CH:CHEMICAL ENGINEERING

Duration: Three Hours   *Maximum Marks*:100

Please read the following instructions carefully:

General Instructions:

1. Total duration of examination is 180 minutes (3 hours).

2. The clock will be set at the server. The countdown timer in the top right corner of screen will display the remaining time available for you to complete the examination. When the timer reaches zero, the examination will end by itself. You will not be required to end or submit your examination.

3. The Question Palette displayed on the right side of screen will show the status of each question using one of the following symbols:

1	You have not visited the question yet.
3	You have not answered the question.
5	You have answered the question.
7	You have NOT answered the question, but have marked the question for review.
9	You have answered the question, but marked it for review.

The Marked for Review status for a question simply indicates that you would like to look at that question again. *If a question is answered and Marked for Review, your answer for that question will be considered in the evaluation.*

Navigating to a Question

4. To answer a question, do the following:
   a. Click on the question number in the Question Palette to go to that question directly.
   b. Select an answer for a multiple choice type question. Use the virtual numeric keypad to enter a number as answer for a numerical type question.
   c. Click on **Save and Next** to save your answer for the current question and then go to the next question.
   d. Click on **Mark for Review and Next** to save your answer for the current question, mark it for review, and then go to the next question.
   e. **Caution: Note that your answer for the current question will not be saved, if you navigate to another question directly by clicking on its question number.**
5. You can view all the questions by clicking on the **Question Paper** button. Note that the options for multiple choice type questions will not be shown.

Answering a Question

6. Procedure for answering a multiple choice type question:
    a. To select your answer, click on the button of one of the options
    b. To deselect your chosen answer, click on the button of the chosen option again or click on the **Clear Response** button
    c. To change your chosen answer, click on the button of another option
    d. To save your answer, you MUST click on the **Save and Next** button
    e. To mark the question for review, click on the **Mark for Review and Next** button**. *If an answer is selected for a question that is Marked for Review, that answer will be considered in the evaluation.***

7. Procedure for answering a numerical answer type question:
    a. To enter a number as your answer, use the virtual numerical keypad
    b. A fraction (eg.,-0.3 or -.3) can be entered as an answer with or without '0' before the decimal point
    c. To clear your answer, click on the **Clear Response** button
    d. To save your answer, you MUST click on the **Save and Next** button
    e. To mark the question for review, click on the **Mark for Review and Next** button**. *If an answer is entered for a question that is Marked for Review, that answer will be considered in the evaluation.***

8. To change your answer to a question that has already been answered, first select that question for answering and then follow the procedure for answering that type of question.

9. Note that ONLY Questions for which answers are saved or marked for review after answering will be considered for evaluation.

Paper specific instructions:

1. There are a total of 65 questions carrying 100 marks.Questions are of multiple choice type or numerical answer type. A multiple choice type question will have four choices for the answer with only **one** correct choice. For numerical answer type questions, the answer is a number and no choices will be given**. A number as the answer should be entered** using the virtual keyboard on the monitor.

2. Questions Q.1 – Q.25 carry 1mark each. Questions Q.26 – Q.55 carry 2marks each. The 2marks questions include two pairs of common data questions and two pairs of linked answer questions. The answer to the second question of the linked answer questions depends on the answer to the first question of the pair. If the first question in the linked pair is wrongly answered or is not attempted, then the answer to the second question in the pair will not be evaluated.

3. Questions Q.56 – Q.65 belong to General Aptitude (GA) section and carry a total of 15 marks. Questions Q.56 – Q.60 carry 1mark each, and questions Q.61 – Q.65 carry 2marks each.

4. Questions not attempted will result in zero mark. Wrong answers for multiple choice type questions will result in **NEGATIVE** marks. For all 1 mark questions, ⅓ mark will be deducted for each wrong answer. For all 2 marks questions, ⅔ mark will be deducted for each wrong answer. However, in the case of the linked answer question pair, there will be negative marks only for wrong answer to the first question and no negative marks for wrong answer to the second question. There is no negative marking for questions of numerical answer type.

5. Calculator is allowed. Charts, graph sheets or tables are **NOT** allowed in the examination hall.

6. Do the rough work in the Scribble Pad provided.

Q. 1 – Q. 25 carry one mark each.

Q.1   The number of emails received on six consecutive days is 11, 9, 18, 18, 4 and 15, respectively. What are the median and the mode for these data?

(A) 18 and 11, respectively

(B) 13 and 18, respectively

(C) 13 and 12.5, respectively

(D) 12.5 and 18, respectively

Q.2   For two rolls of a fair die, the probability of getting a 4 in the first roll and a number less than 4 in the second roll, up to 3 digits after the decimal point, is _____

Q.3   Which of the following statements are TRUE?
P. The eigenvalues of a symmetric matrix are real
Q. The value of the determinant of an orthogonal matrix can only be +1
R. The transpose of a square matrix **A** has the same eigenvalues as those of **A**
S. The inverse of an 'n × n' matrix exists if and only if the rank is less than 'n'

(A) P and Q only   (B) P and R only   (C) Q and R only   (D) P and S only

Q.4   Evaluate

$$\int \frac{dx}{e^x - 1}$$

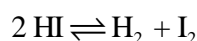(Note: C is a constant of integration.)

(A) $\dfrac{e^x}{e^x - 1} + C$

(B) $\dfrac{\ln\left(e^x - 1\right)}{e^x} + C$

(C) $\ln\left(\dfrac{e^x}{e^x - 1}\right) + C$

(D) $\ln\left(1 - e^{-x}\right) + C$

Q.5   A gaseous system contains H_2, I_2, and HI, which participate in the gas-phase reaction

$$2\,HI \rightleftharpoons H_2 + I_2$$

At a state of reaction equilibrium, the number of thermodynamic degrees of freedom is _____

Q.6   The thermodynamic state of a closed system containing a pure fluid changes from (T_1, p_1) to (T_2, p_2), where T and p denote the temperature and pressure, respectively. Let Q denote the heat absorbed (> 0 if absorbed by the system) and W the work done (> 0 if done by the system). Neglect changes in kinetic and potential energies. Which one of the following is CORRECT?

(A) Q is path-independent and W is path-dependent

(B) Q is path-dependent and W is path-independent

(C) (Q − W) is path-independent

(D) (Q + W) is path-independent

Q.7   An equation of state is explicit in pressure p and cubic in the specific volume v. At the critical point 'c', the isotherm passing through 'c' satisfies

(A) $\dfrac{\partial p}{\partial v} < 0,\ \dfrac{\partial^2 p}{\partial v^2} = 0$ (B) $\dfrac{\partial p}{\partial v} > 0,\ \dfrac{\partial^2 p}{\partial v^2} < 0$

(C) $\dfrac{\partial p}{\partial v} = 0,\ \dfrac{\partial^2 p}{\partial v^2} > 0$ (D) $\dfrac{\partial p}{\partial v} = 0,\ \dfrac{\partial^2 p}{\partial v^2} = 0$

Q.8   The units of the isothermal compressibility are

(A) m^{-3} (B) Pa^{-1} (C) $m^3\ Pa^{-1}$ (D) $m^{-3}\ Pa^{-1}$

Q.9   An open tank contains two immiscible liquids of densities ($800\ kg/m^3$ and $1000\ kg/m^3$) as shown in the figure. If $g = 10\ m/s^2$, under static conditions, the gauge pressure at the bottom of the tank in Pa is _____
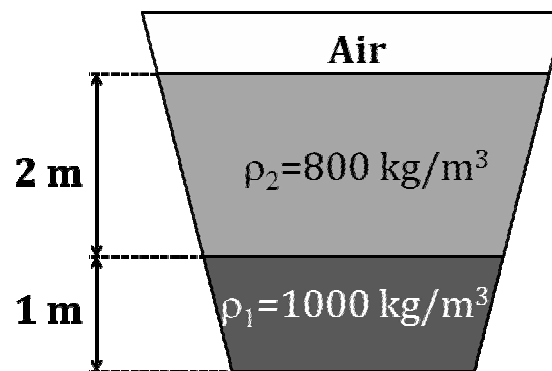

Q.10   The apparent viscosity of a fluid is given by

$0.007 \left| \dfrac{dV}{dy} \right|^{0.3}$ where $\left(\dfrac{dV}{dy} \right)$ is the velocity gradient. The fluid is

(A) Bingham plastic   (B) dilatant   (C) pseudoplastic   (D) thixotropic

Q.11
The mass balance for a fluid with density (ρ) and velocity vector $\left(\vec{V} \right)$ is

(A) $\dfrac{\partial \rho}{\partial t} + \nabla \cdot \left(\rho \vec{V} \right) = 0$ (B) $\dfrac{\partial \rho}{\partial t} + \vec{V} \cdot \left(\nabla \rho \right) = 0$

(C) $\dfrac{\partial \rho}{\partial t} + \rho \left(\nabla \cdot \vec{V} \right) = 0$ (D) $\dfrac{\partial \rho}{\partial t} - \vec{V} \cdot \left(\nabla \rho \right) = 0$

Q.12   An incompressible Newtonian fluid, filled in an annular gap between two concentric cylinders of radii R_1 and R_2 as shown in the figure, is flowing under steady state conditions. The outer cylinder is rotating with an angular velocity of Ω while the inner cylinder is stationary. Given that $(R_2 - R_1) \ll R_1$, the profile of the θ-component of the velocity V_θ can be approximated by,
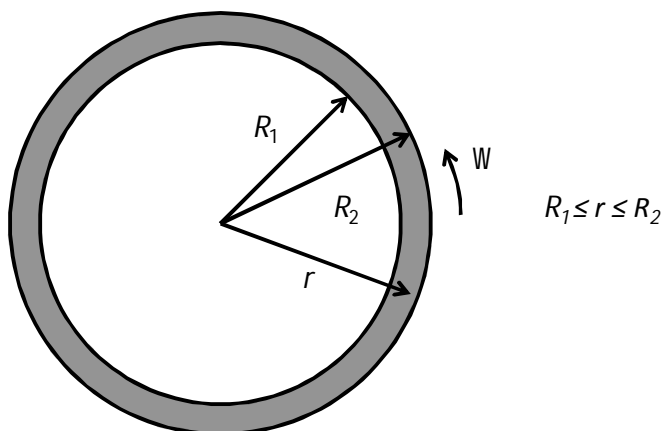
(A) $R_2 \Omega$ (B) $\dfrac{(r - R_2)}{(R_2 - R_1)} r\Omega$ (C) $\dfrac{(r + R_1)}{(R_2 + R_1)} R_1 \Omega$ (D) $\dfrac{(r - R_1)}{(R_2 - R_1)} R_2 \Omega$

Q.13   For a Newtonian fluid flowing in a circular pipe under steady state conditions in fully developed laminar flow, the Fanning friction factor is

(A) $0.046 \, \mathrm{Re}^{-0.2}$ (B) $0.0014 + \dfrac{0.125}{\mathrm{Re}^{0.32}}$

(C) $\dfrac{16}{\mathrm{Re}}$ (D) $\dfrac{24}{\mathrm{Re}}$

Q.14   In the Tyler standard screen scale series, when the mesh number increases from 3 mesh to 10 mesh, then

(A) the clear opening decreases

(B) the clear opening increases

(C) the clear opening is unchanged

(D) the wire diameter increases

Q.15   Taking the acceleration due to gravity to be 10 m/s^2, the separation factor of a cyclone 0.5 m in diameter and having a tangential velocity of 20 m/s near the wall is _____

Q.16   The effectiveness of a heat exchanger in the ε-*NTU* method is defined as

(A) $\dfrac{\text{increase in temperature of the cold fluid}}{\text{decrease in temperature of the hot fluid}}$

(B) $\dfrac{\text{actual exit temperature attained by the cold fluid}}{\text{maximum exit temperature attainable by the cold fluid}}$

(C) $\dfrac{\text{actual exit temperature attained by the hot fluid}}{\text{minimum exit temperature attainable by the hot fluid}}$

(D) $\dfrac{\text{actual heat transfer rate}}{\text{maximum possible heat transfer rate from hot fluid to cold fluid}}$

Q.17   In a pool boiling experiment, the following phenomena were observed.
P. Natural convection
Q. Film boiling
R. Transition boiling
S. Nucleate boiling

What was the CORRECT sequence of their occurrence?

(A) P, Q, R, S   (B) S, R, Q, P   (C) Q, R, P, S   (D) P, S, R, Q

Q.18   A hole of area 1 cm^2 is opened on the surface of a large spherical cavity whose inside temperature is maintained at 727 °C. The value of Stefan-Boltzmann constant is 5.67×10^{-8} W/m^2-K^4. Assuming black body radiation, the rate at which the energy is emitted (in W) by the cavity through the hole, up to 3 digits after the decimal point, is _____

Q.19   The packing of an existing absorption tower is replaced with a new type of packing. The height of the packing and the inlet conditions are maintained the same as before. Tests reveal that the number of transfer units is lower than before. This indicates that the tower with the new packing, when compared to that with the old packing, will

(A) have a higher rate of absorption of the solute from the gas stream

(B) have a lower rate of absorption of the solute from the gas stream

(C) have the same rate of absorption of the solute from the gas stream

(D) have a lower height of transfer unit

Q.20   A wet solid is dried over a long period of time by unsaturated air of nonzero constant relative humidity. The moisture content eventually attained by the solid is termed as the

(A) unbound moisture content

(B) bound moisture content

(C) free moisture content

(D) equilibrium moisture content

Q.21 The exit age distribution for a reactor is given by E(t) = δ(t - 4), where t is in seconds. A first order liquid phase reaction (k = 0.25 s^{-1}) is carried out in this reactor under steady state and isothermal conditions. The mean conversion of the reactant at the exit of the reactor, up to 2 digits after the decimal point, is _____

Q.22 An isothermal liquid phase zero order reaction A $\rightarrow$ B (k = 0.5 mol/m^3-s) is carried out in a batch reactor. The initial concentration of A is 2 mol/m^3. At 3 seconds from the start of the reaction, the concentration of A in mol/m^3 is _____

Q.23 The overall rates of an isothermal catalytic reaction using spherical catalyst particles of diameters 1 mm and 2 mm are r_{A1} and r_{A2} (in mol (kg-catalyst)$^{-1}$ h^{-1}), respectively. The other physical properties of the catalyst particles are identical. If pore diffusion resistance is very high, the ratio r_{A2}/r_{A1} is _____

Q.24 In the manufacture of sulphuric acid by the contact process, the catalytic oxidation of SO_2 is carried out in multiple stages mainly to

(A) increase the reaction rate by providing inter-stage heating

(B) increase the overall conversion by providing inter-stage heating

(C) increase the overall conversion by providing inter-stage cooling

(D) decrease the overall conversion by removing sulphur trioxide between stages

Q.25 Match the following.

Group 1	**Group 2**
(P) Viscosity	(1) Pyrometer
(Q) Pressure	(2) Hot wire anemometer
(R) Velocity	(3) Rheometer
(S) Temperature	(4) Piezoelectric element

(A) P-4, Q-3, R-1, S-2   (B) P-3, Q-4, R-2, S-1

(C) P-3, Q-4, R-1, S-2   (D) P-4, Q-3, R-2, S-1

Q. 26 to Q. 55 carry two marks each.

Q.26 For the function
$$f(z) = \frac{1}{(2-z)(z+2)}$$
the residue at z = 2 is _____

Q.27   The solution of the differential equation

$\dfrac{dy}{dx} - y^2 = 0$, given $y = 1$ at $x = 0$ is

(A) $\dfrac{1}{1+x}$ (B) $\dfrac{1}{1-x}$ (C) $\dfrac{1}{(1-x)^2}$ (D) $\dfrac{x^3}{3} + 1$

Q.28   The solution of the differential equation

$\dfrac{d^2 y}{dx^2} - \dfrac{dy}{dx} + 0.25 y = 0$, given $y = 0$ at $x = 0$ and $\dfrac{dy}{dx} = 1$ at $x = 0$ is

(A) $x e^{0.5x} - x e^{-0.5x}$ (B) $0.5 x e^x - 0.5 x e^{-x}$

(C) $x e^{0.5x}$ (D) $-x e^{0.5x}$

Q.29   The value of the integral

$\int_{0.1}^{0.5} e^{-x^3} dx$

evaluated by Simpson's rule using 4 subintervals (up to 3 digits after the decimal point) is _____

Q.30   In a process occurring in a closed system F, the heat transferred from F to the surroundings E is 600 J. If the temperature of E is 300 K and that of F is in the range 380 - 400 K, the entropy changes of the surroundings (ΔS_E) and system (ΔS_F), in J/K, are given by

(A) $\Delta S_E = 2$, $\Delta S_F = -2$ (B) $\Delta S_E = -2$, $\Delta S_F = 2$

(C) $\Delta S_E = 2$, $\Delta S_F < -2$ (D) $\Delta S_E = 2$, $\Delta S_F > -2$

Q.31   A binary liquid mixture is in equilibrium with its vapor at a temperature $T = 300$ K. The liquid mole fraction x_1 of species 1 is 0.4 and the molar excess Gibbs free energy is 200 J/mol. The value of the universal gas constant is 8.314 J/mol-K, and γ_i denotes the liquid-phase activity coefficient of species i. If $\ln(\gamma_1) = 0.09$, then the value of $\ln(\gamma_2)$, up to 2 digits after the decimal point, is _____

Q.32   Water (density 1000 kg/m^3) is flowing through a nozzle, as shown below and exiting to the atmosphere. The relationship between the diameters of the nozzle at locations 1 and 2 is $D_1 = 4 D_2$. The average velocity of the stream at location 2 is 16 m/s and the frictional loss between location 1 and location 2 is 10000 Pa. Assuming steady state and turbulent flow, the gauge pressure in Pa, at location 1 is _____
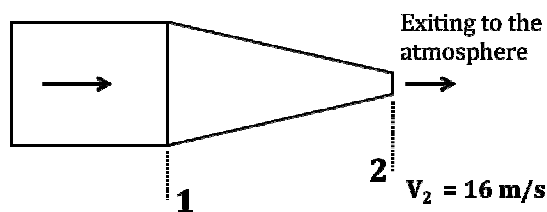
Q.33   In the elutriation leg of a commercial crystallizer containing a mixture of coarse and very fine crystals of the same material, a liquid is pumped vertically upward. The liquid velocity is adjusted such that it is slightly lower than the terminal velocity of the coarse crystals only. Hence

(A) the very fine and coarse crystals will both be carried upward by the liquid

(B) the very fine and coarse crystals will both settle at the bottom of the tube

(C) the very fine crystals will be carried upward and the coarse crystals will settle

(D) the coarse crystals will be carried upward and the very fine crystals will settle

Q.34   100 ton/h of a rock feed, of which 80% passed through a mesh size of 2.54 mm, were reduced in size such that 80% of the crushed product passed through a mesh size of 1.27 mm. The power consumption was 100 kW. If 100 ton/h of the same material is similarly crushed from a mesh size of 5.08 mm to a mesh size of 2.54 mm, the power consumption (in kW, to the nearest integer) using Bond's law, is _____

Q.35   Calculate the heat required (in kJ, up to 1 digit after the decimal point) to raise the temperature of 1 mole of a solid material from 100 °C to 1000 °C. The specific heat (C_p) of the material (in J/mol-K) is expressed as $C_p = 20 + 0.005T$, where T is in K. Assume no phase change. _____

Q.36   In a double pipe counter-current heat exchanger, the temperature profiles shown in the figure were observed. During operation, due to fouling inside the pipe, the heat transfer rate reduces to half of the original value. Assuming that the flow rates and the physical properties of the fluids do not change, the LMTD (in °C) in the new situation is
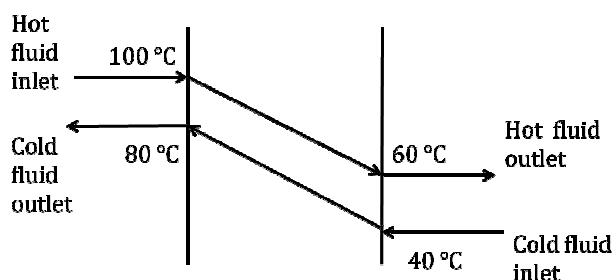
(A) 0   (B) 20   (C) 40   (D) indeterminate

Q.37   The vapor-liquid equilibrium curve of a binary mixture A-B, may be approximated by a linear equation over a narrow range of liquid mole fractions ($0.2 < x_A < 0.3$) as follows

$$y_A^* = 1.325\, x_A + 0.121$$

Here y_A^* is the mole fraction of A in the vapor. 100 moles of a feed ($x_{A,F} = 0.28$) is batch distilled to a final residue ($x_{A,W} = 0.2$). Using the Rayleigh equation, the number of moles of the residue left behind in the distillation unit, up to 2 digits after the decimal point, is _____

Q.38   A crosscurrent cascade of N ideal stages is used to treat a feed stream of molar flow rate E. The feed stream contains a solute which is to be recovered by a pure solvent having a molar flow rate S. The solvent is divided equally between these N stages. The linear equilibrium curve relating the mole fractions x and y* of the solute in the raffinate and the extract respectively, is given by y* = m x. Assume dilute conditions. The ratio of the solute mole fraction in the original feed to that in the exit raffinate stream i.e. $\left(x_0 / x_N \right)$ is given by

(A) $\left[1 + \left(\dfrac{mS}{NE} \right) \right]^N$

(B) $\left[1 + \left(\dfrac{NS}{mE} \right) \right]^N$

(C) $\left[1 + \left(\dfrac{NE}{mS} \right) \right]^N$

(D) $\left[1 + \left(\dfrac{mE}{NS} \right) \right]^N$

Q.39   A study was conducted in which water was pumped through cylindrical pipes made of a sparingly soluble solid. For a given pipe and certain flow conditions, the mass transfer coefficient k_c has been calculated as 1 mm/s using the correlation

$$Sh = 0.025\, Re^{0.6}\, Sc^{0.33}$$

If the velocity of the fluid and the diameter of the pipe are both doubled, what is the new value of k_c in mm/s, up to 2 digits after the decimal point? _____

Q.40   The gas phase decomposition of azomethane to give ethane and nitrogen takes place according to the following sequence of elementary reactions.

$$(CH_3)_2N_2 + (CH_3)_2N_2 \xrightarrow{k_1} (CH_3)_2N_2 + [(CH_3)_2N_2]^*$$

$$[(CH_3)_2N_2]^* + (CH_3)_2N_2 \xrightarrow{k_2} (CH_3)_2N_2 + (CH_3)_2N_2$$

$$[(CH_3)_2N_2]^* \xrightarrow{k_3} C_2H_6 + N_2$$
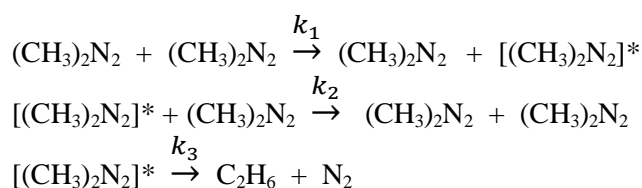
Using the pseudo-steady-state-approximation for $[(CH_3)_2N_2]^*$, the order with respect to azomethane in the rate expression for the formation of ethane, in the limit of high concentrations of azomethane, is _____

Q.41   A first order liquid phase reaction is carried out isothermally at a steady state in a CSTR and 90% conversion is attained. With the same inlet conditions and for the same overall conversion, if the CSTR is replaced by two smaller and identical isothermal CSTRs in series, the % reduction in total volume, to the nearest integer, is _____

Q.42   Match the reactant-product combination in Group 1 with the unit process in Group 2.

Group 1   **Group 2**
(P) propylene - butanol   (1) Pyrolysis
(Q) cumene - phenol   (2) Dehydrogenation
(R) butane - butadiene   (3) Hydroformylation
(S) ethylene dichloride - vinyl chloride   (4) Peroxidation

(A) P-3, Q-2, R-4, S-1   (B) P-2, Q-4, R-3, S-1

(C) P-1, Q-3, R-2, S-4   (D) P-3, Q-4, R-2, S-1

Q.43   Identify which of the following statements are FALSE.
(P) Oils with an oleic radical (1 double bond) are more suitable than oils with a linolenic radical (3 double bonds) as film forming vehicles for paints
(Q) Production of synthesis gas from coal and steam is an endothermic process
(R) Use of chlorine for bleaching of wood pulp results in the release of dioxins
(S) In the manufacture of urea from ammonia, the main intermediate product formed is ammonium bicarbonate

(A) P and Q only   (B) R and S only

(C) Q and R only   (D) P and S only

Q.44   A unit gain 2nd order underdamped process has a period of oscillation 1 second and decay ratio 0.25. The transfer function of the process is

(A) $\dfrac{1}{0.024\,s^2 + 0.067\,s + 1}$ (B) $\dfrac{1}{0.067\,s^2 + 0.024\,s + 1}$

(C) $\dfrac{1}{0.021\,s^2 + 0.1176\,s + 1}$ (D) $\dfrac{1}{0.1176\,s^2 + 0.021\,s + 1}$

Q.45   A control valve, with a turndown ratio of 50, follows equal percentage characteristics. The flow rate of a liquid through the valve at 40% stem position is 1 m^3/h. What will be the flow rate in m^3/h at 50% stem position, if the pressure drop across the valve remains unchanged? (Up to 2 digits after the decimal point.) _____

Q.46   The purchase cost of a heat exchanger of 20 m^2 area was Rs. 500000 in 2006. What will be the estimated cost (in Rs. to the nearest integer) of a similar heat exchanger of 50 m^2 area in the year 2013? Assume the six-tenths factor rule for scaling and the cost index for 2006 as 430.2. The projected cost index for the year 2013 is 512.6. _____

Q.47   A plant manufactures compressors at the rate of N units/day. The daily fixed charges are Rs. 20000 and the variable cost per compressor is Rs. $500 + 0.2\ N^{1.3}$. The selling price per compressor is Rs. 1000. The number of compressors to be manufactured, to the nearest integer, in order to maximize the daily profit is _____
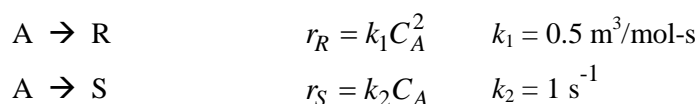
Common Data Questions

Common Data for Questions 48 and 49:

A reverse osmosis unit treats feed water (F) containing fluoride and its output consists of a permeate stream (P) and a reject stream (R). Let C_F, C_P, and C_R denote the fluoride concentrations in the feed, permeate, and reject streams, respectively. Under steady state conditions, the volumetric flow rate of the reject is 60 % of the volumetric flow rate of the inlet stream, and $C_F = 2$ mg/L and $C_P = 0.1$ mg/L.

Q.48   The value of C_R in mg/L, up to one digit after the decimal point, is _____

Q.49   A fraction f of the feed is bypassed and mixed with the permeate to obtain treated water having a fluoride concentration of 1 mg/L. Here also the flow rate of the reject stream is 60% of the flow rate entering the reverse osmosis unit (after the bypass). The value of f, up to 2 digits after the decimal point, is _____

Common Data for Questions 50 and 51:

 Liquid reactant A decomposes as follows

$$A \rightarrow R \qquad\qquad r_R = k_1 C_A^2 \qquad k_1 = 0.5\ \text{m}^3/\text{mol-s}$$
$$A \rightarrow S \qquad\qquad r_S = k_2 C_A \qquad k_2 = 1\ \text{s}^{-1}$$

An aqueous feed of composition $C_{A0} = 30$ mol/m^3, $C_{R0} = 2$ mol/m^3, and $C_{S0} = 1$ mol/m^3 enters a CSTR in which the above reactions occur. Assume isothermal and steady state conditions.

Q.50   If the conversion of A is 80 %, the concentration of R in the exit stream in mol/m^3, to the nearest integer, is _____

Q.51   What is the % conversion of A, to the nearest integer, so that the concentration of S in the exit stream is 11.8 mol/m^3? _____

Linked Answer Questions

Statement for Linked Answer Questions 52 and 53:

The vapor liquid equilibrium relation for an ideal binary system is given by

$$y_A^* = \frac{\alpha_{AB} x_A}{1 + (\alpha_{AB} - 1) x_A}$$

Here x_A and y_A^* are the mole fractions of species A in the liquid and vapor, respectively. The relative volatility (α_{AB}) is greater than unity.

Q.52   The liquid mole fraction x_A at which the maximum difference between the equilibrium vapor mole fraction and liquid mole fraction occurs is

(A) $\dfrac{1}{(1+\sqrt{\alpha_{AB}})}$ (B) $\dfrac{0.75}{(1+\sqrt{\alpha_{AB}})}$

(C) $\dfrac{0.5}{(\sqrt{\alpha_{AB}}+1)}$ (D) $\dfrac{0.75}{(\sqrt{\alpha_{AB}}+1)}$

Q.53   A liquid having the composition found in the first part of the linked answer question, is flash distilled at a steady state to a final liquid mole fraction of 0.25. If α_{AB} is 2.5, the fraction of the feed vaporized is

(A) 0.08   (B) 0.20

(C) 0.67   (D) 0.74

Statement for Linked Answer Questions 54 and 55:

Consider the following transfer function

$$G_p(s) = \frac{5}{(2s+1)^4}$$

(Note: The unit of the process time constant is in seconds.)

Q.54   The crossover frequency (in rad/s) of the process is

(A) 20   (B) 0.1   (C) 0.5   (D) 0.05

Q.55   For the computation of Ziegler-Nichols settings, the ultimate period (in s/cycle) and the ultimate gain are

(A) π and 0.8, respectively   (B) 4π and 0.8, respectively

(C) 4π and 1.25, respectively   (D) π and 1.25, respectively

General Aptitude (GA) Questions

Q. 56 – Q. 60 carry one mark each.

Q.56   If $3 \leq X \leq 5$ and $8 \leq Y \leq 11$ then which of the following options is TRUE?

(A) $\frac{3}{5} \leq \frac{X}{Y} \leq \frac{8}{5}$

(B) $\frac{3}{11} \leq \frac{X}{Y} \leq \frac{5}{8}$

(C) $\frac{3}{11} \leq \frac{X}{Y} \leq \frac{8}{5}$

(D) $\frac{3}{5} \leq \frac{X}{Y} \leq \frac{8}{11}$

Q.57   The Headmaster _____ to speak to you.

Which of the following options is incorrect to complete the above sentence?

(A) is wanting

(B) wants

(C) want

(D) was wanting

Q.58   Mahatama Gandhi was known for his humility as

(A) he played an important role in humiliating exit of British from India.

(B) he worked for humanitarian causes.

(C) he displayed modesty in his interactions.

(D) he was a fine human being.

Q.59   All engineering students should learn mechanics, mathematics and how to do computation.
                    I   II   III   IV
Which of the above underlined parts of the sentence is not appropriate?

(A) I   (B) II   (C) III   (D) IV

Q.60   Select the pair that best expresses a relationship similar to that expressed in the pair:
water: pipe::

(A) cart: road   (B) electricity: wire
(C) sea: beach   (D) music: instrument

Q. 61 to Q. 65 carry two marks each.

Q.61   Velocity of an object fired directly in upward direction is given by $V = 80 - 32\,t$, where t (time) is in seconds. When will the velocity be between 32 m/sec and 64 m/sec?

(A) (1, 3/2)   (B) (1/2, 1)

(C) (1/2, 3/2)   (D) (1, 3)

Q.62 In a factory, two machines M1 and M2 manufacture 60% and 40% of the autocomponents respectively. Out of the total production, 2% of M1 and 3% of M2 are found to be defective. If a randomly drawn autocomponent from the combined lot is found defective, what is the probability that it was manufactured by M2?

(A) 0.35 (B) 0.45 (C) 0.5 (D) 0.4

Q.63 Following table gives data on tourists from different countries visiting India in the year 2011.

Country	Number of Tourists
USA	2000
England	3500
Germany	1200
Italy	1100
Japan	2400
Australia	2300
France	1000

Which two countries contributed to the one third of the total number of tourists who visited India in 2011?

(A) USA and Japan

(B) USA and Australia

(C) England and France

(D) Japan and Australia

Q.64 If $|-2X + 9| = 3$ then the possible value of $|-X| - X^2$ would be:

(A) 30 (B) -30 (C) -42 (D) 42

Q.65 All professors are researchers
Some scientists are professors

Which of the given conclusions is logically valid and is inferred from the above arguments:

(A) All scientists are researchers

(B) All professors are scientists

(C) Some researchers are scientists

(D) No conclusion follows

END OF THE QUESTION PAPER