estion No. **1** is **compulsory.**
mpt any **four** questions from remaining **seven** questions.
ure to the **right** indicate **full** marks.
sume suitable data whenever **necessary.**

r the following subquestions :

(a) State the laws of Radiations. **4**

(b) Explain the terms capacity and economy in steam heated evaporator. **4**

(c) Give the physical significance of the Groups : **4**
Reynold's number, Grashof Number, Prandtl Number and Nusselt Number.

(d) One end of a very long aluminium rod of 3 mm in a diameter is connected to a wall at 413 K, while the other end protrudes into a room whose air temperature is 288 K. **4**
Determine the total heat dissipated by a rod.
Data—
(1) Thermal conductivity for alluminium. 150 W/m-c
(2) Film transfer coefficient between rod surface and environment ; 300 $w/m^2k$.

(e) State (only) assumption made by Nusselt in deriving film transfer coefficient in heat transfer during condensing vapours on vertical plate. **4**

(a) Derive the expression for heat transfer through furnace wall made of three different materials in series. Assume $k_1$, $k_2$, $k_3$ be the thermal conductivities of materials and $x_1$, $x_2$, $x_3$ be the respective thickness. Assume hot face and cold face temperature $T_1$ and $T_2$ respectively. **10**

(b) Determine the amount of heat that will be conducted per square meter of wall surface through a wall of a building with 22 °C temperature drop between inside and outside surfaces. The wall is built with a 20 cm thick concrete core covered on the inside with a 2 cm thick layer of gypsum plaster and an extenal layer of face brick (10 cm thick) attached to the concrete wall with a 1 cm thick layer of cement mortor. **10**
Data :
The Thermal Conductivities for material concrete, gypsum plaster, cement mortor, face brick are 1·36, 0·48, 1·16, 1·32, w/m °C respectively.

(a) Show by dimension analysis that Nusselt number is the function of Prandtl Number and Reynold's Number for the case of forced convection. **12**

(b) Air at 101·325 kPa and 308 K flows across a 50 mm diameter cylinder at a velocity of 50 m/sec. The cylinder surface is maintained at a temperature of 423 K. Estimate the heat loss per unit length of the cylinder. **8**
**Data :**
Physical properties of air at the film temperature of 365-J-k are :
$\mu = 2{\cdot}14 \times 10^{-5}$ kg/m sec, $\rho = 0{\cdot}966$ kg/m$^3$, K = 0·0312 W/m-c,
Npr = 0·695.
The average heat transfer coefficient may be calculated using following correlation—
$$N_{Nu} = 0{\cdot}0266 \ (N_{Re})^{0\cdot805} \ (Npr)^{1/3}.$$

4. Fuel Oil at the rate of 1·1 kg/sec is heated passing through the annulus of a counter flow double pipe heat exchanger from 10°C to 20°C by using hot water available from the engine at 71 °C. The water flows through copper tube at (OD = 2·13 cm and ID = 1·86 cm) with a velocity of 0·76 M/sec. The oil passes through the annulus formed by inner copper tube and outer steel pipe (OD = 3·34 cm and ID = 3 cm).

Waterside fouling factor — $f_w = 0{\cdot}0004\ m^2\ ^\circ C/w$

Oilside fouling factor—$f_o = 0{\cdot}0009\ m^2 °C/m$.

Take the following properties of water and oil.

| Property | Water | Oil |
|---|---|---|
| $\rho$ (kg/m$^3$) | 982 | 854 |
| $C_p$(kJ/kg° C) | 4·187 | 1·884 |
| K (w/m ° C) | 0·657 | 0·138 |
| $\gamma$ (m$^2$/sec) | $4{\cdot}18 \times 10^{-7}$ | $7{\cdot}43 \times 10^{-6}$ |

Neglect the resistance of copper tube.

For Calculation of film transfer coefficients of bothsides, use—

$N_{Nu} = 0{\cdot}023\ (N_{Re})^{0.8}\ (Npr)^{0.3}$

5. (a) Explain the different regims of Boiling. 1

(b) Derive Q (rate of heat transfer by radiating/with 'n' shields = $\frac{1}{n+1}$ Q without shield. 1

6. Saturated steam at 353 K condenses on a vertical plate of 1 meter length which is maintained at 343 k. 1

Estimate :

(i) Average heat transfer coefficient

(ii) Local heat transfer coefficient at 0·5 m height

(iii) The film thickness at 0·5 m height.

Properties of condensate film at temperature of 348 K are—

$\rho = 975\ kg/m^3$, $k = 0{\cdot}671$ W/mk, $\mu = 3{\cdot}8 \times 10^{-4}$ N-s/m$^2$

Latent heat of condensation of steam = 2300 kJ/kg.

7. Write a short note on any **four** : 2

(a) Plate heat exchanger

(b) Various feed arrangement of multiple effect evaporator

(c) Extended surfaces for heat transfer

(d) Optimum insulation thickness on cylinder

(e) Unsteady state heat transfer in hot solid body to cold air (lumped heat capacity Analysis).