Name: ______________________

Class: ______________________

Due Date: ______________________

Physics Topic 26B Thermodynamics – Entropy, Second and Third Law, Statistics

Answer the following questions. The solutions to this worksheet can be found on the YouTube channel Go Physics Go.

1. C: Define *entropy* S. Units?

2. C: Describe the equation $\Delta S = \frac{\Delta Q}{T}$.

3. C: The change in entropy S of a system is defined as $\Delta S = \frac{\Delta Q}{T}$.

    a. What can we do to make ΔS positive?

    b. What can we do to make ΔS negative?

4. E: A cup of hot chocolate at a temperature of 90.0°C is in a room with an ambient temperature of 23.0°C. If the temperature of the hot chocolate and room do not change and 1.97×10^3 J of energy flows out of the hot chocolate to the room then determine the change in entropy.

5. E: Two large cubes filled with water are separated by a thin thermally conducting metal plate. The temperature of the water in cube 1 is 82.0°C and the temperature of the water in cube 2 is 39.0°C. Determine the change in entropy of the whole system if heat flows between the plate at 249 Joules per second.

6. E: 400. g of ice at 0.00°C melts to water at a constant temperature. The latent heat of fusion of $\mathrm{H_2O}$ is $3.34 \times 10^5\ \frac{\mathrm{J}}{\mathrm{kg}}$. Determine the change in entropy.

7. E: 500. g of water at 0.00°C freezes to ice at a constant temperature. The latent heat of fusion of $\mathrm{H_2O}$ is $3.34 \times 10^5\ \frac{\mathrm{J}}{\mathrm{kg}}$. Determine the change in entropy.

8. E: 600. g of boiling water at 100.°C vaporizes to steam at a constant temperature. The latent heat of vaporization of $\mathrm{H_2O}$ is $2.26 \times 10^6\ \frac{\mathrm{J}}{\mathrm{kg}}$. Determine the change in entropy.

9. E: 800. g of steam at 100.°C condenses to water at a constant temperature. The latent heat of vaporization of $\mathrm{H_2O}$ is $2.26 \times 10^6\ \frac{\mathrm{J}}{\mathrm{kg}}$. Determine the change in entropy.

10.E: A piston is slowly compressed so the temperature of the ideal gas inside it remains at 40.0°C. 748 J of work is done on the gas. Determine the change in entropy of the gas.

11.E: A piston is slowly expanded so the temperature of the ideal gas inside it remains at 68.3°C. 498 J of work is done by the gas. Determine the change in entropy of the gas.

12.C: Describe the equation $S = k_{\mathrm{B}} \ln \Omega$.

13.E: Determine the entropy of a system which has 7.53×10^{45} microstates.

14.C: State the *second law of thermodynamics.*

15.C: State the *Clausius version* of the *second law of thermodynamics.*

16.C: State the *Kelvin version* of the *second law of thermodynamics.*

17.C: State the *arrow of time* and *entropy* in terms of the *second law of thermodynamics*.

18.C: State the *third law of thermodynamics.*

19.C: Describe the equation $PV^{\frac{5}{3}} = \text{constant}$.

20.E: An ideal gas is initially held at a pressure of 1.23×10^4 Pa, a volume of 9.06×10^{-1} m^3, and a temperature of 348 K. The ideal gas then expands adiabatically to a new volume of 1.00×10^1 m^3. Determine the final pressure and final temperature of the ideal gas.

21. E: An ideal gas is initially held at a pressure of 7.65×10^4 Pa, a volume of 9.63×10^{-1} m^3, and a temperature of 388 K. The ideal gas then compresses adiabatically to a new volume of 8.28×10^{-1} m^3. Determine the final pressure and final temperature of the ideal gas.

22.E: In an adiabatic process the volume of a piston increases from $145\ \mathrm{cm}^3$ to $194\ \mathrm{cm}^3$. By which factor does the pressure change?

23.E: In an adiabatic process the pressure of a piston increases from 3.03×10^5 Pa to 7.07×10^5 Pa. By which factor does the volume change?

24.C: Define *heat engine* and *heat pump.*

25.C: **Use a pencil!** Carefully and clearly draw the *Carnot cycle*. Label the vertical axis and the horizontal axis. Label the adiabatic processes and isothermal processes.

26.C: In general the efficiency of an engine is $\eta = \frac{\text{useful work}}{\text{input energy}}$. For a *Carnot engine* $\eta_{\text{carnot}} = 1 - \frac{T_{\text{cold}}}{T_{\text{hot}}}$.

a. Is the *Carnot cycle* a fast or slow process?

b. Is the *Carnot cycle* realistic?

c. Is the *Carnot cycle* efficient?

27.E: Calculate the efficiency of a Carnot engine operating between the following temperatures.

a. 123°C and 23.0°C

b. 223°C and 123°C

c. 323°C and 223°C

28.E: Suppose you have 12 two-sided fair unbiased coins. You throw them all up and count the number of heads and number of tails. You want to determine the number of arrangements to land one head, two heads, three heads, etc. and also its probability. Complete the table below: