

## Chapter 9

### Answers to Questions

1. *Word equation:*

Silicon Tetrachloride + Water → Silicon Dioxide + Hydrogen Chloride

*Formulas:*

Next, the chemical formulas are needed. As these are all covalent compounds, the formulas are comparatively easy to construct:

Silicon tetrachloride = SiCl<sub>4</sub>

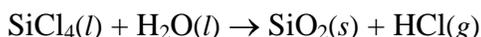
Water = H<sub>2</sub>O

Silicon dioxide = SiO<sub>2</sub>

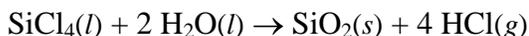
Hydrogen chloride = HCl

*Formula equation:*

The unbalanced formula equation is:



Thus the balanced formula equation is:



2. *Word equation:*

Sodium Chloride + Lead(II) Nitrate → Lead(II) Chloride + Sodium Nitrate

*Formulas:*

Next, the chemical formulas are needed. As these are all ionic compounds, the formulas are more difficult to construct:

Sodium chloride contains the Na<sup>+</sup> ion and the Cl<sup>-</sup> ion. The formula is NaCl.

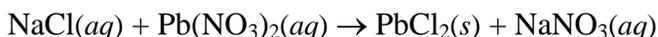
Lead(II) nitrate contains the Pb<sup>2+</sup> ion and the NO<sub>3</sub><sup>-</sup> ion. The formula is Pb(NO<sub>3</sub>)<sub>2</sub>.

Lead(II) chloride contains the Pb<sup>2+</sup> ion and the Cl<sup>-</sup> ion. The formula is PbCl<sub>2</sub>.

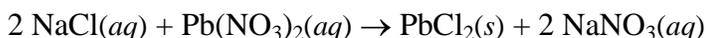
Sodium nitrate contains the Na<sup>+</sup> ion and the NO<sub>3</sub><sup>-</sup> ion. The formula is NaNO<sub>3</sub>.

*Formula equation:*

The unbalanced formula equation is:



Thus the balanced formula equation is:



3. *Word equation:*

Butane + Oxygen → Carbon Dioxide + Water

*Formulas:*

Next, the chemical formulas are needed. As these are all covalent compounds, the formulas are comparatively easy to construct:

Butane = C<sub>4</sub>H<sub>10</sub>

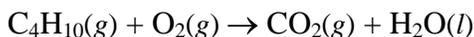
Oxygen = O<sub>2</sub>

Carbon dioxide = CO<sub>2</sub>

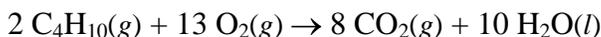
Water = H<sub>2</sub>O

*Formula equation:*

The unbalanced formula equation is:



Thus the balanced formula equation is:



4. *Word equation:*

Magnesium Nitride + Water → Magnesium Hydroxide + Ammonia

*Formulas:*

Next, the chemical formulas are needed. The formulas of the ionic compounds are more difficult to construct:

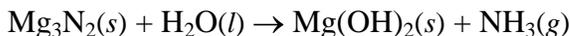
Magnesium nitride contains the Mg<sup>2+</sup> ion and the N<sup>3-</sup> ion. The formula is Mg<sub>3</sub>N<sub>2</sub>.

Magnesium hydroxide contains the Mg<sup>2+</sup> ion and the OH<sup>-</sup> ion. The formula is Mg(OH)<sub>2</sub>.

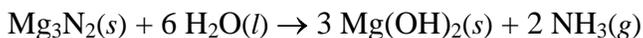
Ammonia = NH<sub>3</sub>

*Formula equation:*

The unbalanced formula equation is:

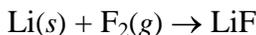


Thus the balanced formula equation is:

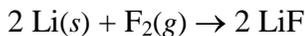


5. (a) This is a combination reaction of two elements, one metal and one nonmetal, so an ionic compound will be formed. As lithium forms Li<sup>+</sup> and fluorine forms F<sup>-</sup>, the product has to be LiF.

The unbalanced equation is:



The balanced equation is:



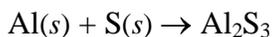
(b) This is a combination reaction of an acid oxide (nonmetal oxide) and water to give an acid. As the product contains 2H, 1S, and 4O, the formula of the acid must be H<sub>2</sub>SO<sub>4</sub> (sulfuric acid).

The balanced equation is:



6. (a) This is a combination of two elements, one metal and one nonmetal, so an ionic compound will be formed. As aluminum forms Al<sup>3+</sup> and sulfur S<sup>2-</sup>, the product has to be Al<sub>2</sub>S<sub>3</sub>.

The unbalanced equation is:



The balanced equation is:



(b) This is a combination reaction of a basic oxide (metal oxide) and water to give a base (a metal hydroxide). Lithium ion is  $\text{Li}^+$  and hydroxide ion is  $\text{OH}^-$ , so the compound formed will be  $\text{LiOH}$ .

The unbalanced equation is:



The balanced equation is:

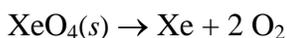


7. (a) This is a decomposition reaction of two nonmetals. The element xenon is monatomic,  $\text{Xe}$ . The element oxygen is diatomic,  $\text{O}_2$ .

The unbalanced equation is:

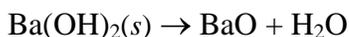


The balanced equation is:



(b) This is the decomposition of a base (an ionic compound containing the hydroxide ion). These decompose to give a basic oxide (metal oxide) and water. If 2H and 1O are removed from  $\text{Ba}(\text{OH})_2$ , the other product is  $\text{BaO}$ . This makes sense as barium ion is  $\text{Ba}^{2+}$  and oxide ion is  $\text{O}^{2-}$ , so  $\text{BaO}$  would be the expected formula.

The balanced equation is:



8. (a) This is a decomposition of a metal and a nonmetal. The element silver is  $\text{Ag}$ . The element oxygen is diatomic,  $\text{O}_2$ .

The unbalanced equation is:

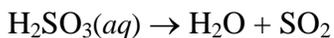


The balanced equation is:



(b) This is the decomposition of an acid. These decompose to give an acidic oxide (nonmetal oxide) and water. If 2H and 1O are removed from  $\text{H}_2\text{SO}_3$ , the other product is  $\text{SO}_2$ .

The balanced equation is:

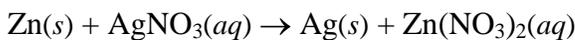


9. (a) iron (b) sodium

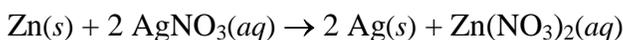
10. (a) calcium (b) copper.

11. (a) According to the activity series, zinc replaces the silver ion in silver nitrate. The zinc ion is  $\text{Zn}^{2+}$  and the nitrate ion is  $\text{NO}_3^-$ , so zinc nitrate is  $\text{Zn}(\text{NO}_3)_2$ .

The unbalanced equation is:

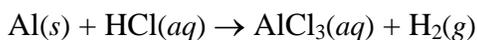


The balanced equation is:

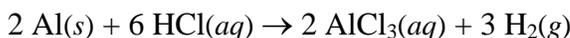


(b) According to the activity series, aluminum replaces the hydrogen ion in hydrochloric acid. The aluminum ion is  $\text{Al}^{3+}$  and the chloride ion is  $\text{Cl}^-$ , so aluminum chloride is  $\text{AlCl}_3$ . The element hydrogen exists as the diatomic molecule  $\text{H}_2$ .

The unbalanced equation is:

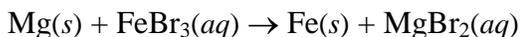


The balanced equation is:

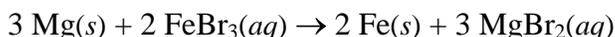


12. (a) According to the activity series, magnesium replaces the iron(III) ion in iron(III) chloride. The magnesium ion is  $\text{Mg}^{2+}$  and the bromide ion is  $\text{Br}^-$ , so magnesium bromide is  $\text{MgBr}_2$ .

The unbalanced equation is:



The balanced equation is:



(b) According to the activity series, calcium replaces one of the hydrogen atoms in water. The calcium ion is  $\text{Ca}^{2+}$  and the hydroxide ion is  $\text{OH}^-$ , so calcium hydroxide is  $\text{Ca}(\text{OH})_2$ . The element hydrogen exists as  $\text{H}_2$ .

The unbalanced equation is:

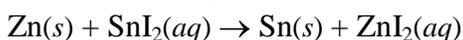


The balanced equation is:



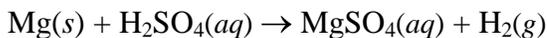
13. (a) According to the activity series, zinc replaces the tin(II) ion in tin(II) iodide. The zinc ion is  $\text{Zn}^{2+}$  and the iodide ion is  $\text{I}^-$ , so zinc iodide is  $\text{ZnI}_2$ .

The balanced equation is:



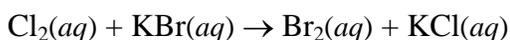
(b) According to the activity series, magnesium replaces the hydrogen ions in sulfuric acid. The magnesium ion is  $\text{Mg}^{2+}$  and the sulfate ion is  $\text{SO}_4^{2-}$ , so magnesium sulfate is  $\text{MgSO}_4$ . The element hydrogen exists as the diatomic molecule  $\text{H}_2$ .

The balanced equation is:

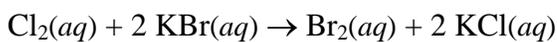


14. (a) According to the halogen replacement series, chlorine replaces the bromide ion in potassium bromide. The potassium ion is  $\text{K}^+$  and the chloride ion is  $\text{Cl}^-$ , so potassium chloride is  $\text{KCl}$ . The element bromine exists as the diatomic molecule  $\text{Br}_2$ .

The unbalanced equation is:

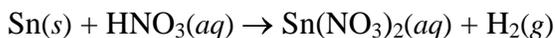


The balanced equation is:

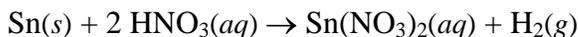


(b) According to the activity series, tin replaces the hydrogen ion in nitric acid. As mentioned in the text, if a metal can have two possible charges, it is always the lower charge that is formed in a single replacement reaction. The tin ion is  $\text{Sn}^{2+}$  (not  $\text{Sn}^{4+}$ ) and the nitrate ion is  $\text{NO}_3^-$ , so tin(II) nitrate is  $\text{Sn}(\text{NO}_3)_2$ . The element hydrogen exists as the diatomic molecule  $\text{H}_2$ .

The unbalanced equation is:



The balanced equation is:



15. (c) aluminum hydroxide and (d) barium sulfate

16. (b) calcium chloride and (c) sodium sulfate

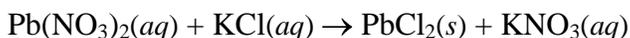
17. (a) In this ion exchange:

Lead(II) ion,  $\text{Pb}^{2+}$ , will combine with chloride ion,  $\text{Cl}^-$ , to form lead(II) chloride,  $\text{PbCl}_2$ .

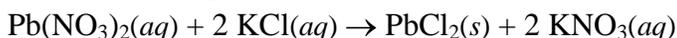
Potassium ion,  $\text{K}^+$ , will combine with nitrate ion,  $\text{NO}_3^-$ , to form potassium nitrate,  $\text{KNO}_3$ .

According to the solubility rules, potassium nitrate is soluble, but lead(II) chloride is insoluble. So this is a double replacement reaction to produce a precipitate.

The unbalanced equation is:



The balanced equation is:



(b) In this ion exchange:

Magnesium ion,  $\text{Mg}^{2+}$ , will combine with hydroxide ion,  $\text{OH}^-$ , to form magnesium hydroxide,  $\text{Mg}(\text{OH})_2$ .

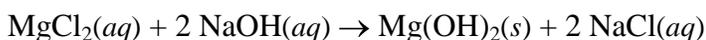
Sodium ion,  $\text{Na}^+$ , will combine with chloride ion,  $\text{Cl}^-$ , to form sodium chloride,  $\text{NaCl}$ .

According to the solubility rules, sodium chloride is soluble, but magnesium hydroxide is insoluble. So this is a double replacement reaction to produce a precipitate.

The unbalanced equation is:



The balanced equation is:



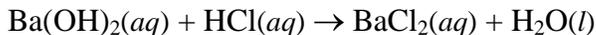
18. (a) In this ion exchange:

Barium ion,  $\text{Ba}^{2+}$ , will combine with chloride ion,  $\text{Cl}^-$ , to form barium chloride,  $\text{BaCl}_2$ .

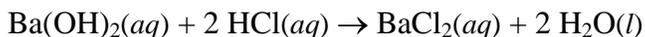
Hydrogen ion,  $\text{H}^+$ , will combine with hydroxide ion,  $\text{OH}^-$ , to form water,  $\text{H}_2\text{O}$ .

According to the solubility rules, barium chloride is soluble. So this is a double replacement reaction to produce water (a neutralization reaction).

The unbalanced equation is:



The balanced equation is:



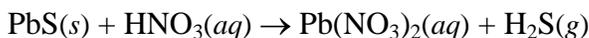
(b) In this ion exchange reaction:

Lead(II) ion,  $\text{Pb}^{2+}$ , will combine with nitrate ion,  $\text{NO}_3^-$ , to form lead(II) nitrate,  $\text{Pb}(\text{NO}_3)_2$ .

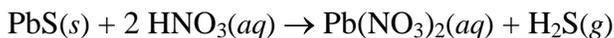
Hydrogen ion,  $\text{H}^+$ , will combine with sulfide ion,  $\text{S}^{2-}$ , to form hydrogen sulfide,  $\text{H}_2\text{S}$ .

According to the solubility rules, lead(II) nitrate is soluble. Hydrogen sulfide is a gas. So this is a double replacement reaction to produce a gas.

The unbalanced equation is:



The balanced equation is:



19. (a)  $\text{KOH}(s)$  *dissolve in water*  $\text{K}^+(aq) + \text{OH}^-(aq)$

(b)  $\text{FeSO}_4(s)$  *dissolve in water*  $\text{Fe}^{2+}(aq) + \text{SO}_4^{2-}(aq)$

20. (a)  $\text{Al}(\text{NO}_3)_3(s)$  *dissolve in water*  $\text{Al}^{3+}(aq) + 3 \text{NO}_3^-(aq)$   
 (b)  $(\text{NH}_4)_3\text{PO}_4(s)$  *dissolve in water*  $3 \text{NH}_4^+(aq) + \text{PO}_4^{3-}(aq)$

21. (a) In writing the total ionic equation for this single replacement reaction:

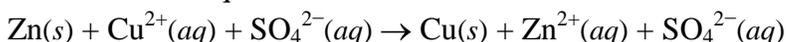
$\text{Zn}(s)$ , being a solid element, stays the same.

$\text{CuSO}_4(aq)$  consists of  $\text{Cu}^{2+}(aq)$  ions and  $\text{SO}_4^{2-}(aq)$  ions.

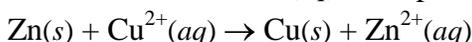
$\text{Cu}(s)$ , being a solid element, stays the same.

$\text{ZnSO}_4(aq)$  consists of  $\text{Zn}^{2+}(aq)$  ions and  $\text{SO}_4^{2-}(aq)$  ions.

The total ionic equation is:



The sulfate ion,  $\text{SO}_4^{2-}(aq)$ , is a spectator ion, so the net ionic equation is:



- (b) In writing the total ionic equation for this single replacement reaction:

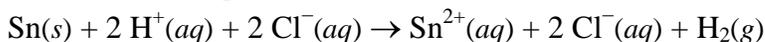
$\text{Sn}(s)$ , being a solid element, stays the same.

$\text{HCl}(aq)$  consists of  $\text{H}^+(aq)$  ions and  $\text{Cl}^-(aq)$  ions.

$\text{SnCl}_2(aq)$  consists of  $\text{Sn}^{2+}(aq)$  ions and  $\text{Cl}^-(aq)$  ions.

$\text{H}_2(g)$ , being a covalently-bonded gas, stays the same.

The total ionic equation is:



The chloride ion,  $\text{Cl}^-(aq)$ , is a spectator ion, so the net ionic equation is:



22. (a) In writing the total ionic equation for this single replacement reaction:

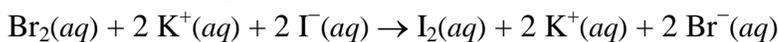
$\text{Br}_2(aq)$ , being a covalently-bonded molecule, stays the same.

$\text{KI}(aq)$  consists of  $\text{K}^+(aq)$  ions and  $\text{I}^-(aq)$  ions.

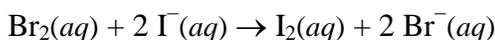
$\text{I}_2(aq)$ , being a covalently-bonded molecule, stays the same.

$\text{KBr}(aq)$  consists of  $\text{K}^+(aq)$  ions and  $\text{Br}^-(aq)$  ions.

The total ionic equation is:



The potassium ion,  $\text{K}^+(aq)$ , is a spectator ion, so the net ionic equation is:



- (b) In writing the total ionic equation for this single replacement reaction:

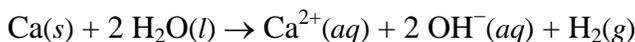
$\text{Ca}(s)$ , being a solid element, stays the same.

$\text{H}_2\text{O}(l)$ , being a covalently-bonded molecule, stays the same.

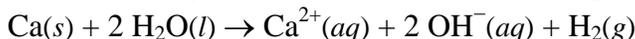
$\text{Ca}(\text{OH})_2(aq)$  consists of  $\text{Ca}^{2+}(aq)$  ions and  $\text{OH}^-(aq)$  ions.

$\text{H}_2(g)$ , being a covalently-bonded gas, stays the same.

The total ionic equation is:



There are no spectator ions, so the net ionic equation will be exactly the same.



23. (a) In writing the total ionic equation for this double replacement reaction:

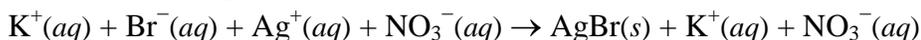
$\text{KBr}(aq)$  consists of  $\text{K}^{+}(aq)$  ions and  $\text{Br}^{-}(aq)$  ions.

$\text{AgNO}_3(aq)$  consists of  $\text{Ag}^{+}(aq)$  ions and  $\text{NO}_3^{-}(aq)$  ions.

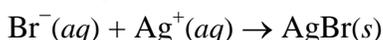
$\text{AgBr}(s)$ , being a solid compound, stays the same.

$\text{KNO}_3(aq)$  consists of  $\text{K}^{+}(aq)$  ions and  $\text{NO}_3^{-}(aq)$  ions.

The total ionic equation is:



The potassium ion,  $\text{K}^{+}(aq)$ , and the nitrate ion,  $\text{NO}_3^{-}(aq)$  are spectator ions, so the net ionic equation is:



- (b) In writing the total ionic equation for this double replacement reaction:

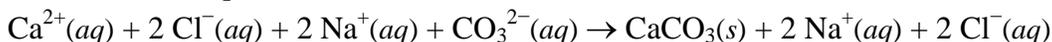
$\text{CaCl}_2(aq)$  consists of  $\text{Ca}^{2+}(aq)$  ions and  $\text{Cl}^{-}(aq)$  ions.

$\text{Na}_2\text{CO}_3(aq)$  consists of  $\text{Na}^{+}(aq)$  ions and  $\text{CO}_3^{2-}(aq)$  ions.

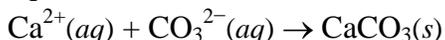
$\text{CaCO}_3(s)$ , being a solid compound, stays the same.

$\text{NaCl}(aq)$  consists of  $\text{Na}^{+}(aq)$  ions and  $\text{Cl}^{-}(aq)$  ions.

The total ionic equation is:



The chloride ion,  $\text{Cl}^{-}(aq)$  and the potassium ion,  $\text{K}^{+}(aq)$  are spectator ions, so the net ionic equation is:



24. (a) In writing the net ionic equation for this double replacement reaction:

$\text{NH}_4\text{Cl}(aq)$  consists of  $\text{NH}_4^{+}(aq)$  ions and  $\text{Cl}^{-}(aq)$  ions.

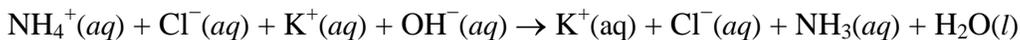
$\text{KOH}(aq)$  consists of  $\text{K}^{+}(aq)$  ions and  $\text{OH}^{-}(aq)$  ions.

$\text{KCl}(aq)$  consists of  $\text{K}^{+}(aq)$  ions and  $\text{Cl}^{-}(aq)$  ions.

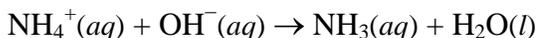
$\text{NH}_3(aq)$ , being a covalently-bonded molecule, stays the same.

$\text{H}_2\text{O}(l)$ , being a covalently-bonded molecule, stays the same.

The total ionic equation is:



The chloride ion,  $\text{Cl}^{-}(aq)$  and the potassium ion,  $\text{K}^{+}(aq)$  are spectator ions, so the net ionic equation is:



- (b) In writing the total ionic equation for this double replacement reaction:

$\text{Ba}(\text{OH})_2(\text{aq})$  consists of  $\text{Ba}^{2+}(\text{aq})$  ions and  $\text{OH}^{-}(\text{aq})$  ions.

$\text{HCl}(\text{aq})$  consists of  $\text{H}^{+}(\text{aq})$  ions and  $\text{Cl}^{-}(\text{aq})$  ions.

$\text{BaCl}_2(\text{aq})$  consists of  $\text{Ba}^{2+}(\text{aq})$  ions and  $\text{Cl}^{-}(\text{aq})$  ions

$\text{H}_2\text{O}(\text{l})$ , being a covalently-bonded molecule, stays the same.

The total ionic equation is:



The chloride ion,  $\text{Cl}^{-}(\text{aq})$  and the barium ion,  $\text{Ba}^{2+}(\text{aq})$  are spectator ions, so the net ionic equation is:

