The first law: Although energy assumes many forms, the total quantity of energy is constant, and when energy disappears in one form it appears simultaneously in other forms.
The second law: The entropy change of any system and its surrounings, considered together, and resulting from any real process, is positive, approaching zero when the process approaches reversibility.

1. Describe an imaginary process that satisfies the first law but violates the second law of thermodynamics.
e.g. The hot coffee getting even hotter in a coller room as a result of heat transfer from the room air.

2. Describe an imaginary process that satisfies the second law but violates the first law of thermodynamics.
e.g. Extracts zero-point energy to heat a quantity of gas. Energy is being created, so the first law is violated, and the entrophy of the system is increasing as the gas heats up.
There is not the exclusive answer.

3.Use the principle of entropy increase to explain the water freezing.
Liquid water is more disordered than ice, but we study the entropy of isolated systems, not individual objects. For example, a basin of water is not an isolated system in cold weather, because the water exchanges energy with the outside atmosphere. The second law of thermodynamics applies to isolated systems that obey the conservation of energy. So the process of freezing doesn't violate the principle of entropy increase. The *total* entropy change of the system is still increasing.

4. A Carnot heat engine operates between a source at 1000 K and a sink at 300 K. If the heat engine is supplied with heat at a rate of 800 kJ/min, determine (a) the thermal efficiency and (b) the power output of this heat engine.
(a) the thermal efficiency:

$$\eta = 1 - \frac{T_C}{T_H} = 1 - \frac{300}{1000} = 0.7$$

(b)

$$\mathrm{Q} = 0.7 \times 800\mathrm{kJ/min} = 560\mathrm{kJ/min}$$

5. A completely reversible heat pump has a COP of 1.6 and a sink temperature of 300 K. Calculate (a) the temperature of the source and (b) the rate of heat transfer to the sink when 1.5 kW of power is supplied to this heat pump.
COP: coefficient of performance

(a)

$$\begin{cases} \mathrm{COP} = \dfrac{1}{1 - T_C/T_H} = 1.6 \\ T_H = 300K \end{cases} \Rightarrow T_C = 112.5K$$

(b)

$$\begin{cases} \mathrm{COP} = \dfrac{Q_H}{W} = 1.6 \\ W = 1.5kW \end{cases} \Rightarrow Q_H = 2.4kW$$

6. Heat in the amount of 100 kJ is transferred directly from a hot reservoir at 1200 K to a cold reservoir at 600 K. Calculate the entropy change of the two reservoirs and determine if the increase of entropy principle is satisfied.

$$\Delta S_1 = -100kJ/1200K = -0.083kJ/K$$
$$\Delta S_2 = +100kJ/600K = 0.167kJ/K$$
$$\Delta S = \Delta S_1 + \Delta S_2 = 0.083kJ/K$$

$\Delta S > 0 \Rightarrow$ the increase of entropy principle is satisfied.

7. A rigid tank contains 5 kg of saturated vapor steam at 100°C. The steam is cooled to the ambient temperature of 25°C.
(a) Sketch the process with respect to the saturation lines on a T-v diagram.
(b) Determine the entropy change of the steam, in kJ/K.
(c) For the steam and its surroundings, determine the total entropy change associated with this process, in kJ/K.