CHEM 1A Winter 2021: Final

Lecturer: Prof. Fokwa

March 17, 2021

Time: 3 h

Please note: This test has a total of 400 points (Parts I, II and III) and 15 pts bonus questions (Part IV). The test covers chapters 1-7.
Allowed for the test are: a blanc paper sheet, a copy of the periodic table given on the sample final and below, a pen and a scientific calculator (non-graphing).

Part I: Chapters 1, 2 and 3: 27 Multiple Choices (5 pts each; 135 pts in total)

_____ 1. If the following operations are carried out, how many significant figures should be reported in the answer?

(2.3) / (21.13 − 1.271)

a. 1
b. 2
c. 3
d. 4
e. 5

_____ 2. For each of the elements below, there are only two naturally occurring isotopes. Using information in your periodic table, identify the pair in which the heavier isotope is the more abundant one.
a. ^{63}Cu and ^{65}Cu
b. ^{85}Rb and ^{87}Rb
c. ^{10}B and ^{11}B
d. ^{79}Br and ^{81}Br
e. ^{14}N and ^{15}N

_____ 3. Nitrogen and oxygen combine to form several different nitrogen oxides. In one case, 4.2 g of nitrogen reacted with 9.6 g of oxygen. In another case, 8.4 g of nitrogen reacted completely with 4.8 g of oxygen. Which pair of nitrogen oxides is consistent with these data?
a. NO and N_2O
b. N_2O and N_2O_5
c. NO and NO_2
d. NO and N_2O_4
e. N_2O_4 and N_2O

_____ 4. Which of the following is a heterogeneous mixture?
a. air
b. sugar dissolved in water
c. muddy river water
d. brass (an alloy of copper and zinc)
e. table salt (sodium chloride)

_____ 5. Jupiter's mass is estimated to be 1.90×10^{27} kg, and it has a diameter of 142,984 km. Assuming that Jupiter is spherical, estimate its density (the volume of a sphere is $(4\pi r^3)/3$).
a. 0.620 g/cm^3
b. 1.61 g/cm^3
c. 1.24 g/cm^3
d. 0.00124 g/cm^3
e. 1240 g/cm^3

_____ 6. Which of the following quantities has two significant figures?
a. 0.4
b. 101
c. 1.10×10^3
d. 0.0902
e. 1.4×10^{-3}

_____ 7. Sublimation is the process in which a _____ is converted into a _____.
    a. liquid; solid
    b. gas; liquid
    c. gas; solid
    d. liquid; gas
    e. solid; gas

_____ 8. The concentration (in % by volume) of methyl *tert*-butyl ether (MTBE) was determined in four samples of the same gasoline. What is the average value, and which measurement was the most accurate, compared to the average?

Sample	% (v/v) MTBE
1	5.01
2	4.96
3	5.08
4	5.11

    a. 5.042, sample 1
    b. 5.0425, sample 3
    c. 5.043, sample 3
    d. 5.04, sample 4
    e. 5.04, sample 1

_____ 9. For each of the elements below, there are only two naturally occurring isotopes. Using information in your periodic table, identify the pair in which the heavier isotope is the more abundant one.
    a. ^{63}Cu and ^{65}Cu
    b. ^{85}Rb and ^{87}Rb
    c. ^{10}B and ^{11}B
    d. ^{79}Br and ^{81}Br
    e. ^{14}N and ^{15}N

_____ 10. The elements below are used in fireworks. Which one is *not* classified correctly according to its position in the periodic table?
    a. Sodium is an alkali metal.
    b. Strontium is an alkaline earth metal.
    c. Iron is a transition metal.
    d. Phosphorus is a nonmetal.
    e. Sulfur is a metalloid.

_____ 11. Which element (A–E) combination in the periodic table below will make an ionic compound with the lowest charged ions?

    a. D and A
    b. B and E
    c. C and E
    d. B and A
    e. C and B

_____ 12. Which transition in a hydrogen atom will cause emission of the longest wavelength photon?
    a. $n_1 = 6$ to $n_2 = 3$
    b. $n_1 = 4$ to $n_2 = 2$
    c. $n_1 = 3$ to $n_2 = 1$
    d. $n_1 = 3$ to $n_2 = 1$
    e. $n_1 = 10$ to $n_2 = 9$

____ **13.** Indicate which of the following common laboratory devices will deliver 25 mL of a solution with the greatest precision.
   a. a 50 mL Erlenmeyer flask (without volume divisions)
   b. a 50 mL beaker (with volume divisions every 10 mL)
   c. a 25 mL volumetric pipette (with a to-deliver error of 0.01 mL at 25°C)
   d. a 50 mL graduated cylinder (with volume divisions every 2 mL)
   e. a 25 mL Erlenmeyer flask (without volume divisions)

____ **14.** Which statement regarding the organization of the periodic table is *not* correct?
   a. Mendeleev arranged known elements with similar chemical properties in columns.
   b. The elements go from gases to liquids to solids in order down the columns in Mendeleev's periodic table.
   c. Mendeleev's predictions of the chemical properties of unknown elements facilitated their discovery.
   d. Mendeleev arranged the elements in order of increasing atomic mass.
   e. The modern periodic table arranges elements in order of increasing atomic number.

____ **15.** Which statement is *not* correct?
   a. Electrons have a negative electrical charge.
   b. Protons have a positive electrical charge.
   c. Neutrons do not have an electrical charge.
   d. In an atom, there is no interaction between electrons and protons.
   e. In an atom, the interaction between electrons and neutrons is attractive.

____ **16.** The two major isotopes of bromine are ^{79}Br and ^{81}Br. Assume that the masses of the ^{79}Br and ^{81}Br isotopes are 79.00 u and 81.00 u, respectively. The weighted average atomic mass of bromine is 79.90 u. What are the relative % abundances of each isotope? Estimate without detailed calculations!

Choice	% Abundance of ^{81}Br	% Abundance of ^{79}Br
A	21.0%	79.0%
B	81.0%	19.0%
C	45.1%	54.9%
D	64.9%	35.1%
E	53.0%	47.0%

   a. Choice A   d. Choice D
   b. Choice B   e. Choice E
   c. Choice C

____ **17.** Which monatomic ion most likely does *not* exist?
   a. Mg^{2+} d. S^{2-}
   b. Al^{2+} e. I^-
   c. K^+

____ 18. Which listing has the orbitals in order of increasing energy in a multielectron atom?
    a. $3s < 3p < 3d < 4s$
    b. $5s < 4d < 5p$
    c. $5s < 3d < 5p$
    d. $2p_x < 2p_y < 2p_z$
    e. $3s < 2p < 4s$

____ 19. Which of the following elements would you expect to have the greatest first ionization energy?
    a. C
    b. N
    c. Li
    d. Be
    e. B

____ 20. Which one of the following is a molecular compound? Molecular compounds also are known as covalent compounds.
    a. Na_2O
    b. PH_3
    c. FeO
    d. CaO
    e. Fe_2O_3

____ 21. Identify the *incorrect* statement(s). A solution _____

    I. can be a solid, liquid, or gas.
    II. is a homogeneous mixture.
    III. can be heterogeneous or homogeneous.

    a. Only I is incorrect.
    b. Only II is incorrect.
    c. Only III is incorrect.
    d. Both I and II are incorrect.
    e. Both I and III are incorrect.

____ 22. Chemical analysis of an organic compound found the following composition: 40.0% C, 53.5% O, and 6.7% H. If the molar mass is 180.2 g/mol, how many empirical formula units are there in the molecular formula?

    a. 2
    b. 4
    c. 8
    d. 6
    e. 7

____ 23. If you had equal masses of each of the following substances, which would occupy the greatest volume?
    a. ice ($d = 0.917$ g/mL)
    b. water ($d = 0.997$ g/mL)
    c. beeswax ($d = 0.960$ g/mL)
    d. cocoa butter ($d = 0.910$ g/mL)
    e. aluminum ($d = 2.70$ g/mL)

____ 24. Which of the following is the ground-state electron configuration of the Ca^{2+} ion?
    a. $1s^2 2s^2 2p^6 3s^2 3p^6 4s^2 4p^2$
    b. $[Ar]4s^2$
    c. $[Ar]4s^2 4p^2$
    d. $[Ar]$
    e. $1s^2 2s^2 2p^6 3s^2 3p^6 4s^2$

____ 25. What is the ground-state electron configuration of a P^{3-} ion?
    a. $1s^2 2s^2 2p^6 3s^2 3p^4$
    b. $1s^2 2s^2 2p^6 3s^2 3p^5$
    c. $1s^2 2s^2 2p^6 3s^2 3p^6$
    d. $1s^2 2s^2 2p^6 3s^2 3p^2$
    e. $1s^2 2s^2 2p^6 3s^2 3p^8$

____ 26. Which prediction regarding the formation of a monatomic ion most likely is *not* correct?
a. Rubidium (Rb) forms a +1 cation by losing an *s* electron.
b. Strontium (Sr) forms a +2 cation by losing two *s* electrons.
c. Bromine (Br) forms a −1 anion by adding an electron to a *p* orbital.
d. Scandium (Sc) forms a +3 cation by losing two *s* electrons and a *p* electron.
e. Sulfur (S) forms a −2 anion by adding one electron to each of two *p* orbitals.

____ 27. Which combination of quantum numbers is possible for an atom with five orbitals in one subshell?
a. $n = 1, \ell = 0$ d. $n = 4, \ell = 2$
b. $n = 2, \ell = 1$ e. $n = 5, \ell = 0$
c. $n = 4, \ell = 3$

Part II: Chapters 4 and 5: 27 Multiple Choices (5 pts each; 135 pts in total)

____ 28. Indicate which one of the following does *not* contain a polar covalent bond.
a. CN^- d. NO
b. CO e. Br_2
c. HF

____ 29. What is the formula for Strontium nitride?
a. SrN d. SrN_2
b. Sr_3N_2 e. Sr_2N_3
c. Sr_2N

____ 30. Which of the following compounds has a T-shaped molecular geometry?
a. ICl_3 d. BrF_5
b. PH_3 e. SiF_4
c. PCl_5

____ 31. The following salts are used in fireworks. Which one has an *incorrect* formula or is *not* named correctly?
a. Li_2CO_3, lithium carbonate   d. CuO, copper(II) oxide
b. $CaSO_4$, calcium sulfite   e. NH_4Cl, ammonium chloride
c. $CaCO_3$, barium carbonate

____ 32. The formula for a holmium phosphite compound is $Ho_3(PO_3)_4$. What would be the formula for a holmium sulfite compound given that the charge of holmium is the same in both compounds?
a. $Ho_2(SO_3)_3$ d. $Ho(SO_3)_2$
b. $Ho(SO_4)_2$ e. $Ho(SO_4)_3$
c. $Ho(SO_3)_2$

____ 33. What types of bonds form between the chlorine and oxygen atoms of the chlorate ion (ClO_3^-) to minimize the formal charge?
a. single   d. triple
b. double   e. between single and double
c. between double and triple

____ 34. Arrange the molecules B_2, O_2, and N_2 from highest to lowest bond order.
a. $B_2 > O_2 > N_2$ d. $O_2 > B_2 > N_2$
b. $N_2 > O_2 < B_2$ e. $B_2 > N_2 > O_2$
c. $N_2 > B_2 > O_2$

____ 35. Use the given energy levels of diatomic molecules derived from molecular orbital theory to predict the magnetic properties of F_2 and the dication F_2^{2+}.

    a. F_2 (paramagnetic); F_2^{2+} (paramagnetic)
    b. F_2 (paramagnetic); F_2^{2+} (diamagnetic)
    c. F_2 (diamagnetic); F_2^{2+} (diamagnetic)
    d. Neither have magnetic properties; only metals have magnetic properties.
    e. F_2 (diamagnetic); F_2^{2+} (paramagnetic)

____ 36. Which one of the following species has four electrons in antibonding π molecular orbitals?
    a. C_2^{2-} d. Br_2^+
    b. O_2^+ e. Br_2^{2-}
    c. N_2^{2-}

____ 37. What is the valence electron molecular orbital electron configuration of the N_2^+ cation?
    a. $(\sigma_{2s})^2(\sigma^*_{2s})^2(\pi_{2p})^4(\sigma_{2p})^2(\sigma^*_{2p})^2(\pi^*_{2p})^1$
    b. $(\sigma_{2s})^2(\sigma^*_{2s})^2(\sigma_{2p})^2(\pi_{2p})^4(\sigma^*_{2p})^2(\pi^*_{2p})^1$
    c. $(\sigma_{2s})^2(\sigma^*_{2s})^2(\sigma_{2p})^2(\pi_{2p})^4(\pi^*_{2p})^3$
    d. $(\sigma_{2s})^2(\sigma^*_{2s})^2(\pi_{2p})^4(\sigma_{2p})^1$
    e. $(\sigma_{2s})^2(\sigma^*_{2s})^2(\sigma_{2p})^2(\pi_{2p})^6(\pi^*_{2p})^1$

____ 38. Manganese(IV) oxide is a brown insoluble solid often found as a product of reactions of potassium permanganate. What is the formula of manganese(IV) oxide?
    a. Mn_4O d. MnO_2
    b. MnO_4 e. Mn_2O_2
    c. MnO

____ 39. What is the formal charge on the peripheral nitrogen atom in dinitrogen oxide (N_2O)?
    a. 0   d. -1
    b. $+1$ e. -2
    c. $+2$

____ 40. Oxygen has two common molecular anions: peroxide (O_2^{2-}) and superoxide (O_2^-). Use the MO energy level diagram below to identify which one of the following statements is *not* correct. These molecular orbitals are formed from the $2s$ and $2p$ atomic orbitals.

    a. The bond order of the peroxide is 1.
    b. The superoxide has a shorter bond than the peroxide.
    c. Oxygen, O_2, has a stronger bond than either of these oxides.
    d. Like O_2, the peroxide is paramagnetic.
    e. The superoxide has a stronger bond than the peroxide.

____ 41. The local molecular geometry and the hybridization around each carbon atom in benzene (C_6H_6 with a hexagonal ring structure) is _____
    a. square planar and *sp*.   d. trigonal planar and sp^2.
    b. trigonal planar and *sp*.   e. T-shaped and sp^2.
    c. tetrahedral and sp^3.

____ 42. How many total equivalent Lewis structures (resonance) are needed to describe the nitrite anion, NO_2^-?
    a. 1   d. 4
    b. 2   e. 0
    c. 3

____ 43. What is the formal charge of each C and N atom (from left to right), in the following resonance structure of CH_2N_2?

    a. 0, 0, 0   d. 0, −1, +1
    b. −1, +1, 0   e. −1, −1, +1
    c. 0, +1, −1

____ 44. Which of the following molecules has a carbon atom that is neither sp^2 nor sp^3 hybridized?
    a. C_2H_6 d. CH_3Cl
    b. HCN   e. $C_2H_2Cl_2$
    c. C_2H_4

____ 45. Which of the following has a central atom with the same hybridization as the nitrogen in ammonia?
    a. SO_2 d. H_2O
    b. OCS   e. CO_2
    c. CS_2

____ 46. For which of the following molecules is the electron pair geometry trigonal bipyramidal and the molecular geometry pyramidal?
    a. SF_4 d. PH_3
    b. SiH_4 e. ClF_3
    c. BF_3

____ 47. Which of the following molecules or ions has a square planar shape?
    a. XeF_4 d. NH_4^+
    b. SO_3^{2-} e. O_3
    c. $COCl_2$

____ 48. Indicate the species that does *not* have 8 valence electrons.
    a. S^{2-} d. P^{2-}
    b. Na^+ e. Ar
    c. Al^{3+}

____ 49. Indicate the element with the smallest electronegativity.
    a. K   d. B
    b. Cs   e. Li
    c. Al

____ 50. Both hydrazine (N_2H_4) and diazene (N_2H_2) have two nitrogen atoms bonded together. In a valence bond picture of the N—N bonds, _____ hybrid orbitals overlap for hydrazine and _____ hybrid orbitals overlap for diazene.
    a. sp; sp d. sp^3; sp^2
    b. sp; sp^2 e. sp^2; sp
    c. sp^2; sp^3

_____ **51.** Which of the molecules below has (have) 10 electrons around the central atom in a Lewis structure that has all atoms with a formal charge of zero?

<div align="center">

I. SO_3 II. $POCl_3$ III. $SOCl_2$ IV. PF_3

</div>

  a. I only
  b. II only
  c. IV only

  d. both I and IV
  e. both II and III

_____ **52.** Which of the following molecular species is diamagnetic?
  a. B_2
  b. F_2^+
  c. O_2^{2-}

  d. N_2^-
  e. C_2^+

_____ **53.** Which one of the following acids has an *incorrect* formula or is *not* named correctly?
  a. HCl, hydrochloric acid
  b. HF, hydrofluoric acid
  c. HNO_2, nitric acid

  d. H_2CO_3, carbonic acid
  e. H_2SO_4, sulfuric acid

_____ **54.** Which one of the following ionic compounds has an *incorrect* formula or is *not* named correctly?
  a. CuO, copper(II) oxide
  b. Co_2O_3, cobalt(III) oxide
  c. MgS, magnesium sulfide

  d. Cu_2S, copper(I) sulfide
  e. CoO_2, cobalt dioxide

Part III: Chapters 6 and 7: 26 Multiple Choices (5 pts each; 130 pts in total)

_____ **55.** Which is the interaction responsible for the unexpected high density of liquid water if compared to ice?
  a. ion–ion
  b. ion–dipole
  c. dipole–dipole

  d. hydrogen bonding
  e. dispersion or London forces

_____ **56.** Which of the following polar compounds is likely to have the lowest vapor pressure?
  a. CH_3OCH_3
  b. $CH_3CH_2CH_2OH$
  c. $(CH_3)_2CO$

  d. H_2CO
  e. CO

_____ **57.** Which of the following molecules has the highest boiling point?
  a. CH_4
  b. SiH_4
  c. SnH_4

  d. GeH_4
  e. Br_2

_____ 58. When potassium bromide dissolves in water, which picture best represents the solution?
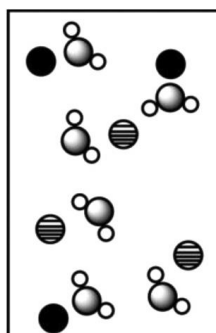
● = K⁺   ○○ = H₂O

⊜ = Br⁻
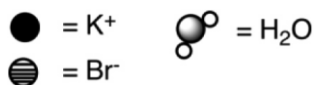
a.
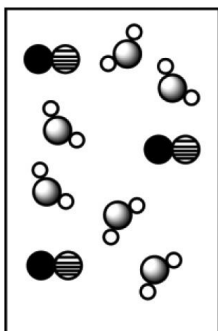
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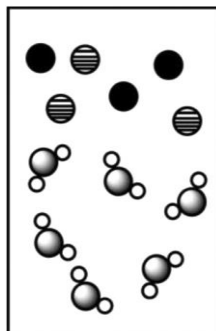
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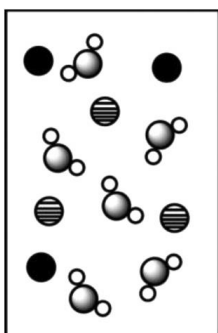
d.

_____ 59. A reaction vessel contains equal masses of solid magnesium metal and oxygen gas. The mixture is ignited and burns with a burst of light and heat, producing solid MgO. The mass of the MgO is less than the initial mass of the magnesium and oxygen. What is your explanation for this apparent loss of mass?

    a. Conservation of mass is violated in this reaction.
    b. Not all of the oxygen reacted.
    c. Some of the mass was converted into energy (heat and light) as $E = mc^2$.
    d. Not all of the magnesium reacted.
    e. Measurement must be in error because mass is conserved in chemical reactions.

_____ 60. Which of the following compounds is capable of dipole–dipole interactions?

    a. CH_4 d. SF_6
    b. CO_2 e. CH_3OCH_3
    c. NH_4^+

_____ 61. Which best describes the intermolecular forces present in PH_3?

    a. dipole–dipole, hydrogen bonding, and dispersion forces
    b. dispersion forces only
    c. dipole–dipole forces only
    d. dipole–dipole and dispersion forces
    e. ion–dipole and dispersion forces

_____ 62. Sulfur trioxide from coal-fired power plants combines with water in the atmosphere to produce acid rain. What is the product when one molecule of SO_3 reacts with one molecule of water?
   a. two molecules of sulfurous acid
   b. one molecule of sulfuric acid
   c. one sulfate ion
   d. two sulfite ions
   e. one molecule of sulfurous acid

_____ 63. Saccharose ($C_{12}H_{22}O_{11}$) is oxidized by molecular oxygen to carbon dioxide and water. How many oxygen molecules are needed for each molecule of saccharose that is oxidized?
   a. 8   d. 14
   b. 6   e. 12
   c. 1

_____ 64. In which of the following reaction mixtures, where A reacts with B in the following balanced equation, is B the limiting reactant?

$$A + 2B \rightarrow AB_2$$

A ●
B ○

a.

d.

b.

e.

c.
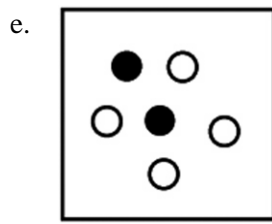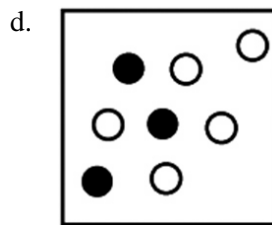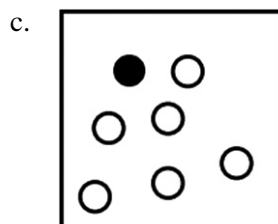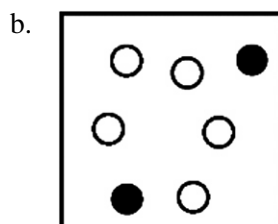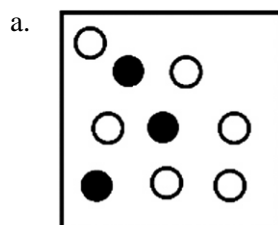
_____ 65. A range of organic molecules can undergo combustion. If pyridine (C_5H_5N) undergoes combustion through the following balanced chemical reaction, how much carbon dioxide can be produced when 3.2 g of pyridine reacts?

$$4C_5H_5N + 27O_2 \rightarrow 10H_2O + 20CO_2 + 4NO$$

   a. 0.36 g   d. 5.8 g
   b. 1.2 g   e. 8.9 g
   c. 1.8 g

_____ 66. Which of the following compounds do you expect to be most soluble in water?
   a. CO_2 d. SiO_2
   b. CCl_4 e. PH_3
   c. O_2

_____ 67. Burning coal that contains sulfur releases sulfur trioxide gas into the atmosphere, where it combines with water to form sulfurous and sulfuric acid, thereby producing acid rain. Assume sulfur in coal is in the form of pyrite ($FeS_2(s)$), which reacts with molecular oxygen to produce $Fe_2O_3(s)$ and $SO_3(g)$. Write the balanced equation for this reaction and report the sum of the stoichiometric coefficients, written as integers.
   a. 17   d. 25
   b. 12   e. 18
   c. 29

_____ 68. Baking soda ($NaHCO_3$, 84.0 g/mol) requires acids from other ingredients to generate the carbon dioxide needed to make bread rise. The following equation describes this reaction, where HB is some unspecified acid. If 20.4 g of baking soda are used in a recipe and enough acid is present for a complete reaction, how many moles of carbon dioxide are generated?

$$HB + NaHCO_3 \rightarrow H_2O + CO_2 + NaB$$

   a. 0.464 mol   d. 0.204 mol
   b. 0.334 mol   e. 0.232 mol
   c. 0.243 mol

_____ 69. Hydrogen peroxide decomposes to produce water and oxygen. Which relationship regarding the quantities of reactants and products associated with this reaction is *not* correct?

$$2H_2O_2 \rightarrow 2H_2O + O_2$$

   a. 2 molecules $\rightarrow$ 2 molecules + 1 molecule
   b. 34.0 g $\rightarrow$ 18.0 g + 16.0 g
   c. 68.0 g $\rightarrow$ 36.0 g + 32.0 g
   d. $2x$ mol $\rightarrow$ $2x$ mol + x mol
   e. $y(34.0$ g$) \rightarrow y(18.0$ g$) + y(32$ g$)$

_____ 70. The density of water decreases as it is cooled from 4.0°C to freezing because _____
   a. water molecules decrease in size as they cool because energy is released.
   b. a regular, repeating network of hydrogen bonds between water molecules is formed.
   c. water molecules become more rigid as they cool.
   d. hydrogen bonds in liquid water are longer than they are in ice.
   e. all substances contract just before freezing.

_____ 71. At ambient temperature, F_2 and Cl_2 are both gases while Br_2 is a liquid and I_2 is a solid. This is due to _____
   a. dipole–dipole forces increasing with increasing molecular weight.
   b. both dispersion and polarity increasing with increasing molecular weight.
   c. dispersion forces increasing with increasing molecular weight.
   d. molecule polarity increasing with increasing molecular weight.
   e. ion–dipole forces increasing with increasing molecular weight.

_____ 72. Carbon dioxide is being used as an environmentally safe liquid solvent for reactions. If the reaction is run at a temperature of 15°C, what must the minimum pressure of the reaction vessel be? The phase diagram for carbon dioxide is shown below.
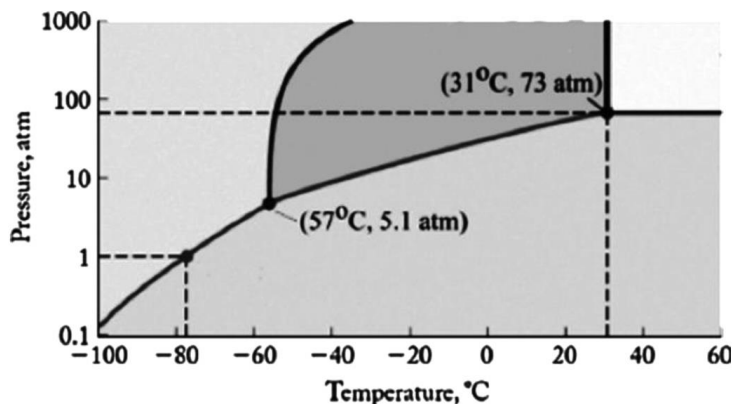
a. about 1 atm
b. about 10 atm
c. about 100 atm

d. about 500 atm
e. about 5 atm

_____ 73. Which is the dominant interaction between water molecules?

a. ion–ion
b. ion–dipole
c. dipole–dipole

d. hydrogen bonding
e. dispersion or London forces

_____ 74. One form of elemental sulfur is a ring of eight sulfur atoms. How many moles of molecular oxygen are consumed when one mole of this sulfur allotrope burns (combustion) to make sulfur dioxide?

a. 3
b. 6
c. 12

d. 8
e. 24

_____ 75. Ammonia undergoes combustion to produce nitrogen monoxide and water, both as gases. Write the balanced equation for this reaction and report the sum of the stoichiometric coefficients, written as integers.

a. 17
b. 13
c. 23

d. 21
e. 19

_____ 76. Which statement about a balanced chemical reaction equation is always correct?

a. The total number of moles of the products equals the total number of moles of the reactants.
b. The number of atoms of each kind is the same for the products as for the reactants.
c. The sum of the stoichiometric coefficients for the products equals the sum of the stoichiometric coefficients for the reactants.
d. The sum of the masses of gaseous reactants equals the sum of the masses of gaseous products.
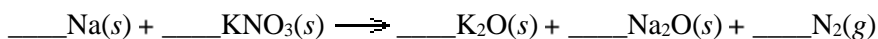e. The sum of the masses of solid products equals the sum of the masses of solid reactants.

EXAM B

_____ 77. 10.00 g of aluminum sulfide and 10.00 g of water react until the limiting reactant is used up. Balance the reaction equation, identify the limiting reactant, and report the mass of H_2S that can be produced from these reactants.
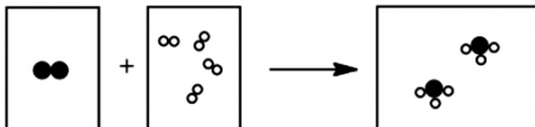
$$\_\_\_\_Al_2S_3 + \_\_\_\_H_2O \longrightarrow \_\_\_\_Al(OH)_3 + \_\_\_\_H_2S$$

a. 9.458 g   d. 13.89 g
b. 10.00 g   e. 6.80 g
c. 15.00 g
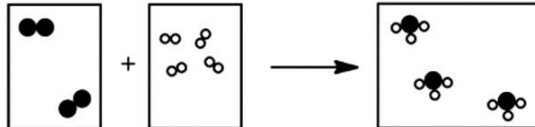
_____ 78. One reaction that occurs during the deployment of an air bag is shown below, where sodium metal reacts with potassium nitrate. If 5.10 g of sodium and 305 g of potassium nitrate react in an airbag, how many grams of KNO_3 remain because of the limited amount of sodium present? Balance the reaction equation first.
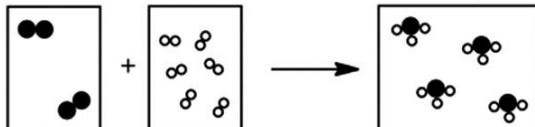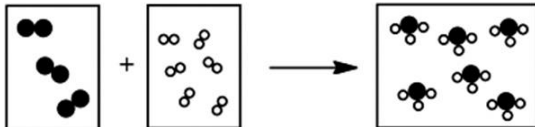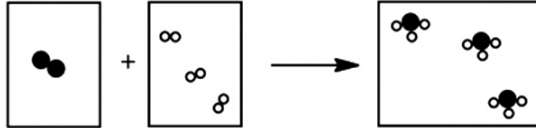
$$\_\_\_\_Na(s) + \_\_\_\_KNO_3(s) \longrightarrow \_\_\_\_K_2O(s) + \_\_\_\_Na_2O(s) + \_\_\_\_N_2(g)$$

a. 2.24 g   d. 112 g
b. 303 g   e. 301 g
c. 193 g

_____ 79. Which of the following cartoons depict a balanced reaction?

13

_____ 80. Which of the following cartoons depict a balanced reaction?

a.

b.

c.

d.

e.
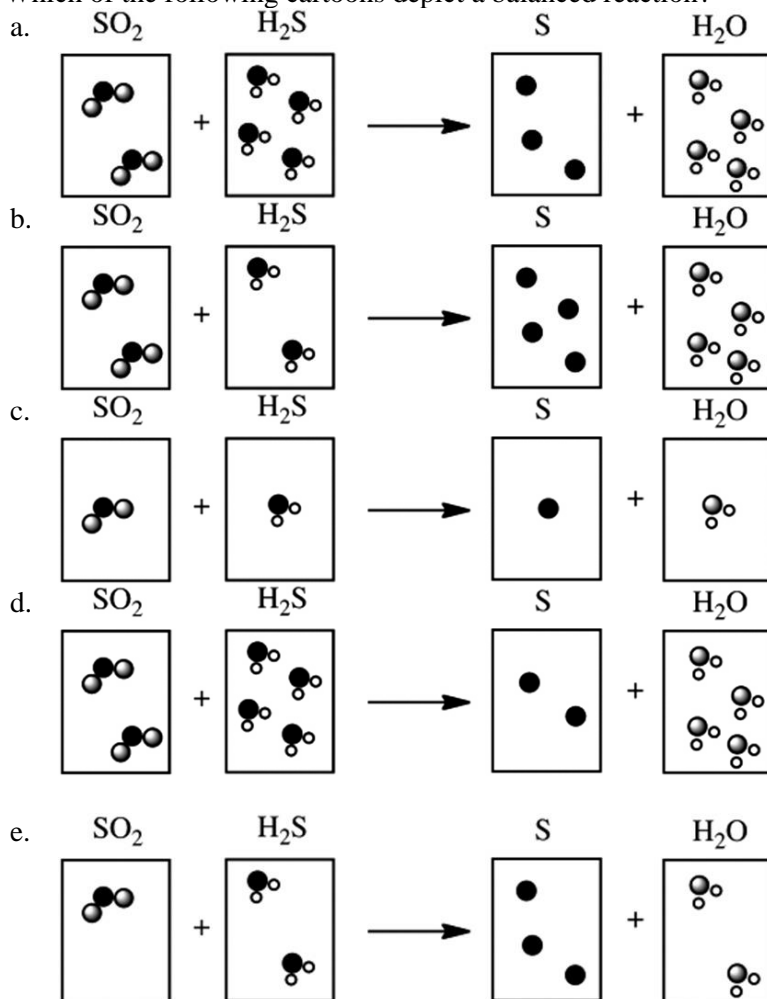
Part IV: Bonus Questions (5 pts each; 15pts in total)

____ 81. Calcite has a chemical formula of $CaCO_3$, and one gram occupies approximately 0.369 cm^3. Pyrite (FeS_2) is 1.8 times denser than calcite. What is the density of FeS_2?

a. 2.7 g/cm^3 d.   2.2 g/cm^3
b. 0.66 g/cm^3 e.   1.5 g/cm^3
c. 4.9 g/cm^3

____ 82. According to the molecular orbital energy-level diagram below, which one of the following statements is *not* correct about NO, NO^+, and NO^-? These molecular orbitals are formed from the $2s$ and $2p$ atomic orbitals.
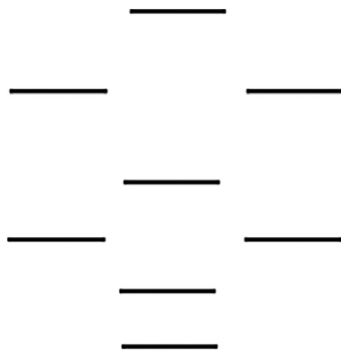
a. The bond order in NO is 2.5.
b. NO^+ has the shortest bond.
c. Only one of these species is paramagnetic.
d. The bond order in NO^- is 2.0.
e. NO^- has the weakest bond.

____ 83. Which of the following liquids will have the highest surface tension?

a. dimethylamine, $(CH_3)_2NH$ d. 1-propanol, $CH_3CH_2CH_2OH$
b. dimethylsulfide, $(CH_3)_2S$ e. ethylene glycol, $HOCH_2CH_2OH$
c. water, H_2O

Useful equation, constants and conversions:

$$\text{density} = \frac{\text{mass}}{\text{volume}}$$

$c = \lambda v$ (λ is wavelength; v is frequency; $c = 2.998 \times 10^8$ m/s)

$$E = h v \qquad E = \frac{hc}{\lambda} \; ; \qquad \lambda = \frac{hc}{E} = \frac{hc}{mc^2} = \frac{h}{mc} = \frac{h}{mu}$$

$$\frac{1}{\lambda} = \left(1.097 \times 10^{-2} \text{nm}^{-1}\right)\left(\frac{1}{n_1^2} - \frac{1}{n_2^2}\right) \qquad \Delta E = -2.178 \times 10^{-18} \text{ J}\left(\frac{1}{n_{final}^2} - \frac{1}{n_{initial}^2}\right)$$

$h = 6.626 \times 10{-}34$ J•s (Planck's constant); Avogadro's number $N = 6.022 \times 10^{23}$/mol

$KE_{electron} = h v - \Phi$, where Φ = work function.

Mean: $\bar{x} = \dfrac{\Sigma_i(x_i)}{n}$; Standard deviation(s): $s = \sqrt{\dfrac{\Sigma_i(x_i - \bar{x})^2}{n-1}}$

$$\text{Percent Yield} = \frac{\text{actual yield}}{\text{theoretical yield}} \times 100\%$$

Beer's aw: $A = \varepsilon \cdot b \cdot c$

Molarity: $M = \dfrac{n}{V}$

Bond Order = (# bonding e$^-$ − # antibonding e$^-$)/2

Mass solute: $m_{solute} = V \times M \times \mathcal{M}$

Dilution equation: $V_{initial} \times M_{initial} = V_{dilute} \times M_{dilute}$

Potential energy (PE): $PE = m \times g \times h$
(m = mass; g = acceleration due to gravity; h = vertical distance)
Kinetic energy (KE): $KE = \frac{1}{2}mu^2$ (m = mass; u = velocity)
Total energy = PE + KE

Electrostatic Potential Energy: $E_{el} \propto \dfrac{(Q_1 \times Q_2)}{d}$

Internal energy: $\Delta E = q + w = q - P\Delta V$

$\Delta H = \Delta E + P\Delta V$; $\quad \Delta H_{rxn} = \dfrac{q_{rxn}}{\text{mol rxn}}$

Heat capacity: $q = C\,\Delta T$
Specific heat (c_s): $q = mc_s\Delta T$
Molar heat capacity (c_p): $q = nc_p\Delta T$
Phase change: $q = n\Delta H_{fus}$; $q = n\Delta H_{vap}$

Clapeyron Equation $\ln\left(\frac{P_2}{P_1}\right) = \frac{\Delta H_{vap}}{R}\left(\frac{1}{T_1} - \frac{1}{T_2}\right)$ Gas constant: R = 8.314 J/(mol K) = 0.08206 atm L/(mol K)

$h = \dfrac{2T\cos\theta}{r\rho g}$ $\quad$ g = acceleration = 9.8 m/s^2; ρ is the density; T = surface tension; r = radius of the tube;

ϑ = contact angle between the liquid and the tube.

Periodic Table of the Elements

1 H 1.008																	2 He 4.003
3 Li 6.939	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 32.06	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 58.71	29 Cu 63.54	30 Zn 65.37	31 Ga 69.72	32 Ge 72.59	33 As 74.92	34 Se 78.96	35 Br 79.91	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 (99)	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 (267)	105 Ha (268)	106 Sg (271)	107 Bh (272)	108 Hs (270)	109 Mt (276)	110 Ds (281)	111 Rg (280)	112 Cn (285)	113 Uut (284)	114 Fl (289)	115 Uup (288)	116 Lv (293)	117 Uus (294)	118 Uuo (294)

58 Ce 140.1	59 Pr 140.1	60 Nd 144.2	61 Pm 144.9	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
90 Th 232.0	91 Pa 231	92 U 238.0	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 Lw (262)