CHEMISTRY 101
Hour Exam III
December 6, 2018
McCarren

Name ______________________________

Signature ______________________________

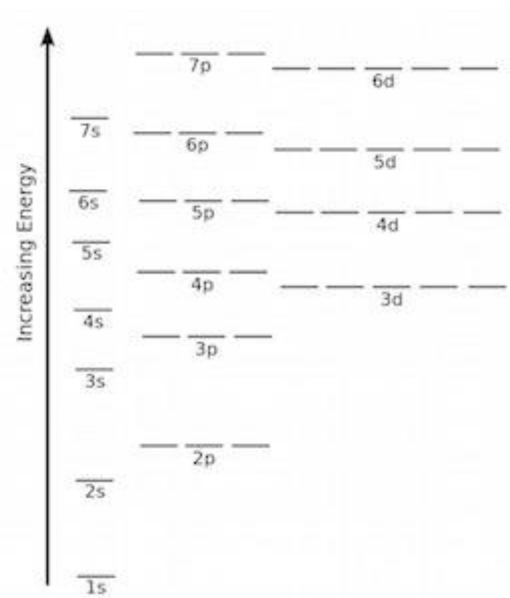
Section ______________________________

"Find the good. It's all around you. Find it, showcase it and you'll start believing in it." – Jessie Owens, Olympic sprinter

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	(15 pts.)	________
17	(15 pts.)	________
Total	(60 pts)	________

Useful information:



Part 1: Multiple Choice

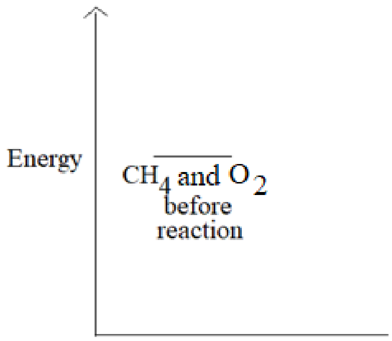
1. Which of the following is **not** a correct electron configuration for an atom of iron? This can be a ground state **or** excited state electron configuration.
   a) $1s^22s^22p^63s^23p^64s^23d^6$
   b) $[Ar]4s^23d^6$
   c) $[Ne]4s^23d^6$
   d) $1s^22s^22p^63s^23p^64s^23d^54p^1$
   e) All of these are correct electron configurations of an atom of iron.

2. Which of the following sets shows an isoelectronic series?
   a) S, S^{2-}, S^-
   b) Na, Li, K
   c) C, N, O
   d) F^-, Cl^-, Ne
   e) S^{2-}, Cl^- K^+

3. The following five demonstrations were performed in lecture. How many of the following represent **endothermic** processes? The system is underlined in each case.
   - **Liquid nitrogen** becoming gaseous nitrogen when poured into the air.
   - **Water in a flower** freezing when liquid nitrogen is poured over it.
   - The **oxygen and hydrogen gas** that react together in a Pringles can rocket resulting in a large pop and the production of flames.
   - **Water** is heated on a hot plate until it boils.
   - **Two solids** mixed in a beaker result in the outside of the beaker becoming ice cold to the touch.

   a) 1
   b) 2
   c) 3
   d) 4
   e) 5 (All are endothermic processes.)

4. We have seen a lecture demonstration in which soap bubbles holding natural gas (CH_4) are placed on a hand and lit with a match. This results in the natural gas within the bubbles reacting with oxygen in the air to form carbon dioxide and water. An <u>incomplete</u> energy diagram for this reaction is shown below. To correctly finish this diagram, where should the carbon dioxide and water be placed on the diagram to represent the energy absorbed or released after the reaction?



CO_2 and H_2O should appear on the energy diagram…

a) *Lower* in energy than CH_4 and O_2, because energy was released to the surroundings as a result of the combustion reaction.
b) *Lower* in energy than CH_4 and O_2, because water and carbon dioxide react much more easily with air than CH_4 does.
c) *At the same level* as CH_4 and O_2, because energy is never created or destroyed, it simply changes form as a result of the reaction.
d) *Higher* in energy than CH_4 and O_2, because energy was put in by lighting the match to get the process to begin.
e) *Higher* in energy than CH_4 and O_2, because the oxygen in the air was used up in order to make the process occur.

5. Each of the following statements represent major developments in the history of atomic structure. Which development is <u>not</u> still believed today?

a) Atoms are not created or destroyed in chemical reactions, they are merely rearranged.
b) Atoms contain tiny, negatively charged particles known as electrons.
c) The negatively charged electrons within an atom are found within a positively charged cloud.
d) Atoms contain neutral particles called neutrons in their centers.
e) Atoms of each element contain a set of unique quantized energy levels due to their different electron arrangements.

6. Consider a neutral atom of magnesium and its most stable ion, Mg^{+2}. Which of the following identifies the atom or ion with the largest radius **and** explains why that atom or ion has the greatest radius?

   Mg Mg^{+2}

   a) ***Mg***: Both of the atoms and ions have the same number of protons in the nucleus, but neutral magnesium has the greatest number of electrons, meaning the electrons will repel from one another and result in a larger radius.
   b) ***Mg***: Magnesium is a neutral atom with the same number of protons and electrons. Neutral atoms are always larger than ions of the same atom regardless of whether those ions have lost or gained electrons.
   c) ***Mg^{+2}*:** This positively charged magnesium ion has gained two electrons, which means that the greater number of electrons results in more repulsions and interactions between the electrons, resulting in a greater atomic size.
   d) ***Mg^{+2}*:** The nucleus of this magnesium ion has gained two protons, which increases the size of the atom due to the greater nuclear attraction.
   e) ***Both of the atoms and ions are the same size***: size does not depend on whether the substance is an atom or ion – if atoms and ions of the same element are present, then they are both the same size.

7. Which of the following statements regarding ionization energy is **completely true**?

   a) A stable ion of sulfur has a higher ionization energy than a neutral atom of sulfur because sulfur has extra electrons making them easier to remove.
   b) Fluorine has a higher first ionization energy than oxygen because an atom of fluorine is larger than an atom of oxygen.
   c) Ionization energy and electronegativity have the same meaning, so if an atom has a higher ionization energy, it will also have a higher electronegativity.
   d) An atom with a lower ionization energy also has a lower atomic radius because electrons are easier to remove from smaller atoms.
   e) The second ionization energy (i.e. energy to remove a second electron) of an element is always higher than the first ionization energy because it is more difficult to remove an electron from a positively charged ion than a neutral atom.

8. Which of the following statements is **false** about orbitals as they relate to the structure of the atom?
   a) Orbitals present a probability map of where an electron is likely to be.
   b) The way an electron moves and its location remains unknown.
   c) Electrons can become excited and can move to higher energy orbitals.
   d) A single "d" orbital can hold 10 electrons, and a single "p" orbital can hold 6.
   e) Together, all of the orbitals in principal energy level 3 can hold 18 total electrons.

Draw the Lewis Structures for each of the molecules listed below and use them to answer the next four questions.

Br_2O CF_4 NCl_3 C_2H_4

9. Which of these molecules has a tetrahedral shape?
   a) Br_2O
   b) CF_4
   c) NCl_3
   d) C_2H_4
   e) None of these molecules have a tetrahedral shape.

10. Which two of these molecules are **<u>polar</u>**?
    a) Br_2O and CF_4
    b) Br_2O and NCl_3
    c) NCl_3 and C_2H_4
    d) Br_2O and C_2H_4
    e) CF_4 and C_2H_4

11. For which of these molecules is the bond angle the largest?
    a) Br_2O
    b) CF_4
    c) NCl_3
    d) C_2H_4
    e) Two of the molecules have the same largest bond angle.

12. For how many of the molecules can resonance structures be drawn?
    a) 0 (Resonance structures can be drawn for none of the molecules.)
    b) 1
    c) 2
    d) 3
    e) 4 (Resonance structures can be drawn for all of the molecules.)

Draw Lewis structures for each of the molecules below and use them to answer the next three questions.

BH_3 SF_4 $KrCl_2$ Cl_2O

13. For how many of these molecules is it <u>impossible</u> to satisfy the octet rule for all atoms in the molecule?

a) 0
b) 1
c) 2
d) 3
e) 4 (None obey the octet rule for all atoms.)

14. Select the option which identifies the strongest intermolecular force in each of the following molecules.

	BH_3	**$KrCl_2$**	**Cl_2O**
a)	London dispersion	London dispersion	Dipole-dipole
b)	Ionic	Dipole-dipole	Dipole-dipole
c)	London dispersion	Dipole-dipole	Dipole-dipole
d)	London dispersion	London dispersion	London dispersion
e)	Dipole-dipole	Dipole-dipole	Dipole-dipole

15. Rank the molecules BH_3, $KrCl_2$, and Cl_2O from lowest to highest boiling point. It is possible that two or more of the molecules are predicted to have the same boiling point.

a) $BH_3 = KrCl_2 = Cl_2O$
b) $Cl_2O < KrCl_2 < BH_3$
c) $Cl_2O < KrCl_2 = BH_3$
d) $BH_3 = KrCl_2 < Cl_2O$
e) $BH_3 < KrCl_2 < Cl_2O$

Free Response - please write your answers completely in the spaces below.

16. Consider the electron configurations below. Each represents the expected electron configuration of a neutral atom, and the configuration can be written in the ground **or** excited state.

a. Give the symbol of the neutral atom given by the electron configuration and give the number of unpaired electrons in the electron configuration ***as written***. An orbital diagram is located on the front cover of the exam which may be helpful.

	Configuration	Element Identity	Number of Unpaired Electrons
1)	$[Ar]4s^2 3d^{10} 4p^4$		
2)	$1s^2 2s^2 2p^2 3s^2$		
3)	$[Kr]5s^1 4d^5$		

b. The atomic radii of the three elements are 48 pm, 103 pm, and 190 pm (not necessarily in that order). Match each of elements 1), 2), and 3) with its corresponding radius.

1) ____________

2) ____________

3) ____________

c. Consider the element that you assigned to have a radius of 48 pm. For a neutral atom of this element, is it possible for an electron to ever be closer to the nucleus than 48 pm? Is it possible for an electron to be further away from the nucleus than 48 pm? Explain in each case.

d. Each of elements 1), 2), and 3) is able to form a bond with oxygen. How many of these bonds are polar? Explain thoroughly. In your answer, be sure to:

- Identify which of the three bonds are polar and which of the three the bonds are nonpolar.
- Explain the difference between a polar bond and a nonpolar bond. (Note: you need to actually explain what these mean in terms of the behavior of electrons, do not just state how to identify whether a bond is polar or nonpolar.)

17. The substances XeF_4 and XeF_2Cl_2 both have the same electron pair geometry, molecular shape, and bond angles.

   a. Draw the Lewis structures of XeF_4 and both the polar and nonpolar forms of XeF_2Cl_2 in the spaces below. Use the structures you draw to completely fill out the table indicating geometry, bond angles, and molecular shape.

Lewis Structures		
A	**B**	**C**
XeF_4 (nonpolar)	XeF_2Cl_2 (polar)	XeF_2Cl_2 (nonpolar)

Electron Pair Geometry	Molecular Shape	Bond Angle(s)

   b. These three molecules (labeled A, B, and C) all have the same molecular shape, but do not have the same boiling point. Rank them from lowest to highest boiling point in the spaces below and justify your answer, including identifying the strongest intermolecular forces between each molecule. Use the letters A, B, and C in your ranking.

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In parts a. and b., we examined structures with similar shape, but with different formulas. It is also possible to have structures with similar formulas but different arrangements of atoms.

c. There are two possible arrangements of atoms for a molecule with the empirical formula C_2H_6O. These are CH_3OCH_3 and CH_3CH_2OH. Draw the Lewis structure for both of these arrangements and give the molecular geometry, shape, and bond angles around the **oxygen** atom. Then determine if each molecule is polar or nonpolar overall.

	Lewis Structure	Electron Pair Geometry Around Oxygen	Molecular Shape Around Oxygen	Bond Angle(s) Around Oxygen	Overall molecule polarity
CH_3OCH_3					
CH_3CH_2OH					

d. Do CH_3OCH_3 and CH_3CH_2OH have the same boiling point? Explain why or why not, including describing the strongest intermolecular forces present between each molecule. If they do not have the same boiling point, state which arrangement has the highest boiling point and justify your answer.

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

Chem 101 Scratch Paper

NOTHING WRITTEN ON THIS PAGE WILL BE GRADED

Periodic Table of the Elements

Key

Atomic number → 67
Symbol → Ho
Name → Holmium
Atomic mass → 164.93

	1A	2A	3B	4B	5B	6B	7B	8B	8B	8B	1B	2B	3A	4A	5A	6A	7A	8A	
1	1 H Hydrogen 1.008																	2 He Helium 4.003	1
2	3 Li Lithium 6.941	4 Be Beryllium 9.012											5 B Boron 10.81	6 C Carbon 12.01	7 N Nitrogen 14.01	8 O Oxygen 16.00	9 F Fluorine 19.00	10 Ne Neon 20.18	2
3	11 Na Sodium 22.99	12 Mg Magnesium 24.31											13 Al Aluminum 26.98	14 Si Silicon 28.09	15 P Phosphorus 30.97	16 S Sulfur 32.07	17 Cl Chlorine 35.45	18 Ar Argon 39.95	3
4	19 K Potassium 39.10	20 Ca Calcium 40.08	21 Sc Scandium 44.96	22 Ti Titanium 47.88	23 V Vanadium 50.94	24 Cr Chromium 52.00	25 Mn Manganese 54.94	26 Fe Iron 55.85	27 Co Cobalt 58.93	28 Ni Nickel 58.69	29 Cu Copper 63.55	30 Zn Zinc 65.38	31 Ga Gallium 69.72	32 Ge Germanium 72.59	33 As Arsenic 74.92	34 Se Selenium 78.96	35 Br Bromine 79.90	36 Kr Krypton 83.80	4
5	37 Rb Rubidium 85.47	38 Sr Strontium 87.62	39 Y Yttrium 88.91	40 Zr Zirconium 91.22	41 Nb Niobium 92.91	42 Mo Molybdenum 95.94	43 Tc Technetium (98)	44 Ru Ruthenium 101.1	45 Rh Rhodium 102.9	46 Pd Palladium 106.4	47 Ag Silver 107.9	48 Cd Cadmium 112.4	49 In Indium 114.8	50 Sn Tin 118.7	51 Sb Antimony 121.8	52 Te Tellurium 127.6	53 I Iodine 126.9	54 Xe Xenon 131.3	5
6	55 Cs Cesium 132.90	56 Ba Barium 137.3	57 La Lanthanum 138.9	72 Hf Hafnium 178.5	73 Ta Tantalum 180.9	74 W Tungsten 183.9	75 Re Rhenium 186.2	76 Os Osmium 190.2	77 Ir Iridium 192.2	78 Pt Platinium 195.1	79 Au Gold 197.0	80 Hg Mercury 200.6	81 Tl Thallium 204.4	82 Pb Lead 207.2	83 Bi Bismuth 209.0	84 Po Polonium (209)	85 At Astatine (210)	86 Rn Radon (222)	6
7	87 Fr Francium (223)	88 Ra Radium 226	89 Ac Actinium (227)	104 Rf Rutherfordium (261)	105 Db Dubnium (262)	106 Sg Seaborgium (263)	107 Bh Bohrium (262)	108 Hs Hassium (265)	109 Mt Meitnerium (266)	110 Ds Darmstadtium (269)	111 — – (272)	112 — – (277)		114 — – (285)		116 — – (289)			7

		58	59	60	61	62	63	64	65	66	67	68	69	70	71	
Lanthanides	6	58 Ce Cerium 140.115	59 Pr Praseodymium 140.9076	60 Nd Neodymium 144.24	61 Pm Promethium (145)	62 Sm Samarium 150.36	63 Eu Europium 151.965	64 Gd Gadolium 157.25	65 Tb Terbium 158.9253	66 Dy Dysprosium 162.50	67 Ho Holmium 164.9303	68 Er Erbium 167.26	69 Tm Thulium 168.9342	70 Yb Ytterbium 173.04	71 Lu Lutetium 174.967	6
Actinides	7	90 Th Thorium 232.0381	91 Pa Protactinium 231.0359	92 U Uranium 238.0289	93 Np Neptunium (237)	94 Pu Plutonium (244)	95 Am Americium (243)	96 Cm Curium (247)	97 Bk Berkelium (247)	98 Cf Californium (251)	99 Es Einsteinium (252)	100 Fm Fermium (257)	101 Md Mendelevium (258)	102 No Nobelium (259)	103 Lr Lawrencium (260)	7