CHEMISTRY 101
Hour Exam III
April 25, 2024
Dr. E. McCarren

Name _____KEY_____

Signature _____

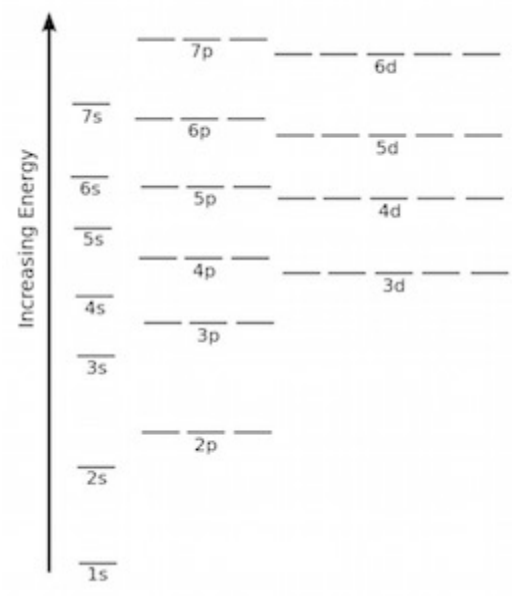
Section _____

"The big talent is persistence." – Octavia E. Butler, American author

This exam contains 17 questions on 9 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

+2 points each

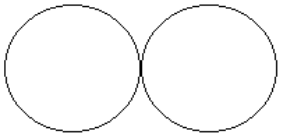
1. Which of the following processes is **endothermic**? The system is underlined in each case.
    a. A racquetball hardens in liquid nitrogen.
    b. Natural gas is burned in a furnace.
    c. **Ice melts on a warm day.**
    d. Sulfuric acid is added to a solution and the solution gets very hot.
    e. Gaseous water vapor condenses into liquid water.

2. Which of the following is **true** related to exothermic processes?

    In an exothermic process…
    a. the products have higher energy than the reactants.
    b. energy is transferred into the system
    c. the surroundings lose heat from the system.
    d. **the products are more stable than the reactants.**
    e. activation energy is not needed to start a reaction.

3. Which of the following is still considered to be **true** related to our understanding of atomic structure?
    a. Atoms are the smallest possible indivisible particles.
    b. Negatively charged electrons orbit the center of an atom on circular paths.
    c. An atom contains a positively charged cloud which holds electrons.
    d. All atoms of a single element are identical to one another.
    e. **The outer electrons of an atom are most likely to participate in bond formation.**

4. The following diagram displays a p orbital similar to those that we have discussed in class. Which of the following is **true** related to this p orbital?



    a. This p orbital can hold six electrons.
    b. Electrons are in either the left side or right side of the orbital at any given time.
    c. Electrons move along the surface of the area designated by the orbital.
    d. **Electrons may be located either inside or outside the area designated by the p orbital.**
    e. Electrons may be positively or negatively charged when they are located within the p-orbital.

5. Which of the following is the correct ground state electron configuration for a neutral atom of tellurium (#52)?
   a. **[Kr]$5s^2 4d^{10} 5p^4$**
   b. [Kr]$5s^2 5d^{10} 5p^4$
   c. [Kr]$4s^2 4d^{10} 5p^4$
   d. [Ar]$4s^2 3d^{10} 4p^4$
   e. [Ar]$5s^2 4d^{14}$

6. The electron configuration below is for a neutral atom in an excited state. Which of the following is true related to this electron configuration?

$1s^2 2s^2 2p^6 3s^2 3p^3 4s^1 3d^1$

   a. This is the electron configuration for a neutral atom of scandium.
   b. The atom represented by this configuration has six valence electrons overall.
   c. **The atom represented by this electron configuration is a halogen.**
   d. There are two unpaired electrons in this configuration as written.
   e. The third energy level is completely full of electrons as written in this configuration.

7. Which option correctly ranks the following neutral atoms from smallest to largest atomic radius?

O F C Ne N

   a. **Ne < F < O < N < C**
   b. C < N < O < F < Ne
   c. N < O < C < Ne < F
   d. F < Ne < C < O < N
   e. O < C < F < Ne < N

8. Atoms are smaller near the right of a horizontal row on the periodic table and larger to the left on the periodic table. Which best explains *why* this happens?
    a. The atoms to the right of periodic table have a greater number of electrons which decreases atomic size.
    b. There are more energy levels of electrons towards the left of the periodic table which pushes electrons further from the nucleus.
    c. The atoms to the right of the periodic table have lost electrons which decreases the size of the atom.
    d. **The increased protons to the right of the periodic table attract the electrons more strongly.**
    e. Metal atoms are on the left of the periodic table which are smaller than nonmetal atoms.

9. What is a London dispersion force?
    a. Attractions between the positive and negative ends of separate molecules.
    b. **Attractions between molecules due to random movements of electrons.**
    c. Strong attractions between molecules which have F, O, and N atoms.
    d. Attractions between cations and anions of ionic compounds.
    e. Bonds within compounds which maintain the compound's internal structure.

10. Select the option which best fills in the blank below.

    Substances with stronger intermolecular forces are _____ likely to be found in the gas phase at room temperature and have _____ boiling points than substances with weaker forces.
    a. **less; higher**
    b. more; higher
    c. less; lower
    d. more; lower
    e. equally; lower

11. Which choice below best describes a polar molecule?

    A polar molecule always…

    a. has lone pairs of electrons around the central atom.
    b. **has one end that is more negative and another that is more positive.**
    c. has electrons evenly distributed around the central atom.
    d. has atoms of only one type of element attached to the central atom.
    e. consists of at least one atom of hydrogen.

The five molecules listed below all contain one or more atoms of fluorine. Draw Lewis structures these molecules and use them to answer the next several questions.

HF SF_2 SF_4 IF_5 IF_3

12. Which of the structures has 20 valence electrons in its Lewis structure?
    a. HF
    b. **SF_2**
    c. SF_4
    d. IF_5
    e. IF_3

13. Which of the structures has a T-shape?
    a. HF
    b. SF_2
    c. SF_4
    d. IF_5
    e. **IF_3**

14. How many of the structures have 5 effective pairs of electrons around the central atom?
    a. 1
    b. **2**
    c. 3
    d. 4
    e. 5 (All five structures have five effective pairs of electrons.)

15. How many of the molecules are polar?
    a. 1
    b. 2
    c. 3
    d. 4
    e. **5 (All five molecules are polar.)**

Please go on to the next page.

Part 2: Free Response

16. Each of the following statements compares the chemical properties of a pair of atoms or ions. Explain the comparisons by answering the questions below.

a. It is harder to remove an electron from a neutral atom of sodium (Na) than a neutral atom of rubidium (Rb). Why is this? Explain. Your explanation should include the reasoning behind this ionization energy trend at an atomic level (addressing protons, electrons, and energy levels), and should go beyond simply stating the trend.

+4 points total

+1 compare protons & electrons

+1 compare energy levels

+2 explanation

It is harder to remove an electron from sodium because it has a higher first ionization energy than rubidium. There are more protons, electrons, and energy levels in an atom of rubidium than there are in an atom of sodium. This means that the outer electrons are easier to remove because they are in much higher levels located further from the nucleus of the rubidium atom. The sodium atom has a smaller number of energy levels, so the outer electrons are located closer to the nucleus of the atom. Because the nucleus attracts these electrons more strongly, they are more difficult to remove.

b. A neutral atom of sulfur (S) has smaller radius than the most stable ion of sulfur (S^{2-}). Why is this? Explain. Your explanation should include the following:

- The number of protons in each species
- The number of electrons in each species
- How the numbers of protons and electrons relate to size

+4 points total

+1

+1 +1

+1

Both neutral sulfur and the sulfur ion have <u>16 protons</u> in their nuclei, though the <u>neutral sulfur atom has 16 electrons</u> and the <u>sulfur ion has 18 electrons</u>. Although the nuclei of both atoms have the same amount of attraction because they have the same number of protons, the <u>18 electrons in the sulfur ion spread out more around the nucleus of the atom for the sulfur ion</u>, which means that the sulfur ion ends up being larger than the neutral sulfur atom.

c. The bond formed between an atom of carbon and an atom of nitrogen (N – C) is less polar than the bond formed between an atom of nitrogen and an atom of hydrogen (N – H). Why this this? Explain. Your explanation should include the following:

+4 points total

- The definition of a bond
- The definition of electronegativity
- A comparison of electronegativity differences between the atoms in each of the bonds
- How electronegativity differences relate to bond polarity

+1 **A bond is a force which connects two atoms together.**

Electronegativity is the ability of an atom to attract electrons within a bond

+1 **to itself. If there are larger electronegativity differences between two atoms, the bonds are more polar.**

+1 **Because N and C have a smaller electronegativity difference between both atoms than N and H, the N-C bond is less polar.**

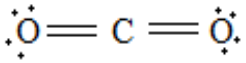
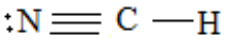
+1 **Generally, electrons will spend more time near the atom in the bond which is more electronegative. (In both of these examples, that is referring to the N atom.)**

Please go on to the next page.

17. Consider each of the following pairs of molecules. The two molecules in each pair both have the same molecular shape. For each of the molecules, draw the correct Lewis structure and use the Lewis structure to determine the shape, polarity, and strongest intermolecular forces present between molecules of each substance. Then, identify the molecule in each pair which has a higher boiling point. Note: you do not need to draw multiple resonance structures if a molecule displays resonance. You only need to draw one possible structure.

+4.5 points total

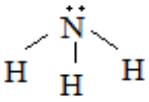
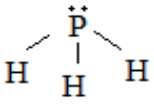
Pair 1

Molecule	Lewis Structure	Shape	Polar or nonpolar?	Strongest Intermolecular Forces
CO_2		Linear	Nonpolar	London dispersion forces
HCN		Linear	Polar	Dipole-dipole forces
The substance with the higher boiling point in this pair is ____HCN____.				

+0.5 points each blank

+4.5 points total

Pair 2

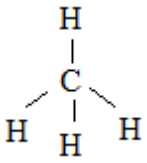
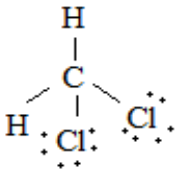
Molecule	Lewis Structure	Shape	Polar or nonpolar?	Strongest Intermolecular Forces
NH_3		Trigonal pyramid	Polar	Hydrogen bonds
PH_3		Trigonal pyramid	Polar	Dipole-dipole forces
The substance with the higher boiling point in this pair is ___NH_3_____.				

+0.5 points each blank

Please go on to the next page.

+4.5 points total

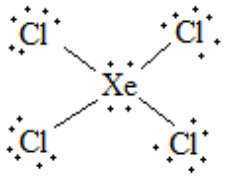
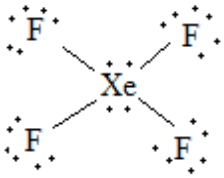
Pair 3

Molecule	Lewis Structure	Shape	Polar or nonpolar?	Strongest Intermolecular Forces
CH_4		**Tetrahedral**	**Nonpolar**	**London dispersion forces**
CH_2Cl_2		**tetrahedral**	**Polar**	**Dipole-dipole forces**
The substance with the higher boiling point in this pair is _____**CH_2Cl_2**_____.				

+0.5 points each blank

Pair 4

+4.5 points total

Molecule	Lewis Structure	Shape	Polar or nonpolar?	Strongest Intermolecular Forces
$XeCl_4$		**Square planar**	**Nonpolar**	**London dispersion forces**
XeF_4		**Square planar**	**Nonpolar**	**London dispersion forces**
The substance with the higher boiling point in this pair is _____**$XeCl_4$**_____.				

+0.5 points each blank

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