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(to be entered by the teacher)

CHEMISTRY 205/2 Section Lec 52

MID TERM EXAMINATION with ANSWERS

Number of pages: 12

October 19, 2017 6:00 - 7:00pm

Instructor: G. DÉNÈS

Materials allowed: Calculators with no storage capacity
Printed translation dictionaries

Materials NOT allowed: Books, notes
Not your own periodic tables. One is attached to the questionnaire.
No sharing of calculators
No technical/scientific dictionary
No electronic dictionary
No scrap paper. There are extra pages for rough calculation on the
questionnaire.

INSTRUCTIONS:

1. This is a multiple choice examination.
 2. Circle only one answer number for each question. There is only one correct answer for each question.
 3. If you circle more than one answer number for a question, you will get a "zero" for that question.
 4. If you have already circled an answer and you change your mind, erase the other answers, or clearly cross them out. Ambiguous answers will be counted as being wrong.
 5. Only the circle around the question number will count. I will not read any calculation or anything else you may write on the questionnaire.
 6. Do not write anything else on the front of the pages. Use the extra pages on the back of the questionnaire for your calculations.
 7. Answer every question.
 8. All the questions are worth the same mark.
 9. All group numbers used throughout this questionnaire are in the current official numbering system defined by the IUPAC.
 10. When you are finished writing your exam, raise your hand and remain seated. The teacher or the invigilator will come to pick up your questionnaire and have you sign the attendance sheet, after checking your ID card. Do NOT leave your seat until the teacher allows you to.
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***** QUESTIONS START HERE *****

1. Tell which of the observations listed below identify *chemical properties*:

1. When water boils, bubbles are produced.
2. When a gas condenses to give a liquid, heat is evolved.
3. When calcium carbonate is placed in an acid, bubbles are produced.
4. Water boils at 100 °C
5. Ice is less dense than water

Solution: calcium carbonate is the salt of a weak acid. It is decomposed by a strong acid to give the weak acid carbonic acid, that is a solution of CO₂ in water beyond saturation, therefore CO₂ bubbles off. This is a chemical reaction (bonds are broken, new bonds are formed), while in all the other possible answers, no chemical bond is broken, they are physical phenomena.

2. You have a 100.0 mL graduated cylinder containing 50.0 mL of water. You drop a 154 g piece of brass (density $\rho = 8.56 \text{ g/cm}^3$) into the water. What is the final water level in the graduated cylinder?

1. 79.9 mL
2. 68.0 mL
3. 57.1 mL
4. 51.3 mL
5. 48.1 mL

Solution: density = mass/volume $\Rightarrow \rho = m/V \Rightarrow V = m/\rho = 154 \text{ g} / 8.56 \text{ g.cm}^{-3} = 17.99 \text{ cm}^3$
volume of the piece of brass = 19.99 cm³ = 19.99 mL (since 1 cm³ = 1 mL)
Total volume = volume of water + volume of the piece of brass = 50.0 + 17.99 = 67.99 mL
V = 67.99 mL = 68.0 mL with 3 significant figures.

3. Give the *number of significant figures* in 0.01200300

1. 3
2. 5
3. 9

4. 8
5. 7

Solution: Leading zeroes are not significant figures, captive zeroes are always significant figures, and trailing zeroes are also significant zeroes since there is a decimal point $\Rightarrow 0.01200300 \Rightarrow 12$ significant figures.

4. Hydrated nickel(II) chloride is a beautiful green, crystalline compound. When heated strongly, the compound is fully dehydrated to give anhydrous nickel(II) chloride. If 0.235 g of $\text{NiCl}_2 \cdot x \text{H}_2\text{O}$ gives 0.128 g of anhydrous nickel(II) chloride on heating, what is the value of x ?

1. 8
2. 6
3. 5
4. 4
5. 2

Solution:

$$\text{NiCl}_2: m = 0.128 \text{ g}, n = m/M = 0.128 \text{ g} / 129.59 \text{ g}\cdot\text{mol}^{-1} = 9.8773 \times 10^{-4} \text{ mol}(\text{BaCl}_2)$$

$$m(\text{H}_2\text{O}) = m(\text{NiCl}_2 \cdot x\text{H}_2\text{O}) - m(\text{NiCl}_2) = 0.235 \text{ g} - 0.128 \text{ g} = 0.107 \text{ g}$$

$$\text{H}_2\text{O}: m = 0.107 \text{ g}, n = m / M = 0.107 \text{ g} / 18.015 \text{ g}\cdot\text{mol}^{-1} = 5.9395 \times 10^{-3} \text{ mol}(\text{H}_2\text{O})$$

$$x = 5.9395 \times 10^{-3} \text{ mol}(\text{H}_2\text{O}) / 9.8773 \times 10^{-4} \text{ mol}(\text{BaCl}_2) = 6.013 \approx 6$$

$$\Rightarrow \text{NiCl}_2 \cdot 6\text{H}_2\text{O}$$

5. The artificial element technetium, Tc, is a transition metal and it is used in many medical studies. Give the number of electrons, protons and neutrons in an atom of technetium-99. Circle the correct answer number for each column

	electrons	protons	neutrons
1.	43	43	99
2.	43	43	56
3.	56	56	56
4.	43	56	99
5.	56	43	99

Solution: Tc-99. Periodic table: $Z = 43 \Rightarrow 43$ neutrons and also 43 electrons

Atomic mass (A) = Number of protons (Z) + number of neutrons (N)
 $A = Z + N \Rightarrow N = A - Z = 99 - 43 = 56$ neutrons

6. Tell which of the following element is an *alkaline earth metals*:

1. Mercury
2. Potassium
3. Magnesium
4. Aluminum
5. Copper

Hint: Alkaline earth metals are in group 2.

7. If you have 7.89 mg of the element *krypton*, Kr, tell how many atoms this represents.

1. 9.42×10^{-5} atoms
2. 942 atoms
3. 1.58×10^{19} atoms
4. 5.67×10^{19} atoms
5. 8.47×10^{20} atoms

Solution : number of moles (n) = mass (m) / molar mass (M)

$$n = m/M = [7.89 \text{ mg} \times (1 \times 10^{-3} \text{ kg} / 1 \text{ g})] / 83.80 \text{ g}\cdot\text{mol}^{-1} = 9.4153 \times 10^{-5} \text{ mol}$$

number of atoms = number of moles / Avogadro's number

$$\text{number of atoms} = 9.4153 \times 10^{-5} \text{ mol} \times 6.022 \times 10^{23} \text{ atoms}\cdot\text{mol}^{-1} = 5.67 \times 10^{19} \text{ atoms}$$

8. An unknown compound was found to contain only carbon, hydrogen and nitrogen. Chemical analysis showed it contains 74.0% C and 8.70% H, in mass percent. Its molar mass was measured to be 162 g/mol. What is the empirical formula of nicotine?

1. $\text{C}_6\text{H}_8\text{N}$
2. $\text{C}_8\text{H}_{10}\text{N}$
3. $\text{C}_{10}\text{H}_{14}\text{N}_2$

4. $C_{12}H_{16}N_2$
5. C_5H_7N

Solution: $\%N = 100 - \%C - \%H = 100 - 74.0 - 8.70 = 17.3\%N$

In 100 g of compound, there is:

$m(C) = 74.0 \text{ g}$, $n(C) = m(C) / M(C) = 74.0 \text{ g} / 12.01 \text{ g}\cdot\text{mol}^{-1} = 6.1615 \text{ mol}(C)$

$m(H) = 8.70 \text{ g}$, $n(H) = m(H) / M(H) = 8.70 \text{ g} / 1.008 \text{ g}\cdot\text{mol}^{-1} = 8.6310 \text{ mol}(H)$

$m(N) = 17.3 \text{ g}$, $n(N) = m(N) / M(N) = 17.3 \text{ g} / 14.007 \text{ g}\cdot\text{mol}^{-1} = 1.2351 \text{ mol}(N)$

$\text{mol}(N) \text{ smaller} \Rightarrow C : H : N = 4.99 : 6.99 : 1 \Rightarrow C_5H_7N$

Note: the molar mass is not needed to determine the empirical formula.

9. Choose the correct answer among the following statements about monoatomic ions

1. Cations are larger than the atom that generates them
2. Cations have about the same size than the atom that generates them
3. Anions are smaller than the atom that generates them
4. Anions are larger than the atom that generates them
5. Cations and anions have about the same size as the atom that generates them

Hint: more electrons attracted by the same number of protons \Rightarrow less attraction per electron, and more repulsion by a larger number of electrons

10. Give the names of SnCl_2

1. Tin(II) chloride and stannous chloride
2. Tin(II) chloride and stannic chloride
3. Tin dichloride and stannous chloride
4. Tin dichloride and stannic chloride
5. Dichlorotin(II) and stannous chloride.

Solution: Metal with non-metal \Rightarrow nomenclature of ionic compounds \Rightarrow No prefixes

Oxidation number of Sn = +2 \Rightarrow Sn(II)

+2 is the low oxidation number of Sn \Rightarrow suffix "ous" \Rightarrow stannous

11. An element has an allotropic form that conducts electricity very well and another that does not. The

allotrope that conducts electricity is black colored and soft. The allotrope that does not conduct electricity is colorless and extremely hard. Tell what elements these allotropes belongs to:

1. Phosphorus
2. Carbon
3. Sulfur
4. Silicon
5. Calcium

Solution: Two of the allotropes of carbon are **graphite** (electrical conductor, black color, soft) and **diamond** (electrical insulator, colorless, very hard)

12. Choose the correct names for the two following ways of writing the chemical formula of ethanol.

- | | C_2H_6O | CH_3CH_2OH |
|----|--------------------|--------------------|
| 1. | Condensed formula | Molecular formula |
| 2. | Condensed formula | Structural formula |
| 3. | Molecular formula | Condensed formula |
| 4. | Structural formula | Condensed formula |
| 5. | Molecular formula | Structural formula |
-

13. The chemical composition of a compound is the following in mass %:

C: 53.84 % H: 6.456 % N: 8.971 % S: 10.27 % O: 20.49 %

Determine its empirical formula.

1. $C_{14}H_{20}N_2SO_4$
2. $C_{12}H_{20}NS_2O_4$
3. $C_{14}H_{21}N_2SO_3$
4. $C_{16}H_{22}NSO_2$
5. $C_{16}H_{20}N_2SO_3$

Solution: In 100 g of compound, there are:

$m(C) = 53.84 \text{ g}$, $n(C) = m(C) / M(C) = 53.84 \text{ g} / 12.01 \text{ g}\cdot\text{mol}^{-1} = 4.4829 \text{ mol}(C)$

$m(H) = 6.456 \text{ g}$, $n(H) = m(H) / M(H) = 6.456 \text{ g} / 1.008 \text{ g}\cdot\text{mol}^{-1} = 6.4048 \text{ mol}(H)$

$m(N) = 8.971 \text{ g}$, $n(N) = m(N) / M(N) = 8.971 \text{ g} / 14.007 \text{ g}\cdot\text{mol}^{-1} = 0.64047 \text{ mol}(N)$

$m(S) = 10.27 \text{ g}$, $n(S) = m(S) / M(S) = 10.27 \text{ g} / 32.07 \text{ g}\cdot\text{mol}^{-1} = 0.32023 \text{ mol(S)}$
 $m(O) = 20.49 \text{ g}$, $n(O) = m(O) / M(O) = 20.49 \text{ g} / 15.999 \text{ g}\cdot\text{mol}^{-1} = 1.2807 \text{ mol(O)}$
 $\text{mol(S) smaller} > \text{C} : \text{H} : \text{N} : \text{S} : \text{O} = 14 : 20 : 2 : 1 : 4 \Rightarrow \text{C}_{14}\text{H}_{20}\text{N}_2\text{SO}_4$

14. Choose the formula of sodium carbonate among the following:

1. NaCO_3
2. $\text{Na}(\text{CO}_3)_2$
3. $\text{Na}_3(\text{CO}_3)_2$
4. $\text{Na}_2(\text{CO}_3)_3$
5. Na_2CO_3

Solution: Carbonate = CO_3^{2-} , sodium = $\text{Na}^+ \Rightarrow 2 \text{ Na}^+$ required for each CO_3^{2-} to have electrical neutrality
 $\Rightarrow \text{Na}_2\text{CO}_3$

15. Give the name of SF_4 according to the official system of nomenclature

1. Sulfur fluoride
2. Sulfur(IV) tetrafluoride
3. Monosulfur tetrafluoride
4. Sulfur(IV) fluoride
5. Sulfur tetrafluoride

Solution: S and F are two non-metals \Rightarrow nomenclature of molecular compounds (covalent bonds) \Rightarrow prefixes used.

Fluorine is the most electronegatif \Rightarrow it takes the "ide" suffix \Rightarrow fluoride.

There are 4 F in the molecule \Rightarrow tetrafluoride \Rightarrow Sulfur tetrafluoride

16. The first xenon compound to be prepared was XePtF_6 , where Pt is the transition metal platinum(V). Tell what is the oxidation number of xenon in XePtF_6 ,

1. +8
2. +6
3. +4

4. +2
5. +1

Solution: F has the highest electronegativity and belongs to group 17 => Oxidation number ON(F)

$\text{ON(F)} = 17 - 18 = -1 \Rightarrow -6$ for 6 F

$\text{Pt(V)} \Rightarrow \text{ON(Pt)} = +5$

For electroneutrality, $\text{ON(Xe)} = +1$

17. Tell which of the following compounds is a mixed oxidation state compound

1. FeO
2. MgO
3. PbO
4. CO
5. InO

Solution: Allowed oxidation numbers: +2 allowed in Fe, Mg, Pb, and C

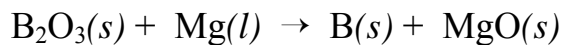
In: allowed: +3 and +1; not allowed: +2 => InO is actually In_2O_3 , i.e. In(I)In(III)O_2 .

18. Tell who measured the mass of the electron.

1. Rutherford
2. Thomson
3. Millikan
4. None of the above
5. Becquerel

Solution: Thomson measured the ratio charge/mass, Millikan measured the charge, hence the mass could be calculated.

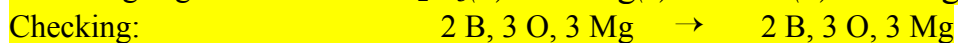
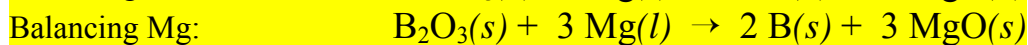
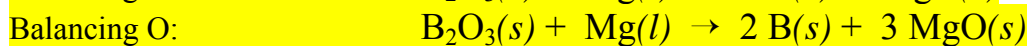
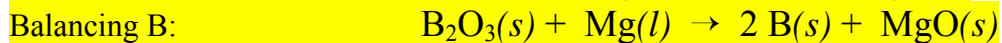
19. Boron element can be prepared by high temperature reaction of boron oxide with aluminum, according to the following unbalanced equation:



Balance the above equation and tell what is the stoichiometric coefficient of Mg.

1. 1
2. 2
3. 3
4. 4
5. 6

Solution:



20. Tell which of the following compounds is the most likely to be insoluble in water

1. Hydrogen fluoride
2. Magnesium nitrate
3. Calcium carbonate
4. Potassium iodide
5. Calcium bicarbonate.

Hint: Use Coulomb's law: product of the charges of the ions equal to -4 in Calcium carbonate, and to -1 or -2 in the others. HF is molecular highly polar.