1. (6 points) Two flasks of equal volume are filled with a gas. Flask A contains H_2 at 0°C and 1 atm pressure. Flask B contains CO_2 at 0°C and 1atm pressure. Compare these two gases, using the postulates of KMT, with respect to each of the following: [hint: start with a definition]

    a. The average kinetic energy per molecule

    b. The average molecular velocity.

    c. The number of molecules

2. (4 points) An incandescent light bulb is filled with 6.00×10^{-5} mol of argon. The bulb has a volume of 800.0 mL. What is the pressure of the argon in the light bulb at 75°C?

3. (7 points) Give the name or electron configuration for the following elements or ions. [You can give noble gas core]:
   a. As^{5+}
   b. Thallium (element 81)
   c. Iron(II)
   d. Phosphorus
   e. $[Ar]4s^1 3d^{10}$
   f. $[Xe]6s^2$
   g. Ge^{2+}

4. (5 points) What is the molar mass of a compound that takes 2.0 times longer to effuse through a porous plug than it did for the same amount of XeF_2 at the same temperature and pressure?

5. (4 points) State which of the following sets of quantum numbers would be possible and which would not. Using one or two sentences (not <,>, =,≥, or any with slashes-use your words) explain what is wrong with the quantum numbers that are not possible. Note: missing the spin quantum number is not an error.

    a. [1,0,0]

    b. n =5, l = 9, ml = -1

    c. [-5, 0, 1]

    d. [2, -1, 0]

6. (5 points) Circle the best choice in the list:

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

    b. Lowest **<u>second</u>** ionization energy: Mg, Ne, Na

    c. Smallest atom: Sn, I, At

    d. Impossible shell designation: 4g, 5d, 4p

    e. Largest negative electron affinity: O, B, N

7. (8 points) Fill in the blanks with the correct response:

   a. The number of orbitals with the quantum numbers [3,2,0] is

   b. When n = 2, the angular momentum quantum number ,l, can be what value(s)

   c. The total number of electrons with n=4, l = 1 is

   d. Two electrons in the same _____ must have opposite spin.

   e. The 2p orbitals of an atom have identical shapes but differ in their _____ .

   f. A nodal surface is one at which the probability of finding an electron is _____..

   g. A 6f orbital has _____angular nodes. .

   h. A 12d orbital has _____ radial nodes? .

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.

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:	$2\ H_{2(g)} + O_{2(g)} \rightarrow 2\ H_2O_{(g)}$	$\Delta H = -483.7$ k

9. (5 points) An ideal gas initially at 1,209 mmHg and 30.00°C occupies 2,567 mL. Calculate the final temperature in **°C**, if the conditions are changed to a pressure of 1.50 atm and volume of 5.32 L

10. (7 points) A self-contained breathing apparatus uses canisters containing potassium superoxide, KO_2. The superoxide consumes the CO_2 exhaled by a person and replaces it with oxygen. What mass of potassium superoxide is required to react with 8.00 L of carbon dioxide at 22.0°C and 767 mmHg?

$$4KO_{2(s)} + 2CO_{2(g)} \rightarrow 2K_2CO_{3(s)} + 3O_{2(g)}$$

11. (10 points) A sample of gold metal must absorb radiation with a minimum frequency of 1.2619×10^{15}s-1 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? (ϕ)
    b. (2 points) What wavelength radiation will provide a photon of this energy?
    c. (2 points) If the surface of the gold sample is radiated with light of wavelength 106 nm, what is the maximum possible kinetic energy of the emitted electrons?

12. (4 points) One measure of the strength of the bonds holding the ions together is the melting point. the more strongly the ions are held together, the higher the melting point. MgO has a melting point of 2852°C. Which of these would you predict is the melting point of MgS: ≈2000°C, ≈2850°C, ≈ 4000°C? Explain your reasoning using columbic interactions.

13. (14 points) The atoms and ions Na, Mg^{+}, Al^{2+}, and Si^{3+} all have the same number of electrons—they are an iso-electronic series. (No, I did not make a mistake on the charges!)

i. (4 points) Draw the box diagram of the valence electrons of the of the **atoms** of these ions. (if the ion is Li^{+}, Li is the atom)

ii. (4 points) Draw the box diagram of the valence electrons of the **ions**.

iii. (1 point) How many electrons does each **ion** have?

iv. (1 point) How many protons does each **ion have?**

v. (1 point) For which of these **ions** will the effective nuclear charge acting on the outermost electron be the greatest?

vi. (1 point) How will it affect the size? Explain in one or two sentences.

vii. (2 Points) Based on effective nuclear charge (Z_{eff}), which one will have the largest ionization energy? Explain in one or two sentences.

14. (6 points) Heats of formation are often used to determine the desirability of a fuel for rockets. Using the heats of formation below, calculate the $\Delta H°_{rxn}$ for the reaction of chlorine trifluoride with dimethyl hydrazine in the following reaction:

$$4ClF_{3(l)} + (CH_3)_2N_2H_{2(l)} \rightarrow 2CF_{4(g)} + N_{2(g)} + 4HCl_{(g)} + 4HF_{(g)}$$

$\Delta H°_{f(HCl(g))} = -92.30$kJ/mol, $\Delta H°_{f(HF(g))} = -268.61$kJ/mol, $\Delta H°_{fCF4(g)} = -679.9$kJ/mol,

$\Delta H°_{fClF3} = -158.87$kJ/mol, $\Delta H°_{f(CH3)2N2H2(l)} = 48.3$kJ/mol,

15. (6 points) A 0.692 g sample of glucose ($C_6H_{12}O_6$) is burned in a constant volume calorimeter. The temperature rises from 21.70°C to 25.22°C. The bomb calorimeter has a heat capacity, C_v, of 656.5J/K. what is the quantity of heat evolved per mole of glucose?

16. (6 points) A 50.0-g sample of water at 100.00°C was placed in an insulated cup. Then 25.3-g of zinc at 25.00°C was added to the water. The temperature of the water dropped to 96.68°C. What is the specific heat of the zinc?

17. [4 points] An electron in the hydrogen atom can undergo only set transitions. Calculate the wavelength (4 significant figures) for an electron transitioning from n =12 to n =3.

18. (8 points) Given below are several electron configurations that might be correct for the nitrogen atom. Indicate (**by circling)** whether each of these representations are the ground state (GS), the excited state (ES), or un-allowed (forbidden) state (FS). Using Hund's rule, the Pauli principle, and Aufbau (building up), BRIEFLY explain your choices. [Some might violate more than one rule.]

1s	2s	2p	3s			
$\uparrow\downarrow$	$\uparrow\downarrow$	$\uparrow$ $\uparrow$ $\downarrow$	__	GS	ES	FS

a. Reason for your choice:

1s	2s	2p	3s			
$\uparrow\downarrow$	$\uparrow\downarrow$	$\uparrow$ $\uparrow$ $\uparrow$	__	GS	ES	FS

b. Reason for your choice:

1s	2s	2p	3s			
$\uparrow\downarrow$	$\uparrow\uparrow$	$\downarrow$ $\downarrow$ $\downarrow$	__	GS	ES	FS

c. Reason for your choice:

1s	2s	2p	3s			
$\uparrow\downarrow$	__	$\uparrow$ $\uparrow$ $\uparrow$	$\uparrow\downarrow$	GS	ES	FS

d. Reason for your choice:

Scratch Paper