CHEMISTRY 101
Hour Exam III
December 5, 2019
Leveritt/McCarren

Name ________KEY_________________________

Signature _________________________________

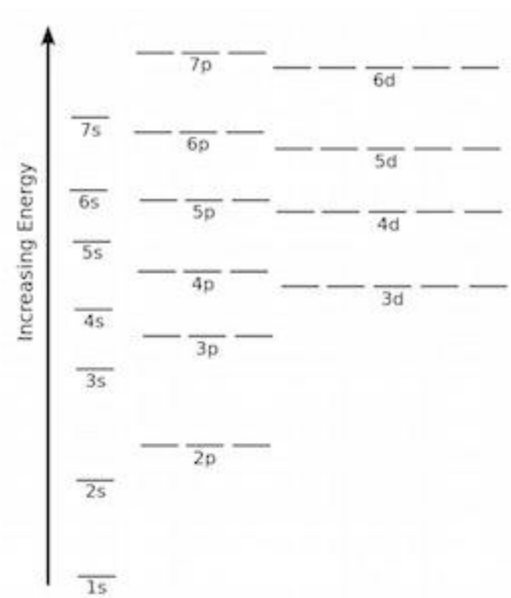
Section ____

"But I also realize that winning doesn't always mean getting first place; it means getting the best out of yourself."   — Meb Keflezighi, Olympic runner

This exam contains 17 questions on 10 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. Which of the following choices correctly ranks the atoms below in order of least to greatest atomic radius?

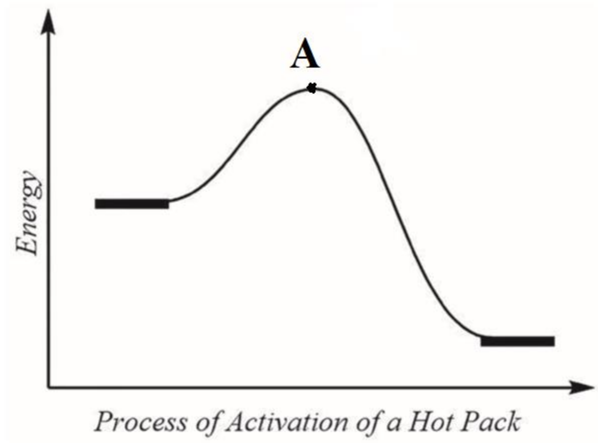
    a. Al < Si < S < O
    b. O < S < Si < Al
    c. Al < S < Si < O
    d. O < Si < S < Al
    e. S < Si < O < Al

2. Dry ice is made of solid carbon dioxide. If we place a piece of dry ice in water, bubbles form and rise to the surface of the water. If we say this is an **endothermic** process, how did we define the system? Choose the best system and explanation.
    a. *The dry ice*: The dry ice absorbs heat so that it becomes a gas.
    b. *The dry ice*: Carbon dioxide molecules in the dry ice undergo a chemical change resulting in oxygen gas leaving within the bubbles.
    c. *The air surrounding the beaker*: The air molecules gain heat as the bubbles are added to the atmosphere.
    d. *The water*: The water loses heat as its temperature drops.
    e. *The water*: Heat is added to the water which makes it boil.

3. Which of the following statements about atomic theory is still believed to be true?
    a. All atoms of the same element are identical.
    b. Negatively charged particles are embedded in a positively charged cloud throughout the atom.
    c. As verified by Rutherford, only positively charged particles called protons are found inside the nucleus.
    d. Electrons can only transition between different circular orbits outside the nucleus of the atom.
    e. **Atoms are mostly empty space.**

4. During the "flame test" demonstration both in lab and lecture, we lit solutions of various salts with a match and observed different colored flames. Which is **false** regarding the different color flames we saw during the "flame test" experiment?
    a. As the salts were lit, electrons moved further from the nucleus.
    b. The flames were different colors for each element due to different electron arrangements within the atoms of those elements.
    c. The energy added by lighting the match was smaller in magnitude than the energy released as the flames burned.
    d. Light is released as the electrons returned to the ground state.
    e. The salts were in an excited state before they were lit with the match.

5. Consider the energy diagram shown below which represents the activation of the "hot pack" as seen in lab. The hot pack was at room temperature, and after it was "activated" it produced significant heat. What is represented by the point marked "A" on the diagram?



<u>Point A</u> represents the hot pack….

a. <u>Before it is activated:</u> The hot pack loses heat overall because the surroundings get warmer.
b. <u>Before it is activated:</u> The hot back is highest in energy before it is activated.
c. <u>As it is activated: Energy is added to "start" the hot pack to give off heat.</u>
d. <u>After it is activated:</u> The hot pack has less potential energy after it is activated.
e. <u>After it is activated:</u> The hot pack has lost heat as a result of the activation.

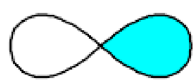
6. Consider the complete ground state electron configuration for a neutral atom of sulfur.

Which of the following is **<u>not</u>** shown by the electron configuration?
a. There are 8 total electrons in the 2^{nd} energy level.
b. There are 6 total electrons present within "s" shape orbitals.
c. <u>There are 4 valence electrons.</u>
d. The 3p electrons are expected to be higher in energy than the 3s electrons.
e. All of these are true about the electron configuration of sulfur.

Please go on to the next page.

7. Lithium and potassium both react strongly when placed into water. Which of these has a higher first ionization energy? Choose the correct answer and explanation.
    a. Lithium: Because lithium has only three electrons, the repulsions between those electrons are greater. Because greater repulsions between electrons make the atom less stable, this makes electrons easier to remove.
    b. Lithium: The outermost electrons of an atom of lithium are positioned in energy levels closer to the nucleus, which means the attraction of the nucleus is greater.
    c. Both have equal ionization energies: Lithium and potassium both have only one valence electron so it is equally difficult to remove that electron.
    d. Potassium: There are more protons in the nucleus of potassium, which hold the electrons more tightly. This makes the outer electrons harder to remove.
    e. Potassium: The outer electrons are positioned in the 4s orbitals which are higher in energy than the 2s orbitals of lithium's outer electrons.

8. Consider the image below of a single "2p" orbital. Consider that there are typically two electrons assigned to each orbital. Can a 2p electron in the ground state be located outside of this orbital? Choose the correct answer *and* explanation.



    a. Yes. However, this only occurs a small percentage of the time.
    b. Yes. Electrons can be located between orbitals only when they are "jumping" between energy levels.
    c. No. Electrons can be located outside of 2s orbitals but not outside 2p orbitals.
    d. No. The electrons move along the outer surface of the orbital as designated by the path shown.
    e. No. The orbital is a space which always contains the electrons.

Please go on to the next page.

Draw Lewis structures for the following molecules, predict the shapes and electron pair geometries. Use these to answer questions 9 - 11.

CO_2 IF_3 NF_3 $XeCl_4$

9. How many of these molecules are **nonpolar**?
   a. 0 (All are polar.)
   b. 1
   c. 2
   d. 3
   e. 4 (All are nonpolar.)

10. Which of these molecules does **not** have at least one bond angle that is 180°?
   a. CO_2
   b. IF_3
   c. NF_3
   d. $XeCl_4$
   e. All molecules have at least one bond angle that is 180°.

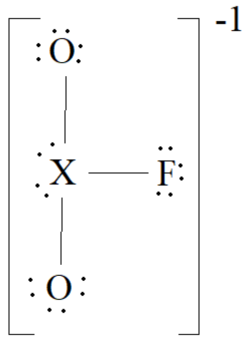
11. Which of these substances has the lowest boiling point?
   a. CO_2
   b. IF_3
   c. NF_3
   d. $XeCl_4$
   e. More than one of these molecules has the same lowest boiling point.

For questions 12 and 13, compare the molecules CH_3OCH_3 and CH_3CH_2OH.

12. How does the polarity of these molecules compare?
   a. Both molecules are nonpolar.
   b. Only CH_3OCH_3 is polar.
   c. Only CH_3CH_2OH is polar.
   d. Both molecules are polar.
   e. The polarity of both CH_3OCH_3 and CH_3CH_2OH depends on whether they are mixed with polar or nonpolar substances.

13. Which of these molecules display hydrogen bonding forces between identical like molecules?
   a. Both molecules display hydrogen bonding forces.
   b. Only CH_3OCH_3 displays hydrogen bonding forces.
   c. Only CH_3CH_2OH displays hydrogen bonding forces.
   d. Neither molecule displays hydrogen bonding forces.
   e. Either molecule can display hydrogen bonding forces if mixed with another substance containing hydrogen atoms.

14. Consider an unknown element X that bonds with fluorine and oxygen to form the **ion** shown below.



Which of the following elements could be "X" that would produce this Lewis structure?

a. S
b. P
c. Si
d. I
e. Kr

15. Consider an unknown element Z.
- Element Z has two unpaired electrons in its orbital filling diagram in its ground state.
- Compound ZO_2 displays dipole-dipole forces.

What is the identity of element Z? (Hint! An orbital diagram is on the front page.)

a. Mg
b. C
c. P
d. S
e. Cl

Please go on to the next page.

Part 2: Free Response

16. Use what you have seen in class to explain each of the following phenomena below.

a. Consider the N^{3-}, O^{2-}, and F^- ions. Rank these ions from smallest to largest and explain why you ranked them the way you did. Note that your explanation must go beyond just stating a trend – explain why using your understanding of the structure of the atom.

+4 points

+1 **Smallest to largest: F^-,O^{-2}, N^{3-}**

+1 **Each of these ions has the same number of electrons in the same number of energy levels – all have 10 electrons and have the same electron configuration as a neutral atom of neon.**

+1 **However each has a different number of protons in the nucleus.**

- **N^{3-} has 7 protons.**
- **O^{2-} has 8 protons.**
- **F^- has 9 protons.**

+1 **The attraction of the nucleus is greater in the atom that has a larger number of protons. This means the ions with more protons is smaller. Therefore, the fluorine ion is able to pull the outer electrons closer to the nucleus, which results in the smallest ion. The nitrogen ion would be the largest because it has the lowest number of protons in the nucleus.**

b. A possible excited state electron configuration for a neutral atom is $\mathbf{1s^22s^22p^63s^23p^64s^15s^15p^1}$. Identify this element and explain how you determined its identity. Then, give the ground state electron configuration for this atom.

+4 points

+1 **This is atom of scandium.**

+1 **We can determine this by adding the number of electrons (indicated by the superscripts) to get 21 electrons.**

Sum of the superscripts: 2 + 2+ 6 + 2+ 6+ 1+ 1+1 = 21 electrons.

+2 **The ground state electron configuration of scandium is $1s^22s^22p^63s^23p^64s^23d^1$.**

(Another acceptable answer is [Ar]$4s^23d^1$.)

c. In lab, we observed a series of colors given off from a glowing tube of hydrogen gas similar to the spectrum shown below. These showed that energy within atoms was quantized. How is it possible to tell from this spectrum that energy is quantized? How would the light have appeared different if it was not quantized?

+4 points

Quantized energy indicates that there are only specific amounts of energy permitted.

In the case of the light, each color of light has a specific wavelength which corresponds to a specific color.

+2

This spectrum shows that hydrogen only gives off specific colors of light, indicating that electrons are only found at certain energy levels. Therefore, energy is quantized within the atom because not all colors are visible.

+2

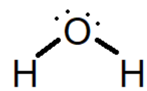
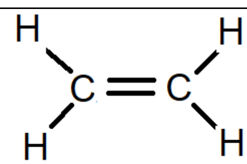
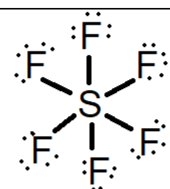
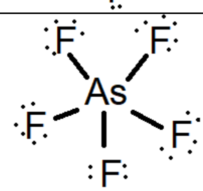
If the light was not quantized and instead all possible energy levels were available we would see the full rainbow of colors in the spectrum which is also visible as white light.

Please go on to the next page.

17. The table below gives the formulas for several substances we have discussed so far this semester.

a. Fill out the table below with the correct Lewis structure, shape, and polarity for each molecule.

+10 points

Substance	**Lewis structure**	**Molecular shape (around one central atom)**	**Polar or Nonpolar?**
H_2O		**Bent or v-shape**	**Polar**
C_2H_2		**Linear**	**Nonpolar**
C_2H_4		**Trigonal planar**	**Nonpolar**
SF_6		**Octahedral**	**Nonpolar**
AsF_5		**Trigonal bipyramid**	**Nonpolar**

2 points each line

1 points Lewis structure, +0.5 shape, +0.5 polarity

If they have the wrong Lewis structure and therefore the wrong shape, they do not get continuation credit.

Use the information in this table to answer the questions on the next page.

b. Water is a liquid at room temperature and sulfur hexafluoride is gas. Why is this? Explain, giving the most important intermolecular force for each substance.

+4 points

+2

+1

+1

Water is a liquid at room temperature and sulfur hexafluoride is a gas because water has stronger intermolecular forces than sulfur hexafluoride does. Because water is a polar molecule with H-O bonds, hydrogen bonds are able to form between separate water molecules. These bonds are stronger than the London dispersion forces within the nonpolar sulfur hexafluoride molecule. Therefore, water becomes a gas at a much higher temperature than SF_6 and is in the liquid phase at room temperature.

c. We saw C_2H_2 gas react with oxygen to form carbon dioxide and water inside a pumpkin. Was this an exothermic or endothermic process? Designate a system, surroundings, and explain from the perspective of the system.

+4 points

+1

+1

System: C_2H_2 and oxygen gas
Surroundings: Pumpkin, air, etc

If we consider the C_2H_2 gas to be the system, this was an

+1

exothermic process because heat was released from the pumpkin in the form of the flame.

+1

(Other answers are possible if they designated the system differently. For example, it is possible to say that it is an endothermic process if the pumpkin is the system because the pumpkin gained heat that was given off in the reaction.)