CHEMISTRY 121 FINAL EXAM

Record your answers on the machine readable answer sheet provided. Scratch work is to be done on the paper provided with the examination instructions. **DO NOT MAKE ANY MARKS ON THIS EXAMINATION BOOK.**

QUESTIONS 1-50 COUNT ONE POINT EACH.

1. Which of the following metric relationships is correct?
   a) 1 microliter $= 1 \times 10^{-9}$ liters
   b) 1 megagram $= 1 \times 10^{9}$ grams
   c) 1 millimeter $= 1 \times 10^{-3}$ meters
   d) 1 nanogram $= 1 \times 10^{-6}$ grams
   e) 1 centimeter $= 1 \times 10^{2}$ meters

2. The degree of agreement among several measurements of the same quanity is called _____. It reflects the reproducibility of a given type of measurement.
   a) accuracy   b) error   c) precision   d) significance   e) certainty

3. How many significant figures are there in the number 0.03220?
   a) 2   b) 3   c) 4   d) 5   e) 6

4. The density of gasoline is 0.7025 g/mL at 20°C. When gasoline is added to water:
   a) it will float on top.
   b) it will sink to the bottom.
   c) it will mix so you can't see it.
   d) the mixture will improve the running of the motor.
   e) none of these things will happen.

5. The scientist whose experiment involving scattering of alpha-particles by gold foil led him to conclude that the nucleus of an atom contains a dense center of positive charge is:
   a) J.J. Thomson   b) Lord Kelvin   c) Ernest Rutherford   d) William Thomson   e) John Dalton

6. Which of the following complete atomic symbols is **incorrect**?
   a) $^{14}_{6}C$ b) $^{37}_{17}Cl$ c) $^{32}_{13}P$ d) $^{39}_{19}K$ e) $^{14}_{8}N$

7. $^{40}_{20}Ca^{2+}$ has

   a) 20 protons, 20 neutrons, and 18 electrons
   b) 22 protons, 20 neutrons, and 20 electrons
   c) 20 protons, 22 neutrons, and 18 electrons
   d) 22 protons, 18 neutrons, and 18 electrons

8. All of the following are true **except**:
   a) Ions are formed by adding electrons to a neutral atom.
   b) Ions are formed by changing the number of protons in an atom's nucleus.
   c) Ions are formed by removing electrons from a neutral atom.
   d) An ion has a positive or negative charge.
   e) Metals tend to form positive ions

9. How many oxygen atoms are there in one formula unit of $Ca_3(PO_4)_2$?
   a) 2   b) 4   c) 6   d) 8   e) none of these

10. Which of the following are **incorrectly** paired?
    a) Copper, Co   b) Silver, Ag   c) Iron, Fe   d) Lead, Pb   e) Sodium, Na

11. The correct name for Hg_2^{2+} is:
    a) mercury(I) ion   b) mercury ion   c) mercury(II) ion   d) hydrogen ion   e) hydrogen(II) ion

12. All of the following are in aqueous solution. Which is **incorrectly** named?
    a) $HC_2H_3O_2$, acetic acid
    b) HBr, bromic acid
    c) H_2SO_3, sulfurous acid
    d) HNO_2, nitrous acid
    e) $HClO_3$, chloric acid

13. The correct formula for tin(II) sulfate is:
    a) $SnSO_4$
    b) $Sn(SO_4)_2$
    c) $TiSO_4$
    d) $Ti(SO_4)_2$
    e) TiS_8

14. The nucleus of an atom of $^{112}_{49}In$ contains:

    a) 49 protons, 63 neutrons, 49 electrons
    b) 49 protons, 49 neutrons.
    c) 49 protons, 49 alpha particles
    d) 49 protons, 63 neutrons
    e) 49 protons, 112 neutrons

15. How many moles of hydrogen sulfide are contained in a 35.0-g sample of this gas?
    a) 2.16 mol   b) 1.03 mol   c) 7.43 mol   d) 10.4 mol   e) 6.97 mol

16. What is the coefficient for oxygen when the following equation is balanced ?
    $$NH_3 + O_2 \; ---> \; NO_2 + H_2O$$
    a) 3   b) 6   c) 7   d) 12   e) 14

17. The empirical formula of a group of compounds is CHCl. Lindane, a powerful insecticide, is a member of this group. The molar mass of lindane is 290.8. How many atoms of carbon does a molecule of lindane contain?
    a) 2   b) 3   c) 4   d) 6   e) 8

18. A 20.0-g sample of HF is dissolved in water to give 2.0×10^2 mL of solution. The concentration of the solution is:
    a) 1.0 M   b) 3.0 M   c) 0.10 M   d) 5.0 M   e) 10. M

19. A chemist needs 225 mL of 2.4 M HCl. What volume of 12 M HCl must be dissolved in water to form this solution?
    a) 3.4 mL   b) 7.2 mL   c) 21 mL   d) 6.8 mL   e) 45 mL

20. Which of the following is a strong acid?
    a) HF   b) $HC_2H_3O_2$ c) HCl   d) HClO   e) HBrO

21. In which of the following does nitrogen have an oxidation state of +4 ?
    a) HNO_3 b) NO_2 c) N_2O d) NH_4Cl e) $NaNO_2$

22. In the reaction $2Cs + Cl_2 \; ---> \; 2CsCl$, Cl_2 is:
    a) the reducing agent.
    b) the oxidizing agent.
    c) oxidized.
    d) the electron donor.
    e) two of these.

23. Consider four 1-L flasks containing gases at STP. Flask A contains NH_3 gas, Flask B contains NO_2 gas, Flask C contains N_2 gas and Flask D contains O_2 gas. Which contains the largest number of molecules?
    a) flask A
    b) flask B
    c) flask C
    d) flask D
    e) all contain the same number of molecules

24. For which gas do the molecules have the highest average velocity at 25°C?
    a) He   b) Cl_2 c) CH_4 d) NH_3 e) all gases the same

25. Predict what would happen to a closed sample of a gas whose temperature increased while its volume decreased.
    a) Its pressure would decrease
    b) Its pressure would increase.
    c) Its pressure would hold constant
    d) The number of moles of the gas would decrease.
    e) The average kinetic energy of the molecules of the gas would decrease.

26. A gas sample is held at constant pressure. The gas occupies 3.62 L of volume when the temperature is 21.6°C. Determine the temperature at which the volume of the gas is 3.45 L.
    a) 309 K   b) 281 K   c) 20.6 K   d) 294 K   e) 326 K

27. Calculate the density of nitrogen at STP.
    a) 0.312 g/L   b) 0.625 g/L   c) 0.800 g/L   d) 1.25 g/L   e) 1.60 g/L

28. Samples of two metals of equal mass but with different heat capacities are originally at the same temperature. If the same amount of heat is added to both samples, for which metal will the final temperature be lower (assume that no phase change, such as melting, occurs).
    a) The metal with the higher heat capacity.
    b) The metal with the lower heat capacity.
    c) Both undergo the same change in temperature.
    d) You need to know the initial temperatures of the metals.
    e) You need to know which metals you have.

29. $CH_4(g) + 4Cl_2(g) \longrightarrow CCl_4(g) + 4HCl(g)$, $\Delta H = -434$ kJ
    Based on the above reaction, what energy change occurs when 1.2 moles of methane react?
    a) 5.2×10^2 kJ are released.
    b) 5.2×10^2 kJ are absorbed.
    c) 3.6×10^2 kJ are released.
    d) 3.6×10^2 kJ are absorbed.
    e) 4.3×10^2 kJ are released.

30. How many f orbitals have the value $n = 3$?
    a) 0   b) 1   c) 3   d) 5   e) 7

31. How many electrons in an atom can have the quantum numbers $n = 3, l = 2$?
    a) 2   b) 5   c) 6   d) 10   e) 18

32. Which of the following combinations of quantum numbers is not allowed?

	n	l	$m_{(l)}$	$m_{(s)}$
a)	1	1	0	½
b)	3	0	0	- ½
c)	2	1	-1	½
d)	4	3	-2	- ½
e)	4	2	0	½

33. Which of the following atoms would have the largest first ionization energy?
    a) Mg
    b) Cl
    c) S
    d) Ca
    e) Na

34. A fluoride ion is isoelectronic with which of the following?
    a) a sodium ion
    b) a chloride ion
    c) an oxygen atom
    d) two of the above
    e) none of the above

35. The electron configuration of Ti^{+2} is
    a) $[Ar]4s^2$ b) $[Ar]4s^1 3d^1$ c) $[Ar]3d^2$ d) $[Ar]4s^2 3d^2$ e) none of these

36. An element has the electron configuration $[Kr]4d^{10}5s^2 5p^2$. The element is a(n)
    a) nonmetal   b) actinide   c) metal   d) lanthanide   e) transition element

37. All halogens have the following number of valence electrons:
    a) 2   b) 3   c) 5   d) 7   e) none of these

38. Fe has ____ that is (are) unpaired in its d orbitals.
    a) 1 electron   b) 2 electrons   c) 3 electrons   d) 4 electrons   e) None of these.

39. Consider the following orderings.
    I. Al < Si < P < S
    II. Be < Mg < Ca < Sr
    III. I < Br < Cl < F
    IV. Na^+ < Mg^{2+} < Al^{3+} < Si^{4+}

    Which of these give(s) a correct order for the radii of the atoms or ions ?
    a) I   b) II   c) III   d) IV   e) II, IV

40. For the elements Rb, F, and O, the order of increasing electronegativity is:
    a) Rb < F < O
    b) Rb < O < F
    c) O < F < Rb
    d) F < Rb < O
    e) None of these

41. Which of the following groups contains no ionic compounds?
    a) HCN, NO_2, $Ca(NO_3)_2$
    b) PCl_5, $LiBr$, $Zn(OH)_2$
    c) KOH, CCl_4, SF_4
    d) NaH, CaF_2, $NaNH_2$
    e) CH_2O, H_2S, NH_3

42. Which of the following molecules does not have a dipole moment?
    a) HCl b) CO c) NCl_3 d) BCl_3 e) All have a dipole moment

43. Which of the following has the smallest ionic radius?
    a) Ca^{2+} b) Cl^- c) Li^+ d) O^{2-} e) Be^{2+}

44. Select the correct molecular geometry for OF_2
    a) tetrahedral   b) linear   c) trigonal planar   d) bent   e) none of these

45. Which one of the following decreases as the strength of the attractive intermolecular forces increases?
    a) The heat of vaporization.
    b) The normal boiling temperature.
    c) The viscosity of a liquid.
    d) The heat of fusion.
    e) The vapor pressure of a liquid.

46. In which of the following groups of substances would dispersion forces be the only *significant* factors in determining boiling points?

       I. Cl_2 II. HF   III. Ne   IV. KNO_2 V. CCl_4

a) I, III, V   b) I, II, III   c) II, IV   d) II, V   e) III, IV, V

47. A certain solid substance that is very hard, has a high melting point, and does not conduct electricity unless melted is most likely to be:

a) I_2 b) NaCl   c) CO_2 d) H_2O e) Cu

48. A certain substance has the phase diagram shown below. At which of the following values of T and P is the substance a pure liquid?

a) $T= 8°C$, $P=1$ atm
b) $T=10°C$, $P=0.5$ atm
c) $T=70°C$, $P=1.2$ atm
d) $T=80°C$, $P=1$ atm
e) $T=10°C$, $P=1$ atm
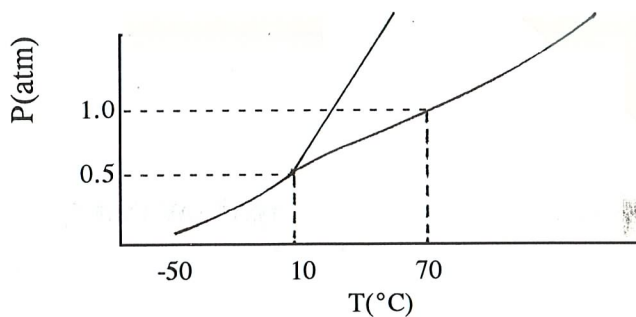
49. Rank the following compounds according to increasing solubility in water.
I. $CH_3-CH_2-CH_2-CH_3$
II. $CH_3-CH_2-O-CH_2-CH_3$
III. CH_3-CH_2-OH

a) I<II<III   b) I<III<II   c) III<II<I   d) III<I<II   e) No order is correct.

50. A nonvolatile solute added to a solvent raises the boiling point of the solution because
a) the temperature to cause boiling must be great enough to boil not only the solvent but also the solute.
b) the solute particles lower the solvent's vapor pressure, thus requiring a higher temperature to cause boiling.
c) the solute particles raise the solvent's vapor pressure, thus requiring a higher temperature to cause boiling.
d) the solute increases the volume of the solution, and an increase in volume requires an increase in the temperature to reach the boiling point (derived from $PV = nRT$).
e) two of the above are correct.

QUESTIONS 51 THROUGH 75 COUNT TWO POINTS EACH.

51. It is estimated that uranium is relatively common in the earth's crust, occurring in amounts of 4 g/metric ton. A metric ton is 1000 kg. At this concentration, what mass of uranium is present in 1.0 mg of the earth's crust?
a) 4×10^{-9} grams   b) 4×10^{-6} grams   c) 4×10^{-6} grams   d) 4×10^{-5} g   e) 4×10^{-2} g

52. A piece of indium with a mass of 16.6 g is submerged in 46.5 cm^3 of water in a graduated cylinder. The water level increased to 48.6 cm^3. The correct value for the density of indium from these data is:

a) 0.34 g/cm^3 b) 0.36 g/cm^3 c) 2.8 g/cm^3 d) 2.9 g/cm^3 e) 7.9 g/cm^3

53. Convert 4301 mL to qts. (1 L = 1.06 qt)
a) 4559 qts   b) 4.058 qts   c) 4058×10^{-3} qts   d) 4058 qts   e) 4.559 qts

54. Suppose the reaction $Ca_3(PO_4)_2 + 3H_2SO_4 ---> 3CaSO_4 + 2H_3PO_4$ is carried out starting with 103 g of $Ca_3(PO_4)_2$ and 75.0 g of H_2SO_4. How much phosphoric acid will be produced?
a) 65.0 g   b) 50.0 g   c) 112 g   d) 32.5 g   e) 97.6 g

55. Phenol is a compound that contains 76.57% carbon, 6.43% hydrogen, and 17.0% oxygen. The empirical formula of phenol is
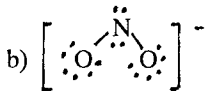a) CHO   b) CH_2O c) C_3H_3O d) C_2HO e) C_6H_6O
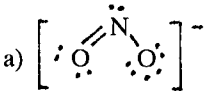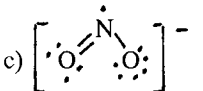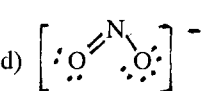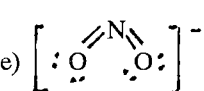
56. Gallium consists of two isotopes of masses 68.95 amu and 70.95 amu with abundances of 60.16% and 39.84%, respectively. What is the average atomic mass of gallium?
a) 69.95   b) 70.15   c) 71.95   d) 69.75   e) 69.55

57. Iron is produced from its ore by the reactions:
$$2C(s) + O_2(g) ---> 2CO(g)$$
$$Fe_2O_3(s) + 3CO(g) ---> 2Fe(s) + 3 CO_2(g)$$
How many moles of $O_2(g)$ are needed to produce 1.0 mole of Fe(s) ?

   a)   0.5 mole O_2 b)   0.75 mole O_2 c)   1.0 mole O_2 d)   1.5 mole O_2

58. Consider the fermentation reaction of glucose: $C_6H_{12}O_6$ $\xrightarrow{\text{yeast}}$ $2C_2H_5OH + 2CO_2$

   A 1.00-mole sample of $C_6H_{12}O_6$ was placed in a vat with 100 g of yeast. If 46 grams of C_2H_5OH were obtained, what was the percent yield of C_2H_5OH ?
   a)   50.%   b)   56%   c)   100%   d)   42%   e)   none of these

59. How many grams of sodium acetate trihydrate, $NaC_2H_3O_2 \cdot 3H_2O$ are needed to prepare 350. mL of a 0.250 M solution of sodium acetate?
   a)   0.972 g   b)   7.18 g   c)   9.10 g   d)   11.9 g   e)   87.5 g

60. A 5.00 g sample of an unknown metal chloride requires 70.90 mL of 0.2010 M $AgNO_3$ to precipitate all of the chloride as AgCl. What is the percentage of chloride in the sample?
   a)   50.6%   b)   10.1%   c)   1.43%   d)   20.2%   e)   none of the above

61. What mass of NaOH is required to completely neutralize with 25.0 mL of 1.2 M H_2SO_4 ?
   a)   1.2 g   b)   1.8 g   c)   2.4 g   d)   3.5 g   e)   none of these

62. Given the following oxidation-reduction reaction which is carried out in acidic media: $Fe^{2+} + Cr_2O_7^{2-} ---> Fe^{3+} + Cr^{3+}$ answer the following question: The coefficient for water in the balanced reaction is
   a)   1.   b)   3.   c)   5.   d)   7.   e)   none of these

63. When 0.72 g of a liquid is vaporized at 110°C and 0.967 atm, the gas occupies a volume of 0.559 L. The empirical formula of the gas is CH_2. What is the molecular formula of the gas?
   a) CH_2 b) C_2H_4 c) C_3H_6 d) C_4H_8 e)   none of these

64. A sample of chlorine gas prepared at 15°C and 740. torr has a volume of 5.10 L. Calculate the volume of this sample of chlorine gas at standard conditions of temperature and pressure.
   a)   6.41 L   b)   4.71 L   c)   5.89 L   d)   11.4 l   e)   2.97 L

65. What volume is occupied by 19.6 g of methane (CH_4) at 27°C and 1.59 atm?
   a)   1.71 l   b)   18.9 L   c)   27.7 L   d)   302 L   e) not enough data to calculate

66. A gaseous mixture containing 1.5 mol Ar and 3.5 mol CO_2 has a total pressure of 7.0 atm. What is the partial pressure of CO_2 ?
   a)   1.8 atm   b)   2.1 atm   c)   3.5 atm   d)   4.9 atm   e)   2.4 atm

67. You have a 28.2-g sample of a metal heated to 95.2°C. You drop it in a calorimeter with 100.g of water at 25.1°C. The final temperature of the metal and water is 31.0°C. Assuming no heat loss to the surroundings nor the calorimeter, calculate the specific heat capacity of the metal. (The specific heat capacity of water is 4.18 J/g°C)
   a)   0.335 J/g°C   b)   0.98 J/g°C   c)   1.1 J/g°C   d)   1.4 J/g°C   e)   none of these

68. Given: $Cu_2O(s) + ½ O_2(g) ---> 2CuO(s)$ $\Delta H° = -144$ kJ
             $Cu_2O(s) ---> Cu(s) + CuO(s)$ $\Delta H° = +11$ kJ

   Calculate the standard enthalpy of formation of CuO(s).
   a)   -166 kJ   b)   -299 kJ   c)   +299 kJ   d)   +155 kJ   e)   -155 kJ

69. The heat combustion of acetylene, C_2H_2(g), at 25°C, is -1299 kJ/mol. At this temperature, $\Delta H_f°$ values for CO_2(g) and $H_2O(\ell)$ are -393 and -286 kJ/mol, respectively. Calculate $\Delta H_f°$ for acetylene.

   a) 2376 kJ/mol   b) 625 kJ/mol   c) 227 kJ/mol   d) -625 kJ/mol   e) none of these

70. Which of the following is a valid Lewis structure for the nitrite ion, NO_2^- ?

   a) $\left[\ddot{\underset{..}{O}} = N - \ddot{\underset{..}{O}}: \right]^-$
   b) $\left[:\ddot{O} \cdot \overset{..}{N} \cdot \ddot{\underset{..}{O}}: \right]^-$
   c) $\left[:\ddot{O} \overset{\cdot}{N} \ddot{\underset{..}{O}}: \right]^-$
   d) $\left[:\ddot{O} = N \ddot{\underset{..}{O}}: \right]^-$
   e) $\left[:\ddot{\underset{..}{O}} = N \ddot{\underset{..}{O}}: \right]^-$

71. How much energy is needed to convert 64.0 grams of ice at 0.00°C to water at 75.0°C ?

          specific heat (ice) = 2.10 J/(g°C)
          specific heat (water) = 4.18 J/(g°C)
          heat fusion = 333 J/g
          heat of vaporization = 2258 J/g

   b) 10.1 kJ   b) 20.7 kJ   c) 31.4 kJ   d) 41.4 kJ   e) 65.8 kJ

72. A solution of hydrogen peroxide is 30.0% H_2O_2 by mass and has a density of 1.11 g/cm³. The molarity of the solution is:

   a) 7.94 M   b) 8.82 M   c) 9.79 M   d) 0.980 M   e) none of these

73. Calculate the molality of C_2H_5OH in a water solution that is prepared by mixing 50.0 mL of C_2H_5OH with 100.0 mL of H_2O at 20°C. At 20°C the density of C_2H_5OH is 0.789 g/mL and the density of water is 1.00 g/mL.

   a) 0.086 m   b) 0.094 m   c) 1.24 m   d) 8.56 m   e) none of these

74. A 5.50-gram sample of a compound as dissolved in 250. grams of benzene. The freezing point of this solution is 1.02°C below that of pure benzene. What is the molar mass of this compound? (*Note:* K_f for benzene = 5.12°C/m)

   a) 22.0 g/mol   b) 110.g/mol   c) 220.g/mol   d) 44.0 g/mol   e) none of these

75. The molar mass of a solid as determined by freezing point depression is 10% higher than the true molar mass. Which of the following experimental errors could not account for this discrepancy?

   a) Not all the solid was dissolved.
   b) More than the recorded amount of solvent was pipetted into the solution.
   c) The solid dissociated slightly into two particles when it dissolved.
   d) Some solid was left on the weighing paper.
   e) Before the solution was prepared, the container was rinsed with solvent and not dried.