Thermodynamics Pre-Nationals Exam II

Partial credit may be given where work is shown. **Give all answers to three significant figures**.

1) Water
   a. What purpose do water baths usually serve in thermodynamics? [1]

   b. What property of water allows it to serve this purpose? [1]

   c. Describe the water-involving experiment which originally proved that mechanical energy could be converted to thermal energy? Also, give the scientist, and the year of this experiment. [4]

   d. Liquid water reaches peak density at what temperature? The non-polar n-octane has boils at 125°C and melts at -57°C, at what temperature does it reach peak density. Explain why water's peak density is not 0°C. [4]

2) Adiabatic Processes
   a. Adiabatic processes meet what restriction. [1]

   b. A reversible, adiabatic process can also be called what? [1]

   c. If a process undergoes an adiabatic expansion, which of the following increase, and which decrease? U, P, V, T, H, S [6]

d. Draw a reversible adiabat on both a PV diagram and a TS diagram. On the PV diagram, also draw in isotherms. [4]

e. Give two practical way of making a process adiabatic. [2]

3) Calorimetry
   a. 3.2kg of water are in a .89kg aluminum pot, which is thermally isolated from its surroundings and at 23.2°C. A .3kg copper bar is dropped in at 346°C. What temperature is the water after the system reaches equilibrium? [4]

   b. After the events described above, the copper bar is removed from the system. Describe what happens, with all relevant calculations. [2]

c. Describe the design of a bomb calorimeter. What do people use it for? [2]

4) Chemistry
    a. Using standard entropies and heats of formation, compute the change in enthalpy and change in free energy for the combustion of butane (C_4H_{10}). combustion reactions of hydrocarbons form $CO_{2(g)}$ and $H_2O_{(g)}$. [6]

5) Processes
    a. A monatomic, ideal gas at 0°C and 1atm occupies 57.3L. It expands isothermally to 4 times its volume, is then compressed isobarically to its original volume, after which it is returned to its original temperature, isochorically. Calculate ΔU, q, and w for 1 cycle. Pay attention to the signs. [8]

    b. Determine whether ΔU, q, and w would increase, decrease, or stay constant if the gas were diatomic. [4]

6) Using the example of a rectangular prism of width x, height y, and depth z, derive the approximate relationship between the coefficient of linear expansion and the coefficient of volumetric expansion. Under what conditions does this approximation break down? Work must be shown. [8]

7) The laws of thermodynamics: Identify each sentence as an expression of the laws of thermodynamics, by number. [8]
   a. Any non-crystalline substance will always have entropy.
   b. The universe tends to proceed in the direction that increases disorder.
   c. Temperature is the only variable needed to determine if two objects are in thermal equilibrium
   d. Internal energy is a state function
   e. $\Delta S \geq 0$
   f. If A is in thermal equilibrium with B, and B with C, then A is in thermal equilibrium with C
   g. Heat flows from areas of high temperature to areas of low temperature.
   h. $\Delta U = q + w$
8) History of Thermodynamics
   a. Who is considered the father of statistical thermodynamics? [1]

   b. What equation did he derive? Give the value of any constants, and identify all variables. [4]

   c. On what significant object (to him) is that equation engraved? [1]

   d.