Name : ___KEY___   Signature : _____

Student Number : _____

Circle your *recitation* **Section :**   Sect.1   12 F   (Prof. Sultan)

                                            Sect. 2   8 Th   (Prof. El-Rassy)

                                            Sect. 3   12:30 Th   (Prof. El-Rassy)

Useful Information

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

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

Constant for the Bohr energy levels $C = 2.178 \times 10^{-18}$ J (Rydberg's constant)

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

$1pm = 10^{-12}$ 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.

- Which of the following relations is NOT directly related to the physical quantity or concept that accompanies it?

  ✓ a. $E_n = -C/n^2$; energy of the nth Bohr orbit.
  ✓ b. $\lambda = h/mv$; small particles possess wave properties.
  ✓ c. $\Delta x\, \Delta(mv) \geq h/4\pi$; impossibility of measuring both the position and momentum of an elementary particle.
  ✓ d. $H\Psi = E\Psi$; time independent Schrödinger wave equation.
  ✗ (e.) $mvr = nh/2\pi$; Planck's quantization of absorption or emission of energy.

  Bohr's assumption of quantization of angular momentum

- Which of the following statements is <u>incorrect</u>?

  ✓ a. All p orbitals have zero electron density on the nucleus.
  ✗ (b.) Any d orbital has two angular nodes and one radial node.
  ✓ c. All s orbitals have non-zero probability density on the nucleus.
  ✓ d. All f orbitals have three angular nodes.
  ✓ e. The angular nodes in a $3d_{z^2}$ atomic orbital are conical surfaces.
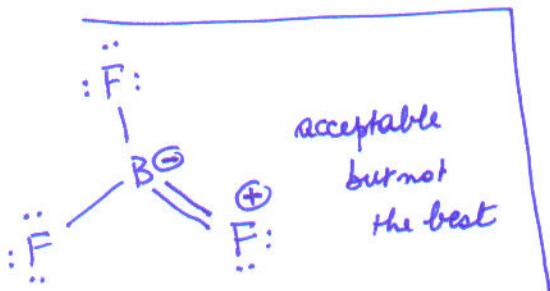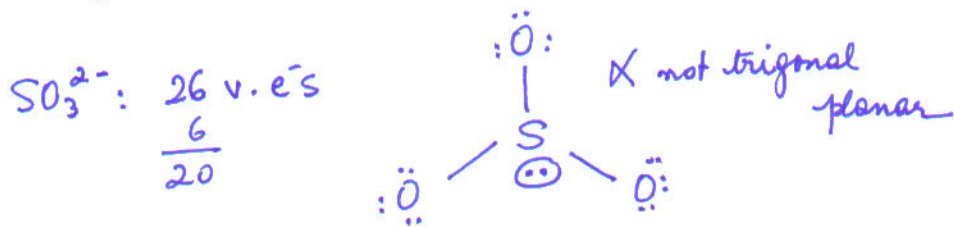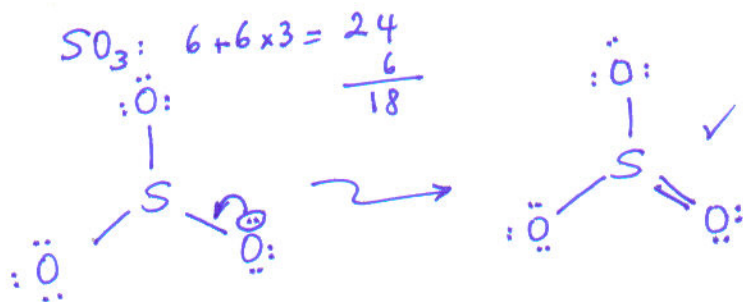
- Which of the following statements is <u>not correct</u> in relation to the physical significance of the Schrödinger wave equation (SWE), its solutions and their representations?

  ✓ a. The Born interpretation of the wave function says that the square of the wave function is proportional to the probability of finding the electron in a given region of space.
  ✓ b. For a many-electron atom, the SWE is solved numerically and the wave function is improved by successive numerical iterations.
  ✓ c. The wave function for a hydrogenic orbital has an explicit mathematical form and can be written as the product of a radial and an angular part.
  ✗ (d.) Boundary surfaces give the detailed distribution of electron density inside the orbital. *No details. only include 90% of the e⁻ density*
  ✓ e. The wave function is not a tool we obtain by experiment.

- Which of the following **cannot** be represented by a Lewis structure with 2 single bonds and one double bond, with a trigonal planar geometry? (Not necessarily the best)

  ✓ a. CO_3^{2-}
  ✓ b. NO_3^-
  ✓ c. SO_3
  ✗ (d.) SO_3^{2-}
  ✓ e. BF_3

  e.
  b.
  d.
  d.

  SO_3: $6 + 6 \times 3 = 24$ / $\frac{6}{18}$

  acceptable but not the best

  SO_3^{2-}: 26 v. e's / $\frac{6}{20}$
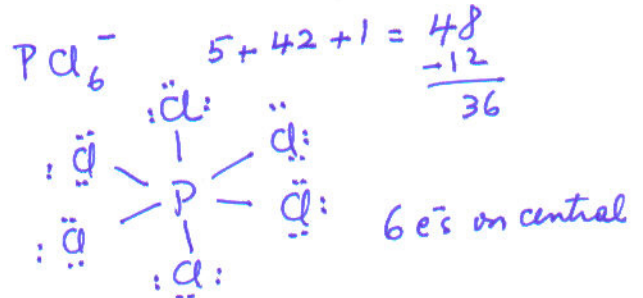
  ✗ not trigonal planar

- In which of the following transitions of an exited hydrogen atom, will the emitted light fall in the visible region ($\lambda \approx 400$ to 700 nm)?

    a. $5 \rightarrow 1$
    ⓑ. $6 \rightarrow 2$
    c. $7 \rightarrow 3$
    d. $5 \rightarrow 4$
    e. $2 \rightarrow 1$

Visible: Balmer series $\}$ $n_2 = 3, 4, 5, 6, \ldots \longrightarrow n_1 = 2$

- Which of the following molecules/ions has an expanded octet?

    ✓a. SF_6
    ✓b. XeO_3 (see below)
    ✓c. PCl_6^-
    ✓d. $IF_3 \longrightarrow$ 10 e⁻'s on central
    ⓔ. All of the above

PCl_6^- $5 + 42 + 1 = \dfrac{48}{\substack{-12 \\ \hline 36}}$

6 e⁻'s on central

- Which of the following electronic configurations is <u>not</u> a correct ground state configuration for the element shown:

    ✓a. Mo: $[Kr]5s^1 4d^5$
    ✓b. Ac: $[Rn]7s^2 6d^1$
    ✓c. Cd: $[Kr]5s^2 4d^{10}$
    ✓d. Os: $[Xe]6s^2 4f^{14} 5d^6$
    ⓔ. Lu: $[Xe]6s^2 4f^{14}$ ✗ $[Xe]6s^2 4f^{14} 5d^1$
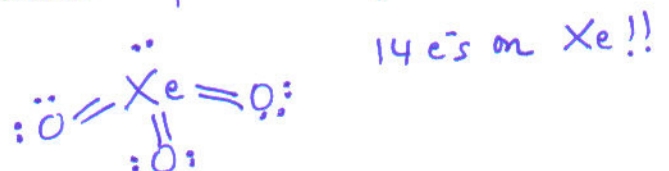
- In which of the following compounds does the bond between the central atom and bromine have the greatest ionic character?

    a. KBr
    ⓑ. CsBr
    c. $SeBr_2$
    d. $AsBr_2$
    e. $CaBr_2$

Cs is the most electropositive atom! (far lower-left corner)

XeO_3: $8 + 18 \star = \dfrac{26}{\substack{6 \\ \hline 20}}$

no expanded octet!
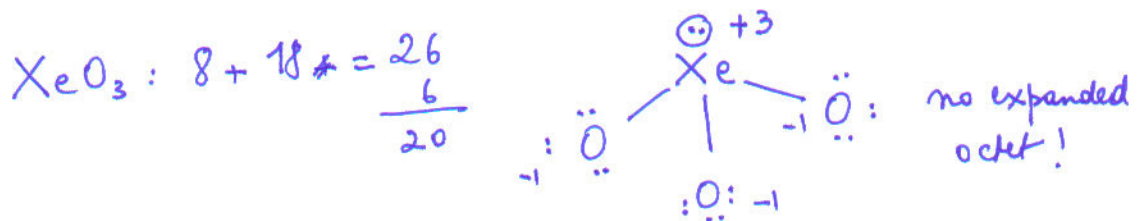
But the best one with all formal charges = zero

14 e⁻'s on Xe !!

- In each of the following, the maximum number of electrons in an atom having the shown set of quantum numbers is indicated. In which case is the indicated maximum number of electrons <u>wrong</u>?

✓ a. $n = 2$; $\ell = 1$; $m_\ell = -1$; $m_s = +1/2$: **1**

✗ b. $n = 0$; $\ell = 0$, $m_\ell = 0$: **2** *impossible*

✓ c. $n = 3$; $\ell = 2$: **10**

✓ d. $n = 4$; **32** → $2n^2 = 32$

✗ e. $n = 4$; $m_\ell = -1$: **8** ✗ 6 → 6 only.

    s   p   d   f

    x   2   2   2

(f.) b) and e)

- Which of the following molecules has a non-zero dipole moment?

(a.) SF_4 *see-saw*

b. CO_2 *linear*

c. BH_3 *trigonal planar*

d. PF_5 *Trigonal bipyramidal*

e. XeF_4 *Octahedral*

$XeF_4 = 8 + 28 = 36$

$\frac{8}{28}$

AB_4E_2
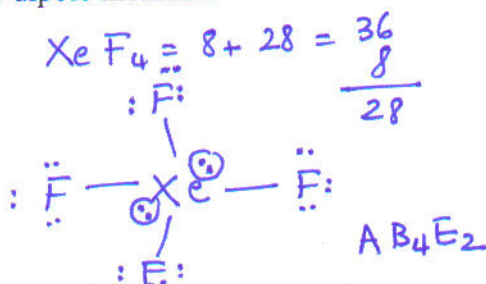
- The uncertainty on the velocity of an electron is $\Delta v = 0.100$ m/s. Calculate the minimum uncertainty on the position of that electron then evaluate the ratio of the latter to the Bohr radius (52.9 pm).
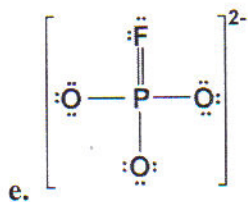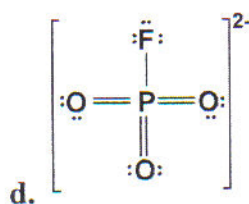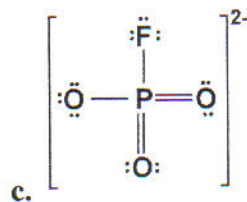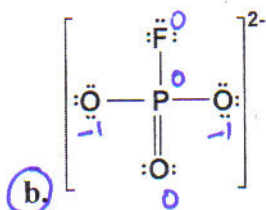
(a.) 1.09×10^7

b. 5.79×10^{-4}

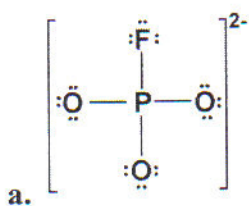c. 9.96×10^{-24}

d. 1.38×10^8

e. 1.09×10^{-5}

$\Delta x \, \Delta p \geq \frac{h}{4\pi}$

$\Delta x \geq \frac{h}{m \Delta v} = \frac{7.27 \times 10^{-3} \, m}{4\pi} = 5.79 \times 10^{-4} \, m$

$\frac{\Delta x}{a_0} = \frac{5.79 \times 10^{-4}}{52.9 \times 10^{-12}} = 1.09 \times 10^7$

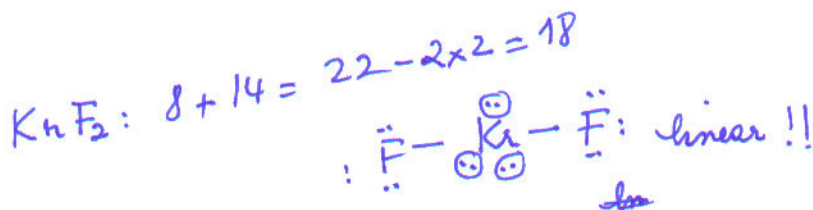- Which of the following is the best Lewis structure for the ion PO_3F^{2-}?

a.

b.

c.

d.

e.

- According to VSEPR theory, which one of the following molecules should be bent (nonlinear)?

  ✗ a. CO_2 linear
  ✗ b. C_2H_2 linear
  ✗ c. $BeCl_2$ linear
  ✓ (d.) TeO_2 bent (like SO_2)
  ✗ e. KrF_2 linear

  KrF_2: $8 + 14 = 22 - 2 \times 2 = 18$

  $:\ddot{F} - \overset{\cdot\cdot}{\underset{\cdot\cdot}{Kr}} - \ddot{F}:$ linear !!

- Which of the following statements is conform with the experiment of Stern and Gerlach?

  ✗ a. Either B or Na atoms could be used in the experiment.
  ✗ b. The splitting of the beam of atoms in a magnetic field into two, was caused by both orbital and spin angular momenta.
  ✓ (c) The half-integer value of the spin quantum number can be inferred from equating the number of m_s values with the number of splittings (two).
  ✗ d. A beam of atoms with a closed shell electron configuration would split in a magnetic field.
  ✗ e. None of the above.

- Which of the following is a nodal plane in the $d_{x^2-y^2}$ orbital?
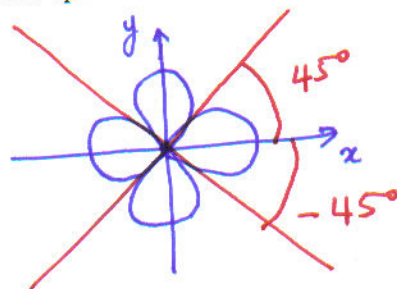
  ✗ a. xy plane
  ✗ b. yz plane
  ✗ c. xz plane
  ✓ d. A plane perpendicular to the xy plane at an angle of $+45°$ with the x axis.
  ✓ e. A plane perpendicular to the xy plane at an angle of $-45°$ with the x axis.
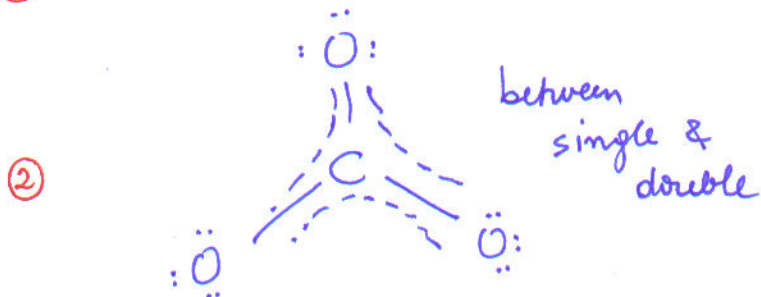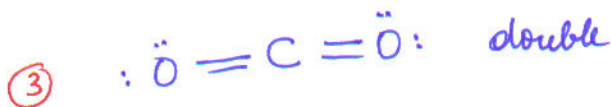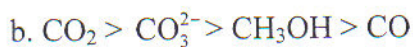 (f.) d) and e).

- Consider the CO_2 molecule. Which of the following statements is correct?

  ✗ a. The lone pairs in the oxygen atoms occupy sp hybrid orbitals.
  ✗ b. The sigma bond between C and O is formed by the overlap of two sp^2 hybrid orbitals on the two atoms.
  ✓ (c.) The p orbitals used in forming the hybrid orbitals of the O atoms are p_z and p_x on one atom and p_z and p_y on the other.
  ✗ d. The π bond between one O atom and the C atom results from the overlap of an sp hybrid orbital on C and an sp^2 hybrid orbital on O.
  ✗ e. From the viewpoint of VSEPR theory, the C atom and each of the two O atoms have four effective pairs.

- Which one of the following is most likely to be an ionic compound?

  (a) CaI_2 ✓
  b. GaAs ✗
  c. NO_2 ✗
  d. CBr_4 ✗
  e. H_2O ✗

  1

- Order the following species with respect to carbon-oxygen bond length (longest to shortest)

  a. $CH_3OH > CO_2 > CO_3^{2-} > CO$

  b. $CO_2 > CO_3^{2-} > CH_3OH > CO$

  c. $CH_3OH > CO > CO_2 > CO_3^{2-}$

  (d) $CH_3OH > CO_3^{2-} > CO_2 > CO$

  e. $CO > CO_2 > CO_3^{2-} > CH_3OH$

longest   H O—CH₃ single

③   :Ö=C=Ö: double

②
:Ö:

)||⟍

⟋C⟍

:Ö   Ö:

between
single &
double

shortest   :C≡O: triple

- Consider the total radial probability distributions for the helium (He), Neon (Ne) and argon (Ar) atoms shown in the following diagram:
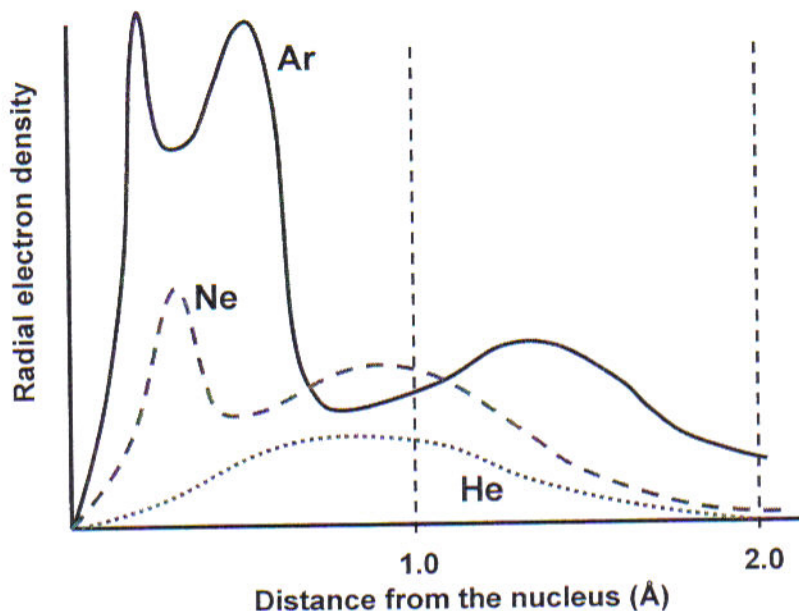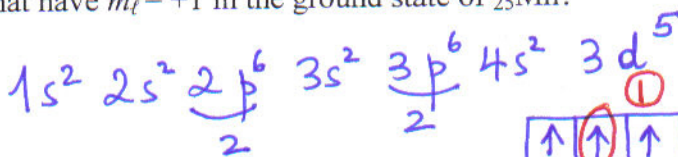

Which of the following information <u>cannot</u> be inferred from the above diagram?

a. There are three main quantum energy levels in argon, two in neon and one in helium.
b. The first energy level is more penetrating in Ar than in Ne than in He.
c. He, Ne and Ar are noble gases.
d. The order of decreasing atomic size is Ar > Ne > He.
e. The second energy level is more penetrating in Ar than in Ne.
f. None of the above.

- What is the number of electrons that have $m_\ell = +1$ in the ground state of $_{25}Mn$?

a. 5 electrons
b. 6 electrons
c. 4 electrons
d. 7 electrons
e. 12 electrons

$1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6\ 4s^2\ 3d^5$

$2 + 2 + 1 = 5$