

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

Name _____

Signature _____

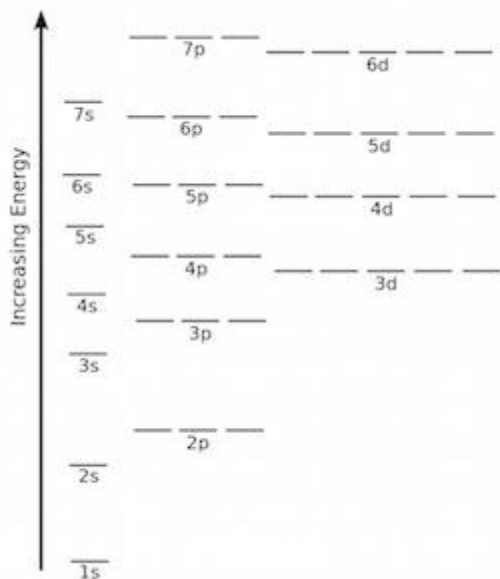
Section _____

“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. $\text{Al} < \text{Si} < \text{S} < \text{O}$
- b. $\text{O} < \text{S} < \text{Si} < \text{Al}$
- c. $\text{Al} < \text{S} < \text{Si} < \text{O}$
- d. $\text{O} < \text{Si} < \text{S} < \text{Al}$
- e. $\text{S} < \text{Si} < \text{O} < \text{Al}$

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.



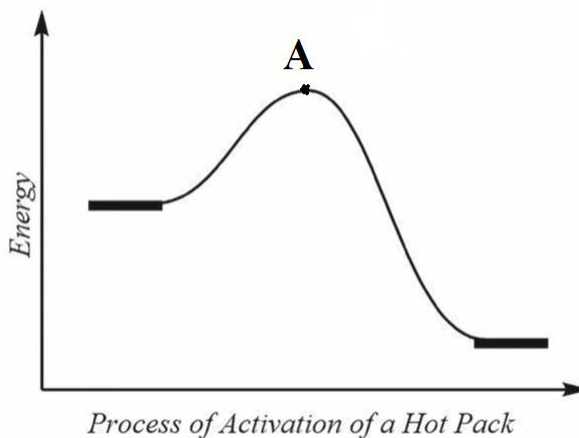
3. Which of the following statements about atomic theory is still believed to be true?

- 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?



Point A represents the hot pack....

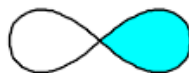
- Before it is activated: The hot pack loses heat overall because the surroundings get warmer.
 - Before it is activated: The hot pack is highest in energy before it is activated.
 - As it is activated: Energy is added to “start” the hot pack to give off heat.
 - After it is activated: The hot pack has less potential energy after it is activated.
 - After it is activated: 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 **not** shown by the electron configuration?

- There are 8 total electrons in the 2nd energy level.
- There are 6 total electrons present within “s” shape orbitals.
- There are 4 valence electrons.
- The 3p electrons are expected to be higher in energy than the 3s electrons.
- 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.
- 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.
 - 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.
 - Both have equal ionization energies: Lithium and potassium both have only one valence electron so it is equally difficult to remove that electron.
 - Potassium: There are more protons in the nucleus of potassium, which hold the electrons more tightly. This makes the outer electrons harder to remove.
 - 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.



- Yes. However, this only occurs a small percentage of the time.
- Yes. Electrons can be located between orbitals only when they are "jumping" between energy levels.
- No. Electrons can be located outside of 2s orbitals but not outside 2p orbitals.
- No. The electrons move along the outer surface of the orbital as designated by the path shown.
- 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. Then, predict the shapes and electron pair geometries. Use these to answer questions 9-11.

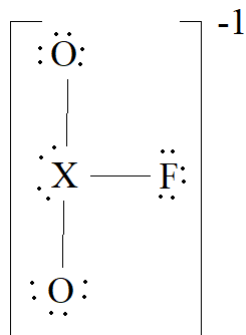


9. How many of these molecules are **nonpolar**?
- 0 (All are polar.)
 - 1
 - 2
 - 3
 - 4 (All are nonpolar.)
10. Which of these molecules does **not** have at least one bond angle that is 180° ?
- CO_2
 - IF_3
 - NF_3
 - XeCl_4
 - All molecules have at least one bond angle that is 180° .
11. Which of these substances has the lowest boiling point?
- CO_2
 - IF_3
 - NF_3
 - XeCl_4
 - More than one of these molecules has the same lowest boiling point.
-

For questions 12 and 13, compare the molecules CH_3OCH_3 and $\text{CH}_3\text{CH}_2\text{OH}$.

12. How does the polarity of these molecules compare?
- Both molecules are nonpolar.
 - Only CH_3OCH_3 is polar.
 - Only $\text{CH}_3\text{CH}_2\text{OH}$ is polar.
 - Both molecules are polar.
 - The polarity of both CH_3OCH_3 and $\text{CH}_3\text{CH}_2\text{OH}$ depends on whether they are mixed with polar or nonpolar substances.
13. Which of these molecules display hydrogen bonding forces between identical like molecules?
- Both molecules display hydrogen bonding forces.
 - Only CH_3OCH_3 displays hydrogen bonding forces.
 - Only $\text{CH}_3\text{CH}_2\text{OH}$ displays hydrogen bonding forces.
 - Neither molecule displays hydrogen bonding forces.
 - 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.

- b. A possible excited state electron configuration for a neutral atom is $1s^2 2s^2 2p^6 3s^2 3p^6 4s^1 5s^1 5p^1$. Identify this element and explain how you determined its identity. Then, give the ground state electron configuration for this atom.

Please go on to the next page.

- 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?



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.

Substance	Lewis structure	Molecular shape (around one central atom)	Polar or Nonpolar?
H ₂ O			
C ₂ H ₂			
C ₂ H ₄			
SF ₆			
AsF ₅			

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.
- 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.



You have reached the end of the test. Anything written after this page will not be graded.

Chem 101 Scratch Paper

NOTHING WRITTEN ON THIS PAGE WILL BE GRADED

Periodic Table of the Elements

1A	1 H Hydrogen 1.008	2A	3A	4A	5A	6A	7A	8A										
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										
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										
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
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
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 Platinum 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)
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 - -	112 - -	114 - -	116 - -	116 - -	116 - -	116 - -	116 - -

Key

Atomic number	67	Symbol
Name	Holmium	Atomic mass

HO

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 Gadolinium 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
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)

Lanthanides

Actinides