

Q1) Consider turbulent flow in a pipe under isothermal conditions. Let  $r$  denote the radial coordinate and  $z$  denote the axial flow direction. On moving away from the wall towards the centre of the pipe, the  $rz$ -component of the Reynolds stress

- (A) Increases and then decreases
- (B) Decreases and then increases
- (C) Remains unchanged
- (D) Only increases

Q2) In soap manufacturing, the triglycerides present in oils and fats are hydrolyzed to mainly produce

- (A) Fatty acids and glycerol
- (B) Glycerol only
- (C) Fatty acids only
- (D) Glycerol and paraffins

Q3) Catalytic reforming is commonly used in the petroleum industry to improve fuel quality. The undesirable reaction in the catalytic reforming of naphtha is

- (A) Hydrocracking of paraffins
- (B) Dehydrogenation of naphthenes
- (C) Isomerization of naphthenes
- (D) Cyclization of paraffins

Q4) Choose the option that correctly pairs the given measurement devices with the quantities they measure.

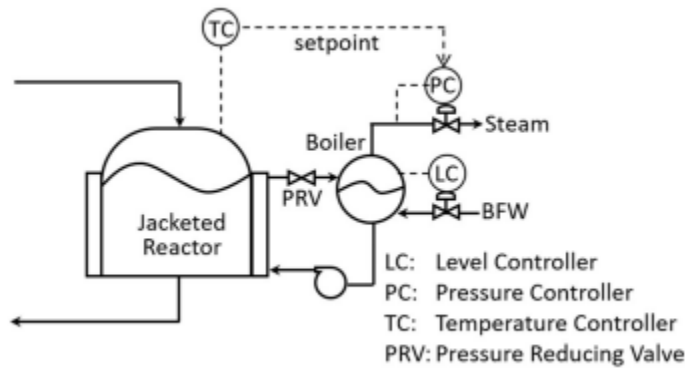
<i>Sl No</i>	<i>Measurement Device</i>	<i>Sl No</i>	<i>Measurement Quantity</i>
I	Bourdon Gauge	A	Temperature
II	Orifice Plate Metre	B	Concentration
III	Pyrometer	C	Pressure
IV	Colorimeter	D	Flow Rate
V	Pirani Gauge	E	Liquid Level

- (A) I-E II-C III-D IV-B V-A
- (B) I-C II-D III-A IV-B V-C
- (C) I-C II-D III-E IV-A V-D
- (D) I-D II-C III-A IV-E V-C

Q5) The chemical formula of Glauber's salt, used in the Kraft process, is

- (A)  $\text{Na}_2\text{CO}_3 \cdot 10\text{H}_2\text{O}$
- (B)  $\text{Na}_2\text{S}_2\text{O}_4 \cdot 2\text{H}_2\text{O}$
- (C)  $\text{Na}_2\text{HPO}_4 \cdot 2\text{H}_2\text{O}$
- (D)  $\text{Na}_2\text{SO}_4 \cdot 10\text{H}_2\text{O}$

Q6) A control system on the jacket side of a reactor is shown in the figure. Pressurised water flows through the jacket to cool the reactor. The heated water flashes in the boiler. The exothermic reaction heat thus generates steam. Fresh boiler feed water (BFW) is added to make-up for the loss of water as steam. Assume that all control valves are air-to-open. The controller action, 'direct' or 'reverse', is defined with respect to the controller. Select the option that correctly specifies the action of the Controllers.

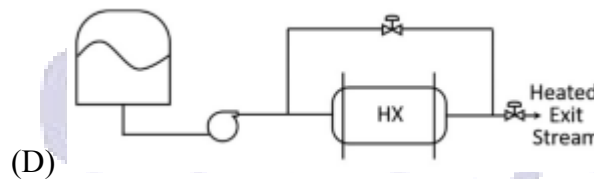
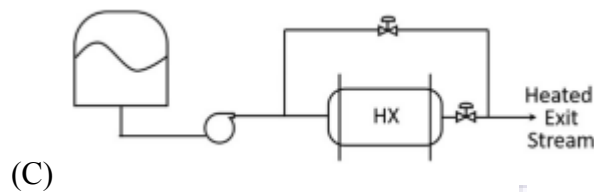
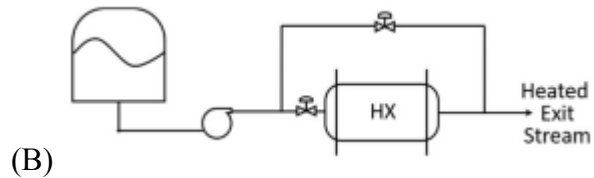
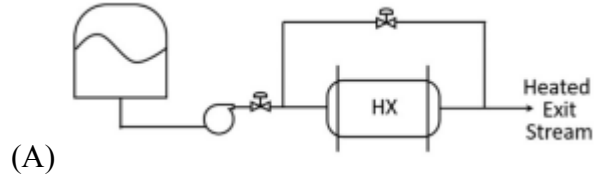


- (A) PC: Reverse, LC: Direct, TC: Reverse
- (B) PC: Direct, LC: Reverse, TC: Direct
- (C) PC: Direct, LC: Reverse, TC: Reverse
- (D) PC: Reverse, LC: Direct, TC: Direct

Q7) A simple distillation column is designed to separate an ideal binary mixture to specified distillate and bottoms purities at a given column pressure. If  $RR_{\min}$  is the minimum reflux ratio for this separation, select the statement that is **NOT CORRECT** with regard to the variation in the total annualised cost (TAC) of the column with reflux ratio (RR).

- (A) TAC has a minimum with respect to RR
- (B) The sharpest rise in TAC occurs as RR approaches  $RR_{\min}$  from above
- (C) The sharpest decrease in TAC occurs as RR approaches  $RR_{\min}$  from above
- (D) TAC increases with RR for  $RR \gg RR_{\min}$

Q8) Liquid flowing through a heat exchanger (HX) is heated. A bypass stream is provided to control the temperature of the heated exit stream. From the given plumbing options, the one that provides the most effective temperature control for large disturbances while avoiding vaporisation in the heat exchanger is

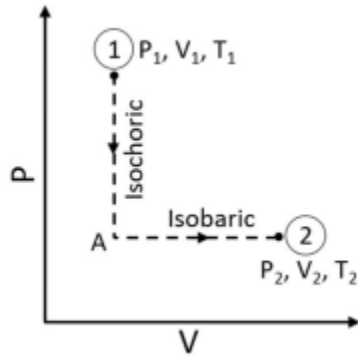


Q9) The area of a circular field is  $25 \text{ m}^2$ . The radius,  $r$ , is to be determined using the Newton-Raphson iterative method. For an initial guess of  $r = 2.500 \text{ m}$ , the revised estimate of  $r$  after one iteration is \_\_\_\_\_ m (rounded off to three decimal places).

Q10) A perfectly insulated double pipe heat exchanger is operating at steady state. Saturated steam enters the inner pipe at  $100 \text{ }^\circ\text{C}$  and leaves as saturated water at  $100 \text{ }^\circ\text{C}$ . Cooling water enters the outer pipe at  $75 \text{ }^\circ\text{C}$  and exits at  $95 \text{ }^\circ\text{C}$ . The overall heat transfer coefficient is  $1 \text{ kWm}^{-2} \text{ K}^{-1}$  and the heat transfer area is  $1 \text{ m}^2$ . The average specific heat capacity of water at constant pressure is  $4.2 \text{ kJ kg}^{-1} \text{ K}^{-1}$ . The required cooling water flow rate is \_\_\_\_\_  $\text{kg s}^{-1}$  (rounded off to two decimal places).

Q11) A wet solid containing 20% (w/w) moisture (based on mass of bone-dry solid) is dried in a tray-dryer. The critical moisture content of the solid is 10% (w/w). The drying rate ( $\text{kg m}^{-2} \text{ s}^{-1}$ ) is constant for the first 4 hours, and then decreases linearly to half the initial value in the next 1 hour. At the end of 5 hours of drying, the percentage moisture content of the solid is \_\_\_\_\_ % (w/w) (rounded off to one decimal place)

Q12)  $N$  moles of an ideal gas undergo a two-step process as shown in the figure. Let  $P$ ,  $V$  and  $T$  denote the pressure, volume and temperature of the gas, respectively. The gas, initially at state-1 ( $P_1, V_1, T_1$ ), undergoes an isochoric (constant volume) process to reach state-A, and then undergoes an isobaric (constant pressure) expansion to reach state-2 ( $P_2, V_2, T_2$ ). For an ideal gas,  $C_p - C_v = NR$ , where  $C_p$  and  $C_v$  are the heat capacities at constant pressure and constant volume, respectively, and assumed to be temperature independent. The heat gained by the gas in the two-step process is given by.



- (A)  $P_2(V_2 - V_1) + C_v(T_2 - T_1)$
- (B)  $P_2(V_2 - V_1) + C_p(T_2 - T_1)$
- (C)  $C_p(T_2 - T_1) + C_v(T_2 - T_1)$
- (D)  $P_2V_2 - P_1V_1$

Q13) Two large parallel planar walls are maintained at 1000 K and 500 K. Parallel radiation shields are to be installed between the two walls. Assume that the emissivities of the walls and the shields are equal. If the melting temperature of the shields is 900 K, the maximum number of shield(s) that can be installed between the walls is (are)

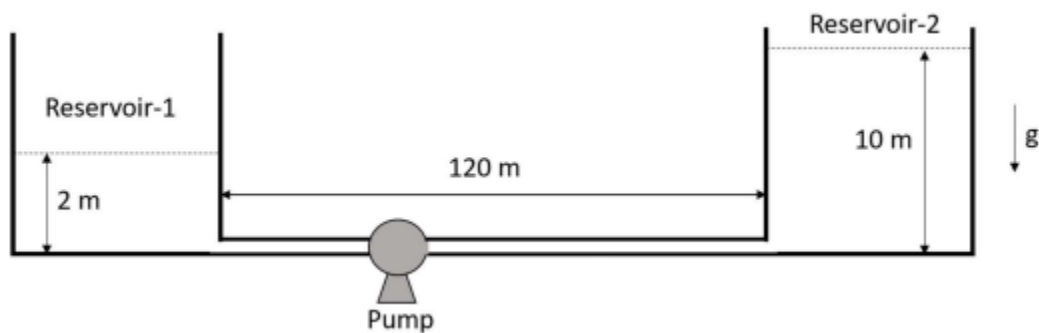
- (A) 1
- (B) 0
- (C) 2
- (D) 3

Q14) Match the product in Group-1 with the manufacturing process in Group-2. The correct combination is

Group 1		Group 2	
P	Nitric Acid	I	Trona Process
Q	Phosphoric Acid	II	Twitchell Process
R	Potassium Chloride	III	Ostwald's Process
S	Stearic Acid	IV	Haifa Process

- (A) P-III, Q-I, R-IV, S-II  
 (B) P-IV, Q-I, R-II, S-III  
 (C) P-III, Q-IV, R-I, S-II  
 (D) P-I, Q-IV, R-II, S-III

Q15) Two reservoirs located at the same altitude are connected by a straight horizontal pipe of length 120 m and inner diameter 0.5 m, as shown in the figure. A pump transfers the liquid of density  $800 \text{ kg m}^{-3}$  at a flow rate of  $1 \text{ m}^3 \text{ s}^{-1}$  from Reservoir-1 to Reservoir-2. The liquid levels in Reservoir-1 and Reservoir-2 are 2 m and 10 m, respectively. Assume that the reservoirs' cross-section areas are large enough to neglect the liquid velocity at the top of the reservoirs. All minor losses can be ignored. The acceleration due to gravity is  $9.8 \text{ ms}^{-2}$ . If the friction factor for the pipe-flow is 0.01, the required power of the pump is \_\_\_\_\_ kW (rounded off to one decimal place).



Q16) A cylindrical fin of diameter 24 mm is attached horizontally to a vertical planar wall. The heat transfer rate from the fin to the surrounding air is 60% of the heat transfer rate if the entire fin were at the wall temperature. If the fin effectiveness is 10, its length is \_\_\_\_\_ mm (rounded off to the nearest integer).

Q17) An equimolar binary mixture is to be separated in a simple tray-distillation column. The feed rate is  $50 \text{ kmol min}^{-1}$ . The mole fractions of the more volatile component in the top and bottom products are 0.90 and 0.01, respectively. The feed as well as the reflux stream are saturated liquids. On application of the McCabe-Thiele method, the operating line for the stripping section is obtained as

$$y = 1.5x - 0.005$$

where  $y$  and  $x$  are the mole fractions of the more volatile component in the vapour and liquid phases, respectively. The reflux ratio is \_\_\_\_\_ (rounded off to two decimal places).

Q18) If the temperature of saturated water is increased infinitesimally at constant entropy, the resulting state of water will be

- (A) Liquid
- (B) Liquid – vapour coexistence
- (C) Saturated vapour
- (D) Solid

Q19) For an exothermic reversible reaction, which one of the following correctly describes the dependence of the equilibrium constant ( $K$ ) with temperature ( $T$ ) and pressure ( $P$ ) ?

- (A)  $K$  is independent of  $T$  and  $P$
- (B)  $K$  increases with an increase in  $T$  and  $P$
- (C)  $K$  increases with  $T$  and decreases with  $P$
- (D)  $K$  decreases with an increase in  $T$  and is independent of  $P$

Q20) Water is flowing under laminar conditions in a pipe of length  $L$ . If the diameter of the pipe is doubled, for a constant volumetric flow rate, the pressure drop across the pipe.

- (A) decreases 2 times
- (B) decreases 16 times
- (C) increases 2 times
- (D) increases 16 times

Q21) The local velocity of a fluid along a streamline can be measured by

- (A) Pitot tube
- (B) Venturi meter
- (C) Rotameter
- (D) Orifice meter

Q22) In a mixing tank operating at very high Reynolds number ( $>10^4$ ), if the diameter of the impeller is doubled (other conditions remaining constant), the power required increases by a factor of

- (A)  $1/32$
- (B)  $1/4$
- (C) 4
- (D) 32

Q23) For heat transfer across a solid-fluid interface, which one of the following statements is NOT true when the Biot number is very small compared to 1?

- (A) Conduction resistance in the solid is very small compared to convection resistance in the fluid
- (B) Temperature profile within the solid is nearly uniform
- (C) Temperature drop in the fluid is significant
- (D) Temperature drop in the solid is significant

Q24) In the McCabe-Thiele diagram, if the  $x$ -coordinate of the point of intersection of the  $q$ -line and the vapour-liquid equilibrium curve is greater than the  $x$ -coordinate of the feed point, then the quality of the feed is

- (A) super-heated vapour
- (B) liquid below bubble point
- (C) saturated vapour
- (D) saturated liquid

Q25) For which of the following combinations, does the absorption operation become gas-film controlled?

- P. The solubility of gas in the liquid is very high
- Q. The solubility of gas in the liquid is very low
- R. The liquid-side mass transfer coefficient is much higher than the gas-side mass transfer coefficient
- S. The liquid-side mass transfer coefficient is much lower than the gas-side mass transfer coefficient

- (A) P & Q
- (B) P & R
- (C) P & S
- (D) Q & R

Q26) The half-life of an  $n^{\text{th}}$  order reaction in a batch reactor depends on  
(A) only the rate constant  
(B) only the rate constant and the order of the reaction  
(C) only the rate constant and the initial reactant concentration  
(D) the rate constant, initial reactant concentration, and the order of the reaction

Q27) In petroleum refining, catalytic reforming is used to convert  
(A) Paraffins and naphthenes to aromatics  
(B) Paraffins to hydrogen and carbon monoxide  
(C) Gas oil to diesel and gasoline  
(D) Light olefins to gasoline

Q28) The final boiling points of gasoline, diesel, atmospheric gas oil (AGO) and lubricating oils vary as  
(A) gasoline > diesel > AGO > lubricating oils  
(B) lubricating oils > AGO > diesel > gasoline  
(C) AGO > lubricating oils > diesel > gasoline  
(D) lubricating oils > diesel > AGO > gasoline

Q29) The Bode stability criterion is applicable when  
(A) Gain and phase curves decrease continuously with frequency  
(B) Gain curve increases and phase curve decreases with frequency  
(C) Gain curve and phase curve both increase with frequency  
(D) Gain curve decreases and phase curve increases with frequency

Q30) An equimolar mixture of A and B (A being more volatile) is flash distilled continuously at a feed rate of 100 kmol/h, such that the liquid product contains 40 mol% of A. If the relative volatility is 6, then the vapor product, in kmol/h, is  
(A) 10  
(B) 20  
(C) 25  
(D) 45

Q31) Heat integration is planned in a process plant at an investment Rs.  $2 \times 10^6$ . This would result in a net energy savings of 20 GJ per year. If the nominal rate of interest is 15% and the plant life is 3 years, then the breakeven cost of energy, in Rs. per GJ (adjusted to the nearest hundred), is  
(A) 33500  
(B) 43800  
(C) 54200  
(D) 65400



Q32) Match the process in Group I with the catalyst in Group II

Group I	Group II
P. Fischer-Tropsch synthesis	I. Nickel
Q. Formaldehyde from methanol	II. $\text{Fe}_2\text{O}_3$
R. Hydrogenation of vegetable oils	III. Silver
S. Dehydrogenation of ethylbenzene	IV. Cobalt

- (A) P-III, Q-IV, R-I, S-II  
(B) P-IV, Q-II, R-I, S-III  
(C) P-IV, Q-III, R-I, S-II  
(D) P-III, Q-IV, R-II, S-I

Q33) Match the polymer in Group I to the polymer characteristic in Group II

Group I	Group II
P. Polyethylene	I. Elastomer
Q. Phenol-formaldehyde polymer	II. Fiber
R. Polyisoprene	III. Thermoplastic
S. Polyester	IV. Thermosetting polymer

- (A) P-III, Q-IV, R-I, S-II  
(B) P-IV, Q-II, R-III, S-I  
(C) P-III, Q-II, R-I, S-IV  
(D) P-IV, Q-III, R-I, S-II

Q34) Gradient of a scalar variable is always

- (A) a vector  
(B) a scalar  
(C) a dot product  
(D) zero

Q35) From the following list, identify the properties which are equal in both vapour and liquid phases at equilibrium

- P. Density                      Q. Temperature  
R. Chemical potential        S. Enthalpy

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

Q36) In order to achieve the same conversion under identical reaction conditions and feed flow rate for a non-autocatalytic reaction of positive order, the volume of an ideal CSTR is

- (A) always greater than that of an ideal PFR  
(B) always smaller than that of an ideal PFR  
(C) same as that of an ideal PFR  
(D) smaller than that of an ideal PFR only for first order reaction

Q37) In a completely opaque medium, if 50% of the incident monochromatic radiation is absorbed, then which of the following statements are CORRECT?

- P. 50% of the incident radiation is reflected  
Q. 25% of the incident radiation is reflected  
R. 25% of the incident radiation is transmitted  
S. No incident radiation is transmitted

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

Q38) Packed towers are preferred for gas-liquid mass transfer operations with foaming liquids because

- (A) in packed towers, high liquid to gas ratios are best handled  
(B) in packed towers, continuous contact of gas and liquid takes place  
(C) packed towers are packed with random packings  
(D) in packed towers, the gas is not bubbled through the liquid pool

Q39) Slurries are most conveniently pumped by a

- (A) syringe pump  
(B) diaphragm pump  
(C) vacuum pump

(D) gear pump

Q40) Which ONE of the following statements is CORRECT for the surface renewal theory?

- (A) Mass transfer takes place at steady state
- (B) Mass transfer takes place at unsteady state
- (C) Contact time is same for all the liquid elements
- (D) Mass transfer depends only on the film resistance



