

**UNIVERSITY OF VICTORIA**

**CHEMISTRY 101**  
**From Atoms to Materials**

**In-term Test 1**  
**May 31<sup>st</sup>, 2024**  
**9:00-10:00 am**  
**ECS 116**

**VERSION A**

Display your student ID card on your desk.

Do not begin until instructed by the invigilator.

Print and code your last name, first name, and your student ID number on the blue bubble sheet.

This test has 25 multiple choice questions on 6 pages.

A Data Sheet is provided.

The Sharp EL510 is the only approved calculator for this test.

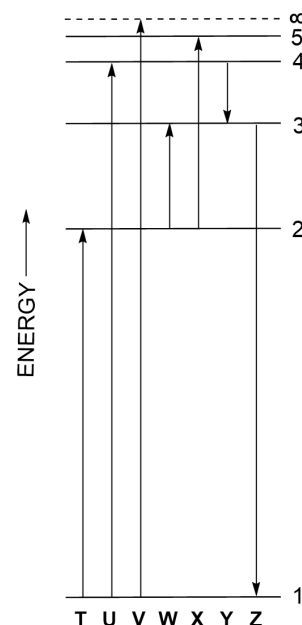
Select the best response for each question and record your answer on the blue bubble sheet.

Hand in the blue bubble sheet at the end of the test.

Only answers entered on the bubble sheet by the student by 10 am will be marked.

1. Which of the following molecules is polar?  
A.  $\text{BrCl}_3$       B.  $\text{CF}_4$       C.  $\text{KrF}_4$       D.  $\text{AlCl}_3$       E.  $\text{CO}_2$
2. Why does beryllium (Be) have a positive electron affinity (i.e. why is it unfavorable for a Be atom to accept an electron when it is favorable for Li and B to do so)?  
A. It has a low  $Z_{\text{eff}}$   
B. It has a high  $Z_{\text{eff}}$   
C. It has a full shell of valence electrons  
D. The electron has to go into a higher-energy 2p orbital  
E. Be has a high electronegativity
3. What is the wavelength (in nm) of an electron travelling at 1% the speed of light?  
A. 0.242      B. 24.2      C.  $2.42 \times 10^{-10}$   
D. 458      E.  $4.58 \times 10^{-4}$
4. Which of the following ions has 3 unpaired electrons?  
A.  $\text{S}^{2-}$       B.  $\text{Cl}^+$       C.  $\text{Cr}^{2+}$       D.  $\text{Pb}^{2+}$       E.  $\text{Ni}^+$

5. The figure at right depicts the possible energy levels of a hydrogen atom (not to scale). What wavelength of light (in nm) is required for transition X?
- A. 95      B. 380      C. 434  
D. 486      E. 656



6. Which element has the highest first ionization energy? (careful here!)
- A. Be      B. B      C. C      **D. N**      E. O
7. Which of the following is expected to be the correct order of **atomic radii** from smallest to largest?
- A. O < S < F      B. Rb < K < Na      **C. S < Si < Mg**  
D. Cl < S < O      E. Cl < As < P
8. Which of the following statements about the uncertainty principle is FALSE?
- A. We cannot determine the exact position and momentum of a particle simultaneously.
- B. A particle's momentum is inversely proportional to its position.
- C. The more precisely we know a particle's momentum, the more certain we are of its position.**
- D. The dual nature of matter sets a limit on how precisely we can know the location and momentum of an object.
- E. The product of the uncertainty in position and the uncertainty in momentum must be at least  $h/(4\pi)$ .
9. Based on relative electronegativities, which of these is the MOST polar bond?
- A. O-N      B. O-C      **C. O-B**      D. P-S      E. Cl-Br
10. To determine the energy change for the formation of solid crystalline NaF from sodium metal and fluorine gas, we need to know the heat of atomization of sodium, the heat of atomization of fluorine, the ionization energy of sodium, the electron affinity of fluorine, and what other quantity?
- A. The electronegativities of both Na and F
- B. The electrostatic force between  $\text{Na}^+$  and  $\text{F}^-$
- C. The Na-F bond enthalpy (*i.e.* bond energy)
- D. The dipole moment of the Na-F bond
- E. The lattice energy of NaF**
11. How many pairs of non-bonding electrons (lone pairs) are on the S atom in the Lewis structure of  $\text{SF}_4$ ?
- A. 4      B. 3      C. 2      **D. 1**      E. 0

12. Calculate  $Z_{\text{eff}}$  for a valence electron in an aluminum (Al) atom, assuming that:

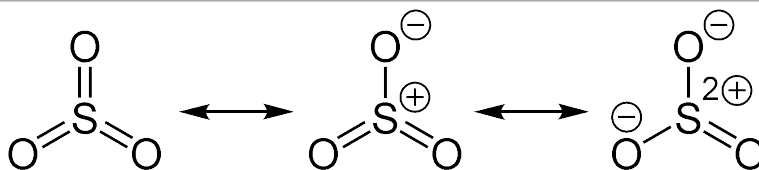
- i. Core electrons are perfect at screening valence electrons from the nuclear charge
- ii. Electrons within the same shell are unable to screen the nuclear charge

A. 4      B. 3      C. 2      D. 1      E. 0

13. Which of these phenomena provide evidence for quantization?

- A. Line spectra
- B. The photoelectric effect
- C. Blackbody radiation
- D. The splitting of a beam of silver atoms in a non-homogeneous magnetic field
- E. All of the above

14. Below are some (not all!) of the resonance structures for the  $\text{SO}_3$  molecule. Non-bonding electrons are not shown. Which statement(s) about the  $\text{SO}_3$  molecule is (are) **incorrect**?



- (i) All the S-O bond lengths are the same
- (ii) The sulfur atom has a partial positive charge and the oxygen atoms have partial negative charges
- (iii) The O-S-O bond angles are all  $120^\circ$
- (iv) The bonds between S and O are longer than a normal S=O double bond but shorter than a normal S-O single bond
- (v) The molecule overall has a dipole moment of 0

A. i, iii      B. ii      C. iv      D. v      E. none of the statements are incorrect

15. For orbitals within the same shell (same  $n$ ), which of following statements is TRUE?

- A. The number of angular nodes increases as  $l$  increases.
- B. The energy of the orbitals decreases as  $l$  increases.
- C. The total number of nodes increases as  $l$  increases.
- D. The number of radial nodes increases as  $l$  increases.
- E. None of the above.

16. What is the **molecular geometry** of  $[\text{AsF}_4]^+$  ?

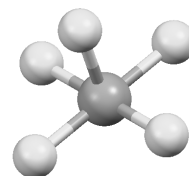
- A. Trigonal planar      B. **Tetrahedral**      C. Square planar  
D. See-saw      E. Square pyramidal

17. What is the **electron domain geometry** of  $\text{XeF}_2$ ?

- A. Trigonal planar      B. Octahedral      C. **Trigonal bipyramidal**  
D. Tetrahedral      E. Linear

18. How many lone pairs does the central atom of the structure at right possess?

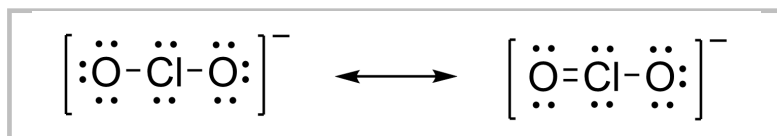
- A. 0      B. **1**      C. 2  
D. 4      E. Impossible to determine



19. Consider the reaction:  $\text{CH}_4 + \text{Cl}_2 \rightarrow \text{CH}_3\text{Cl} + \text{HCl}$ . What is the approximate enthalpy change for this reaction in kJ/mol?

- A. -71      B. 277      C. -277      D. **-107**      E. 107

20. Consider the two resonance structures for  $\text{ClO}_2^-$  shown below. What is the formal charge on Cl in each of the two resonance structures respectively?

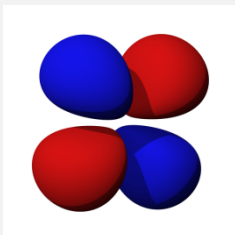


- A. 0, -1      B. -1, 0      C. 0, 0      D. 0, +1      E. **+1, 0**

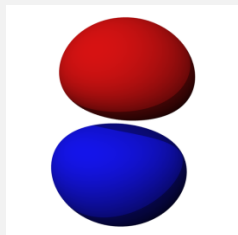
21. Which of these ionic compounds has the highest lattice energy?

- A.  **$\text{Sc}_2\text{O}_3$**       B.  $\text{Na}_2\text{O}$       C.  $\text{AlCl}_3$       D.  $\text{MgS}$       E.  $\text{NaCl}$

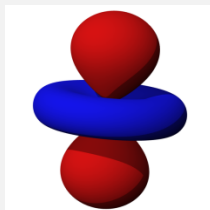
Below are some depictions of orbitals. Questions 1 and 2 refer to these pictures.



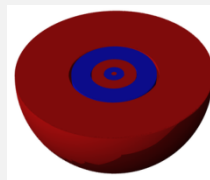
**1**



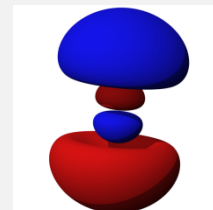
**2**



**3**



**4**



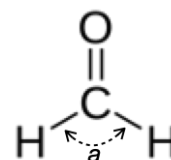
**5**

22. There is a picture of a  $d$  orbital in image(s):  
 A. 1, 3 and 5 only      B. 1 only      C. 1 and 3 only      D. 1 and 5 only      E. 3 only

23. Which set of quantum numbers  $n, l$  can be valid for the orbital in image 1 above?  
 A. 4,3      B. 3,2      C. 3,1      D. 2,2      E. 2,3

24. Which electron configuration is INCORRECT for the ground state atom listed?  
 A. Mg = [Ne]  $3s^2$       B. Ge = [Ar]  $4s^2 3d^{10} 4p^2$       C. Br = [Ar]  $4s^2 3d^{10} 3p^5$   
 D. Ta = [Xe]  $6s^2 4f^{14} 5d^3$       E. Ag = [Kr]  $4s^1 3d^{10}$

25. What is the bond angle marked 'a' in the structure at right?  
 A.  $109.5^\circ$       B. slightly under  $120^\circ$       C.  $120^\circ$   
 D. slightly over  $120^\circ$       E.  $106.5^\circ$



**END**