Name ______________________ Test 3

PHYS 0109 Fall 2003

A few equations

$PV = nRT$ $MM = d\,RT/P$

$P_{tot} = P_a + P_b$

$KE_{ave} = \dfrac{3\ RT}{2\ N_A}$ $\frac{1}{2}mv^2 = \dfrac{3\ RT}{2\ N_A}$

c = □□

$E_{photon} = h$□

□$E = -R_H(1/n_f^2 - 1/n_i^2)$

h□ $= R_H(1/n_{lo}^2 - 1/n_{hi}^2)$

A few constants

$R = 0.08206\ L\cdot atm\cdot mol^{-1}\cdot K^{-1}$

$R = 8.314\ J\cdot mol^{-1}\cdot K^{-1}$

$N_A = 6.022 \times 10^{23}\ mol^{-1}$

1 torr = 1 mm Hg

1 atm = 101,325 Pa

760 torr = 1 atm

0 °C = 273.15 K

$R_H = 2.18 \times 10^{-18}$ J

$h = 6.626 \times 10^{-34}\ J\cdot s$

$c = 2.9979 \times 10^8$ m/s

$m_e = 9.11 \times 10^{-31}$ kg

$m_p = 1.6 \times 10^{-27}$ kg

n has integral values 1,2,3...

l has integral values from 0 to n – 1

m_l has integral values between (and including) l to $-l$

m_s can be $+^1/_2$ or $-^1/_2$

0 °C = 273.15 K

1. (16 pts.) Identical containers were each charged with a sample of gas at 300 °C. One container was charged with H_2 to a pressure of 1.5 atm and the other was charged with $CH_3CH_2CH_3$ to a pressure of 1.5 atm.

a. On average, H_2 molecules are moving slower, faster, or at the same speed as $CH_3CH_2CH_3$ molecules.

faster

b. On average, the kinetic energy of an H_2 molecule is higher, lower, or the same as the kinetic energy of an $CH_3CH_2CH_3$ molecule.

same

c. The density of H_2 is higher, lower, or the same as $CH_3CH_2CH_3$.

lower

d. The number of moles of H_2 is higher than, less than, or the same as the number of moles of $CH_3CH_2CH_3$.

same

2. (10 pts.) An electron moves from a 3p orbital to a 2s orbital.

a. Is energy released or absorbed as the electron moves from the 3p to the 2s orbital.

released

b. Is a photon emitted or is a photon absorbed as the electron moves from the 3p to the 2s orbital.

emitted

3. (8 pts.) A reactor was charged with 3.50 atm of HCl and 6.0 atm of $CHCCH_3$. Determine the partial pressure of the $CH_3CCl_2CH_3$ that forms, the volume and the temperature of the reactor stays constant throughout the reaction.

$$2\ HCl(g)\ +\ CHCCH_3(g) \longrightarrow CH_3CCl_2CH_3(g)$$

Since volume and temperature remain constant, pressure can be used for stoichiometry.

$$3.50\text{ atm HCl} \times \frac{1\text{ atm } CH_3CCl_2CH_3}{2\text{ atm HCl}} = 1.75\text{ atm } CH_3CCl_2CH_3 \text{ possible from HCl}$$

$$6.0\text{ atm } CHCCH_3 \times \frac{1\text{ atm } CH_3CCl_2CH_3}{1\text{ atm } CHCCH_3} = 6.0\text{ atm } CH_3CCL_2CH_3 \text{ possible from } CHCCH_3$$

The partial pressure of the CH_3CClCH_3 that forms will be 1.75 atm.

4. (8 pts.) Calculate the energy of a photon that has a wavelength of 100.0 nm.

$E_{photon} = h\nu$ and $c = \lambda\nu$, so $E_{photon} = hc/\lambda$

$E_{photon} = (6.626 \times 10^{-34}\ J{\bullet}s)(2.9979 \times 10^{8}\ m{\bullet}s^{-1})/(100.0 \times 10^{-9}\ m)$

$E_{photon} = 1.9864 \times 10^{-18} \Rightarrow 1.986 \times 10^{-18}\ J$

5. (8 pts.) Determine the ground state electron configuration of In.

$[Kr]\ 5s^2 4d^{10} 5p^1$ or $1s^2\ 2s^2 2p^6\ 3s^2 3p^6\ 4s^2 3d^{10} 4p^6\ 5s^2 4d^{10} 5p^1$

6. (8 pts.) The following sets of quantum numbers are intended to describe the energy of an electron. Which of the following sets of quantum numbers are valid?

a. $n = 1$ $l = 1$ $m_l = 1$ $m_s = +^1/_2$ not valid

b. $n = 2$ $l = 1$ $m_l = 0$ $m_s = +^1/_2$ valid

c. $n = 3$ $l = 0$ $m_l = 0$ $m_s = +^1/_2$ valid

d. $n = 4$ $l = 2$ $m_l = -2$ $m_s = -^1/_2$ valid

7. (4 pts.) For each of the following pairs of elements, identify the smaller element.

a. **F** vs Br

b. **F** vs Na

8. (4 pts.) For each of the following pairs of elements, identify the more electronegative element.

a. **Na** vs Cs

b. **Cl** vs Al

9. (4 pts.) For each of the following pairs of elements, identify the element with the lower ionization energy.

a. F vs **Br**

b. F vs **Na**

10. (8 pts.) At 23.0 °C, 0.5611 g of an unknown gas occupies a volume of 345.6 mL at a pressure of 750.0 torr. Determine the molar mass of the unknown gas.

$$(750/760 \text{ atm})(0.3456 \text{ L}) = n\,(0.08206 \text{ L·atm·mol}^{-1}\text{·K}^{-1})(23.0 + 273.15)\text{K}$$

$$n = 0.0140339 \text{ mol}$$

$$MM = \frac{0.5611 \text{ g}}{0.014034 \text{ mol}} = 39.98 \text{ g}$$

11. (12 pts.) Label the following statements true or false (vague or illegible labels will be marked wrong).

___T___ Bohr's model of the atom only works for atoms like hydrogen that have one electron.

___F___ Quantum mechanics models an electron as a particle that orbits around a nucleus like the moon orbits around the earth.

___F___ According to Bohr, two electrons can fit into a given orbital.

___F___ According to quantum mechanics, only one electron can fit into a given orbital.

12. (10 pts.) A 90.0-mL sample of hydrogen gas was collected by displacing water from an inverted beaker. The pressure of the gas in the beaker was 771 torr, the temperature of the gas in the beaker was 23.0 °C. The vapor pressure of water at 23.0 °C is 21.07 torr. Determine the number of moles of hydrogen in the flask.

$P_{tot} = P_{H2} + P_{H2O}$

771 torr = P_{H2} + 21.07 torr

P_{H2} = 749.93 torr

(749.9/760 atm)(0.0900 L) = n (0.08296 L•atm•K^{-1}•mol^{-1})(273.15 + 23.0) K

n = 0.00365417 => 0.00365 mol H_2