

**Final Exam Chem151 17 Dec 2015**  
**(50 points)**

Name:

Equations and constants

$$N_A = 6.022 \times 10^{23} \text{ mol}^{-1} \quad h = 6.626 \times 10^{-34} \text{ Js} \quad c = 3.00 \times 10^8 \text{ ms}^{-1}$$

$$m_p = 1.67 \times 10^{-27} \text{ kg} \quad m_e = 9.11 \times 10^{-31} \text{ kg} \quad q_e = -1.60 \times 10^{-19} \text{ C} \quad 1\text{eV} = 1.6 \times 10^{-19} \text{ J}$$

$$\text{H-like atoms/ions: } \frac{1}{\lambda} = R_H \left( \frac{1}{n_{low}^2} - \frac{1}{n_{high}^2} \right) \quad E_n = \frac{-Z^2(13.6\text{eV})}{n^2} \quad R_H = 1.097 \times 10^7 \text{ m}^{-1}$$

$$\text{Pressure conversions: } 1 \text{ atm} = 1.01325 \times 10^5 \text{ Pa} = 760 \text{ mm Hg} = 760 \text{ torr}$$

$$\text{Ideal Gas Constant: } R = 8.314 \text{ J K}^{-1} \text{ mol}^{-1} = 0.08206 \text{ L atm mol}^{-1} \text{ K}^{-1}$$

$$v_{rms} = \sqrt{\frac{3RT}{MM}} \quad E_{kin} = \frac{3}{2}nRT \quad P_{tot} = P_A + P_B + P_C + \dots \quad P_A = \chi_A P_{tot} \quad n_A = \chi_A n_{tot}$$

Question 1 (12 points)

(a) Sketch a Rutherford model of the atom for the most abundant isotope of palladium (Pd). Indicate the location and number of protons, electrons and neutrons.

(b) Write the electron configuration of Pd. What is its net spin?

(c) Pd can be used as for hydrogen storage. If the %mass of hydrogen in palladium hydride is 3.65%, calculate the empirical formula of the palladium hydride.

(d) What is the oxidation state of Pd based on your empirical formula in (c)?

(e) If all the hydrogen in a 120.0 g sample of palladium hydride was released as molecular hydrogen gas by heating at 500°C, calculate the volume of gas released at 1 atm.

(f) Calculate the root mean square speed (in m/s) of the hydrogen gas molecules.

(g) If platinum hydride has the same formula as palladium hydride (where Pt replaced Pd), would it be a more or less preferable hydrogen storage material. (The use of hydrogen would be for fuel cells on vehicles of some sort.) Support your answer with a brief (1-2 sentence) explanation.

Question 2 (8 points)

(a) The nitrogen atom is slightly larger than the oxygen atom. Explain.

(b) However, the nitrogen molecule is slightly smaller than the oxygen molecule. Explain.

(c) Assuming both gases behave ideally, which has the higher kinetic energy at R.T.P.?

(d) Nitrogen gas and oxygen gas can react to form nitrogen dioxide gas.

(i) Write a balanced chemical equation for this reaction.

(ii) If an initial sample of 50.0 g of nitrogen gas and 50.0 g of oxygen gas reacted to form nitrogen dioxide in 43% yield, calculate the mass of nitrogen dioxide produced in the reaction.

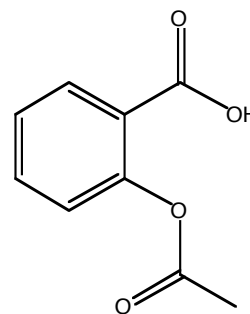
Question 3 (6 points)

(a) Do  $\text{PF}_3$  and  $\text{ClF}_3$  have net dipoles? Draw complete Lewis structures and predict the molecular shape of each molecule to support your answer.

(b) Draw the Lewis structure of the azide anion ( $\text{N}_3^-$ ). Predict its molecular shape, net dipole, and state the hybridization on each atom.

Question 4 (10 points)

The structure of aspirin (acetylsalicylic acid) is shown on the right.



(a) What is the molecular formula of aspirin?

(b) How many C–C *sigma*-bonds are there in aspirin?

(c) Calculate the volume of 0.2 M NaOH required to completely neutralize 3.25 g of aspirin, a monoprotic acid. (That's the amount in about 10 aspirin pills.)

(d) If the same 3.25 g of aspirin was instead completely combusted, and the product carbon dioxide was dissolved in 75.0 mL of water to form carbonic acid ( $\text{H}_2\text{CO}_3$ ), calculate the molarity of hydrogen ions ( $\text{H}^+$ ) if carbonic acid dissociates into  $\text{H}^+$  and  $\text{CO}_3^{2-}$  ions.

(e) If the carbonic acid solution in (d) was poured into a new container containing 50.0 mL of a 0.500 M  $\text{BaCl}_2$  solution, a white precipitate of barium carbonate ( $\text{BaCO}_3$ ) is formed. If this reaction proceeds with 100% yield, calculate the concentration of all remaining ions in solution.

Question 5 (10 points)

Magnesium ( $\text{Mg}$ ) is a solid at room temperature. Molecular fluorine ( $\text{F}_2$ ) is a gas at room temperature.  $\text{Mg}$  and  $\text{F}_2$  can combine to form the solid compound  $\text{MgF}_2$ .

(a) Identify the oxidizing and reducing agents in this reaction.

(b) Explain why  $\text{F}_2$  is a gas at room temperature.

(c) Would  $\text{MgF}_2$  conduct electricity at room temperature? Explain.

(d) In  $\text{MgF}_2$ , are the Mg “particles” smaller, larger or the same size as the F “particles”? Explain.

(e) Where do you expect to see a big jump in ionization energies for Mg (between the 1<sup>st</sup> and 2<sup>nd</sup>, or 2<sup>nd</sup> and 3<sup>rd</sup> or 3<sup>rd</sup> and 4<sup>th</sup>, etc...)?

(f) Magnesium has three stable isotopes,  $^{24}\text{Mg}$ ,  $^{25}\text{Mg}$  and  $^{26}\text{Mg}$ . Its most common radioactive isotope is  $^{28}\text{Mg}$  with a half-life of 21 hours.

(i) Write a nuclear reaction to demonstrate the type of radioactive decay one would expect  $^{28}\text{Mg}$  to undergo and explain your choice.

(ii) If you had a sample of 10.0 g of  $^{28}\text{Mg}$ , how much would be left after 84 hours?

Question 6 (4 points)

(a) From what  $n$  level does the electron fall to give a 434 nm *Balmer line* in the hydrogen spectra? Use a calculation to support your answer.

(b) If a 434 nm photon were to strike gold (work function of 4.6 eV), would it eject electrons? Use a calculation to support your answer.

Extra Credit (3 points – all or nothing)

$\text{ClF}_3$  has a much higher boiling point than  $\text{PF}_3$ , however,  $\text{ClF}_3$  is chemically much more reactive than  $\text{PF}_3$ . Explain.