
b) P-I, Q-II, R-IV, S-III
c) P-IV, Q-III, R-II, S-I
d) P-II, Q-I, R-IV, S-III

(GATE CH 2017)

29) A box has 6 red balls and 4 white balls. A ball is picked at random and replaced in the box, after which a second ball is picked. The probability of both the balls being red, rounded to 2 decimal places, is (GATE CH 2017)

30) An aqueous salt-solution enters a crystallizer operating at steady state at $25°C$. The feed temperature is $90°C$ and the salt concentration in the feed is 40 weight %. The salt crystallizes as a pentahydrate. The crystals and the mother liquor leave the crystallizer. The molecular weight of the anhydrous salt is 135. The solubility of the salt at $25°C$ is 20 weight %.
The feed flowrate required for a production rate of 100 kg/s of the hydrated salt, rounded to the nearest integer. is kg/s (GATE CH 2017)

31) Reaction $A \rightarrow B$ is carried out in a reactor operating at steady state and 1 mol/s of pure A at $425°C$ enters the reactor. The outlet stream leaves the reactor at $325°C$. The heat input to the reactor is 17 kW. The heat of reaction at the reference temperature of $25°C$is 30 kJ/mol. The specific heat capacities (in kJ/mol.K) of A and B are 0.1 and 0.15. respectively.
The molar flowrate of B leaving the reactor, rounded to 2 decimal places, is mol/s (GATE CH 2017)

32) The pressure of a liquid is increased isothermally. The molar volume of the liquid decreases from $50.45-106 m^3/mol$ to $48\times10 m^3/mol$ during this process. The isothermal compressibility of the liquid is 10 Pa, which can be assumed to be independent of pressure. The change in the molar Gibbs free energy of the liquid, rounded to nearest integer is J/mol (GATE CH 2017)

33) A sparingly soluble gas (solute) is in equilibrium with a solvent at 10 bar. The mole fraction of the solvent in the gas phase is 0.01. At the operating temperature and pressure, the fugacity coefficient of the solute in the gas phase and the Henry's law constant are 0.92 and 1000 bar, respectively. Assume that the liquid phase obeys Henry's law. The MOLE PERCENTAGE of the solute in the liquid phase, rounded to 2 decimal places, is (GATE CH 2017)

34) The vapour pressure of a pure substance at a temperature 7 is 30 bar. The actual and ideal gas values of g/RT for the saturated vapour at this temperature 7 and 30 bar are 7.0 and 7.7. respectively. Here. g is the molar Gibbs free energy and R is the universal gas constant.
The fugacity of the saturated liquid at these conditions, rounded to 1 decimal place, is (GATE CH 2017)

35) Oil is being delivered at a steady flowrate through a circular pipe of radius $1.25\times10^{-}2$ m and length 10 m. The pressure drop across the pipe is 500 Pa.
The shear stress at the pipe wall, rounded to 2 decimal places, is Pa.

36) The following table provides four sets of Fanning friction factor data, for different values of Reynolds number (Re) and roughness factor (k/D)

	Re	10^2	10^3	10^5	10^6
	$\left(\frac{k}{D}\right)$	0	0.001	0	0.001
Set I	f	0.16	0.016	16×10^{-5}	16×10^{-5}
Set II	f	0.016	0.16	0.0055	0.0045
Set III	f	0.16	0.016	0.0045	0.0055
Set IV	f	0.0045	0.0055	0.016	0.16

Which of the above sets of friction factor data is correct? (GATE CH 2017)

a) Set I
b) Set II
c) Set III
d) Set IV

(GATE CH 2017)

37) A propeller (diameter D = 15 m) rotates at N = 1 revolution per second (rps). To understand the flow around the propeller. a lab-scale model is made. Important parameters to study the flow are velocity

of the propeller tip ($V = \pi ND$), diameter D and acceleration due to gravity (g). The lab-scale model is 1/100th of the size of the actual propeller.

The rotation speed of the lab-scale model, to the nearest integer, should be rps (GATE CH 2017)

38) Size analysis was carried out on a sample of gravel. The data for mass fraction χ_1 and average particle diameter D_{pi} of the fraction is given in the table below:

x_i	D_{pi}
0.2	5
0.4	10
0.4	20

The mass mean diameter of the sample. to the nearest integer, is (GATE CH 2017)

39) Let $I_{b\lambda}$ be the spectral blackbody radiation intensity per unit wavelength about the wavelength λ. The blackbody radiation intensity emitted by a blackbody over all wavelengths is

a) $\frac{dI_{b\lambda}}{d\lambda}$ b) $\frac{d^2I_{b\lambda}}{d\lambda^2}$ c) $\int_0^\infty I_{b\lambda}d\lambda$ d) $\int_0^\infty \lambda I_{b\lambda}d\lambda$

(GATE CH 2017)

40) A fluid flows over a heated horizontal plate maintained at temperature T_w The bulk temperature of the fluid is T_∞ The temperature profile in the thermal boundary layer is given by:

$$T = T_w + (T_w - T_\infty)\left[\frac{1}{2}\frac{y}{\delta_t}^3 - \frac{3}{2}\frac{y}{\delta_t}\right] \tag{5}$$

Here. y is the vertical distance from the plate, δ_t is the thickness of the thermal boundary layer and k is the thermal conductivity of the fluid.

The local heat transfer coefficient is given by

a) $\frac{k}{2\delta_t}$ b) $\frac{k}{\delta_t}$ c) $\frac{3k}{2\delta_t}$ d) $\frac{2k}{\delta_t}$

(GATE CH 2017)

41) In nucleate boiling. the pressure inside a bubble is higher than the pressure of the surrounding liquid. Assuming that both the liquid and vapour are saturated, the temperature of the liquid will ALWAYS be

a) b) c)

(GATE CH 2017)

42) The vapor phase composition and relative volatilities (with respect to n-propane) on an ideal tray of a distillation column are

Component	Methane	Ethane	n-Propane
Mole fraction in vapour	0.12	0.28	0.60
Relative volatility	10	4	1

The mole fraction of n-propane in the liquid phase, rounded to 2 decimal places, is

(GATE CH 2017)

43) The Sherwood number $S * h_L$ correlation for laminar flow over a flat plate of length L is given

$$S h_L = 0.664 Re_L^{0.5} S c^(1/3) \tag{6}$$

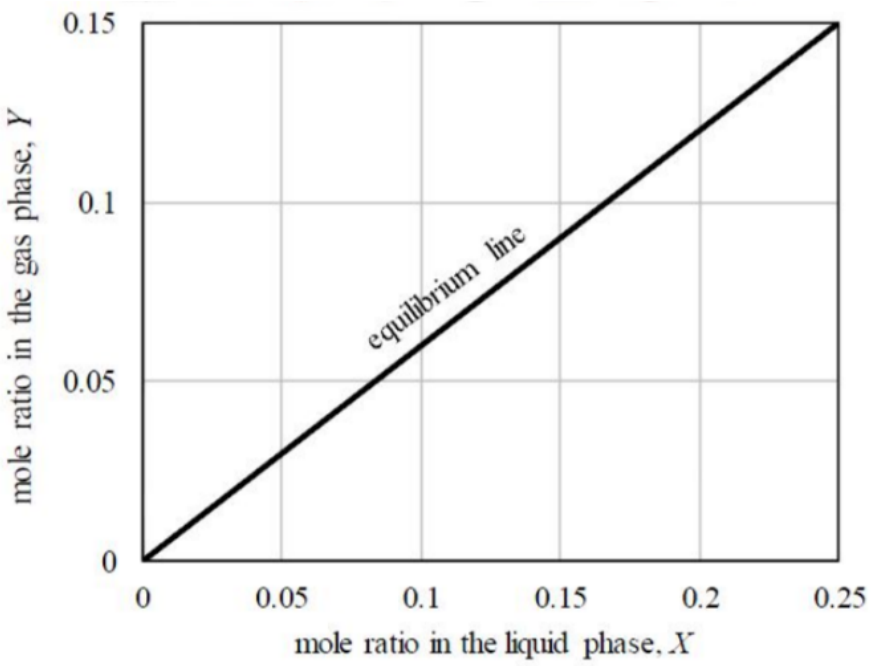
where Re_L and Sc represent Reynolds number and Schmidt number, respectively.

This correlation, expressed in the form of Chilton-Colburn j_D factor. is

a) $j_D = 0.664$ b) $j_D = 0.664 Re_L^{-0.5}$ c) $j_D = 0.664 Re_L$ d) $j_D = 0.664 Re_L^{0.5} S c^{2/3}$

(GATE CH 2017)

44) In a countercurrent stripping operation using pure steam, the mole ratio of a solute in the liquid stream is reduced from 0.25 to 0.05. The liquid feed flowrate, on a solute-free basis, is 3 mol/s. The equilibrium line for the system is given in the figure below.



The MINIMUM flowrate of pure steam for this process, rounded to 1 decimal place, is mol/s is (GATE CH 2017)

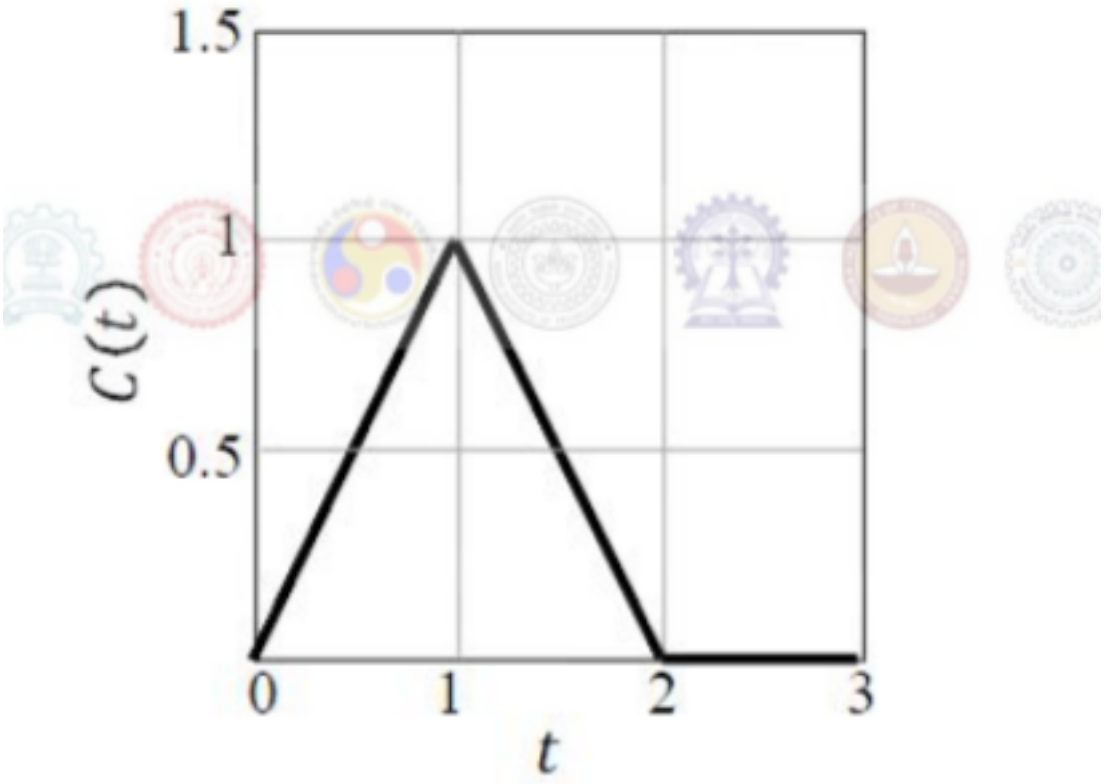
45) In a batch adsorption process. 5 g of fresh adsorbent is used to treat 1 liter of an aqueous phenol solution. The initial phenol concentration is 100 mg/liter. The equilibrium relation is given by

$$q = 1.3C \tag{7}$$

where q' is the amount of phenol adsorbed in mg of phenol per gram of adsorbent, and C is the concentration of phenol in mg/liter in the aqueous solution.

When equilibrium is attained between the adsorbent and the solution, the concentration of phenol in the solution, rounded to 1 decimal place, is mg/liter. (GATE CH 2017)

46) The C-curve measured during a pulse tracer experiment is shown below. In the figure, C(t) is the concentration of the tracer measured at the reactor exit in mol/liter at time t seconds



The mean residence time in the reactor, rounded to 1 decimal place, is S (GATE CH 2017)

47) The following liquid phase second-order reaction is carried out in an isothermal CSTR at steady state

$$A \rightarrow R, -r_a = 0.00502 C_A^2 mol/m^3.hr \tag{8}$$

where C_A is the concentration of the reactant in the CSTR. The reactor volume is $2m^3$, the inlet flowrate is $0.5m^3/hr$ and the inlet concentration of the reactant is 1000 mol/m The fractional conversion, rounded to 2 decimal places is (GATE CH 2017)

48) The reversible reaction of t-butyl alcohol (TBA) and ethanol (EtOH) to ethyl t-butyl ether (ETBE) is

$$TBA + EtOH \leftrightharpoons ETBE + Water \tag{9}$$

The equilibrium constant for this reaction is Kc = 1. Initially. 74 g of TBA is mixed with 100 g of aqueous solution containing 46 weight% ethanol. The molecular weights are: 74 g/mol for TBA, 46 g/mol for EtOH. 102 g/mol for ETBE. and 18 g/mol for water. The mass of ETBE at equilibrium, rounded to 1 decimal place, is (GATE CH 2017)

49) The following gas-phase reaction is carried out in a constant-volume isothermal batch reactor

$$A + B \rightarrow R + S \tag{10}$$

The reactants A and B as well as the product S are non-condensable gases. At the operating temperature, the saturation pressure of the product R is 40 kPa.

Initially, the batch reactor contains equimolar amounts of A and B (and no products) at a total pressure of 100 kPa. The initial concentrations of the reactants are $C_{A,0} = ?_{B,0} = 12.5 mol/m^3$. The rate of reaction is given by $-r_A = 0.08 C_A C_B mol/m^3.s$.

The time at which R just starts condensing, rounded to 1 decimal place, is (GATE CH 2017)

50) The transfer function of a system is

$$\frac{1}{4s^2 + 1.2s + 1} \tag{11}$$

For a unit step increase in the input, the fractional overshoot, rounded to 2 decimal places. is (GATE CH 2017)

51) The open loop transfer function of a process with a proportional controller (gain Kc) is

$$G_O L = K_c \frac{e^{-2s}}{s} \tag{12}$$

Based on the Bode criterion for closed-loop stability, the ultimate gain of the controller, rounded to 2 decimal places, is (GATE CH 2017)

52) The characteristic equation of a closed-loop system is

$$6s^3 + 11s^2 + 6s + 1 + K = 0, where K > 0 \tag{13}$$

The value of K beyond which the system just becomes unstable, rounded to the nearest integer is (GATE CH 2017)

53) A bond has a maturity value of 20.000 Rupees at the end of 4 years. The interest is compounded at the rate of 5% per year
The initial investment to be made, rounded to the nearest integer, is Rupees (GATE CH 2017)

54) The total cost C_T of an equipment in terms of the operating variables x and y is

$$C_T = 2x + \frac{12000}{xy} + y + 5 \tag{14}$$

The optimal value of C_T rounded to 1 decimal place, (GATE CH 2017)

Group-1
P) Fluidized bed

55) Match the equipment in Group-1 with the process in Group-2 Q) Multistage adiabatic reactor with inter-stage c
R) Fourdrinier machine
S) Diaphragm cell

a) P-IV, Q-III, R-I, S-II
b) P-IV, Q-III, R-II, S-I
c) P-III, Q-IV, R-I, S-II
d) P-III, Q-IV, R-II, S-I

(GATE CH 2017)

56) The bacteria in milk are destroyed when it heated to 80 degree Celsius.

a) would be b) will be c) is d) was

(GATE CH 2017)

57) with someone else's email account is now a very serious offence.

a) Involving b) Assisting c) Tampering d) Incubating

(GATE CH 2017)

58) Consider the following sentences:
All benches are beds. No bed is a bulb. Some bulbs are lamps.
Which of the following can be inferred?

i. Some beds are lamps.
ii. Some lamps are beds.

a) Only i b) Only ii c) Both i and ii d) Neither i nor ii

(GATE CH 2017)

59) If the radius of a right circular cone is increased by 50%. its volume increases by

a) 75% b) 100% c) 125% d) 237.5%

(GATE CH 2017)

60) The following sequence of numbers is arranged in increasing order: 1, x, x, x, y, y, 9,16,18. Given that the mean and median are equal. and are also equal to twice the mode the value of y is

a) 5 b) 6 c) 7 d) 8

(GATE CH 2017)

61) The old concert hall was demolished because of fears that the foundation would be affected by the construction of the new metro line in the area. Modern technology for underground metro construction tried to mitigate the impact of pressurized air pockets created by the excavation of large amounts of soil. But even with these safeguards. it was feared that the soil below the concert hall would not be stable. From this one can infer that

a) the foundations of old buildings create pressurized air pockets underground, which are difficult to handle during metro construction
b) metro construction has to be done carefully considering its impact on the foundations of existing buildings
c) old buildings in an area form an impossible hurdle to metro construction in that area
d) pressurized air can be used to excavate large amounts of soil from underground areas.

(GATE CH 2017)

62) Students applying for hostel rooms are allotted rooms in order of seniority. Students already staying in a room will move if they get a room in their preferred list. Preferences of lower ranked applicants are ignored during allocation. Given the data below. which room will Ajit stay in?

Names	Student seniority	Current room	Room preference list
Amar	1	P	R,S,Q
Akbar	2	None	R, S
Anthony	3	Q	P
Ajit	4	5	Q,P,R

a) P b) Q c) R d) S

(GATE CH 2017)

63) The last digit of $2171^7 + 2172^9 + 2173^{11} + 2174^{13}$ is

a) 2 b) 4 c) 6 d) 8

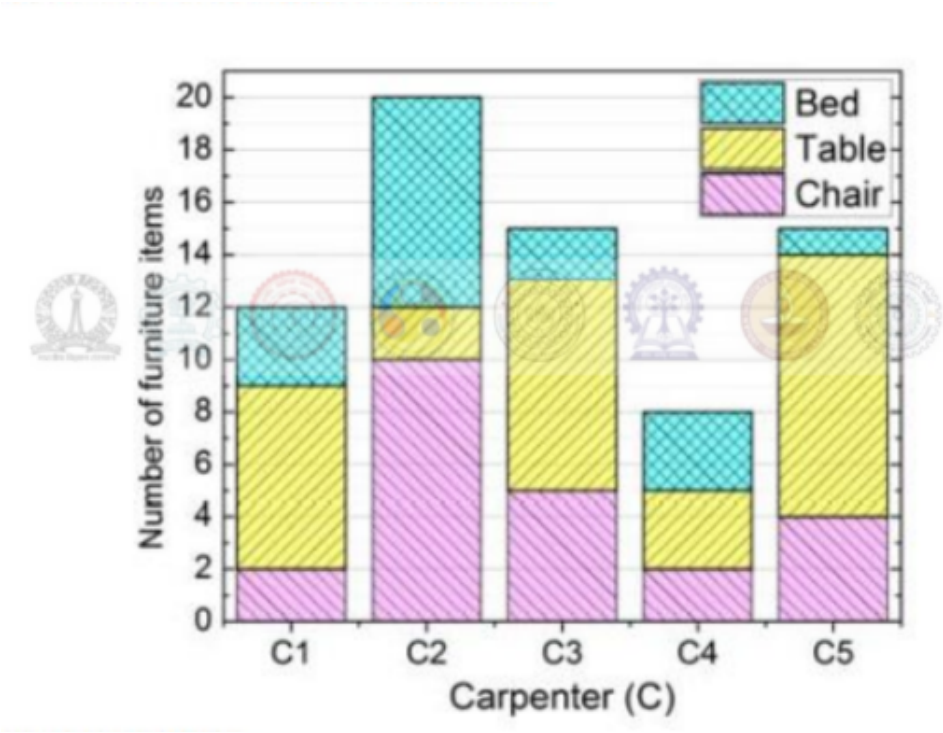
(GATE CH 2017)

64) Two machines M1 and M2 are able to execute any of four jobs P. Q. R and S. The machines can perform one job on one object at a time. Jobs P. Q. R and S take 30 minutes. 20 minutes. 60 minutes and 15 minutes each respectively. There are 10 objects each requiring exactly 1 job. Job P is to be performed on 2 objects. Job Q on 3 objects. Job R on 1 object and Job S on 4 objects. What is the minimum time needed to complete all the jobs?

a) 2 hours b) 2.5 hours c) 3 hours d) 3.5 hours

(GATE CH 2017)

65) The bar graph below shows the output of five carpenters over one month. each of whom made different items of furniture: chairs, tables. and beds.



Consider the following statements.

i. The mumber of beds made by carpenter C2 is exactly the same as the number of tables made by carpenter C3.

ii. The total number of chairs made by all carpenters is less than the total number of tables.

Which one of the following is true?

a) Only i b) Only ii c) Both i and ii d) Neither i nor ii

(GATE CH 2017)