Name: _____ Date: _____

1. What is the **name** of the element that has the atomic symbol Na?
   A) Nickel
   B) Sodium
   C) Neon
   D) Nitrogen
   E) Niobium

2. Choose the **FALSE** statement regarding lab safety.
   A) The panic button should be used to bring emergency assistance to your lab only if it is safe to enter.
   B) Teaching Assistants have the right to ask you to leave the lab for safety violations.
   C) Goggles should be worn at all times, even after you have completed your experimental work.
   D) Getting a head-start on the lab by coming in early before the TAs arrive is advisable, and will get you extra marks.
   E) Emergency assistance on campus is most readily accessed by dialing 88.

You are not permitted to enter the lab without the TA present for supervision.

3. How many **atoms of potassium** would be present in 6.05 mL of a 2.582 mol L^{-1} solution of potassium oxide?
   A) 4.38×10^{23}
   B) 9.67×10^{21}
   C) 2.61×10^{19}
   D) 1.88×10^{22}
   E) 4.35×10^{20}

Moles of K_2O = Conc. of K_2O × volume of K_2O
= 2.582 mol L^{-1} × 0.00605 L = 0.0156_{211} mol

Moles of K = Moles of K_2O × 2 = 0.0312_{422} mol

Atoms of Na = moles of Na × N_A (Avogadro's number)
= 0.0312_{422} mol × (6.022×10^{23} mol^{-1}) = 1.88×10^{22}

4. Which of the following statements is **FALSE**?
   A) Glucose ($C_6H_{12}O_6$) and acetic acid (CH_3COOH) have the same empirical formula.
   B) If only the percentages of each element that comprise a molecule are known a molar mass cannot be determined.
   C) Mass is an intensive property.
   D) The molecular formula does not determine the chemical properties of a compound.
   E) Analysis of isotopically-enriched water can be used to deduce historical global temperatures.

The mass of a substance is dependent on how much substance is present. Therefore it is and extensive property.

5. What is the **density** of F_2 gas at 376 ^oC and 2.36 atm?
   A) 7.25 g/L
   B) 1.68 g/L
   C) 5.51 g/L
   D) 2.79 g/L
   E) 4.83 g/L

$PV = nRT$ $\quad n = m/MM$ $\quad d = m/V$

Substitute: $PV = \frac{mRT}{MM}$

Rearrange: $\frac{PMM}{RT} = \frac{m}{V}$ $\quad$ Substitute: $\frac{PMM}{RT} = d$

$$d = \frac{(2.36)(37.996)}{(0.08206)(376+273.15)} = 1.68 \text{ g/L}$$

6. A certain organic molecule contains only oxygen, carbon, and hydrogen. When 0.3869 g of the organic molecule is burned it produced 0.7729 g of CO_2 and 0.3165 g of H_2O. What is the **empirical formula** of the organic molecule? **Similar to Tutorial 1 Challenge Q**
   A) $C_3H_6O_2$
   B) C_2H_4O
   C) C_2H_6O
   D) $C_3H_8O_2$
   E) CH_2O

Moles of C in organic molecule = Moles of CO_2

Moles of CO_2 = mass of CO_2/MM_{CO2}

$= 0.7729 \text{ g} / 44.009 \text{ g mol}^{-1} = 0.01756_{23168}$ mol

Moles of H in organic molecule = 2 × Moles of H_2O

2 × Moles of H_2O = 2 × mass of H_2O/MM_{H2O}

$= 2 \times 0.3165 \text{ g} / 18.0148 \text{ g mol}^{-1} = 0.03513_{77756}$ mol

Mass of O in organic molecule = total mass – mass of C – mass of H

= 0.3869 – (moles of C × MM_C) – (moles of H × MM_H)

$= 0.3869 - (0.01756_{23168} \times 12.011) - (0.03513_{77756} \times 1.0079)$

$= 0.1405_{42244}$ g

Moles of O = mass of O / MM_O

$= 0.1405_{42244} \text{ g} / 15.999 \text{ g mol}^{-1}$

$= 0.008784_{43928}$ mol

Therefore: $C_{0.01756}H_{0.03513}O_{0.008784}$

$= C_2H_4O$

7. In the synthesis of SO_3 from S(s) and O_2(g), water impurities result in production of H_2SO_3 and H_2SO_4 and decrease the percent yield for the synthesis of SO_3 to 84.56%. If 2.586 kg of sulfur is burned in 8.296 kg of oxygen (O_2), **how much SO_3 gas** would be obtained?

A) 13.97 kg
B) 5.460 kg
C) 4.846 kg
D) 2.185 kg
E) 9.936 kg

$2S(s) + 3O_2(g) \rightarrow 2SO_3(g)$

Moles of S(s) = mass of S/MM_S (divided by coefficient)
= 2586 g / 32.066 g mol^{-1} = 80.64_{6167} mol (40.32_{3083})

Moles of O_2 = mass of O_2/MM_{O2} (divided by coefficient)
= 8296 g / 31.998 g mol^{-1} = 259.2_{662} mol (86.42_{206})

Therefore S(s) is limiting… moles of SO_3 produced = moles of S(s) × 84.56% yield
= 80.64_{6167} mol × 84.56% = 68.19_{4399} mol

Mass of SO_3 = moles of SO_3 × MM_{SO3} = 68.19_{4399} × 80.063 = $5459._{8482}$ g = 5.460 kg

8. Which configurations correspond to **ground states** of **metallic** elements?

(i) [Ar] $4s^2\ 3d^{10}$ (ii) [He] $2s^1\ 2p^1$ (iii) [Ar] $4s^2\ 4p^1$
(iv) [Ne] $3s^2\ 3p^3$ (v) [Ne] $3s^1$

A) v, ii
B) ii, iv
C) i, iii
D) i, v
E) iii, iv

(i) ground state of Zn metal
(ii) excited state of Mg metal
(iii) excited state of Sc metal
(iv) ground state of P (non-metal)
(v) ground state of Na metal

9. The *emission* spectrum of atomic hydrogen can be divided into several well-separated series of lines, associated with particular transitions. The Paschen series, in the near infrared, contains all transitions ending at $n = 3$. Calculate the **longest wavelength** observed in the Paschen series.

A) 1.29 μm
B) 1.88 μm
C) 91.6 nm
D) 656 nm
E) 2.10 μm

From $E = hc/\lambda$, longest wavelength = smallest energy
Therefore, smallest transition ending in n = 3, n = 4 → n = 3.

$E = R_H (1/n_i^2 - 1/n_f^2)$
$= 2.178 \times 10^{-18}/(1/(4)^2 - 1/(3)^2)$
$= -1.058_{75} \times 10^{-19}$ J

$E = hc/\lambda$
$1.058_{75} \times 10^{-19} = (6.6256 \times 10^{-34})(2.9979 \times 10^{8})/\lambda$
$= 1.876 \times 10^{-6} = 1.88$ μm

10. In an experimental set up for measuring the photoelectric effect in metals, using a laser emitting incident light at a wavelength of 2.840 nm, the following observations were made:

For sample A, no electrons were detected; for sample B, the kinetic energy of the electrons was 8.21×10^{-21} J, for sample C, the speed of the electrons was 7.12×10^{5} m/s, and for sample D, the wavelength of the electrons was 1.46×10^{-9} m.

Rank the work functions (threshold energy) of these samples from highest to lowest.

A) A > D > B > C
B) A > B > D > C
C) B > D > C > A
D) D > B > C > A
E) A > C > B > D

$E_{incident} = hc/\lambda = (6.6256 \times 10^{-34})(2.9979 \times 10^{8})/(2.840 \times 10^{-9}) = 6.994 \times 10^{-19}$ J

$E_{incident}$ = work function + KE

Sample A: no electrons ejected therefore work function > 6.994×10^{-17} J

Sample B: work function = 6.994×10^{-17} J $- 8.21 \times 10^{-21}$ J = $6.99_3 \times 10^{-17}$ J

Sample C: KE = $\frac{1}{2}mu^2 = \frac{1}{2}(9.10 \times 10^{-31})(7.12 \times 10^{5})^2 = 2.306 \times 10^{-19}$
Therefore work function = 6.994×10^{-17} J $- 2.306 \times 10^{-19} = 6.97_1 \times 10^{-17}$ J

Sample D: RECALL: an electron is not a photon and you must use DeBroglie equation
$\lambda = h/m_e u$; $1.460 \times 10^{-9} = (6.6256 \times 10^{-34})/(9.10 \times 10^{-31})$ u; u = $4.89_{69} \times 10^{5}$ m/s
KE = $\frac{1}{2}mu^2 = \frac{1}{2}(9.10 \times 10^{-31})(4.89_{69} \times 10^{5})^2 = 1.13_{15} \times 10^{-19}$
Therefore work function = 6.994×10^{-17} J $- 1.13_{15} \times 10^{-19} = 6.98_3 \times 10^{-17}$ J

11. Which one of the following statements is **FALSE?**

A) As the principal quantum number, *n*, increases, so does the average distance from the nucleus where the electron may be found.
B) As the wavelength of light increases, the energy decreases.
C) When $l = 2$, m_l can be –2, –1, 0, 1, or 2.
D) Light is emitted when electrons are promoted to higher energy levels.
E) The photoelectric effect occurs when light strikes the surface of a metal and electrons are ejected.

Light is absorbed when electrons are promoted to higher energy levels and emitted when electrons relax to lower energy levels.

12. Which one of the following is **NOT an allowed set** of quantum numbers (n, l, m_l , m_s) for an electron?

A) 2, 2, 1, –½
B) 2, 1, –1, –½
C) 3, 2, 0, ½
D) 3, 1, –1, ½
E) 1, 0, 0, ½

possible values of $l = 0, \ldots, n - 1$.

13. What is the **maximum** number of electrons having the principal quantum $n = 3$ for a given atom?

A) 18
B) 2
C) 3
D) 6
E) 8

For $n = 3$ shell, $l = 0, 1, 2$ therefore a total of 3 subshells;

For $l = 0$, $m_l = 0$ therefore 1 orbital;
For $l = 1$, $m_l = -1, 0, 1$ therefore 3 orbitals;
For $l = 2$, $m_l = -2, -1, 0, 1, 2$ therefore 5 orbitals;

Therefore a total of 9 orbitals exist for $n = 3$ and each orbital can contain up to 2 electrons for a total of 18 electrons.

14. Which of the following statements about periodic trends are **TRUE**?
(i) The bonds in a molecule of SO_3 are ionic.
(ii) The ions Ca^{2+} and S^{2-} are isoelectronic because they contain the same number of electrons.
(iii) The metallic character of elements in row three increases with atomic number.
(iv) The energy required for removing an electron from an atom in the gas phase is called the atom's ionization energy.

A) ii, iii
B) ii, iv
C) iii, iv
D) i, iii
E) i, iv

i) FALSE. S is less electronegative than O because electronegativity increases up a group. Both are non-metals and therefore the bonds are polar covalent.
ii) TRUE. Ca^{2+} and S^{2-} are isoelectronic and both have the same electron configuration as Ar.
iii) FALSE. Metallic character increases going across a row from right to left. Therefore metallic character decreases with increasing atomic number in row 3.
iv) TRUE. The energy required for removing an electron from an atom in the gas phase is called the atom's **ionization energy**.

15. Which of the following statements about periodic trends are **TRUE**?
(i) The ground-state electron configuration of Ca has no unpaired electrons.
(ii) The oxide of sulfur is a basic oxide.
(iii) Li loses electrons more easily than Cs.
(iv) The electronegativity of nitrogen is smaller than that of fluorine.

A) i, iv
B) i, iii
C) ii, iv
D) ii, iii
E) i, ii

i) TRUE. Ca has two paired 4s electrons.
ii) FALSE. Metal oxides are basic, non-metal oxides are acidic.
iii) FALSE. Ionization energy increases going up a group.
iv) TRUE. Electronegativity increases going across a period from left to right.

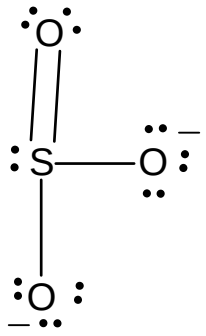
16. Which atom/ion has the **largest radius**?
    A) Ba^{2+}
    B) Br^{-}
    C) Rb^{+}
    D) Te^{2-}
    E) Kr

Rb^{+}, Br^{-} and Kr are isoelectronic and have electron configurations resembling Kr.
S
Te^{2-}, and Ba^{2+} are isoelectronic and have electron configurations resembling Xe.
Radius generally increases going down a group and therefore Te^{2-}, and Ba^{2+} are likely largest. Te^{2-} would have the largest radius because Ba^{2+} has more protons pulling on the electrons (greater Z_{eff}).

17. Which atom has the **lowest** (least negative) electron affinity?
    A) Mg
    B) B
    C) Al
    D) S
    E) F

The electron is added to a new subshell and is very unfavourable.

18. What is the **electron pair geometry** for the sulfite anion, SO_3^{2-}?
    A) Trigonal bypyramidal
    B) Tetrahedral
    C) Octahedral
    D) Trigonal pyramidal
    E) Trigonal planar

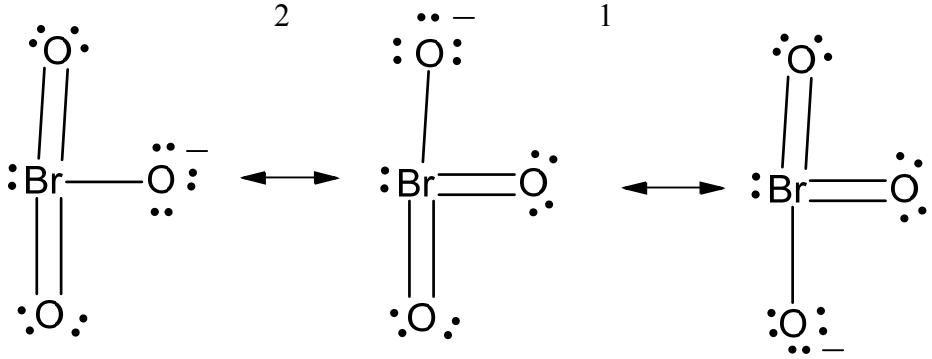


AX_3E – **electron pair geometry = tetrahedral**
– molecular shape = trigonal pyramidal

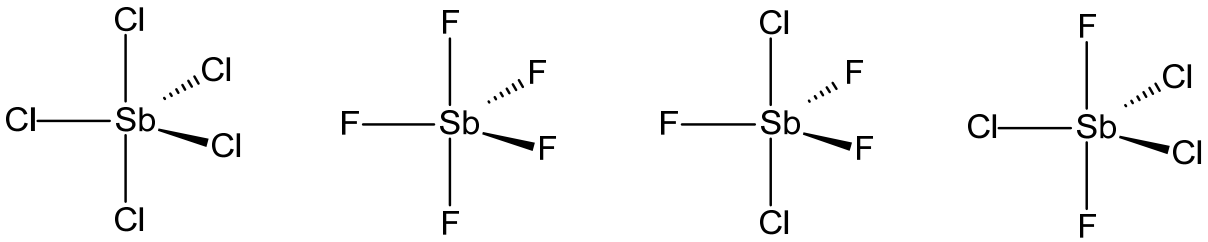
19. Determine the **FALSE** statement regarding bonding.
A) NH_4Cl has only covalent bonding. Ionic bonding is also present.
B) The bonding in BaF_2 is ionic.
C) In a coordinate covalent bond, both electrons originate from one atom.
D) The bond in H_2 is non-polar (pure) covalent.
E) The bonds in CO_2 are polar covalent.

20. Consider the charge minimized Lewis structure for the bromate ion (BrO_3^-). What is the average Br-O bond order, number of resonance structures for the ion and lone pairs of electrons on bromine (respectively)?

	bond order	resonance structures	electron lone pairs
A)	$^4/_3$	1	2
B)	$^5/_3$	3	1
C)	$^5/_3$	2	2
D)	3	3	2
E)	$^4/_3$	2	1



21. A series of molecules have the general formula $SbF_nCl_{(5-n)}$ where n = 0,1,2,3,4,5. How many **unique, non-polar** molecules exist for this series.
A) 2
B) 5
C) 4
D) 1
E) 3



The lone electron pairs on the terminal atoms have been omitted for clarity. They each possess 6 lone electrons.

22. Which of the following elements is **most electronegative**?
    A) As
    B) Si
    C) Li
    D) Ga
    E) Cl

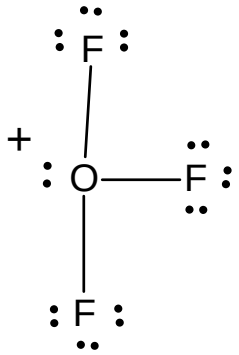
    Electronegativity increases up a group and from left to right.

23. In which of the following species would you expect to see the **largest, unequal** distribution of electron density.
    A) H_2
    B) LiBr
    C) CsF
    D) HCl
    E) HI

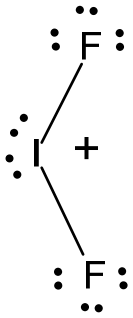
    Electronegativity increases up a group and from left to right. Cs is bottom left of the periodic table and F is top right. Therefore these will have the greatest difference in electronegativity and will have the largest unequal distribution of electron density with the most density on F (most electronegative) and least on Cs (least electronegative).

24. Determine the **FALSE** statement regarding the Lewis structure of the trifluorooxonium ion (OF_3^+)
    A) The ion only has single bonds.
    B) There are 6 bonding electrons within the ion.
    C) The oxygen atom has a formal charge of +1.
    D) The formal charge on all fluorine atoms is 0.
    E) There are 11 lone pairs of electrons within the ion.

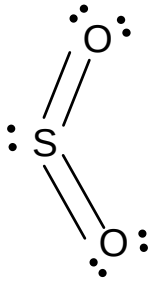
    There are only 10 lone pairs of electrons.



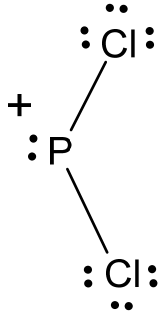
25. Which of the following molecules would be **linear**?
    A) IF_2^+
    B) SO_2
    C) PCl_2^+
    D) H_2Se
    E) NO_2^+



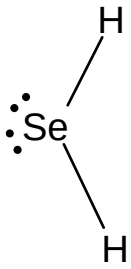
AX_2E_2
Bent



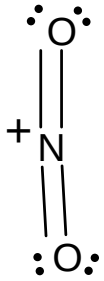
AX_2E
Bent



AX_2E
Bent



AX_2E_2
Bent



AX_2
Linear