Dr. Zellmer | Chemistry 1250 | T, R
Time: 7 PM Sun. | Spring Semester 2022 | January 30, 2022
40 min | Quiz II

Name KEY Rec. TA/time

1. (2 pts) Select the combination of statements which are **CORRECT**.

1) The mass number of an atom is the number of neutrons in the nucleus.
2) The number of protons in atom is its atomic number.
3) The number of electrons is greater than the number of protons in a cation.
4) The masses of a proton and a neutron are both approximately 1 amu.
5) Isotopes of an element differ in the number of neutrons.

a) 1, 3, 4 b) 2, 3 c) 1, 2, 3 d) 1, 4, 5 e)* 2, 4, 5

2) The number of **protons** in an atom is its **atomic number**.
4) The **masses** of a **proton** (1.00728 amu) and a **neutron** (1.00866 amu) are both **approx**. **1 amu**.
5) **Isotopes** of an element **differ** in the number of **neutrons**. (# protons and electrons are the same)

The corrected answers for 1 & 3 would be:

1) The **mass number** of an atom is the **sum** of the number of **neutrons and protons** in the nucleus.
3) A **cation** is a **positive ion** which has **fewer electrons** than **protons**.

2. (2 pts) Consider the following species. Which of these are isotopes of each other?

$$^{109}_{52}X,\ ^{109}_{50}X,\ ^{111}_{51}X,\ ^{111}_{52}X$$

$^{A}_{Z}E$ E = atomic symbol
Z = atomic number = # p (protons)
A = mass number = #p + #n (n is neutron)
charge = #p − $\#e^-$

Z, the atomic number, distinguishes one element from another
A, the mass number, distinguishes between isotopes of the same element. Isotopes have the same number of protons but different numbers of neutrons.

3. (4 pts) An element has two naturally occurring isotopes, ^{35}X and ^{37}X, with atomic masses of 34.969 amu and 36.966 amu, respectively. The natural abundances of ^{35}X and ^{37}X are 55.78% and 44.22%, respectively. Calculate the atomic weight of this element.

Atomic weights are a weighted average of the masses of all the naturally occurring isotopes of an element.

At. wt. = (0.5578) (34.969 amu) + (0.4422) (36.966 amu)

= 19.5**0**57082 amu + 16.3**4**63652 amu

At. wt. = 35.8**5**20734 amu = 35.85 amu (4 s.f.)

4. (2 pts) Examine the following group of elements.

$_{38}$Sr	$_{34}$Se	$_{18}$Ar
$_{52}$Te	$_{27}$Co	$_{48}$Cd
$_{82}$Pb	$_{7}$N	$_{32}$Ge

The number of **representative (main-group) metals** is(are): 2

The number of **metalloids** (semimetals) is(are): 2

Selenium (Se), Nitrogen (N), and Argon (Ar) are nonmetals.
Strontium (Sr) and Lead (Pb) are **representative metals**.
Cobalt (Co) and Cadmium (Cd) are transition metals.
Germanium (Ge) and Tellurium (Te) are **metalloids (semimetals)**.

5. (2 pts) Which of the following formulas are possible molecular formulas for the empirical formula $C_3H_5O_2$?

a) $C_5H_{10}O_2$ b) $C_5H_{12}O_4$ c)* $C_6H_{10}O_4$ d) $C_9H_{15}O_3$ e)* $C_9H_{15}O_6$

The molecular formula is always an integer multiple of the empirical formula.

$$C_6H_{10}O_4 = (C_3H_5O_2)_2$$

$$C_9H_{15}O_6 = (C_3H_5O_2)_3$$

Also, for molecules containing only C & H or C, H & O the number of H atoms in the empirical formula can be an odd number. However, in the **molecular formula** there has to be an **even number** of **H atoms**.

6. (3 pts) Fill in the blanks in the table below for the isotope indicated.

Symbol	number of protons	number of neutrons	number of electrons	atomic number	mass number
$^{138}_{56}Ba^{2+}$	56	82	54	56	138

$^{A}_{Z}E$ E = atomic symbol
Z = atomic number = # p (protons)
A = mass number = #p + #n (n is neutron)
charge = #p − #e$^-$

7. (2 pts) Which of the following pairs of names and formulas is **<u>INCORRECT</u>**?

a) iron (III) bisulfate, $Fe(HSO_4)_3$
b) chlorous acid, $HClO_2$ (aq)
c) trinitrogen pentoxide, N_3O_5
d) zinc dihydrogen phosphate, $Zn(H_2PO_4)_2$
e)* zirconium (IV) hypobromite, $Zr_4(BrO)$

For ionic compounds you need to know the charge on both the cation and anion and the charges have to balance since ionic compounds are neutral (like NaCl). For group 1A and 2A metals the cations formed always have a +1 and +2 charges, respectively. Also, Al, Zn and Ag are always +3, +2 and +1, respectively. Other metals can have multiple charges depending on the compound and their charges are given as Roman Numerals in parentheses in the name. In ionic compounds groups 5A, 6A and 7A have charges of −3, −2 and −1 respectively. You have to memorize some polyatomic ions (names, formulas and charges).

For molecular compounds the less electronegative element is generally written first in the formula and is named first in the name. The second element (more electronegative element) in the formula is named by using the stem of the name and the suffix -ide. Numerical prefixes, indicating the numbers of each atom, precede the names of both elements. Common exceptions are for compounds containing H and an element from groups 3A, 4A and 5A (BH_3, CH_4, NH_3, etc.).

How can you tell if the compound is molecular and not ionic? Generally if the compound is composed of a metal and nonmetal it is ionic. Generally if the compound contains only nonmetals or nonmetal and semimetal it is molecular. The most common exceptions to this is when a compound contains ammonium ions, NH_4^+, such as NH_4Cl, $(NH_4)_2SO_4$, etc. All the elements in the compounds listed (and others with NH_4^+ ions) contain all nonmetals but are ionic because of the presence of the NH_4^+ ions.

The following are the correct formulas for the names given:

a) **iron(III) bisulfate** (Ionic)

$$Fe^{3+} \quad (HSO_4)^- \Rightarrow Fe(HSO_4)_3$$

Criss-cross
Charges

Charge on iron is +3 (a Roman Numeral is needed since Fe can be +2 or +3 in compounds). You should know that SO_4^{2-} is sulfate with a −2 charge. Adding 1 H^+ to sulfate gives bisulfate (or hydrogen sulfate), HSO_4^-. Since there is a +3 charge on the Fe and the HSO_4^- has a −1 charge there has to be 3 HSO_4^- ions for every one Fe^{3+}. This gives a total positive charge of +3 and a total negative charge of −3.

b) **chlorous acid** (molecular acid since it as (aq))

$HClO_2$ (aq) from chlorite, ClO_2^-. When enough H^+ is added to an -ite anion to make it a neutral molecule it is named as an -ous acid (when it is in solution).

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7. (cont.)

c) **trinitrogen pentoxide** (molecular)

$$\mathbf{N_3O_5}$$

The name for a binary molecular compound uses Greek prefixes to indicate the number of atoms of each type are in the molecule.

d) **zinc(II) dihydrogen phosphate** (Ionic)

$$Zn^{2+} \quad (H_2PO_4)^- \Rightarrow Zn(H_2PO_4)_2$$

Criss-cross
Charges

Charge on zinc is +2 (no Roman Numeral is needed since Zn is always +2 in compounds). You should know that PO_4^{3-} is sulfate with a −3 charge. Adding 1 H^+ to phosphate gives hydrogen phosphate, HPO_4^{2-}. Adding 1 H^+ to this gives dihydrogen phosphate, $H_2PO_4^-$. Since there is a +2 charge on the Zn and the $H_2PO_4^-$ has a −1 charge there has to be 2 $H_2PO_4^-$ ions for every one Zn^{2+}. This gives a total positive charge of +2 and a total negative charge of −2.

e) **zirconium(IV) hypobromite** (Ionic) This one had the incorrect formula for the name given.

$$Zr^{4+} \quad (BrO)^- \Rightarrow Zr(BrO)_4$$

Criss-cross
Charges

Charge on zirconium is +4 (given as Roman Numeral IV in name). You should know that BrO_3^- is bromate with a −1 charge and one fewer oxygen is an -ite, BrO_3^- and one fewer than the -ite is hypo-ite, BrO^-. Criss-cross the charges and you get the correct subscripts in this case. The 1 zirconium provides a total positive charge of +4. The 4 hypobromites gives a total negative charge of −4.

8. (5 pts) Balance the following equation. What is the <u>sum</u> of the <u>coefficients</u> of the **REACTANTS**? (If present, don't forget the coefficients of 1.)

The products of complete combustion are CO_2 and H_2O.

$$\underline{\ 2\ }\ C_{12}H_{22}O_6 \quad + \quad \underline{\ 29\ }\ O_2 \quad \rightarrow \quad \underline{\ 24\ }\ CO_2 \quad + \quad \underline{\ 22\ }\ H_2O$$

A) <u>Balance C</u> (Appears in greatest amount in any cmpd. other than H and O - for combustion reactions always balance C first)

$$C_{12}H_{22}O_6 \quad + \quad O_2 \quad \rightarrow \quad 12\ CO_2 \quad + \quad H_2O$$

(# C's in $C_{12}H_{22}O_6$)

B) <u>Balance H</u> (leave oxygen until end)

$$C_{12}H_{22}O_6 \quad + \quad O_2 \quad \rightarrow \quad 12\ CO_2 \quad + \quad 11\ H_2O$$

(½ # H's in $C_{12}H_{22}O_6$)

C) <u>Balance O</u> 6 – O + (Need 29 O atoms from O_2) → 24 – O + 11 – O = (35 – O on rt.)
Use 29/2 O_2 (½ of 29 O = O gives 29 O atoms)

$$C_{12}H_{22}O_6 \quad + \quad (29/2)\ O_2 \quad \rightarrow \quad 12\ CO_2 \quad + \quad 11\ H_2O$$

Often, in the fraction the numerator equals the number of atoms you need and the denominator equals the subscript for that element in the compound. If this had been O_3 you would have used 29/3. The fraction may not always be quite this simple but often is.

D) <u>Multiply by 2:</u>

$$\underline{\mathbf{\ 2\ }}\ C_{12}H_{22}O_6 \quad + \quad \underline{\mathbf{\ 29\ }}\ O_2 \quad \rightarrow \quad \underline{\mathbf{\ 24\ }}\ CO_2 \quad + \quad \underline{\mathbf{\ 22\ }}\ H_2O$$

24 C atoms	=	24 C atoms
44 H atoms	=	44 H atoms
70 O atoms	=	70 O atoms

9. (4 pts) Balance the following equation. (**Must show all work. This means to show your steps and show the atoms are balanced. Show coeff. of 1**.)

__2__ $Sc(OH)_3$ + __3__ H_2SO_4 → __1__ $Sc_2(SO_4)_3$ + __6__ H_2O

A) Balance Sc (appears in greatest amount in any cmpd., other than O, H and SO_4)

2 $Sc(OH)_3$ + H_2SO_4 → _$Sc_2(SO_4)_3$ + H_2O

B) Balance SO_4^{2-} ion as a unit (appears as a SO_4^{2-} unit on both sides)

2 $Sc(OH)_3$ + 3 H_2SO_4 → _$Sc_2(SO_4)_3$ + H_2O

C) Balance H (appears in only 1 product - easier to bal. ; 12 H on left, need 12 on right)

2 $Sc(OH)_3$ + 3 H_2SO_4 → _$Sc_2(SO_4)_3$ + 6 H_2O

You could have balanced O atoms before H atoms. Then you would ignore the O atoms in SO_4^{2-} units since those O atoms already balanced. 6-O in 2 $Sc(OH)_3$ → need 6 H_2O

D) Balance O (technically the O atoms in SO_4 already balanced)

2 $Sc(OH)_3$ + 3 H_2SO_4 → _$Sc_2(SO_4)_3$ + 6 H_2O

O atoms are also now already balanced (18 O atoms on left and 18 O atoms on right).

10. (4 pts) Calculate the **mass percent** composition of **phosphorus** in $Ca_3(PO_4)_2$.
(At. wts: Ca = 40.08, P = 30.97, O = 16.00) (**Must show all work.**)

$$\text{Mass \% of element} = \frac{\text{mass element}}{\text{total mass}} \times 100\%$$

From a molecular or empirical formula:

$$\text{mass \%} = \frac{\text{mass element}}{\text{MW (or FW)}} \times 100\%$$

Ca : 3 x 40.08 amu = 120.24 amu

P : 2 x 30.97 amu = 61.94 amu

O : 8 x 16.00 amu = 128.00 amu

FW for $Ca_3(PO_4)_2$ = 310.18 amu (5 s.f.)

$$\% \text{ Ca} = \frac{120.24 \text{ amu}}{310.18 \text{ amu}} \times 100\ \% = 38.765\ \% \text{ Ca (5 s.f.)}$$

$$\% \text{ P} = \frac{61.94 \text{ amu}}{310.18 \text{ amu}} \times 100\ \% = \mathbf{19.97\ \%\ P} \text{ (4 s.f.)}$$

$$\% \text{ O} = \frac{128.00 \text{ amu}}{310.18 \text{ amu}} \times 100\ \% = 41.266\ \% \text{ O (5 s.f.)}$$