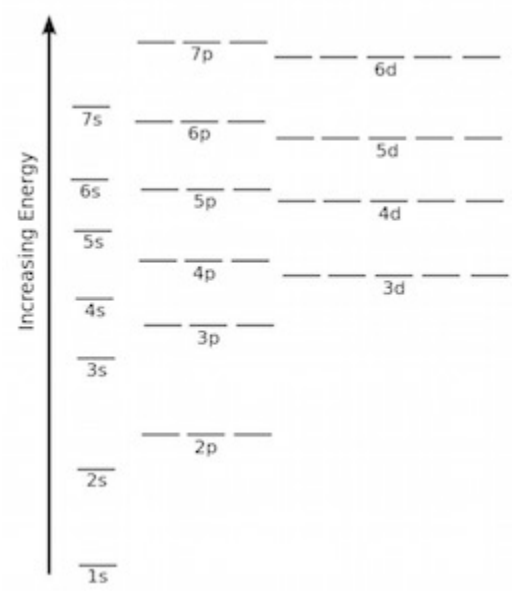
CHEMISTRY 101 Name _____KEY_____
Hour Exam III
December 5, 2024 Signature _____
McCarren/Formigao Gameiro
Section _____

"Learn from yesterday, live for today, and hope for tomorrow. The important thing is not to stop questioning." – Albert Einstein

This exam contains 17 questions on 8 numbered pages. **Check now** to make sure you have a complete exam. You have one hour and thirty minutes to complete the exam. Determine the best answer to the first 15 questions and enter these on the special answer sheet. Also, circle your responses in this exam booklet. Show all of your work and provide complete answers to questions 16 and 17.

1-15	(30 pts.)	_____
16	(12 pts.)	_____
17	(18 pts.)	_____
Total	(60 pts)	_____

Useful information:



Part 1: Multiple Choice

1. How many of the processes below are **exothermic**? The system is underlined in each case.
   - **Water freezes to become ice.**
   - **Hydrogen and oxygen gases react and burn to become water vapor.**
   - Two solids are mixed in a beaker and the outside of the beaker becomes colder.
   - **A racquetball hardens in liquid nitrogen.**

   a. 0 (None of the process are exothermic.)
   b. 1
   c. 2
   d. 3
   e. 4 (All four of the processes are exothermic.)

2. Which of the following statements is **false** related to atoms and energy?
   a. An exothermic process may require activation energy to begin.
   b. An endothermic process may require activation energy to begin.
   c. An endothermic process means energy is added to the system.
   d. An exothermic process means energy leaves the system.
   e. The products are lower in energy than the reactants for an endothermic process.

3. Which is **true** related to our understanding of the current model of the atom?
   a. The center of the atom contains a small, positively charged nucleus.
   b. Each atom of a given element is identical to all other atoms of that element.
   c. Atoms can be considered to be solid spheres.
   d. Atoms give off white light when energy in the form of heat is added.
   e. Bonds between atoms occur due to interactions of the electrons that are closest to each atom's center.

4. Which of the following is **true** related to orbitals and atoms?
   The orbitals of an atom…
   a. show the specific locations of electrons.
   b. predict where electrons are most often.
   c. describe the path of electron travel.
   d. become less complex further from the nucleus.
   e. are solid objects outside the nucleus.

5. Select the answer which accurately fills in the blanks below:

   The ground state electron configuration for a neutral atom of _____ is the same as the ground state electron configuration for the most stable ion of _____ in an ionic compound.

   a. calcium; calcium
   b. selenium; krypton
   c. <u>xenon; barium</u>
   d. oxygen; neon
   e. lithium; sodium

6. Choose the option below which correctly ranks the bonds given from least polar to most polar.

   Ag – F Cs – F S – F Se – F

   a. Cs – F < Ag – F < Se – F < S – F
   b. Cs – F < Se – F < Ag – F < S – F
   c. Se – F < Ag – F < S – F < Cs – F
   d. <u>S – F < Se – F < Ag – F < Cs – F</u>
   e. S – F < Ag – F < Se – F < Cs – F

7. Which of the following neutral atoms is the largest?
   a. <u>Cr</u>
   b. Mn
   c. Fe
   d. Co
   e. Ni

8. Which of the following neutral atoms has the highest first ionization energy?
   a. Cr
   b. Mn
   c. Fe
   d. Co
   e. <u>Ni</u>

Consider the pairs of compounds described in each of the questions below. Draw Lewis structures for the compounds, determine the electron pair geometry, molecular shape, and polarity. Use these to answer each of the questions.

9. Consider the compounds IF_3 and PCl_5. What is similar about these two species?

   These two compounds have the same…

   a. <u>Electron pair geometry</u>
   b. Shape
   c. Polarity (both are either polar or both nonpolar)
   d. At least two of options a. – c. above are the same.
   e. <u>None</u> of options a. – c. above are the same.

10. Consider the compounds NH_3 and CH_2O. What is similar about these two species?

    These two compounds have the same…

    a. Electron pair geometry
    b. Shape
    c. <u>Polarity (both are either polar or nonpolar)</u>
    d. At least two of options a. – c. above are the same.
    e. <u>None</u> of options a. – c. above are the same.

11. Consider the compounds H_2O and OF_2. What is similar about these two species?

    These two compounds have the same…

    a. Electron pair geometry
    b. Shape
    c. Polarity (both are either polar or nonpolar)
    d. <u>At least two of options a. – c. above are the same.</u>
    e. <u>None</u> of options a. – c. above are the same.

12. Consider the compounds SO_2 and CO_2. What is similar about these two species?

    These two compounds have the same…

    a. Electron pair geometry
    b. Shape
    c. Polarity (both are either polar or nonpolar)
    d. At least two of options a. – c. above are the same.
    e. <u>None of options a. – c. above are the same.</u>

13. Consider each of the five molecules below, all of which come from examples on the previous page. For which of the molecules below is it necessary to draw resonance structures?
    a. IF_3
    b. PCl_5
    c. $\underline{SO_2}$
    d. OF_2
    e. CH_2O

14. Which has a larger radius, the neutral atom of phosphorus (P) or the ion of phosphorus (P^{3-})? Choose the correct answer *and* best explanation.
    a. *P is larger.* Neutral atoms are stabler than their ion counterparts, so they are larger than their corresponding ions.
    b. *P is larger.* The electron configuration consists of fewer electrons, so there is more space for them to spread out around the nucleus.
    c. *Both species are the same size.* Because there are 15 protons in the nucleus for both, the electrons are equally attracted to the center of the atom.
    d. $\underline{P^{3-}}$ *is larger.* Additional electrons end up repelling each other and becoming positioned further from the nucleus.
    e. P^{3-} *is larger.* Additional electrons also mean additional protons are added, which creates a larger particle.

15. Which requires less energy to remove an outer electron from, the neutral atom of neon (Ne) or the most stable ion of magnesium (Mg^{+2})? Choose the correct answer *and* best explanation.
    a. *The magnesium ion:* Following the periodic trend, magnesium is further down and to the left on the periodic table, making it a larger ion with electrons further from the nucleus.
    b. *The magnesium ion:* The greater number of protons in the magnesium nucleus means that the magnesium electrons are spread further from the nucleus which makes them easier to remove.
    c. *Both require the same amount of energy:* Both have ten electrons which spread out evenly outside the nuclei of both species.
    d. *The neon atom:* Ground state electrons in neon are closer to the nucleus, making them easier to remove.
    e. *The neon atom:* Fewer protons in the nucleus of the neon atom result in a weaker attraction between the outer electrons and the nucleus compared to magnesium.

Please go on to the next page.

Part 2: Free Response

16. Name that element! For each of the six clues given below, determine the name of each element. The element may be anything between atomic #1 and #36 on the periodic table. Elements may be used once, more than once, or not at all.

+2 points each blank, no partial credit

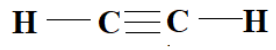
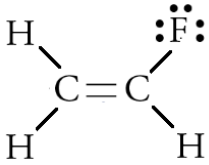
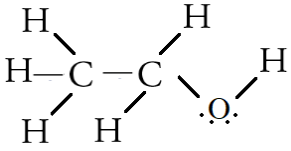
	Clue	**Element Name**
a.	This element has a neutral ground state neutral electron configuration of $[Ar]4s^2 3d^{10} 4p^4$	**selenium**
b.	There are three elements in the third period (horizontal row) which have one unpaired electron in their ground state orbital diagrams. This element is the most electronegative of all three.	**chlorine**
c.	When this second-row element bonds with three atoms of hydrogen, the resulting trigonal pyramid molecule exhibits hydrogen bonding forces between itself and other molecules.	**nitrogen**
d.	This alkaline earth metal has a total of eight electrons in the third energy level.	**calcium**
e.	This element shares electrons evenly in a bond with an atom of oxygen.	**oxygen**
f.	This neutral element has an excited state electron configuration of $1s^2 2s^2 2p^6 3s^2 3p^3 4s^1 3d^2$.	**argon**

17. Consider each of the sets of molecules to answer the following questions. For each set of molecules, draw the Lewis structures, provide the shape around the designated atom, and determine whether the entire molecule is polar or nonpolar. Then, answer the questions below each set.

Set 1

a. Consider the set of molecules below, each of which contain two carbon atoms. Draw the Lewis structures, provide the shape around the designated atom, and state whether the entire molecule is polar or nonpolar. Also, give the strongest intermolecular forces each substance displays.

+6 points total

Molecule	Lewis Structure	Shape around one of the carbon atoms	Polar or nonpolar?	Strongest Intermolecular Forces
C_2H_2		**Linear**	**Nonpolar**	**London dispersion forces**
CH_2CHF		**Trigonal planar**	**Polar**	**Dipole-dipole forces**
CH_3CH_2OH		**Tetrahedral**	**Polar**	**Hydrogen bonding forces**

+0.5 points per blank, no partial credit

+3 points total

b. Rank the three molecules from lowest to highest boiling point by filling in formulas in the boxes below. Explain your answer, being sure to address the strongest intermolecular forces between molecules of each substance.

+1 all three boxes filled in correctly, no partial credit

C_2H_2 < **CH_2CHF** < **CH_3CH_2OH**

+2 coherent explanation, continuation credit possible

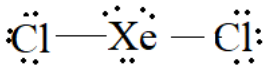
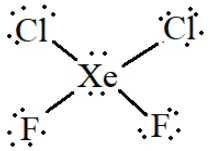
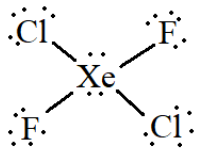
For molecules of similar size, hydrogen bonding forces are stronger than dipole dipole forces, which are stronger than London dispersion forces. As a result, CH_3CH_2OH has the highest boiling point because it can form hydrogen bonds, followed by CH_2CHF which displays dipole-dipole forces, and finally by C_2H_2, which has the weakest forces due to its London dispersion forces.

Set 2

+6 points total

c. Consider the set of molecules below, each of which contains a central xenon atom. Draw the Lewis structures, provide the shape around the designated atom, and state whether the entire molecule is polar or nonpolar if not already provided. Also, give the strongest intermolecular forces each substance displays.

+0.5 points per blank, no partial credit, polar/nonpolar already filled in are also given 0.5 points for a total of 6 possible.

	Molecule	Lewis Structure	Shape around the central atom	Polar or nonpolar?	Strongest Intermolecular Forces
A	$XeCl_2$		**Linear**	**nonpolar**	**London dispersion forces**
B	XeF_2Cl_2		**Square planar**	polar	**Dipole-dipole forces**
C	XeF_2Cl_2		**Square planar**	nonpolar	**London dispersion forces**

+3 points total

d. Rank the molecules from lowest to highest boiling point by filling in formulas in the boxes below. Use the letters A, B, and C in the boxes to represent each molecule. Explain your answer, being sure to address the strongest intermolecular forces between molecules of each substance.

+1 all three boxes filled in correctly, no partial credit

A < **C** < **B**

+2 coherent explanation, continuation credit possible

Molecules A and C both form only the weakest London dispersion forces. However, molecule A has a lower molar mass, which means it has the very lowest boiling point, followed by molecule C. Molecule B is polar which makes it able to form dipole-dipole interactions. This gives it the highest boiling point of the three molecules.

Stop. You have reached the end of the exam. Nothing written after this page will be graded.