

Last Name:
First Name:

ID #

on the signature list:
(to be entered by the teacher)

CHEMISTRY 205/2 Section Lec 01

MID TERM EXAMINATION with ANSWERS

Number of pages: 12

October 19, 2017

11:45am - 12:45pm

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.
-

***** QUESTIONS START HERE *****

1. The scientist Charles measured how the volume of gases changes when temperature is changed, all other conditions being the same. He repeated the measurements on many gases, and he found that, in all cases, the volume of the gas increases linearly with increasing temperature. Tell which of the following cases applies to Charles's finding.

1. It is an observation.
2. It is a hypothesis.
3. It is a law.
4. It is a model
5. It is a theory

Hint: Observed all the time under given conditions, no explanation offered.

2. Tell which of the following energies is responsible for the **temperature**:

1. The chemical energy.
2. The kinetic energy.
3. The nuclear energy.
4. The electrostatic energy.
5. The potential energy,

Hint: Atomic vibrations

3. Tell which of the following methods you would use to separate several liquids that have a different boiling points.

1. Chemical reactions.
2. Chromatography
3. Filtration
4. Electrolysis
5. Distillation

Example: separate ethanol from water

4. Elements A and B combine together to give several compounds. When 1.188 g of B combines with 1.000 g of A, the compound obtained has the formula AB_2 . Tell what is the formula of the compound obtained when 0.891 g of B combines with 1.000 g of A.

1. AB
2. A_2B_3
3. AB_3
4. AB_4
5. AB_6

Solution: 1.188 g of B + 1.000 g of A \Rightarrow AB_2 .
0.891 g of B + 1.000 g of A \Rightarrow AB_x , with $x < 2$ since 0.891 g of B < 1.188 g of B
 $0.891 \text{ g of B} / 1.188 \text{ g of B} = 0.75 \Rightarrow x = 2 \times 0.75 = 1.50 \Rightarrow AB_x = AB_{1.50} = A_2B_3$

5. Tell which of the following law was applied in the above question :

1. Proust's law of definite proportions
2. Dalton's law of multiple proportions
3. Dalton's atomic theory
4. Gay-Lussac's law
5. Avogadro's hypothesis

Hint: The composition of two compounds made of the same elements was compared

6. Tell which of the following scientists discovered that most of the mass of the atom is contained in the nucleus.

1. Thomson
2. Marie Curie
3. Ernest Rutherford
4. Henri Becquerel
5. Antoine Lavoisier

7. Tell how much energy would be released if one mole of ^{12}C atoms were fully converted to energy according to the relativity theory

1. 2.8753×10^{22} kJ
2. 7.5656×10^{23} kJ
3. 9.5926×10^6 kJ
4. 1.0785×10^{12} kJ
5. 1.0785×10^{-12} kJ

Solution: $E = mc^2$
mass of 1 mol of $^{12}\text{C} = 12$ g by definition = 1.2×10^{-2} kg
 $c = 2.9979 \times 10^8$ m.s $^{-1}$
 $E = 1.2 \times 10^{-2}$ kg $\times [2.9979 \times 10^8 \text{ m.s}^{-1}]^2 = 10.78488 \times 10^{14}$ kg.m 2 .s $^{-2} = 1.0785 \times 10^{15}$ J
since 1 J = 1 kg.m 2 .s $^{-2}$
 1.0785×10^{15} J $\Rightarrow E = 1.0785 \times 10^{12}$ kJ

8. Give the number of electrons, protons and neutrons contained in $^{63}_{29}\text{Cu}^{2+}$

	Number of electrons	Number of protons	Number of neutrons
1.	27	63	29
2.	54	52	92
3.	29	27	63
4.	29	27	34
5.	27	29	34

Solution: $Z = 29 \Rightarrow 29$ protons
 $2+$ sign $\Rightarrow 29 - 2 = 27$ electrons
number of neutrons = mass number - number of protons = $63 - 29 = 34$

9. The formula of sodium molybdate is Na_2MoO_4 , give the formula of barium (Ba) molybdate

1. Ba_3MoO_4
2. $\text{Ba}_2(\text{MoO}_4)_3$

3. Ba_2MoO_4
4. BaMoO_4
5. $\text{Ba}(\text{MoO}_4)_2$

Solution: Replacing two Na^+ in Na_2MoO_4 , by $x \text{Ba}^{2+}$ requires only one Ba^{2+} to keep electrical neutrality $\Rightarrow x = 1 \Rightarrow \text{BaMoO}_4$

10. Tell what is the oxidation number of oxygen in O_2F_2 .

1. +1
2. +2
3. -1
4. -2
5. -0.5

Hint: F is more electronegative than O, and F has an oxidation number of -1 (17-18).

11. An element is present in large amount in the Earth crust combined to oxygen. It can also be used to make artificial oils and rubbery materials important for repelling water and for their chemical inertness and heat resistance. Tell what is that element.

1. Calcium
2. Silicon
3. Iron
4. Sodium
5. Carbon

Solution: Many rocks are silicates, made of SiO_2 and other metal oxides.

Silicones, containing Si, are water repellants and are more inert chemically and thermally than petroleum based oils.

12. A compound containing only carbon and hydrogen was analyzed by combustion in an excess of oxygen. Some amount of carbon dioxide (not measured) and 42.8 mg of water were produced upon combustion of 47.6 mg of the unknown compound. In a separate experiment, the molar mass of the unknown compound was

measured to be between 115 and 125 g.mol⁻¹. Tell what are the empirical formula and the molecular formula of the unknown compound.

1. C₄H₅ and C₈H₁₀
2. C₃H₄ and C₆H₈
3. C₃H₄ and C₉H₁₂
4. C₂H₆ and C₄H₁₂
5. C₂H₆ and C₆H₁₈

Solution: $0.0428 \text{ g H}_2\text{O} / 18.015 \text{ g.mol}^{-1} \text{ H}_2\text{O} = 2.3758 \times 10^{-3} \text{ mol H}_2\text{O} \Rightarrow 4.7516 \times 10^{-3} \text{ mol H}$ (2 mol H for 1 mol H₂O)

$m(\text{H}) = n(\text{H}) \times M(\text{H}) = 4.7896 \text{ g}(\text{H})$

$m(\text{C}) = m(\text{sample}) - m(\text{H}) = 47.6 \text{ mg} - 4.7896 \text{ mg} = 42.8104 \text{ mg}(\text{C})$

$n(\text{C}) = m(\text{C}) / M(\text{C}) = 0.0428104 \text{ g}(\text{C}) / 12.01 \text{ g.mol}^{-1}(\text{C}) = 3.56456 \times 10^{-3} \text{ mol}(\text{C})$

$n(\text{H}) / n(\text{C}) = 4.7516 \times 10^{-3} \text{ mol} / 3.56456 \times 10^{-3} \text{ mol} = 1.333$

$n(\text{H}) / n(\text{C}) = 1.333 \Rightarrow \text{CH}_{1.333} \Rightarrow \text{empirical formula} = \text{C}_3\text{H}_4$.

$M(\text{empirical formula}) = 3 \times 12.01 \text{ g.mol}^{-1} + 4 \times 1.008 \text{ g.mol}^{-1} = 40.062 \text{ g.mol}^{-1}$

$M(\text{compound}) / M(\text{empirical formula}) = 115 \text{ to } 125 \text{ g.mol}^{-1} / 40.062 \text{ g.mol}^{-1} \approx 3$

$\Rightarrow \text{Formula}(\text{compound}) = \text{Formula}(\text{empirical formula}) \times 3 = \text{C}_3\text{H}_4 \times 3 = \text{C}_9\text{H}_{12}$

13. Tell what is the formula of vanadium(V) oxide.

1. V₂O₅
2. VO₅
3. V₅O₂
4. V₅O
5. V₅O₅

Solution: V(V) \Rightarrow +5 oxidation number \Rightarrow -5 required from O to have the compound electrically neutral

Oxidation number of oxygen = -2 (group 16 \Rightarrow 16-18 = -2) \Rightarrow -2 x 2.5 = -5

$\Rightarrow \text{VO}_{2.5} \Rightarrow \text{V}_2\text{O}_5$

14. Tell which of the following compounds contains an unexpected oxidation state for the least electronegative element.

1. TeO₂

2. SO₂
3. CO₂
4. SnO₂
5. ClO₂

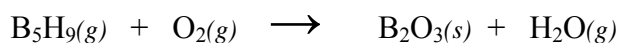
Solution: -2 oxidation number of oxygen => -4 for 2 O => +4 from the other element
+4 oxidation number allowed for Te, S, C and Sn, and not allowed for Cl. Cl, in group 17, can have only the oxidation numbers +7, +5, +3, +1 and -1 => ClO₂ is unexpected.

15. Tell what is the name of O₂F₂.

1. Oxygen(II) fluoride
2. Fluorine dioxide
3. Difluorine dioxide
4. Oxygen difluoride
5. Dioxygen difluoride

Solution: two non-metals => covalent bonding => prefixes used
Fluorine is the most electronegative => its name goes last and it takes the suffix "ide".

16. Pentaborane-9 burns in oxygen to produce boron oxide and water according to the following unbalanced chemical equation:

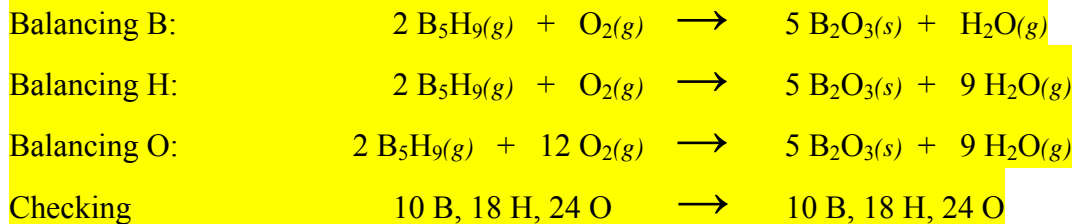


Tell what is the stoichiometric coefficient of molecular oxygen in the balanced equation.

1. 9
2. 20
3. 18
4. 24
5. 12

Solution:





17. Tell which of the following mixture of solutions will result in a precipitation reaction:

1. $\text{HCl}(aq) + \text{Al}(\text{NO}_3)_3(aq)$
2. $\text{Na}_2\text{CO}_3(aq) + \text{NH}_4\text{Cl}(aq)$
3. $\text{Ca}(\text{HCO}_3)_2(aq) + \text{HBr}(aq)$
4. $\text{Pb}(\text{NO}_3)_2(aq) + \text{NaClO}_3(aq)$
5. $\text{Pb}(\text{NO}_3)_2(aq) + \text{NaI}(aq)$

Solution: PbI_2 is the only insoluble compound.

18. Tell which of the following is a strong acid in water

1. HF
2. KOH
3. HClO
4. HClO_4
5. CH_3COOH

Solution: HF, HClO and CH_3COOH are weak acids, KOH is a strong base

19. Give the name of $\text{H}_2\text{SO}_3(aq)$ and tell whether it is a strong acid or a weak acid.

1. Sulfuric acid, a weak acid
2. Sulfuric acid, a strong acid

3. Sulfurous acid, a weak acid
4. Sulfurous acid, a strong acid
5. Hydrosulfuric acid, a weak acid

Solution:

If the name starts with "hydro", there is no oxygen

H₂SO₄: sulfuric acid: more O, higher oxidation number of S => suffix "ic" and strong acid

H₂SO₃: sulfurous acid: less O, lower oxidation number of S => suffix "ous" and weak acid.

20. A 1.000 g sample of hydrated barium chloride, BaCl₂·xH₂O was heated to result in complete dehydration that yielded 0.852 g of anhydrous barium chloride. Tell what is the formula of hydrated barium chloride.

1. BaCl₂·4H₂O
2. BaCl₂·3H₂O
3. BaCl₂·2H₂O
4. BaCl₂·H₂O
5. BaCl₂·6H₂O.

Solution:

BaCl₂: m = 0.852 g, n = m/M = 0.852 g / 208.23 g·mol⁻¹ = 4.09163 x 10⁻³ mol(BaCl₂)

m(H₂O) = m(BaCl₂·xH₂O) - m(BaCl₂) = 1.000 g - 0.852 g = 0.148 g

H₂O: m = 0.148 g, n = m / M = 0.148 g / 18.015 g·mol⁻¹ = 8.2154 x 10⁻³ mol(H₂O)

x = 8.2154 x 10⁻³ mol(H₂O) / 4.09163 x 10⁻³ mol(BaCl₂) = 2.008 ≈ 2

=> BaCl₂·2H₂O