Name

1. (5 points) One of the most important molecules in biochemical systems is adenosine triphosphate, ATP. ATP has a molecular formula of $C_{10}H_{12}N_5O_{13}P_{3(s)}$. Write the equation for the standard enthalpy of formation for 1 mole of adenosine triphosphate. (elemental P is $P_{4(s,\ wwhite)}$)

2. (5 points) The optic nerve needs a minimum of 2.00 x 10^{-17} J of energy to trigger a series of impulses that eventually reach the brain for the eye to detect visible light. How many photons of yellow-orange light with a λ = 589 nm are emitted from a low-pressure sodium lamp in a parking lot?

3. (5 point) Calculate the standard enthalpy of reaction, using enthalpies of formation for the reaction below. Show your work for full credit; Show positive and negative signs clearly in answers for clarity.

$$O_{2(g)} + 4NH_{3(g)} \rightarrow 2\ N_2H_{4(g)} + 2\ H_2O_{(g)}$$

$\Delta H°f\ (NH_{3(g)}) = -46.19$ kJ/mol; $\Delta H°f\ (H_2O_{(g)}) = -241.82$kJ/mol;
$\Delta H°f(N_2H_{4(g)}) = 95.40$ kJ/mol; $\Delta H°f\ (H_2O_{(l)}) = -285.83$kJ/mol

4. (10 points) Given below are several electron configurations that might be correct for the oxygen atom. Indicate whether each of these representations are the ground state, the excited state, or un-allowed (forbidden) state. Using Hund's rule, the Pauli principle, and aufbau (building up), BRIEFLY explain your choices. [Some might violate more than one rule.]

a) ↑↓ ↑↓ ↓↑ ↑ ↓ ___ ES GS FS
1s 2s 2p 3s

b) ↑↓ ↑↓ ↑ ↑ ↑↓ ___ ES GS FS
1s 2s 2p 3s

c) ↑↓ ↑↓ ↑↑ ↑ ↑ ___ ES GS FS
1s 2s 2p 3s

d) ↑↓ ↑↓ ↑ ↑ ↑ ↑ ES GS FS
1s 2s 2p 3s

e) ↑↓ ↑↓ ↑↓ ↑↓ ___ ___ ES GS FS
1s 2s 2p 3s

5. (8 points total) The combustion of 0.1584 g benzoic acid increases the temperature of a bomb calorimeter by 2.54°C.
    a. (4 points) Calculate the heat capacity of the calorimeter. The energy released by the combustion of benzoic acid is —26.42 kJ per gram.
    b. (4 points) A 0.2130 g sample of the vanillin is burned in the same calorimeter, and the temperature increases by 3.25°C. What is the energy of combustion of vanillin in kJ/g? Show positive and negative signs clearly in answers for clarity.

6. (6 points) A sample of platinum metal must absorb radiation with a minimum energy (Work function, ϕ)of 6.35 eV before it can emit an electron from its surface via the photoelectric effect.
    a. (2 points) What is the minimum energy required to produce this effect in Joules? [1.6022×10^{-19}J = 1 eV]
    b. (2 points) What wavelength radiation will provide a photon of this energy?
    c. (2 points) If the surface of the platinum sample is radiated with light of wavelength 55.4 nm, what is the maximum possible kinetic energy of the emitted electrons?

7. **EXTRA CREDIT** (6 points) The bromine monochloride molecule, has a bond length of 213.8 pm and a dipole moment of 0.518D.
   a. Which atom in the molecule is expected to have a negative charge. Briefly explain your choice.
   b. Calculate the effective charges on the Br and Cl atoms in the molecule in units of the electron charge e. (constants and formula on front page).
   c. Draw the molecule showing the direction of the dipole and the charge in e^{-}(i.e., the fraction of the charge of an electron) units on each atom in the molecule

8. (6 points) Ammonia will burn in the presence of a platinum catalyst to produce nitric oxide, NO. Determine the heat of reaction at constant pressure? Show your work for full credit; Show positive and negative signs clearly in answers for clarity.

PATHWAY OF INTEREST $4\ NH_{3(g}+5\ O_{2(g)}\rightarrow 4\ NO_{(g)} + 6\ H_2O_{(g)}$

PATHWAY 1:	$N_{2(g)} + O_{2(g)}\rightarrow 2\ NO_{(g)}$	$\Delta H = +180.6$ kJ
PATHWAY 2:	$N_{2(g)} + 3\ H_{2(g)}\rightarrow 2\ NH_{3(g)}$	$\Delta H = -91.8$ kJ
PATHWAY 3:	$2\ H_{2(g)} + O_{2(g)}\rightarrow 2\ H_2O_{(g)}$	$\Delta H = -483.7$ kJ

9. [4 points] An electron in the hydrogen atom can undergo only set transitions. Calculate the wavelength for an electron transitioning from n =12 to n =3. Based on n_f, is this visible, infrared, or ultraviolet light? Explain your choice.

10. (8 points) A 28.2 g sample of nickel is heated to 99.8 °C and placed in a coffee cup calorimeter containing 150.0 g of water at 23.5°C. After the metal cools (and the water warms!) the final temperature of the metal and the water is 25.0°C. Calculate the specific heat capacity of nickel, if no heat escapes to the environment. Show positive and negative signs clearly in answers for clarity.

11. (6 points) Give the electron configuration for the following elements or ions. [You can give noble gas core]:

    a. Sb

    b. Polonium

    c. Nickel (III) ion

    d. Cu

    e. Cr^{2+}

    f. Co^{2+}

12. 6 points) Fill in the blanks with the correct response:
    a. The number of orbitals with the quantum numbers [3,1,1] is

    b. The number of un-paired electrons in a Co^{2+} ion is

    c. When n = 5, the angular momentum quantum number***, l***, can be what value(s)

    a) Of, the 3s, the $5fy^3$, and the $9d_{xy}$ orbitals, the orbital with the smallest number of radial nodes.

    d. The sub shell with the quantum numbers [7,3] is

    e. Which color of visible light has the lowest energy?

    f. Light with a short wavelength has a (high/low) energy. (

13. **Part 1** (0.25 points) Assuming constant pressure, Determine the relative energies, based on the following descriptions:

   a. Surroundings get hotter and the volume of the system increases.
   b. Surroundings get hotter and the volume of the system decreases
   c. Surroundings get colder and the system expands in volume.
   d. Surroundings get hotter and the volume of the system does not change.

system	The q of the system is +/—?	The value of w is +/—?	ΔE is +/— or undetermined
A			
B			
C			
D			

Part 2: (3 points) Fluorine and chlorine gas react to make chlorine trifluoride. Before the reaction, the volume of the gaseous mixture was 10.00 L. After the reaction, the volume was 3.00 L. Calculate the value of the total energy change for the creation of one mole of chlorine trifluoride, ΔE, in kilojoules. [HINT: w =-PΔV] (This will come in handy: 101.33 J = 1L•atm) the pressure is 95.0 atm.

Show positive and negative signs clearly in answers for clarity.

$$\frac{3}{2} F_{2(g)} + \tfrac{1}{2} Cl_{2(g)} \rightarrow ClF_{3(g)} \qquad \Delta H^\circ_f = -158.87 \text{ kJ/mol}$$

Express your answer with the appropriate units.

14. (10 points) Circle the best choice in the list and explain your choice based on shielding effects, quantum shielding, and/or Z_{eff}. Writing true or false = zero points. (use the back of the page for more space-number your answers)

    a. Smallest radius: Ca^{2+}, Sr^{2+}, Ra^{2+}

    b. Lowest first ionization energy: K, Ca, Sc

    c. Smallest atom: As, I, Br

    d. Largest negative electron affinity: O, B, Na

    e. The largest ion or atom Al^{3+}, Al, Al^{2+}

15. (12 points) A quantity of Neon gas originally at 5.25 atm in a 2.00-L container at 26.0°C is transferred to a 12.5 L container at 20°C. A quantity of He originally at 5.25 atm and 26.0°C in a 5.00-L container is transferred to the same container (12.5L) containing the neon.

    a. (3 points) What is the pressure of the neon in the new container?
    b. (3 points) What new pressure of the He gas?
    c. (2 points) What is the total pressure of the new container?
    d. (4 points) What are the mole fractions of He and Ne in the new container?

16. (6 points) The titanium (II) ion is iso-electronic with the calcium atom. Briefly explain your answers for each part.
    (a) Are there any differences in the electron configurations of titanium (II) and calcium?
    (b) Will the 2s orbital in calcium be more stable than the 2s orbital in titanium?
    (c) Will calcium and titanium (II) have the same number of unpaired electrons?

17. **(6 points)** A 23.5-mL volume of hydrochloric acid reacts completely with a solid sample of $MgCO_3$. The volume of CO_2 formed is 154 mL at 25.98°C and 731.6 mmHg. What is the molarity of the acid solution?

$$2HCl_{(aq)} + MgCO_{3(s)} \rightarrow CO_{2(g)} + H_2O_{(l)} + MgCl_{2(aq)}$$

18. (5 points) Using your knowledge of the everyday and super hero world, place the following sources of light in order of increasing energy: [This means: start with the smallest (lowest) energy and end at the highest energy. Do not put numbers next to the letters; you need to write out the correct order of letters. You will receive no credit if you are not clear about your answer.]:

    a. Gamma rays that turned Bruce Banner into the Hulk
    b. The red color in red dye no. 28; a component of an insecticide used to kill Mediterranean fruit flies
    c. Infrared heat from the wires in your toaster used to burn toast
    d. Superman's x-ray vision used to see through walls and watch nefarious evil deed doers.
    e. The green color of the Green Lantern's lamp

19. (6 points) At a given temperature and pressure, it takes 4.85 minutes for a 1.5 L sample of helium effuse through a membrane. How long does it take for 1.5 L of fluorine effuse under the same conditions? Rate = distance/time. Assume that the membranes are 3.0 nm long.