You may use a writing implement, hand-calculator, and your Periodic Table (unmarked, tan, honor code) as obtained in this course. **NO** scratch paper is permitted! As requested of the faculty by the Student Executive Committee, students must sit in every other seat during the test. The PROPER METHOD (i.e., Problem Set 0) must be shown clearly on all problems, and final answers must be expressed in appropriate form. Pay attention to dimensions!! When blanks for answers are provided, write your answer to be graded in the blank---we may not grade answers written in other locations!

These constants may apply to problems on this test:
- \( h = 6.626076 \times 10^{-34} \text{ J}\cdot\text{s} \)
- \( c = 2.99792458 \times 10^8 \text{ m/s} \)
- \( 1 \text{ u} = 1.660540 \times 10^{-27} \text{ kg} \)
- \( 1 \text{ eV} = 1.602177 \times 10^{-19} \text{ J} \)

**Dimensions of the Joule (J) = kg·m²·s⁻²**

- Mass of electron, \( m_e = 0.00054857990 \text{ u} \)
- Mass of proton, \( m_p = 1.00727647 \text{ u} \)
- Mass of neutron, \( m_n = 1.00866490 \text{ u} \)

- Charge of electron, \( e = 1.6021773 \times 10^{-19} \text{ C} \)
- Vacuum permittivity, \( \varepsilon_0 = 8.8541878 \times 10^{-12} \text{ C}^2\cdot\text{J}^{-1}\cdot\text{m}^{-1} \)
- \( \text{LD}_{50} \) (human radiation) = 5 Gy
- 1 Gy = 1 J·kg⁻¹

- \( \pi \) (should be on your calculator, in case it is not....) = 3.1415926

- \( k \) (Dr. Uffelman's little constant in Coulomb's law) = \( \frac{e^2}{4\pi\varepsilon_0} = 2.3070795 \times 10^{-28} \text{ J} \cdot \text{m} \)

- Rydberg constant, \( R = \frac{e^4 m_e}{8 \varepsilon_0^2 h^2} = 2.18 \times 10^{-18} \text{ J} \)

**Gas Constant** \( R = 0.08206 \text{ L}·\text{atm}·\text{mol}^{-1}·\text{K}^{-1} \)

**DO NOT DETACH THIS PAGE FROM YOUR TEST!!!!**

It is your responsibility to make sure the test you turn in has 5 securely fastened pages.
1. (7 pts) For the reaction \(2\text{Na(s)} + 2\text{HCl(g)} \rightarrow \text{H}_2(g) + 2\text{NaCl(s)}\) how many \text{liters}\ of \text{H}_2\ gas (MW = 2.02) will be produced at 50.0 °C and a pressure of 0.850 atm if 6.24 g of sodium reacts completely with an excess of gaseous HCl?

Answer:_________________

2. (6 pts) If 3.2 moles of He occupy a volume of 86.5 L at a certain pressure and temperature, how many \text{mL}\ of volume will 7.9 moles of He occupy under the same pressure and temperature conditions?

Answer:_________________

3. (7 pts) To 0.0075 L of a 0.250 M Na\(_2\)SO\(_4\) solution are added 9.2 mL of a 0.250 M Na\(_3\)PO\(_4\) solution. This mixture is then diluted with pure water to the 250.0 mL calibration mark in a volumetric flask. Determine the final molarity of Na\(^+\).

Answer:_________________

4. (2 pts) If you wanted to calculate the wavelength of a baseball, what fundamental equation would you use:

__________________________________________.

5. (2 pts) If you wanted to calculate the energy of a photon of a given wavelength, what fundamental equation(s) would you use:

__________________________________________.

6. (2 pts) If you wanted to calculate the half-life of an isotope, and you had its decay constant, what fundamental equation would you use:

__________________________________________.

7. (2 pts) In the area to the right of this question, draw a \(\pi^*_{2p}\) M.O. (be sure to indicate phases and label and identify nodes):
8. (9 pts) Write the oxidation numbers for the elements in the following entities:

\[
\begin{align*}
\text{CH}_2\text{ClBr (C central atom)} & \quad \text{CaO}_2 & \quad \text{S}_2\text{O}_3^{2-} \\
\text{C} & \quad \text{Ca} & \quad \text{S (outer)} \\
\text{H} & \quad \text{O} & \quad \text{S (central)} \\
\text{Cl} & \quad & \\
\text{Br} & 
\end{align*}
\]

9. (6 pts) Define the following terms briefly and accurately according to lecture and F&R material (do NOT illustrate them).

(a) Bronsted base: ___________________________________________________

(b) Lewis acid: _____________________________________________________

(c) Polarizability: __________________________________________________

10. (4 pts) Which of the following molecules have polar bonds? [Circle your choice(s)]

\[
\begin{align*}
\text{CO}_2 & \quad \text{CH}_4 & \quad \text{NH}_3 & \quad \text{CHCl}_3 & \quad \text{H}_2 \\
\end{align*}
\]

11. (12 pts) Show by appropriate formula(s) what occurs when each of the following substances is mixed (individually) with water. Clearly use the formula(s) to distinguish between ions, molecules, and solids in the final aqueous mixtures. You must write a formula or formulas to adequately answer the question.

\[
\begin{align*}
\text{NaKSO}_4 & \quad \text{H}_2\text{S} & \quad \text{Ni(OH)}_2 \\
\text{NH}_4\text{OAc} & \quad \text{K}_4[\text{Fe(CN)}_6] & \quad \text{CH}_2\text{Cl}_2 \\
\end{align*}
\]

12. (3 pts) To do a reaction between \(\text{HPO}_4^{2-}\) and \(\text{H}_3\text{O}^+\) what two compounds might you choose to make the two separate reagent solutions (for the mixing together)?

\[
\begin{align*}
\text{_________} & \quad \text{_________} \\
\end{align*}
\]

13. (20 pts) Each of the pairs of substances listed below were first mixed with water separately. Then the two aqueous mixtures were combined with thorough stirring. For each pair:
(a) show by appropriate formula(s) what would be present in the separate mixtures; and then  
(b) deduce and write the balanced chemical equation for the reaction(s) which occurs when the  
two mixtures are combined. If no reaction occurs upon mixing, write "NR".

(I) NH₄HSO₄ and excess potassium hydroxide

(a)

(b)

(II) calcium carbonate and excess nitric acid

(a)

(b)

(III) CoSO₄ and 6 equivalents of NaSCN

(a)

(b)

(IV) Ammonia and sodium acetate

(a)

(b)

(V) Silver sulfate and hydrobromic acid

(a)

(b)

14. (18 pts) Circle the letter of all of the following that are true. The following equations might or might not help at some point:  \(<v^2>^{1/2} = (3RT/M)^{1/2}\) and  \(<E_{KE}> = (3/2)RT\)
(a) An ideal gas particle has zero volume.

(b) Ideal gas particles experience attractive and repulsive forces with one another.

(c) Collisions between ideal gas particles are elastic.

(d) Gas particles of different masses and at the same temperature have the same root mean squared velocity.

(e) As one increases the temperature of a gas sample the average root mean squared velocity of the molecules increases.

(f) Extrapolation of Charles’ Law plots led to the definition of absolute zero.

(g) Soft-soft Lewis acid/base combinations are favorable due to the formation of polar covalent bonds.

(h) CaO is an example of a favorable hard-hard Lewis acid-base combination.

(i) In a Lewis acid/base reaction, the Lewis base loses control and ownership of its electron pair.

(j) \(2\text{AgI}_\text{(s)} + \text{Zn}_\text{(s)} \rightarrow \text{Zn}^{2+} + 2\text{Ag}_\text{(s)} + 2\text{I}^-\) is a redox reaction.

(k) A redox reaction always has both an oxidizing agent and a reducing agent.

(l) You would expect CHF₃ to be a very polarizable molecule.

(m) Molecular orbital theory requires resonance arrows to account for bond delocalization.

(n) In valence bond theory, the sigma bond between the O and C in CO₂ could be described as the overlap of an sp² hybridized orbital on O with an sp hybridized orbital on C.

(o) Valence bond theory is an inherently localized model of bonding.

(p) CCl₄ is a polar molecule.

(q) The van der Waals equation allows for gas particles to have volume.

(r) Gas particles of different masses and at the same temperature have the same average kinetic energy.

PLEDGE: ____________________________________________