| Reg.No. | | | | | | | | | | |
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# MANIPAL UNIVERSITY

**Fourth Semester B.Tech.(Chemical Engineering)**

**MAKE UP EXAMINATION – JUNE/JULY 2017**

**SUBJECT: HEAT TRANSFER OPERATIONS (CHE 2202)**

**Time : 3 hrs** **Max Marks: 100**

- **Answer all questions.**
- **Missing data, if any, may be assumed suitably.**

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| 1A. | Derive an expression to determine the temperature distribution (T) and heat flow (Q) for a hollow cylinder with uniform internal heat generation. | (10 marks) |
| 1B. | Derive an expression for unsteady state heat conduction. State its assumptions. | (6 marks) |
| 1C. | Explain radiation measurements in gases and the use of radiation shield. | (4 marks) |
| 2A. | A spherical thin walled metallic container is used to store liquid nitrogen at 80 K. The container has a diameter of 0.5 m and is covered with an evacuated, reflective insulation composed of silica powder. The insulation is 25 mm thick, and its outer surface is exposed to ambient air at 310K. The convection coefficient is known to be 20 $W/m^2$ K. The latent heat of vaporization and the density of the liquid nitrogen are 2 x $10^5$J/kg and 804 $kg/m^3$, respectively. Thermal conductivity of evacuated silica powder (300 K) is 0.0017 W/m.K What is the rate of heat transfer to the liquid nitrogen ? | (8 marks) |
| 2B. | An electrically heated sphere with diameter D = 6 cm is exposed to ambient air at $T_\infty = 25°C$ providing a heat transfer coefficient of 20 $W/m^2$-K. The surface of the sphere is to be maintained at temperature $T_i = 125°C$. Calculate the heat loss for the following cases: The bare sphere (uninsulated) and sphere covered with an insulation ($k$ = 1 W/m-K) having a radius corresponding to the critical radius of insulation for the sphere. | (8 marks) |
| 2C. | A thermocouple used to measure the temperature of hot air flowing in a duct whose walls are maintained at 400 K shows a temperature reading of 650 K. Assuming the emissivity of the thermocouple junction to be 0.6 and the convection heat transfer coefficient as 80 $W/m^2$.K, determine the actual temperature of the air. | (4 marks) |
| 3A. | Define NTU and effectiveness of heat exchanger? Derive a relationship between them for parallel type heat exchanger. | (10 marks) |
| 3B. | Derive the Reynold's Analogy equation and give the limitations of the same. | (10 marks) |

<table>
<tr><td>4A.</td><td>A chemical plant produces 300 metric tonnes of sulphuric acid per day.The acid is to be cooled from 60°C to 40°C by 500 metric tonnes of water per day which has an initial temperature of 15°C.A counter flow cooler consisting of concentric pipes 12.5 mm thick is to be used.The inner pipe through which the acid flows is 7.5 cm bore and the outer one is 12.5 cm bore.The outside diameter of the inner pipe is 10 cm.The physical properties of the fluids at the mean temperature are as follows:
<table>
<tr><td>Properties</td><td>Acid</td><td>Water</td></tr>
<tr><td>Density (kg/m$^3$)</td><td>1800</td><td>998.2</td></tr>
<tr><td>Heat capacity (kcal/kg °C)</td><td>0.35</td><td>1.0</td></tr>
<tr><td>Thermal conductivity (kcal/hr.m°C)</td><td>0.26</td><td>0.575</td></tr>
<tr><td>Viscosity (kg/m hr)</td><td>40.3</td><td>3.96</td></tr>
</table>
Thermal conductivity of the pipe material is 40 kcal/hr.m.°C. Calculate the length of the pipe required.</td><td>(10 marks)</td></tr>
<tr><td>4B.</td><td>Cold water leading to a shower enters a thin walled double pipe counter flow heat exchanger at 0.25 kg/s at 15°C and is heated to 45°C by hot water that enters at 100°C and 3 kg/s. If the overall heat transfer coefficient is 950 W/m$^2$-K, determine the heat transfer rate and the area of the heat exchanger by $\varepsilon - NTU$ method. Assume specific heat of water to be 4180 J/kg-K.</td><td>(5 marks)</td></tr>
<tr><td>4C.</td><td>Explain condensation heat transfer.Describe boiling point curve and different types of boiling.</td><td>(5 marks)</td></tr>
<tr><td>5A.</td><td>Determine the heat transfer coefficient for water flowing in a pipe of 4.2 cm diameter at a velocity of 8 m/s. The temperature of the tube wall is 82ºC and water enters at 25 ºC and leaves at 57 ºC.<br><br>Physical properties of water are given below:<br>$\rho$ = 990 kg/m$^3$<br>k = 0.63 W/mK<br>$\mu$ = 7 x 10$^{-4}$ Ns/m$^2$<br>$C_p$ = 4160 J/kgK<br>$\mu_{82\,^\circ C}$ = 3.54 x 10$^{-4}$ Ns/m$^2$<br>Use all the equations given below for finding out heat transfer coefficient:<br>Dittus-Boltzer equation,Sieder Tate equation and Coulburn j-H factor</td><td>(10 marks)</td></tr>
<tr><td>5B.</td><td>Write short notes on the following:<br><br>(i) Wein’s Displacement law and Stefan Boltzmann law<br><br>(ii) Transient heat conduction<br><br>(iii)Heat transfer in packed bed.<br><br>(iv) Fin Effectiveness<br><br>(v) Internal flow</td><td>(10 marks)</td></tr>
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