



4. Diamond has a very high thermal conductivity as compared to pure metals. This is due to CO3 [K2]
- a) Flow of free electrons                      b) Propagation of lattice vibrational waves
- c) Transfer of kinetic energy between the randomly moving molecules due to their collisions                      d) Very high density
5. Assertion (A): The internal combustion engine does operate on a thermodynamic cycle as it involves an open system CO2 [K3]
- Reasoning (R): The working fluid enters the system at one set of conditions and leaves at another
- a) Both A and R are true and R is the correct explanation of A                      b) Both A and R are true and R is not the correct explanation of A
- c) A is true but R is false                      d) A is false but R is true
6. The value of Prandtl number for air is about CO4 [K1]
- a) 0.1                      b) 0.3
- c) 1.7                      d) 0.7
7. Thermal radiation extends over the range of..... CO3 [K2]
- a) 0.01 to 0.1  $\mu\text{m}$                       b) 0.1 to 100  $\mu\text{m}$
- c) 100 to 250  $\mu\text{m}$                       d) 250 to 1000  $\mu\text{m}$
8. The concept of overall heat transfer is used in case of heat transfer by CO3 [K1]
- a) Conduction                      b) Conduction and convection
- c) Convection                      d) Convection and radiation
9. Assertion (A): A thin region near the surface, called boundary layer, where the velocity gradient are large CO3 [K3]
- Reasoning (R): due to no slip condition to be satisfied at the surface of the plate, the velocity of the fluid is reduce to zero relative to the surface.
- a) Both A and R are true and R is the correct explanation of A                      b) Both A and R are true and R is not the correct explanation of A
- c) A is true but R is false                      d) A is false but R is true
10. The non-dimensional parameter called Schmidt number, comprising density  $\rho$ , viscosity  $\mu$  and mass diffusivity D is given by CO4 [K1]
- a)  $\mu/\rho D$                       b)  $D\rho/\mu$
- c)  $\mu D/\rho$                       d)  $\mu\rho/D^2$

**PART B (10 x 2 = 20 Marks)**  
**(Answer not more than 40 words)**

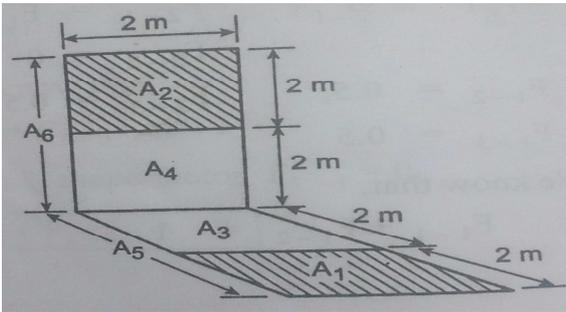
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|---|-----|-------------------|
| 11. Define quasi- static process, and discuss its importance.                                 | CO1 | [K1]              |
| 12. For same compression ratio efficiency of Otto cycle is higher than diesel cycle. Justify? | CO2 | [K2]              |
| 13. Draw the p-V and T-s diagram for Brayton cycle.   | CO2 | [K1]              |
| 14. State Fourier's Law of heat conduction.   | CO3 | [K <sub>1</sub> ] |
| 15. Work producing device can't be 100% efficient. Justify?                                   | CO1 | [K2]              |
| 16. Comment on the significance of boundary layer.  | CO3 | [K <sub>3</sub> ] |
| 17. What is the driving potential parameter for free convection flow?                         | CO3 | [K <sub>2</sub> ] |
| 18. What is meant by shape factor and mention its physical significance?                      | CO3 | [K <sub>2</sub> ] |
| 19. State Kirchhoff's law of radiation.   | CO4 | [K <sub>1</sub> ] |
| 20. Discuss the analogy between heat and mass transfer.                                       | CO4 | [K <sub>2</sub> ] |

**Answer any FIVE Questions:-**  
**PART C (5 x 14 = 70 Marks)**  
**(Answer not more than 300 words)**

**Q.No. 21 is Compulsory**

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|---|-----|------|
| 21. A composite slab is made of three layer 15cm, 10cm and 12cm thickness respectively. The first layer is made of material with $k=1.45 \text{ W/m K}$ , for 60% of the area and the rest of the material with $k=2.5 \text{ W/m K}$ . The second layer is made material with $k=12.5 \text{ W/m K}$ for 50% of area and rest of material with $k=18.5 \text{ W/m K}$ . The third layer is made of single material of $k=0.76 \text{ W/m K}$ . The composite slab is exposed on one side to warm at $26^\circ\text{C}$ and cold air at $-20^\circ\text{C}$ . The inside heat transfer coefficient is $15 \text{ W/m}^2\text{K}$ . The outside heat transfer coefficient is $20 \text{ W/m}^2\text{K}$ . Determine the heat flow rate and interface temperatures. | CO3 | [K3] |
| 22. The steam supply to an engine comprises two streams which mix before entering the engine. One stream is supplied at the rate of $0.01 \text{ kg/s}$ with an enthalpy of $2569 \text{ kJ/kg}$ and a velocity of $20 \text{ m/s}$ . The other stream is supplied at the rate of $0.1 \text{ kg/s}$ with an enthalpy of $2569 \text{ kJ/kg}$ and a velocity of $120 \text{ m/s}$ . At the exit from the engine the fluid leaves as two streams, one of water at the rate of $0.001 \text{ kg/s}$ with an enthalpy of $420 \text{ kJ/kg}$ and the other of steam; the fluid velocities at the exit are negligible. The engine develops a shaft power of $25 \text{ kW}$ . The heat transfer is negligible. Evaluate the enthalpy of the second exit stream.       | CO2 | [K3] |
| 23. (i) Derive three-Dimensional heat conduction equation in the spherical coordinate system and discuss the special cases. (10)  | CO3 | [K2] |
| (ii) Is efficiency of a Reversible engine higher than irreversible engine. If so Justify the statement (4)  | CO1 | [K2] |

24. Find the shape factor  $F_{1-2}$  for the figure shown below. In the fig., the area  $A_1$  and  $A_2$  are perpendicular but do not share the common edge. CO3 [K3]



25. (i) An air stream at  $0^\circ\text{C}$  is flowing along a heated plate at  $90^\circ\text{C}$  at a speed of  $75\text{ m/s}$ . (7) CO3 [K3]  
The plate is  $45\text{ cm}$  long and  $60\text{ cm}$  wide. Assuming the transition of boundary layer to take place at  $\text{Re}_{x,c} = 5 \times 10^5$  calculate the average values of friction coefficient and heat transfer coefficient for the full length of the plate. Hence, calculate the rate of energy dissipation from the plate.
- (ii) Two circular discs of diameter  $0.3\text{ m}$  each placed parallel to each other at a distance (7) CO3 [K3]  
of  $0.2\text{ m}$ . One disc is maintained at a temperature of  $750^\circ\text{C}$  and the other at  $350^\circ\text{C}$  and their corresponding emissivities are  $0.3$  and  $0.6$ . Calculate heat exchange between the discs.
26. (i) Draw the Diesel cycle on  $p$ - $V$  and  $T$ - $s$  diagrams. Derive the expression for its (10) CO2 [K2]  
efficiency.
- (ii) The food compartment of a refrigerator, is maintained at  $4^\circ\text{C}$  by removing heat (4) CO2 [K3]  
from it at a rate of  $360\text{ kJ/min}$ . If the required power input to the refrigerator is  $2\text{ W}$ , determine a) the coefficient of performance of refrigerator and b) the rate of heat rejection to the room that houses the refrigerator
27. (i) A mixture of  $\text{O}_2$  and  $\text{N}_2$  with their partial pressure in the ratio of  $0.21$  to  $0.79$  is in a (8) CO4 [K3]  
container at  $25^\circ\text{C}$ . Calculate the molar concentration, the mass density, the mole fraction and the mass fraction of each species for a total pressure of  $1\text{ bar}$ . What would be the average molecular weight of the mixture?
- (ii) Explain the similarity between the Fick's law of diffusion and the Fourier's law of (6) CO4 [K2]  
heat conduction.

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