

# Chem 1301A Midterm Test

October 27, 2019      2.00 hours



Western  
Science

**Leave the section number and the exam code blank**

*Message from the Dean:* All answer sheets are subject to a common data analysis that identifies anomalies of statistical significance in the selection of right and wrong answers by pairs of students. The course instructor is required to report all statistically significant results that suggest that cheating may have occurred. All such incidents will be subject to further investigation. All proven cases of cheating will be subject to severe academic penalties. If you are currently seated near someone with whom you had studied, and you think you may choose many of the same answers as that person, please raise your hand now and ask a proctor to reseal you.

This test contains 30 multiple-choice questions of equal value. Be sure you have a complete test paper. There is no penalty for incorrect answers.

A periodic table and data are on the last page, which may be detached for use.

Place your student ID card on your desk.

Molecular model kits are permitted, but the sharing of models or pieces is strictly forbidden.

The only calculator that may be used is a Sharp EL-510R, RN, or RT calculator. No other electronic devices may be in your possession, even for timekeeping purposes.

Proctors and instructors will not interpret, translate, clarify, or explain questions, nor will they confirm, verify, or assist you with your answers or your thinking. Therefore, you are not permitted to ask any questions related to the content of the test.

**Please note:**

**The Scantron must be completed within the duration of the test.** Be sure to fill in your student ID on the Scantron bubbles. If you fill in the ID bubbles incorrectly, your Scantron may not be processed. At the end of the test, everyone you must put your pencil down. Your Scantron, whether completed or not, will be collected. Under no circumstances will this booklet be used for marking purposes. The answers on your Scantron are considered to be your official answers, so please ensure that you complete your Scantron accurately. Answers that cannot be read by the Scantron computer will be marked as being incorrect.

If you do not leave before the last 15 minutes, please stay in your seat until you are permitted to leave.

1. Which one of the following statements regarding the periodic table is incorrect?
  - A) The *d*-block elements are found in Groups 3–12.
  - B) The pnictogen elements are found in Group 15.
  - C) The chalcogen elements are found in Group 14.
  - D) The *p*-block elements are found in Groups 13–18.
2. For elements in the same group, when the value of  $n$ , the principal quantum number, increases...
  - A) The first ionization energy of the atom increases.
  - B) The atomic radius of the atom decreases.
  - C) The electronegativity of the atom increases.
  - D) The electron affinity of the atom decreases.
3. Effective nuclear charge is best described as...
  - A) The net positive charge experienced by the valence electrons, accounting for screening from the core electrons.
  - B) The net positive charge experienced by a valence electron, accounting for screening from the core and additional valence electrons.
  - C) The net positive charge experienced by the valence electrons, accounting for screening from the neutrons in the nucleus.
  - D) The net positive charge experienced by the core electrons, accounting for screening from the valence electrons.

4. Based on periodic trends, which one of A – D correctly ranks the species from lowest to highest ionization energy?

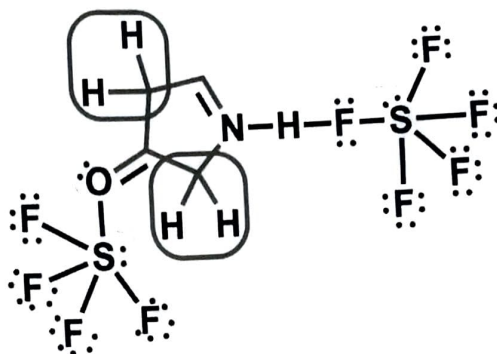
	lowest	→	highest
A)	Li	Cl	Fr
B)	Br	Bi	H
C)	Cl <sup>+</sup>	Cl	Cl <sup>-</sup>
D)	K	Si	C

5. How many of the following statements are correct, based on periodic trends?

- Br has a higher electronegativity than does Cl
- Be<sup>2+</sup> has a larger radius than does Li<sup>+</sup>
- Mg has a larger radius than does Be.
- O<sup>2-</sup> has a larger radius than does F<sup>-</sup>

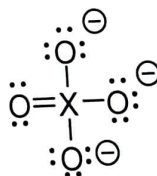
- A) 1  
B) 2  
C) 3  
D) 4

6. Assign formal charges to this rather unusual molecule, which contains hydrogen and fluorine bonded to two atoms. How many atoms have formal charges, and is the overall structure charged or neutral? (Ignore the atoms in the two boxes.)



- A) 7 atoms, and the overall charge is neutral  
 B) 5 atoms, and the overall charge is positive  
 C) 6 atoms, and the overall charge is neutral  
 D) 4 atoms, and the overall charge is neutral
7. Consider the Lewis structure below. Which element could X be?

- A) Br  
 B) N  
 C) S  
 D) As



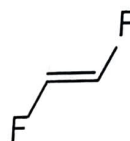
8. What is the formula of each of the species shown below?

A)	C <sub>4</sub> H <sub>10</sub>	C <sub>3</sub> H <sub>7</sub>	C <sub>2</sub> H <sub>6</sub> N
B)	C <sub>4</sub> H <sub>10</sub>	C <sub>3</sub> H <sub>8</sub>	C <sub>2</sub> H <sub>7</sub> N
C)	C <sub>4</sub> H <sub>9</sub>	C <sub>3</sub> H <sub>6</sub>	C <sub>2</sub> H <sub>6</sub> N
D)	C <sub>4</sub> H <sub>9</sub>	C <sub>3</sub> H <sub>7</sub>	C <sub>2</sub> H <sub>6</sub> N

9. Consider the best Lewis structure of a neutral molecule. How many of the following statements are correct?
- The number of electrons in the Lewis structure equals the sum of the valence electrons for the atoms.
  - Each atom of a Lewis structure must have eight electrons.
  - Electrons of covalent compounds may be shared between atoms.
  - Hydrogen atoms are often the central atom of a Lewis structure.
- A) 1  
B) 2  
C) 3  
D) 4
10. Which of the following statements is/are correct about the best Lewis structure for the ion  $[CP]^-$ ?
1. The negative formal charge lies on the carbon atom.
  2. There is a lone pair on each of the phosphorus and carbon atoms.
  3. The carbon-phosphorus has a bond order of 2.
- A) 1 only  
B) 3 only  
C) 1 and 2 only  
D) All statements are correct

11. Which statement(s) is/are correct about the best Lewis structure for the periodate ion,  $\text{IO}_4^-$ ?
1. It has a total of three equivalent resonance structures.
  2. All iodine-oxygen bonds are equivalent.
  3. It has an average bond order of 1.5.
- A) 2 only  
B) 1 only  
C) 3 only  
D) 1 and 2 only
12. Which one of the following species has an electron-pair geometry that is the same as the molecular shape?
- A)  $\text{H}_2\text{O}$   
B)  $\text{PBr}_3$   
C)  $\text{O}_3$   
D)  $\text{CH}_3^+$
13. Which one of the following compounds contains the most-polar bond?
- A)  $\text{CF}_4$   
B)  $\text{CH}_4$   
C)  $\text{CH}_2\text{Br}_2$   
D)  $\text{CS}_2$

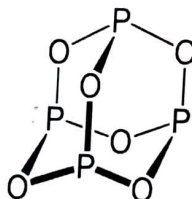
14. How many of the following molecules are polar (have a net dipole moment)?



- A) 1
- B) 2
- C) 3
- D) 4

15. What is the hybridization of the P atoms in  $\text{P}_4\text{O}_6$ ?

- A)  $sp^3d$
- B)  $sp^3$
- C)  $sp^2$
- D)  $sp$



16. Consider nitrous acid,  $\text{HNO}_2$  (HONO). What are the hybridizations of the nitrogen and the internal oxygen atoms?

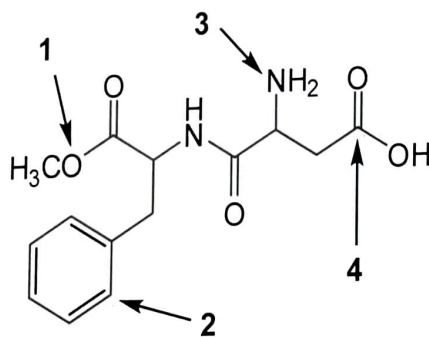
	internal O	N
A)	$sp^3$	$sp^2$
B)	$sp^2$	$sp^3$
C)	$sp^2$	$sp^3$
D)	$sp$	$sp^2$

17. PTFE, otherwise known as Teflon, is made from tetrafluoroethylene ( $F_2C=CF_2$ ). Which of the following statements is/are true about tetrafluoroethylene?

1. It has exactly 4  $\sigma$  and 2  $\pi$  bonds.
2. It is a planar molecule.
3. The molecule can rotate about the carbon-carbon bond.
4. The  $\pi$  bond(s) is/are formed from the sideways overlap of  $p$  orbitals.

- A) 1 and 4 only  
 B) 1, 2, and 3 only  
 C) 2 and 4 only  
 D) All statements are correct

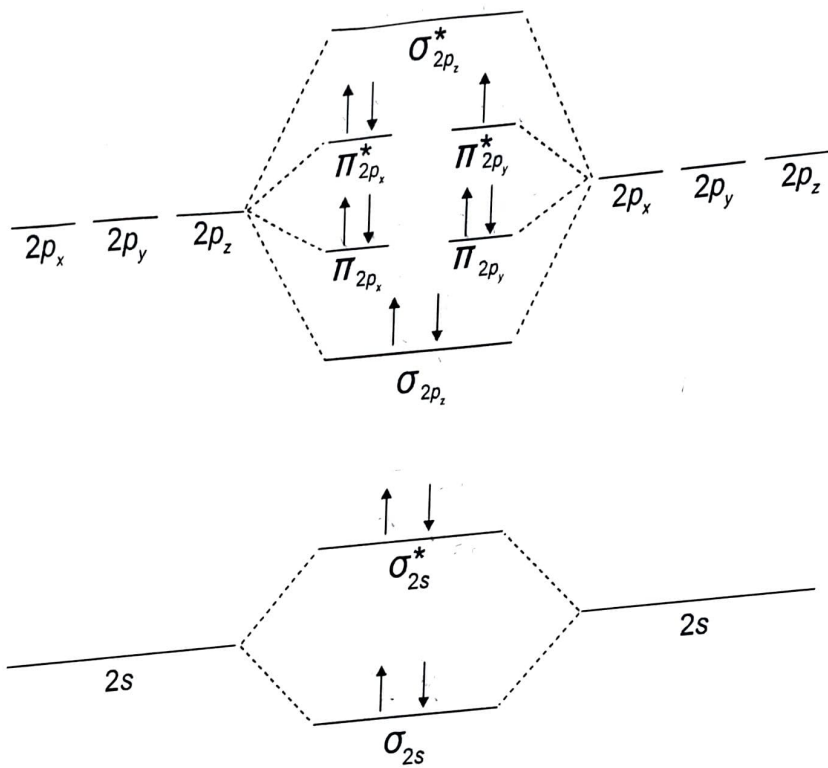
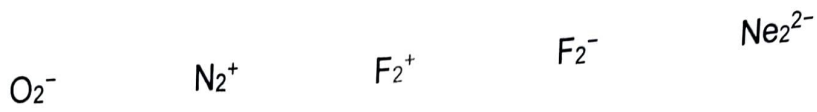
18. Shown below is the structure of aspartame. Which one of A – D correctly describes the hybridization, approximate bond angle, or VSEPR type of each of the indicated carbon, oxygen, and nitrogen atoms?



	1	2	3	4
A)	$sp^3$	$120^\circ$	$109^\circ$	$AX_3$
B)	$AX_2$	$sp$	$AX_3$	$sp^3$
C)	$109^\circ$	$AX_3$	$120^\circ$	$120^\circ$
D)	$AX_2E_2$	$AX_2E_1$	$sp^3$	$120^\circ$

19. Which one of the following correctly describes the molecular shape and the hybridization (according to valence bond theory) of Xe in XeF<sub>2</sub>?
- A) Bent and  $sp^3d$
  - B) Linear and  $sp^3d$
  - C) Bent and  $sp^3$
  - D) Linear and  $sp$
20. Which statement about molecular orbital theory is incorrect?
- A) It can be used to predict the relative energies of the electrons in a molecule.
  - B) Antibonding molecular orbitals are formed from the destructive combination of atomic orbitals.
  - C) It can be used to predict whether atoms and monoatomic ions are paramagnetic or diamagnetic.
  - D) Bonding molecular orbitals are always lower in energy than the atomic orbitals from which they are formed.
21. What is the bond order of a molecule or ion with four electrons in bonding molecular orbitals and two electrons in an antibonding molecular orbital?
- A) 2.5
  - B) 2
  - C) 1.5
  - D) 1

22. How many of the following species have the MO diagram shown below?



- A) 1
- B) 2
- C) 3
- D) 4

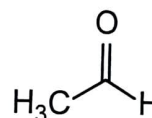
23. Which one of the following species is paramagnetic?

- A)  $Be_2^{2+}$
- B)  $O_2^{2-}$
- C)  $H_2^+$
- D)  $Li_2$

24. Which compound does NOT have dipole-dipole forces as its strongest intermolecular force?

- A)  $\text{CO}_2$
- B)  $\text{CH}_3\text{Br}$
- C)  $\text{CH}_3\text{OCH}_3$
- D)  $\text{CH}_2\text{Cl}_2$

25. Acetaldehyde, shown on the right, is formed in the first step of ethanol metabolism. A sample of pure acetaldehyde contains which of the following intermolecular forces?



- A) Only dipole-dipole
- B) Only hydrogen-bonding
- C) Only dispersion and dipole-dipole
- D) Dispersion, dipole-dipole, and hydrogen-bonding

26. Which one of A – E correctly ranks the compounds in the order of increasing boiling point?

	<div style="display: flex; align-items: center; justify-content: center;"> <span style="margin-right: 10px;"><b>Lowest</b></span> <span style="font-size: 2em; margin-right: 10px;">→</span> <span><b>Highest</b></span> </div>				
A)	$\text{CH}_4$	$\text{CH}_3\text{CH}_3$	$\text{HOCH}_2\text{CH}_2\text{OH}$	$\text{CH}_3\text{CH}_2\text{OH}$	$\text{NaCl}$
B)	$\text{CH}_3\text{CH}_3$	$\text{CH}_4$	$\text{HOCH}_2\text{CH}_2\text{OH}$	$\text{CH}_3\text{CH}_2\text{OH}$	$\text{NaCl}$
C)	$\text{CH}_4$	$\text{CH}_3\text{CH}_3$	$\text{NaCl}$	$\text{HOCH}_2\text{CH}_2\text{OH}$	$\text{CH}_3\text{CH}_2\text{OH}$
D)	$\text{CH}_4$	$\text{CH}_3\text{CH}_3$	$\text{CH}_3\text{CH}_2\text{OH}$	$\text{HOCH}_2\text{CH}_2\text{OH}$	$\text{NaCl}$

27. Which one of the following is expected to have the highest melting point?
- A)  $\text{H}_2\text{O}$
  - B)  $\text{LiF}$
  - C)  $\text{LiCl}$
  - D)  $\text{NaBr}$
28. Which best statement explains why, in any given experiment, you should always be using the same analytical balance?
- A) It is not possible to weigh by difference if different balances are used.
  - B) It is so that we know who did not clean up their spills on the balances.
  - C) It is because there may be some variation between different balances.
  - D) Balances must be calibrated each time before they are used.
29. Which one of the following statements about hydrated compounds is incorrect?
- A) The percentage of water in a hydrated compound may be determined by comparing the mass of the sample before and after heating.
  - B) In oxalic acid dihydrate,  $\text{H}_2\text{C}_2\text{O}_4 \cdot 2\text{H}_2\text{O}$ , the two water molecules are associated by hydrogen bonding.
  - C) Some hydrated compounds can decompose when they are heated, so heating cannot be used to remove water from those compounds.
  - D) In copper(II) sulfate pentahydrate,  $\text{CuSO}_4 \cdot 5\text{H}_2\text{O}$ , the five water molecules are associated by hydrogen bonding.

30. In Experiment 2, you had prepared a coordination complex of iron containing the oxalato ligand. What is the formula for the final complex that was isolated via filtration?

- A)  $K_3[Fe(C_2O_4)_3] \cdot 3H_2O$
- B)  $K_2[Fe(C_2O_4)_3] \cdot 3H_2O$
- C)  $[Fe(C_2O_4)_3] \cdot 2H_2O$
- D)  $K_4[Fe(C_2O_4)_3] \cdot 3H_2O$

**END OF TEST**

**Please verify that you have completed your Scantron correctly. In particular, the bubbles must be completely filled in using dark pencil. If you can see orange print underneath, or the bubble is not completely filled in, your answer may be marked as incorrect and you will not receive credit for your answer.**

**You are welcome to keep this question booklet.**