Chemistry 211 Name: _____
Fall 2024 Please Print
Key 3

Multiple Choice: (4 points each. Put answers in left margin as capital letters.)
$h = 6.626 \times 10^{-34}$ J•s

1. What is the oxidation number of the nitrogen atom in $Ca(NO_2)_2$?

   A) -3 B) -1 C) +1 D) +3 E) +5

2. What is ΔH for the net reaction below?

   $H_{2\,(g)} + F_{2(g)} \longrightarrow 2\,HF_{(g)}$ ΔH = -537 kJ
   $C_{(s)} + 2\,F_{2\,(g)} \longrightarrow CF_{4\,(g)}$ ΔH = -680 kJ
   $2\,C_{(s)} + 2\,H_{2\,(g)} \longrightarrow C_2H_{4\,(g)}$ ΔH = 52.3 kJ
   $C_2H_{4\,(g)} + 8\,F_{2\,(g)} \rightarrow 2\,CF_{4\,(g)} + 4\,HF_{(g)}$ ΔH = ?

   A) -2486 kJ B) -1702 kJ C) -1165 kJ D) 234 kJ E) 1165 kJ

3. Which of the following is false?

   A) The energy of any electron in a hydrogen atom depends only on n.
   B) A node (or nodal surface) is a place of zero electron density.
   C) In any atom, no two electrons may have the same four quantum numbers.
   D) The lowest energy state for an atom is its ground state.
   E) Effective nuclear charge is the number of protons in an atom.

4. The electrons in which orbital type shields **most poorly**?

   A) *d* B) *f* C) *p* D) *s*

5. The $\ell = 2$ subshell may hold a maximum of _____ electrons.

   A) 1 B) 2 C) 6 D) 10 E) 14

6. Which of the following is isoelectronic to Y^{3+}?

   A) Ag^+ B) K^+ C) Kr D) Se^{2-} E) Zr^{2+}

7. With respect to electronegativity values,

   A) B > N > Al B) Al > N > B C) N > B > Al D) B > Al > N E) Al > B > N

8. Four of the following five statements are almost always true of compounds possessing ionic bonds. Which one is not?

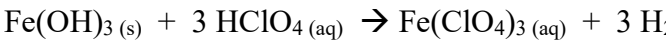
   A) Compounds that dissolve well in water.
   B) Compounds that are solids at room temperature.
   C) Compounds that are brittle.
   D) Compounds that conduct electricity well when liquids.
   E) Compounds that are hard.

9. Nitrogen tends to form _____ covalent bonds.

A) 1 B) 2 C) 3 D) 4 E) 5

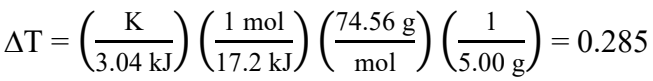
Discussion Questions: (You must show your work to receive credit.

1. What is the balanced equation for the reaction of solid iron(III) hydroxide with aqueous perchloric acid to yield iron(III) perchlorate and water? (6 points)

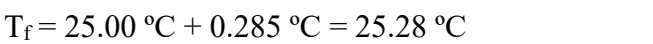


$Fe(OH)_{3\,(s)} + 3\,HClO_{4\,(aq)} \rightarrow Fe(ClO_4)_{3\,(aq)} + 3\,H_2O_{(\ell)}$

2. When a 5.00 g sample of KCl is dissolved in water in a calorimeter that has a total heat capacity of 3.04 $kJ \bullet K^{-1}$, what is the final temperature if the molar heat of solution is 17.2 kJ/mol and the initial temperature is 25.00 ºC. (4 points)



$$\Delta T = \left(\frac{K}{3.04\ kJ}\right)\left(\frac{1\ mol}{17.2\ kJ}\right)\left(\frac{74.56\ g}{mol}\right)\left(\frac{1}{5.00\ g}\right) = 0.285\ K$$

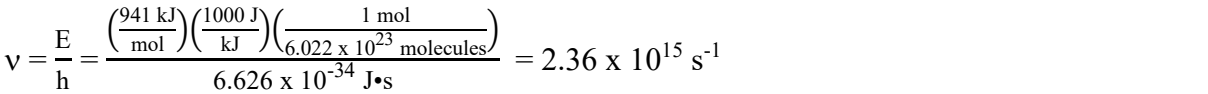


$T_f = 25.00\ ºC + 0.285\ ºC = 25.28\ ºC$

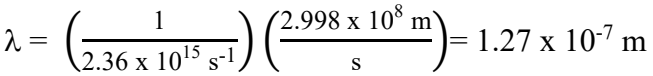
3. Write out the electron configuration of the following and provide the number of unpaired electrons on each (10 points)

Re: [Xe] $6s^2\ 4f^{14}\ 5d^5$, 5 unpaired e^- Cr^{3+}: [Ar] $3d^3$, 3 unpaired e^-

4. A minimum energy of 941 kJ/mol is required to break the bond in N_2. What wavelength of light is required to break the bond in a molecule of nitrogen? Is this the minimum or maximum wavelength necessary? Explain. [NB: It's possible to answer part 2, even if you cannot answer part 1.] (12 points)



$$\nu = \frac{E}{h} = \frac{\left(\frac{941\ kJ}{mol}\right)\left(\frac{1000\ J}{kJ}\right)\left(\frac{1\ mol}{6.022 \times 10^{23}\ molecules}\right)}{6.626 \times 10^{-34}\ J \bullet s} = 2.36 \times 10^{15}\ s^{-1}$$



$$\lambda = \left(\frac{1}{2.36 \times 10^{15}\ s^{-1}}\right)\left(\frac{2.998 \times 10^{8}\ m}{s}\right) = 1.27 \times 10^{-7}\ m$$

Maximum. Frequency and wavelength are inversely proportional. Frequency and energy are directly proportional, so a minimum energy means minimum frequency, which means maximum wavelength.

5. What are the 3 biggest differences between the Bohr/Rutherford and Schrödinger/quantum mechanical models of atoms? (i.e. Do a brief comparison and contrast.) (10 points)

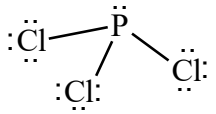
1) In the Bohr atom electrons travel in circles around the nucleus at fixed distances, whereas in the Schrödinger model the electrons exist in 3-dimensional orbitals of varying shapes. Electrons now may exist at any distance from the nucleus.
2) In Bohr the electrons are truly particles, while in Schrödinger they are treated as waves.
3) In Bohr quantization is assumed, in Schrödinger it is a consequence of the math.

6. Based on their positions in the periodic table, predict which atom of the following pairs will have the larger atomic radius. Provide the physical rationale for your choices. (10 points)

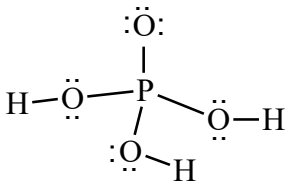
a) O, **Ne** – Both elements occur in the second period, with neon to the right of oxygen. On moving right across a period, protons are added to the nucleus and electrons to the same subshell. Because the added electrons aren't shielded by other electrons in the same subshell, the protons exert a greater pull on the electrons on the atom on the right. This results in a greater attraction (pull) on the electrons causing them to be closer to the nucleus.

b) Mg, **Sr** – These elements are in the same group. Elements in previous shells shield outer electrons well resulting in valence electrons having roughly the same nuclear pull acting on the valence electrons in both atoms, but the strontium electrons have higher principle quantum numbers associated with them. The higher "*n*" values mean the electrons have more energy, resulting in them lying further from the nucleus.

7. Draw the Lewis structures of PCl_3 and H_3PO_4. Which is the most electronegative element in each molecule? (12 points)



Cl most electronegative



O most electronegative