

MIZORAM PUBLIC SERVICE COMMISSION

GENERAL COMPETITIVE EXAMINATIONS FOR RECRUITMENT TO THE POST OF JUNIOR GRADE OF MIZORAM FOREST SERVICE i.e. ASSISTANT CONSERVATION OF FOREST (ACF) UNDER ENVIRONMENT, FOREST & CLIMATE CHANGE DEPARTMENT, GOVERNMENT OF MIZORAM, 2018

CHEMICAL ENGINEERING

Time Allowed : 3 hours

Full Marks : 100

The figures in the margin indicate full marks for the questions.

SECTION - A

1. Choose the most appropriate answer from the choices given. (10×1=10)

(a) Saturated steam at 100 °C is condensing in the shell side of a shell and tube heat exchanger. Cooling water enters the tubes at 30 °C and leaves at 70°C. Calculate the LMTD for counter flow arrangement:

(i) 47.0 °C

(ii) 47.2 °C

(iii) 46.8 °C

(iv) None of the above

(b) The Laplace transform of $e^{-t} \sin t$ is:

(i) $\frac{1}{s^2 + 1}$

(ii) $\frac{1}{s^2 + \omega^2}$

(iii) $\frac{1}{(s+1)^2 + 1}$

(iv) $\frac{1}{(s+1)^2 + \omega^2}$

(c) Spherical shaped pressure vessel is considered to be the most ideal, because:

(i) withstand higher pressure

(ii) Fabrication very easy

(iii) designed without wind load considerations (iv) Supported very easily.

(d) Mass transfer coefficient, k according to penetration theory varies with mass diffusivity as:

(i) $D^{0.5}$

(ii) D

(iii) 1/D

(iv) $D^{1.5}$

(e) In pipe flow, heat is transferred from hot wall to the liquid by:

(i) conduction only

(ii) forced convection only

(iii) forced convection & conduction

(iv) free & forced convection

(f) The effect of scaling in a heat exchanger is accounted through:

(i) heat transfer coefficient

(ii) fouling factors

(iii) insulation factors

(iv) diffusivity factors

- (g) Mass transfer is a result of:
- (i) concentration difference
 - (ii) diffusion
 - (iii) both (i) and (ii)
 - (iv) none of these
- (h) A multiple effect evaporator as compared to a single effect evaporator of the same capacity has:
- (i) lower heat transfer area
 - (ii) lower steam economy
 - (iii) higher steam economy
 - (iv) none of these
- (i) Thermal conductivity is minimum for:
- (i) silver
 - (ii) chrome-nickel steel
 - (iii) Aluminium
 - (iv) carbon steel
- (j) Kinematic viscosity is equal to:
- (i) dynamic viscosity x density
 - (ii) density/dynamic viscosity
 - (iii) dynamic viscosity/density
 - (iv) 1/(dynamic viscosity)(density)

2. Answer any five from the following questions in brief: (5×2=10)

- (a) What is Cake-filtration.
- (b) Distinguish strong resins and weak resins.
- (c) Define reverse osmosis.
- (d) When and why do we prefer to use backward-feed evaporator?
- (e) Distinguish between laminar and turbulent flow.
- (f) Write the Fourier's law of heat conduction.
- (g) Write the transfer function for a PID controller and list the parameters.
- (h) Why is boiling point elevation important in evaporators?

3. Choose any two from the following: (2×5=10)

- (a) Explain the minimum fluidisation velocity.
- (b) State the difference between the natural convection and forced convection.
- (c) Derive mass transfer coefficients in gas phase.
- (d) Describe Relative volatility. Deduce an expression for relative volatility of component 'A' binary mixture.

4. Answer any two from the following: (2×5=10)

- (a) A large container 360 m long, 70 m wide and 25 m deep is being dragged in sea at a constant speed of 10 m/s. Calculate power required to drag such container. The temperature of sea water is 10°C. (The C_D - Re, L chart gives the value of flow over a plate, $C_D = 0.001$)
- (b) Design a PID controller for the following process using Ziegler-Nichols tuning.
- (c) Solve the following linear differential equation using Laplace Transform

$$\frac{d^2 y}{dt^2} + 3 \frac{dy}{dt} - y = 5t; \quad \left. \frac{d^2 y}{dt^2} \right|_{t=0} = 0; \quad y|_{t=0} = 2$$

- (d) Explain Bernoulli's theorem. Deduce its mathematical expression.

5. Answer any one from the following: (1×10=10)

- (a) Name the three principal modes of boiling. Explain all.
- (b) What is Rittinger's law. Find its mathematical expression. What are its limitations?

SECTION - B

6. Answer the following. (10×1=10)
- (a) Which of the following plastic is not recommended for storing food items?
 - (i) Poly ethylene terephthalate
 - (ii) Polyethylene
 - (iii) Polypropylene
 - (iv) Polystyrene
 - (b) In petroleum refining , the process used for conversion of hydrocarbons to aromatics is:
 - (i) catalytic cracking
 - (ii) catalytic reforming
 - (iii) hydro treating
 - (iv) alkylation
 - (c) Generally, no corrosion allowance in wall thickness of a part is required, if the thickness is more than:
 - (i) 5mm
 - (ii) 10mm
 - (iii) 20mm
 - (iv) 30mm
 - (d) Which of the following ratios defines the recycle ratio in a chemical process?
 - (i) recycle stream/fresh feed stream
 - (ii) gross feed stream/recycle feed stream
 - (iii) recycle stream/ gross feed stream
 - (iv) none of these
 - (e) When a multistage tray tower uses a minimum reflux ratio it implies:
 - (i) Infinite trays and maximum reboiler heat load
 - (ii) Minimum trays and minimum reboiler heat load
 - (iii) Infinite trays and minimum reboiler heat load
 - (iv) Minimum trays and maximum reboiler heat load
 - (f) Liquefied petroleum Gas (LPG) used for household cooking comprises mainly of:
 - (i) propane & butane
 - (ii) butane & ethane
 - (iii) methane & ethane
 - (iv) methane & carbon monoxide
 - (g) A material contains 20% water on wet basis. The moisture content of the material on dry basis is _____
 - (h) The rate constant of a reaction depends upon _____
 - (i) Essential oils are usually obtained using _____
 - (j) One of the steps during refining of cane sugar consists of addition of hydrated lime to the sugar syrup followed by carbonation of the resulting solution. The purpose of this step is to _____
7. Answer *any five* from the following questions in brief: (5×2=10)
- (a) List out the variables affecting the rate of the reaction.
 - (b) Explain the importance of chemical reactor in a chemical plant.
 - (c) Briefly explain the classification of detergent.
 - (d) Differentiate batch reactor from steady-state flow reactors.
 - (e) What is Polystyrene? Where do we find its application?
 - (f) Explain Effects of Acid Deposition.
 - (g) What are the methods for estimation and calculation of depreciation?
 - (h) Explain Break Even Analysis.

8. Choose any two from the following: (2×5=10)
- (a) What is first Law of Thermodynamics? Explain its significance.
 - (b) What is saponification value? Differentiate soft soaps and hard soaps.
 - (c) What are physical parameters of water? How are they measured?
 - (d) What are the Factors that influence siting of landfill?
9. Answer any two from the following: (2×5=10)
- (a) Suppose that in a test 20 kg of propane (C_3H_8) is burned with 400 kg of air to produce 44 kg CO_2 and 12 kg of CO. What was the percentage excess air?
 - (b) Estimate the fugacity of ethane at 122.2 K and 5 bar using the truncated virial EOS. For ethane $T_c = 305.4K$, $P_c = 48.84$ bar, $\omega = 0.099$
 - (c) A textile dryer is found to consume 4 m³/hr of natural gas with a calorific value of 800 kJ/mole. If the throughput of the dryer is 60 kg of wet cloth per hour, drying it from 55% moisture to 10% moisture, estimate the overall thermal efficiency of the dryer taking into account the latent heat of evaporation only.
 - (d) It is required to prepare 1250 kg of a solution composed of 12 wt.% ethanol and 88 wt.% water. Two solutions are available, the first contains 5 wt.% ethanol, and the second contains 25 wt.% ethanol. How much of each solution are mixed to prepare the desired solution?
10. Answer any one of the following: (1×10=10)
- (a) Describe the method of extraction of vegetable oil from seed with neat flow diagram.
 - (b) Explain in detail with a neat diagram the process technology of Sulfate (Kraft) Pulping Process.

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