Explanation Chapter 5

5.1 Process 1: A block slides down an inclined plane with friction and no restraining forces.
Process 2: A cold canned drink is left in a warmer room where its temperature rises as a result of heat transfer.
Are these processes reversible or irreversible?
a) 1) reversible; 2) reversible
b) 1) reversible; 2) irreversible
c) 1) irreversible; 2) reversible
d) 1) irreversible; 2) irreversible
e) You need more information to know this
Ans: D.
1) As the block slides down the plane, two things happen, (a) the potential energy of the block decreases, and (b) the block and plane warm up because of the friction between them. The potential energy that has been released can be stored in some form in the surroundings (e.g., perhaps in a spring). When we restore the system to its original condition, we must (a) restore the potential energy by lifting the block back to its original elevation, and (b) cool the block and plane back to their original temperatures.

The potential energy may be restored by returning the energy that was stored during the original process as the block decreased its elevation and released potential energy. The portion of the surroundings in which this energy had been stored would then return to its original condition as the elevation of the block is restored to its original condition.

In order to cool the block and plane to their original temperatures, we have to remove heat from the block and plane. When this heat is transferred to the surroundings, something in the surroundings has to change its state (e.g., perhaps we warm up some water in the surroundings). This change in the surroundings is permanent and cannot be undone. Hence, the original process is irreversible.
2) The process cannot be reversed because it involves heat transfer through a finite temperature difference. Heat cannot flow from a lower to a higher temperature.

5.2 A system undergoes a process from A to state B and back to A. The process from A to B is reversible and the process back from B to A is irreversible.
How will the entropy change for state A?
a) After the process the entropy of state A will be larger
b) After the process the entropy of state A will be smaller
c) After the process the entropy of state A will be the same
d) You need more information to know this
Ans: C. The entropy of state A will not change. Entropy is a state property and it has a fixed value at a fixed state. It only depends on the properties of the state (e.g. temperature, pressure, phase), however during the process entropy can be generated.

5.3 Is an isothermal process always internally reversible?
a) Yes
b) No
Ans: B. An isothermal process can be irreversible. Examples: 1) A system that involves paddle-wheel work while losing an equivalent amount of heat. 2) A piston-cylinder device in which work is done by compression and an equivalent amount of heat is lost.

5.4 Which property is constant in a reversible adiabatic process?
a) pressure
b) volume
c) temperature
d) entropy
Ans: D. For a reversible process, $dQ = TdS$ and in an adiabatic process $dQ = 0$ therefore for a reversible adiabatic process $dS = 0$ (entropy is constant, called an isentropic process).

5.5 It is stated that work is entropy free. Sometimes it is claimed that work will not change the entropy of a fluid flowing through a steady-state adiabatic device with a single inlet and outlet. Is this claim right?
a) Yes, because it is an adiabatic device
b) Yes, because it is a steady-state flow
c) Only for a reversible process
d) No this is never right
Ans: C. The claim that work will not change the entropy of a fluid flowing through a steady-state adiabatic device with single inlet and outlet is true only if the process is also reversible. Since no real process is reversible, there will be an entropy increase in real processes in the fluid during the adiabatic process in devices such as pumps, compressors and turbines.

5.6 What is stated in the third law of Thermodynamics?
a) Conservation of mass
b) Conservation of energy
c) The increase of entropy principle
d) If two systems are both in equilibrium with a third system, they are in thermal equilibrium with each other
e) The entropy of a pure crystalline substance at absolute zero temperature is zero
Ans: E. The first law states that energy is always conserved. The increase of entropy principle is stated in the second law of thermodynamics. The zeroth law states that if two systems are both in equilibrium with a third system, they are in thermal equilibrium with each other. The statement, the entropy of a pure crystalline substance at absolute zero temperature is zero, is known as the third law of thermodynamics. Conservation of mass is not a law of thermodynamics.

5.7 What is stated in the second law of Thermodynamics?
a) The increase of entropy principle
b) The increase of exergy principle
c) Conservation of energy
d) Conservation of mass
e) Conservation of entropy
Ans: A. The increase of entropy principle is stated in the second law of thermodynamics. The first law states that energy is always conserved. Conservation of mass is also true but this is not known as the first law of thermodynamics. Conservation of entropy is not true, it increases.

5.8 Steam flows through an actual adiabatic nozzle. The entropy will ....?
a) Increase
b) Decrease
c) Remain the same
Ans: A. It is a naturally occurring process, therefore the entropy increases.

5.9 Ahmed argues the entropy of a piece of steel decreases as it cools. Jan thinks this is a violation of the second law of thermodynamics (i.e. the increase of entropy principle). Who is right and why?
a) Jan, because entropy can never decrease according to the increase of entropy principle
b) Jan, because this is a spontaneous process what cannot be reversed
c) Jan, but only is the process is irreversible
d) Ahmed, because the process is reversible
e) Ahmed, because the entropy of the surroundings will increase more
Ans: E. Ahmed is right. The temperature of the surrounding air is lower than the temperature of the steel and therefore the entropy of the surrounding air increases even more during that process than the entropy of the steel decreases. This makes the total entropy change, steel plus surroundings, positive in agreement with the second law of thermodynamics.

5.10 An ideal compressor uses 100 kW. Does a non-ideal compressor use more or less power?
a) Less
b) The same
c) More
d) You cannot tell
Ans: C. Real world processes require more power than ideal processes due to irreversibility.

5.11 An ideal turbine generates 10 MW. Does a non-ideal turbine generate more or less power?
a) Less
b) The same
c) More
Ans: A. Real world processes generate less power than ideal processes due to for example friction, a part of the power is converted into heat.

5.12 What is the main cause that turbines are not ideal?
a) Steam flowing past the turbine blades
b) Flue gasses leaving the system
c) Friction with the axle
d) Because the steam turns into a liquid state in the turbine
Ans: A.