CHM 4 – Optional worksheet: Ion names/formulas

The goal of this optional worksheet is to help you recognize patterns that will help you memorize the ion names and symbols on our "*Important elements/ions to know for CHM 4, 1A, and 1B*" handout. It will help if you have that handout and a periodic table to refer to while completing this worksheet

PART I: Recognizing patterns in ion charges.

Look at Table 1 below. The columns of elements are arranged like groups 15 - 17 of the periodic table. The element is symbol is in the upper left of each box. Also in each box are the common monatomic ion for the element and in some cases common polyatomic ions.

1. Many monatomic ions have predictable charges. What pattern do you see in the charges of the monatomic ions in Table 1 that will make it easy to learn them?

2. What pattern do you see in the charge of the given polyatomic ion and the charge formed by the corresponding monatomic ions in Table 1 that will make it easy to learn them?

3. There are a few polyatomic ions on your "*Important elements/ions*" handout that contain elements from Table 1, but that DO NOT fit the model described in questions 1 and 2. Identify these ions since you will have to remember that they don't fit the pattern of expected charges:

Table 1

Group 15	Group 16	Group 17
N N^{3-}	**O** O^{2-}	**F** F^-
P P^{3-} PO_3^{3-} PO_4^{3-}	**S** S^{2-} SO_3^{2-} SO_4^{2-} $S_2O_3^{2-}$	**Cl** Cl^- ClO^- ClO_2^- ClO_3^- ClO_4^-
As As^{3-} AsO_4^{3-}		**Br** Br^- BrO^- BrO_2^- BrO_3^- BrO_4^-
		I I^- IO^- IO_2^- IO_3^- IO_4^-

PART II: Recognizing trends based on adding H^+ ions.

The upper right corner of the "*Important elements/ions*" handout shows a group of ions formed by adding an H^+ to one of the other polyatomic ions on the handout. As long as you know the name of the starting ion, you can predict the name and formula of the new ion made by adding the H^+ ion.

4. Looking at the first row in Table 2, what is the relationship between the names of the CO_3^{2-} ion and the HCO_3^- ion?

5. Use the relationship from question 4 to fill in the names of the $HC_2O_4^-$ and HS^- ions in Table 2. Compare your answers with those given on the "*Important elements/ions*" handout.

6. What happens to the overall ion charge when an H^+ is added to carbonate, oxalate and sulfide?

7. Use the relationship from question 6 to predict the remaining formulas in Table 2. Compare your answers with those given on the "*Important elements/ions*" handout.

Table 2

starting ion		ion made by adding H+			
Formula	Name	Formula	Name		
CO_3^{2-}	carbonate	HCO_3^-	hydrogen carbonate		
$C_2O_4^{2-}$	oxalate	$HC_2O_4^-$			
S^{2-}	sulfide	HS^-			
SO_3^{2-}	sulfite		hydrogen sulfite		
SO_4^{2-}	sulfate		hydrogen sulfate		
PO_4^{3-}	phosphate		hydrogen phosphate		dihydrogen phosphate

Part III: Recognizing trends based on oxyanions containing a halogen.

8. Table 3 displays a list of formulas. The formulas are grouped according to the number of oxygen atoms. Using your "*Important elements/ions*" handout (or from memory if you can!), fill in the blanks in Table 3 with the names of the polyatomic ions that correspond to the given formulas.

Table 3

1 oxygen atom	2 oxygen atoms	3 oxygen atoms	4 oxygen atoms
BrO^- _____	BrO_2^- _____	BrO_3^- _____	BrO_4^- _____
ClO^- _____	ClO_2^- _____	ClO_3^- _____	ClO_4^- _____
IO^- _____	IO_2^- _____	IO_3^- _____	IO_4^- _____

Beyond the pattern we saw in Part I of this worksheet (that all of the ions have a -1 charge), let's look at what other patterns we see in these 12 ions...

9. The names of the ions in Table 3 with only 1 oxygen all have a common format, consisting of a prefix, a root and a suffix. Circle, in Table 3, the prefix and suffix that they all have in common.

10. The ions in Table 3 with 2 and 3 oxygen atoms have names with only a root and a suffix. Circle, in Table 3, the suffix that they all have in common.

11. The names of the ions in Table 3 with 4 oxygen atoms all have a common format, consisting of a prefix, a root and a suffix. Circle, in Table 3, the prefix and suffix that they all have in common.

Part IV: Summary of what we've learned so far (with a few other things thrown in!)

Monatomic ions:

- We can figure out the formulas based on typical charges from periodic table;
- We can figure out the name by changing the ending to "-ide".

Example: the element fluorine becomes fluoride when it changes from F to F^- (with its charge making sense based on its position in the periodic table).

Polyatomic ions:

- On our "*Important elements/ions*" handout there is only one ion with a "+1", only five are "-3". The majority have a "-1" or "-2" charge.

- Some ions form a series that only vary in the number of "O" atoms. These ions often have names that share a common root with predictable prefixes/suffixes.

The following each have 4 ions in their series:

prefix/suffix	brom	chlor	iod
per- -ate	BrO_4^-	ClO_4^-	IO_4^-
-ate	BrO_3^-	ClO_3^-	IO_3^-
-ite	BrO_2^-	ClO_2^-	IO_2^-
hypo- -ite	BrO^-	ClO^-	IO^-

Example: BrO_4^- is called *perbromate ion* ("per-" + "brom" + "-ate")

The following each have 2 ions in their series:

prefix/suffix	nitr	phosph	sulf
-ate	NO_3^-	PO_4^{3-}	SO_4^{2-}
-ite	NO_2^-	PO_3^{3-}	SO_3^{2-}

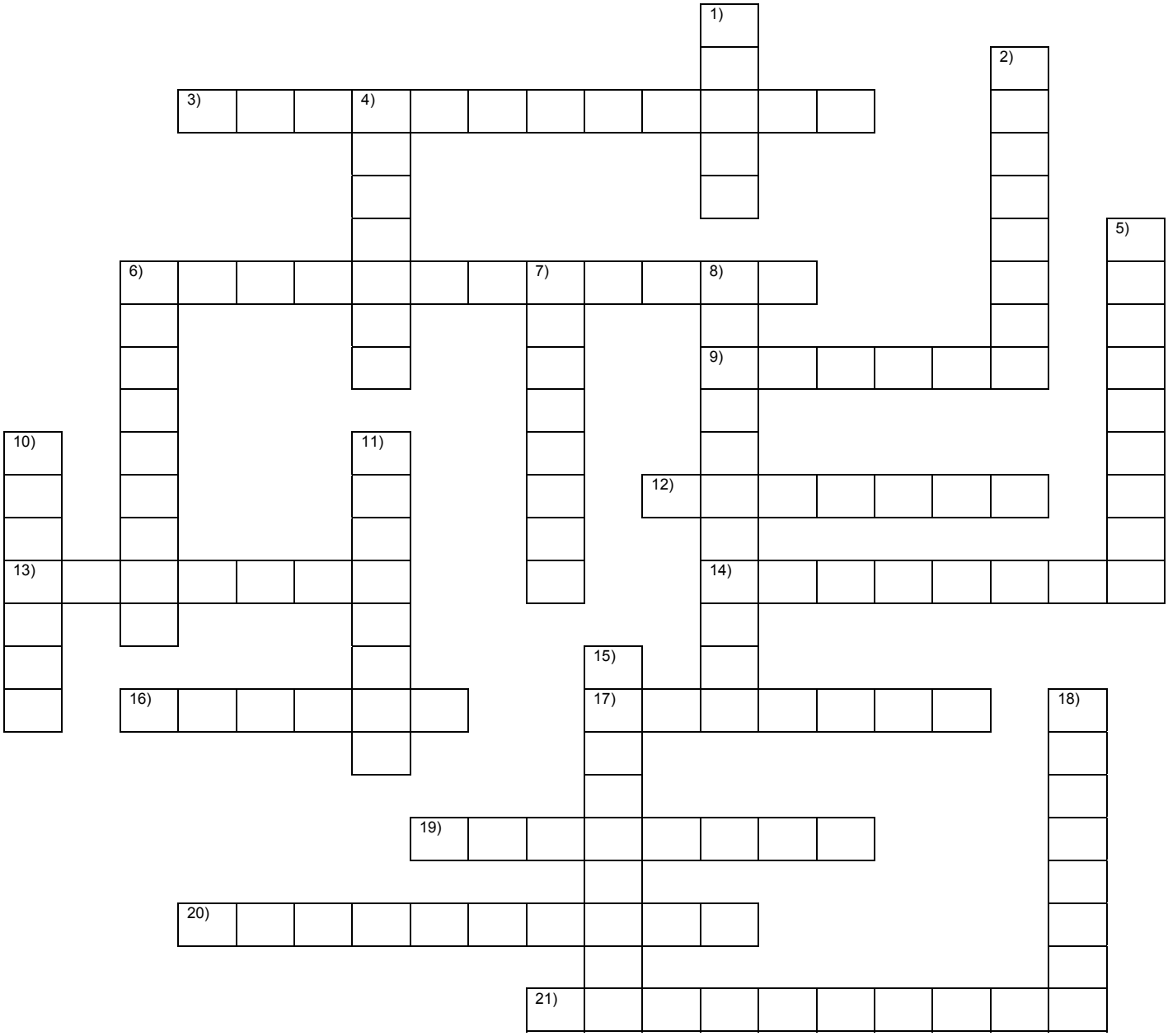
Ions made by adding "H^+":

- Once we know the name of the root ion, we can make many new names by adding "hydrogen" and "dihydrogen" to the name and H^+ to the formula. Each H^+ we add to the formula will cancel out -1 of the charge.

Example: PO_4^{3-} is phosphate, so HPO_4^{2-} is hydrogen phosphate and $H_2PO_4^-$ is dihydrogen phosphate.

Part V: Extra practice - crossword puzzle

Write the name of the ion that corresponds to each of the "DOWN" and "ACROSS" clues in the key below. See if you can complete it without needing to look at your "*Important elements/ions".* Spelling counts.



DOWN			
1)	O^{2-}	7)	NH_4^+
2)	ClO_2^-	8)	$S_2O_3^{2-}$
4)	$C_2O_4^{2-}$	10)	CN^-
5)	OH^-	11)	AsO_4^{3-}
6)	PO_3^{3-}	15)	CO_3^{2-}
		18)	O_2^{2-}

ACROSS			
3)	ClO^-	14)	F^-
6)	MnO_4^-	16)	BO_3^{3-}
9)	IO_3^-	17)	$C_2H_3O_2^-$
12)	SO_3^{2-}	19)	CrO_4^{2-}
13)	N^{3-}	20)	$Cr_2O_7^{2-}$
		21)	BrO_4^-