UNIVERSITY OF VICTORIA

CHEMISTRY 101
From Atoms to Materials

In-term Test 1
October 14, 2022
6-7 pm
ECS 123, BWC B150, DTB A120

VERSION B

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 8 pages.

A Data Sheet is provided.

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

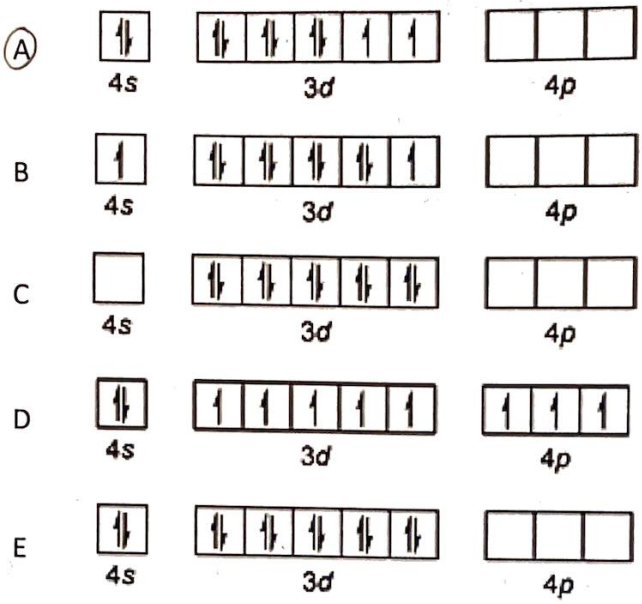
Select the best response for each question and record your answer on the blue bubble sheet.

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

Only answers entered on the bubble sheet by the student by 7PM will be marked.

1. Inspect the electron configurations below. Which electron configuration is the ground state of a nickel (Ni) atom?

$Ni = [Ar]\,4s^2 3d^8$



2. Which of the following atoms has the largest atomic radius?

A. Li B. Mg C. As (D) Ba E. Hg

3. Which element has the highest first ionization energy?

(A). Be B. B C. C D. N E. O

Be: $[He]2s^2$ B: $[He]2s^2 2p^1$ C: $[He]2s^2 2p^2$ N: $[He]2s^2 2p^3$ O: $[He]2s^2 2p^4$

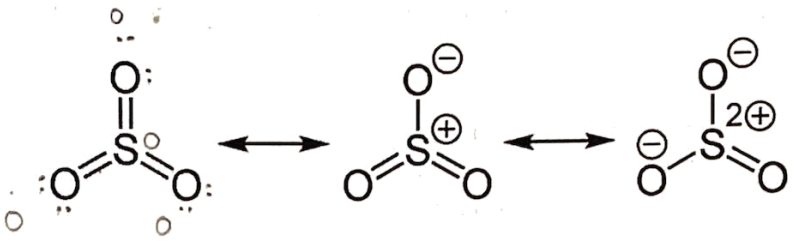
4. Assuming that the core electrons are completely effective at shielding the valence electrons from the charge of the nucleus and the valence electrons provide no shielding for each other, what would be the effective nuclear charge (Z_{eff}) acting on the valence electrons in an atom of silicon (Si)?

Si ⇒ 4 valence
10 core

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

$Z_{eff} = Z - S$
$= 14 - 10$
$= 4$

5. Below are some (not all!) of the resonance structures for the SO_3 molecule. Non-bonding electrons are NOT shown. Which statement(s) about the SO_3 molecule is (are) INCORRECT?



(i) The S-O bond lengths are all 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° ✓
(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 ✓

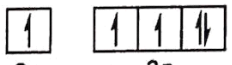
A. i, iii B. ii (C) iv D. v E. none of the statements are incorrect

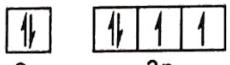
6. Based on relative electronegativities, which of these is the MOST polar bond?

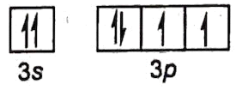
largest EN difference

A. F-F B. F-Cl (C) F-C D. Si-P E. C-N

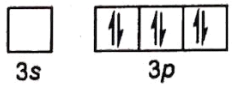
7. Which of these electron configurations is forbidden?

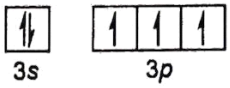
A 

B 

(C) 

same spin in 3s

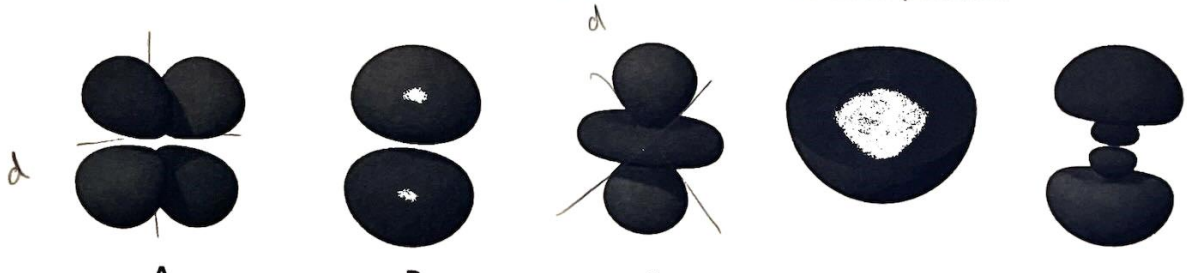
D 

E 

8. 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 Na^+ and F^-
   C. The Na-F bond enthalpy (*i.e.* bond energy)
   (D). The lattice energy of NaF
   E. The dipole moment of the Na-F bond

Below are some depictions of orbitals. Questions 9 - 10 refer to these pictures.



$\ell = n-1$

$\ell = 0\ 1\ (2)\ 3$
$s\ p\ (d)\ f$

9. Which of these pictures depicts a *d* orbital?

   (A) A and C B. A C. C D. A, C and E E. A and E

10. Which set of quantum numbers n,ℓ can be valid for the orbital A in the figure above?

   A. 2,2 B. 4,3 C. 3,1 (D) 3,2 E. 2,3

11. What is the wavelength (in **nm**) of an electron travelling at 1% of the speed of light?

   A. 0.242 B. 24.2 (C) 2.42×10^{-10} D. 458 E. 4.58×10^{-4}

$v = 0.01 \times 3 \times 10^8\ m\ s^{-1}$

$$\lambda = \frac{h}{mv}$$

$$= \frac{6.63 \times 10^{-34}}{9.109 \times 10^{-31} \times 0.01 \times 3 \times 10^8}$$

$$= 2.42 \times 10^{-10}$$

12. 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

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

A. NaCl B. Na_2O C. $AlCl_3$ D. MgS (E) Sc_2O_3

787

14. Which of these elements has the highest THIRD ionization energy?

A. S B. P C. Si D. Al (E) Mg

S^{2+}: $[Ne]\,3s^2 3p^2$ P^{2+}: $[Ne]\,3s^2 3p^3$ Si^{2+}: $[Ne]\,3s^2$ Al^{2+}: $[Ne]\,3s^1$ Mg^{2+}: $[Ne]$ ✓

15. Which of the following statements about the uncertainty principle is FALSE?

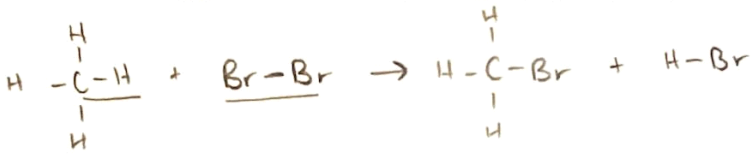
A. We cannot determine the exact position and momentum of a particle simultaneously. ✓
(B) The process of measuring a particle's position causes its momentum to change unpredictably.
C. The more precisely we know a particle's momentum, the more certain we are of its position. ✓
D. The dual nature of 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/4π. ✓

16. 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.

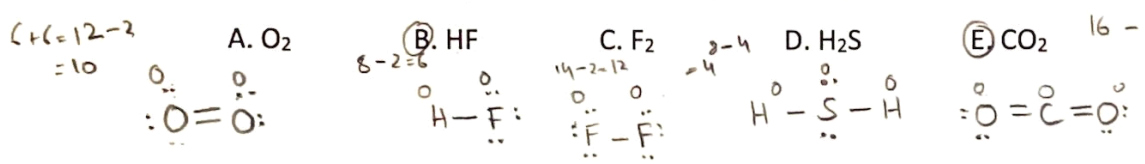
17. Consider the reaction: $CH_4 + Br_2 \rightarrow CH_3Br + HBr$. How would you estimate the enthalpy change for this reaction?

(A) ΔH_{rxn} = [D(C-H) + D(Br-Br)] – [D(C-Br) + D(H-Br)]
B. ΔH_{rxn} = [D(C-Br) + D(Br-Br)] – [D(C-H) + D(H-Br)]
C. ΔH_{rxn} = [D(C-Br) + D(H-Br)] – [D(C-H) + D(Br-Br)]
D. ΔH_{rxn} = [D(C-H) + D(H-Br)] – [D(C-Br) + D(Br-Br)]
E. ΔH_{rxn} = [D(H-Br) + D(Br-Br)] – [D(C-Br) + D(H-Br)]



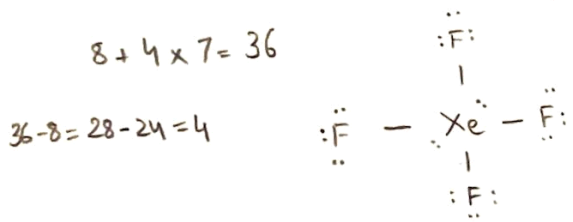
18. Which of the following molecules has the greatest dipole moment?

A. O_2 (B) HF C. F_2 D. H_2S (E) CO_2



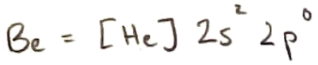
19. How many pairs of non-bonding electrons (i.e. lone pairs) are on the Xe atom in the Lewis structure of XeF_4?

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



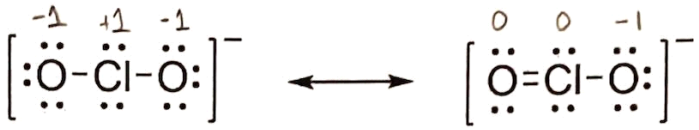
20. Why does beryllium (Be) have a positive electron affinity (i.e. why is it unfavorable for a Be atom to accept an electron when it is favorable for Li and B to do so?)

A. It has a low Z_{eff}
B. It has a high Z_{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



21. Consider the two resonance structures for ClO_2^- shown below. What is the formal charge on Cl in each of the two resonance structures respectively?

valence − shared



Ⓐ +1, 0 B. −1, 0 C. 0, 0 D. 0,+1 E. 0, −1

22. What is the electron configuration for copper (Cu)?

exception

Cu = [Ar] $4s^1$ $3d^{10}$

A. [Kr] $5s^2$ $4d^9$
B. [Ar] $4s^2$ $3d^9$
Ⓒ [Ar] $4s^1$ $3d^{10}$
D. [Ne] $5s^1$ $4d^{10}$
E. [Ar] $5s^2$ $4d^{10}$

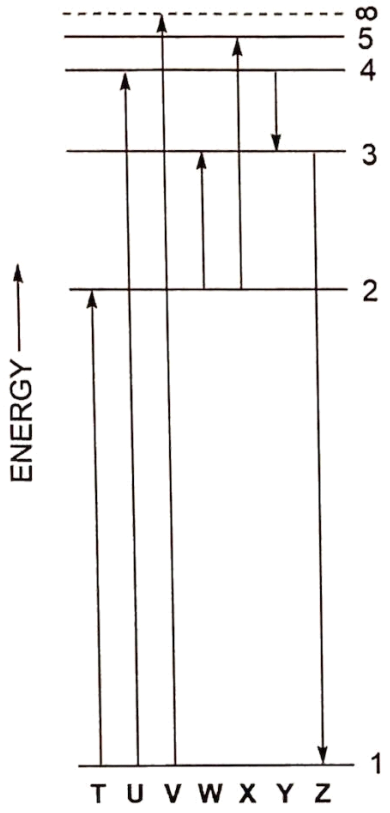
23. How many unpaired electrons are there in the ground state electron configuration of Ga^{3+}?

A.4 B. 3 C. 2 D. 1 Ⓔ 0

Ga [Ar] $4s^2$ $3d^{10}$ $3p^1$

Ga^{3+} : [Ar] $3d^{10}$

Below is the energy level diagram for the possible energy levels of a hydrogen atom (not to scale). Use the diagram to answer questions 24 and 25 about the hydrogen atom.



↑ absorption

↓ release

24. Which transition involves the smallest absorption of energy?

Ⓐ W B. Y C. Z D. T E. V

25. What wavelength of light (in nm) is required for transition X?

A. 95 B. 380 Ⓒ 434 D. 486 E. 656

$E = h\nu$ $c = \lambda\nu$

$E = h\frac{c}{\lambda}$

$$E = -2.18\times10^{-18}\left(\frac{1}{5^2} - \frac{1}{2^2}\right)$$

$$\frac{hc}{\lambda} = -2.18\times10^{-18}\left(\frac{1}{25} - \frac{1}{4}\right)$$

$$\frac{hc}{\lambda} = 4.578\times10^{-19}$$

$$\lambda = \frac{6.63\times10^{-34}\times3\times10^{8}}{4.578\times10^{-19}}$$

$$= 434\times10^{-9}\ m$$

END