

Time: 2 1/4 hours

Chemistry 200
Basic Chemistry
Final Exam

August 25, 1997
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Name: _____

Student Number: _____

Major: _____

Useful Information

Avogadro's number: $N_A = 6.023 \times 10^{23}$ molec/mol

Gas constant: $R = 0.08206$ L atm/mol K

Ion product of water $K_w = 1.00 \times 10^{-14}$

Planck's constant: $h = 6.626 \times 10^{-34}$ J s

Speed of light $c = 2.998 \times 10^8$ m/s

<u>Indicator</u>	<u>Color in acid</u>	<u>Color in base</u>	<u>pH range</u>
Phenolphthalein	colorless	pink	8.3 - 10.0
Bromothymolblue	yellow	blue	6.0 - 7.6
Methyl orange	orange	yellow	3.1 - 4.4

<u>Electronegativities:</u>	P	Br	Hg	Cl	O	H	C
	2.1	2.8	1.9	3.0	3.5	2.1	2.5

I. /122
II. /30
III. /24
IV. /24

TOTAL /200

Good Luck

I. (122 pts) In nearly all of the following questions, one of the proposed answers is correct.

Only the questions marked with an asterisk (*) could admit more than one correct answer.

Circle the letter corresponding to the correct answer(s).

1. A small rock has a mass of 55.0 g. The rock is placed in a graduated cylinder containing water. The water level in the cylinder changes from 25.0 cm^3 to 40.0 cm^3 when the rock is submerged. The density of the rock is:

- a. 2.20 g/cm^3
- b. 3.67 g/cm^3
- c. 1.38 g/cm^3
- d. 0.846 g/cm^3
- e. 1.18 g/cm^3

2. Which of the following is equivalent to 61.6 m^2 ?

- a. 6160 cm^2
- b. $6.16 \times 10^6 \text{ mm}^2$ ✓
- c. $61.6 \times 10^{-2} \text{ dm}^2$
- d. $6.16 \times 10^4 \text{ mm}^2$
- e. $6.16 \times 10^{-5} \text{ km}^2$

3. A chocolate milk shake has an average density 2.00 g/cm^3 . The volume of the container that holds it is 250 cm^3 . The milk shake consists of 90.0% milk products and 10.0% chocolate powder by volume. Assuming that density of the milk is 1.50 g/cm^3 , calculate the mass of chocolate powder that was used to make the drink.

- a. 162 g
- b. 37.5 g
- c. 50.0 g
- d. 43.8 g
- e. 87.5 g

*4. Which of the following processes involves a chemical change?

- a. Glucose dissolves in water
- b. Ice melts
- c. Bread becomes moldy
- d. A piece of wood is sawed
- e. A match burns
- f. Food is digested
- g. Iodine dissolves in carbon tetrachloride
- h. Tooth decaying

5. A hypothetical element Z exists in two isotopic forms ^{50}Z and ^{52}Z . The atomic mass of Z is 50.50. The percentage abundance of each isotope is:

- a. 49.0% ^{50}Z ; 51.0% ^{52}Z
- b. 80.0% ^{50}Z ; 20.0% ^{52}Z
- c. 75.0% ^{50}Z ; 25.0% ^{52}Z
- d. 50.0% ^{50}Z ; 52.0% ^{52}Z
- e. 65.3% ^{50}Z ; 34.7% ^{52}Z

6. What is the mass of one molecule of B_2H_6 ?

- a. 27.67 g
- b. 9.188×10^{-23} g
- c. 2.756×10^{-22} g
- d. 4.594×10^{-23} g
- e. 2.297×10^{-23} g
- f. 7.657×10^{-23} g

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7. Allicin is the compound responsible for the characteristic smell of garlic. An analysis of the compound gives the following percent composition by mass: C: 44.4% ; H: 6.21% ; S: 39.5% ; O: 9.86%. The molar mass of the compound is found to be 162 g/mol. The molecular formula of the compound is:
- $C_6H_{10}S_2O$
 - $C_8H_2SO_2$
 - $C_7H_{14}SO_2$
 - $C_3H_{14}S_2O_3$
 - $C_5H_6S_2O_2$
8. A quantity of 73.0 g of NH_3 gas is mixed with an equal mass of HCl. The mass of the solid NH_4Cl formed is:
- 107 g
 - 122 g
 - 229 g
 - 115 g
 - 336 g
9. The volume of the gas remaining in the container (from the previous question) measured at $14.0^\circ C$ and 752 mm Hg is:
- 2.66 L
 - 47.6 L
 - 54.6 L
 - 102 L
 - 150 L

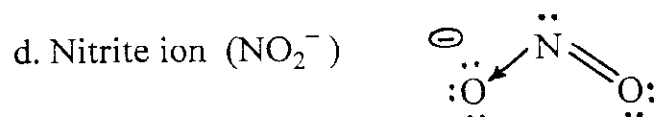
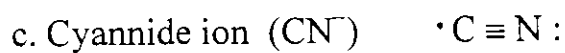
10. Calculate the density of hydrogen bromide (HBr) gas at 733 mm Hg and 46°C.

- a. 2.15 g/L
- b. 2.98 g/L
- c. 3.09 g/L
- d. 3.48 g/L
- e. 3.61 g/L

11. Which of the following ordering is the correct one for **decreasing** ionization energy of the elements shown?

- a. C>N>O>S>Se
- b. O>N>C>S>Se
- c. O>N>C>Se>S
- d. N>O>C>S>Se
- e. N>O>C>Se>S

*12. Which of the following is an acceptable Lewis structure for the indicated chemical species?



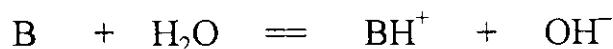
13. The following are five sets of quantum numbers. Each set is followed by the maximum number of electrons in an atom that can possess the proposed set. In which of these sets is the number of electrons wrong?

- a. $n = 4, l = 2$; 10 electrons.
- b. $n = 5, l = 3, m = -1$; 2 electrons.
- c. $n = 3, l = 3$; zero electron.
- d. $n = 3, m = 0$; 4 electrons.
- e. $n = 3, l = 2, m = +1, m_s = -1/2$; one electron.

14. A solution of glucose in water has a boiling point equal to 100.10°C . The freezing point of the solution is:
(For water: $K_b = 0.52^\circ\text{C}/m$, $K_f = 1.86^\circ\text{C}/m$)

- a. -0.028°C
- b. -28.1°C
- c. 0.028°C
- d. 0.35°C
- e. -0.35°C

15. A weak base B ionizes according to the equation:



The pH of a 0.300 M solution of this base is 10.66 . The ionization constant K_b of the base is:

- a. 1.52×10^{-3}
- b. 1.60×10^{-21}
- c. 2.08×10^{-7}
- d. 6.96×10^{-7}
- e. 5.40×10^{-5}

16. How many milliliters of an HCl solution which is 20.0% by mass and whose density is 1.098g/mL are needed to prepare 8.00 liters of a 0.155 M solution?

- a. 206 mL
- b. 5.65 mL
- c. 226 mL
- d. 45.8 mL
- e. 641 mL

17. Which of the following elements corresponds correctly to the electronic configuration (in the last-filled sublevels) shown next to it?

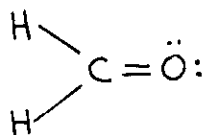
- a. Ag: $5s^2 4d^9$
- b. Mo: $5s^2 4d^4$
- c. Se: $4s^2 3d^{10} 4p^2$
- d. La: $6s^2 4f^1$
- e. Lu: $6s^2 4f^{14} 5d^1$

*18. Which of the following molecules is nonpolar?

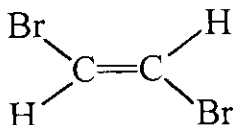
- a. PBr_3
- b. HgCl_2 (covalent not ionic)

c. OCl_2

d. H_2CO



e.



19. 0.50 mg of HCl is dissolved in 2.00 L of water. Two drops of methyl orange indicator are added to the resulting solution. The color of the solution will be:

- a. Red
- b. Yellow
- c. Orange
- d. Pink
- e. Colorless

20. A 0.2688 g sample of a monoprotic acid neutralizes 16.4 mL of 0.08133 M KOH solution. The molar mass of the acid is:

- a. 18.4 g/mol
- b. 54.2 g/mol
- c. 89.0 g/mol
- d. 133 g/mol
- e. 202 g/mol

*21. Which of the following compounds is not an Arrhenius base?

- a. KOH
- b. CH₃COOH
- c. NaOH
- d. Ca(OH)₂
- e. Mg(OH)₂
- f. CH₃OH
- g. Cu(OH)₂
- h. Fe(OH)₃
- i. HOCH₂CH₂OH

22. 73.0 mL of a 0.257 M H_2SO_4 solution are titrated with a sodium hydroxide (NaOH) solution. The volume of titrant used was 50.0 mL. The molarity of the base solution is:
- a. 0.352 M
 - b. 0.375 M
 - c. 0.416 M
 - d. 0.750 M
 - e. 0.176 M
23. A 0.0560 g quantity of acetic acid (molar mass 60.05 g/mol) is dissolved in enough water to make 50.0 mL of solution. Given that for acetic acid $K_a = 1.80 \times 10^{-5}$, the pH of the solution is:
- a. 6.47
 - b. 3.24
 - c. 3.02
 - d. 1.73
 - e. 1.25
24. What is the momentum ($p=mv$) of a light photon whose energy is 9.93×10^{-19} J? (Hint: use DeBroglie's relation)
- a. $3.31 \times 10^{-29} \text{ kg m s}^{-1}$
 - b. $1.50 \times 10^8 \text{ kg m s}^{-1}$
 - c. $6.67 \times 10^{-23} \text{ kg m s}^{-1}$
 - d. $5.43 \times 10^{-28} \text{ kg m s}^{-1}$
 - e. $3.31 \times 10^{-27} \text{ kg m s}^{-1}$

II. (30 pts) Complete the missing information:

A _____ is a small packet of energy and is sometimes viewed as a light _____.

The energy released by say, a chlorine atom when an electron is added to it is called the _____ of the atom.

The model of the kinetic theory of gases (KTG) is based on the picture that molecules are _____ and that the intermolecular forces are _____.

The conjugate acid of the H_2O molecule is H_3O^+ and its conjugate base is OH^- .

When a liquid is in equilibrium with its vapor, the rate of _____ is equal to the rate of _____. Hence the two processes do not stop when equilibrium is established and the equilibrium is said to be _____.

If _____ mL of a 0.850 M salt solution are pipetted and transferred quantitatively to a 250 mL volumetric flask and then the solution is made up to the mark, the resulting solution has a molarity of 0.102 M.

In the Bohr model of the hydrogen atom, the electron orbits around the nucleus in _____ trajectories, each representing a discrete _____.

When considered on a very small scale (such as that of atoms and molecules), matter manifests itself both as _____ and as _____. This dual nature of matter is known as the _____.

4.00 g of sugar of formula $\text{C}_{12}\text{H}_{22}\text{O}_{11}$ contain _____ hydrogen atoms.

A solution containing 2.50 g of a protein of molar mass 1.8×10^5 g/mol in 100 mL of water exhibits an osmotic pressure of _____ mm Hg at 300 K.

The element Polonium (Po) is in group _____ and period _____ .

III. (24 pts) Write balanced chemical equations for each of the following chemical reactions.

1. The preparation of carbonic acid (H_2CO_3) from a suitable nonmetal oxide.
2. The preparation of $\text{Cu}(\text{OH})_2$ from a metal oxide.
3. The preparation of the salt FeCl_2 from the metal Fe.
4. The preparation of AlCl_3 from the elements.
5. The reaction of phosphoric acid (H_3PO_4) with calcium hydroxide $\text{Ca}(\text{OH})_2$.
6. The reaction of nitrogen pentoxide (N_2O_5) with sodium hydroxide (NaOH).

IV. (24 pts) Sketch qualitatively and label **CLEARLY** diagrams for each of the following:

1. The plot of the volume (V) of a gas versus temperature (t) in $^{\circ}\text{C}$ at constant pressure. On the graph, give the slope and the intercept of the plot.

2. A plot of temperature versus energy (or time of continuous energy supply) for a substance undergoing phase changes solid to liquid to gas. Indicate on the diagram the melting point and the boiling point of the substance.

3. A plot of the variation of vapor pressure of a liquid with temperature.
Indicate the boiling point of the liquid.

4. A $2p_x$ orbital and a $2s$ orbital showing the nodal zones.