Name: _____ Date: _____

1. Let k be the Boltzmann constant. If the configuration of the molecules in a gas changes so that the multiplicity is reduced to one-third its previous value, the entropy of the gas changes by:

A) $\Delta S = 0$
B) $\Delta S = 3k \ln 2$
C) $\Delta S = -3k \ln 2$
D) $\Delta S = -k \ln 3$
E) $\Delta S = k \ln 3$

2. Consider the following processes: The temperature of two identical gases are increased from the same initial temperature to the same final temperature. Reversible processes are used. For gas A the process is carried out at constant volume while for gas B it is carried out at constant pressure. The change in entropy:

A) is the same for A and B
B) is greater for A
C) is greater for B
D) is greater for A only if the initial temperature is low
E) is greater for A only if the initial temperature is high

3. In a reversible process the system:

A) is always close to equilibrium states
B) is close to equilibrium states only at the beginning and end
C) might never be close to any equilibrium state
D) is close to equilibrium states throughout, except at the beginning and end
E) is none of the above

4. An engine that in each cycle does positive work and rejects thermal energy, with no thermal energy input, would violate:

A) the zeroth law of thermodynamics
B) the first law of thermodynamics
C) the second law of thermodynamics
D) the third law of thermodynamics
E) Newton's second law

5. For all irreversible processes involving a system and its environment:

A) the entropy of the system does not change
B) the entropy of the system increases
C) the total entropy of the system and its environment does not change
D) the total entropy of the system and its environment increases
E) none of the above

6. An inventor suggests that a house might be heated by using a refrigerator to draw energy as heat from the ground and reject energy as heat into the house. He claims that the energy supplied to the house as heat can exceed the work required to run the refrigerator. This:

A) is impossible by first law
B) is impossible by second law
C) would only work if the ground and the house were at the same temperature
D) is impossible since heat energy flows from the (hot) house to the (cold) ground
E) is possible

7. The change in entropy is zero for:

A) reversible adiabatic processes
B) reversible isothermal processes
C) reversible processes during which no work is done
D) reversible isobaric processes
E) all adiabatic processes

8. A Carnot engine operates between 400 K and 500 K. Its efficiency is:

A) 20%
B) 25%
C) 44%
D) 79%
E) 100%

9. A slow (quasi-static) process is NOT reversible if:

A) the temperature changes
B) energy is absorbed or emitted as heat
C) work is done on the system
D) friction is present
E) the pressure changes

10. A cyclical process that transfers thermal energy from a high temperature reservoir to a low temperature reservoir with no other change would violate:

A) the zeroth law of thermodynamics
B) the first law of thermodynamics
C) the second law of thermodynamics
D) the third law of thermodynamics
E) none of the above

11. Let k be the Boltzmann constant. If the configuration of molecules in a gas changes from one with a multiplicity of M_1 to one with a multiplicity of M_2, then entropy changes by:

A) $\Delta S = 0$
B) $\Delta S = k(M_2 - M_1)$
C) $\Delta S = kM_2/M_1$
D) $\Delta S = k \ln (M_2 M_1)$
E) $\Delta S = k \ln (M_2/M_1)$

12. For all reversible processes involving a system and its environment:

A) the entropy of the system does not change
B) the entropy of the system increases
C) the total entropy of the system and its environment does not change
D) the total entropy of the system and its environment increases
E) none of the above

13. An engine in each cycle absorbs thermal energy from a reservoir and does an equivalent amount of work, with no other changes. This engine violates:

A) the zeroth law of thermodynamics
B) the first law of thermodynamics
C) the second law of thermodynamics
D) the third law of thermodynamics
E) none of the above

14. An engine absorbs thermal energy of magnitude $|Q_H|$ from a high temperature reservoir, does work of magnitude $|W|$, and rejects thermal energy of magnitude $|Q_L|$ to a low temperature reservoir. Its efficiency is:

A) $|Q_H|/|W|$
B) $|Q_L|/|W|$
C) $|Q_H|/|Q_L|$
D) $|W|/|Q_H|$
E) $|W|/|Q_L|$

15. Let S^{irrev} denote the change in entropy of a sample for an irreversible process from state A to state B. Let S^{rev} denote the change in entropy of the same sample for a reversible process from state A to state B. Then:

A) $S^{\text{irrev}} > S^{\text{rev}}$
B) $S^{\text{irrev}} = S^{\text{rev}}$
C) $S^{\text{irrev}} < S^{\text{rev}}$
D) $S^{\text{irrev}} = 0$
E) $S^{\text{rev}} = 0$

16. A hot object and a cold object are placed in thermal contact and the combination is isolated. They transfer energy until they reach a common temperature. The change ΔS_h in the entropy of the hot object, the change ΔS_c in the entropy of the cold object, and the change ΔS^{net} in the entropy of the combination are:

A) $\Delta S_h > 0$, $\Delta S_c > 0$, $\Delta S^{\text{net}} > 0$
B) $\Delta S_h < 0$, $\Delta S_c > 0$, $\Delta S^{\text{net}} > 0$
C) $\Delta S_h < 0$, $\Delta S_c > 0$, $\Delta S^{\text{net}} < 0$
D) $\Delta S_h > 0$, $\Delta S_c < 0$, $\Delta S^{\text{net}} > 0$
E) $\Delta S_h > 0$, $\Delta S_c < 0$, $\Delta S^{\text{net}} < 0$

17. The thermodynamic state of a gas changes from one with 3.8×10^{18} microstates to one with 7.9×10^{19} microstates. The Boltzmann constant is 1.38×10^{-23} J/K. The change in entropy is:

A) $\Delta S = 0$
B) $\Delta S = 1.04 \times 10^{-23}$ J/K
C) $\Delta S = -1.04 \times 10^{-23}$ J/K
D) $\Delta S = 4.19 \times 10^{-23}$ J/K
E) $\Delta S = -4.19 \times 10^{-23}$ J/K

18. One mole of an ideal gas expands reversibly and isothermally at temperature T until its volume is doubled. The change of entropy of this gas for this process is:

A) $R \ln 2$
B) $(\ln 2)/T$
C) 0
D) $RT \ln 2$
E) $2R$

19. According to the second law of thermodynamics:

A) all engines have the same efficiency
B) all reversible engines have the same efficiency
C) the efficiency of any engine is independent of its working substance
D) the efficiency of a Carnot engine depends only on the temperatures of the two reservoirs
E) all Carnot engines theoretically have 100% efficiency

20. A perfectly reversible heat pump with a coefficient of performance of 14 supplies thermal energy to a building to maintain its temperature at 27º C. If the pump motor does work at the rate of 1 kW, at what rate does the pump supply thermal energy to the building?

A) 15 kW
B) 3.85 kW
C) 1.35 kW
D) 1.07 kW
E) 1.02 kW

21. After one complete cycle of a reversible engine, which of the following quantities is NOT zero?

A) the change ΔS of the entropy of the working gas
B) the change ΔP of the pressure of the working gas
C) the change ΔE_{int} of the internal energy of the working gas
D) the work W done by the working gas
E) the change ΔT of the temperature of the working gas

22. An ideal gas expands into a vacuum in a rigid vessel. As a result there is:

A) a change in entropy
B) an increase of pressure
C) a change in temperature
D) a decrease of internal energy
E) a change in phase

23. An Carnot refrigerator runs between a cold reservoir at temperature T_C and a hot reservoir at temperature T_H. You want to increase its coefficient of performance. Of the following, which change results in the greatest increase in the coefficient? The value of ΔT is the same for all changes.

A) Raise the temperature of the hot reservoir by ΔT
B) Raise the temperature of the cold reservoir by ΔT
C) Lower the temperature of the hot reservoir by ΔT
D) Lower the temperature of the cold reservoir by ΔT
E) Lower the temperature of the hot reservoir by $\frac{1}{2}\Delta T$ and raise the temperature of the cold reservoir by $\frac{1}{2}\Delta T$

24. The difference in entropy $\Delta S = S_B - S_A$ for two states A and B of a system can computed as the integral $\int dQ/T$ provided:

A) A and B are on the same adiabat
B) A and B have the same temperature
C) a reversible path is used for the integral
D) the change in internal energy is first computed
E) the energy absorbed as heat by the system is first computed

25. Which of the following is NOT a state variable?

A) Work
B) Internal energy
C) Entropy
D) Temperature
E) Pressure

Answer Key

1. D
2. C
3. A
4. B
5. D
6. E
7. A
8. A
9. D
10. E
11. E
12. C
13. C
14. D
15. B
16. B
17. D
18. A
19. D
20. A
21. D
22. A
23. B
24. C
25. A