Name: _____(Please print) I.D. Number: _____

CHEM 205 - SECTION 53 - MID TERM EXAM

February 29th, 2016; 18:00 – 19:15 Instructor: P.H. Bird

Instructions:

THIS IS A CLOSED BOOK EXAM and NO MATERIALS ARE TO BE SHARED.

- Please attempt all questions and read the instruction to each section carefully
- The periodic table attached is the only one you are allowed to use. Please, do **not** tear it off.
- Blank space on page 7 is provided for rough work.
- Calculators are allowed.
- No *electronic* dictionaries are allowed.
- Cell phones are not allowed. Turn them off and leave them in your bag or coat.
- Please be sure to fill in your name and 8-digit ID on this paper and the "scantron" sheet, both written out, and by filling in the appropriate circles
- **The scantron sheets MUST be filled in with a PENCIL**

Please do not write in this space.

Section I	Section II	Section III	Total
/5	/30	/7	/42

Section I. Complete each of the following five statements with the appropriate word(s). They are worth 1 mark each question.

1. Pure carbon can exist in several forms, known as __allotropes__. Examples include diamond, graphite, and buckminsterfullerene.
2. Mendeleev's original periodic table placed the elements in order of increasing _atomic__ _masses_, while the modern periodic table places the elements in order of increasing _atomic__ __numbers__.
3. In their reactions to form ionic compounds, metals generally lose electrons to become _cations___, and nonmetals generally gain electrons to become _anions____.
4. A(n) __reducing_____ agent loses electrons in an redox reaction.
5. The net ionic equation for the reaction of iron(II) chloride and potassium oxalate is shown below.

   $Fe^{2+}(aq) + C_2O_4^{2-}(aq) \rightarrow FeC_2O_4(s)$

   The chloride and potassium ions are referred to as __spectator__ ions because they are not involved in the reaction.

Section II. The following 15 questions are multiple choice. They are worth 2 marks each. You may do rough work on your exam paper, but it will not be marked. You *must* mark your answers *using a soft pencil* on the machine readable answer ("scantron") form provided. *Do not forget to mark your name and student number. (Your birth date and sex is of no interest to me!)*

1. According to the kinetic-molecular theory of matter, particles in a gas
   a. Are packed closely together in a regular array.
   b. Are packed closely together like solids, but they are not confined to specific positions.
   c. Are randomly distributed throughout the entire container.
   d. Vibrate back and forth about an average position.
   e. Move slower as the temperature increases.
2. A piece of metal with a mass of 33.2 g is submerged in 10.0 mL of water in a graduated cylinder and the volume rises to 22.3 mL. What is the density of the metal?
   a. Magnesium, 1.74 g/cm^3
   b. Aluminum, 2.70 g/cm^3
   c. Copper, 8.96 g/cm^3
   d. Silver, 10.5 g/cm^3
   e. Iron, 7.87 g/cm^3

   Density = mass/volume
   = 33.2/(22.3 – 10.0)

3. Two electronic balances are tested using a standard weight. The true mass of the standard is 1.3111 g. The results of 5 individual measurements on each balance are recorded below.

	Balance A	Balance B
	0.8888 g	1.3110 g
	0.9959 g	1.3109 g
	1.1182 g	1.3111 g
	1.0033 g	1.3110 g
	0.9918 g	1.3110 g
average mass =	0.9996 g	1.3110 g

Which statement best describes the comparative results for the two balances?

a. A: better precision, better accuracy. B: better precision, better accuracy.
b. A: better precision, better accuracy. B: worse precision, worse accuracy.
c. A: worse precision, better accuracy. B: better precision, better accuracy.
d. A: worse precision, worse accuracy. B: better precision, better accuracy.
e. A: worse precision, worse accuracy. B: better precision, worse accuracy.

4. J. J. Thomson determined the charge to mass ratio of electrons by

a. Creating a charge on amber by rubbing it with a cloth.
b. Deflecting cathode rays with magnetic and electric fields.
c. Exposing photographic plates to radioactive uranium ores.
d. Striking a beryllium target with particles emitted from radioactive polonium.
e. Bombarding gold foil with alpha particles.

5. What is the atomic symbol for an element that has 30 neutrons and a mass number of 55?

a. Cs
b. At
c. Zn
d. Hg
e. Mn

6. Which gaseous element comprises over three quarters of the Earth's atmosphere?

a. nitrogen
b. helium
c. oxygen
d. argon
e. hydrogen

7. What is the correct formula for an ionic compound that contains aluminum ions and carbonate ions?

a. $AlCO_3$
b. $Al(CO_3)_2$
c. $Al(CO_3)_3$
d. $Al_2(CO_3)_3$ $2 \times Al^{3+}$, $3 \times CO_3^{2-}$
e. $Al_3(CO_3)_2$

8. All of the following statements concerning ionic compounds are correct *except*

   a. As the ion charges increase, the attraction between the ions increases.
   b. Ionic compounds form extended 3-dimensional networks called crystal lattices.
   c. Although not ductile like metals, ionic compounds are often malleable.
   d. Positive and negative ions are attracted to each other by electrostatic forces.
   e. Ionic crystals tend to be rigid, and they cleave along planes.

9. The compound P_4S_3 is used in matches. It reacts with oxygen to produce P_4O_{10} and SO_2. The balanced chemical equation is shown below.

   $$P_4S_3(s) + 8O_2(g) \rightarrow P_4O_{10}(s) + 3SO_2(g)$$

   What mass of O_2 will react with 0.641 grams of P_4S_3?

   a. 0.0466 g
   b. 0.0932 g
   c. 0.186 g
   d. 0.372 g
   e. 0.746 g

   Mol. Mass P_4S_3 = 220.09, O_2 = 32.00
   Mols of P_4S_3 = 0.641/220.09 = 2.912×10^{-3}
   $\therefore$ Mols O_2 = $2.912 \times 10^{-3} \times 8 = 0.02330$
   Mass of O_2 = 0.02330 x 32.00

10. A white solid is either $Pb(NO_3)_2$ or $Zn(NO_3)_2$. If an aqueous solution is prepared, which reagent will allow you to distinguish between the two compounds by the formation of a precipitate?

    a. KBr
    b. HNO_3
    c. CH_3CO_2H
    d. NH_4ClO_4
    e. $LiNO_3$

    Because $PbBr_2$ is insoluble

11. What is the oxidation number of each atom in sodium perbromate, $NaBrO_4$?

    a. Na = +1, Br = –1, O = –2
    b. Na = +1, Br = +1, O = –2
    c. Na = +1, Br = +7, O = –2
    d. Na = –1, Br = –1, O = +2
    e. Na = +1, Br = –1, O = 0

    In BrO_4^-:
    Ox # Br + 4 x (ox # O) = –1
    Ox # Br + 4 x (–2) = –1
    Ox # Br = +7

12. An aqueous hydrochloric acid solution has a pH of 4.15. What mass of HCl is present in 1.0 L of this solution?

    a. 7.2×10^{-5} g
    b. 2.6×10^{-3} g
    c. 0.58 g
    d. 23 g
    e. 150 g

    Molarity = $10^{-4.15}$ = 7.08×10^{-5} mol L^{-1}
    Mass HCl in 1 L = 7.08×10^{-5} x (1.008 + 35.45)

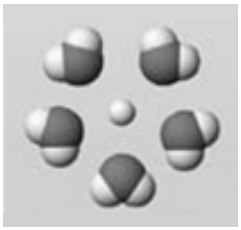
13. Which of the following is normally stored under oil to prevent its reaction with oxygen (from the air) and water?

    a. White phosphorus
    b. Red phosphorus
    c. Sodium
    d. Hydrogen
    e. Sulphur

14. When water is heated *but before it boils*, bubbles form and rise to the surface. What do the bubbles contain?

a. Hydrogen
b. Hydrogen and oxygen
c. Water vapour
d. Mostly air (oxygen and nitrogen) and some water vapor
e. H^+ and OH^- ions

15. Which statement about this dissolved ion surrounded by water molecules is <u>*correct*</u>?



a. The water molecules direct their O atoms towards the ion because the water molecules can pack together more efficiently that way.
b. Based on the orientation of the water molecules we can tell that the ion is a cation.
c. Based on the orientation of the water molecules we can tell that the ion is an anion.
d. The picture correctly represents the water molecules arranged in a "flat" pentagon around the ion.
e. always be five water molecules regardless of the size of the ion.

Section III. Answer the following 2 question with *complete* written answers on this exam paper. Use the next page for rough work, or if you need more space. *Be sure to provide some explanation of the steps in your calculations in words.* No explanation - half-marks *max*!

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1. (3 marks) Bromine has two naturally occurring isotopes. The average mass of natural bromine is 79.904 u. If 50.54% of bromine is found as bromine–79 (78.9183 u), what is the atomic mass of the other isotope, and its probable identity?

The observed average mass of an element with several isotopes is an average weighted by the natural abundance fractions. For just two isotopes, this would be:

Average mass = mass isotope 1 x abundance isotope 1 + mass isotope 2 x abundance isotope 2

So: 79.904 = 0.5054 x 78.9183 + (1 – 0.5054) x mass isotope 2

Mass isotope 2 = 80.91 u (N.B. the answer is limited to 4 sig. figs. by the given % abundances.)

Rounding to the nearest whole number suggests the other isotope is bromine-81, ^{81}Br

2. (4 marks) Sulfur trioxide is made industrially from the reaction of sulfur dioxide and oxygen. How many tons of SO_3 can be made from the reaction of 3.00 tons SO_2 with 2.02 tons O_2? (One metric ton is 1000 kg)

Balanced equation:

$$2\ SO_2 + O_2 \rightarrow 2\ SO_3$$

Molar masses:	64.04 u	32.00 u	80.07 u

Work in grams and scale up to tons at the end!

Starting quantities (moles)	3.00/64.04 = 0.04682 mol	2.02/32.00 = 0.06313 mol

Required molar ratio $SO_2:O_2 = 2:1 = 2$
The actual molar ratio $= 0.04682:0.063125 = 0.7417$ which is < 2
$\therefore$ O_2 is in excess, and SO_2 is the limiting reagent.

Quantity in moles of SO_3 that can be made:
= moles of the SO_2 consumed
= 0.04682 mol
$\equiv 0.04682 \times 80.07 = 3.74$ g

Simply scaling up from grams to tons, 3.74 tons of SO_3 can be produced.

Working throughout in tons is OK, too: just a bit more work writing the big numbers down!

Do not report impossible results! Only about 5 tons of material went into the reaction so the answer could not possibly exceed that total mass.

Use this space below for rough work or continuation of the Section III answers.

Periodic Table of the Elements

1																	18
1 **H** 1.008	2											13	14	15	16	17	2 **He** 4.00
3 **Li** 6.941	4 **Be** 9.012											5 **B** 10.81	6 **C** 12.01	7 **N** 14.007	8 **O** 15.999	9 **F** 18.998	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** 47.87	23 **V** 50.94	24 **Cr** 52.00	25 **Mn** 54.94	26 **Fe** 55.85	27 **Co** 58.93	28 **Ni** 58.69	29 **Cu** 63.55	30 **Zn** 65.39	31 **Ga** 69.72	32 **Ge** 72.61	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** (97.91)	44 **Ru** 101.07	45 **Rh** 102.91	46 **Pd** 106.42	47 **Ag** 107.87	48 **Cd** 112.41	49 **In** 114.82	50 **Sn** 118.71	51 **Sb** 121.76	52 **Te** 127.60	53 **I** 126.90	54 **Xe** 131.29
55 **Cs** 132.91	56 **Ba** 137.33	**La-Lu**	72 **Hf** 178.49	73 **Ta** 180.95	74 **W** 183.84	75 **Re** 186.21	76 **Os** 190.2	77 **Ir** 192.22	78 **Pt** 195.08	79 **Au** 196.97	80 **Hg** 200.59	81 **Tl** 204.38	82 **Pb** 207.2	83 **Bi** 208.98	84 **Po** 208.98	85 **At** 209.99	86 **Rn** 222.02
87 **Fr** 223	88 **Ra** 226.03	**Ac-Lr**	104 **Rf** (261)	105 **Db** (262)	106 **Sg** (263)	107 **Bh** (262)	108 **Hs** (265)	109 **Mt** (266)									

57 **La** 138.91	58 **Ce** 140.12	59 **Pr** 140.91	60 **Nd** 144.24	61 **Pm** (145)	62 **Sm** 150.35	63 **Eu** 151.97	64 **Gd** 157.25	65 **Tb** 158.93	66 **Dy** 162.50	67 **Ho** 164.93	68 **Er** 167.26	69 **Tm** 168.93	70 **Yb** 173.04	71 **Lu** 174.97
89 **Ac** 227.03	90 **Th** 232.04	91 **Pa** 231.04	92 **U** 238.03	93 **Np** (237)	94 **Pu** (245)	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)