Instructions: You should have with you several number two pencils, an eraser, your 3" x 5" note card, a calculator, and your University ID Card. If you have notes with you, place them in a sealed backpack and place the backpack OUT OF SIGHT or place the notes directly on the table at the front of the room.

Fill in the front page of the Scantron answer sheet with your last name, first name, middle initial, and student identification number. Leave the class section number and the test form number blank.

This exam consists of 25 multiple-choice questions. Each question has four points associated with it. Select the best multiple-choice answer by filling in the corresponding circle on the rear page of the answer sheet. If you have any questions before the exam, please ask. If you have any questions during the exam, please ask the proctor. Open and start this exam when instructed. When finished, place your Scantron form in the appropriate stack and present your University ID Card to the proctor. You may keep the exam packet, so please show your work and mark the answers you selected on it.
Please read each exam question carefully. Terms such as correct, false, unpaired, pairs, H-C-F bond angle, H-C-H angle, greatest, and smallest are used.

1. There are **unpaired** electrons in a ground-state oxide ion (O\(^2\)).
   - (A) 0
   - (B) 1
   - (C) 2
   - (D) 3
   - (E) 4

2. The ground-state electron configuration of a sodium ion (Na\(^+\)) is:
   - (A) 1s\(^2\)2s\(^2\)3s\(^3\)p\(^2\)
   - (B) 1s\(^2\)2s\(^2\)3s\(^1\)
   - (C) 1s\(^2\)2s\(^2\)2p\(^6\)
   - (D) 1s\(^2\)2s\(^2\)p\(^2\)3s\(^3\)p\(^2\)
   - (E) 1s\(^2\)2s\(^2\)p\(^4\)

3. Consider Ba, As, F, Ge, and He. The atom with the **largest** atomic size is:
   - (A) Ba
   - (B) As
   - (C) F
   - (D) Ge
   - (E) He

4. Consider Mg\(^{2+}\) and Mg. Consider F\(^-\) and F. Which of the following statements is correct?
   - (A) Mg\(^{2+}\) is larger than Mg and F\(^-\) is larger than F.
   - (B) Mg\(^{2+}\) is smaller than Mg and F\(^-\) is larger than F.
   - (C) Mg\(^{2+}\) is smaller than Mg and F\(^-\) is smaller than F.
   - (D) Mg\(^{2+}\) is larger than Mg and F\(^-\) is smaller than F.
   - (E) This question is ambiguous and cannot be answered without a data table.

Mg\(^{2+}\) is smaller than Mg - Mg\(^{2+}\) has the same number of protons, but 2 fewer e-.
F\(^-\) is larger than F - F\(^-\) has the same number of protons, but 1 greater e-.
5. Ionization energy is:

(A) the energy required to separate protons from neutrons
(B) the energy required to remove an electron
(C) the energy required to pull on a pair of electrons
(D) the energy required to push two electrons together
(E) the energy required to form a Noble Gas from a Group 7 element

6. Consider an oxygen atom in the ground-state. Which of the following statements is false?

(A) An oxygen atom has 8 total electrons; 2 are core electrons and 6 are valence electrons. True
(B) The Lewis Dot Structure for an oxygen atom has 6 electrons (dots). True
(C) An oxygen atom is larger than a nitrogen atom. False. O is to the right, smaller than N.
(D) There are two unpaired electrons in the oxygen atom. True
(E) The oxygen atom is paramagnetic.

7. The Lewis Dot Structure of CO₂ depicts:

(A) There are no lone pairs of electrons
(B) There is one lone pair of electrons
(C) There are two lone pairs of electrons
(D) There are three lone pairs of electrons
(E) There are four lone pairs of electrons

8. The oxygen bond order in the nitrate ion (NO₃⁻) is:

(A) 1.00
(B) 1.33
(C) 1.50
(D) 2.00
(E) 3.00
9. A student proposes the Lewis Dot Structure below for ClO$_2^-$. Determine the formal charges on each atom in this structure.

\[
\begin{array}{c}
\text{O} & \text{Cl} & \text{O} \\
6 & \text{Cl} & \text{O} \\
-1 & -1 & -1
\end{array}
\]

(A) The left oxygen has a formal charge of 0; the chlorine -1; and the right oxygen 0
(B) The left oxygen has a formal charge of -1; the chlorine -1; and the right oxygen 0
(C) The left oxygen has a formal charge of 0; the chlorine -1; and the right oxygen -1
(D) The left oxygen has a formal charge of 0; the chlorine 0; and the right oxygen -1
(E) The left oxygen has a formal charge of -1; the chlorine 0; and the right oxygen 0

10. The H-O-H bond angle in water, H$_2$O, is:

(A) 180°
(B) 120°
(C) 109.5°
(D) A little greater than 109.5°
(E) A little less than 109.5°

11. The molecular geometry of CF$_4$ is:

(A) bent
(B) trigonal planar
(C) trigonal pyramidal
(D) tetrahedral
(E) octahedral
12. The molecular geometry of NH₃ is:
   (A) bent
   (B) trigonal planar
   (C) trigonal pyramidal
   (D) linear
   (E) octahedral

13. The H-C-H bond angle in monofluoromethane (CH₃F) is:
   (A) 90°
   (B) 120°
   (C) 109.5°
   (D) A little greater than 109.5°
   (E) A little less than 109.5°

14. The F-S-F bond angle in sulfur hexafluoride (SF₆) is:
   (a) 90°
   (b) 120°
   (c) 109.5°
   (d) A little greater than 109.5°
   (e) A little less than 109.5°

15. Consider O, P, Al, Zn, and Fr. The atom with the greatest electronegativity is:
   (A) O
   (B) P
   (C) Al
   (D) Zn
   (E) Fr
16. Consider the following five molecules: NH₃, O₂, O₃, SF₆, and CO₂. How many of these are polar molecules?

(A) One
(B) Two
(C) Three
(D) Four
(E) Five

17. Consider ethene, C₂H₄. Ethene contains:

(A) no π-bonds
(B) one π-bond
(C) two π-bonds
(D) three π-bonds
(E) four π-bonds

18. There are 3 resonance forms for the nitrate ion (NO₃⁻).
19. Consider the molecule below and identify the correct statement.

\[ \text{H} \quad \text{H} \quad \text{C} \quad \text{C} \quad \text{C} \quad \text{H} \\
\text{H} \quad \text{H} \quad \text{C} \quad \text{C} \quad \text{C} \quad \text{H} \\
\text{H} \quad \text{H} \quad \text{C} \quad \text{C} \quad \text{C} \quad \text{H} \\
\text{O} \]

(A) There is one carbon that has an sp\(^2\) hybridization scheme.
(B) There are two carbons that have sp\(^2\) hybridization schemes.
(C) There are three carbons that have sp\(^2\) hybridization schemes.
(D) There are four carbons that have sp\(^2\) hybridization schemes.
(E) There are five carbons that have sp\(^2\) hybridization schemes.

20. Consider C\(_2\)H\(_6\), C\(_2\)H\(_4\), and C\(_3\)H\(_2\). Which of these has the strongest carbon-carbon bond?

(A) C\(_2\)H\(_6\). \[ \text{C} - \text{C} \]
(B) C\(_2\)H\(_4\). \[ \text{C} = \text{C} \]
(C) C\(_3\)H\(_2\). \[ \text{C} \equiv \text{C} \]

21. Consider MO (Molecular Orbital Theory). For the O\(_2\) molecule, there are _____ electrons in the \(\sigma\_p\) bonding orbital?

(A) 0 \[ \uparrow \quad \uparrow \]
(B) 1 \[ \uparrow \quad \uparrow \]
(C) 2 \[ \uparrow \quad \uparrow \]
(D) 3 \[ \uparrow \quad \uparrow \quad \uparrow \]
(E) 4 \[ \uparrow \quad \uparrow \quad \uparrow \quad \uparrow \]
22. Molecular orbital theory predicts the \( \text{N}_2^- \) ion (a minus one charge) has:

(A) no unpaired electrons
(B) one unpaired electron
(C) two unpaired electrons
(D) three unpaired electrons
(E) six unpaired electrons

23. Consider MO (Molecular Orbital Theory). The \( \text{F}_2 \) molecule is:

(A) paramagnetic
(B) diamagnetic
(C) trimagnetic
(D) tetramagnetic
(E) gymnasticmagnetic

24. Molecular orbital theory predicts the \( \text{O}_2^{2+} \) ion (a positive two charge) has a bond order of:

(A) 0.0
(B) 1.0
(C) 1.5
(D) 2.0
(E) 3.0

25. Because of Chemistry 122...

(A) I named my cats Linus and Lewis.
(B) I aspire to be a stand up comedian.
(C) I get lots of dates by using pick-up lines that include the words polar, paramagnetic, dipole, lobes, 180 degrees, see-saw, wedge, and orbitals.
(D) My taste in music has improved.
(E) My octahedrals hurt.

[Any response will receive full credit; even no response.]