

FORM "A"

This exam is made up of an answer sheet, two cover sheets and 8 numbered pages. Below are instructions for coding the answer sheet. The last page of this exam contains some useful equations and constants, plus the periodic table.

On the answer sheet:

1. **Use #2 pencil. Erase cleanly.**
2. Print your **NAME** in the appropriate designated spaces, then blacken in the letter boxes below each printed letter, last name first, then your first name initial.
3. Fill in your university **ID** number under **STUDENT NUMBER**.
4. Under **SECTION** write the five digit number that corresponds to your section designation, and then blacken in the corresponding number of boxes. **For 102B students**, the numbers are: BQ2 = 00012, BQ3 = 00013, BQ4 = 00014, BQ6 = 00016, BQ7 = 00017, BQ8 = 00018, BQA = 00021, BQB = 00022, BQC = 00023, BQD = 00024, BQG = 00027, BQH = 00028, BQI = 00029. **For 102C students**, the numbers are: CQ1 = 00031, CQ2 = 00032, CQ3 = 00033, CQ4 = 00034, CQ5 = 00035, CQ6 = 00036, CQ7 = 00037, CQ8 = 00038, CQ9 = 00039, CQA = 00041, CQB = 00042, CQC = 00043, CQE = 00045
5. Under **NETWORK ID** print your University Network ID beginning on the left hand side with box #1, and then blacken in the corresponding letters, numbers and/or dashes under each character. Do not fill in a character for any unused boxes.
6. Under **TEST FORM** blacken the letter corresponding to the form designated on the upper left hand corner of the exam booklet.
7. Your TA's name should be printed for **INSTRUCTOR** and write your section number for **SECTION** in the lines provided.
8. **Sign** your name (do not print) on the line provided. Print your name underneath it.
9. **Mark** only one answer per question and do not use the answer sheet for scratch paper or make any stray marks on it. Erase cleanly if you wish to change an answer. The exam itself can be used for scratch paper.

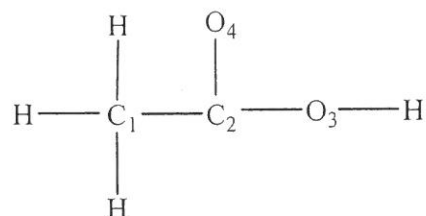
Work carefully and efficiently. If your answer differs from one given in the last proper significant figure, mark that answer as correct and not the response "none of these". All questions are worth the same.

1. Draw a Lewis structure for ozone, O_3 . Which of the following statements regarding O_3 is **false**?
- a) A total of three resonance structures can be drawn for O_3 .
 - b) All of the oxygen-oxygen bonds in O_3 are equivalent in length and strength.
 - c) The central oxygen atom in O_3 is sp^2 hybridized.
 - d) The electrons in the π bond(s) in O_3 are delocalized over the entire surface of the molecule.
 - e) The bond angle in O_3 is approximately 120° .

2. How many of the following five elements has/have one (1) unpaired electron in the ground state?

Rb, Sc, Cu, Ga, I

- a) 1 b) 2 c) 3 d) 4 e) 5 (All have one unpaired electron.)
3. Acetic acid is an organic compound with the following skeletal structure.

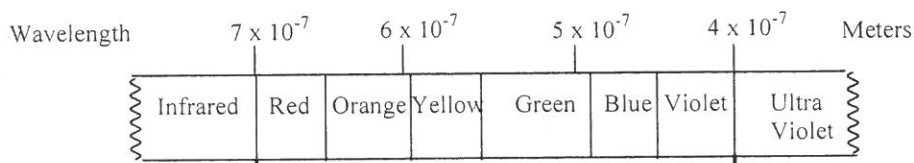


Complete the Lewis structure for acetic acid. Which of the following statements concerning acetic acid is **false**?

- a) There is one π bond in acetic acid.
 - b) The oxygen atom labeled 3 (O_3) is sp hybridized.
 - c) The carbon-carbon bond is formed from overlap of an sp^3 hybrid orbital on C_1 with an sp^2 hybrid orbital on C_2 .
 - d) There are seven sigma bonds in acetic acid.
 - e) C_2 uses an unhybridized p atomic orbital to form one of the bonds to the oxygen atom labeled 4 (O_4).
4. Bismuth aluminate ($Al_6Bi_2O_{12}$) is a medication used to treat upset stomachs. If 0.500 g of bismuth aluminate is digested, calculate the mass of bismuth consumed. Bi is element #83.
- a) 0.500 g b) 0.271 g c) 0.367 g d) 0.135 g e) 0.162 g

5. A 97-g sample of caffeine contains 3.01×10^{23} molecules of caffeine. If a typical 10-hour energy drink contains 420 mg of caffeine, how many moles of caffeine are present in the drink?
- a) 1.1×10^{-3} mol b) 4.4 mol c) 1.1 mol d) 8.8 mol e) 2.2×10^{-3} mol
6. When molten sulfur reacts with chlorine gas, a vile smelling orange liquid forms. The formula of the compound is either SCl or S₂Cl₂. Which of the following Lewis structures could be the correct structure for this compound?
- a) $\text{:}\ddot{\text{S}}\text{---}\ddot{\text{Cl}}\text{:}$ b) $\text{:}\ddot{\text{Cl}}\text{---}\ddot{\text{S}}\text{=}\ddot{\text{S}}\text{---}\ddot{\text{Cl}}\text{:}$ c) $\ddot{\text{S}}\text{=}\ddot{\text{Cl}}\text{---}\ddot{\text{Cl}}\text{=}\ddot{\text{S}}$
- d) $\ddot{\text{S}}\text{=}\ddot{\text{Cl}}$ e) $\text{:}\ddot{\text{Cl}}\text{---}\ddot{\text{S}}\text{---}\ddot{\text{S}}\text{---}\ddot{\text{Cl}}\text{:}$

Use the following figure to answer the next two questions:



7. In the fireworks industry, strontium is used to produce red colors, while barium is used to produce green colors. Which of the following is **true** concerning the electronic transitions associated with these two colors?
- a) Strontium emits a photon of electromagnetic radiation having a higher frequency than barium.
- b) Barium emits a photon of electromagnetic radiation having a larger energy than strontium.
- c) Strontium emits a photon of electromagnetic radiation having a faster velocity than barium.
- d) Barium emits a photon of electromagnetic radiation having a longer wavelength than strontium.
8. One of the visible lines in a hydrogen emission spectrum corresponds to the $n = 3$ to $n = 2$ electronic transition. Using the figure above, what color light is this transition?
- a) reddish-orange b) yellowish-green c) green d) blueish-green e) violet

9. Assuming 100 is an exact number in the following mathematical expression, what is the answer to the following percent calculation expressed to the correct number of significant figures?

$$\frac{8.9250 - 8.905}{8.9250} \times 100$$

- a) 0.2% b) 0.22% c) 0.224% d) 0.2241% e) 0.22409%
10. Consider the combustion reaction of ethanol, $\text{CH}_3\text{CH}_2\text{OH}$, an organic compound. How many moles of oxygen gas are required to react completely with one mole of ethanol? Hint: balance the equation.
- a) 7.0 mol b) 3.5 mol c) 2.5 mol d) 3.0 mol e) 6.0 mol
11. How many of the following four compounds have at least one atom in the Lewis structure that **must** violate the octet rule?



- a) 0 b) 1 c) 2 d) 3
- e) 4 (All must violate the octet rule for at least one atom in the Lewis structures.)
12. In how many of the following bonds is the bond dipole correctly indicated?
- $\begin{array}{ccccc} \delta+ & \delta- & \delta+ & \delta- & \delta+ & \delta- & \delta+ & \delta- & \delta+ & \delta- \\ \text{H} & \text{---} & \text{Cl} & \text{---} & \text{I} & \text{---} & \text{Br} & \text{---} & \text{Br} & \text{---} & \text{Si} & \text{---} & \text{S} & \text{---} & \text{P} & \text{---} & \text{O} \end{array}$
- a) 1 b) 2 c) 3 d) 4 e) 5 (All are correct.)
13. Which of the following compounds has the largest molar mass?

- a) ammonium chloride
b) iron(III) phosphate
c) potassium nitrate
d) carbon tetrachloride
e) water

14. Identify the ion which has 31 neutrons, a 2+ net charge, and has 26 electrons.
- a) $^{57}_{28}\text{Ni}^{2+}$ b) $^{57}_{31}\text{Ga}^{2+}$ c) $^{59}_{31}\text{Ga}^{2+}$ d) $^{59}_{28}\text{Ni}^{2+}$ e) $^{55}_{24}\text{Cr}^{2+}$
15. Consider the following sets of consecutive ionization energies (in some hypothetical units) for two unknown elements, X and Y (I.E. = ionization energy).

	X	Y
1 st I.E.	1100	800
2 nd I.E.	1900	1600
3 rd I.E.	2900	3200
4 th I.E.	5000	4400
5 th I.E.	6300	16,000
6 th I.E.	21,000	20,000
7 th I.E.	29,000	25,000

Which of the following could be these two elements, X and Y?

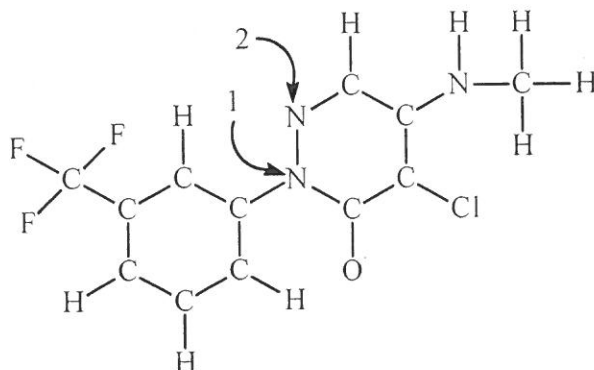
- a) X = C, Y = Ge b) X = P, Y = Si c) X = B, Y = Be
- d) X = Mg, Y = Al e) X = O, Y = F
16. Which of the following statements is **false**?
- a) NH_4NO_3 , a component of fertilizers, is an example of an ionic compound.
- b) CaCl_2 , a salt used to help melt ice in the winter time, contains an alkaline earth metal cation and halogen anions.
- c) $\text{HC}_2\text{H}_3\text{O}_2$, a component of vinegar, is an acid.
- d) C_3H_8 , a component of natural gas, is an example of a covalent compound.
- e) N_2O , commonly known as laughing gas, is composed of N^+ and O^{2-} ions.
17. Each of the following are examples of:
- Black coffee
Red table wine
Brass
- a) pure substances. b) heterogeneous mixtures. c) compounds.
- d) homogeneous mixtures. e) elements.

18. Which of the following molecules or ions has the **largest** bond angle?
- a) SF_2^{2-} b) SCl_3^+ c) PF_2^- d) SO_3 e) ClO_2^+
19. Which of the following statements is **false** concerning the Bohr model of the hydrogen atom?
- a) The model predicts that an electron can move from the $n = 2$ circular orbit to the $n = 7$ circular orbit by absorbing a photon of appropriate energy.
- b) The model predicts that an electron moving from the $n = 5$ to the $n = 1$ circular orbit moves closer to the nucleus.
- c) The model accurately predicts the existence of the s, p, d, and f atomic orbitals.
- d) According to the model, the energy emitted by an electron falling from the $n = 6$ energy level to the $n = 4$ energy level for hydrogen is given by the expression
$$\Delta E = -2.178 \times 10^{-18} \left(\frac{1}{4^2} - \frac{1}{6^2} \right).$$
- e) The model predicts that the energy of the photon absorbed to excite an electron from the $n = 2$ energy level to the $n = 5$ energy level is equal to the energy of the photon emitted when the electron moves from the $n = 5$ energy level back to the $n = 2$ energy level.

The next two questions concern the following series of elements: N, O, F, Mg

20. Which of the following correctly ranks these elements in order of **increasing** first ionization energy?
- a) $\text{F} < \text{O} < \text{N} < \text{Mg}$ b) $\text{Mg} < \text{O} < \text{N} < \text{F}$ c) $\text{N} < \text{O} < \text{F} < \text{Mg}$
- d) $\text{Mg} < \text{N} < \text{O} < \text{F}$ e) $\text{F} < \text{N} < \text{O} < \text{Mg}$
21. Now consider the ions these elements (N, O, F, Mg) are expected to form when in stable ionic compounds. Which of the following correctly ranks these **ions** in order of **increasing** atomic radius?
- a) $\text{F}^- < \text{N}^{3-} < \text{O}^{2-} < \text{Mg}^{2+}$ b) $\text{F}^- < \text{O}^{2-} < \text{N}^{3-} < \text{Mg}^{2+}$
- c) $\text{Mg}^{2+} < \text{O}^{2-} < \text{N}^{3-} < \text{F}^-$ d) $\text{Mg}^{2+} < \text{F}^- < \text{O}^{2-} < \text{N}^{3-}$
- e) $\text{N}^{3-} < \text{O}^{2-} < \text{F}^- < \text{Mg}^{2+}$

Norflurazon is an organic molecule that is an effective herbicide. Below is an incomplete Lewis structure for norflurazon. Using the guidelines covered in class regarding Lewis structures for organic compounds, complete a Lewis structure and answer the following two questions. Ignore any possible resonance structures.



22. How many sp^3 hybridized carbon and nitrogen atoms are in the completed Lewis structure?
- a) 2 b) 3 c) 4 d) 5 e) 6
23. What are the approximate bond angles as predicted by the VSEPR model about the nitrogen atom labeled 1 and the nitrogen atom labeled 2, respectively?
- a) 109° ; 120° b) 180° ; 90° c) 120° ; 90°
d) 120° ; 120° e) 109° ; 90°
-
24. Consider the ground state electron configurations for the following ions. Which ion has 19 electrons in various p atomic orbitals in the ground state?
- a) Sb^{2+} b) Kr^+ c) I^- d) I^{2-} e) Sr^-
25. When aluminum metal is heated with an element from Group 6A of the periodic table, an ionic compound forms. When the experiment is performed with an unknown Group 6A element, the product is 12.35% Al by mass. What is the formula of the compound?
- a) Al_2O_3 b) Al_2S_3 c) Al_2Se_3 d) Al_2Te_3 e) Al_3S_2

Draw Lewis structures for the following five compounds then answer the next two questions.



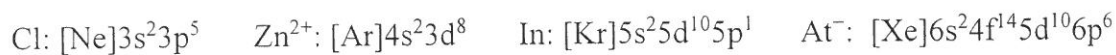
26. How many of the above five compounds are polar?

- a) 1 b) 2 c) 3 d) 4
e) 5 (All five of these compounds are polar.)

27. Which compound has a see-saw shape (molecular structure)?

- a) CS_2 b) SiBr_4 c) KrF_4
d) AsCl_5 e) SeI_4

28. How many of the following are **correct** ground state electron configurations for the atom or ion listed? Indium is element #49.



- a) 0 (None are correct.) b) 1 c) 2 d) 3
e) 4 (All four of these electron configurations are correct.)

29. Which of the following statements is **true**?

- a) Dalton proposed that the atom is mostly empty space.
b) Dalton discovered the electron.
c) Dalton was the first to theorize that atoms consist of smaller particles called electrons, protons, and neutrons.
d) Dalton disproved the plum pudding model of the atom by performing the alpha particle bombardment of metal foil experiment.
e) Dalton's atomic theory didn't account for isotopes.

30. By considering electrons to have wave properties, we can better explain:
- a) the existence of ionic bonds.
 - b) the idea of orbitals as probability distributions.
 - c) why water is a bent molecule.
 - d) the need for resonance structures when drawing some Lewis structures.
 - e) the rationale for balancing chemical equations.
31. How many of the following four molecules have two pi (π) bonds and two sigma (σ) bonds?
- HCN, CO₂, SO₂, C₂H₂ (H—C—C—H is the skeletal structure.)
- a) 0 b) 1 c) 2 d) 3
 - e) 4 (All of these molecules have two pi bonds and two sigma bonds.)
32. Which of the following is an endothermic process?
- a) A reaction where heat is produced.
 - b) Combustion of natural gas in a furnace.
 - c) Adding an electron to a noble gas.
 - d) The formation of an H₂ molecule from two H atoms.
 - e) A reaction with a negative ΔH (enthalpy change) value.
33. Which of the following bonds has the **most** ionic character?
- a) Be—F b) F—F c) H—F d) O—F e) N—F
34. 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

1 1A																18 8A	
1 H 1.008	2 2A											13 3A	14 4A	15 5A	16 6A	17 7A	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											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 47.90	23 V 50.94	24 Cr 52.00	25 Mn 54.94	26 Fe 55.85	27 Co 58.93	28 Ni 58.70	29 Cu 63.55	30 Zn 65.39	31 Ga 69.72	32 Ge 72.59	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 101.1	45 Rh 102.9	46 Pd 106.4	47 Ag 107.9	48 Cd 112.4	49 In 114.8	50 Sn 118.7	51 Sb 121.8	52 Te 127.6	53 I 126.9	54 Xe 131.3
55 Cs 132.9	56 Ba 137.3	57 La* 138.9	72 Hf 178.5	73 Ta 180.9	74 W 183.9	75 Re 186.2	76 Os 190.2	77 Ir 192.2	78 Pt 195.1	79 Au 197.0	80 Hg 200.6	81 Tl 204.4	82 Pb 207.2	83 Bi 209.0	84 Po 209	85 At 210	86 Rn 222
87 Fr 223	88 Ra 226	89 Ac† 227	104 Rf 261	105 Db 262	106 Sg 266	107 Bh 262	108 Hs 265	109 Mt 266	110 Ds 271	111	112						
*Lanthanides		58 Ce 140.1	59 Pr 140.9	60 Nd 144.2	61 Pm 145	62 Sm 150.4	63 Eu 152.0	64 Gd 157.3	65 Tb 158.9	66 Dy 162.5	67 Ho 164.9	68 Er 167.3	69 Tm 168.9	70 Yb 173.0	71 Lu 175.0		
†Actinides		90 Th 232.0	91 Pa 231	92 U 238	93 Np 244	94 Pu 242	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 260		