CHEM 103
R&R—extra Final Exam practice :)
28 June 2024
Adapted from an undated document

Note that the ideal gas constant R = 62.36 L torr mol^{-1} K^{-1} when using torr instead of atm.

1. Write the full and net ionic equations for each of the processes below.

       a. Silver nitrate + sodium oxalate

       b. Hydrobromic acid + ammonia

       c. Iron(II) nitrate + sodium hydroxide

       d. Acetic acid + barium hydroxide

2.
       a. Write the full ground state electron configurations of S, K, Ti, and Sn.

       b. Write the noble gas notation electron configurations for Ni, Ge, Cs, and Br.

3. An electron in a hydrogen atom is excited from the ground state to the n = 4 state. Comment on the correctness of following statements.

a. n = 4 is the first excited state.

b. It takes more energy to ionize (remove) the electron from n = 4 than from the ground state.

c. The wavelength of light emitted when the electron drops from n = 4 to n = 1 is longer than that from n = 4 to n = 2.

d. The wavelength the electron absorbs in going from n = 1 to n = 4 is the same as that emitted when it goes from n = 4 to n = 1.

4. Below is a list of successive ionization energies, expressed in kJ mol^{-1}, for a period 3 element. Identify the element and explain how you came to that conclusion.

I_1 = 1012; I_2 = 1900; I_3 = 2910; I_4 = 4960; I_5 = 6270; I_6 = 22 200

5. Arrange these compounds in order of increasing boiling point. Explain your reasoning.

a. CH_4 b. CH_3CH_3 c. CH_3CH_2Cl d. CH_3CH_2OH

6. Which type of intermolecular force accounts for each of these differences?

    a. CH_3OH boils at 65 °C; CH_3SH boils at 6 °C.
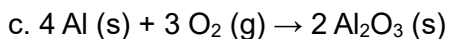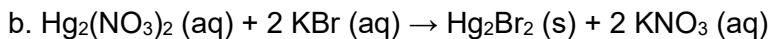
    b. Xe is a liquid at atmospheric pressure and 120 K, while Ar is a gas under the same conditions.

   c. Kr, atomic weight 84 g/mol, boils at 120.9 K, while Cl_2, molecular weight 71 g/mol, boils at 238 K.

    d. Acetone boils at 56 °C, while 2-methylpropane boils at -12 °C.


acetone   2-methylpropane
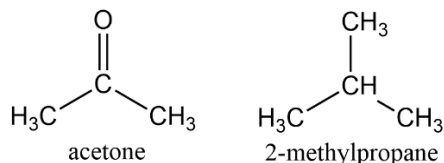
7. For each of the following reactions, determine whether it is a redox reaction. If it is a redox reaction, identify which element is oxidized and which is reduced; provide before-and-after oxidation states.

    a. $Sn\ (s) + 4\ HNO_3\ (aq) \rightarrow SnO_2\ (s) + 4\ NO_2\ (g) + 2\ H_2O\ (l)$

    b. $Hg_2(NO_3)_2\ (aq) + 2\ KBr\ (aq) \rightarrow Hg_2Br_2\ (s) + 2\ KNO_3\ (aq)$

    c. $4\ Al\ (s) + 3\ O_2\ (g) \rightarrow 2\ Al_2O_3\ (s)$

8. Compute the ΔH for the following reactions using bond enthalpies:

    a. __ H_2 (g) + __ Br_2 (g) → __ HBr (g)

    b. __ H_2O_2 (g) → __ H_2O (g) + __ O_2 (g)
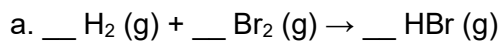
9. Below is the structure of the penicillin class of antibiotics (R represents a variable group).
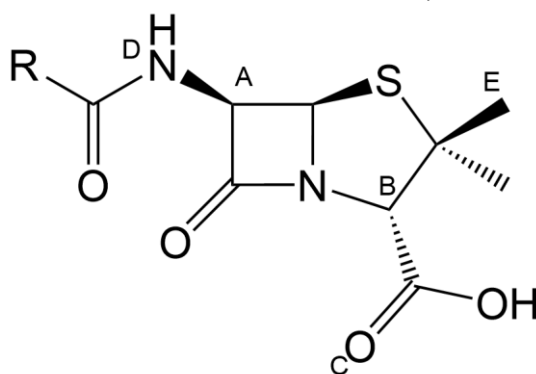
a. Fill in all lone pairs in the above molecule. Remember the octet rule!

b. What is the hybridization of the atoms labeled A-E?

    A: B: C: D: E:

c. What is the electron geometry at the atoms labeled B-E?

    B: C: D: E:

d. Discuss one way penicillin can interact with the aqueous environment of the body using IMFs.

10. What mass of sodium acetate can be obtained from mixing 15.0 g $NaHCO_3$ with 150. mL of 0.100 M acetic acid?

11. Formic acid, HCOOH, is a monoprotic weak acid.

   a. Write the full and net ionic equations for the reaction of aqueous formic acid and aqueous potassium hydroxide.

   b. If you combine 60.0 g formic acid and 60.0 g potassium hydroxide, how much water (in grams) will you produce? Which is the limiting reactant?

12. Sweat cools the body because evaporation is an endothermic process:

$$H_2O\ (l) \rightarrow H_2O\ (g) \qquad \Delta H°_{rxn} = +\ 44.01\ kJ$$

Estimate the mass of water that must evaporate from the skin to cool the body by 0.50 °C. Assume a body mass of 95 kg and that the specific heat capacity of the body is 4.0 J $(g·K)^{-1}$.

13. Lakes that have been acidified by acid rain (HNO_3 and H_2SO_4) can be neutralized by a process called liming, in which limestone ($CaCO_3$) is added to the acidified water. What mass of limestone (in kg) would be required to completely neutralize a 15.2 billion-liter lake that is 1.8×10^{-5} M in H_2SO_4 and 8.7×10^{-6} M in HNO_3?

14. Find the mass of barium metal (in grams) that must react with oxygen gas to produce enough barium oxide to prepare 1.0 L of a 0.10 M solution of OH^-.

15. CaO (s) reacts with water to form $Ca(OH)_2$ (aq). If 6.50 g CaO is combined with 99.70 g H_2O in a coffee cup calorimeter, the temperature of the resulting solution increases from 21.7 °C to 43.1 °C. Calculate the enthalpy change for the reaction per mole of CaO. Assume that the specific heat capacity of the solution is 4.18 J $(g \cdot K)^{-1}$.

16. If you put 120 volts of electricity through a pickle, the pickle will smoke and start glowing orange-yellow (or so I hear). The light is emitted because sodium ions in the pickle become excited; their return to the ground state results in light emission.

    a. The wavelength that is emitted is 589 nm. Calculate its frequency.

    b. What is the energy of 0.10 mol of these photons?

    c. Calculate the energy gap between the excited and ground states for the sodium ion.

17. Fill in the molecular orbital diagram for F_2. Give the bond order and identify whether F_2 is diamagnetic or paramagnetic.

(Diagram sourced from https://ch301.cm.utexas.edu/imfs/#mo/mo-theory-all.php)
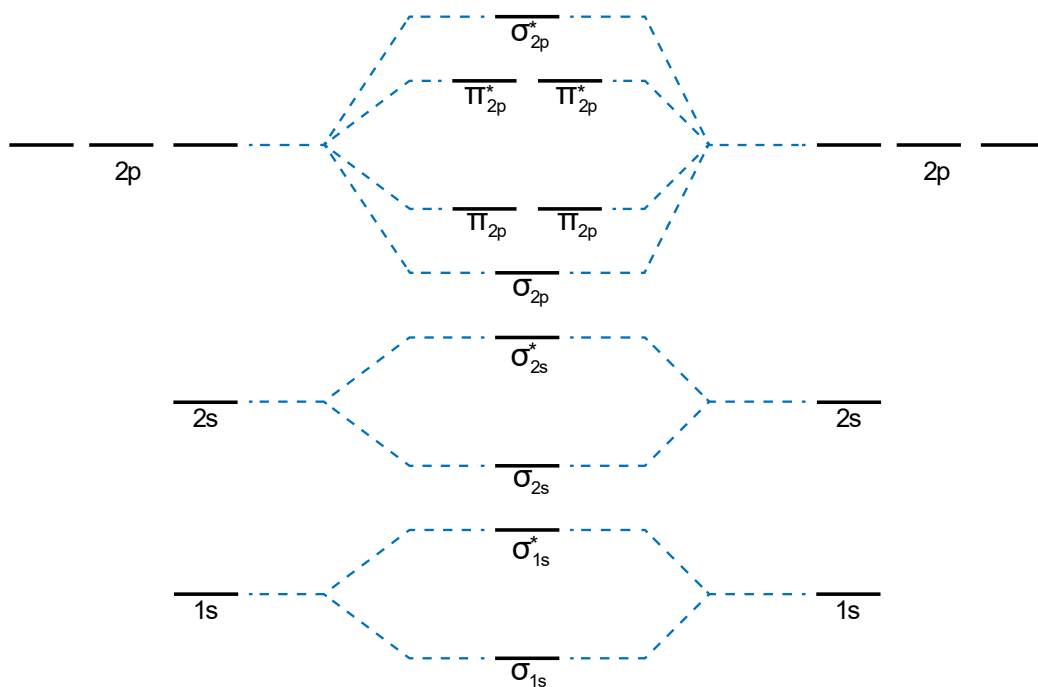
18. A gaseous compound containing hydrogen and carbon is decomposed and found to contain 82.66% carbon and 17.34% hydrogen by mass. The mass of 158 mL of the gas, measured at 556 torr and 25 °C, was 0.275 g. What is the molecular formula of the compound?

GOOD LUCK!