CH 221 Chapter Two Part 2 Concept Guide

1. Ion Charges

Question
What charge are the following ions expected to have?
(a) ionic barium (b) ionic oxygen (c) ionic potassium

Solution
(a) Barium is expected to form cations. Elements in periodic Group 2A form ions of +2 charge, therefore barium is expected to form Ba^{2+}.
(b) Oxygen is expected to form anions. It is in periodic Group 6A, and forms O^{2-}.
(c) Potassium is expected to form cations. Elements in periodic Group 1A form ions of +1 charge, therefore potassium will form K^{+}.

2. Ion Charge and Empirical Formula

Problem
Aluminum acts as a metal and oxygen acts as a nonmetal when they react. Predict the empirical formula for aluminum oxide.

Approach
Aluminum loses 3 valence electrons to form Al^{3+}, whereas oxygen gains 2 valence electrons to form O^{2-}.

Solution:
When ionic compounds form from elements, the total charge on the cations must balance out the total negative charge on the anions. We will need two Al ions, which give a +6 charge, for every 3 oxygen ions, which give a -6 charge. The empirical formula is: Al_2O_3.

3. Electrostatic Forces

Question
Which compound's ions are held together by stronger forces: LiBr or MgS?

Solution
The most significant difference between the two compounds is the charges on the individual ions. Li and Br have +1 and -1 charges, respectively. Mg and S have +2 and -2 charges, respectively. The higher charges on Mg and S (+2 and -2, in relation to +1 and -1 in LiBr) lead to stronger electrostatic forces.

4. Ionic Compounds

Problem
Give the number and identify the constituent ions in the following ionic compounds:
(a) NaF (b) $CaCl_2$ (c) $Cu(NO_3)_2$ (d) $NaCH_3CO_2$.

Solution

(a) 1 Na^+ and 1 F^- ion (b) 1 Ca^{2+} ion and 2 Cl^- ions
(c) 1 Cu^{2+} ion and 2 NO_3^- ions (d) 1 Na^+ and 1 $CH_3CO_2^-$ ion

5. Nomenclature

Problem

Give the formula for each of the following ionic compounds:
(a) ammonium nitrate (b) cobalt(II) sulfate (c) nickel(II) cyanide.

Solution

(a) NH_4NO_3 (b) $CoSO_4$ (c) $Ni(CN)_2$

6. Nomenclature

Problem

Name the following ionic compounds:
(a) Li_2CO_3 (b) $KHSO_3$ (c) CuCl and $CuCl_2$.

Solution

(a) Lithium carbonate (b) Potassium hydrogen sulfite
(c) Copper(I) chloride and copper(II) chloride

7. Nomenclature

Question

What are the names of each of these molecules?
(a) CO_2 (b) S_2F_{10} (c) BF_3

Solution

The symbol of the cation is always given first, followed by the anion symbol. The correct names for the above molecules are:
(a) carbon dioxide (b) disulfur decafluoride (c) boron trifluoride

8. Nomenclature

Problem

Give the name for each of the following compounds:
(a) PI_3 (b) SCl_2 (c) XeO_3

Solution

(a) Phosphorus triiodide (b) Sulfur dichloride (c) Xenon trioxide

9. Naming Hydrogen-containing Compounds

Question
What is the name of HBr?

Solution
Hydrogen monobromide or hydrobromic acid

10. Nomenclature

Problem
Give the formula for each of the following compounds:
(a) zinc(II) carbonate (b) sodium phosphate (c) aluminum chloride.

Solution
(a) $ZnCO_3$ (b) Na_3PO_4 (c) $AlCl_3$

11. Molar Mass

Question
What is the molar mass of NaOH?

Approach
To find the molar mass of a compound, we must list the elements in the compound's formula and determine the number of atoms of each element in the formula. Then, for each element, we need to look up the molar mass. Once we have found the mass contributed by each element for one mole of the compound, the molar mass is calculated by adding these individual masses.

Solution
1 mol Na in NaOH = (1)22.98977 g/mol = 22.98977 g
1 mol O in NaOH = (1)15.9994 g/mol = 15.9994 g
1 mol H in NaOH = (1)1.0079 g/mol = 1.0079 g

Molar mass of 1 mol NaOH = 22.98977 g + 15.9994 g + 1.0079 g = 39.9971 g/mol NaOH

12. Molar Mass

Question
What is the molar mass of $Cu(NO_3)_2$?

Approach
To find the molar mass of a compound, we must list the elements in the compound's formula and determine the number of atoms of each element in the formula. Then, for each element, we need to look up the molar mass. Once we have found the mass contributed by each element for one mole of the compound, the molar mass is calculated by adding these individual masses.

Solution

1 mol Cu in $Cu(NO_3)_2$ = (1)63.546 g/mol = 63.546 g
2 mol N in $Cu(NO_3)_2$ = (2)14.0067 g/mol = 28.0134 g
6 mol O in $Cu(NO_3)_2$ = (6)15.9994 g/mol = 95.9964 g

Molar mass of 1 mol $Cu(NO_3)_2$ = 63.546 g + 28.0134 g + 95.9964 g = 187.556 g/mol of $Cu(NO_3)_2$

13. Converting Mass to Moles

Question
What quantity, in moles, does 107 g HBr represent?

Solution
The molar mass of HBr is 80.912 g/mol. The number of moles of HBr is:
107 g HBr * 1 mol HBr/80.912 g HBr = 1.32 mol HBr

14. Molar Mass and Moles

Question
Which represents a greater number of moles: 4.5 g of carbon dioxide or 4.5 g of sodium chloride?

Solution
The molar masses are 44.01 g for CO_2 and 58.44 g for NaCl. The numbers of moles of each compound is calculated using the molar mass:
4.5 g CO_2 * 1mol CO_2/44.01 g CO_2 = 0.10 mol CO_2
4.5 g NaCl * 1 mol NaCl/58.44 g NaCl = 0.077 mol NaCl

There are more moles of CO_2 than of NaCl.

15. Atomic Mass

Question
What is the average atomic mass of chlorine?

Mass of ^{35}Cl	34.96885 amu
Mass of ^{37}Cl	36.96712 amu
Isotopic abundance of ^{35}Cl	75.77 %
Isotopic abundance of ^{37}Cl	24.23 %

Approach
Consider the mass and abundance of the isotopes of chlorine.

Solution:
Step 1. There are 2 naturally occurring isotopes of chlorine: ^{35}Cl and ^{37}Cl. A sample of chlorine shows that the 2 isotopes are not present in equal amounts. The percent abundance is calculated by dividing the number of atoms of a given isotope by the total number of atoms of all isotopes of that element, times one hundred.

$$\text{Percent abundance} = \frac{\text{number of atoms of a given isotope}}{\text{total number of atoms of that element}} \times 100\%$$

Step 2. The average atomic mass is

$$\text{Atomic mass} = \sum_{\text{all isotopes}} \text{isotopic mass x fractional abundance}$$

For chlorine, the atomic mass is

Atomic mass = 34.96885 amu * 0.7577 + 36.96712 amu * 0.2423 = 35.45 amu

16. Converting Mass to Atoms

Question
The 1989 nutritional recommended dietary allowance (RDA) of iron for a female age 19-24 is 15 mg. How many iron atoms is this?

Approach
Mass must be converted to moles, then moles must be converted to atoms. Avogadro's number (6.022×10^{23}) will be needed, as will the molar mass of iron. Note: in molar calculations, all masses must be converted to grams.

Solution:
Follow the series of multiplication steps below to convert mass to atoms.

$$(15 \text{ mg Fe}) \left(\frac{1 \text{ g}}{1000 \text{ mg}}\right)\left(\frac{1 \text{ mol Fe}}{55.847 \text{ g Fe}}\right)\left(\frac{6.022\text{x}10^{23}}{1 \text{ mol Fe}}\right) = 1.6 \times 10^{20} \text{ Fe atoms}$$

In 15 mg of iron there are 1.6×10^{20} Fe atoms.

17. Converting Mass to Molecules and Atoms

Question
How many ozone molecules and how many oxygen atoms are contained in 48.00 g ozone, O_3?

Approach
First, write the equation for the synthesis of ozone. Then, to calculate the number of ozone molecules in 48.00 g ozone, convert mass to molecules using the molecular weight of ozone and Avogadro's number (6.022×10^{23}). Next, to calculate the number of oxygen atoms, start with the mass of ozone, convert this to grams, use a mole-to-mole ratio to convert ozone to O_2, and finally, use Avogadro's number to obtain the number of oxygen atoms.

Solution:
Step 1. Write the equation for the synthesis of ozone, and calculate its mass.

$3 O_2(g) \rightarrow 2 O_3(g)$ O_3 = 3(15.999 g/mol) = 47.997 g/mol

Step 2. To calculate the number of ozone molecules from its mass, multiply grams of ozone, molecular weight of ozone, and Avogadro's number.

$$48.00\text{g } O_3 \cdot \frac{1 \text{ mol } O_3}{49.997\text{g } O_3} \cdot \frac{6.022 \times 10^{23} \text{ molecules}}{1 \text{ mol } O_3} = 6.022 \times 10^{23} \text{ molecules } O_3$$

The number of molecules of ozone in 48.00 grams is 6.022×10^{23} molecules.

Step 3. To calculate the number of atoms of oxygen, multiply three atoms of oxygen per molecule of ozone and the number of molecules of ozone.

$$6.022 \times 10^{23} \text{ molecules } O_3 \cdot \frac{3 \text{ atoms O}}{1 \text{ molecule } O_3} = 1.807 \times 10^{24} \text{ atoms O}$$

The number of oxygen atoms in 48.00 g of ozone is 1.807×10^{24} atoms.

18. Empirical Formula

Question
A 1.27 g sample of an oxide contains 0.55 g phosphorus and 0.72 g oxygen. What this oxide's empirical formula?

Approach
First, it is necessary to determine from the experimental data the number of moles of atoms of each element present. The simplest ratio is then found by dividing the numbers of moles of each element by the number of moles of the element present in the smallest amount.

Solution
Step 1. Calculate the number of moles of phosphorus and oxygen.
(0.55 g P)(1 mol P/30.97 g P) = 0.018 mol P
(0.72 g O)(1 mol O/16.00 g O) = 0.045 mol O

Step 2. Divide the numbers of moles by the number of moles of the element present in the smallest amount: P.
0.018 mol P/0.018 mol P = 1.0
0.045 mol O/0.018 mol P = 2.5

Thus, the empirical formula is $P_{1.0}O_{2.5}$.

Step 3. Double all numbers in the formula to convert the fraction to a whole number.
$2(P_{1.0}O_{2.5}) = P_2O_5$

The empirical formula is P_2O_5.

19. Percent Composition

Question
A 2.91 g sample of potassium metal when burned in oxygen formed a compound weighing 6.11 g and containing only potassium and oxygen. What is the percent composition of each element in this compound?

Approach

The percent composition is the percent by mass of each element in the compound, which is given by the mass of that element divided by the total mass of the compound, times 100.

Solution

The percent potassium in this compound is:

%K = (2.91 g / 6.11 g compound)(100%) = 47.6 %

The percent oxygen in this compound is:

6.11 g compound - 2.91 g K = 3.20 g O

%O = (3.20 g / 6.11 g compound)(100%) = 52.4 %

The percent composition of the compound is 47.6% potassium and 52.4% oxygen.