CHEMISTRY 101 Name _____KEY_____
Hour Exam III
April 25, 2019 Signature _____
McCarren

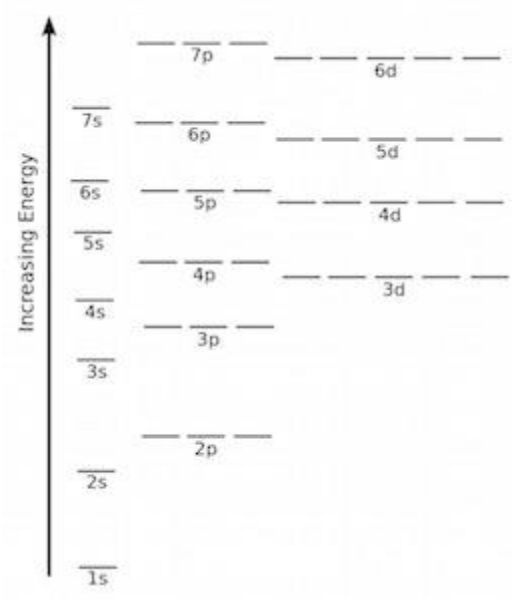
Section _____

"No winter lasts forever. No spring skips its turn." – Hal Borland

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 processes can be considered *endothermic* from the perspective of the system? The system is underlined in each case.
   a. Natural gas burns when ignited with a flame with soap bubbles on top of a hand.
   b. Two solids mixed in a beaker result in the outside of the beaker becoming colder to the touch.
   c. A racquetball freezes in liquid nitrogen.
   d. A copper salt releases a blue flame after it has been ignited as its electrons return to the ground state.
   e. Water in a glass evaporates after being left on the counter for several days.

2. Consider a neutral atom of manganese (Mn). How many total electrons are present in the third energy level (n=3)? It may be helpful to write the complete electron configuration for this atom.
   a. 5
   b. 10
   c. 11
   d. 13
   e. 15

3. Which of the following is **true** regarding the following excited state electron configuration for an unknown element X? (An orbital diagram is on the front page of this exam and may be helpful for answering this question.)

$$\mathbf{1s^2 2s^2 2p^6 3s^2 3p^2 4s^1 3d^1}$$

   a. This element is a noble gas.
   b. There is one unpaired electron in this configuration as written.
   c. This is an electron configuration for an atom of scandium.
   d. In its ground state, this element has six valence electrons.
   e. To get this excited state atom to return to the ground state, energy would be released in the form of white light.

Please go on to the next page.

4. Consider the compound CaF_2. Which is a correct electron configuration for the stable calcium **ion** as it appears in this compound?
   a. $[He]2s^22p^5$
   b. $[He]2s^22p^6$
   c. $\underline{[Ne]3s^23p^6}$
   d. $[Ar]4s^2$
   e. $[Ar]4s^23d^2$

5. Which statement is **true** regarding a bond formed between sulfur and fluorine?

   When sulfur and fluorine bond…
   a. Energy must be added to create the bond between sulfur and fluorine.
   b. **Electrons are likely to spend more time near the fluorine atom than the sulfur atom**.
   c. A bond created between sulfur and fluorine is *more polar* than a bond created between calcium and fluorine.
   d. Electrons are shared evenly between the sulfur and the fluorine atom.
   e. All of the above are true.

6. Write the ground state electron configuration for a neutral atom of sodium. Which of the following statements is **true** regarding the electrons, orbitals, and electron configuration of a sodium atom?
   a. Electrons in the 1s level of sodium rotate around the nucleus on the spherical surface of the 1s orbital.
   b. A neutral atom of sodium and an ion of sodium have the same electron configuration.
   c. In the ground state, all electrons are paired.
   d. There is only one possible excited state electron configuration of a sodium atom.
   e. In its ground state, an electron is located in a 3s orbital, but that electron can move to a 4s orbital if excited.

Please go on to the next page.

Use the following sets of atoms and ions to answer the next two questions.

Set 1	Rb	K	Na
Set 2	Ca^{+2}	Ar	Cl^{-}
Set 3	Li^{+}	He	Be^{+2}
Set 4	S	S^{-}	S^{-2}

7. Which **two** of the sets of atoms and ions show an **isoelectronic series**?

   a. Sets 2 and 4
   b. Sets 1 and 2
   c. Sets 1 and 4
   d. Sets 2 and 3
   e. Sets 3 and 4

8. In which **two** of the sets are the atoms and ions correctly organized from smallest to largest radius?
   a. Sets 2 and 4
   b. Sets 1 and 2
   c. Sets 1 and 4
   d. Sets 2 and 3
   e. Sets 3 and 4

9. We have seen hydrogen and oxygen gas react to form water in multiple demonstrations this semester. Select the statement which is **true** about the bonds between the hydrogen and oxygen atom within the water molecule compared to the bonds within oxygen gas and hydrogen gas.

   The bonds within the water molecule are _____ in potential energy than those in hydrogen and oxygen gas, because _____.

   a. *Lower*; water has polar covalent bonds and polar bonds always have less energy compared to non-polar covalent bonds in hydrogen and oxygen.
   b. *Lower*; water is less likely to react than oxygen and hydrogen gases.
   c. *Higher*; energy must be added by lighting a match in order for the reaction to occur.
   d. *Higher*; water can be broken into H^{+} and OH^{-} ions after energy is added.
   e. *Equal*; atoms are not created or destroyed when hydrogen and oxygen gas react to form water.

10. Our understanding of atomic structure has changed significantly over the past two-hundred fifty years. Which of the following early ideas regarding atomic structure is still accepted to be true?
    a. <u>Atoms are not created or destroyed in typical chemical reactions.</u>
    b. Atoms are neutral because a positively charged cloud balances out the negative charges of the electrons within the atom.
    c. Electrons circle the nucleus of the atom on paths set at specific points around the nucleus.
    d. Two of the ideas (a-c) are still accepted to be true.
    e. All of these ideas (a-c) are still accepted to be true.

11. Draw the Lewis structures for the molecules CF_2Cl_2 and XeF_2Cl_2 and consider their molecular shapes. How do the polarities of these two compounds compare?
    a. Both of these compounds are always polar.
    b. Both of these compounds are always nonpolar.
    c. Both of these compounds may be either polar or non-polar depending on the arrangement of the atoms.
    d. XeF_2Cl_2 is always polar and CF_2Cl_2 may be polar or nonpolar depending on the arrangement of the atoms.
    e. <u>CF_2Cl_2 is always polar and XeF_2Cl_2 may be polar or nonpolar depending on the arrangement of the atoms.</u>

12. A compound including central atom X forms the compound XCl_5 as it bonds with chlorine. XCl_5 ends up as a molecule with octahedral geometry and square pyramid shape. Which of the following could be element X?
    a. C
    b. P
    c. <u>I</u>
    d. Xe
    e. S

Please go on to the next page.

Consider the five compounds given below. Draw Lewis structures for each of these compounds, determine their molecular shapes and polarity, and use them to answer the next several questions.

HCN CH_3F CH_3OH NH_3 CH_3CH_3

13. Which of these compounds contains a triple bond?
    - **a. HCN**
    - b. CH_3F
    - c. CH_3OH
    - d. NH_3
    - e. CH_3CH_3

14. How many of these compounds are expected to be soluble in water?
    - a. 1
    - b. 2
    - c. 3
    - **d. 4**
    - e. 5 (All compounds are water soluble.)

15. How many of these compounds have hydrogen bonds between themselves and other molecules?
    - a. 1
    - **b. 2**
    - c. 3
    - d. 4
    - e. 5 (All compounds can form hydrogen bonds.)

Please go on to the next page.

16. Consider each of the following scenarios related to periodic trends, energy, and orbitals. Use your understanding of chemistry to thoroughly explain your answers to each of the following questions. Limit your answers to the space provided.

Periodic Trends

a. An atom of cesium contains more protons than an atom of sodium, and an atom of cesium is larger than an atom of sodium. An atom of chlorine contains more protons than an atom of sodium. However, an atom of sodium is larger than an atom of chlorine. Why is this? Explain.

+3 total

An atom of sodium is larger than an atom of chlorine because chlorine contains more protons in the nucleus. +1 **This means that the protons are better able to pull in the outer electrons and make the chlorine atom smaller. On the other hand, an atom of cesium contains more protons than an atom of sodium but these protons are in higher energy levels which are further from the nucleus.** +1 **This makes the atom of cesium larger than the atom of sodium.** +1

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b. It is more difficult to remove an electron from cation Ca^{+2} than it is to remove an electron from a neutral atom of calcium (Ca). Why is this? Explain.

+3 total

It is more difficult to remove an electron from Ca^{+2} than it is to remove an electron from a neutral atom of calcium because Ca^{+2} has already had two electrons removed from it. Therefore, the next electron to be removed in Ca^{+2} is closer to the nucleus than an electron of Ca, and therefore held more tightly by the protons in the nucleus, making it harder to remove. +1 +2

Please go on to the next page.

Endothermic and Exothermic Processes

c. If placed in a freezer at a colder temperature, water freezes and becomes ice. This is an exothermic process. If a match is struck against a matchbook, the match burns and the flame is very hot. This is also an exothermic process. How is it possible that both of these are exothermic processes although one process is very cold and the other is very warm? Explain.

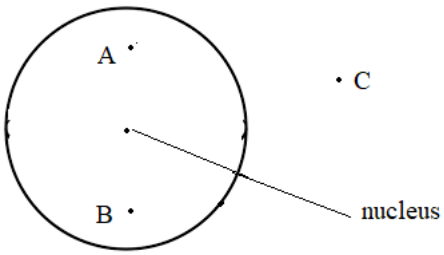
An exothermic process is one in which heat leaves the system. +1

+3 total

Although one of these processes is cold and the other process is warm, heat is leaving the system in both cases. Water freezing and becoming ice loses heat, +1 **and the match burning also releases heat. The temperature of the system does not matter.** +1

Orbitals

d. Consider a hydrogen atom with one electron and electron configuration $1s^1$. The image of the spherical 1s hydrogen orbital shown to the right. In a ground state hydrogen atom, it is possible for the electron to be at points A and B within the orbital. However it is also possible for the electron to be outside the orbital at point C. Using your understanding of atomic orbitals, explain why it is possible to find an electron at point C although it is outside the s orbital.



+3 total

An orbital is a probability map of where an electron is likely to be, though an electron can actually be anywhere. An electron can be found at point C because electrons are only expected to be within orbitals 90% of the time. Ten percent of the time, they can be outside orbitals which means that is possible to find one at point C. (It is just not likely.)

+2/3 if they say it is because the electron can be excited and move further away. (The problem specifically mentions the ground state.)

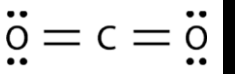
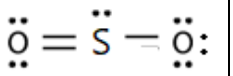
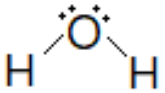
Please go on to the next page.

17. Consider four unknown compounds labeled A, B, C, and D. These compounds can be any of the following:

CO_2	SO_2	H_2	H_2O

You will use your understanding of molecular shape as well as your understanding of intermolecular forces to identify compounds A, B, C, and D.

First, fill out the table below, including a Lewis structure, shape, bond angles, geometry, polarity, and strongest intermolecular force for each molecule. You do not need to include resonance structures.

	Lewis structure	Electron pair geometry	Molecular shape	Bond angles	Polar or Nonpolar?	Strongest Intermolecular Force
CO_2		**Linear**	**Linear**	**180**	**Nonpolar**	**London dispersion forces**
SO_2		**Trigonal planar**	**Bent**	**120**	**Polar**	**Dipole-dipole forces**
H_2		**Linear**	**Linear**	**180**	**Nonpolar**	**London dispersion forces**
H_2O		**Tetrahedral**	**Bent**	**104.5°**	**Polar**	**Hydrogen bonding**

+8 total

0.5 each Lewis structure

0.5 points all together for shape, geometry, angle angles (if any of them are wrong they don't get the 0.5)

0.5 each molecule polar or non polar

0.5 each box with IMFs

Please go on to the next page.

Refer to the compounds on the previous page to answer the questions below.

a. Compound A has the lowest boiling point of all possible molecules listed. What is the identity of compound A? Explain based on the strongest intermolecular forces present in this molecule.

+3 total

+1 **Compound A is H_2. It has London dispersion forces and a** +1

+1 **lower molar mass than CO_2 which means it has the lowest boiling point and is more often a gas.**

b. Compounds A and B both have the same shape. What is the identity of compound B? Explain.

+2 total

Compound B is CO_2 because it is linear (as is H_2).

+1 +1

c. Compounds A, B, and C are gases at room temperature, but compound D is a liquid. Give the identity of compound C and the identity of compound D. Explain how you know.

+1 **Compound C is SO_2 and compound D is H_2O.** +1

+3 total

+1 **The hydrogen bonding forces in water are stronger than the dipole-dipole forces in SO_2 as well as the London dispersion forces in any other molecule. These stronger forces mean that the molecule is more likely to exist in the liquid state, making H_2O compound D.**

d. Of all four compounds on the chart on the previous page, compound D has the highest boiling point. Would TiO_2 be expected to have a higher or lower boiling point than compound D? Explain.

+2 total

+1 **TiO_2 would be expected to have a higher boiling point because its ionic bonding forces are stronger than the hydrogen bonds that**

+1 **compound D forms.**