Time: 3 hours Max. Marks: 80

Note: 1. Assume suitable data if necessary
2. Figures to the right indicate full marks
3. Question No. 1 is compulsory
4. Solve any **three** out of the remaining **five** questions

Q1. Solve any four

A	Derive an expression for the critical radius of insulation for the sphere.	**5**
B	State Fourier and Biot numbers? Also explain the significance of these numbers.	**5**
C	Draw a boiling curve and identify the different boiling regimes. Explain each regime in brief.	**5**
D	State and explain Fick's Law of diffusion.	**5**
E	Explain the valve timing diagram for four-stroke SI engines.	**5**
F	Explain EURO and BHARAT norms.	**5**

Q2.

A A Cylindrical tank of 1.0 m diameter and 5 m total length has hemispherical ends. It contains liquid oxygen, which has a boiling point and heat of vaporization of -180 °C and 210 kJ/kg, respectively. It is required to insulate the tank so as to reduce the boil-off rate of oxygen in a steady state to 14 kg/h. Determine the thermal conductivity of the insulating material if its maximum thickness is limited to 70 mm. Assume room temperature outside the insulation as 25 °C. **10**

B During the trial of a single-cylinder, four-stroke oil engine, the following results were obtained. **10**

Cylinder diameter	20 cm.
Stroke	40 cm
Mean effective pressure	6 bar
Torque	407 Nm
Speed	250 rpm
Oil consumption	4 kg/h
Calorific value of fuel	43 MJ/kg
Cooling water flow rate	4.5 kg/min
Air used per kg of fuel	30 kg
Rise in cooling water temperature	45 °C
Temperature of exhaust gases	420 °C
Room Temperature	20 °C
Mean specific heat of exhaust gas	1kJ/kg K
Specific heat of water	4.18 kJ/kg K

Find the IP, BP and draw up a heat balance sheet for the test in kJ/h.

Q3.

A Discuss the electrical analogy of combined heat conduction and convection in two-layer composite wall. **5**

B A steel ball 50 mm in diameter and at 900 °C is placed in a still atmosphere of 30 °C. Calculate the initial rate of cooling of the ball in °C per min. **5**

C Explain with neat sketch stages of combustion of the CI engine. **10**

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Q4.

A A steel rod (k = 32 W/m°C), 12 mm in diameter and 60 mm long, with an insulated end, is to be used as a spine. It is exposed to surroundings with a temperature of 60°C and a heat transfer coefficient of 55 W/m²°C. The temperature at the base of fin is 95°C. Determine: **10**
(i) The fin efficiency.
(ii) The temperature at the edge of the spine.
(iii) The heat dissipation.

B State and explain kirchoff's law. **5**

C With suitable example/ values prove that during the load test of an engine, increases in the load increases the mechanical efficiency of the engine. **5**

Q5.

A A counter-flow double pipe heat exchanger using superheated steam is used to heat water at the rate of 10500 kg/h. The steam enters the heat exchanger at 180°C and leaves at 130°C. The inlet and exit temperatures of water are 30°C and 80°C, respectively. If the overall heat transfer coefficient from steam to water is 814 W/m^2°C, calculate the heat transfer area. What would be the increase in the area if the fluid flows were parallel? **10**

B A 4-stroke motorcycle petrol engine cylinder consists of 15 hollow fins. If the outside and inside diameters of each fin are 200 mm and 100 mm, respectively, the average fin surface temperature is 475°C, and the atmospheric air temperature is 25°C, calculate the heat transfer rate from the fins When the motor cycle is running at a speed of 60 km/h. The fin may be idealised as a single horizontal flat plate of the same area. **10**
Assume characteristic length is 0.9 times the outside diameter.

$\overline{Nu} = 0.036(Re)^{0.8}\ (Pr)^{0.33}$

$\overline{Nu} = 0.54(Gr.Pr)^{0.25}$

The thermophysical properties of air at 250 °C are
k = 4.266 x 10^{-2} W/m °C, ν = 40.61 x 10^{-6} m^2/s, Pr = 0.677

Q 6.

A Explain with a neat sketch working of the battery ignition system. **5**

B Explain the Fouling of Heat Exchangers. **5**

C Calculate the heat transfer from a 60W incandescent bulb at 115°C to ambient air at 25°C. Assume the bulb is a sphere of 50 mm in diameter. Also, find the percentage of power lost by free convection. **5**

The correlation is given by: Nu = 0.60 $(Gr.Pr)^{1/4}$
The thermophysical properties of air at 70 °C are
k = 2.964 x 10^{-2} W/m °C, ν= 20.02 x 10^{-6} m^2/s Pr = 0.694

D Write down the general heat conduction equation in cartesian coordinates. State the assumptions and get the Fourier, Poisson's and Laplace equations from it. **5**

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