WEEK 4 HOMEWORK DUE on Monday 10/27/08

Multiple Choice

Identify the choice that best completes the statement or answers the question.

1. (1 point) In an isobaric process $4.5 \times 10^4$ J of work is done on a quantity of gas while its volume changes from 2.6 m$^3$ to 1.1 m$^3$. What is the pressure during this process?
   a. $1.2 \times 10^4$ Pa
   b. $2.4 \times 10^4$ Pa
   c. $3.0 \times 10^4$ Pa
   d. $4.1 \times 10^4$ Pa

2. (1 point) What is the work done on the gas as it expands from pressure $P_1$ and volume $V_1$ to pressure $P_2$ and volume $V_2$ along the indicated straight line?

   \[ W = \text{area under the curve: } P_i (V_2 - V_1) + \frac{1}{2} (P_1 - P_i) (V_2 - V_1) = \]
   \[ = (P_1 + \frac{1}{2} P_2 - \frac{1}{2} P_1)(V_2 - V_1) = \]
   \[ = \frac{1}{2} (P_1 + \frac{1}{2} P_2)(V_2 - V_1) = \]
   \[ = \frac{1}{2} (P_1 + P_2)(V_2 - V_1) \]
   
   a. $(P_1 + P_2)(V_1 - V_2)/2$
   b. $(P_1 + P_2)(V_1 - V_2)$
   c. $(P_1 + P_2)(V_1 - V_2)/2$
   d. $(P_1 - P_2)(V_1 + V_2)$

3. (1 point) A system is acted on by its surroundings in such a way that it receives 50 J of heat while simultaneously doing 20 J of work. What is its net change in internal energy?
   a. 70 J
   b. 30 J
   c. zero
   d. -30 J

4. (1 point) In an isovolumetric process by an ideal gas, the system's heat gain is equivalent to a change in:
   a. temperature.
   b. volume.
   c. pressure.
   d. internal energy.

   \[ \Delta U = Q - W = Q - p \Delta V \]
   \[ \text{Isovolumetric: } V = \text{const} \implies \Delta V = 0 \]
   \[ \Delta U = Q \]
5. (1 point) The adiabatic index of a gas is given by which of the following?
   a. $C_p/C_v$
   b. $C_v/C_p$
   c. $C_p - C_v$
   d. $C_p + C_v$

6. (1 point) A 4-mol ideal gas system undergoes an adiabatic process where it expands and does 20 J of work on its environment. What is its change in internal energy?
   a. $-20 J$
   b. $-5 J$
   c. zero
   d. $+20 J$

7. (1 point) A quantity of monatomic ideal gas expands adiabatically from a volume of 2.0 liters to 6.0 liters. If the initial pressure is $P_o$, what is the final pressure?
   a. $9.0 P_o$
   b. $6.2 P_o$
   c. $3.0 P_o$
   d. $0.16 P_o$

8. (2 points) An ideal gas at pressure, volume, and temperature, $P_o$, $V_o$, and $T_o$, respectively, is heated to point A, allowed to expand to point B also at A's temperature $2T_o$, and then returned to the original condition. The internal energy increases by $3P_oV_o/2$ going from point $T_o$ to point A. How much heat entered the gas from point $T_o$ to point $A$?

   \[
   \Delta U = Q = \frac{3}{2} nR \Delta T
   \]

   From gas law, $PV = nRT$

   \[
   \Delta P \cdot V = nR \Delta T
   \]

   \[
   Q = \frac{3}{2} \Delta P \cdot V = \frac{3}{2} (2P_o - P_o) \cdot V_o = \frac{3}{2} P_o V_o
   \]
9. (2 points) A cylinder containing an ideal gas has a volume of 2.0 m³ and a pressure of 1.0 \times 10^5 \text{ Pa} at a temperature of 300 K. The cylinder is placed against a metal block that is maintained at 900 K and the gas expands as the pressure remains constant until the temperature of the gas reaches 900 K. The change in internal energy of the gas is +6.0 \times 10^5 \text{ J}. How much heat did the gas absorb?
   a. 0
   b. 4.0 \times 10^5 \text{ J}
   c. 6.0 \times 10^5 \text{ J}
   d. 10 \times 10^5 \text{ J}

10. (1 point) A heat engine exhausts 3000 J of heat while performing 1500 J of useful work. What is the efficiency of the engine?
   a. 15%  
   b. 33%  
   c. 50%  
   d. 60%

11. (1 point) A turbine takes in 1000-K steam and exhausts the steam at a temperature of 500 K. What is the maximum theoretical efficiency of this system?
   a. 24%  
   b. 33%  
   c. 50%  
   d. 67%

12. (2 points) During each cycle of operation a refrigerator absorbs 55 cal from the freezer compartment and expels 85 cal to the room. If one cycle occurs every 10 s, how many minutes will it take to freeze 500 g of water, initially at 0°C? \((L_v = 80 \text{ cal/g})\)
   a. 800 min  
   b. 4400 min  
   c. 120 min  
   d. 60 min

13. (1 point) A gasoline engine with an efficiency of 30.0% operates between a high temperature \(T_1\) and a low temperature \(T_2 = 320 \text{ K}\). If this engine operates with Carnot efficiency, what is the high-side temperature \(T_1\)?
   a. 1070 K  
   b. 868 K  
   c. 614 K  
   d. 457 K
14. (1 point) Which of the following choices best corresponds to what is required by the second law of thermodynamics for any process taking place in an isolated system?
   a. entropy decreases
   b. entropy remains constant
   c. entropy increases
   d. entropy equals work done on the system

15. (1 point) A 2.00-kg block of ice is at STP (0°C, 1 atm) while it melts completely to water. What is its change in entropy? (For ice, $L_f = 3.34 \times 10^5$ J/kg)
   a. zero
   b. $584 \text{ J/K}$
   c. $1220 \text{ J/K}$
   d. $2450 \text{ J/K}$

16. (2 points) The surface of the Sun is at approximately 5700 K and the temperature of the Earth's surface is about 290 K. What total entropy change occurs when 1000 J of heat energy is transferred from the Sun to the Earth?
   a. $2.89 \text{ J/K}$
   b. $3.27 \text{ J/K}$
   c. $3.62 \text{ J/K}$
   d. $3.97 \text{ J/K}$

\[ \Delta S_{\text{Sun}} = -\frac{1000 \text{ J}}{5700 \text{ K}} = -0.18 \text{ J/K} \]
\[ \Delta S_{\text{Earth}} = +\frac{1000 \text{ J}}{290 \text{ K}} = +3.45 \text{ J/K} \]
\[ \Delta S_{\text{total}} = \Delta S_{\text{Sun}} + \Delta S_{\text{Earth}} = -0.18 \text{ J/K} + 3.45 \text{ J/K} = 3.27 \text{ J/K} \]