Answers to Exercise 6.4
Entropy: System, Surroundings and Universe

1.

(a) SOMETIMES

A reaction which increases the entropy of the system is thermodynamically allowed if it also increases the entropy of the universe.

As long it does not decrease the entropy of the surroundings by more than it increases the entropy of the system, this reaction can be thermodynamically allowed.

(b) SOMETIMES

A reaction which increases the entropy of the surroundings is thermodynamically allowed if it also increases the entropy of the universe.

As long it does not decrease the entropy of the system by more than it increases the entropy of the surroundings, this reaction can be thermodynamically allowed.

(c) ALWAYS

A reaction which increases the entropy of the universe is always thermodynamically allowed.

(d) SOMETIMES

A reaction which decreases the entropy of the system is thermodynamically allowed if it increases the entropy of the universe.

As long as it increases the entropy of the surroundings by more than it decreases the entropy of the system, this reaction can be thermodynamically allowed.

(e) SOMETIMES

A reaction which decreases the entropy of the surroundings is thermodynamically allowed if it increases the entropy of the universe.

As long as it increases the entropy of the system by more than it decreases the entropy of the surroundings, this reaction can be thermodynamically allowed.

(f) NEVER

A reaction which decreases the entropy of the universe is never thermodynamically allowed.

2.

(a) A reaction can increase the entropy of the system by:

- Increasing the number of gas particles in the system
- Decreasing the order of particles in the system (e.g. melting a crystalline solid)

Or any other means which increases the number of microstates possible for the system.

(b) A reaction can increase the entropy of the surroundings by:

- Being exothermic (heating the surroundings, increasing the number of accessible energetic microstates for the particles in the surroundings).

(c) A reaction can decrease the entropy of the system by:

- Decreasing the number of gas particles in the system
- Increasing the order of particles in the system (e.g. precipitating a crystalline solid)

Or any other means which decreases the number of microstates possible for the system.

(d) A reaction can decrease the entropy of the surroundings by:

- Being endothermic (pulling heat from the surroundings, decreasing the number of accessible energetic microstates for the particles in the surroundings).