

1. An air conditioner removes heat steadily from a house at a rate of 750 kJ/min while drawing electric power at a rate of 6 kW. Determine (a) the COP of this air conditioner and (b) the rate of heat transfer to the outside air.
2. A cold storage is to be maintained at  $-5^{\circ}\text{C}$  while the surroundings are at  $35^{\circ}\text{C}$ . The heat leakages from the surroundings in to the cold storage are estimated to be 29 kW. The actual coefficient of performance (C.O.P), of the refrigeration plant is one third of an ideal plant working between the same temperatures. Find the power required to drive the plant?
3. Consider two Carnot heat engines operating in series. The first engine receives heat from the reservoir at 1800 K and rejects the waste heat to another reservoir at temperature  $T$ . The second engine receives this energy rejected by the first one, converts some of it to work, and rejects the rest to a reservoir at 300 K. If the thermal efficiencies of both engines are the same, determine the temperature  $T$ .
4. An automobile engine with a power output of 75 KW has a thermal efficiency of 30 %. If the heating value of the fuel used is 40,000 KJ/Kg, determine the fuel consumption rate.
5. A steam power plant with a thermal efficiency of 20 % consumes coal at a rate of 55 tonnes hour. If the heating value of the coal is 27,000 KJ/kg, determine the power output of the plant.
6. Two reversible heat engines are arranged in series between temperatures  $500^{\circ}\text{C}$  and  $0^{\circ}\text{C}$ . The heat input from the heat source at  $500^{\circ}\text{C}$  is 300 KJ. The work output of the first engine is twice of the second engine. Determine the  $T_2$ ,  $\eta_1$ ,  $\eta_2$  and  $Q_3$ .
7. A reversible heat engine operates between two reservoirs of  $600^{\circ}\text{C}$  and  $40^{\circ}\text{C}$ . The engine drives a reversible refrigerator, which operates between reservoirs at temperatures of  $40^{\circ}\text{C}$  and  $-20^{\circ}\text{C}$ . The heat transfer to the engine is 2.0 MJ and the net work output of the combined engine and refrigerator plant is 360 kJ. Find the heat transfer to the refrigerant and the net heat transfer to the reservoir at  $40^{\circ}\text{C}$ ? Also find these values if the efficiency of the engine and C.O.P of the refrigerator are each 40 % of their maximum possible values?
8. A refrigerator is to remove heat from the cooled space at a rate of 300 kJ/min to maintain its temperature at  $-8^{\circ}\text{C}$ . If the air surrounding the refrigerator is at  $25^{\circ}\text{C}$ , determine the minimum power input required for this refrigerator. **(0.622 kW)**

