Chapter 4
Nomenclature and Chemical Equations

Chapter Objectives

1. To learn how to name a compound
2. To write balanced chemical equations to represent chemical reactions

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Introduction

A chemical reaction occurs when new substances form. To describe chemical reactions, chemists use ***chemical equations*** which summarize both the ***qualitative*** information, i.e. what chemicals react and what products form, and ***quantitative*** information, i.e. the relative amount of reactants consumed and products produced. In this chapter, we will learn how to describe the qualitative information of a reaction by writing chemical formulas of substances and chemical equations. The quantitative information of a reaction will be discussed in the next chapter.

Nomenclature of Compounds

From the last chapter, we learnt that compounds contain either ionic bonds or covalent bonds. Depending on the type of bonds present in a compound, different rules are applied to its naming.

(i) Ionic Compounds

In ionic compounds, there are both cations and anions. The ions can be either monatomic or polyatomic. ***Monatomic cations*** can be divided into two categories. One category includes cations that are unique to their elements. For example, a hydrogen atom always forms a hydrogen ion, H^+, while a sodium atom always forms a sodium ion, Na^+. The ions share the same names with their original atoms. This applies to most representative metals and a few d-block elements such as silver and zinc.

When writing the chemical formula of an ion, its charge must be stated with a superscript. The magnitude of the charge is always expressed before the sign of the charge. Calcium atoms can form calcium ions with a +2 charge. Therefore, the chemical formula for a calcium ion is Ca^{2+}.

The charges of the monatomic cations formed by most representative elements can be deduced by their group numbers. Sodium is in group IA so the charge of its ion is +1, while calcium is in group IIA and the charge of its ion is +2.

Some common monatomic cations unique to their elements are listed in Table 4.1. Among them, it should be noted that there are two *d*-block elements, zinc and silver, which form unique ions.

Table 4.1 Common Monatomic Cations Unique to Their Elements

Charge	Name	Symbol	Charge	Name	Symbol	Charge	Name	Symbol
+1	Hydrogen	H^+	+2	Magnesium	Mg^{2+}	+3	Aluminum	Al^{3+}
	Lithium	Li^+		Calcium	Ca^{2+}			
	Sodium	Na^+		Strontium	Sr^{2+}			
	Potassium	K^+		Barium	Ba^{2+}			
	Rubidium	Rb^+		Zinc	Zn^{2+}			
	Cesium	Cs^+						
	Silver	Ag^+						

The other category includes cations which are formed by the same kind of metal atom but are capable of having different charges. These ions are mainly produced from transition elements. For examples, iron forms either an iron(II) ion, Fe^{2+}, or an iron(III) ion, Fe^{3+}; copper forms either a copper(I) ion, Cu^+, or a copper(II) ion, Cu^{2+}. The names of the ions include both the name of the original atoms and the charges of the ions written in Roman numerals embraced within parentheses. The common ions of this type are listed in Table 4.2 on the next page.

Table 4.2 Common Monatomic Cations Not Unique to Their Elements

Charge	Name	Symbol	Charge	Name	Symbol	Charge	Name	Symbol
+1	Copper(I)	Cu^+	+2	Manganese(II)	Mn^{2+}	+3	Chromium(III)	Cr^{3+}
				Iron(II)	Fe^{2+}		Iron(III)	Fe^{3+}
				Copper(II)	Cu^{2+}			
				Tin(II)	Sn^{2+}			
				Mercury(II)	Hg^{2+}			
				Lead(II)	Pb^{2+}			

Polyatomic cations usually have names different from that of their constituent atoms. In SAT chemistry, there are two polyatomic cations to memorize. They are ammonium ion, NH_4^+, and hydronium ion, H_3O^+, as list in Table 4.3. NH_4^+ is known to form ionic compounds with some anions while H_3O^+ is only stable in aqueous solution.

Table 4.3 Common Polyatomic Cations

Charge	Name	Symbol
+1	Ammonium	NH_4^+
	Hydronium	H_3O^+

Monatomic anions are named by replacing the end of the element names with "-ide". For example, an oxygen atom can form an oxide ion, O^{2-}, while a fluorine atom can form a fluoride ion, F^-. The charge of the ions can be deduced by subtracting 8 from its group number, except for the hydride ion. Oxygen is in group VIA and its ion has a 6 – 8 = -2 charge. Fluorine is in group VIIA and its ion has a 7 – 8 = -1 charge. The common monatomic anions are listed in Table 4.4 on the next page.

Table 4.4 Common Monatomic Anions

Charge	Name	Symbol	Charge	Name	Symbol	Charge	Name	Symbol
-1	Hydride	H^-	-2	Oxide	O^{2-}	-3	Nitride	N^{3-}
	Fluoride	F^-		Sulfide	S^{2-}		Phosphide	P^{3-}
	Chloride	Cl^-						
	Bromide	Br^-						
	Iodide	I^-						

Most polyatomic anions are produced by acid dissociation in water. For example, nitric acid, HNO_3, and sulfuric acid, H_2SO_4, dissolve in water to give nitrate ions, NO_3^-, and sulfate ions, SO_4^{2-}, respectively. These ions generally contain a central nonmetal atom surrounded by oxygen atoms. The number of oxygen atoms surrounding a specific nonmetal atom can vary which gives rise to a series of anions as shown in Table 4.5. If a series only contains two members, which is most commonly the case, the member that has more oxygen is named by replacing the end of the name of the central atom with "-ate", while another one is named by replacing with "-ite". Examples are sulfate, SO_4^{2-} and sulfite, SO_3^{2-}. There is a four-member series related to chlorine that is worth memorizing. The members are perchlorate ion, ClO_4^-, chlorate ion, ClO_3^-, chlorite ion, ClO_2^- and hypochlorite ion, ClO^-.

Table 4.5 Series of Common Polyatomic Anions

Charge	Name	Symbol	Charge	Name	Symbol
-1	Nitrite	NO_2^-	-2	Sulfite	SO_4^{2-}
	Nitrate	NO_3^-		Sulfate	SO_4^{2-}
-1	Hypochlorite	ClO^-	-2	Carbonate	CO_3^{2-}
	Chlorite	ClO_2^-			
	Chlorate	ClO_3^-	-3	Phosphite	PO_3^{3-}
	Perchlorate	ClO_4^-		Phosphate	PO_4^{3-}

The maximum number of oxygen atoms varies with different central atoms. The elements in the second period can have at most three oxygen atoms in their ions, while the elements in the third period can have up to four oxygen atoms in their ions. In addition, the negative charges on these ions decrease across the period. This trend is shown in Table 4.6.

Table 4.6 Polyatomic Anions with the Greatest Number of Oxygen Atom

	Group IVA	Group VA	Group VIA	Group VIIA
Second period	CO_3^{2-}	NO_3^-		
Third period		PO_4^{3-}	SO_4^{2-}	ClO_4^-

The anions with multiple charges are able to receive hydrogen ions to form other anions. A carbonate ion, CO_3^{2-}, can receive one hydrogen ion to form a hydrogen carbonate ion, HCO_3^-. Phosphate ion can receive one or two hydrogen ions to form a hydrogen phosphate ion, HPO_4^{2-}, or a dihydrogen phosphate ion, $H_2PO_4^-$ respectively. When there is one ionizable hydrogen atom in the ion, “Hydrogen” is added preceding the ion name. When there are two ionizable hydrogen atoms, “di” is added as a prefix to the name. For each addition of a hydrogen ion, the charge of the ion is lowered by one. Therefore, HPO_4^{2-} has one less negative charge than PO_4^{3-}. Further examples are shown in Table 4.7.

Table 4.7 Anions Formed by the Combination of Hydrogen Ions and Polyatomic Anions

Charge	Name	Symbol	Charge	Name	Symbol
-2	Carbonate	CO_3^{2-}	-2	Sulfate	SO_4^{2-}
-1	Hydrogen carbonate	HCO_3^-	-1	Hydrogen sulfate	HSO_4^-
-3	Phosphate	PO_4^{3-}			
-2	Hydrogen phosphate	HPO_4^{2-}			
-1	Dihydrogen phosphate	$H_2PO_4^-$			

Some polyatomic anions have special names and require memorization. They are listed in Table 4.8.

Table 4.8 Series of Common Polyatomic Anions

Charge	Name	Symbol	Charge	Name	Symbol
-1	Hydroxide	OH^{-}	-2	Oxalate	$C_2O_4^{2-}$
	Cyanide	CN^{-}		Acetate	$C_2H_3O_2^{-}$
	Permanganate	MnO_4^{-}		Chromate	CrO_4^{2-}
				Dichromate	$Cr_2O_7^{2-}$

To name an ionic compound, the name of a cation is always followed by that of an anion. The compound comprising sodium ions and chloride ions is thus named sodium chloride, while that comprising iron(III) ions and oxide ions is called iron(III) oxide.

In writing chemical formulas, the charges of cations must balance that of anions. A simple method to match the charges of cations and anions with a correct ratio is shown in Table 4.9

Table 4.9 Procedure in Deducing Chemical Formulas for Ionic Compounds

	Example 1 Calcium carbonate	Example 2 Ammonium sulfate	Example 3 Iron(III) oxide
1. Write chemical formulas for the ions.	Ca^{2+}, CO_3^{2-}	NH_4^{+}, SO_4^{2-}	Fe^{3+}, O^{2-}
2. Write the superscripts of the ions as the subscripts of the opposite ions. Use parentheses for polyatomic ions.	$Ca_2^{2+}(CO_3^{2-})_2$	$(NH_4^{1+})_2(SO_4^{2-})_1$	$Fe_2^{3+}O_3^{2-}$
3. Write the formulas in the simplest whole-number ratio	$Ca_1^{2+}(CO_3^{2-})_1$	$(NH_4^{+})_2(SO_4^{2-})_1$	$Fe_2^{3+}O_3^{2-}$
4. Drop the charges on the ions, the subscript 1, and the parentheses if there is only one polyatomic ion in the formula.	$CaCO_3$	$(NH_4)_2SO_4$	Fe_2O_3

(ii) Covalent Compounds

Simple rules for naming and writing formulas of binary covalent compounds, inorganic acids and some other common compounds will be discussed in this section. Naming covalent compounds is usually complicated and it will be covered in Chapter 13.

Binary covalent compounds are generally named according to the following rules:

1. The order of the elements in a chemical name is the same as that in the chemical formula.
2. The first element uses its own name while the second element is named by ending with "ide" similar to the anions in ionic compounds.
3. The number of atoms in the molecular formula is specified with prefixes listed in Table 4.10. For example, N_2O is named as dinitrogen monoxide.
4. When the first element contains only one atom, its prefix is neglected. CO_2 is named as carbon dioxide but not monocarbon dioxide.
5. If oxygen is the second element, the vowels "a" or "o" at the end of a prefix is dropped. Therefore, CO is called carbon monoxide, not carbon mon<u>o</u>oxide; N_2O_5 is called dinitrogen pentoxide, not dinitrogen pent<u>a</u>oxide.

Table 4.10 Prefixes in Naming Covalent Compounds

Number of atom	Prefix	Number of atom	Prefix
1	Mono-	6	Hexa-
2	Di-	7	Hepta-
3	Tri-	8	Octa-
4	Tetra-	9	Nona-
5	Penta-	10	Deca-

For an acid that does not possess any oxygen atoms, "hydro" is used as the prefix and "ic" is used as the suffix to the name of the anion it produces in water. HF dissociates in water to produce fluoride ions; therefore it is named hydrofluoric acid.

For an acid that contains oxygen atoms, the name of its anion ends in "ic". HNO_3 dissociates in water to give nitrate ions, NO_3^-, and so it is called nitric acid. Some common acids are listed in Table 4.11 on the next page.

Table 4.11 Common Acids

Chemical name	Chemical formula	Chemical name	Chemical formula
Hydrofluoric acid	HF	Nitric acid	HNO_3
Hydrochloric acid	HCl	Sulfuric acid	H_2SO_4
Hydrobromic acid	HBr	Phosphoric acid	H_3PO_4
Hydroiodic acid	HI	Acetic acid	$HC_2H_3O_2$

Writing and Balancing Chemical Equations

A chemical equation tells us what reactants and what products are involved in a chemical reaction. An example is shown below:

$$2\text{Na}(s) + 2\text{H}_2\text{O}(l) \rightarrow 2\text{NaOH}(aq) + \text{H}_2(g)$$

It is a convention to write the reactants on the left and the products on the right. The letters enclosed in the parenthesis tell us the states of the substances: *s* denotes a solid, *l* denotes a liquid, *g* denotes a gas and *aq* denotes an aqueous solution, i.e. a homogeneous mixture in water. Therefore, the above chemical equation informs us that solid sodium reacts with liquid water to give an aqueous solution of sodium hydroxide and gaseous hydrogen. The numbers in front of the chemical formulas are called the ***coefficients***. They represent the relative ratios between every reactant and product so that the numbers of atoms on both sides of the equation are balanced. When the coefficient equals to one, by convention, it is usually ignored in the equation. For the previous example, we can check whether the equation is balanced by the following table:

	$2\text{Na}(s)$	+	$2\text{H}_2\text{O}(l)$	→	$2\text{NaOH}(aq)$	+	$\text{H}_2(g)$
Each of the formulas contains	1Na		2H, 1O		1Na, 1O, 1H		2H
The coefficients of the formulas	2		2		2		1
The total number of atoms in the formulas	2Na		4H, 2O		2Na, 2O, 2H		2H
The total number of atoms on each side		2Na, 4H, 2O				2Na, 4H, 2O	

We can see that on both sides there are two sodium atoms, four hydrogen atoms and two oxygen atoms. Therefore, the equation is balanced.

When writing a chemical equation for a reaction, the first thing is to make sure that the chemical formulae of the reactants and the products are correctly written. The next step is to balance the equation. Most chemical reactions can be balanced by simple inspection. Gaining experience in balancing equations is more important than following the sophisticated systematic steps. Nevertheless, some useful reminders for balancing equations are listed below:

1. Manipulate only the coefficients when balancing equations. Never change the subscripts of the formulas because the subscripts are unique to each compound.
2. Leave the atoms that appear as an element to the very last for balancing. For example, the following equation contains an oxygen gas, which is an element. Oxygen should be chosen as the last element to balance.

Unbalanced equation	$\ldots CH_4(g) + \ldots O_2(g)$	$\rightarrow$	$\ldots CO_2(g) + \ldots H_2O(g)$
Balancing C	$1\ CH_4(g) + \ldots O_2(g)$	$\rightarrow$	$1\ CO_2(g) + \ldots H_2O(g)$
Balancing H	$1\ CH_4(g) + \ldots O_2(g)$	$\rightarrow$	$1\ CO_2(g) + 2\ H_2O(g)$
Balancing O	$1\ CH_4(g) + 2\ O_2(g)$	$\rightarrow$	$1\ CO_2(g) + 2\ H_2O(g)$
Balanced equation	$CH_4(g) + 2O_2(g)$	$\rightarrow$	$CO_2(g) + 2H_2O(g)$

3. Polyatomic ions can be regarded as individual entities if they do not decompose in a reaction. In the following equation, there are polyatomic ions, NH_4^+ and NO_3^-. They do not decompose and each of them is balanced on both sides. There is no need to check whether the numbers of nitrogen, hydrogen and oxygen atoms are balanced on both sides respectively.

Unbalanced equation	$\ldots NH_4Cl(aq) + \ldots Pb(NO_3)_2(aq)$	$\rightarrow$	$\ldots NH_4NO_3(aq) + \ldots PbCl_2(s)$
Balancing Pb	$\ldots NH_4Cl(aq) + 1\ Pb(NO_3)_2(aq)$	$\rightarrow$	$\ldots NH_4NO_3(aq) + 1\ PbCl_2(s)$
Balancing Cl	$2\ NH_4Cl(aq) + 1\ Pb(NO_3)_2(aq)$	$\rightarrow$	$\ldots NH_4NO_3(aq) + 1\ PbCl_2(s)$
Balancing (NH_4)	$2\ NH_4Cl(aq) + 1\ Pb(NO_3)_2(aq)$	$\rightarrow$	$2\ NH_4NO_3(aq) + 1\ PbCl_2(s)$
Balanced equation	$2NH_4Cl(aq) + Pb(NO_3)_2(aq)$	$\rightarrow$	$2NH_4NO_3(aq) + PbCl_2(s)$

4. Sometimes, it is convenient to use fractions to balance chemical equations involving diatomic molecules. In the reaction of sodium metal and water, hydrogen gas is released as diatomic molecules. We can start guessing the coefficient of H_2 to be one half to make balancing easier.

Unbalanced equation	$\ldots Na(s) + \ldots H_2O(l) \rightarrow \ldots NaOH(aq) + \ldots H_2(g)$
Balancing Na	$1\, Na(s) + \ldots H_2O(l) \rightarrow 1\, NaOH(aq) + \ldots H_2(g)$
Putting one half before H	$1\, Na(s) + \ldots H_2O(l) \rightarrow 1\, NaOH(aq) + 1/2 H_2(g)$
Balancing H	$1\, Na(s) + 1\, H_2O(l) \rightarrow 1\, NaOH(aq) + 1/2 H_2(g)$
Balanced equation	$Na(s) + H_2O(l) \rightarrow NaOH(aq) + 1/2H_2(g)$

The smallest whole numbers can then be retrieved by multiplying the whole equation by 2. The previous equation thus turns into:

Multiplying by 2	$[\ Na(s) + H_2O(l) \rightarrow NaOH(aq) + 1/2H_2(g)\ ] \times 2$
Balanced equation	$2Na(s) + 2H_2O(l) \rightarrow 2NaOH(aq) + H_2(g)$

When chemical reactions take place in an aqueous solution, some compounds dissociate to produce ions. Not all ions take part in a chemical reaction though. These ions are called ***spectator ions***. For example, in the below equation,

$$Cu(s) + 2AgNO_3(aq) \rightarrow 2Ag(s) + Cu(NO_3)_2(aq)$$

both $AgNO_3$ and $Cu(NO_3)_2$ are dissolved in water as stated by the state symbol, aq. They fully dissociate into the corresponding ions in water respectively such that the formulas, $AgNO_3$(aq) and $Cu(NO_3)_2$(aq), actually imply the following:

$$AgNO_3(aq) = Ag^+(aq) + NO_3^-(aq) \quad \text{and} \quad Cu(NO_3)_2(aq) = Cu^{2+}(aq) + 2NO_3^-(aq)$$

The full equation can be rewritten as the equation below which shows all the ions and thus is called the ***complete ionic equation***:

$$Cu(s) + 2Ag^+(aq) + 2NO_3^-(aq) \rightarrow 2Ag(s) + Cu^{2+}(aq) + 2NO_3^-(aq)$$

The same amount of nitrate ions appears on both sides of the equation. This shows that nitrate ions are not necessarily involved in the reaction and thus are the spectator ions.

To make the chemical equations concise, the spectator ions are cancelled on both sides as shown below:

$$\mathrm{Cu}(s) + 2\mathrm{Ag}^{+}(aq) \rightarrow 2\mathrm{Ag}(s) + \mathrm{Cu}^{2+}(aq)$$

The resulting equation is called the ***net ionic equation***.

Ionic equations require balancing of both the number of atoms and the number of charges. In the previous example, there are one copper atom and two silver atoms on both sides. For the charges, two Ag^{+} give rise to a total of 2 units of positive charges on the left while one Cu^{2+} ion yields the same amount of positive charges on the right. The charges are thus balanced. Not all ionic equations can be balanced by simple inspection. More complicated examples will be discussed in chapter 11.

Summary

1. Ionic compounds are named according to their cations and anions.
2. Covalent compounds are named according to the elements present.
3. Chemical equations give information on both the identity and the relative quantities of reactants and products.
4. A net ionic equation can be obtained by crossing out the spectator ions on both sides of a chemical equation.
5. A summary of ions to be memorized is given on the next two pages.

Key Words

Chemical equation
Qualitative
Quantitative
Monatomic cations
Polyatomic cations
Monatomic anions
Polyatomic anions
Coefficient
Spectator ion
Complete ionic equation
Net ionic equation

Tables of Cations

Charges					
+1		+2		+3	
Hydrogen	H^+	Magnesium	Mg^{2+}	Aluminum	Al^{3+}
Lithium	Li^+	Calcium	Ca^{2+}	Chromium(III)	Cr^{3+}
Sodium	Na^+	Strontium	Sr^{2+}	Iron(III)	Fe^{3+}
Potassium	K^+	Barium	Ba^{2+}		
Rubidium	Rb^+	Zinc	Zn^{2+}		
Cesium	Cs^+	Manganese(II)	Mn^{2+}		
Silver	Ag^+	Iron(II)	Fe^{2+}		
Copper(I)	Cu^+	Copper(II)	Cu^{2+}		
Ammonium	NH_4^+	Tin(II)	Sn^{2+}		
Hydronium	H_3O^+	Mercury(II)	Hg^{2+}		
		Lead(II)	Pb^{2+}		

Tables of Anions

Charges					
-1		-2		-3	
Hydride	H^-	Oxide	O^{2-}	Nitride	N^{3-}
Fluoride	F^-	Sulfide	S^{2-}	Phosphide	P^{3-}
Chloride	Cl^-	Sulfite	SO_4^{2-}	Phosphite	PO_3^{3-}
Bromide	Br^-	Sulfate	SO_4^{2-}	Phosphate	PO_4^{3-}
Iodide	I^-	Carbonate	CO_3^{2-}		
Nitrite	NO_2^-	Hydrogen phosphate	HPO_4^{2-}		
Nitrate	NO_3^-	Oxalate	$C_2O_4^{2-}$		
Hypochlorite	ClO^-	Acetate	$C_2H_3O_2^-$		
Chlorite	ClO_2^-	Chromate	CrO_4^{2-}		
Chlorate	ClO_3^-	Dichromate	$Cr_2O_7^{2-}$		
Perchlorate	ClO_4^-				
Hydrogen carbonate	HCO_3^-				
Hydrogen sulfate	HSO_4^-				
Dihydrogen phosphate	$H_2PO_4^-$				
Hydroxide	OH^-				
Cyanide	CN^-				
Permanganate	MnO_4^-				

Exercise on Nomeclature

Fill the table below.

Chemical Name	Formula
Silver oxide	
Iron(III) chloride	
Potassium permanganate	
Lead(II) sulfide	
Ammonium chloride	
Phosphorus pentachloride	
Lithium carbonate	
Hydroiodic acid	
Sodium silicate	
Copper(II) hydroxide	
Lithium phosphide	
Cesium fluoride	
Dioxygen difluoride	
Tin(II) bromide	
Manganese(II) oxide	
Carbon tetrachloride	
Sodium cyanide	
Barium sulfate	
Dinitrogen monoxide	
Magnesium chlorate	
Chromium(III) nitrate	
Calcium sulfite	
Lithium hydride	
Phosphoric acid	
Mercury(II) iodide	
Sodium hydrogencarbonate	
Aluminum nitride	

Chemical Name	Formula
	$CaCl_2$
	H_2SO_4
	Fe_2O_3
	NH_4NO_3
	SF_6
	N_2O_5
	Li_3N
	SO_3
	$Al_2(SO_4)_3$
	CO
	$SnCl_2$
	$NaClO$
	AgI
	$K_2Cr_2O_7$
	$CuBr$
	NaH_2PO_4
	$CaSO_4$
	NCl_3
	$Sr(C_2H_4O_2)_2$
	Cl_2O
	$LiHCO_3$
	ZnS
	$MgSO_4$
	$Cr(OH)_3$
	S_2Cl_2
	$CaCO_3$
	$Cu(NO_3)_2$

Review Questions

Part A

Questions 1-4 refer to the following.

(A) A_2B
(B) AB
(C) AB_2
(D) AB_3
(E) A_2B_3

Which of the above represents the formula of the most common compound of elements A and B as shown in the pairs below?

	A	B
1.	Ca	Cl
2.	Al	O
3.	P	H
4.	H	S

Part B

	I		II
101.	Copper(II) oxide is the chemical name of Cu_2O	BECAUSE	the formula contains two copper atoms.
102.	In writing a net ionic equation for the reaction of NaOH(*aq*) and HCl(*aq*) producing NaCl(*aq*) and H_2O(*l*), Na^+(*aq*) and Cl^-(*aq*) can be neglected.	BECAUSE	Na^+(*aq*) and Cl^-(*aq*) are spectator ions.

Part C

$$\mathrm{K}\ C_2H_6(g) + \mathrm{K}\ O_2(g) \rightarrow \mathrm{K}\ CO_2(g) + \mathrm{K}\ H_2O(g)$$

5. When the above chemical equation is balanced and all coefficients are reduced to the smallest whole numbers, the coefficient for H_2O is

(A) 3
(B) 4
(C) 6
(D) 8
(E) 12

$$\mathrm{K}\ Cu^{2+} + \mathrm{K}\ I^{-} \rightarrow \mathrm{K}\ CuI + \mathrm{K}\ I_2$$

6. When the above chemical equation is balanced and all coefficients are reduced to the smallest whole numbers, which of the following statement(s) is/are correct?

I. The coefficient for Cu^{2+} is 1.
II. The coefficient for I^{-} is 3.
III. The coefficient for I_2 is 1.

(A) I only
(B) II only
(C) III only
(D) I and II only
(E) I, II and III

Answers and Explanation

Answers to Exercise on Nomenclature

Chemical Name	Formula
Silver oxide	Ag_2O
Iron(III) chloride	$FeCl_3$
Potassium permanganate	$KMnO_4$
Lead(II) sulfide	PbS
Ammonium chloride	NH_4Cl
Phosphorus pentachloride	PCl_5
Lithium carbonate	Li_2CO_3
Hydroiodic acid	HI
Sodium silicate	Na_2SiO_3
Copper(II) hydroxide	$Cu(OH)_2$
Lithium phosphide	Li_3P
Cesium fluoride	CsF
Dioxygen difluoride	O_2F_2
Tin(II) bromide	$SnBr_2$
Manganese(II) oxide	MnO
Carbon tetrachloride	CCl_4
Sodium cyanide	$NaCN$
Barium sulfate	$BaSO_4$
Dinitrogen monoxide	N_2O
Magnesium chlorate	$Mg(ClO_3)_2$
Chromium(III) nitrate	$Cr(NO_3)_3$
Calcium sulfite	$CaSO_3$
Lithium hydride	LiH
Phosphoric acid	H_3PO_4
Mercury(II) iodide	HgI_2
Sodium hydrogencarbonate	$NaHCO_3$
Aluminum nitride	AlN

Chemical Name	Formula
Calcium chloride	$CaCl_2$
Sulfuric acid	H_2SO_4
Iron(III) oxide	Fe_2O_3
Ammonium nitrate	NH_4NO_3
Sulfur hexafluoride	SF_6
Dinitrogen pentoxide	N_2O_5
Lithium nitride	Li_3N
Sulfur trioxide	SO_3
Aluminum sulfate	$Al_2(SO_4)_3$
Carbon monoxide	CO
Tin(II) chloride	$SnCl_2$
Sodium hypochlorite	$NaClO$
Silver iodide	AgI
Potassium dichromate	$K_2Cr_2O_7$
Copper(I) bromide	$CuBr$
Sodium dihydrogen phosphate	NaH_2PO_4
Calcium sulfate	$CaSO_4$
Nitrogen trifluoride	NCl_3
Strontium acetate	$Sr(C_2H_4O_2)_2$
Dichlorine monoxide	Cl_2O
Lithium hydrogen carbonate	$LiHCO_3$
Zinc sulfide	ZnS
Magnesium sulfate	$MgSO_4$
Chromium(III) hydroxide	$Cr(OH)_3$
Disulfur dichloride	S_2Cl_2
Calcium carbonate	$CaCO_3$
Copper(II) nitrate	$Cu(NO_3)_2$

Answer to Review Questions

Question number	Answer	Explanation
1	C	Ca is a metal and Cl is a nonmetal. Therefore, they form an ionic compound. Ca is a group IIA element and it forms Ca^{2+} while Cl is a group VIIA element and it forms Cl^{-}. To balance the charges, the ratio of Ca^{2+} to Cl^{-} must be 1 : 2 and so the formula becomes $CaCl_2$, which matches the answer C.
2	E	Al is a metal and O is a nonmetal. Therefore, they form an ionic compound. Al is a group IIIA element and it forms Al^{3+} while O is a group VIA element and it forms O^{2-}. To balance the charges, the ratio of Al^{3+} to O^{2-} must be 2 : 3 and so the formula becomes Al_2O_3, which matches the answer E.
3	D	Both P and H are nonmetals. Therefore, they form a covalent compound. P is a group VA element which shares three electrons while H shares one electron to achieve the electron configuration of He. So one P atom can share electrons with three H atoms. The simplest formula is PH_3, which matches the answer D.
4	A	Both H and S are nonmetals. Therefore, they form a covalent compound. H shares one electron to achieve the electron configuration of He while S is a group VIA element and it shares two electrons. So one S atom can share electrons with two H atoms. The simplest formula is H_2S, which matches the answer A.
101	F, T	The correct name for Cu_2O is copper(I) oxide because Cu^{+} ions instead of Cu^{2+} ions are found in Cu_2O. The roman numeral represents the charge on an ion or the oxidation number of an atom, despite of the number of atoms in a chemical formula.
102	T, T, CE	Since Na^{+}(*aq*) ions can be found in both the reactant, NaOH(*aq*), and the product, NaCl(*aq*), they do not take part in the reaction and act as spectator ions. Likewise, Cl^{-}(*aq*) ions are also found in both the reactant and the product. Thus, both Na^{+}(*aq*) and Cl^{-}(*aq*) can be neglected in the net ionic equation.

Question number	Answer	Explanation
5	C	We can balance the chemical equation in the following steps: Original equation $\quad \ldots C_2H_6(g) + \ldots O_2(g) \rightarrow \ldots CO_2(g) + H_2O(g)$ Balancing C $\quad \underline{1}\, C_2H_6(g) + \ldots O_2(g) \rightarrow \underline{2}\, CO_2(g) + \ldots H_2O(g)$ Balancing H $\quad \underline{1}\, C_2H_6(g) + \ldots O_2(g) \rightarrow \underline{2}\, CO_2(g) + \underline{3}\, H_2O(g)$ Balancing O $\quad \underline{1}\, C_2H_6(g) + \underline{7/2}\, O_2(g) \rightarrow \underline{2}\, CO_2(g) + \underline{3}\, H_2O(g)$ Multiplying by 2 $\quad \underline{2}\, C_2H_6(g) + \underline{7}\, O_2(g) \rightarrow \underline{4}\, CO_2(g) + \underline{6}\, H_2O(g)$ Therefore, the coefficient of H_2O is 6. It should be noted that this is only one of the many methods in arriving at the same answer.
6	C	We should balance the atoms first: Original equation $\quad \ldots Cu^{2+} + \ldots I^- \rightarrow \ldots CuI + \ldots I_2$ Balancing Cu $\quad \underline{1}\, Cu^{2+} + \ldots I^- \rightarrow \underline{1}\, CuI + \ldots I_2$ Balancing I $\quad \underline{1}\, Cu^{2+} + \underline{3}\, I^- \rightarrow \underline{1}\, CuI + \underline{1}\, I_2$ However, we notice that the number of charges on the left equals to +2 + (-1) × 3 = -1 which is not neutral as shown on the right. Careful inspection on Cu^{2+} and I^- reveals that the ratio of Cu^{2+} to I^- must be 1: 2 to keep the reactant side neutral. Therefore, we can try the following: Balancing charges $\quad \underline{1}\, Cu^{2+} + \underline{2}\, I^- \rightarrow \ldots CuI + \ldots I_2$ Balancing Cu $\quad \underline{1}\, Cu^{2+} + \ldots I^- \rightarrow \underline{1}\, CuI + \ldots I_2$ Balancing I $\quad \underline{1}\, Cu^{2+} + \underline{2}\, I^- \rightarrow \underline{1}\, CuI + \underline{1/2}\, I_2$ Multiplying by 2 $\quad \underline{2}\, Cu^{2+} + \underline{4}\, I^- \rightarrow \underline{2}\, CuI + \underline{1}\, I_2$ It should be noted that this is only one of the many methods in arriving at the same answer. Therefore, only option III is correct and the answer is C.