Name : _____ **KEY** _____   Major : _____

Student Number : _____   Signature : _____

Useful Information

Planck's constant $h = 6.626 \times 10^{-34}$ J s

Speed of light $c = 2.998 \times 10^{8}$ m s^{-1}

Constant for the Bohr energy levels $C = 2.18 \times 10^{-18}$ J (Rydberg's constant)

$1 \text{nm} = 10^{-9}$ m

Mass of electron $m_e = 9.109 \times 10^{-31}$ kg

There are 20 questions. In each question, only ONE of the proposed answers is right. Circle the letter corresponding to the right answer.
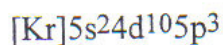
- According to VSEPR theory, the geometry of the PH_3 molecule is best described as

  A. linear.
  B. trigonal planar.
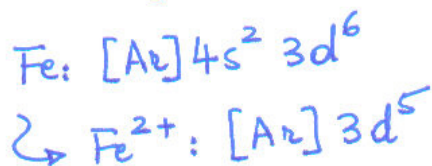 C. tetrahedral.
  D. bent.
  E. trigonal pyramidal.

- Which element has the following electron configuration?
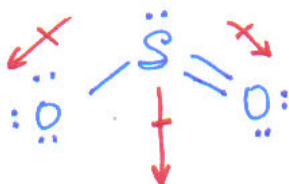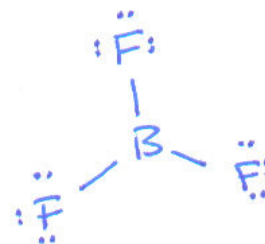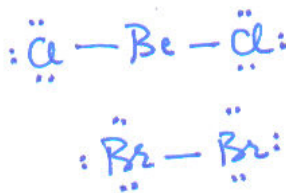
  $[Kr]5s^2 4d^{10} 5p^3$

  A. Sn

  B. Sb

  C. Pb

  D. Bi

  E. Te

- Which of the following is the electron configuration of the Fe^{3+} ion?

  A. $[Ar]3d^5$
  B. $[Ar]4s^1 3d^5$
  C. $[Ar]4s^2 3d^3$
  D. $[Ar]3d^6$
  E. $[Ar]4s^2 3d^9$

  Fe: $[Ar] 4s^2 3d^6$

  $\hookrightarrow Fe^{2+}: [Ar] 3d^5$

- Which one of the following molecules has a dipole moment?

  A. $BeCl_2$
  B. Br_2
  C. BF_3
  D. SO_2
  E. CO_2

- Calculate the wavelength of a neutron that has a velocity of 200 cm/s. The mass of a neutron = 1.675×10^{-27} kg.

  A. 1.98×10^{-9} m
  B. 216 nm
  C. 1.8×10^{50} m
  D. 198 nm
  E. 5.05 mm

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

$$= \frac{6.626 \times 10^{-34}}{1.675 \times 10^{-27} \times 200 \times 10^{-2}}$$

$$= 1.98 \times 10^{-7} m = \boxed{198 \, nm}$$

- What is the energy in joules of a mole of photons associated with red light of wavelength 7.00×10^2 nm?

  A. 256 kJ
  B. 1.71×10^5 J
  C. 4.72×10^{-43} J
  D. 12.4 kJ
  E. 2.12×10^{42} J

$$E = N_A \, \varepsilon = h\nu = h\frac{c}{\lambda} \otimes N_A$$

$$= 6.626 \times 10^{-34} \times \frac{2.998 \times 10^8}{7.00 \times 10^2 \times 10^{-9}} \times 6.023 \times 10^{23}$$

$$= \boxed{1.71 \times 10^5 \, J}$$

- What is <u>not</u> common between the Lewis structures of NO_3^-, CO_3^{2-} and SO_3 ?

  A. They are all isoelectronic. ✓ (valence)

  B. They all have three resonance contributing structures. ✓

  C. Their resonance structures are not equivalent. No. they are!

  D. When considered from the viewpoint of VSEPR theory, they are yield trigonal planar ✓ molecules.

  E. For each molecule, each resonance structure has two single bonds and one double bond. ✓

  (handwritten: $5 + 18 + 1 = 24$ valence e^-, with Lewis structure of NO_3^-)
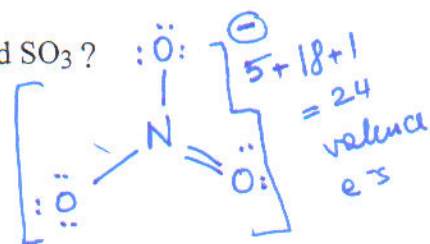
- In which one of the following molecules is the central atom sp² hybridized?

  sp² A. SO_2
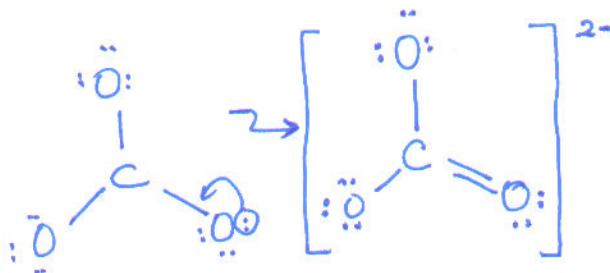 sp B. N_2O
  sp C. $BeCl_2$
  sp³ D. NF_3
  dsp³ E. PF_5

N_2O: $5 \times 2 + 6 = 16 - 4 = 12$

(handwritten Lewis structures of N_2O)

$:N \equiv N = O:$

$SO_3 \approx 24$ valence
same idea...

$CO_3^{2-}: 4 + 18 + 2 = 24$ valence
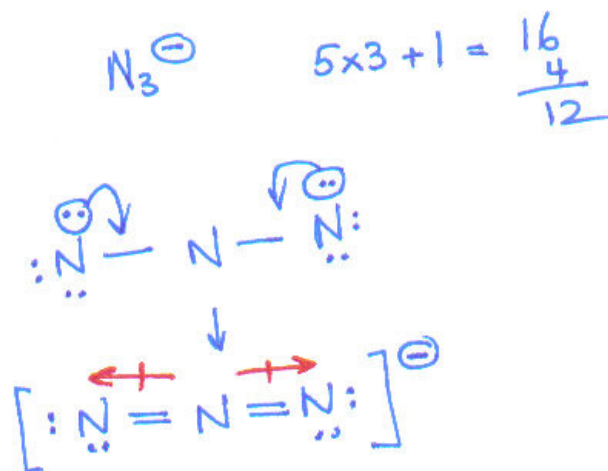
(handwritten Lewis structure of CO_3^{2-})

- Which one of the following elements is a transition element?

  A. Sr
  B. Pb
  C. As
  → (D.) Hg
  E. H

- Which one of the following molecules is nonpolar?

  A. NH_3

  B. OF_2

  C. CH_3Cl

  D. H_2O

  (E.) N_3^-

  (handwritten) $N_3^{\ominus}$ $5\times3+1 = \dfrac{16}{}$ $\begin{array}{r}16\\4\\\hline 12\end{array}$

  $:\!\overset{\cdot\cdot}{N}\!\!-\!\!N\!\!-\!\!\overset{\cdot\cdot}{N}\!:$

  $\left[:\!\overset{\cdot\cdot}{N}\!=\!N\!=\!\overset{\cdot\cdot}{N}\!:\right]^{\ominus}$

- A possible set of quantum numbers for the last electron added to complete an atom of germanium (Ge) in its ground state is

  (handwritten) last e^- is in $4p$

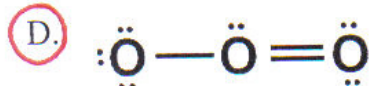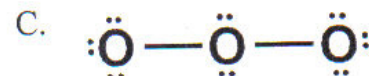 | | n | l | m_l | m_s |
  |---|---|---|---|---|
  | A. | 4 | 0 | 0 | + 1/2 |
  | B. | 3 | 0 | +1 | − 1/2 |
  | (C.) | 4 | ① | −1 | + 1/2 |
  | D. | 3 | 1 | +1 | − 1/2 |
  | E. | 4 | 2 | +2 | − 1/2 |

  (handwritten) not possible (d e^-)
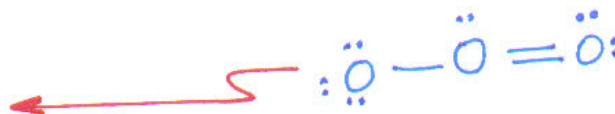
- Consider an element with the following electron configuration: $[Xe]6s^24f^7$. What is this element?

  A. Sm
  (B.) Eu
  C. Gd
  D. Am
  E. Cm

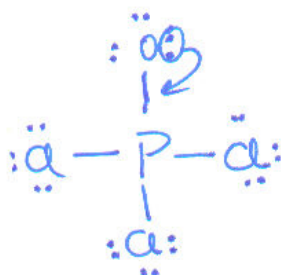- Which one is a correct Lewis structure for ozone, O_3?

O_3 $18 e^-$s
$\frac{4}{14}$

A. $:\ddot{O}-\ddot{O}=\ddot{O}:$

B. $\ddot{O}-\ddot{O}=\ddot{O}:$

C. $:\ddot{O}-\ddot{O}-\ddot{O}:$

(D.) $:\ddot{O}-\ddot{O}=\ddot{O}$

E. $\ddot{O}-\ddot{O}-\ddot{O}:$
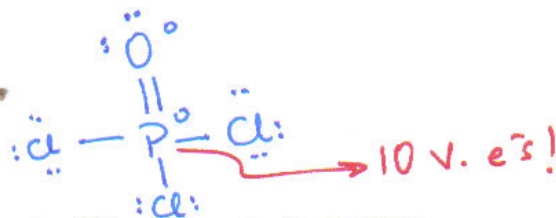
$:\ddot{O}- \ddot{O} -\ddot{O}:$

$:\ddot{O}-\ddot{O}=\ddot{O}:$

- Which one of the following compounds does not follow the octet/duet rule?

Hint: Consider the BEST Lewis structure in each case.

A. NF_3

B. SiF_4

(C.) $POCl_3$

D. AsH_3

E. HCl

$:\ddot{O}:$

$:\ddot{Cl}-P-\ddot{Cl}:$
$|$
$:\ddot{Cl}:$

$POCl_3: 5+6+21 = 32 \; e^-$s
$\frac{8}{24}$

$:\ddot{O}:$
$||$
$:\ddot{Cl}-P=\ddot{Cl}:$
$|$
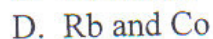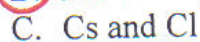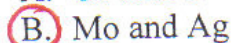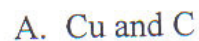$:\ddot{Cl}:$ $\rightarrow 10$ v. e^-s!

- The maximum number of electrons in a atom that have the following set of quantum numbers is:

$n = 4 \quad l = +3 \quad m_l = -2 \quad m_s = +1/2$

A. 0

(B.) 1

C. 2

D. 6

E. 10

- Which choice lists two elements with electron configurations that are well-known exceptions to the Aufbau principle?

A. Cu and C

(B.) Mo and Ag

C. Cs and Cl

D. Rb and Co

E. Fe and Co

$Mo: 5s^1 \, 4d^5$ $Ag: 5s^1 \, 4d^{10}$
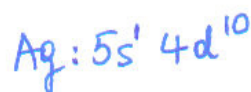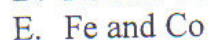
- Calculate the wavelength, in nanometers, of the light emitted by a hydrogen atom when its electron falls from the n = 7 to the n = 4 principal energy level. Recall that the energy levels of the H atom are given by:

$E_n = -2.18 \times 10^{-18}$ J $(1/n^2)$

A. 4.45×10^{-20} nm
B. 2.17×10^{-6} nm
C. 9.18×10^{-20} nm
D. 1.38×10^{14} nm
E. 2.17×10^3 nm

$\Delta E = R_H \left(\frac{1}{16} - \frac{1}{49}\right) = \frac{hc}{\lambda}$
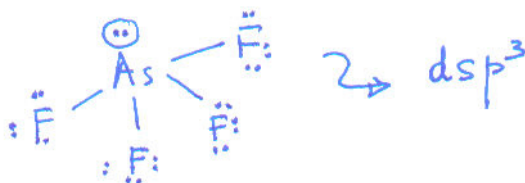
$= 2.18 \times 10^{-18} (0.0421) = \frac{hc}{\lambda}$

$\hookrightarrow \lambda = 2.16 \times 10^{-6}$ m

$= \boxed{2.16 \times 10^3 \text{ nm}}$

- What is the hybridization of As in the AsF_4^- ion?

A. sp
B. sp^2
C. sp^3
D. sp^3d
E. sp^3d^2

$5 + 7 \times 4 + 1 = 34 \text{ e's} \quad -8 = 26$

$\rightarrow dsp^3$

- The work function for potassium (K) is 2.25 eV. Calculate the kinetic energy of the ejected electron when a photon of wavelength 490 nm hits the surface of a potassium metal sheet.

A. 4.78 eV
B. 0.28 eV
C. 2.53 eV
D. 0.18 eV
E. 3.65 eV

$E = h\nu = \frac{hc}{\lambda} = 4.05 \times 10^{-19}$ J

$= 2.53$ eV

$E = \underbrace{h\nu_0}_{\phi} + K.E$

work function

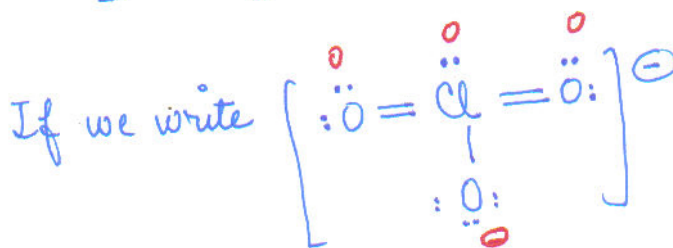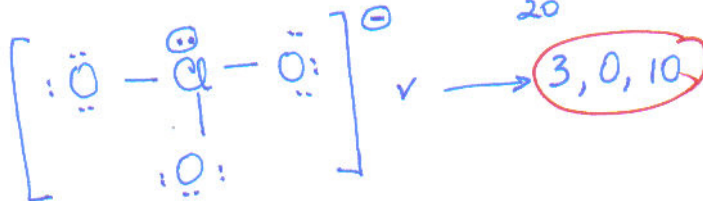$\hookrightarrow K.E = E - \phi$

$= 2.53 - 2.25$

$= \boxed{0.28 \text{ eV}}$

- The Lewis structure for a chlorate ion, ClO_3^-, should show _____ single bond(s), _____ double bond(s), and _____ lone pair(s).

A. 2, 1, 10
B. 3, 0, 9
C. 2, 1, 8
D. 3, 0, 10
E. 2, 1, 10

$ClO_3^{\ominus} : 7 + 18 + 1 = 26$

$\frac{6}{20}$

$v \longrightarrow \boxed{3, 0, 10}$

If we write ... $1, 2, 8$

No choice for this!