

## CHEMISTRY 1 – Test n°3

Duration: 1h 30 min

*No document allowed. Only « collège » type calculators are authorized.  
The marking-scheme is for information only.*

Data:

	H	C	N	O	F	Na	Si	Cl	Mn	I
Z	1	6	7	8	9	11	14	17	25	53
Electronegativity	2.1	2.5	3.0	3.5	4	0.9	1.8	3.0	1.5	2.5

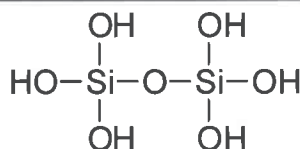
**I) Chemical bonding: Silicon and Carbon containing compounds (13 points)**

- 1) Give the electronic configuration of Silicon (Si). Find the group, period and block it belongs to.  
How many electrons are found in its valence shell?
- 2) Why is Silicon not considered as a metal?
- 3) Using Slater's rule, compute the value of the effective charge ( $Z^*$ ) experienced by an electron located in the outer sub-shell of Silicon.

**Slater's rule:** contribution of the electrons localized in the  $n'$  orbital on the screen constant which applies on an electron localized in the orbital  $n$  are gathered in the following table:

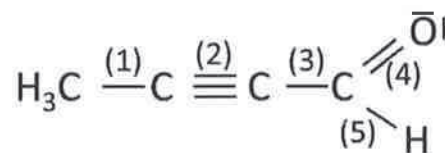
Orbital of the electron	$n' < n-1$	$n' = n-1$	$n' = n$	$n' > n$
1s	-	-	0.30	0
$ns, np$	1.00	0.85	0.35	0
$nd$	1.00	1.00	1.00 for $s$ and $p$ 0.35 for $d$	0

- 4) Let's consider the following molecule:



- a. According to the VSEPR theory, what is the geometry found around the central Oxygen atom.
- b. Give an approximate value to the Si-O-Si angle.
- c. Give an approximate value to the O-Si-O angle.
- d. Give an approximate value to the H-O-Si angle.
- e. What is the hybridization state of the Silicon atoms in this molecule? Give the oxidation numbers of each atom.
- f. How many  $\sigma$  bonds,  $\pi$  bonds and non bonding doublets does this molecule contain?

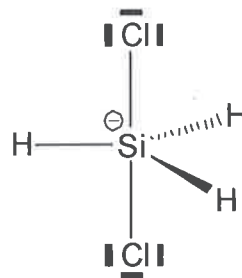
- 5) In the following molecule, for every numbered bond,



- a. Give the type of bonding ( $\sigma$ ,  $\pi$  or both).
- b. Give the type of constitutive atomic orbitals (hybrid or not) that are responsible for the bonding.
- c. Rank the C-C bonds (1 to 3) with respect to their length.

6) Give the Lewis structure of the Silicate ion  $\text{SiO}_3^{2-}$  (oxidation number of each O is [-II]). Write two equally representative resonance formulas.

7) How can you explain the formation of the following ion?  
What is its hybridization state?



8) Attribute the following pKa (4.75, 2.86, 0.65, 0.50) to the corresponding carboxylic acids:  $\text{CH}_3\text{-COOH}$ ,  $\text{CF}_3\text{-COOH}$ ,  $\text{CCl}_3\text{-COOH}$ ,  $\text{CH}_2\text{Cl-COOH}$ . Qualify your answer.

### II) Crystalline solid state (2 points)

- 1) How many crystalline systems are there? How many total Bravais lattices are associated with these crystalline systems? How many crystalline systems possess a tri-rectangular geometry?
- 2) Give the possible Bravais lattices associated with the cubic system. How many nodes are contained in these cubic cells?

### III) Redox reactions (4 points)

For each of the following reactions (1) to (4):

1) Identify and give the oxidation numbers of the atoms that undergo a change in their oxidation states. *Hints: no O-O bonds in  $\text{MnO}_4^-$ ;  $\text{Na}_2\text{S}$  ( $2\text{Na}^+$ ,  $\text{S}^{2-}$ ) and  $\text{NaNO}_3$  ( $\text{Na}^+$ ,  $\text{NO}_3^-$ ) are ionic compounds,  $\text{HNO}_3$  is a strong acid*

2) For each redox couple, tell if is associated to an oxidation or reduction half-reaction.

3) Balance the reactions, in acidic media if needed, using the change of oxidation numbers.

