THERMODYNAMICS

FIRST LAW OF THERMODYNAMICS – CLOSED SYSTEM

1. The inner and outer surface of a 5-m × 6-m brick wall of thickness 30 cm and thermal conductivity 0.69 W/m · ºC are maintained at temperatures of 20 ºC and 5 ºC, respectively. Determine the rate of heat transfer through the wall, in W.

2. An aluminum pan whose thermal conductivity is 237 W/m · ºC has a flat bottom whose diameter is 20 cm and thickness 0.4 cm. heat is transferred steadily to boiling water in the pan through its bottom at a rate of 500 W. If the inner surface of the bottom of the pan is 105 ºC, determine the temperature of the outer surface of the bottom pan.

3. A 5-cm diameter spherical ball whose surface is maintained at a temperature of 70 ºC is suspended in the middle of a room at 20 ºC. If the convection heat transfer coefficient is 15 W/m^2 · ºC and the emissivity of the surface is 0.8, determine the total rate of heat transfer from the ball.

4. How air at 80 ºC is blown over a 2-m × 4-m flat surface at 30 ºC. If the convection heat transfer coefficient is 55 W/m^2 · ºC, determine the rate of heat transfer from the air to the plate, kW.

5. A thin metal plate is insulated at the back and exposed to solar radiation at the front surface. The exposed surface of the plate has an absoptivity of 0.6 for solar radiation. If solar radiation is incident on the plate at a rate of $700W/m^2$ and the surrounding air is 25 ºC, determine the surface temperature of the plate when the heat loss by convection equals the solar energy absorbed by the plate. Assume the convection heat transfer coefficient to be 50 W/m^2 · ºC, and disregard any heat loss by radiation.

6. A mass of 5 kg of saturated water vapour at 200 kPa is heated at constant pressure until the temperature reaches 300 ºC. Calculate the work done by the steam during this process.

7. A frictionless piston-cylinder device initially contains 200 L of saturated liquid refrigerant-134a. The piston is free to move, and its mass is such that it maintains

a pressure of 800 kPa on the refrigerant. The refrigerant is now heated until its temperature rises to 50 ºC. Calculate the work done during this process.

8. A mass of 1.2 kg of air at 150 kPa and 12 ºC is contained in a gas-tight, frictionless piston-cylinder device. The air is now compressed to a final pressure 0f 600 kPa. During the process, heat is transferred from the air such that the temperature inside the cylinder remains constant. Calculate the work done during this process.

9. A frictionless piston-cylinder device contains 2 kg of nitrogen at 100 kPa and 300 K. Nitrogen is now compressed slowly according to the relation $PV^{1.4}$ = constant until it reaches a final temperature of 360 K. Calculate the work done during this process.

10. A piston-cylinder device contains 50 kg of water at 150 kPa and 25 ºC. The cross-sectional area of the piston is 0.1 m^2. Heat is now transferred to the water, causing part of it to evaporate and expand. When the volume reaches 0.2 m^3, the piston reaches a linear spring whose spring constant is 100 kN/m. ore heat is transferred to the water until the piston rises 20 cm more. Determine (a) the final pressure and temperature and (b) the work done during this process. Also, show the process on a P-V diagram.

11. Determine the work required to accelerate an 800-kg car from rest to 100 km/h on a level road.

12. Determine the work required to accelerate a 2000-kg car from rest to 70 km/h on an uphill road with a vertical rise of 40 m.

13. Determine the power required for a 2000-kg car to climb a 100-m-long uphill road with a slope of 30º (from horizontal) in 10 s *(a)* at a constant velocity, *(b)* from rest to a final velocity of 30 m/s, and *(c)* from 35 m/s to a final velocity of 5 m/s. Disregard friction, air drag, and rolling resistance.

14. Carbon dioxide contained in a piston-cylinder device is compressed from 0.3 to 0.1 m^3. During the process, the pressure and volume are related by $P = aV^{-2}$, where a = 8 $kPa.m^6$. Calculate the work done on the carbon dioxide during this process.