1																	18
1 H 1.008	2											13	14	15	16	17	2 He 4.003
3 Li 6.941	4 Be 9.012											5 B 10.81	6 C 12.01	7 N 14.01	8 O 16.00	9 F 19.00	10 Ne 20.18
11 Na 22.99	12 Mg 24.31	3	4	5	6	7	8	9	10	11	12	13 Al 26.98	14 Si 28.09	15 P 30.97	16 S 32.07	17 Cl 35.45	18 Ar 39.95
19 K 39.10	20 Ca 40.08	21 Sc 44.96	22 Ti 47.87	23 V 50.94	24 Cr 52.00	25 Mn 54.94	26 Fe 55.85	27 Co 58.93	28 Ni 58.69	29 Cu 63.55	30 Zn 65.38	31 Ga 69.72	32 Ge 72.64	33 As 74.92	34 Se 78.96	35 Br 79.90	36 Kr 83.80
37 Rb 85.47	38 Sr 87.62	39 Y 88.91	40 Zr 91.22	41 Nb 92.91	42 Mo 95.94	43 Tc (98)	44 Ru 101.07	45 Rh 102.91	46 Pd 106.42	47 Ag 107.87	48 Cd 112.41	49 In 114.82	50 Sn 118.71	51 Sb 121.76	52 Te 127.60	53 I 126.90	54 Xe 131.29
55 Cs 132.91	56 Ba 137.33	57 La 138.91	72 Hf 178.49	73 Ta 180.95	74 W 183.84	75 Re 186.21	76 Os 190.23	77 Ir 192.22	78 Pt 195.08	79 Au 196.97	80 Hg 200.59	81 Tl 204.38	82 Pb 207.20	83 Bi 208.98	84 Po (209)	85 At (210)	86 Rn (222)
87 Fr (223)	88 Ra (226)	89 Ac (227)	104 Rf (267)	105 Db (268)	106 Sg (269)	107 Bh (270)	108 Hs (270)	109 Mt (278)	110 Ds (281)	111 Rg (282)	112 Cn (285)	113 Nh (286)	114 Fl (289)	115 Mc (290)	116 Lv (293)	117 Ts (294)	118 Og (294)

58 Ce 140.12	59 Pr 140.91	60 Nd 144.24	61 Pm (145)	62 Sm 150.36	63 Eu 151.96	64 Gd 157.25	65 Tb 158.93	66 Dy 162.50	67 Ho 164.93	68 Er 167.26	69 Tm 168.93	70 Yb 173.04	71 Lu 174.97
90 Th 232.04	91 Pa 231.04	92 U 238.03	93 Np (237)	94 Pu (244)	95 Am (243)	96 Cm (247)	97 Bk (247)	98 Cf (251)	99 Es (252)	100 Fm (257)	101 Md (258)	102 No (259)	103 Lr (266)

This exam should have exactly 20 questions. Each question is equally weighted at 5 points each. Bubble in your answer choices on the bubblehseet provided. Your score is based on what you bubble on the bubblesheet and not what is circled on the exam.

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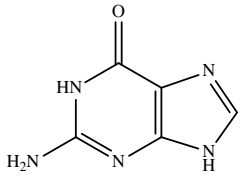
1. What is the chemical formula for the following molecule?



- a. $C_5H_5N_5O$
- b. $C_4H_2N_4O$
- c. $C_5H_2N_3O$
- d. $C_7H_2N_4O$
- e. $C_7H_6N_4O$

Explanation: Count the carbons, nitrogen, oxygen and hydrogen. There is only one implied hydrogen. This gives: $C_5H_5N_5O$

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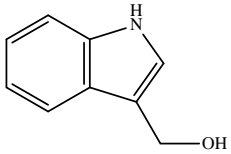
2. (Part 1 of 2) Consider the structure of indole-3-carbinol, an ingredient in brocolli that contributes to its nutritional value, for the next two questions.



What is the chemical formula for indole-3-carbinol?

- a. $C_{10}H_9NO$
- b. C_9H_9NO
- c. C_9H_7NO
- d. $C_{10}H_7NO$
- e. C_9H_2NO

Explanation: Count the carbons, nitrogen, oxygen and hydrogen. Use the octet of carbon to count the implied hydrogens. This gives: C_9H_9NO

---

3. (Part 2 of 2) Refer again to the previous structure of indole-3-carbinol. How many total lone pairs exist on this structure? (even though they aren't shown)

- a. 0
- b. 1
- c. 3
- d. 2
- e. 6

Explanation: There is one nitrogen that needs one lone pair and one oxygen that needs two lone pairs, for a total of three added lone pairs.

---

4. Which substance contains polar covalent bonds?

- a. CH_2F_2
- b. NaF
- c. CsCl
- d. Cl_2
- e. Br_2

Explanation: The only polar covalent molecule listed here is CH_2F_2. The CsCl and the NaF are both ionic compounds.

---

5. Select the series of possible bond orders that reflects increasing bond strengths.

- a. 1, 3, 2
- b. 1, 2, 1.5, 3
- c. 1, 1.5, 1.33, 2
- d. 1, 1.33, 1.5, 2
- e. 3, 2, 1
- f. 2, 1.5, 1

Explanation: Bond strength is proportional to bond order. Fractional bond orders do occur in molecules with resonant line structures. Only the correct answer is ordered from a smallest to a largest number.

---

6. How many lone pairs are in the molecule with the formula $HOCH_2NH_2$?

a. 0

b. 1

c. 2

●d. 3

e. 4

Explanation: The oxygen has two lone pairs and the nitrogen has one lone pair.

---

7. Carbon dioxide has a carbon-oxygen double bond. Carbon monoxide has a carbon-oxygen triple bond. Which of the following statements is true?

a. the bonds in carbon monoxide are weaker and shorter than the bonds in carbon dioxide

●b. the bonds in carbon monoxide are stronger and shorter than the bonds in carbon dioxide

c. the bonds in carbon monoxide are weaker and longer than the bonds in carbon dioxide

d. the bonds in carbon monoxide are stronger and longer than the bonds in carbon dioxide

Explanation: A triple bond is stronger and shorter than a double bond.

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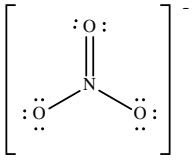
8. What is the formal charge on nitrogen for the nitrate resonance structure shown below?



●a. +1

b. 0

c. -1

d. +3

e. +5

f. -3

Explanation: FC = valence electrons - (bonds + lone pair electrons)

+1 = 5 - 4

---

9. Which of the following best describes the bonds in the hybrid resonance structure for nitrite, NO_2^-?

a. a single N-O bond and a double N-O bond resonating back and forth

b. two N-O single bonds

●c. two N-O 1.5 bonds

d. a single N-O bond and a double O-O bond resonating back and forth

Explanation: NO_2^- is a resonant structure consisting of N-O bonds that have an average 1.5 bond order.

---

10. What is the molecular geometry for NCl_3?

a. T-shape

●b. trigonal pyramid

c. tetrahedral

d. trigonal planar

e. octahedral

Explanation: The nitrogen will have three bonds and one lone pair. This will be a trigonal pyramidal molecular geometry.

---

11. Draw ozone and then determine which of the following statements is/are true.

I. ozone has a trigonal planar electronic geometry

II. the bond angles in ozone are approximately 109.5°

III. the bonds in ozone are weaker than the bond angles in diatomic oxygen

IV. ozone has a bent molecular geometry

a. I, II, III, and IV

b. I and IV

c. I, II, and IV

d. I and III

●e. I, III, and IV

Explanation: The ozone molecule is a resonant structure with a bond order equal to about 1.5, which will result in weaker bonds than oxygen. The structure has a trigonal planar electronic geometry and a bent molecular geometry. The bond angles are slightly less than 120°.

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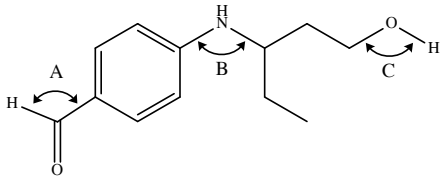
12. What are the bond angles at positions labeled A, B, and C (in that order)?



- a. 120°, 107°, 104.5°
- b. 120°, 109.5°, 109.5°
- c. 107°, 109.5°, 90°
- d. 120°, 120°, 120°
- e. 109.5°, 120°, 178°

Explanation: The aldehyde at position A has 3 areas of electron density and no lone pairs, creating a trigonal planar shape with bond angles of 120. The amine at position B has a core tetrahedral electronic geometry around the nitrogen, with 3 bonds and 1 (implied) lone pair. The lone pair squeezes the remaining bond angles to slightly less than 109.5 - meaning we tweak the angle down to 107. Last, the oxygen at position C has two lone pairs as well as the bonds to the carbon and hydrogen atoms. The core tetrahedral geometry is tweaked by the two lone pairs so that the final bent configuration of the C-O-H bond is a double tweak resulting in 104.5.

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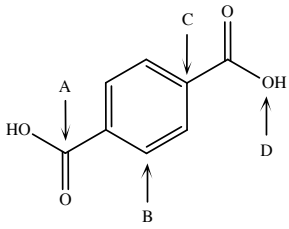
13. Which arrow(s) is/are pointing to a central atom with a trigonal planar molecular geometry?



- a. A, B, and C only
- b. A and C only
- c. A and B only
- d. A, B, C, and D
- e. B and C only

Explanation: When you account for implied hydrogens where necessary, you will see that arrows A, B, and C point to trigonal planar geometries.

---

14. A molecule has three bonds and three lone pairs. What is the molecular geometry?

- a. see-saw
- b. trigonal pyramid
- c. T-shape
- d. trigonal planar
- e. octahedral

Explanation: This will be a T-shaped molecular geometry because it is AX_3E_3 which is octahedral electronic geometry with 3 positions removed (lone pairs).

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15. A molecule has four bonds and one lone pair. What are the electronic and molecular geometries, respectively?

- a. trigonal bipyramidal, seesaw
- b. square pyramidal, seesaw
- c. seesaw, trigonal bipyramidal
- d. seesaw, square pyramidal
- e. trigonal planar, tetrahedral

Explanation: A molecule with five total areas of electron density assumes a trigonal bipyramidal electronic geometry. If only one area is a lone pair, you have AX_4E which leaves 4 bonded atoms in a see-saw molecular geometry. The 1 lone pair occupies an equatorial position (allowing maximal bond angles between the lone pair and the adjacent areas of electron density)

Note that Question now has TWO correct answers

16. What is the product of the ozone-depleting mechanism that allows one chlorine atom to destroy around 100,000 ozone molecules in the stratosphere?

- a. a chlorine radical ← on the KEY
- b. oxygen gas ← also counted correct
- c. ozone
- d. chlorine gas

Explanation: The chlorine radical is a catalyst for the depletion of ozone. It is both a reactant and a product of the ozone-depleting mechanism. AND... more so, oxygen gas is a product, it is what ozone is converted to.

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17. Why are HFCs, the newest refrigerants in use, considered unsustainable?

a. HFCs are cooling down the ozone layer.

b. HFCs are rapidly depleting the ozone layer.

● c. HFCs are potent greenhouse gases.

d. HFCs emit UV radiation.

Explanation: The current concern with HFCs is that they are potent greenhouse gases, even though they do not negatively impact the ozone layer like HCFCs and CFCs.

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18. Which of the following is a reason why greenhouse gases are important to our ecosystems?

● a. Without greenhouse gases, global temperatures would average around -15° C.

b. The planet would be much warmer without greenhouse gases.

c. Greenhouse gases account for the majority of our atmosphere.

d. Greenhouse gases absorb about 99% of the total radiation from the sun.

Explanation: Greenhouse gases make up a minuscule fraction of our atmosphere, but without them, global temperatures would be much colder.

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19. Chlorofluorocarbon (CFC) use as refrigerants has impacted the environment because they...

a. rapidly cooled down the air due to their thermal properties.

b. inadvertently caused an increase in carbon monoxide which is a toxic pollutant.

c. were toxic when inhaled in small quantities.

● d. provided the source of the catalyst that causes ozone depletion.

e. depleted ozone at ground level via direct reaction.

Explanation: CFC use has impacted the environment because they produce chlorine atoms which act as catalysts in ozone depletion.

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20. Which of the following molecules can readily absorb IR radiation?

I. Ar

II. O_2

III. CO_2

IV. CH_2F_2

a. I, II, III, and IV

b. I and IV

c. I, II, and IV

d. I and III

● e. III and IV

Explanation: Carbon dioxide and HFCs are greenhouse gases capable of absorbing IR radiation.

Remember to bubble in ALL your answers BEFORE time is called. Double check your name, uteid, and version number before you turn in your bubblesheet. You must keep your exam for future reference. Please do not lose it. We will not replace it.