ITESM
Q4001 Thermodynamics of Materials
Diagnostic Exam

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1. Which of the following is true about any system that undergoes a reversible thermodynamic process?

→ A. There are no changes in the internal energy of the system.

B. The temperature of the system remains constant during the process.

→ C. The entropy of the system and its environment remain unchanged.

D. The entropy of the system and its environment must increase.

→ E. The net work donde by the system is zero.

2. For which of the following thermodynamic processes is the increase in the internal energy of an ideal gas equal to the heat added to the gas?

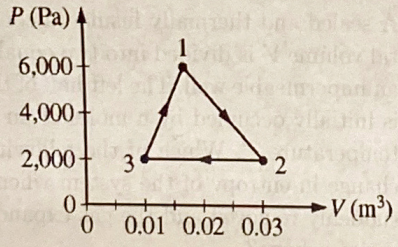
A. Constant temperature

B. Constant volume

C. Constant pressure

D. Adiabatic

→ E. Cyclic



× 3. A sample of nitrogen gas undergoes the cyclic thermodynamic process shown above. Which of the following gives the net heat transferred to the system in the complete cycle $1 \to 2 \to 3 \to 1$?

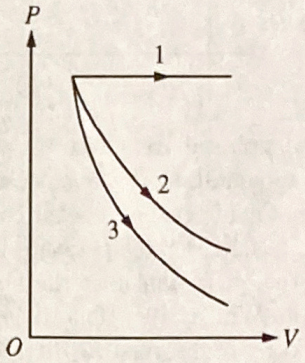
A. −80 J

B. −40 J

→ C. 40 J

D. 80 J

E. 180 J



× 4. For an ideal gas, consider the three thermodynamic processes—labeled 1,2, and 3— shown in the PV diagram above. Each process has the same initial state and the same final volume. One process is adiabatic, one is isobaric and one is isothermal. Which of the following correctly identifies the three processes?

	Adiabatic	Isobaric	Isothermal
A.	1	2	(3)
B.	2	1	(3)
C.	2	3	1
→ D.	3	1	(2)
E.	3	2	1

× 5. A monoatomic ideal gas changes from an initial state (P_i, V_i, T_i, n_i) to a final state (P_f, V_f, T_f, n_f) where $P_i < P_f$, $V_i = V_f$, $T_i < T_f$ and $n_i = n_f$. Which of the following gives the change in entropy of the gas?

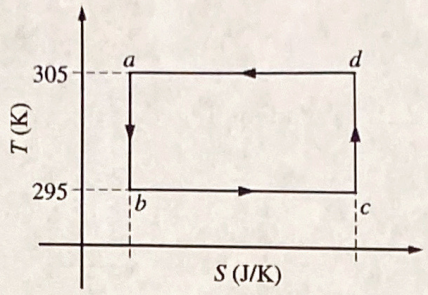
→ A. $\frac{3}{2} nR \ln \frac{T_f}{T_i}$

B. $\frac{3}{2} nR \ln \frac{T_i}{T_f}$

C. $\frac{5}{2} nR \ln \frac{T_f}{T_i}$

D. $\frac{5}{2} nR \ln \frac{T_i}{T_f}$

E. 0



6. The diagram above shows a Carnot cycle for an ideal air conditioner, which is used to cool a house on a hot summer day. The air conditioner absorbs heat at the lower temperature inside and pumps it to the environment at the higher temperature outside. Which of the following gives the ratio of the heat q_{bc} absorbed in the house (i.e. between the points b and c on the cycle) to the work done during the cycle?

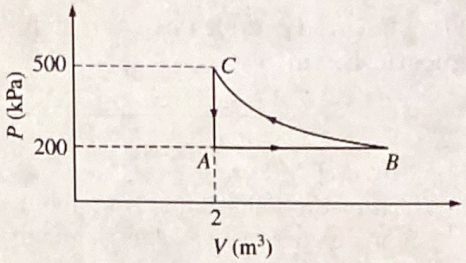
A. 0
B. 0.033
C. 0.97
D. 1.0
E. 30.

7. A three-dimensional harmonic oscillator is in thermal equilibrium with a temperature reservoir at temperature T. The average total energy of the oscillator is

A. $\frac{1}{2}k_BT$
B. k_BT
C. $\frac{3}{2}k_BT$
D. $3k_BT$
E. $6k_BT$

8. Consider the quasi-static adiabatic expansion of an ideal gas from an initial state i to a final state f. Which of the following statements is NOT true?

A. No heat flows into or out of the gas.
B. The entropy of state i equals the entropy of state f.
C. The change of internal energy of the gas is $-\int PdV$.
D. The mechanical work done by the gas is $-\int PdV$.
E. The temperature of the gas remains constant.

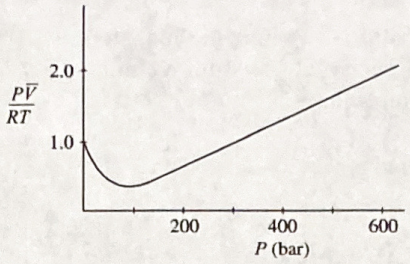


9. A constant amount of an ideal gas undergoes the cyclic process $ABCA$ in the PV diagram shown above. The path BC is isothermal. The work done by the gas during one complete cycle, beginning and ending at A, is most nearly

A. 600 kJ
B. 300 kJ
C. 0
D. −300 kJ
E. −600 kJ

10. A sealed and thermally insulated container of total volume V is divided into two equal volumes by an impermeable wall. The left half of the container is initially occupied by n moles of an ideal gas at temperature T. Which of the following gives the change in entropy of the system when the wall is suddenly removed and the gas expands to fill the entire volume?

A. $2nR\ln 2$
B. $nR\ln 2$
C. $\frac{1}{2}nR\ln 2$
D. $-nR\ln 2$
E. $-2nR\ln 2$



11. The curve shown above illustrates the $P\overline{V}$ behavior of a real gas, where $\overline{V}$ is the molar volume. Acording to the van der Waals model for nonideal gas behavior, the values of $P\overline{V}/RT$ greater than 1.0 at high pressures are due to

A. the effects of increased rate of collisions of the molecules with the walls of the container

B. the effects of dissociation of individual gas molecules

C. the effects of the volume occupied by the molecules themselves

D. the effects of the forces of attraction between the molecules

E. ideal gas behavior in this pressure region

12. Which of the following must be true for adiabatic processes?

A. $C_V = C_P$

B. $\Delta H = 0$

C. $\Delta U = 0$

D. $\Delta S = 0$

E. $q = 0$

13. Which of the following expressions involving fugacity, f, is correct as $P \to 0$?

A. $f = P$

B. $f = \frac{1}{P}$

C. $f = 1$

D. $f = \frac{1}{V}$

E. $f = V$

14. Sodium acetate spontaneously crystallizes out of a supersaturated solution on standing or on the addition of a seed crystal. Which of the following is true for the thermodynamics quantities of this system for this process?

A. $\Delta S < 0, \Delta H < 0$

B. $\Delta S < 0, \Delta G > 0$

C. $\Delta S > 0, \Delta H > 0$

D. $\Delta S > 0, \Delta G < 0$

E. $\Delta G < 0, \Delta H > 0$

$$\left(\frac{\partial U}{\partial V}\right)_T = -P + T\left(\frac{\partial P}{\partial T}\right)_V$$

15. Given the expression above, what is the value of $\left(\frac{\partial U}{\partial V}\right)_T$ for an ideal gas undergoing an isothermal expansion? ($PV = nRT$ for an ideal gas.)

A. $-P + \frac{nR}{V}$

B. nR

C. $-P$

D. 1

E. 0

$$\left(P + \frac{an^2}{V^2}\right)(V - nb) = nRT$$

16. Of the following substances, which is likely to have he largest value of the coefficient a in the van der Waals equation of state for real gases shown above?

A. H_2

B. N_2

C. CH_4

D. NH_3

E. CO_2

17. Which of the following is always true of a spontaneous process?

A. The process is exothermic.

B. The process does not involve any work.

C. The entropy of the system increases.

D. The internal energy of the system decreases.

E. The total entropy of the system plus surroundings increases.

18. The equation $\Delta H = \Delta U + P\Delta V$ is applicable

A. always
B. only for constant pressure processes
C. only for constant temperature processes
D. only for constant volume processes
E. only for constant entropy processes

19. What is the maximum number of phases that can be at equilibrium with each other in a three-component mixture?

A. 2
B. 3
C. 4
D. 5
E. 6

20. What is the limiting high-temperature molar heat capacity at constant volume (C_V) of a gas-phase diatomic molecule?

A. $\frac{3}{2}R$
B. $2R$
C. $\frac{5}{2}R$
D. $3R$
E. $\frac{7}{2}R$