UNIVERSITY OF JOHANNESBURG

FACULTY OF SCIENCE

DEPARTMENT OF CHEMISTRY

MODULE:	**CEM01A1 - INTRODUCTION TO GENERAL CHEMISTRY**
CAMPUS:	APK
EXAM:	Main exam
DATE:	23 May 2019
ASSESSORS:	DR T BREDENKAMP, DR L DEN DRIJVER, DR P MOSHAPO, PROF A MULLER
MODERATOR:	DR BCE MAKHUBELA
DURATION:	3 HOURS
MARKS:	100

INSTRUCTIONS:

1. This paper consists of 17 pages including a Periodic Table and a data sheet.
2. **WRITE YOUR NAME, SURNAME AND STUDENT NUMBER AND LECTURER'S NAME ON THIS SHEET**
3. Only simple, non-programmable scientific calculators are allowed for the test. The use of cell phones is strictly forbidden and all cell phones must be switched off.
4. You can use any colored ink to write the test, except RED. **You are not allowed to write in pencil.**
5. This is a closed book assessment. You are NOT allowed to have any book, memorandum, notes, paper, photographs, document or written/printed material other than the question paper.
6. Use the **correct number of significant figures** when doing calculations.

NAME: _____

SURNAME: _____

STUDENT NUMBER: _____

LECTURER: _____

SECTION A: Answer all questions by circling the correct letter. **[20]**

1. The atomic number of silver, Ag, is 47 and it has an average atomic mass of 107.87. Why is it impossible to determine the number of neutrons in the nucleus of the silver atom using the given information? (1)

   a) The atomic mass is the number of protons plus the number of electrons.
   b) The average mass of silver can change with temperature.
   c) The number of electrons always changes, altering the number of neutrons in the atom.
   d) It is not known which isotopes comprise silver, and the average atomic mass of an element depends on the weighted average of all isotopes of the element.
   e) The atomic number is the number of neutrons plus the number of electrons.

2. Aluminum reacts with a second element, which we will represent by the symbol E, to form a compound whose formula is AlE_3. Element E is most probably: (1)

   a) A halogen.
   b) An alkali metal.
   c) A chalcogen.
   d) A transition metal.
   e) An actinide element.

3. An example of a chemical change is: (1)

   a) Mixing rust with sand.
   b) Sodium combining with chlorine to form table salt.
   c) Mixing chalk with helium in a balloon.
   d) The mixing of glucose with table salt.
   e) The dissolving of table salt in water.

4. Which formula is incorrect because it does not represent an ionic compound written correctly? (1)

a) Na_2O

b) RbBr

c) $BaCl_2$

d) CaO

e) Al_2F_3

5. Freon is a trade name for a group of gaseous compounds once used as propellants in aerosol cans. Which has a higher percentage of chlorine: Freon-12 (CCl_2F_2) or Freon-141b ($C_2H_3Cl_2F$)? (1)

a) Freon-141b, because it contains 60.62% Cl.

b) Freon-12, because 59% of its atoms are chlorine.

c) Freon-12, because it contains 58.63% Cl.

d) Freon-141b, because 60% of its atoms are chlorine.

e) More information is needed to answer this question.

6. Describe the steps to take in diluting a solution of 0.500 *M* HCl to make 250 mL of 0.100 *M* HCl. (2)

a. Add 50 mL of the 0.500 M solution to 1 L of water

b. Take 250 mL of the 0.500 M solution and dilute to 1 L

c. Take 50 mL of the 0.500 M solution and then dilute to 250 mL.

7. Consider the redox equation,
$2VO_4^{3-}(aq) + SO_2(g) + 8H^+(aq) \longrightarrow 2VO^{2+}(aq) + SO_4^{2-}(aq) + 4H_2O(l)$
The oxidizing agent is (1)

a. $SO_2(g)$

b. $SO_4^{2-}(aq$

c. $H^+(aq)$

d. $VO_4^{3-}(aq)$

e. $VO^{2+}(aq)$

8. What is the energy of one photon of microwave radiation with a wavelength of 0.158 m? (2)

a. 1.26×10^{-24} J

b. 3.14×10^{-26} J

c. 3.19×10^{25} J

d. 3.49×10^{-43} J

e. 7.15×10^{40} J

9. Give the ground state electron configuration and number of unpaired electrons for Sb^{3+}. (1)

a. [Kr] $4d^1\ 5s^1$; 2 unpaired electrons

b. [Ar] ; 1 unpaired electron

c. [Kr] $4d^{10}\ 5s^2$; 0 unpaired electrons

d. [Kr] $4d^7\ 5s^2$; 3 unpaired electrons

e. [Ar] $4d^4\ 5s^2$; 4 unpaired electrons

10. Which species has the same bond order as the carbon monoxide molecule? (1)

a. ClF

b. CO_3^{2-}

c. CO_2

d. NO^+

e. O_3

11. Based on the Lewis structure, the number of electron domains in the valence shell of the sulfur atom in the SO_2 molecule is (1)

a. 5

b. 4

c. 3

d. 2

e. 1

12. A sample of a gas in a cylindrical chamber with a movable piston occupied a volume of 11.60 liters when the pressure was 9.97×10^4 Pa and the temperature was 24.9°C. The volume of the system was readjusted to 8.50 liters by moving the piston. What was the pressure exerted on the surface of the piston by the gas if the temperature of the system remained constant? (1)

a. 1.011×10^3 Pa

b. 1.36×10^5 Pa

c. 7.31×10^4 Pa

d. 1.01×10^5 Pa

e. 9.83×10^4 Pa

13. A gas sample occupies a volume of 1.264 L when the temperature is 168.0 ˚C and the pressure is 946.6 torr. How many molecules are in the sample? (1)

a. 2.07×10^{22}
b. 2.62×10^{22}
c. 2.65×10^{23}
d. 2.65×10^{24}
e. 6.88×10^{22}

14 A student is preparing a study of the reaction, $2CO_2(g) \rightleftharpoons 2CO(g) + O_2(g)$, for which $K_c = 26.2$ at 827 ˚C. What is the value of K_p at that same temperature? (2)

a. 2.90×10^{-1}
b. 3.86×10^{-1}
c. 1.78×10^{3}
d. 2.37×10^{3}
e. 2.40×10^{5}

15. If the OH^- ion concentration in an aqueous solution at 25.0 ˚C is 6.6×10^{-4} M, what is the molarity of the H^+ ion? (1)

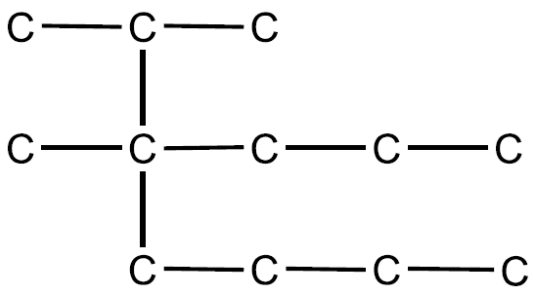
a. 1.5×10^{-1} M
b. 1.5×10^{-4} M
c. 6.6×10^{-10} M
d. 1.5×10^{-11} M
e. 6.6×10^{-11} M

16. The functional group, R—O—R, is found in which one of these types of organic compounds?

(1)

a. alkanes
b. alkenes
c. amines
d. alcohols
e. ethers

17. In the IUPAC system of nomenclature, the alkane hydrocarbon whose skeleton is shown below, is regarded as a derivative of (1)



a. dodecane
b. decane
c. heptane
d. pentane
e. octane

SECTION B: **[80]**

QUESTION 1 **[4]**

Provide the correct name or formula for the following

1.1 Antimony Pentafluoride (1)

1.2 Copper (I) Sulfide (1)

1.3 Mn_2O_3 (1)

1.4 $LiNO_2$ (1)

QUESTION 2 **[3]**

Iodized salt contains a trace amount of calcium iodate, $Ca(IO_3)_2$, to help prevent a thyroid condition called goiter. If the daily recommended intake of iodine is 150 µg per day, how much calcium iodate in grams will you need to consume daily to meet this recommendation?

QUESTION 3 **[6]**

Ethanol, C_2H_5OH, can be converted to acetic acid (the acid in vinegar), $HC_2H_3O_2$, by the action of sodium dichromate in aqueous sulfuric acid according to the following equation.

$3C_2H_5OH\ (aq) + 2Na_2Cr_2O_7\ (aq) + 8H_2SO_4\ (aq) \rightarrow 3HC_2H_3O_2\ (aq) + 2Cr_2(SO_4)_3\ (aq) + 2Na_2SO_4\ (aq) + 11H_2O$

In one experiment, 24.6 g of C_2H_5OH, 86.3 g of $Na_2Cr_2O_7$, and an excess of sulfuric acid were mixed, and 26.6 g of acetic acid ($HC_2H_3O_2$) was isolated.

3.1 What is the theoretical yield of acetic acid? (Show how you identify the limiting reagent) (5)

3.2 What is the percentage yield? (1)

QUESTION 4 **[7]**

A 1.375 g sample of mannitol, a sugar consisting of C, H and O, is burned completely in oxygen to give 1.993 g of carbon dioxide and 0.9519 g of water. Calculate the empirical formula for mannitol.

QUESTION 5 **[6]**

A 3.50 g sample of KCl is dissolved in 10.0 mL of water. The resulting solution is then added to 60.0 mL of a 0.500 M $CaCl_2$(aq) solution. Assuming that the volumes are additive, calculate the concentration of each ion present in the final solution.

QUESTION 6 **[10]**

6.1 Sodium chloride and calcium chloride are used to melt snow and ice on roads in winter. A certain company was marketing a mixture of of these two compounds for this purpose. A chemist, wishing to analyze the mixture, dissolved 2.2463 g

of it in water and precipitated calcium oxalate by adding sodium oxalate, $Na_2C_2O_4$. The calcium oxalate was filtered off, dissolved in sulphuric acid and titrated with 0.1000 M $KMnO_4$ solution. The reaction that occurred was

$$6H^+ + 5H_2C_2O_4 + 2MnO_4^{2-} \rightarrow 10CO_2 + 2Mn^{2+} + 8H_2O$$

The titration required 21.62 mL of the $KMnO_4$ solution.

a. How many moles of $C_2O_4^{2-}$ were present in the precipitate? (3)

b. How many grams of calcium chloride were in the original sample? (1)

c. What is the percentage by mass of calcium chloride in the sample? (1)

6.2 Balance the following equation in acidic solution: (5)

$NO_3^- + Cu \rightarrow NO_2 + Cu^{2+}$

QUESTION 7

Use the Rydberg equation to calculate the wavelength in nanometers of the spectral line of hydrogen for which $n_2 = 6$ and $n_1 = 3$. Report your answer using four significant figures. Is this light visible or invisible? (4)

QUESTION 8

Identify the group of elements that corresponds to each of the generalized electron configurations below and indicate the number of unpaired electrons for each: (4)

a. [noble gas] ns^2np^5

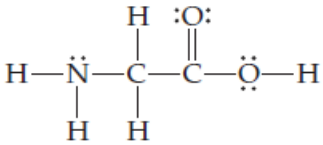
b. [noble gas] $ns^2(n - 1)d^2$

c. [noble gas] $ns^2(n - 1)d^{10}np^1$

d. [noble gas] $ns^2(n - 2)f^6$

QUESTION 9 **[6]**

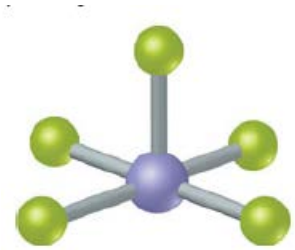
9.1 Consider the Lewis structure for glycine, the simplest amino acid:



a. What are the approximate bond angles about each of the **two** carbon atoms, and what are the hybridizations of the orbitals on each of them? (2)

b. What is the total number of σ bonds in the entire molecule, and what is the total number of π bonds? (2)

9.2 An AB_5 molecule adopts the geometry shown here.



Are there any nonbonding electron pairs on the central atom A? Explain. (2)

QUESTION 10 **[12]**

Chlorine dioxide gas (ClO_2) is used as a commercial bleaching agent. It bleaches materials by oxidizing them. In the course of these reactions, the ClO_2 is itself reduced.

a. What is the Lewis structure for ClO_2? (2)

b. Why do you think that ClO_2 is reduced so readily? (1)

c. When a ClO_2 molecule gains an electron, the chlorite ion, ClO_2^-, forms. Draw the Lewis structure for ClO_2^-. (1)

d. Predict the O–Cl–O bond angle in the ion and electron domain geometry. (2)

e. One method of preparing ClO_2 is by the reaction of chlorine and sodium chlorite:

$$Cl_2(g) + 2NaClO_2(s) \rightarrow 2ClO_2(g) + 2NaCl$$

If you allow 15.0 g of $NaClO_2$ (MM = 90.44 g/mol) to react with 2.00 L of $Cl_2(g)$ at a pressure of 1.50 atm at 21 °C, how many grams of ClO_2 (MM = 67.45 g/mol) can be prepared? (6)

QUESTION 11 **[4]**

You mix equal moles of N_2, O_2, and NO and place them into a container fitted with a movable piston. Then you heat the mixture to 2127 °C, compressing the mixture with the piston to 10.0 atm, where the following reaction occur:

$$N_2(g) + O_2(g) \leftrightarrow 2NO(g)$$

K_p for this reaction at 2127 °C is 0.0025. Is the mixture of gases initially at equilibrium at this temperature and pressure, or does it undergo reaction to the left or to the right?

QUESTION 12 **[6]**

Sulfuryl chloride is used in organic chemistry as a chlorinating agent. At moderately high temperatures it decomposes as follows:

$SO_2Cl_2(g) \leftrightarrow SO_2(g) + Cl_2(g)$

with Kc = 0.045 at 650 K.

A sample of 8.25 g of SO_2Cl_2 is placed in a 1.00-L reaction vessel and heated to 650 K. What fraction of SO_2Cl_2 will decompose?

QUESTION 13 **[4]**

List the following compounds in order of increasing acid strength: $HBrO_2$, $HClO_2$, HBrO. Provide a reason for each why you consider it a stronger acid than the previous compound.

QUESTION 14 **[5]**

A 1.00-L aqueous solution contained 6.78 g of barium hydroxide, $Ba(OH)_2$. What was the pH of the solution at 25 °C?

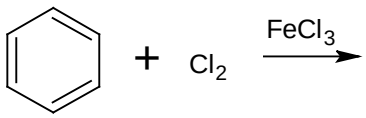
QUESTION 15 **[4]**

15.1 Catalytic cracking is an industrial process used to convert high-molecular-mass hydrocarbons to low-molecular mass hydrocarbons. A petroleum company has a huge supply of heating oil stored as straight-chain $C_{17}H_{36}$, and demand has picked up for shorter chain hydrocarbons to be used in formulating gasoline. The company uses catalytic cracking to create the shorter chains necessary for gasoline. If they produce two molecules in the cracking, and 1-octene is one of them.

a) draw the condensed structural formula of the 1-octene. (1)

b) what is the formula of the other molecule produced? (1)

15.2 Complete the following reaction: (2)



The Periodic Table

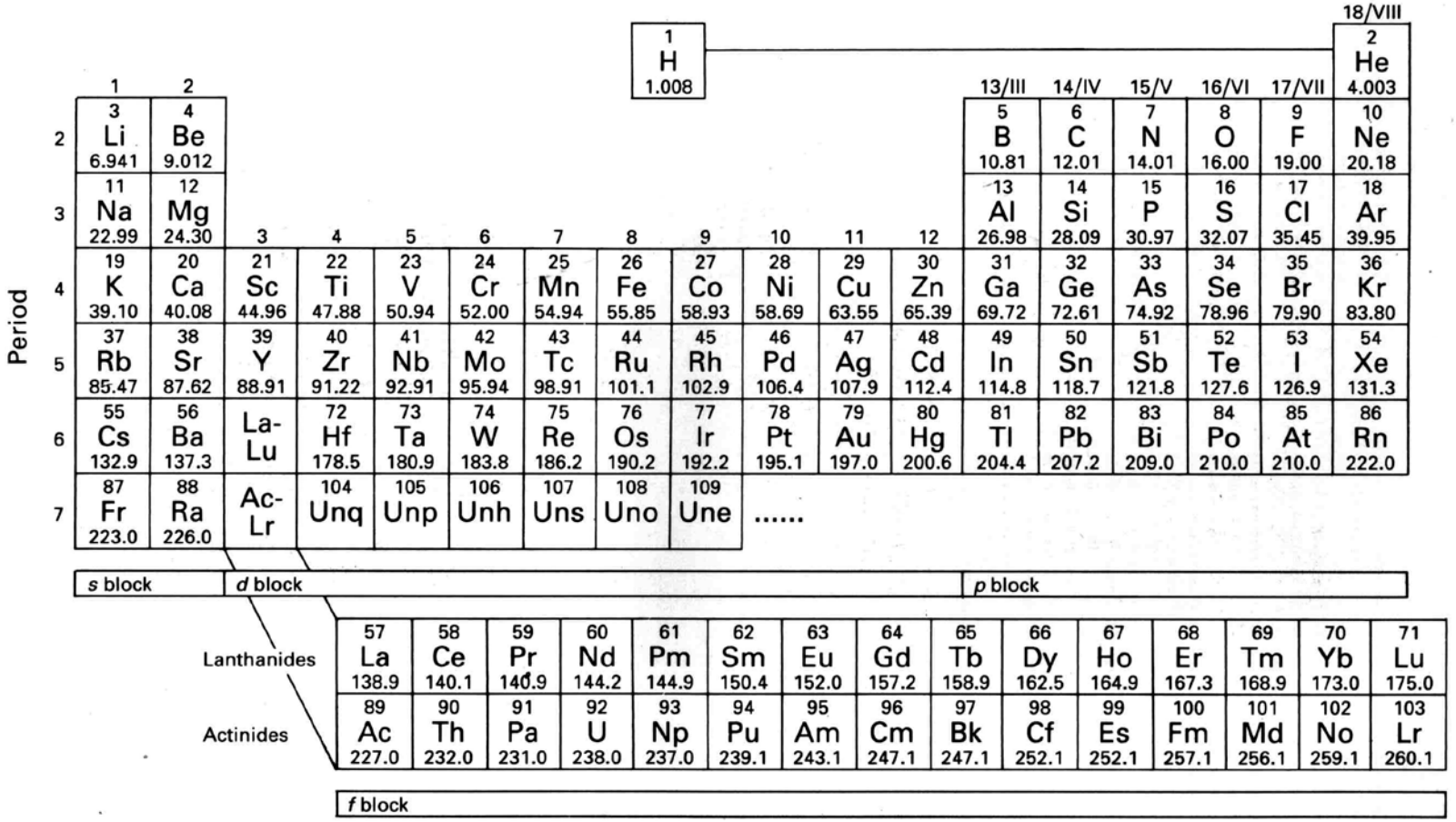


TABLE 5.3 Activity Series for Some Metals (and Hydrogen)

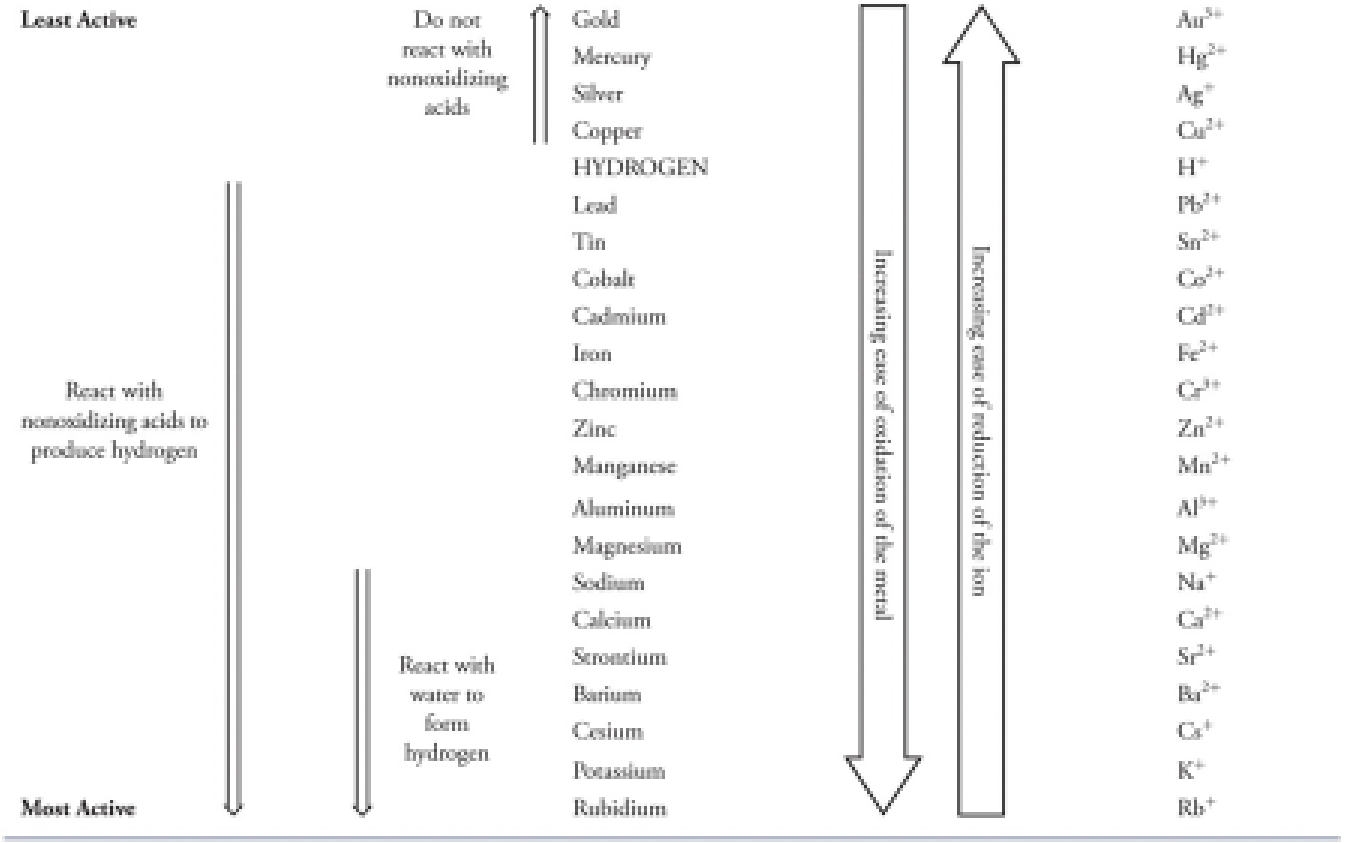


Table 5.3

Constants:

R = 0.08206 L atm mol^{-1} K^{-1} **N_A = 6.022 x 10^{23} mol^{-1}**

h **= 6.626 x 10^{-34} J.s (Planck's constant)** **R_H = 1.097 x 10^{7} m^{-1}**

c **= 2.998 x 10^{8} m.s^{-1}** $\Delta E = -hcR_H\left(\frac{1}{n_f^2}-\frac{1}{n_i^2}\right)$

$$\frac{1}{\lambda}=R_H\left(\frac{1}{n_1^2}-\frac{1}{n_2^2}\right)$$

Mass of proton = 1.67262 x 10^{-27} kg

λ = h/mv