CHEMISTRY 102B/C
Hour Exam I
September 27, 2023
T. Hummel

NAME _____

SIGNATURE _____

SECTION _____

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, CQ8 = 00038, CQA = 00041, CQB = 00042, CQC = 00043, CQD = 00044, CQE = 00045, CQF = 00046.

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. Consider the ionic compound NH_4MnO_4 (ammonium permanganate). How many ions (total) are there in 1.0 mole of ammonium permanganate?

    a) 1.8×10^{24} ions   b) 6 ions   c) 6.0×10^{23} ions

    d) 1.2×10^{24} ions   e) 3.6×10^{24} ions

2. What is the wavelength of a photon of light that can excite the electron in a hydrogen atom from the n = 1 to the n = 8 energy level?

    a) 92.65 nm   b) 104.2 nm   c) 729.7 nm   d) 1261 nm   e) 5837 nm

3. Consider the following five molecules/ions which all have selenium as the central atom.

    SeO_4^{2-} SeF_4 SeF_4^{2-} SeF_5^{+} SeO_2

    In how many of the above molecules/ions is the central selenium atom sp^3 hybridized?

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

    e) 5 (All exhibit sp^3 hybridization by the central selenium atom.)
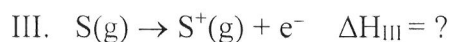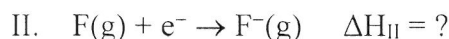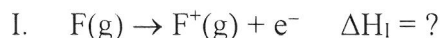
4. A Lewis structure for benzene is:
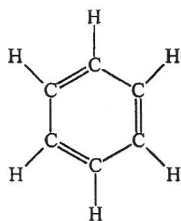
    Which of the following statements concerning benzene is **false**?

    a) Another equivalent (resonant) Lewis structure can be drawn for benzene.
    b) As predicted from the Lewis structure(s), three of the six carbon-carbon bonds are shorter than the other three C-C bonds.
    c) The carbon-carbon sigma bonds are formed from overlap of sp^2 hybrid orbitals from each carbon.
    d) The electrons in the π bonds can be thought of as delocalized above and below the entire ring surface.
    e) Each carbon in benzene has one unhybridized p atomic orbital.

5.   Draw the Lewis structure for SF_4. Which of the following statements concerning SF_4 is
      false?

      a) The hybridization of sulfur in SF_4 is dsp^3.
      b) The molecular shape of SF_4 is square pyramid.
      c) The smallest bond angle in SF_4 is approximately 90°.
      d) SF_4 is polar.
      e) It is impossible to satisfy the octet rule for all atoms in SF_4.

6.   Consider the following three reactions:

      I. $F(g) \rightarrow F^+(g) + e^-$ $\Delta H_I = ?$

      II. $F(g) + e^- \rightarrow F^-(g)$ $\Delta H_{II} = ?$

      III. $S(g) \rightarrow S^+(g) + e^-$ $\Delta H_{III} = ?$

      Which of the following statements (a-c) concerning these reactions is/are **true**?

      a) ΔH for reaction I is equal to the first electron affinity for fluorine.
      b) ΔH for reaction II is equal to the first ionization energy for fluorine.
      c) ΔH for reaction III is larger (more positive) than ΔH for reaction I ($\Delta H_{III} > \Delta H_I$).
      d) All of the above statements (a-c) are true.
      e) None of the above statements (a-c) are true.

7.   A compound has a formula of $NaClO_x$ where x is some whole number. A 100.00 g
      sample of this compound contains 21.6 g of sodium. Which of the following is the
      formula of this compound?

      a) $NaClO$ b) $NaClO_2$ c) $NaClO_3$ d) $NaClO_4$ e) $NaClO_6$
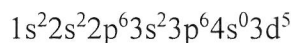
8.   Which of the following statements is **false**?

      a) A homogeneous mixture can be a solid mixture or a gaseous mixture.
      b) It is not possible for five measurements of the same object to be described as accurate
          but imprecise.
      c) An atom is mostly empty space.
      d) One would expect the undiscovered element 122 to be an alkaline earth metal.
      e) A compound is a substance with constant composition that can be broken down into
          elements by chemical processes.

9. Bromine consists of two isotopes and the average mass of a bromine atom is 79.90 amu. Assuming you were able to pick up only one bromine atom, what are the chances that you would pick a bromine atom having a mass of 79.90 amu?

    a) 0%   b) 35%   c) 50%   d) 65%   e) 100%

10. Consider the following ground state electron configuration:

    $$1s^2 2s^2 2p^6 3s^2 3p^6 4s^0 3d^5$$

    Which of the atoms or ions below has this ground state electron configuration?

    a) V^- b) V c) Mn

    d) Mn^+ e) Cr^+

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

    a) Elements in group 5A of the periodic table have a total of 3 unpaired electrons in the ground state.
    b) Iodine has a total of 23 electrons in various p orbitals in the ground state.
    c) Element 114 should have a total of 4 valence electrons in the ground state.
    d) The periodic table predicts that iridium (element #77) should have a total of 7 unpaired electrons in various d orbitals (in the ground state).
    e) Mercury (element #80) has a total of 14 electrons in various f orbitals (in the ground state).

12. A microwave oven emits 1.0×10^{28} photons of wavelength 4.0 cm each minute of operation. If a cup of coffee requires 77,000 J to bring it to boiling, how many seconds are required by this microwave oven to boil the coffee? Assume all the microwave energy is absorbed by the coffee.

    a) 13 seconds   b) 35 seconds   c) 52 seconds

    d) 70 seconds   e) 93 seconds

13. A certain metal ion (M^{n+}) forms an ionic compound with phosphorus. The molar mass of the compound is 238.0 g/mol. If the charge on the metal ion is +2, which of the following is the identity of the metal, M?

    a) Pb   b) U   c) Pm   d) Ge   e) Ni

14. The successive ionization energies for an unknown element are:

$IE_1 = \quad 896$ kJ/mol
$IE_2 = \quad 1{,}752$ kJ/mol
$IE_3 = \quad 14{,}807$ kJ/mol
$IE_4 = \quad 17{,}948$ kJ/mol

In which group in the periodic table does this element belong?

a) alkali metal group
b) alkaline earth metal group
c) boron group
d) nitrogen group
e) oxygen group

15. How many of the following five terms (I-V) did Dalton **not** discuss in his atomic theory?

I. isotopes   II. ions   III. protons   IV. electrons   V. neutrons

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

e) 5; Dalton did **not** discuss any of these terms in his atomic theory.

16. Consider the calculation:

$$\frac{39.0630 - 4.7 + 2.7392}{7.084 \times 3.1978}$$

Which of the following is the answer to this calculation to the correct number of significant figures?

a) 1.6378   b) 1.638   c) 1.64   d) 1.6   e) 2

17. How many of the following four compounds exhibit resonance?

N_2S (N-N-S) ICl_5 TeS_3 H_2CO

a) 0 (none)   b) 1   c) 2   d) 3   e) 4 (All exhibit resonance.)

18. Which of the following statements is **false** concerning the Bohr model of the atom?

   a) The Bohr model correctly predicts the energies of photons emitted by excited hydrogen atoms.
   b) The Bohr model correctly predicts the wavelengths of visible light emitted by excited neon (Ne) atoms.
   c) The symbol **n** in the Bohr model represents allowed circular orbits in which an electron can be located.
   d) The simple, well-defined circular orbits for an electron in the Bohr model are not allowed by the Heisenberg uncertainty principle.
   e) As an electron in the Bohr model absorbs a photon of electromagnetic radiation, the electron moves farther away from the nucleus.

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

   a) The metal ion in TiO_2 has a noble gas electron configuration.
   b) A bond between two identical nonmetals will be a pure (nonpolar) covalent bond.
   c) An S–O bond is an example of a polar covalent bond.
   d) $Ca(NO_3)_2$ is an example of a compound that contains only ionic bonds.
   e) The partial negative end of the bond dipole in the Se–Cl bond should be around the Cl atom.

20. How many of the following are **correct** ground state electron configurations for the element or ion listed? Bi is element #83.

C:	$1s^2 2s^2 2p^3$
Mg:	$[Ar]4s^2$
Si^{2-}:	$[Ne]2s^2 2p^4$
Bi:	$[Xe]6s^2 5f^{14} 6d^{10} 6p^3$

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

21. Apply the hybrid orbital theory to the bonding in a nitrogen molecule (N_2) and complete the following sentence. The nitrogen-nitrogen bonding in N_2 is best described as:

   a) one σ bond due to overlap of an sp^2 hybrid orbital from each nitrogen and one π bond from overlap of unhybridized 2p atomic orbitals.
   b) one σ bond due to overlap of an sp^2 hybrid orbital from each nitrogen and two π bonds from overlap of unhybridized 2p atomic orbitals.
   c) one σ bond due to overlap of an sp hybrid orbital from each nitrogen and two π bonds from overlap of unhybridized 2p atomic orbitals.
   d) one σ bond due to overlap of an sp hybrid orbital from each nitrogen and one π bond from overlap of unhybridized 2p atomic orbitals.

Isolan, an organic compound used as an insecticide, has the following skeletal structure. Complete a Lewis structure and answer the following two questions.
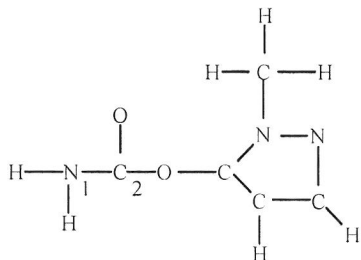
22. How many π bonds are in the complete Lewis structure?

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

23. What are the approximate bond angles about the nitrogen atom labeled 1 and the carbon atom labeled 2, respectively?

    a) 90°; 180°   b) 120°; 120°   c) 120°; 180°   d) 109°; 90°   e) 109°; 120°

24. How many of the following formula/name combinations is/are **correct**?

        Al_2S_3 dialuminum trisulfate

        $CuCO_3$ copper(I) carbonate

        $Fe(ClO_4)_2$ iron(IV) chlorate

        $CsBr$ bromium ceside

        S_2F_4 disulfur tetrafluoride

    a) 1   b) 2   c) 3   d) 4   e) 5 (All are correct.)

25. How many neutrons and electrons are in $^{127}I^-$?

    a) 128 neutrons and 53 electrons   b) 74 neutrons and 54 electrons

    c) 127 neutrons and 54 electrons   d) 127 neutrons and 52 electrons

    e) 74 neutrons and 52 electrons

Consider the following four groups (I-IV) of atoms/ions for the next two questions:

    I. N^+, N, N^-
    II. Al, Ca, Rb
    III. Sn, Se, Ar
    IV. Na^+, F^-, O^{2-}

26. How many of the four groups (I-IV) is/are in order of **increasing** ionization energy (smallest to largest I.E.)?
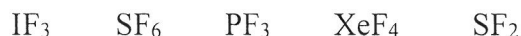
    a) 0 (none)   b) 1   c) 2   d) 3

    e) 4 (All of the groups are in order of increasing ionization energy.)

27. In each group (I-IV), which atom/ion has the **largest** radius?

    a) N^+; Al; Ar; Na^+ b) N^+; Rb; Ar; Na^+ c) N^-; Al; Ar; O^{2-}

    d) N^-; Rb; Sn; O^{2-} e) N^-; Rb; Sn; Na^+

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

$$IF_3 \quad SF_6 \quad PF_3 \quad XeF_4 \quad SF_2$$

28. How many of these molecules are polar?

    a) 1   b) 2   c) 3   d) 4   e) 5 (All are polar.)

29. Which molecule has a trigonal pyramid shape?

    a) IF_3 b) SF_6 c) PF_3 d) XeF_4 e) SF_2

30. Which of the following molecules or ions has the smallest bond angle?

    a) H_2S b) $XeCl_2$ c) O_3 d) HCN   e) NO_3^-

31.   When nitrogen gas reacts with hydrogen gas, gaseous ammonia is produced. Balance the equation for the reaction between nitrogen gas and hydrogen gas to produce ammonia. What is the sum of the coefficients in the best-balanced equation? Note that ammonia is the common name for nitrogen trihydride.

a) 4   b) 9   c) 8   d) 5   e) 6

32.   Assume Illini rays were recently discovered as a new type of electromagnetic radiation and assume that they possess extremely long wavelengths (λ = 100 km). Comparing Illini rays to microwaves (λ = 1.0 cm), which of the following statements (a-c) is/are **true**?

a) A photon of Illini rays is more energetic than a photon of microwaves.
b) The frequency of microwaves is higher than the frequency of Illini rays.
c) Microwaves will have a faster velocity than Illini rays.
d) All of the above statements (a-c) are false.
e) All of the above statements (a-c) are true.

33.   An element in the ground state has one unpaired electron in the 5p atomic orbitals. The element reacts with chlorine to form a covalent compound. Which of the following is this element?

a) Tl   b) At   c) In   d) I   e) Ga

34.   A 25.00 g sample of an unknown solid is placed in a graduated cylinder and then the cylinder is filled to the 50.0 mL mark with benzene. The mass of benzene and solid together is 58.80 g. Assuming that the solid is insoluble in benzene and the density of benzene is 0.880 g/cm^3, what is the density of the unknown solid?

a) 2.16 g/cm^3 b) 0.651 g/cm^3 c) 4.25 g/cm^3 d) 1.18 g/cm^3 e) 3.68 g/cm^3

35.   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

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

$c = \lambda\nu$

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

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

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

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

1 J $= 1$ kg m^2/sec^2

1 mL $= 1$ cm^3

$h = 6.626 \times 10^{-34}$ J•sec

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

$\lambda = h/mv$ (de Broglie equation)

1 cm $= 1 \times 10^{-2}$ m; 1 nm $= 1 \times 10^{-9}$ m

Density = mass/volume

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

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

PERIODIC TABLE OF THE ELEMENTS

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				26 Fe 55.85	←Atomic number ←Atomic mass						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