



Practice, Learn and Achieve
Your Goal with Prepp

UPSC IFOS Exam

Mains Previous Paper

Simplifying
Government Exams

 SSC CHSL	 IAS EXAM	 RRB NTPC	 NTSE	 CDS
 SSC CGL	 CBSE UGC NET	 IBPS PO	 NDA	
 SBI PO	 IBPS CLERK	 AFCAT	 SSC JE	 CTET
 CSIR UGC NET	 CAPF	 IBPS RRB		

www.prepp.in

CHEMICAL ENGINEERING

Paper – I

Time Allowed : **Three Hours**

Maximum Marks : **200**

Question Paper Specific Instructions

Please read each of the following instructions carefully before attempting questions :

*There are **EIGHT** questions in all, out of which **FIVE** are to be attempted.*

*Questions no. 1 and 5 are **compulsory**. Out of the remaining **SIX** questions, **THREE** are to be attempted selecting at least **ONE** question from each of the two Sections A and B.*

Attempts of questions shall be counted in sequential order. Unless struck off, attempt of a question shall be counted even if attempted partly. Any page or portion of the page left blank in the Question-cum-Answer Booklet must be clearly struck off.

All questions carry equal marks. The number of marks carried by a question/part is indicated against it.

*Answers must be written in **ENGLISH** only.*

Unless otherwise mentioned, symbols and notations have their usual standard meanings.

Assume suitable data, if necessary, and indicate the same clearly.

Neat sketches may be drawn, wherever required.

SECTION A

- Q1.** (a) State Fick's first law of diffusion. Prove that $D_{AB} = D_{BA}$. 5
- (b) Calculate the critical speed of a ball mill, 1200 mm in diameter, charged with 75 mm balls. 5
- (c) Air at 300 K and 1.0 atm pressure flows over a flat plate at a speed of 3.0 m/sec. Find out whether the flow would be laminar or turbulent at a distance of 40 cm from the leading edge of the plate. Consider momentum diffusivity of air as $= 1.572 \times 10^{-5} \text{ m}^2/\text{s}$. 5
- (d) Give the selection criteria of choosing the solvent in gas absorption column. 5
- (e) A solution of organic colloids; 10,000 kg/hr is to be concentrated from 15% to 50% solids in a vertical tube evaporator by supplying heat of 4.624 MW. The saturated steam is available at 0.8 atm absolute pressure, latent heat = 2272.62 J/kg. Calculate the economy for the evaporator. 5
- (f) Draw and explain the characteristic curves for centrifugal pump. 5
- (g) The x-directed momentum transfer equation for constant density and viscosity is given by
- $$\rho \left(\frac{\partial v_x}{\partial t} + v_x \frac{\partial v_x}{\partial x} + v_y \frac{\partial v_x}{\partial y} + v_z \frac{\partial v_x}{\partial z} \right) = - \frac{\partial p}{\partial x} + \mu \left[\frac{\partial^2 v_x}{\partial x^2} + \frac{\partial^2 v_x}{\partial y^2} + \frac{\partial^2 v_x}{\partial z^2} \right] + \rho g_x.$$
- Write the assumptions of creeping flow and inviscid flow. Also reduce the above expression for both types of flows. 5
- (h) For fluid allocation in a shell and tube heat exchanger, discuss the general design criteria considering corrosion, fouling, fluid temperature and operating pressure. 5

Q2. (a) Differentiate between the following :

- (i) Dropwise condensation and Film condensation
- (ii) Space and Surface resistance
- (iii) Forced and Free convection
- (iv) Black body and Grey body
- (v) Conduction and Convection

15

(b) A liquid mixture of benzene and toluene containing 50 mole percent benzene is to be separated in a distillation column to achieve 98 mole percent benzene in distillate and 2 mole percent benzene in residue. The feed is a saturated liquid. If the reflux ratio of 4.0 is to be used, find the number of theoretical plates needed for a feed rate of 100 kmol/hr by McCabe-Thiele method. Use relative volatility of benzene-toluene = 2.16. Also, calculate the production rates.

15

(c) Explain the batch sedimentation process showing different zones formed at various stages of settling.

10

Q3. (a) Explain the working of rotary vacuum drum filter with the help of neat sketch.

10

(b) Suppose a 3 inch schedule 80 pipe (inside diameter = 73.66 mm; outside diameter = 88.9 mm) having thermal conductivity of $43 \frac{\text{W}}{\text{m}^\circ\text{C}}$ is covered with 25.4 mm of an insulation having thermal conductivity of $0.06 \frac{\text{W}}{\text{m}^\circ\text{C}}$. The outside of the insulation is exposed to an environment having heat transfer coefficient of $10 \frac{\text{W}}{\text{m}^2\text{C}}$ and temperature is 20°C . The temperature of the inside surface of the pipe is 250°C . Calculate the overall thermal resistance and heat loss for unit length of the pipe with insulation.

15

- (c) Oxalic acid is to be crystallized from a saturated aqueous solution initially at 80°C. To what temperature does the solution have to be cooled to crystallize 95% of the oxalic acid as the dihydrate? 15.

Solubility data vs Temperature of oxalic acid

Temp °C	0	10	20	40	60	80
Solubility c gms/100 gmol H ₂ O	3.5	6	9.5	21.6	44.3	84.4

- Q4.** (a) Explain briefly the following terms : 10

- (i) Relative humidity
- (ii) Adiabatic saturation temperature
- (iii) Wet bulb temperature
- (iv) Equilibrium moisture content
- (v) HETP

- (b) A shell and tube heat exchanger with one shell pass and two tube passes is used to heat 5 kg/s of water from 30°C to 80°C. The water flows in the tubes and condensing steam at 1 atm is used in the shell side. Calculate the area of the heat exchanger, if overall heat transfer coefficient is $900 \frac{\text{W}}{\text{m}^2\text{°C}}$. Suppose, this same heat exchanger is used with entering water at 30°C, but with a water flow rate of 1.3 kg/s. What would be the exit water temperature under these conditions, if overall heat transfer coefficient is $700 \frac{\text{W}}{\text{m}^2\text{°C}}$? The specific heat of water may be considered as $4179 \frac{\text{J}}{\text{kg°C}}$. The relation of effectiveness (ϵ) and number of transfer units (NTU) may be expressed as $\epsilon = 1 - \exp[-\text{NTU}]$. 15

- (c) Water at 20°C is being pumped from a tank to an elevated tank at the rate of 5 litre/s through a 4 inch schedule 40 pipe (Inside Diameter = 0.1023 m) as shown in the figure below. Calculate the power required for the pump considering pump efficiency as 65%. 15

Given Data :

density of water = 998.2 kg/m³

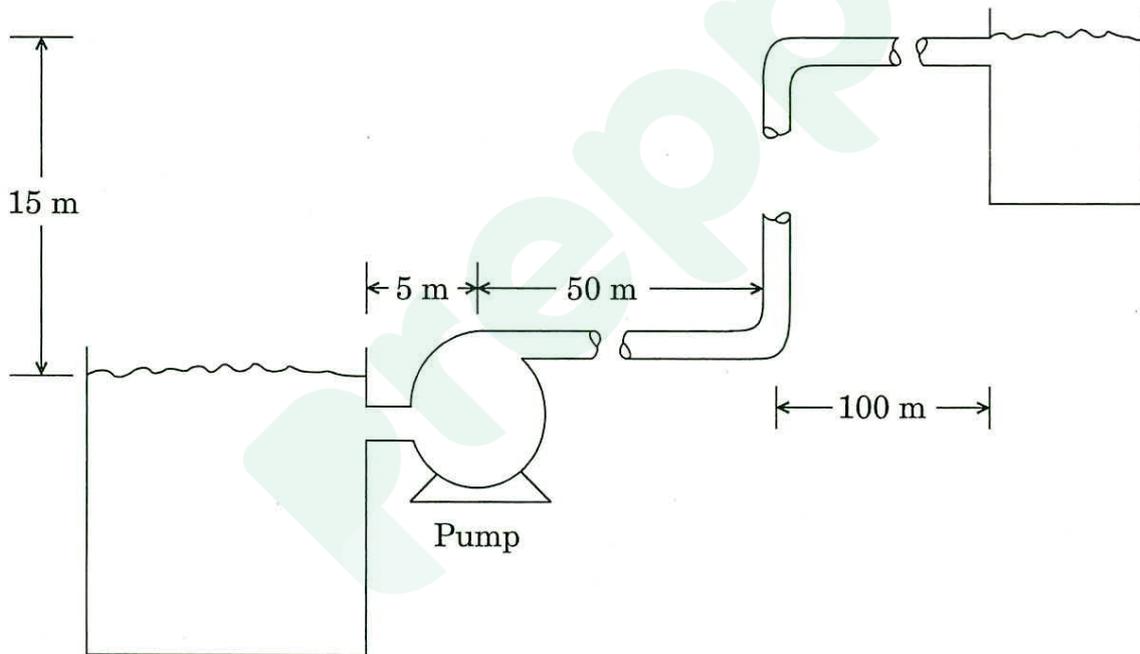
viscosity of water = 1.005 × 10⁻³ Pa-s

loss coefficient for elbow = 0.75

friction factor (f) = $\frac{16}{\text{Reynolds number } (N_{Re})}$ (Laminar flow)

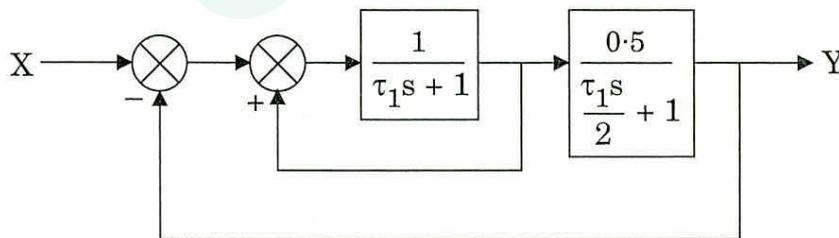
$f = 0.079 N_{Re}^{-0.25}$ (4000 < N_{Re} < 10⁵)

Neglect contraction and expansion losses.



SECTION B

- Q5. (a) List the important characteristics to be considered while selecting a material of construction. 5
- (b) Define the following : 5
- (i) Flux
 - (ii) Permeability
 - (iii) Trans-membrane pressure
 - (iv) Molecular weight cut-off
- (c) Estimate the thickness of the cylindrical vessel having 1.5 m diameter. The vessel is to operate at a pressure of 15 bar absolute and temperature of 300°C. 5
- Given – MOC : Steel (Design stress = 85 N/mm²); A corrosion allowance of 3 mm and Joint efficiency (J) = 1.0.
- (d) What are Horton spheres ? Give its applications. 5
- (e) Define controller's gain, K_c and discuss the effect of value of K_c on the offset. 5
- (f) Find the transfer function $Y(s)/X(s)$ of the system shown in the figure. 5



- (g) List the devices used for high temperature measurement in industry giving their applications. 5

- (h) A step change of magnitude 40 is introduced into a system having transfer function $\frac{Y(s)}{X(s)} = \frac{10}{s^2 + 1.6s + 4}$.

Determine :

5

- (i) Overshoot
- (ii) Maximum value of $y(t)$
- (iii) Ultimate value of $y(t)$

- Q6.** (a) Discuss the algorithm for the design of a skirt support for a tall vertical vessel.

15

- (b) Find the value of K_c for a stable system having the characteristic equation

$$s^3 + 6s^2 + 12s + 6(1 + K_c) = 0$$

using Routh Array test.

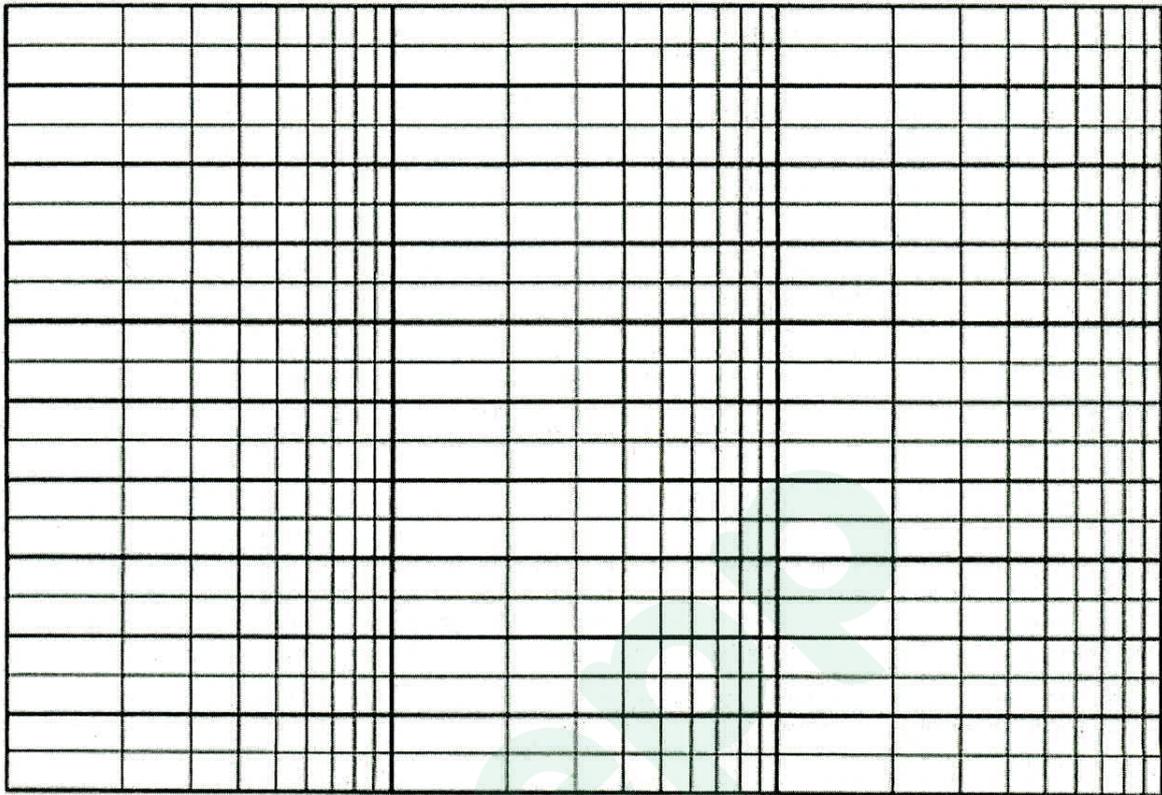
10

- (c) Discuss the different membrane modules used for reverse osmosis.

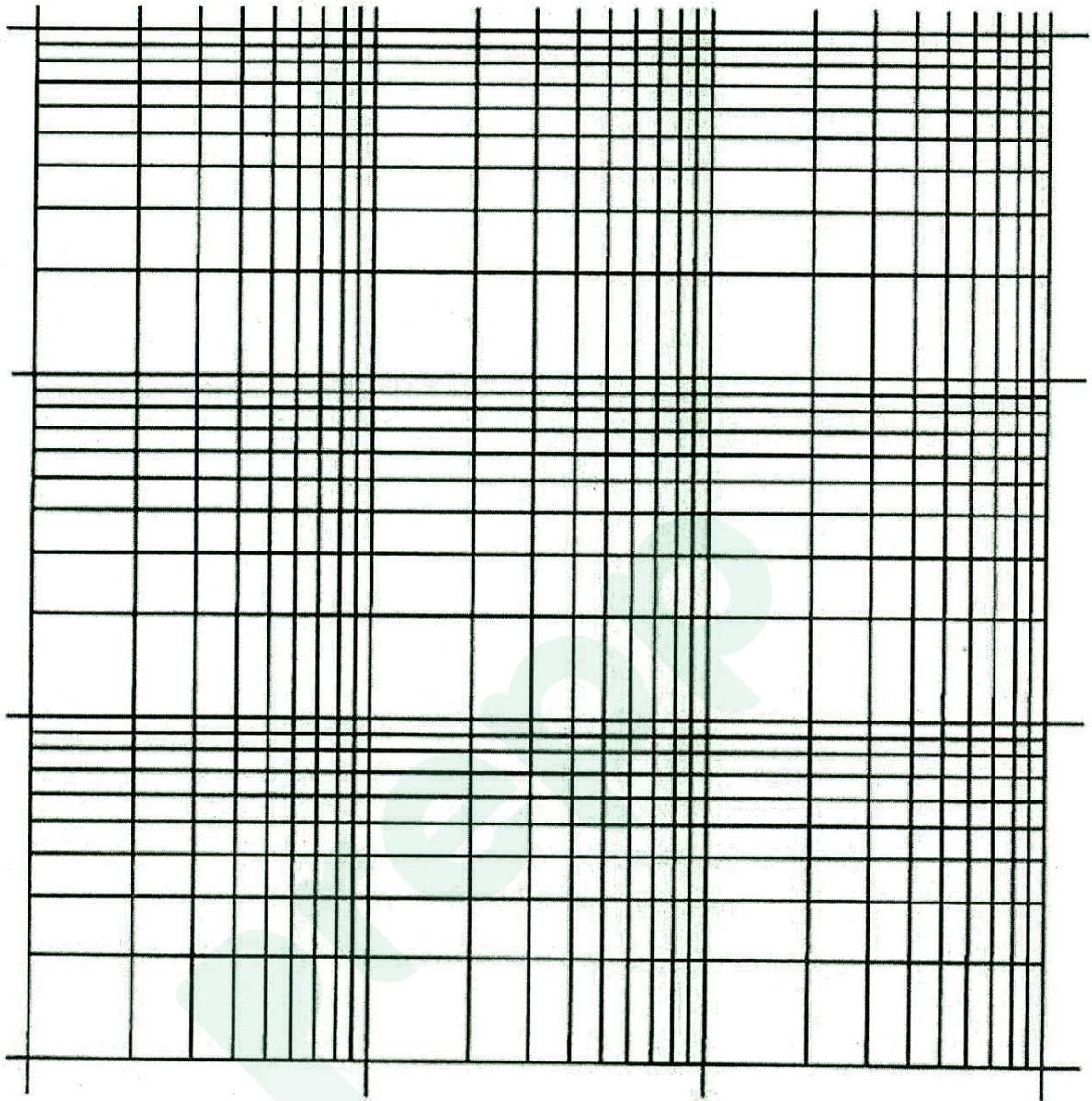
15

Q7. (a) Construct the Bode plot for the system having $G(s) = \frac{1}{(s+1)(s+5)}$. 20

Semi log graph paper



Log log graph paper



- (b) What are the advantages of supercritical fluid separation technique ?
List four applications for the same. 10
- (c) List the different types of closures used for vessels under internal pressure. Draw neat sketches of the same. On what factors does the choice of closure depend ? 10

- Q8.** (a) Describe the working of Bourdon tube pressure gauge with the help of a neat diagram. 10
- (b) Explain the principles of ion-exchange method and its application to water softening process. 15
- (c) Answer the following in brief : 15
- (i) What are the various losses encountered while storing volatile liquids ?
- (ii) What are wind girders ? Why are they provided ?
- (iii) What is reinforcement ? Why is it provided ?

Prepp



Latest Sarkari jobs, Govt Exam alerts, Results and Vacancies

- ▶ Latest News and Notification
- ▶ Exam Paper Analysis
- ▶ Topic-wise weightage
- ▶ Previous Year Papers with Answer Key
- ▶ Preparation Strategy & Subject-wise Books

To know more [Click Here](#)



www.prepp.in