Brooklyn College
Chemistry Department
Final Examination Fall 2007

R= 8.31 J/mol K = 0.0821 L atm/mol K = 62.4 L torr/mol K
$h = 6.63 \times 10^{-34}$ J•s

Standard Pressure = 1 atm = 760 torr = 101.3 kP

$E = h\nu = \frac{hc}{\lambda}$ $c = 3.0000 \times 10^{8}$ m/ s

The decrease in freezing point, $\Delta t_f = k_f\, m$ where k_f is the freezing pt. depression constant, and m is the molality of solute. k_f of water is 1.86°C

Please note that only the stapled exam paper will be graded. The booklets will be discarded.

Some thermodynamic data.

Substance	$\Delta H_f°$ *(kJ/mol)*
$CO_2(g)$	–394
CO(g)	–111
$C_2H_6(g)$	– 84.7
HBr(g)	–36.4
HCl(g)	–92.3
H_2O (*l*)	–286.
HI(g)	+25.9
$H_2O(g)$	–242.
$C_2H_5OH(\ell)$	–278

Specific heat of water = 4.18 joule/g K

Brooklyn College
Chemistry Department
Final Examination in Chemistry 1
Fall 2007

Name_____ Lab Instructor _____

All answers go on these pages. Booklets are for scrap work only.

Multiple Choice Items. (1.3 pts each)

_____1. The correct formula for aluminum nitrate is A) $Al(NO_3)_3$ B) Al_3NO
C) $Al(NO_2)_3$ D) $Al(NO_3)_2$

_____2. The correct name for $Ni_3(PO_4)_2$ is A) nickel (I) phosphate B) nickel (II)phosphate
C) nickel (III) phosphate D) nickel (IV) phosphate

_____3. The Rutherford gold leaf experiment is important because it indicated
A) the existence of electrons B) the nuclear structure of the atom
C) the frequencies of the lines in the hydrogen spectrum D) the charge of the neutron

_____4. What is the formula mass of Magnesium hydroxide? A) 41 B) 58 C) 42
D) 74

_____5. When the equation $C_6H_{14} + O_2 \rightarrow CO_2 + H_2O$
is balanced using the smallest possible whole number coefficients, the coefficient of the O_2 is A) 7 B) 19 C) 30 D) 8

_____6. What is the mass of 0.60 moles of NaOH ? A) 24 g B) 100 g C) 0.010 g
D) 0.60 g

_____7. What mass of water contains the same number of moles as 12.6 g of nitric acid?
A) 3.6 g B) 0.20 g C) 90. g D) 4.5 g

_____8. Which is a possible molecular mass for a hydrocarbon that is 92.3 % carbon and 7.7 % hydrogen by mass ? A) 26 B) 30 C) 6.5 D) 34

_____9. What is the volume of 40. grams of neon gas at a pressure of 1.0 atm. and a temperature of 300. K ? A) 12.5 L B) 34.0 L C) 49 L D) 89 L

_____10. What is the % H_2O in the hydrate, $BaCl_2 \bullet 2H_2O$? (the molar mass of anhydrous $BaCl_2$ is 208) A) 14.8% B) 43 % C) 17.3 % D) 83 %

The balanced equation for the reaction of copper metal with dilute nitric acid is (for q 11 and 12)

$3\ Cu(s) + 8\ HNO_{3(aq)} \rightarrow 3Cu(NO_3)_2(aq) + 2\ NO(g) + 4\ H_2O(l)$

_____11. What is the maximum amount of NO(g) that could be produced in this reaction from 50.0 mL of 2.00 molar HNO_3 ? A) 0.100 mole B) 0.025 mole C) 0.067 mole D) 2.00 mole

_____12. In this reaction, how many **grams** of NO (MM = 30) would be produced when 6.35 grams of Cu metal reacts completely with the acid?
A) 0.46 g B) 2.0 g C) 3.0 g D) 0.23 g

_____13. Which is a strong electrolyte ? A) $HC_2H_3O_2$ B) $C_6H_{12}O_6$ C) H_2SO_4 D) NH_3

_____14. 20.0 mL of 5.00 molar NaOH is diluted with water to a new volume of 100. mL. What is the molarity of the new solution? A) 2.5 M B) 25 M C) 1.00 M D) 0.50 M

_____15. What is the molarity of a solution containing 28.4 grams of Na_2SO_4 (MM = 142 g) in a volume of 200. mL ? A) 1.00 M B) 0.100 M C) 1.42 M D) 0.00100 M

_____16. A chemist needs to prepare a solution that has a sodium ion concentration of 0.100 molar. How much solid Na_2SO_4 must be dissolved to a volume of 250. mL to provide the proper concentration of Na^+ ? A) 0.0250 moles B) 25.0 moles C) 0.0500 moles D) 0.0125 moles

_____17. Of the 4 variables, n, P, V, and T used in describing gases, which two vary directly when the other two remain constant? A) P and V B) T and n C) n and P D) none of these

_____18. How many unpaired electrons are there on an atom of Se in the ground state?
A) 2 B) 4 C) 6 D) 18

_____19. How many orbitals are there in a 4 p sublevel ? A) 3 B) 4 C) 6 D) 7

_____20. Which element has **no** unpaired electrons ? A) K B) Ti C) Cd D) Sb

_____21. How many unpaired electrons are there on a Fe^{3+} ion ? A) 5 B) 4 C) 2 D) 3

_____22. What is the energy, in joules, of a photon that produces light with a wave length of 656, nanometers?
A) 4.0×10^{-7} joules B) 3.03×10^{-19} J C) 4.97×10^{-16} nm D) 3.03×10^{-28} joules

_____23. Assuming that the four visible lines in the hydrogen spectrum, red, blue, violet, and violet, are all produced when electrons drop **to** the second energy level, which of these lines is produced when the electron drops **from** the fourth energy level ? A) red B) blue C) violet

_____24. According to the aufbau rules, for the order in which electrons fill the sublevels in neutral atoms, which of the following sublevels fills **last**? A) 3p B) 3d C) 4s D) 2p

_____25. 30.0 joules of heat are added to a system which then does 35.0 joules of work on its surroundings. What is ΔE for the system? A) + 5.0 J B) –5.0 J C) + 65 J D) –65 J

Use the table of heats of formation on the accompanying page for the next two questions:

_____26. Based on the reaction, $C_2H_5OH\ (l) + 3\ O_{2(g)} \rightarrow 2\ CO_{2(g)} + 3\ H_2O_{(l)}$

how much heat is produced by the complete combustion of 92.0 grams of $C_2H_5OH\ (l)$?
A) 1368 kJ B) 684 kJ C) 2736 kJ D) 808 kJ

_____27. For the following reaction as written: $2\ C_6H_{6(l)} + 15\ O_{2(g)} \rightarrow 12\ CO_{2(g)} + 6\ H_2O_{(l)}$
$\Delta H^o = -6542$ kJ.

Find the heat of formation of $C_6H_{6(l)}$

A) 49 kJ/mol B) –49 kJ/mol C) 98 kJ/mol D) –98 kJ/mol

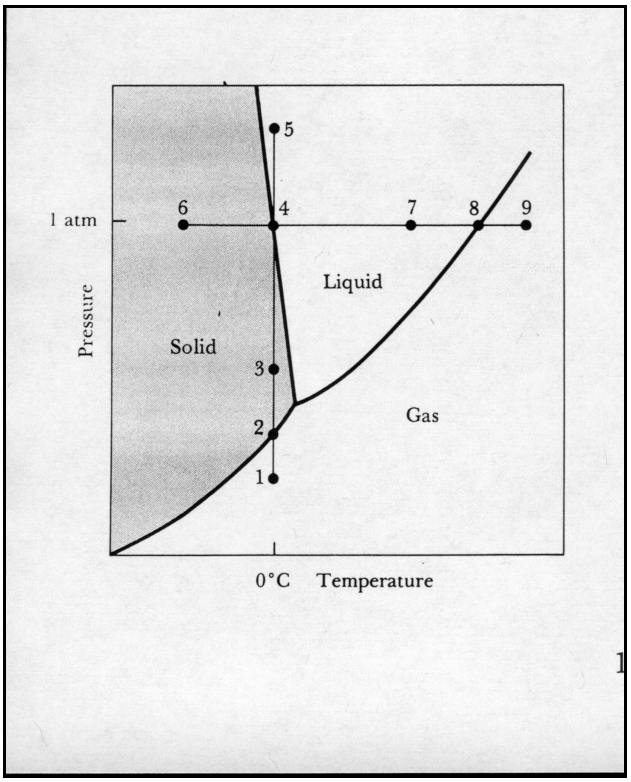
_____28. Which element is expected to have the smallest first ionization energy?
A) Be B) Na C) F D) O

_____29. Which correctly describes the trends as one moves down group 2 on the periodic table? A) Ionization energies and radii increase B)Ionization energies and radii decrease C) Ionization energies increase, while radii decrease D) Ionization energies decrease, while radii increase

_____30. Ionic bonds form when an atom of bromine bonds to an atom of
A) potassium B) iodine C) carbon D) oxygen

_____31. Hydrogen bonds are used to explain which of the following observations?
A) hydrogen is a diatomic gas at room temperature
B) ethanol, C_2H_5OH, is a liquid at room temperature
C) hydrogen iodide has a higher boiling point than hydrogen bromide
D) HNO_3 is an acid

32 to 35. The diagram to the right is the phase diagram for a certain pure substance.



_____32. The normal boiling point of the substance is illustrated by the point numbered A) 4 B) 6 C) 7 D) 8 E) 9

_____33. The change that occurs when the substance goes from point 3 to point 1 is called A) deposition B) freezing C) sublimation D) melting E) Boiling

_____34. The negative slope of the solid-liquid boundary indicates that
A) the triple point occurs at a lower temperature than the normal freezing point B) the solid would float on the liquid C) the solid is denser than the liquid D) the substance will freeze at higher temperatures upon an increase in pressure.

_____35. What state is this substance in when it is at its normal boiling point, a a pressure of 1.50 atm ? A) solid B) liquid C) gas

_____36. Pure acetic acid has a lower vapor pressure than water when both liquids are at the same temperature. Based on this observation, we can best conclude that compared with water, acetic acid has A) weaker attractions B) lower viscosity C) a higher normal boiling point D) a higher rate of evaporation.

Matching. A) CO_3^{2-} B) ClO_3^- C) SO_2 D) ICl_3 E) I_3^- F) CH_2Cl_2 G) OF_2 H) CS_2

_____37. The molecular geometry is tetrahedral

_____38. A molecule with a dipole moment of zero. (do not choose an ion)

_____39. Molecule or ion is "T" shaped

_____40. Molecule or ion is bent, while electron geometry is trigonal planar.

_____41. Molecule or ion has the same shape and structure as the nitrate ion.

_____42. Molecule or ion has the same geometry as a sulfite (SO_3^{2-}) ion

_____43. There is resonance, as a bond is distributed over **three** bonding positions.

MOLECULAR geometries.

A) bent B) trigonal planar (triangular) C) trigonal pyramid D) square-based pyramid

E) Linear F) square planar G) see-saw, or saw horse. H) trigonal bipyramid

_____44. H_2S

_____45. SO_3

_____46. XeF_2

_____47. SF_4^{2-}

_____48. SF_4

_____49. PF_5

_____50. ICl_5

Longer items:

I. (8 pts) A. Draw the Lewis dot structure of a nitrate ion, NO_3^-

B Find the formal charge on each of the atoms in the structure.

C. What is the molecular geometry?

D. Is resonance a factor in your diagram? Why or why not?

II. The formula for hypochlorous acid is sometimes written as HClO, and sometimes as HOCl.

A.Draw the two dot structures, one with the Cl in the middle, and the other with the O in the middle

B. Find the formal charge of each of the atoms in both of your structures.

C. On the basis of formal charge, which is the more likely correct structure?

(6)

III. Given the reaction $2\ Al(s) + 3\ H_2SO_4(aq) \rightarrow Al_{2(}SO_4)_3\ (aq) + 3\ H_2(g)$

A. Determine the **volume** of hydrogen produced when 0.200 **mole** of aluminum reacts with excess 4.00 molar H_2SO_4. The hydrogen is collected at 25° C and a pressure of 760. torr. (1.00 atmosphere).

B. What is the minimum volume of 4.00 molar H_2SO_4 solution that will be sufficient to completely react the entire 0.200 mole of Al ?

IV. A metal tank with a fixed volume of 10.00 liters contains oxygen gas at a pressure of 5.00 atm. measured at a temperature of 27°C. 23.00 grams of C_2H_5OH (ethanol) is added to the tank. A spark ignites the mixture, which reacts until one of the components is used up. (7 pts + 3 E.C.)

The reaction that occurs is $C_2H_5OH(\ell) + O_2(g) \rightarrow CO_2(g) + H_2O(\ell)$

A. Balance the equation.

B. Find the initial number of moles of ethanol, and the initial number of moles of oxygen.

C. Assuming that the liquid water does not occupy any significant volume, find the pressure exerted by the CO_2 gas that is produced in the reaction when the temperature is brought back to 27°C.

D. (3 pts extra) Calculate the amount of heat, in kilojoules, that is produced in this reaction.

V. Antifreeze has the formula $C_2H_4(OH)_2$. (MM = 62)

A solution is prepared using 500 grams of water and 100 grams of antifreeze. Find, for this solution (12 pts)

A. the molality of antifreeze

B. the normal freezing point

C. the mole fraction of water

D. the vapor pressure of the water when this solution reaches a temperature of 100°C.