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CHEMISTRY 205 - SECTION 03 - MID TERM EXAM

March 3rd 2009, 08:45 – 10:00 Instructor: P.H. Bird

Instructions: THIS IS A CLOSED BOOK EXAM and NO MATERIALS ARE TO BE SHARED. Use the backs of the pages for rough work. Please attempt all questions. The periodic table attached is the only one you are allowed to use. No electronic dictionaries are allowed. No cell phones being as calculators are allowed.

Answers: Correct choices: red, Answers or explanations: blue, Editorial Comments: green

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

1. A mixture such as iron filings and sand is called a heterogeneous mixture.
2. A neutron is an atomic particle with a mass of about 1 atomic mass unit, and no charge.
3. A series of measurements which agree very closely with each other would be called precise.
4. The elements in group 1 of the periodic table are called the alkali metals.
5. The compound N_2O_5 would be called dinitrogen pentoxide.

Section II. The following 14 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 form provided. Do not forget to mark your name and student number (your birth date is not required).

1. Which statement concerning NaCl is true?
 - a. NaCl has properties similar to sodium metal and chlorine gas.
 - b. NaCl is a homogeneous mixture.
 - c. NaCl is a heterogeneous mixture.
 - d. The percentage of Na in NaCl is dependent on where the sample is obtained.
 - e. NaCl is composed of ions, which are electrically charged atoms.
2. All of the following are examples of chemical change EXCEPT
 - a. the condensation of steam.
There is no change in the H_2O molecules; only a physical change.
 - b. the rusting of iron.
 - c. the combustion of propane gas.
 - d. the tarnishing of silver.
 - e. the decomposition of water to hydrogen gas and oxygen gas.

3. A common wavelength of light emitted from a red laser pointer is 6.50×10^2 nm. What is the wavelength in meters?
- 6.50×10^{-9} m
 - 6.50×10^{-7} m**
 - 6.50×10^{-5} m
 - 6.50×10^{-3} m
 - 6.50×10^0 m

$$1 \text{ nm} = 10^{-9} \text{ m}$$

4. From the results of his gold foil experiment with alpha particles, Ernest Rutherford concluded that
- electrons have a charge of -1.602×10^{-19} C.
 - atoms contain roughly equal numbers of neutrons and protons.
 - atoms are composed of a small, dense nucleus surrounded by a cloud of electrons.**
 - many atoms have radioactive isotopes.
 - alpha particles are helium nuclei.
5. Lithium has two stable isotopes with masses of 6.01512 amu and 7.01600 amu. The average molar mass of Li is 6.941 amu. What is the percent abundance of each isotope?
- 62.99% Li-6 and 37.01% Li-7
 - 50.00% Li-6 and 50.00% Li-7
 - 12.22% Li-6 and 87.78% Li-7
 - 7.493% Li-6 and 92.51% Li-7**
 - 5.821% Li-6 and 94.18% Li-7

The average molar (atomic in this case) mass is the weighted average of the isotopic masses.

Let P be the percentage of the Li-6 (${}^6\text{Li}$) isotope. Then:

$$6.941 = 6.01512 \times (P)/100 + 7.01600 \times (100 - P)/100$$

$$P = 7.493\%, \text{ and the percentage of } {}^7\text{Li} \text{ is } 92.51\%.$$

6. Identify the ions in $(\text{NH}_4)_2\text{SO}_4$.

- N^{3-} , H^+ , S^{2-} , and O^{2-}
- NH_2^{2+} and H_2SO_4
- NH_4^+ and SO_4^{2-}**

You need to recognize the ammonium ion, NH_4^+ , and the sulphate ion, SO_4^{2-} .

- NH_4^{2+} and SO_4^{2-}
- NH_4^+ and SO_4^-

7. Which atom is most likely to form a +2 ion?

- K
- C
- Kr
- Ba**

A +2 ion is most likely to be formed by a group 2 metal, i.e. Ba.

- Se

8. What is the correct formula for aluminum sulfide?

- a. AlSO_3
- b. $\text{Al}_2(\text{SO}_4)_3$
- c. AlS
- d. $\text{Al}_3(\text{SO}_3)_2$
- e. Al_2S_3

You need to know that aluminum is most often Al^{3+} in its compounds, and sulphide is S^{2-} . The resulting compound must be electrically neutral.

9. What is the correct name of $\text{Sc}_2(\text{SO}_4)_3$?

- a. scandium trisulfite
- b. scandium(III) sulfate

If you recognize SO_4^{2-} as sulphate, you can figure out that the scandium has to be present as the +3 ion. The correct naming of this ion is scandium(III).

- c. scandium(II) sulfide
- d. scandium(III) sulfur tetraoxide
- e. scandium(III) trisulfate

10. What is the molar mass of cobalt(II) chloride hexahydrate?

- a. 94.39 g/mol
- b. 202.5 g/mol
- c. 237.9 g/mol
- d. 135.9 g/mol
- e. 129.8 g/mol

Cobalt chloride comes as red crystals of the hexahydrate, $\text{CoCl}_2 \cdot 6\text{H}_2\text{O}$.
The molar mass = $58.93 + 3 \times 35.45 + 6 \times (16.00 + 2 \times 1.008)$

11. Which one of the following compounds is a *weak* electrolyte when dissolved in water?

a. NaBr

A salt – completely ionized in aqueous solution.

b. $\text{Cu}(\text{NO}_3)_2$

A salt – completely ionized in aqueous solution.

c. NH_3

$\text{NH}_3(\text{aq}) + \text{H}_2\text{O}(\text{l}) \rightleftharpoons \text{NH}_4^+(\text{aq}) + \text{OH}^-(\text{aq})$ (Equilibrium well to the left.)

d. KOH

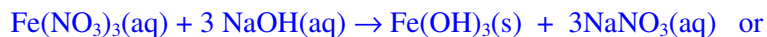
A strong base – completely ionized in aqueous solution.

e. CaCl_2

A salt – completely ionized in aqueous solution.

12. What is the net ionic equation for the reaction of sodium hydroxide with iron(III) nitrate?

- a. $3 \text{Na}^+(\text{aq}) + \text{Fe}^{3+}(\text{aq}) \rightarrow \text{Na}_3\text{Fe}(\text{s})$
- b. $\text{NaOH}(\text{aq}) + \text{FeNO}_3(\text{aq}) \rightarrow \text{FeOH}(\text{s}) + \text{NaNO}_3(\text{aq})$
- c. $\text{Fe}^{3+}(\text{aq}) + 3 \text{NO}_3^-(\text{aq}) \rightarrow \text{Fe}(\text{NO}_3)_3(\text{s})$
- d.** $\text{Fe}^{3+}(\text{aq}) + 3 \text{OH}^-(\text{aq}) \rightarrow \text{Fe}(\text{OH})_3(\text{s})$
- e. $\text{Na}^+(\text{aq}) + \text{NO}_3^-(\text{aq}) \rightarrow \text{NaNO}_3(\text{s})$



(You need to know that most hydroxides are not soluble in water.)

13. What is the oxidation number of phosphorus in CaHPO_4 ?

- a. -3
- b. -1
- c. +1
- d. +3
- e.** +5

The compound consists of Ca^{2+} and hydrogen phosphate, HPO_4^{2-} .

In this ion, the hydrogen has oxidation number +1, and oxygen has oxidation number -2 so:

$$+1 + (\text{oxidation number of P}) + 4 \times (-2) = -2.$$

14. If 5.00 mL of 1.66×10^{-1} M HCl is diluted to exactly 250.0 mL with water, what is the concentration of the resulting solution?

- a.** 3.32×10^{-3} M
- b. 1.33×10^{-2} M
- c. 1.45×10^{-2} M
- d. 4.07×10^{-2} M
- e. 8.30 M

Use $M_1 \times V_1 = M_2 \times V_2$, where M_1 and M_2 are the initial and final concentrations, and V_1 and V_2 are the initial and final volumes.

Section III. Answer the following 3 question with complete written answers on the this exam paper. They are worth 5 marks each. Use the backs of the pages for rough work, or if you need more space. Be sure to provide adequate explanations or details to justify you answers where it is appropriate. No explanation - half-marks max!

1. Spinach has a high iron content (2 mg/90 g serving). However, it is also a source of the oxalate ion, $\text{C}_2\text{O}_4^{2-}$, which combines with iron ions to form an iron oxalate, $\text{Fe}_x(\text{C}_2\text{O}_4)_y$, which prevents your body from absorbing the iron. Analysis of a 0.109 g sample of the iron oxalate shows that it contains 38.82% iron. What is the empirical formula of the compound, and what is the oxidation state of the iron?

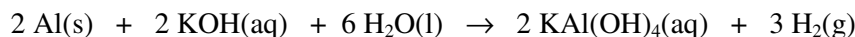
This problem is has a lot of extra unneeded information, including the mass of the iron oxalate analysed, (the 0.106 g).

100 g of the compound contains 38.82 g of Fe $\equiv 38.82 \text{ (g)} / 55.85 \text{ (g mol}^{-1}\text{)} = 0.6951 \text{ mol Fe}$

100 g of the compound contains 61.18 g of $\text{C}_2\text{O}_4^{2-}$ ion $\equiv 61.12 \text{ (g)} / 88.02 \text{ (g mol}^{-1}\text{)} = 0.6951 \text{ mol C}_2\text{O}_4^{2-}$

The empirical formula is obviously $\text{Fe}(\text{C}_2\text{O}_4)$, and the oxidation state of the iron is iron(II) or ferrous iron.

2. You can dissolve an aluminium soft drink can in an aqueous base such as potassium hydroxide solution:



If you place 2.05 g of aluminum in a beaker and add 185 mL of 1.35 M KOH solution, will any aluminium remain? What mass of KAl(OH)_4 could be obtained from the solution?

The starting materials are:

$2.05 \text{ g Al} \equiv 2.05 \text{ (g)} / (26.98) \text{ (g mol}^{-1}\text{)} = 0.07598 \text{ mol Al.}$

A solution containing $(185.0/1000) \text{ (L)} \times 1.35 \text{ (mol L}^{-1}\text{)} = 0.2498 \text{ mol KOH or OH}^-$

To find which, if any, is the limiting reagent, compare the mole ratio with the stoichiometric ratio:

Theoretical moles Al / moles $\text{OH}^- = 2 / 2 = 1$

Actual moles Al / moles $\text{OH}^- = 0.07598 / 0.2498 = 0.7398$

Therefore, Al is the limiting reagent, and will determine the maximum amount of KAl(OH)_4 that can be produced. After the reaction, there will be no aluminum left over. From the stoichiometric ratios, each mole of Al produces one mole of KAl(OH)_4 so:

Moles of KAl(OH)_4 produced = 0.07598 mol

$\equiv 0.07598 \times (39.10 + 226.98 + 4 \times (1.008+16.00)) = 10.2 \text{ g KAl(OH)}_4$

