# K. K. Wagh Institute of Engineering Education & Research, Nashik

(An Autonomous Institute From A.Y. 2022-23)

| WINTER-2025 | |
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| Exam Seat No.: | |
| Academic Year:2025-2026 | Semester:VI |
| Class:TY | Program:B.Tech |
| Branch Code:CHE | Pattern:2022 |
| Name of Course:Heat Transfer Operations | Course Code:CHE223015(A) |
| Max. Marks:60 | Duration:2.30 Hrs. |

**Instructions:** Candidates should read carefully the instructions printed on the Question Paper and on the cover page of the Answer Book, which is provided for their use.

1. This question paper contains 02 page(s).
2. Answer to each new question is to be started on a new page.
3. Assume suitable data wherever required, but justify it.
4. Draw the neat labelled diagrams, wherever necessary.
5. The last columns indicates the Course Outcome and level of Blooms Taxonomy of the Question/sub-question.

| | | Marks | CO |
|---|---|---|---|
| **Question No. 1** | | | |
| 1a) | Water flows at 50$^{o}$C inside a tube of 2.5 cm inside diameter such that $h_i$ = 3500 W/m$^2$ $^{o}$C. The outside of the tube loses heat by free convection with $h_o$ = 7.6 W/m$^2$ $^{o}$C. Calculate the overall heat transfer coefficient and heat loss per unit length of pipe to surroundings air at 20 $^{o}$C. | (6) | CO1 |
| **Question No. 2** | | | |
| 2a) | What is the condenser Heat duty and reboiler Heat duty?<br><br>Discuss on the effect of non-condensable gases present in condensable vapours during condensation | (6) | CO2 |
| **Question No. 3** | | | |
| 3a) | Explain the term "evaporator capacity" and discuss the factors affecting it. Describe the concept of economy in evaporators. How is it calculated, and why is it important in their design? | (8) | CO3 |
| | **OR** | | |
| 3b) | Differentiate between Falling film Evaporator and Rising film Evaporator. | (8) | CO3 |
| 3c) | How does Thermal vapor recompression work in evaporators? Explain it with neat diagram. What is the benefit of TVR in evaporation? | (8) | CO3 |
| | **OR** | | |
| 3d) | An evaporator is operating at atmospheric pressure. It is desired to concentrate a feed from 5 % solute to 20 % solute (by weight) at a rate of 5000 kg/h. Dry saturated steam at a pressure corresponding to the saturation temperature of 399 K (126$_o$ C) is used. The feed is at 298 K (25 $^{o}$C) and the boiling point rise (elevation), i.e., B.P.E. (B.P.R.) is 5 K. The overall heat transfer coefficient is 2350 W/(m$^2$·K). Calculate the economy of the evaporator and the area of heat transfer to be provided.<br><br>**Data:** Treating the solution as a pure water and neglecting the B.P.R., the latent heat of condensation of steam at 399 K is 2185 kJ/kg.<br><br>Latent heat of vaporisation of/evaporation of water at 101.325 kPa and 373 K = 2257 kJ/kg. | (8) | CO3 |

Specific heat of feed = 4.187 kJ/(kg·K)

$\lambda_s$ = latent heat of condensation of steam at 399 K = 2185 kJ/kg

$\lambda_v = \lambda$ = latent heat of vaporisation of water at 373 K = 2257 kJ/kg

**Question No. 4**

4a) A jacketed, agitated reactor consists of a vertical cylinder 1.5 m diameter, with a hemispherical base and a flat, flanged, top. The jacket is fitted to the cylindrical section only and extends to a height of 1 m. The spacing between the jacket and vessel walls is 75 mm. The jacket is fitted with a spiral baffle. The pitch between the spirals is 200 mm. The jacket is used to cool the reactor contents. The coolant used is chilled water at 10 $^oC$ flow-rate 32,500 kg/h, exit temperature 20 $^oC$. (8) CO4

Estimate the heat transfer coefficient at the outside wall of the reactor and the pressure drop through the jacket.

Physical properties at mean temperature of 15 $^oC$, from steam tables: Density= 999 kg/$m^3$, Viscosity= 1.136 mN$m^{-2}$s, Pr = 7.99, $k_f$ = 595 x $10^{-3}$ W$m^{-1}$ $C^{-1}$.

**OR**

4b) Write on the heat transfer between the jackets side fluid and liquid content in the vessel. Which are the factors affecting the overall heat transfer coefficient in it? (8) CO4

4c) The reactor is fitted with a flat blade disc turbine agitator 0.6 m diameter, running at 120 rpm. The vessel is baffled and is constructed of stainless steel plate 10 mm thick. Estimate the heat transfer coefficient at the vessel wall and the overall heat transfer coefficient in the clean condition, if the thermal conductivity of stainless steel as 16 W/m. $^o$ C and jacket side heat transfer coefficient is 1606 W/$m^2$oC and the physical properties of the reactor contents are, (8) CO4

$\rho$ = 850 kg/$m^3$, $\mu$= 80mNs/$m^2$, $k_f$ = 400 x $10^{-3}$ W/m.$^o$C, $C_p$ = 2.65 kJ/kg $^o$C.

**OR**

4d) Discuss on the types of jackets and cooling coils in mechanically agitated process vessel. (8) CO4

**Question No. 5**

5a) Classify the various types of Boilers and list out the Boiler accessories. (8) CO5

**OR**

5b) Discuss on the significance of Super heaters and Economisers in Boiler system (8) CO5

5c) Determine the quantity of heat required to produce 1 kg of steam at a pressure of 6 bar at a temperature of 25 $^oC$. under the following conditions when; (8) CO5

1. Steam is wet with dryness fraction of 0.9
2. Steam is dry saturated
3. Steam is superheated at a constant pressure at temperature of 250 $^oC$ assuming the mean specific heat of superheated steam to be 2.3 kJ/kgK.

Data from Steam Table: The saturation temperature at 6 bar t = 158.8 $^oC$.

The enthalpy of water and steam at 6 bar $h_f$ = 670.4 kJ/kg and $h_{fg}$ = 2085 kJ/kg

**OR**

5d) Explain the Construction and working features of Babcock And Wilcox Boiler with neat sketch. (8) CO5

**····· End of question paper·····**