

CHEMISTRY 102A
Hour Exam I
February 22, 2023
T. Hummel

NAME _____

SIGNATURE _____

SECTION _____

FORM "A"

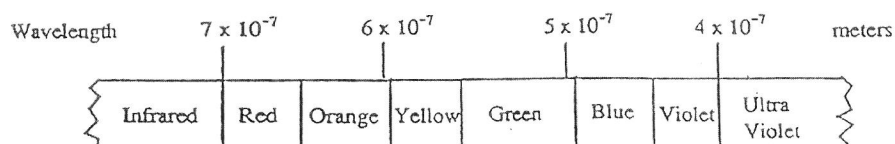
This exam is made up of an answer sheet, two cover sheets and 7 numbered pages. Below are instructions for coding the answer sheet. The last page of this exam contains some useful equations and constants, plus the periodic table.

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 102A students**, the numbers are:
AQA = 00011, AQB = 00012, AQC = 00013, AQD = 00014, AQE = 00015, AQF = 00016,
AQH = 00018, AQJ = 00020, AQK = 00021, AQL = 00022, AQN = 00024, AQO = 00025,
AQP = 00026.
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.

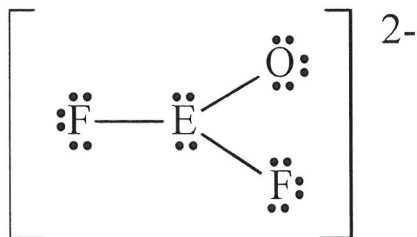
1. Use the figure below to answer the next question:



For hydrogen, the light emitted for the $n = 6$ to $n = 2$ electronic transition is in the visible region of the electromagnetic radiation spectrum (see spectrum above). What is the color of visible light emitted for the $n = 6$ to $n = 2$ electronic transition?

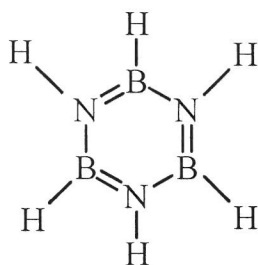
- a) red b) orange c) green d) blue e) violet
2. Which of the following compounds will be least soluble in water? Hint: Water is a polar solvent and “like dissolves like”.
- a) KrF_2 b) PF_3 c) IF_5 d) COS e) SO_2

E in the Lewis structure below is a general symbol for some element. Consider this Lewis structure for the next two questions.



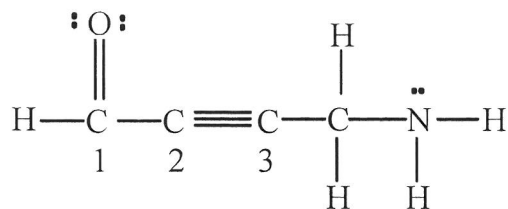
3. Which of the following elements could be E?
- a) C b) Si c) Ne d) Kr e) S
4. Which of the following statements is **false** concerning the EOF_2^{2-} ion?
- a) The predicted VSEPR shape of EOF_2^{2-} is T-shaped.
b) The predicted VSEPR bond angles about the central E atom are 120° .
c) The predicted hybridization of the central E atom is dsp^3 .
d) It is impossible to draw a Lewis structure for EOF_2^{2-} which satisfies the octet rule for all atoms in EOF_2^{2-} .

5. Measured quantities, such as length, mass, or volume, can best be described as:
- a) sometimes certain b) always certain
c) always uncertain d) sometimes uncertain
6. Calculate the number of oxygen atoms in 2.0 g of perchloric acid.
- a) 4.8×10^{22} O atoms b) 6.0×10^{23} O atoms c) 1.7×10^{21} O atoms
d) 3.4×10^{21} O atoms e) 1.2×10^{22} O atoms
7. A Lewis structure for borazine is:



- Which of the following statements is **false** concerning borazine?
- a) Each sigma bond between boron and nitrogen is formed from overlap of a sp^2 hybrid orbital from boron with a sp^2 hybrid orbital from nitrogen.
b) Another resonance Lewis structure can be drawn for borazine.
c) Each boron atom and nitrogen atom in borazine has two unhybridized 2p atomic orbitals.
d) The π electrons in borazine are delocalized above and below the entire ring surface.
e) All boron-nitrogen bond lengths are equivalent in borazine.
8. How many of the following five processes (I-V) are examples of chemical change?
- I. $\text{H}_2\text{O}(\text{l}) \rightarrow \text{H}_2\text{O}(\text{g})$
II. $\text{I}_2(\text{s}) \rightarrow \text{I}_2(\text{g})$
III. $\text{CH}_4(\text{g}) + 2 \text{O}_2(\text{g}) \rightarrow \text{CO}_2(\text{g}) + 2 \text{H}_2\text{O}(\text{l})$
IV. $\text{C}_6\text{H}_{12}\text{O}_6(\text{s}) \rightarrow \text{C}_6\text{H}_{12}\text{O}_6(\text{aq})$
V. $2 \text{H}_2\text{O}_2(\text{aq}) \rightarrow 2 \text{H}_2\text{O}(\text{l}) + \text{O}_2(\text{g})$
- a) 1 b) 2 c) 3 d) 4
e) 5 (All are examples of chemical change.)

9. Which of the following statements regarding the Lewis structure below is **false**?



- a) An sp^2 hybrid orbital from C-1 overlaps with an sp hybrid orbital from C-2 to form the sigma bond between C-1 and C-2.
- b) This molecule has three π bonds.
- c) Two of the atoms in this compound are sp^3 hybridized.
- d) The π bonds between C-2 and C-3 are formed from overlap of sp hybrid orbitals.
- e) There are 10 sigma bonds in this molecule.
10. Which of the following statements is **false** concerning ionization energy (IE)?
- a) The second ionization energy of Ne is greater than the first ionization energy of F.
- b) For an isoelectronic series, the species with the most protons should have the smallest ionization energy.
- c) As the size of an atom increases, ionization energy generally decreases.
- d) As the electronegativity of an atom increases, ionization energy generally increases.
- e) The third ionization energy for magnesium corresponds to the enthalpy change for the reaction: $Mg^{2+}(g) \rightarrow Mg^{3+}(g) + e^-$ $\Delta H = IE_3$.
11. How many of the following are **correct** ground state electron configurations for the element or ion listed? Note: Element #118 is not yet discovered and Zr is element #40.

element #118:	$[Rn] 7s^2 5f^{14} 6d^{10} 7p^6$
Zr:	$[Kr] 5s^2 4d^2$
S^{2-} :	$[Ne] 3s^2 3p^6$
Ge:	$[Ar] 4s^2 3d^{10} 4p^2$

- a) 0 (None are correct.) b) 1 c) 2 d) 3
- e) 4 (All are correct.)
12. Which of the following statements is **true**?
- a) Rutherford's metal foil experiment proved the existence of electrons.
- b) Dalton's atomic theory said that each element is made up of neutrons.
- c) Most of an atom's volume is occupied by its nucleus.
- d) Most of an atom's mass comes from its electrons.
- e) It is possible for an isotope of carbon and an isotope of nitrogen to have the same mass number.

13. Which aspect of the Bohr model is **not** allowed by Heisenberg's uncertainty principle?
- a) discrete atomic energy levels
 - b) simple circular orbits
 - c) deBroglie wavelengths
 - d) atomic orbitals
14. Which of the following correctly orders the radius of the atoms/ions listed from smallest to largest radius?
- a) $F < F^+ < Ca < Br < Rb^- < Sr$
 - b) $F < F^+ < Ca < Sr < Rb^- < Br$
 - c) $F^+ < F < Br < Ca < Rb^- < Sr$
 - d) $F^+ < F < Br < Ca < Sr < Rb^-$
 - e) $F^+ < F < Ca < Sr < Br < Rb^-$
15. Which of the following statements is **false** concerning bonding?
- a) In a C–O bond, electron density on average is greater near the O atom.
 - b) A C–O bond is an example of a polar covalent bond.
 - c) The bond in NaBr is formed by sharing electrons.
 - d) Elements with extremely different electronegativity values tend to form ionic bonds with each other.
 - e) An N–H bond is more polar than a P–H bond.
16. Consider the following **unbalanced** reaction (it is called the thermite reaction):
- $$Fe(s) + Al_2O_3(s) \rightarrow Fe_3O_4(s) + Al(s)$$
- In the best-balanced equation, what is the sum of the coefficients for the reactants and the products?
- a) 24
 - b) 6
 - c) 8
 - d) 9
 - e) 13
17. Which of the following is named **incorrectly**?
- a) $Cr_2(SO_3)_3$ chromium(III) sulfite
 - b) $NaC_2H_3O_2$ sodium acetate
 - c) KNO_2 potassium nitride
 - d) $Ca(OH)_2$ calcium hydroxide
 - e) $NiCO_3$ nickel(II) carbonate
18. Consider the transition metal ions Cu^+ , Ni^{2+} , Zn^{2+} , Cr^{2+} , and Ti^{2+} . How many of these five transition metal ions has/have two (2) unpaired electrons in the ground state?
- a) 1
 - b) 2
 - c) 3
 - d) 4
 - e) 5 (All have 2 unpaired electrons.)

19. A piece of metal has a mass of 1.0107×10^{-2} kg. When it was placed into a 100-mL graduated cylinder containing 30.07 mL of water, the volume of water increased to 32.37 mL. What is the density of the metal (in g/mL) to the correct number of significant figures?
- a) 4.4×10^{-3} g/mL b) 4.394×10^{-3} g/mL c) 4.4 g/mL
d) 4.39 g/mL e) 4.394 g/mL
20. Experiments show that an unknown element, X, has one unpaired electron in the ground state and has an exothermic electron affinity. Its most stable ion exhibited in ionic compounds is known to be isoelectronic with argon. Which of the following elements could be X?
- a) Cl b) Na c) Ca d) S e) Ga
21. Which of the following does **not** correctly describe 16.0 grams of methane, CH₄?
- a) One (1.00) mole of methane.
b) The amount of methane that contains 12.0 g of carbon.
c) The amount of methane that contains 4.0 g hydrogen.
d) The amount that contains $16.0 \times (6.02 \times 10^{23})$ molecules of methane.
e) The amount that contains $4.0 \times (6.02 \times 10^{23})$ atoms of hydrogen.
-
22. In some bonds, the atoms can rotate freely without breaking the bond between the atoms; while in other bonds, the atoms cannot rotate freely unless the bond is broken. How many of the following four molecules has/have at least one bond where the atoms **cannot** freely rotate unless a bond is broken?
- H—C—C—H H—C—N F—O—F $\begin{array}{c} \text{O} \\ | \\ \text{H—C—H} \end{array}$
- a) 0 (none) b) 1 c) 2 d) 3
e) 4 (All have at least one bond where the atoms cannot freely rotate.)
23. Which of the following molecules have at least one bond angle which is approximately 109° as predicted by the VSEPR model? Hint: reference the Lewis structures you drew for the previous question.
- a) H—C—C—H b) H—C—N c) F—O—F d) $\begin{array}{c} \text{O} \\ | \\ \text{H—C—H} \end{array}$
e) None of the above molecules (a-d) have at least one approximate 109° bond angle.
-

24. How many of the following molecules have a square planar shape?



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

e) 5 (All have a square planar shape.)

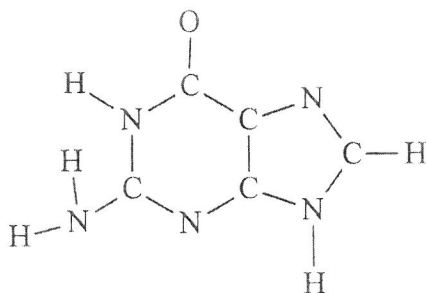
25. Which ion, in each of the following three pairs of ions, has the largest ionization energy?



26. The isotope of an unknown metal, M, has a mass number of 26. The most stable ion of the isotope forms a binary compound with sulfur having the formula MS . How many neutrons does M have?

- a) 14 b) 26 c) 12 d) 10 e) 24

DNA molecules are complex organic compounds found in every living cell which act as the information and control centers for the cell. Part of any DNA molecule is the organic compound guanine which has the following skeletal structure.



Using the guidelines outlined in class for organic compounds, complete a Lewis structure for guanine and answer the following two questions.

27. How many C and N atoms are sp^3 hybridized?

- a) 1 b) 2 c) 3 d) 4 e) 5

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

- a) 1 b) 2 c) 3 d) 4 e) 5

29. When an electron in a 2p orbital of a lithium atom makes a transition to the 2s orbital, a photon of wavelength 670.8 nm is emitted. The energy difference between the 2p and 2s orbitals in lithium is:
- a) 2.96×10^{-10} J b) 2.96×10^{-19} J c) 3.38×10^{-18} J
d) 2.96×10^{-17} J e) 3.38×10^{-20} J
30. A metal M forms an oxide having the formula M_2O_3 . If 100.00 g of M_2O_3 contains 68.42 g of M, what is the atomic mass of the metal, M?
- a) 26.98 amu b) 44.96 amu c) 52.00 amu d) 69.72 amu e) 102.9 amu
31. Which of the following statements is **false**?
- a) The three 6p atomic orbitals have the same energy but they differ in their orientation about the x, y and z axes.
b) 3f atomic orbitals do not exist in the quantum mechanical model of the atom.
c) For neutral charged atoms, the 8s atomic orbital should be lower in energy than the 7d atomic orbitals.
d) An excited state electron configuration for an atom represents a lower energy electron configuration as compared to the ground state electron configuration.
32. How many of the following compounds/ions exhibit resonance and have at least one 120° bond angle as predicted by the VSEPR model?
- SO_3 , SeS_3 , NO_3^- , TeS_3
- a) 0 (none) b) 1 c) 2 d) 3 e) 4 (all)
33. If the frequency of electromagnetic radiation is decreased by a factor of one-half, which of the following statements is **false**?
- a) The number of cycles passing a given point per unit time halves.
b) The velocity of the radiation halves.
c) The wavelength of electromagnetic radiation is doubled.
d) The photon energy of the electromagnetic radiation is halved.
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

USEFUL CONSTANTS/EQUATIONS

$$R_H = 2.178 \times 10^{-18} \text{ J}$$

$$c = \lambda \nu$$

$$E = h\nu = hc/\lambda$$

$$N = 6.022 \times 10^{23}$$

$$c = 2.998 \times 10^8 \text{ m/sec}$$

$$1 \text{ kHz} = 1000 \text{ Hz} = 1000 \text{ s}^{-1}$$

$$1 \text{ J} = 1 \text{ kg m}^2/\text{sec}^2$$

$$1 \text{ mL} = 1 \text{ cm}^3$$

$$h = 6.626 \times 10^{-34} \text{ J}\cdot\text{sec}$$

$$E_n = -R_H Z^2 (1/n^2), Z = \text{atomic number}$$

$$\lambda = h/mv \quad (\text{de Broglie equation})$$

$$1 \text{ pm} = 1 \times 10^{-12} \text{ m}; 1 \text{ nm} = 1 \times 10^{-9} \text{ m}$$

$$\text{Density} = \text{mass/volume}$$

$$\text{Mass \% of A} = \frac{\text{mass of A}}{\text{total mass}} \times 100$$

$$\Delta E = -R_H Z^2 \left(\frac{1}{n_2^2} - \frac{1}{n_1^2} \right)$$

PERIODIC TABLE OF THE ELEMENTS

1 1A H 1.008	2 2A He 4.003																	13 3A B 10.81	14 4A C 12.01	15 5A N 14.01	16 6A O 16.00	17 7A F 19.00	18 8A Ne 20.18
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 47.90	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