

CHEMISTRY 101
Hour Exam III
April 28, 2022
McCarren

Name KEY

Signature _____

Section _____

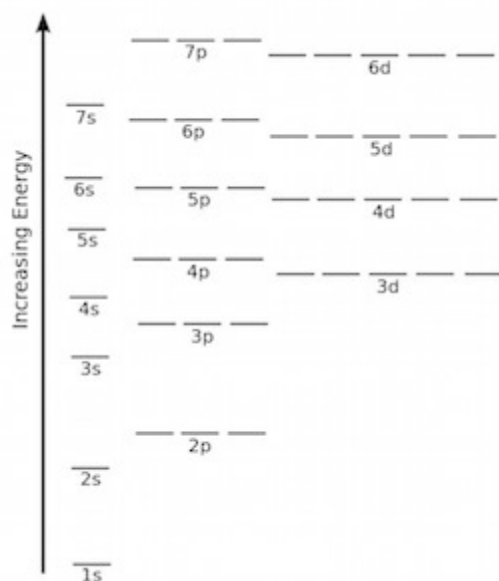
“I never went through an easy fight. Every fight has been hard fought.”

– Katie Taylor, Olympic boxer

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:



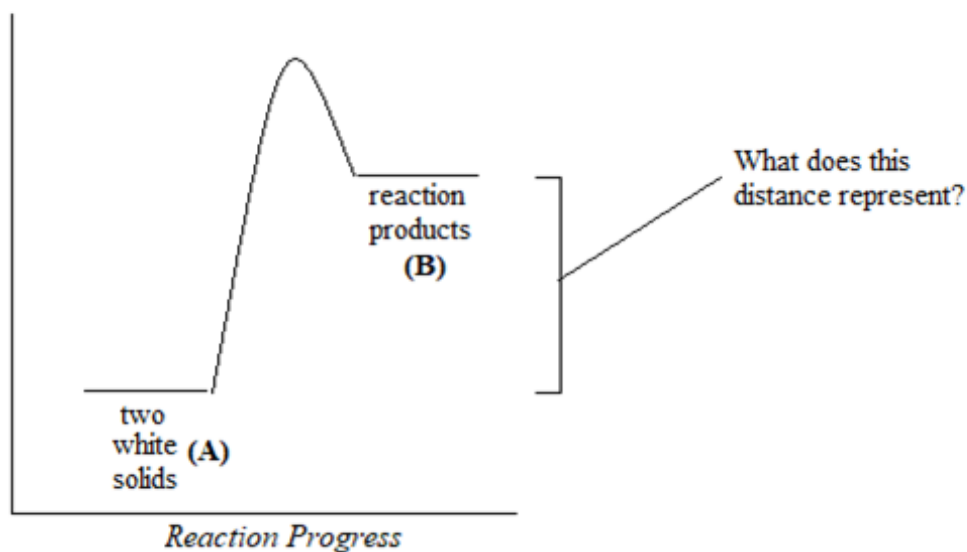
Part 1: Multiple Choice

+2 points
each
multiple-
choice
question

1. We have seen several of the following demonstrations in lecture. Which of the following is an **exothermic** process? The system is underlined in each case.
 - a. Water boils on the stove.
 - b. Two solids mix in a beaker and the beaker becomes colder.
 - c. Ice cream melts on a hot day.
 - d. Liquid nitrogen boils when poured into the air.
 - e. **A racquetball hardens in liquid nitrogen.**
2. Consider the *incomplete* diagram below which describes the process which involved mixing the two white solids in the beaker which froze the beaker to the wooden board. What is represented by the distance between points A and B as shown? (Note: the y-axis of the diagram is purposefully not labeled.)



Process of Mixing Two White Solids in a Beaker



The distance between points A and B shows the amount of overall....

- a. product produced in the reaction.
- b. limiting reactant used in the process.
- c. **energy absorbed during the reaction.**
- d. energy released during the reaction.
- e. energy required to start the reaction.

3. Which of the following is **false** regarding our current understanding of the atom?
- Atoms may lose or gain charged particles called electrons to form ions.
 - An atom primarily consists of empty space.
 - Electrons in an atom are more likely to be located in some places outside the center of the atom compared to others.
 - All neutral atoms of a specific element are made up of the same number of protons, neutrons, and electrons.**
 - All neutral atoms contain a dense positively charged center called a nucleus.

In this unit, we have explored several models which help us to describe atoms, their structure, and the way atoms connect to form molecules. Orbitals, electron configurations, and Lewis structures are three of these models, though all have limitations. Answer the three questions below regarding each of these models.

4. Which of the following is **true** regarding orbitals?

Orbitals...

- become simpler in shape moving further from the nucleus of the atom.
 - provide a road map to describe electron movement.
 - describe where the electrons are located most often.**
 - hold two electrons in a single s orbital and six electrons for in a single p orbital.
 - show the specific locations of each electron.
5. Electron configurations are one of tools we have used to describe atoms of individual elements. What is one of the limitations of using an electron configuration as a model?

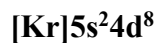
Individual ground state electron configurations for neutral atoms do not....

- contain the correct number of electrons in an atom.
 - demonstrate that electrons are located within energy levels.
 - show uncertainty of electron location.**
 - acknowledge that different shapes of orbitals exist.
 - enable the identification of an element.
6. Lewis structures are one of the models we have used to describe the structure of a molecule. Which of the following is always **true** regarding the use of Lewis structures as a model?

A drawing of a Lewis structure shows....

- a molecule's three-dimensional shape.
- the magnetic properties of a molecule.
- which valence electrons were donated to the structure by which atoms.
- which atoms in a molecule are connected to which.**
- the ways in which electrons travel throughout the molecule.

Use the electron configuration shown below to answer the next two questions.



7. This is the expected ground state electron configuration for which neutral atom?

- a. **Pd**
- b. Ag
- c. Ni
- d. Co
- e. Cu

8. How many unpaired electrons are expected to be present for an atom with this electron configuration? (Hint: an orbital diagram is available on the front cover of the test.)

- a. 1
- b. **2**
- c. 3
- d. 5
- e. 8

9. Which option below correctly ranks the neutral atoms in group 7 from smallest to largest atomic radius?

- a. $\text{I} < \text{Br} < \text{Cl} < \text{F}$
- b. **$\text{F} < \text{Cl} < \text{Br} < \text{I}$**
- c. $\text{I} < \text{Br} < \text{Cl} < \text{F}$
- d. $\text{F} < \text{Br} < \text{Cl} < \text{I}$
- e. $\text{Br} < \text{Cl} < \text{F} < \text{I}$

10. Which option below correctly ranks the atoms and ions below from easiest to remove an electron to hardest to remove an electron?

Ca

Ca^{+2}

Ca^+

	Easiest		Hardest
a.	<u>Ca</u>	<u>Ca^+</u>	<u>Ca^{+2}</u>
b.	Ca^{+2}	Ca^+	Ca
c.	Ca	Ca^{+2}	Ca^+
d.	Ca^{+2}	Ca	Ca^+
e.	Ca^+	Ca^{+2}	Ca

The four molecules below all contain at least one atom of oxygen. Draw Lewis structures for these molecules, determine the shapes, and use them to answer next three questions.



11. Which of these molecules has a linear shape?

- a. **CO₂**
- b. SO₂
- c. OF₂
- d. H₂O
- e. At least two of the molecules have a linear shape.

12. How many of these molecules are polar?

- a. 0 (None of the molecules are polar.)
- b. 1
- c. 2
- d. **3**
- e. 4 (All four of the molecules are polar.)

13. Resonance structures can be drawn for two of these molecules. Which two molecules are these?

- a. SO₂ and OF₂
- b. OF₂ and H₂O
- c. H₂O and SO₂
- d. CO₂ and OF₂
- e. **CO₂ and SO₂**

14. Draw Lewis structures for each of the molecules below. How many of the structures have octahedral electron pair geometry?



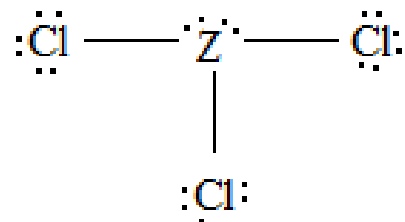
- a. 0 (None of the four structure have octahedral electron pair geometry.)
- b. **1**
- c. 2
- d. 3
- e. 4 (All four of the structures have octahedral electron pair geometry.)

15. The two molecules below both have central atoms which accommodate expanded octets. The central atom(s) for each molecule are nonmetals which reside in the fourth row of the periodic table. Which of the following could be the central atom for each molecule?

Molecule 1



Molecule 2



	Molecule 1	Molecule 2
a.	Br	Kr
b.	Br	Br
c.	Kr	Kr
d.	Se	Se
<u>e.</u>	<u>Kr</u>	<u>Br</u>

Please go on to the next page.

Part 2: Free Response

16. Show what you know. Please thoroughly answer each of the questions in the spaces below.

a. A bond between carbon and oxygen is shown below.



+4
total

Describe the nature of this bond by explaining the following:

- Explain whether electrons are donated, shared unequally, or shared equally within this bond and how you know
- If electrons are donated or shared unequally, which atom the electrons spend most time near, and how you know this based on electronegativity

+1 unequal
sharing

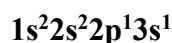
This is a **polar covalent bond** so electrons within the bond are **shared** **unequally**. (They could also say that we know this because they are two different non-metal elements or something like that.) Electrons in this bond **spend more time near the oxygen atom** than they do the carbon atom because oxygen is the atom with a higher **electronegativity**.

+1 how we
know

+1 oxygen

+1 higher EN

b. Consider the excited state electron configuration for a neutral element shown below.



+4
total

Identify this element and also do the following:

- Explain how you identified the element from the excited state configuration
- Give the ground state electron configuration for the neutral atom of the element

+1 carbon

This element is **carbon**. We know this because it has six electrons total (add up the superscript numbers $1+1+2+2 = 6$ which is the same number of electrons that carbon has). The ground state electron configuration of carbon is $1s^2 2s^2 2p^2$.

+1 why

+2 ground
state config

- c. An isoelectronic series consists of atoms and/or ions which all have the same number of electrons. Two ions which both have the same number of electrons are shown below.



These two ions have different sizes. Explain these different sizes by...

+4
total

- Giving the number of protons and electrons in each ion
- Identifying which ion is larger
- Explain why that ion is larger based on the atomic structure of both of the ions

+1 electrons

+1 protons

+1 larger

+1 explanation

Both of these ions have 10 electrons, but the fluorine anion has 9 protons and the sodium cation has 11 protons. The F- ion is larger because although there are the same number of electrons in both, the fluorine ion has fewer protons in its nuclear compared to the sodium ion. This results in a weaker attraction of the nucleus to the electrons from the fluorine compared to the sodium which means that the fluorine atom is larger than the sodium atom.

17. Answer the questions regarding Set 1 and Set 2 of molecules below.

Set 1

The following molecules O₂, I₂, and Br₂ have the same shape but are in different phases at room temperature.

- a. Draw the Lewis structures and give the shapes, polarity, and strongest intermolecular forces for each.

+6
total

+0.5
each
blank

	Lewis structure	Shape	Polar?	Strongest Intermolecular Forces
I ₂	$\text{:}\ddot{\text{I}}\text{---}\ddot{\text{I}}\text{:}$	Linear	No	London dispersion
Br ₂	$\text{:}\ddot{\text{Br}}\text{---}\ddot{\text{Br}}\text{:}$	Linear	No	London dispersion
O ₂	$\text{:}\ddot{\text{O}}\text{=}\ddot{\text{O}}\text{:}$	Linear	No	London dispersion

- b. At room temperature, one of these substances is a solid, one is a liquid, and one is a gas. Identify which is which and fill in the spaces in the table below to indicate this and explain why you ranked them the way you did. Your explanation should include an identification of the strongest intermolecular forces between molecules of each of the substance and an explanation of their relative strengths.

+1

solid	liquid	gas
I ₂	Br ₂	O ₂

+3
total

I₂ is the solid, Br₂ is the liquid, and O₂ is the gas. We know this because all three are nonpolar and only have London dispersion forces. However, I₂ has more total electrons overall, making a more polarizable electron cloud which results in stronger London dispersion forces. Therefore I₂ is a solid because it has the most electrons and strongest forces, Br₂ is the liquid because it has the next highest number of electrons, and O₂ is the gas with the fewest electrons.

+2 coherent
explanation

Set 2

The following molecules all consist of similar atoms but have different boiling points.

- c. Draw the Lewis structures and give the geometry, shape, and bond angle around one carbon atom, and state whether the molecule overall is polar or nonpolar.

		Lewis structure	Geometry (around one carbon atom)	Shape (around one carbon atom)	Bond angles (around one carbon atom)	Polar?
+6 total						
+0.5 each Lewis structure	CH ₃ OH	$ \begin{array}{c} \text{H} \\ \\ \text{H}-\text{C}-\overset{\cdot\cdot}{\text{O}}-\text{H} \\ \\ \text{H} \end{array} $	Tetrahedral	Tetrahedral	109.5°	Yes
+0.5 for each correct shape AND geometry	CH ₂ O	$ \begin{array}{c} \overset{\cdot\cdot}{\text{O}} \\ \\ \text{C} \\ / \quad \backslash \\ \text{H} \quad \text{H} \end{array} $	Trigonal planar	Trigonal planar	120°	Yes
+0.5 for each blank for bond angles and polarity	C ₂ H ₂	H—C≡C—H	Linear	Linear	180°	No

- d. The boiling points for each of these three substances are shown below. Fill in the spaces below by ranking the three molecules in the table from lowest to highest boiling point and then explain your process for doing this. Your explanation should include an identification of the strongest intermolecular forces between molecules of each of the three substances and discussion of their relative strengths.

+3 total	+1	-84.0°C	-19.0°C	64.7°C
		C ₂ H ₂	CH ₂ O	CH ₃ OH

+1 all IMFS correctly identified

C₂H₂ is nonpolar and displays London dispersion forces in bonding. These are the weakest forces so it boils at the lowest temperature. CH₂O is polar and has dipole-dipole interactions which are stronger than London-dispersion forces, so it has the next highest boiling point, and CH₃OH has the highest boiling point because it has the stronger hydrogen bonding forces.

+1 coherent explanation