CHEMISTRY 101
Hour Exam III
April 29, 2021
McCarren

Name _____KEY_____

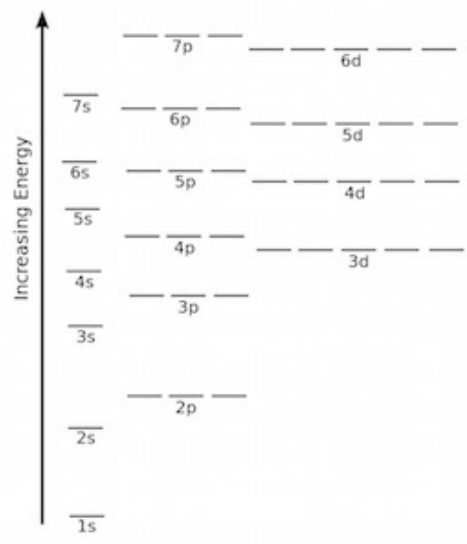
Signature _____

Section _____

"It all begins and ends in your mind. What you give power to has power over you." -Leon Brown

This exam contains 22 questions. The first 15 questions are multiple choice and the remaining questions may be a mix of multiple choice, checkboxes, and drop-down questions. Please be sure to answer all of the questions on the exam. You may use the periodic table and equation sheet provided.

Useful information:



Part 1: Multiple Choice

Computer graded

+2 points each multiple choice question

1. Consider the demonstrations below, as shown in lecture:

Demonstration 1	Demonstration 2
A racquetball placed in liquid nitrogen.	Two white solids were mixed in a beaker and the beaker became colder to the touch.

If we define one of the changes that happens in each demonstration to be **endothermic** with respect to the system, how was the system defined?

	Demonstration 1	Demonstration 2
a.	Racquetball	White solids
b.	**Liquid nitrogen**	**White solids**
c.	Racquetball	Beaker
d.	Liquid nitrogen	Beaker
e.	Racquetball	Air in room

2. Which of the following is **false** regarding our current understanding of the atom?
   a. The exact location of electrons is undetermined.
   b. Atoms consist primarily of empty space.
   c. Atoms can combine to form molecules and compounds.
   d. The same number of atoms are present before and after a chemical reaction.
   e. Valence electrons orbit along the radius of an atom.

3. In the Modern Atomic Theory lab, we looked at the relationship between atomic theory and energy. Which of the following is **true** regarding energy and the atom?
   a. Adding heat to the salts using the Bunsen burner was an exothermic process.
   b. Endothermic processes often require activation energy to begin, but exothermic processes do not.
   c. The salts releasing light in the form of colored flames was an exothermic process.
   d. Electrons become more stable and have less energy when further from the nucleus.
   e. The different colors of light released by the salts had the same amount of energy because they were all coming from the same heat source.

4. Which choice best describes orbitals?

- **a.** Orbitals describe the path of an electron's movement around the nucleus of an atom.
- **b.** Orbitals provide accurate explanations for the precise locations of electrons around an atom's nucleus.
- **c.** Orbitals are places electrons can be found on or inside.
- **d.** **Orbitals are regions of space an electron is usually present in.**
- **e.** Orbitals are specific solid shapes outside the nucleus of the atom.

5. Give the expected ground state electron configuration for a neutral atom of arsenic.

- **a.** $[Ar]4s^2 4p^3$
- **b.** **$[Ar]4s^2 3d^{10} 4p^3$**
- **c.** $[Ar]4s^2 4d^{10} 4p^3$
- **d.** $[Kr]5s^2 4d^{10} 5p^3$
- **e.** $[Ar]4s^3 3d^{10} 4p^3$

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Use electron configurations labeled #1 and #2 below to answer the next two questions. The electron configurations may be in a ground or excited state.

Electron Configuration #1	Electron Configuration #2
$[Ar]4s^2 3d^7 4p^1$	$[Kr]5s^2 4p^{10} 5p^6$

6. What is the total number of unpaired electrons present between both electron configuration #1 and electron configuration #2?
   a. 0 (All electrons paired.)
   b. 1
   c. 2
   d. 4
   e. 8

7. Which of the following could be represented by electron configurations #1 and #2?

	Electron Configuration #1	Electron Configuration #2
a.	Neutral atom of gallium	Neutral atom of krypton
b.	Neutral atom of gallium	Stable ion of iodine
c.	Neutral atom of gallium	Stable ion of rubidium
d.	Neutral atom of nickel	Neutral atom of bromine
e.	**Neutral atom of nickel**	**Stable ion of barium**

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8. Which of the following neutral elements has the **highest** first ionization energy?

a. I
b. Sb
c. Sr
d. Mo
e. Pd

9. Unknown elements X and Z are both found in period 3 (horizontal row 3) of the periodic table. Each atom of element Z has a larger radius than each atom of element X. How many of the following statements are **true** regarding elements X and Z?

    - Element Z has more valence electrons than element X.
    - Element Z has a higher atomic number than element X.
    - Element Z has a higher first ionization energy than element X.
    - Element Z has a higher electronegativity than element X.

    a. 0 (None of the statements are true.)
    b. 1
    c. 2
    d. 3
    e. 4 (All four of the statements are true.)

10. Which of the following is an ionic bond?
    a. Cl bonding with Cl
    b. O bonding with Cl
    c. **Fe bonding with Cl**
    d. bonding with Cl
    e. S bonding with Cl

Draw the Lewis structures for the substances shown below, determine the molecular shapes of each, and use these to answer the questions.

HCN H_2O BH_3

11. Choose the option which arranges the substances in order of **lowest to highest** number of effective pairs of electrons around the central atom.

    a. $HCN < H_2O < BH_3$

    b. **$HCN < BH_3 < H_2O$**

    c. $BH_3 < H_2O < HCN$

    d. $BH_3 < HCN < H_2O$

    e. $H_2O < BH_3 < HCN$

12. Choose the option which arranges the substances in order of **smallest to largest** bond angle around the central atom.

    a. $HCN < H_2O < BH_3$

    b. $HCN < BH_3 < H_2O$

    c. $BH_3 < H_2O < HCN$

    d. $BH_3 < HCN < H_2O$

    e. **$H_2O < BH_3 < HCN$**

13. Choose the option which arranges the substances in order of **lowest to highest** boiling point.

    a. $HCN < H_2O < BH_3$

    b. $HCN < BH_3 < H_2O$

    c. $BH_3 < H_2O < HCN$

    d. **$BH_3 < HCN < H_2O$**

    e. $H_2O < BH_3 < HCN$

Consider each of the molecules as shown below.

$KrBr_2$ **IBr_3** **PBr_5**

14. Select the option which gives the shape for each of the compounds.

	$KrBr_2$	**IBr_3**	**PBr_5**
a.	**Linear**	**t-shape**	**Trigonal bipyramid**
b.	Linear	Trigonal pyramid	Square pyramid
c.	Bent	t-shape	Trigonal bipyramid
d.	Bent	Trigonal pyramid	Square pyramid
e.	Bent	Trigonal planar	Square pyramid

15. Select the option which correctly identifies the strongest intermolecular forces between different molecules of each of the compounds.

	$KrBr_2$	**IBr_3**	**PBr_5**
a.	Dipole-dipole	Hydrogen bonding	Dipole-dipole
b.	London dispersion	London dispersion	London dispersion
c.	Dipole-dipole	Dipole-dipole	London dispersion
d.	Dipole-dipole	Dipole-dipole	Dipole-dipole
e.	**London dispersion**	**Dipole-dipole**	**London dispersion**

Part 2: Free Response

16. Consider the atoms and ions listed below.

S^{2-} Ar K^{+}

Hand graded +4 points total

These three species are listed in order from lowest to highest ionization energy. **Explain why** they are ranked this way.

Your explanation should address:

- The definition of ionization energy
- A comparison of the number of protons in the species
- A comparison of the number of electrons in the species
- The way these factors influence the ranking of the species

+1 **Ionization energy is the amount of energy required to remove an outer electron from an atom.**

+1 **For these three atoms, they have different numbers of protons: 16, 18, and 19, respectively.**

+1 **They all have the same number of electrons, 18, making this an isoelectronic series.**

In this case, the because the electrons are the same, the number of protons (and therefore the amount of nuclear attraction) is what determines how difficult it is to remove an electron and therefore what has the highest ionization energy.

+1 **Because K^{+} has the most protons, the nuclear pull on the electrons is strongest so they are most difficult to remove. As a result it has the highest ionization energy. The opposite is true for S^{-2}. It has the lowest ionization energy because it has the smallest number of electrons.**

17. Consider three atoms listed below.

Ni Co Fe

These three species are listed in order from smallest to greatest atomic radius. **Explain why** they are ranked this way.

Hand graded +4 points total

Your explanation should address:

- The definition of atomic radius
- A comparison of the number of protons in the species
- A comparison of the number of electrons in the species
- The way these factors influence the ranking of the species

+1 **Atomic radius refers to the average size of the atom.**

+1 **Ni has 28 protons, Co has 27 protons, and Fe has 26 protons.**

+1 **Ni has 28 electrons, Co has 27 electrons, and Fe has 26 electrons.**

+1 **Because all of these are in the same row with the same number of energy levels, adding more protons results in a stronger nuclear pull on the electrons. Therefore, nickel has the smallest radius because its protons pull its electrons in closer to its nucleus. Iron has the largest radius because it has the smallest number of protons. This is true even though the number of electrons increase.**

18. Consider the three bonds listed below.

O – O S – O S – F

These three species are ranked from least to greatest bond polarity. **Explain why** they are ranked this way.

Hand graded +4 points total

Your explanation should address:

- The definition of a bond
- The definition of electronegativity and how it relates to bond polarity
- The definition of a polar bond
- The way these factors influence the ranking of the three bonds

+1 **A bond is a force connecting two atoms.**

+1 **Electronegativity is the ability of a particular atom to attract electrons to itself within a bond. Bonds are more polar when there is a bigger EN difference between the atoms.**

+1 **A polar bond occurs when different atoms have different EN values and share electrons unequally.**

+1 **O-O has no EN difference, so it is nonpolar. S-O has some EN difference, and S-F has the greatest EN difference, so it is the most polar bond. Thus, electrons are shared most unequally between S and F compared to the other two pairs of atoms.**

Consider each of the groups of compounds listed below. Answer the questions for each one.

19. The compounds SO_2, CH_2O, and BF_3 each have the **same electron pair geometry**. For each of these compounds, determine the electron pair geometry determine the molecular shape, whether the molecule is polar or nonpolar, and the strongest intermolecular forces present between different molecules of the substance.

Computer graded

+4.5 points (0.375 points each blank)

Formula	Electron pair geometry	Molecular Shape	Polar or nonpolar?	Strongest Intermolecular Forces?
SO_2	Trigonal planar	bent	polar	dipole-dipole
CH_2O	Trigonal planar	Trigonal planar	Polar	Dipole-dipole
BF_3	Trigonal planar	Trigonal planar	nonpolar	London dispersion

20. The compounds CH_4, CH_3F and CH_2F_2 each have the **same molecular shape**. For each of these compounds, determine the electron pair geometry, determine the molecular shape, whether the molecule is polar or nonpolar, and the strongest intermolecular forces present between different molecules of the substance.

Computer graded

+4.5 points (0.375 points each blank)

Formula	Electron pair geometry	Molecular Shape	Polar or nonpolar?	Strongest Intermolecular Forces?
CH_4	tetrahedral	tetrahedral	nonpolar	London dispersion
CH_3F	tetrahedral	tetrahedral	polar	dipole-dipole
CH_2F_2	tetrahedral	tetrahedral	polar	dipole-dipole

21. The compounds HF, PF_3, and IF_5 **all have the same polarity (either all three are polar or all three are nonpolar)**. For each of these compounds, determine the electron pair geometry, the molecular shape, whether the molecule is polar or nonpolar, and the strongest intermolecular forces present between different molecules of the substance.

Computer graded

+4.5 points (0.375 points each blank)

Formula	Electron pair geometry	Molecular Shape	Polar or nonpolar?	Strongest Intermolecular Forces?
HF	**Tetrahedral**	**Linear**	**Polar**	**hydrogen bonds**
PF_3	**tetrahedral**	**trigonal pyramid**	**Polar**	**dipole-dipole**
IF_5	**octahedral**	**square planar**	**Polar**	**dipole-dipole**

22. The compounds CH_3CH_2OH, CH_3OCH_3, both can be simplified to the same formula: C_2H_6O. However, these have different strongest intermolecular forces. On the diagram below, fill in the formula, electron pair geometry around oxygen, molecular shape around oxygen, and polarity for each of the molecules. You will have to determine the strongest intermolecular forces in each.

Computer graded

+4.5 points (0.5625 points each blank)

Formula	Electron pair geometry (around oxygen)	Molecular Shape (around oxygen)	Polar or nonpolar?	Strongest Intermolecular Forces?
CH_3CH_2OH	**Tetrahedral**	**Bent**	**polar**	**Hydrogen bonds**
CH_3OCH_3	**tetrahedral**	**bent**	**Polar**	**Dipole-dipole**