Chemistry 211 Name: _____
Fall 2023 Please Print
Test 3

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

1. Which of the following processes is endothermic?

A) A ball rolling down a hill C) A fire burning E) Steam condensing
B) Boiling water D) Iron rusting

2. What is ΔH for the net reaction below?

$N_{2\,(g)} + O_{2\,(g)} \longrightarrow 2\,NO_{(g)}$ ΔH = 180.5 kJ
$NO_{(g)} + \frac{1}{2}\,O_{2\,(g)} \longrightarrow NO_{2\,(g)}$ ΔH = -57.1 kJ
$N_{2\,(g)} + 2\,O_{2\,(g)} \rightarrow 2\,NO_{2\,(g)}$ ΔH = ?

A) -123.4 kJ B) -66.3 kJ C) 66.3 kJ D) 123.4 kJ E) 132.6 kJ

3. Which of the following sets of quantum numbers is not permissible? (n, ℓ, m_ℓ)

A) 2, 1, 1 B) 3, 3, 0 C) 4, 2, 1 D) 4, 1, -1 E) 5, 4, -1

4. An electron moves from the n = 1 level to the n = 2 level in hydrogen. Its energy changes by a factor of

A) ¼ B) ½ C) $^3/_4$ D) 1 E) 2

5. Which of the following quantum numbers provides information about the energy of the electron in hydrogen?

A) ℓ B) m_ℓ C) m_s D) *n* E) *E*

6. Which of the following species is isoelectronic to As^{2-}?

A) Br B) Br^{2+} C) Ga^{-} D) Kr E) Sb^{2-}

7. What is the energy of one mole of photons of light with a wavelength of 437 nm?

A) 5.86 x 10^{-8} J C) 274 kJ E) 8.77 x 10^5 kJ
B) 3.65 x 10^{-3} kJ D) 2.11 x 10^3 kJ

8. Which atom is least electronegative?

A) Al B) As C) I D) Li E) S

9. Which of the following is least likely to form an elemental ion (i.e. X^{n+} or X^{n-})?

A) Cl B) Mg C) Na D) S E) Si

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

1. Why is ΔH_f^o for XeF_6 is exothermic? [Hint: Writing the reaction should be helpful.] (5 points)

   $Xe + 3\ F_2 \longrightarrow XeF_6$

   In this reaction, 3 F-F bonds are broken, but 6 Xe-F bonds are formed. Bond breakage is endothermic, while bond formation is exothermic. Forming twice as many bonds as are broken likely explains why the reaction is exothermic.

2. Write the formation reaction for ethanol, $C_2H_5OH_{(\ell)}$. (5 points)

   $2\ C_{(s,\ graphite)} + 3\ H_{2\ (g)} + \frac{1}{2}\ O_{2\ (g)} \longrightarrow C_2H_5OH_{(\ell)}$

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

   Fe: [Ar] $4s^2\ 3d^4$, 4 unpaired e^- Sn^{2+}: [Kr] $5s^2\ 4d^{10}$, 4 unpaired e^-

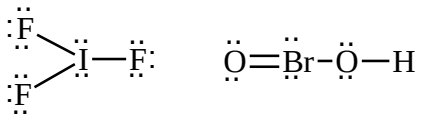
4. Neon signs have a characteristic orange glow that results from passing an electrical current through the gas. The light is emitted because the neon atoms become excited and their return to the ground state results in light emission. (12 points)
   a) The wavelength of the emitted light is 585 nm. What is its frequency?
   b) Calculate the energy gap between the ground and excited state.
   c) What is the energy of 0.10 moles of these photons?

   a) 3.00×10^8 m/s = $(585\ \text{nm})\left(\frac{1\ \text{m}}{10^9\ \text{nm}}\right)$
      $n = 5.13 \times 10^{14}\ s^{-1}$
   b) $E = (6.626 \times 10^{-34}\ \text{J•s})(5.13 \times 10^{14}\ s^{-1})$
      $= 3.40 \times 10^{-19}$ J
   c) $E = (6.626 \times 10^{-34}\ \text{J•s})(5.13 \times 10^{14}\ s^{-1})(0.10\ \text{mol})\left(\frac{6.022 \times 10^{23}\ \text{photons}}{\text{mol}}\right)\left(\frac{1\ \text{kJ}}{1000\ \text{J}}\right)$
      = 20.5 kJ

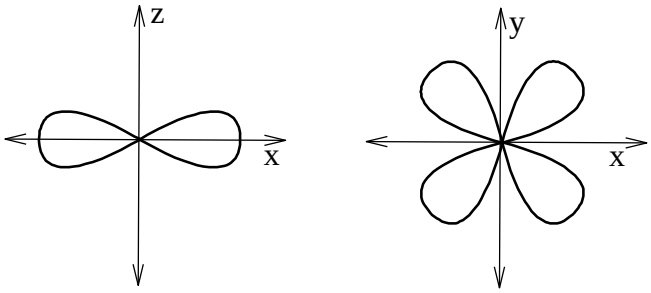
5. In the Bohr model of the ground state of hydrogen, the electron orbits the nucleus in a circle with a radius of 0.53 Å. Is this also true in the quantum-mechanical description of the hydrogen atom? Explain. (5 points)

   In the Bohr model, the electron is a small particle that moves around the nucleus in circular orbits. A Bohr orbit specifies the exact path and energy of the electron. In the quantum-mechanical model, the wave properties of the electron are considered; any attempt to describe the exact path of an electron is inconsistent with the Heisenberg uncertainty principle. The quantum mechanical model is a statistical model which tells us the probability of finding an electron in certain regions around the nucleus. Thus, quantum mechanics would give the probability of finding the electron at 0.53 Å and this probability would always be less than 100%.

6. Draw the Lewis structures of IF_3 and $HBrO_2$. Which is the most electronegative element in each molecule? (12 points)



7. Sketch the shape and orientation of the p_x and d_{xy} orbitals. (5 points)



8. For each of the following pairs, indicate which element has the larger atomic radius and provide your rationale: (10 points)

   a) S *vs*. **<u>Si</u>** Effective nuclear charge increases in moving from left to right in the 3rd row because the newly added electrons don't shield as well as core electrons. As a result, the electrons on sulfur are drawn closer to the nucleus than on silicon.

   b) N *vs*. **<u>P</u>** The valence electrons on nitrogen and phosphorus lie in the n = 2 and n = 3 shells, respectively. A higher principal q.n. means the energy of electrons in those orbitals is higher, resulting in them residing further from the nucleus, making the radius larger.