

Detailed Key SP24 Exam 1

$$Vol = \frac{1000g}{22.57g/cm^3} = 44.31cm^3$$

$$4.00cm \times 4.00cm \times height = volume = 44.31cm^3$$

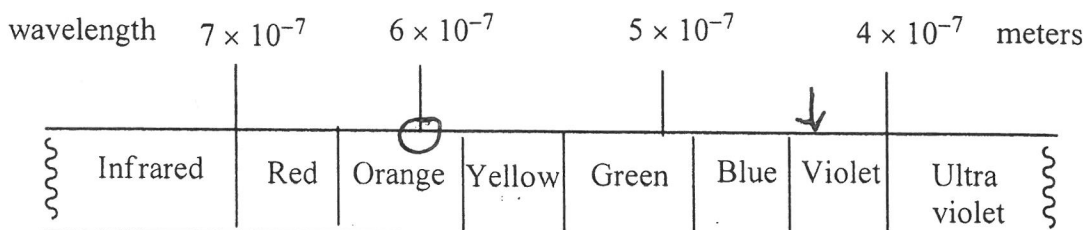
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1. The density of osmium (the densest metal) is 22.57 g/cm³. If a 1.00 kg rectangular block of osmium has two dimensions of 4.00 cm × 4.00 cm, calculate the third dimension of the rectangular block. The volume of a rectangle is length × width × height.

$$height = \frac{44.31cm^3}{16.0cm^2} = 2.77cm$$

- a) 44.3 cm b) 16.0 cm c) 2.77 cm
d) 1.41 cm e) 3.97 cm

Use the figure below to answer the next two questions.



$$v\lambda = c, \lambda = \frac{c}{v} = \frac{2.998 \times 10^8 m/s}{5.0 \times 10^{14} s^{-1}} = 6.0 \times 10^{-7} m$$

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2. What color is electromagnetic radiation having a frequency of 5.0 × 10¹⁴ sec⁻¹?

From figure, $\lambda = 6.0 \times 10^{-7} m$ is orange light

- a) red b) orange c) yellow d) green e) violet

$$\Delta E = -R_H \left(\frac{1}{n_2^2} - \frac{1}{n_1^2} \right) = -2.178 \times 10^{-18} J \left(\frac{1}{2^2} - \frac{1}{5^2} \right) = -4.574 \times 10^{-19} J, E_{photon} = 4.574 \times 10^{-19} J$$

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3. In the emission spectrum for hydrogen, what color is the n = 5 to n = 2 electronic transition?

$$\lambda = \frac{hc}{E} = \frac{6.626 \times 10^{-34} J \cdot s (2.998 \times 10^8 m/s)}{4.574 \times 10^{-19} J} = 4.34 \times 10^{-7} m$$

- a) red b) orange c) yellow d) green e) violet

From figure, $\lambda = 4.34 \times 10^{-7} m$ is violet or blue-violet light. Only violet light listed as an answer.

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4. Consider the compound butane, which has a formula of C₄H₁₀. If a sample of butane contains 2.59 × 10²³ atoms of hydrogen, what mass of butane is present?

$$\text{molar mass } C_4H_{10} = 4(12.01) + 10(1.008) = 58.12g/mol$$

- a) 25.0 g b) 6.25 g c) 5.00 g
d) 1.25 g e) 2.50 g

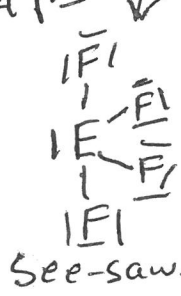
$$2.59 \times 10^{23} \text{ atoms H} \left(\frac{1 \text{ mol H}}{6.022 \times 10^{23} \text{ atoms H}} \right) \left(\frac{1 \text{ mol } C_4H_{10}}{10 \text{ mol H}} \right) \left(\frac{58.12g}{\text{mol } C_4H_{10}} \right) = 2.50g C_4H_{10}$$

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5. An unknown element E forms a covalent compound with fluorine having the formula EF₄. The shape of the EF₄ molecule is see-saw. Which of the following elements could be E? The see-saw shape has 34 valence electrons.

- a) O b) N c) Se d) P e) I

$$34 e^- = x + 4(7), x = 6 = \text{valence electrons of the unknown element E.}$$



E is a group 6 element. But EF₄ has 10e⁻ around central E atom. E can't be O since row 2 elements never have more than 8e⁻ around it. Must be Se.

Radius trend works for neutral atoms, but not for ions. From trend, I is bigger than F. Te^- is isoelectronic with I. Since Te^- has fewer proton in the nucleus, Te^- is bigger than I. Ne^+ is isoelectronic with F. Since F has 1 fewer proton in the nucleus, F is bigger than Ne^+ .

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 1/25

6. Place the following atoms/ions in order of decreasing size (largest to smallest).

F, Te^- , I, Ne^+

- Putting this all together gives an order of $Te^- > I > F > Ne^+$
- a) $Te^- > I > F > Ne^+$ b) $F > Te^- > I > Ne^+$ c) $I > Te^- > F > Ne^+$
 d) $Te^- > F > Ne^+ > I$ e) $Ne^+ > F > Te^- > I$

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7. Which of the following ground state electron configurations is associated with the atom having the largest ionization energy?

From IE trend, expect O to have the largest IE value.

- a) $[Ne]3s^23p^2 = Si$ b) $[Ne]3s^23p^3 = P$ c) $[He]2s^22p^4 = O$

But there is a decrease in ionization energy when going from N to O. So N has largest IE value.

8. The ground state electron configuration for an atom or ion has 2 electrons in the $n=1$ orbital, 8 electrons in $n=2$ orbitals, 18 electrons in $n=3$ orbitals, and 12 electrons in $n=4$ orbitals. Which of the following could be this atom or ion?

electrons = $2 + 8 + 18 + 12 = 40 e^-$. Answers a, b, and c have 40 electrons.

- a) $Zr, 40e^-$ b) $Mo^{2+}, 40e^-$ c) $Sr^{2+}, 40e^-$ d) $Cd, 48e^-$ e) $Pd^{2+}, 48e^-$

Draw the Lewis structure for ICl_5 . How many of the following four statements (I-IV) is/are true regarding ICl_5 ?

$ICl_5: 6(7) = 42$ electrons. $Mo^{2+}: 1s^2 2s^2 2p^6 3s^2 3p^6 4s^2 3d^{10} 4p^6 5s^0 4d^4$

- I. The central atom in ICl_5 has one lone pair of electrons.
 II. Some of the Cl-I-Cl bond angles are approximately 90° . - has octahedral geometry
 III. ICl_5 is polar. - not symmetric; bond dipoles do not all cancel each other out.
 IV. The shape of ICl_5 is square pyramid.

- a) 0 (None are true.) b) 1 c) 2 d) 3 e) 4 (All are true.)

$\bar{O} = C = \bar{O}$, $[\bar{O} = N = \bar{O}]^+$ both CO_2 and NO_2^+ have 2 other resonance structures. But the average bond is a double bond to central atom.

10. A compound or ion has delocalized π electrons resulting in equivalent bonds to oxygen. All of the bonds in this compound or ion are stronger than single bonds yet are significantly weaker than double bonds. Which of the following could be this compound or ion?

- a) CO_2 b) NO_2^+ c) SO_3^{2-} d) NO_3^- e) XeO_3

10/24
 5/29

XeO_3 and SO_3^{2-} are both composed of only single bonds. NO_3^- has 3 resonance structures. Average bond is $(2 + 1 + 1)/3 = 4/3$ or $1\frac{1}{3}$ bond. This fits the data in the problem.

11. Which of the following statements is **false**?

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22/5

- a) When a metal reacts with a nonmetal, an ionic compound is generally produced.
- b) Nonmetals generally form anions when reacted with a metal to form a compound.
- c) Alkaline earth metals generally form stable +2 charged ions when in ionic compounds.
- d) Transition metals generally gain electrons to form stable ions when in ionic compounds. *Metals lose electrons to form cations when in ionic compounds.*
- e) When two nonmetals react with each other, a covalent compound is generally produced.

12. The most stable ion of a certain isotope contains 15 protons and has a mass number of 33. Which of the following statements (a-d) about this ion is **true**? Note: the most stable ion is the ion that forms when this isotope is in an ionic compound.

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- Phosphorus has 15 protons. P forms P^{3-} ions in ionic compounds.*
- a) The net charge of the ion is -3. *Ion has $15 + 3 = 18$ electrons for 3- charge.*
 - b) The ion contains 10 electrons.
 - c) The ion contains 33 neutrons. *# neutrons = $33 - 15 = 18$ neutrons*
 - d) The ion is sulfur.
 - e) All of the above statements (a-d) are false.

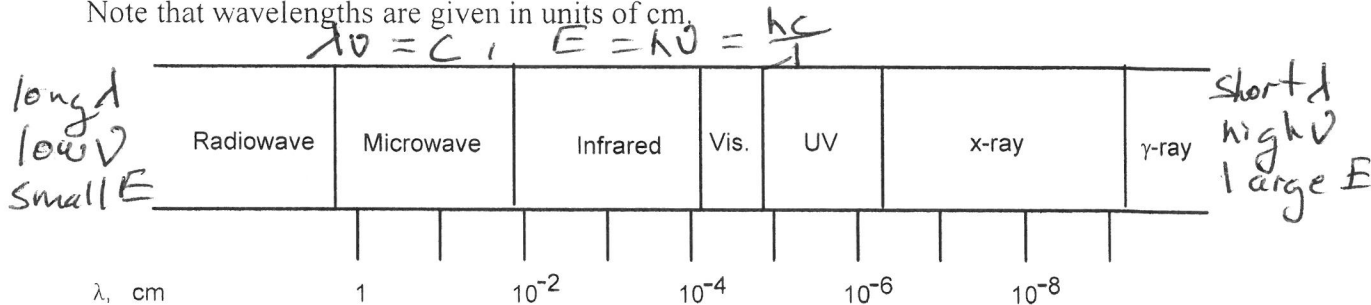
13. When the following calculation is performed, how many significant figures are in the correct answer? $1.00866 - 1.00776 = 0.00090$ ← *by subtraction rule, this is known to 2 sig figs*

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- (1.00866 - 1.00776) × (6.022 × 10²³)*
A 2 sig fig number multiplied by a 4 sig fig number
Answer known to 5 decimal places.
- a) 1 b) 2 c) 3 d) 4 e) 6
- gives a 2 sig fig answer by multiplication rule.*

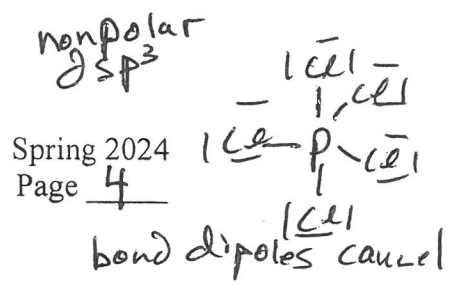
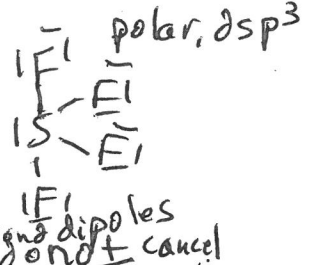
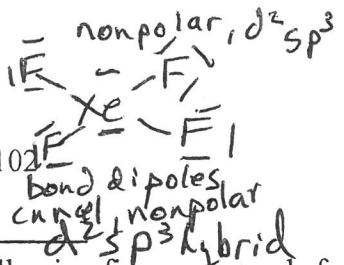
14. Which of the following statements (a-d) about the electromagnetic spectrum is **true**? Note that wavelengths are given in units of cm.

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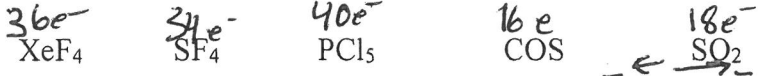


- a) Ultraviolet (UV) radiation has a ~~longer~~ *shorter* wavelength than visible (Vis.) radiation.
- b) The frequency of microwave radiation is ~~higher~~ *lower* than the frequency of visible (Vis.) radiation.
- c) Gamma (γ) ray radiation travels faster than radiowaves because it has a shorter wavelength. *Both travel at c, the speed of light.*
- d) A photon of x-ray radiation is more energetic than a photon of microwave radiation.
- e) None of the above statements (a-d) are true.

Form
A/B
C/D

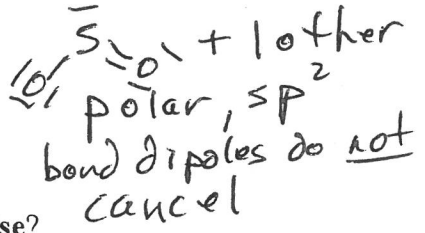


Consider the following five compounds for the next two questions.



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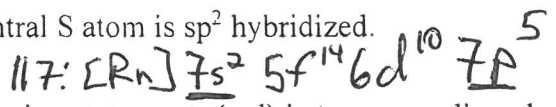
15. How many of these five compounds are polar?
 SF₄, COS, SO₂ are polar.
 a) 1 b) 2 c) 3 d) 4 e) 5 (All are polar.)



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16. Which of the following statements about these five compounds is false?

- F a) In XeF₄, the central Xe atom is sp^3 hybridized.
 T b) In SF₄, the central S atom is dsp^3 hybridized.
 T c) In PCl₅, the central P atom is dsp^3 hybridized.
 T d) In COS, the central C atom is sp hybridized.
 + e) In SO₂, the central S atom is sp^2 hybridized.



Element 117 is the next halogen under At.

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17. Which of the following statements (a-d) is true regarding element 117 (symbolized as X)?

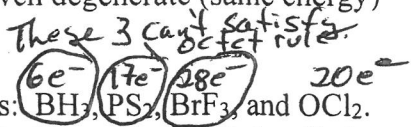
- F a) Element 117 would form a stable compound with potassium having the formula KX.
 F b) Element 117 has 2 unpaired electrons in the ground state.
 F c) Element 117 has one valence electron in the ground state.
 F d) Element 117 has 14 electrons in various f orbitals in the ground state.
 T e) None of the above statements (a-d) are true.

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7p
(1 unpaired electron)

From periodic table, 8s orbitals fill for elements 119+120. The 8s orbitals are higher in energy than the 6d orbitals.

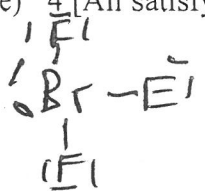
- F a) The periodic table predicts that the 8s atomic orbital will be lower in energy than the 6d atomic orbitals.
 T b) The quantum mechanical model assumes that the electron has wave properties.
 T c) The Heisenberg uncertainty principle implies that we cannot know the exact location of an electron in an atom.
 T d) DeBroglie hypothesized that all matter exhibits both particulate and wave properties.
 T e) The quantum mechanical model tells us that there are seven degenerate (same energy) 4f atomic orbitals.



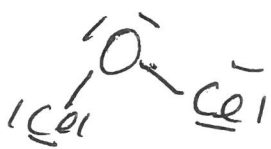
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19. Draw the Lewis structures for the following four compounds: BH₃, PS₂, BrF₃, and OCl₂. How many of these four compounds can satisfy the octet rule (duet rule for H) for all elements in the compound?

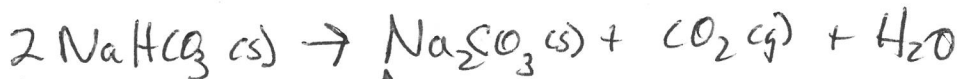
- a) 0 (none) b) 1 c) 2 d) 3 e) 4 [All satisfy the octet rule (duet rule for H)].



BrF₃ can't satisfy octet rule.



OCl₂ can satisfy octet rule.



2:1 mol ratio between NaHCO_3 and Na_2CO_3

20/7
 26/1

20. When heated, baking soda (commonly called sodium bicarbonate) reacts to form solid sodium carbonate, carbon dioxide gas and water vapor. How many moles of sodium carbonate are produced for every 2.0 moles of sodium bicarbonate that are reacted? Assume the only reactant is sodium bicarbonate. (HCO_3^- is the bicarbonate ion formula.)

- a) 1.0 mol sodium carbonate
- b) 1.5 mol sodium carbonate
- c) 2.0 mol sodium carbonate
- d) 2.5 mol sodium carbonate
- e) 3.0 mol sodium carbonate

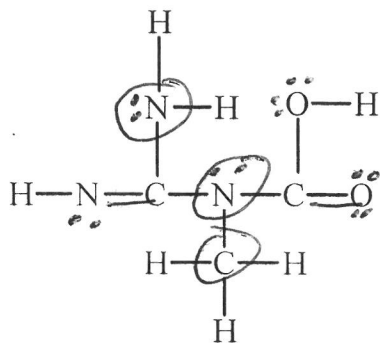
From balanced reaction, 1.0 mol Na_2CO_3 is produced for every 2 mol NaHCO_3 reacted.

21/8
 27/2

21. Which of the following statements (a-c) is/are true?

- Positive charge in tiny dense nucleus.
- a) The positive charge in an atom is uniformly distributed throughout the atom.
 - b) In a neutral atom, the atomic number equals the number of electrons in the atom.
 - c) Most of the mass of an atom is due to the electrons.
 - d) Statements b and c are both true.
 - e) None of the statements (a-c) are true.
- # protons = # of electrons for neutral atom.*
protons and neutrons.

Creatine is an organic compound important to the building of muscle tissue in the body. The skeletal structure of creatine is below. Complete the Lewis structure and answer the next two questions.



Organic Rules

C: 4 bonds + 0 lone pairs
 N: 3 bonds + 1 " "
 O: 2 bonds + 2 " "

The circled N and C atoms all have tetrahedral

22/9
 28/3

22. How many of the carbon and nitrogen atoms exhibit approximately 109° geometry with 109° bond angles.

- a) 0
- b) 1
- c) 2
- d) 3
- e) 4

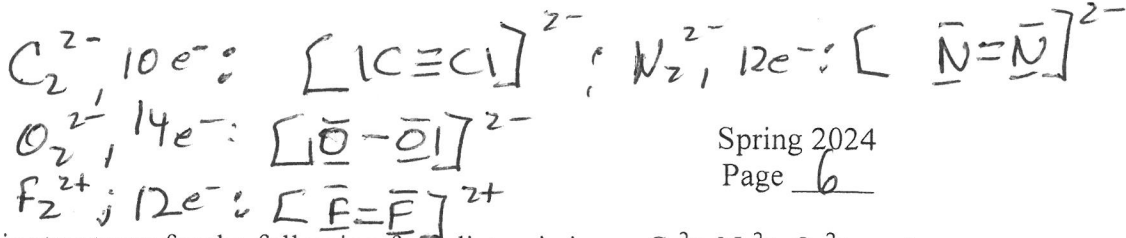
The other C and N atoms are trigonal planar with 120° bond angles.

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23. How many double bonds are in the completed Lewis structure?

- a) 0
- b) 1
- c) 2
- d) 3
- e) 4

See above Lewis structure. Has 2 double bonds.



24/11
11/14

24. Draw the Lewis structures for the following four diatomic ions: C_2^{2-} , N_2^{2-} , O_2^{2-} , and F_2^{2+} . How many of these four diatomic ions must have a double or triple bond in order to satisfy the octet rule? C_2^{2-} , N_2^{2-} , and F_2^{2+} all have a double or triple bond. F_2^{2+} is a singly bonded species.

- a) 0 (none) b) 1 c) 2 **d) 3**
 e) 4 (All of these ions must have a double or triple bond in order to satisfy the octet rule.)

Br and Rb^{2+} both have 35e⁻. But Rb^{2+} has 37 protons in the nucleus, while Br only has 35 protons. Rb^{2+} nucleus attracts the 35e⁻ more strongly, so Rb^{2+} will be smaller than Br.

25/12
12/15

25. Which of the following statements is true concerning atoms of bromine?

- T** a) Br should have a larger radius (larger size) than Rb^{2+} .
 F b) Br should have a smaller ionization energy than Br^{2-} .
 F c) Br should have a larger electronegativity value than Ba (element #56).
 F d) Br should have a smaller radius (smaller size) than Br^{2+} .
 F e) Br should have a larger ionization energy than Ne.

Apply IE trend → IE trend → EN trend

26/3
13/16

26. Which of the following bonds to selenium should be the most pure (nonpolar) covalent bond? Ga and In are metals, so expect Se-Ga and Se-In to be most ionic. From EN trend, Ce has an obviously larger EN value than Se, so Se-Ce will be a polar covalent bond. The trends are opposite each other going from Se-I, so I should have an EN value close to Se, so Se-I bond is most pure covalent.

- a) Se-Ga b) Se-Cl **c) Se-I** d) Se-In

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27. A pure substance that can be broken down into other substances by chemical change is classified as a(n):

- a) mixture b) element c) phase d) solution **e) compound**

28/5
15/18

28. Sarin is a nerve gas whose chemical formula has 2 atoms of oxygen for each molecule of sarin. If 50.0 g of sarin contains 11.4 g of oxygen, calculate the molar mass of sarin.

mol Sarin = $11.4 \text{ g O} \left(\frac{1 \text{ mol O}}{16.00 \text{ g O}} \right) \left(\frac{1 \text{ mol Sarin}}{2 \text{ mol O}} \right) = 0.35625 \text{ mol Sarin in } 50.0 \text{ g Sarin.}$

- a) 280. g/mol b) 35.0 g/mol c) 70. g/mol
 d) 210. g/mol **e) 140. g/mol**
 Molar mass Sarin = $\frac{50.0 \text{ g}}{0.35625 \text{ mol}} = 140. \text{ g/mol}$

29/6
16/19

29. How many of the following four compounds is/are named correctly?

- OK $MgCO_3$, magnesium carbonate
 NO P_2O_5 , phosphorus oxide diphosphorus pentoxide is correct name for this covalent compound
 NO $Co(ClO_2)_3$, cobalt(VI) perchlorate
 OK HNO_3 , nitric acid
 $ClO_2^- = \text{chlorite ion}, ClO_4^- = \text{perchlorate ion}$

- a) 0 (none) b) 1 **c) 2** d) 3 e) 4 (All are correctly named.)

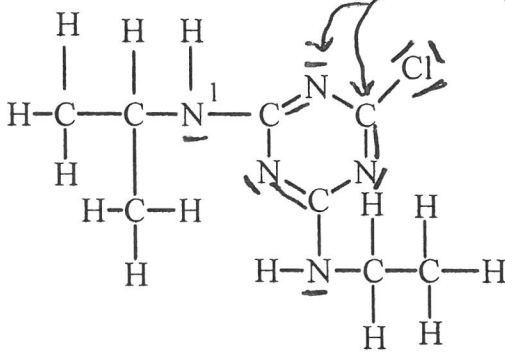
→ cobalt(III) chlorite is correct name for $Co(ClO_2)_3$.

All single bonds are sigma bonds. All double bonds are 1 sigma and 1 pi bond. Apply Lewis structure rules to complete Lewis structure.

30/30
30/30

A widely used herbicide is atrazine, $C_8N_5ClH_{14}$, whose skeletal structure is shown below. Complete a Lewis structure for this organic compound.

28 sigma bonds
+
3 pi bonds



The six C and N atoms in ring exhibit 120° bond angles (trigonal planar geometry), so all are sp^2 hybridized. The other C and N atoms have 109° bond angles (tetrahedral geometry), so they are sp^3 hybridized.

Which of the following statements concerning the Lewis structure for atrazine is false?

- T a) There are no 180° bond angles, so no sp hybrids.
- b) Atrazine has zero atoms which are sp hybridized. *6 of the six C and N atoms in ring are all sp^2 hybridized, eight of the carbon and nitrogen atoms in atrazine have at least one unhybridized p atomic orbital. so there are 6 unhybridized p atomic orbitals.*
- + c) There are 28 sigma (σ) bonds and 3 pi (π) bonds in the Lewis structure. *The other C and N atoms do not have unhybridized p orbitals since they are sp^3 hybridized.*
- T d) The nitrogen atom labeled 1 is sp^3 hybridized. *Exhibits tetrahedral 109° bond angles, so sp^3 hybridized.*
- T e) All the carbon-hydrogen bonds in atrazine are formed from overlap of sp^3 hybrid orbitals from carbon with $1s$ orbitals from hydrogen. *All C and N atoms with H bonded to them exhibit 109° bond angles, so they are sp^3 hybridized. H always uses $1s$ orbitals to form sigma bonds.*

31/31
31/31

31. Which of the following statements about hybrid orbitals is true?
- F a) Valence atomic orbitals always combine with inner core atomic orbitals to produce hybrid orbitals. *we hybridize atomic orbitals to explain 109° and 120° bond angles.*
 - F b) The orientation in space of the hybrid orbitals is identical to the orientation in space of the atomic orbitals from which they are formed.
 - c) An sp^2 hybrid orbital from one atom can overlap to form a bond with an sp^3 hybrid orbital from another atom.
 - F d) Overlap of hybrid orbitals form π bonds. *unhybridized atomic orbitals*
 - F e) Atoms which are sp^2 hybridized form 2 pi bonds. *sp^2 hybrid atoms have only 1 unhybridized p atomic orbital, so can only form 1 π bond.*
32. My answers for this Chemistry 102 exam should be graded with the answer sheet associated with:

- a) Form A b) Form B c) Form C d) Form D e) Form E

See the ring carbon bonded to N_1 in the structure above. This sigma bond is formed from an sp^2 hybrid orbital from the carbon with an sp^3 hybrid from N_1 .