Act on Your Strategy

Chemical formulas: solid barium hydroxide, $Ba(OH)_2(s)$; solution of phosphoric acid, $H_3PO_4(aq)$; solid barium hydrogen phosphate, $BaHPO_4(s)$; liquid water, $H_2O(\ell)$
Skeleton equation: $Ba(OH)_2(s) + H_3PO_4(aq) \rightarrow BaHPO_4(s) + H_2O(\ell)$
Reactants: 1 Ba^{2+}, 2 OH^-, 3 H, 1 PO_4^{3-}
Products: 1 Ba^{2+}, 1 HPO_4^{2-}, 2 H, 1 O
Insert a 2 in front of the $H_2O(\ell)$ to balance the H.
Balanced chemical equation: $Ba(OH)_2(s) + H_3PO_4(aq) \rightarrow BaHPO_4(s) + 2H_2O(\ell)$
The ratio of the coefficients is 1:1:1:2. This is the lowest possible ratio.
Reactants: 1 Ba^{2+}, 2 OH^-, 3 H, 1 PO_4^{3-}
Products: 1 Ba^{2+}, 1 HPO_4^{2-}, 4 H, 2 O

Check Your Solution

The chemical formula for each substance is written correctly. The number of atoms and ions of the elements is equal on both sides of the equation. The coefficients are written in the lowest possible ratio.
The balanced chemical equation for this reaction is:
$Ba(OH)_2(s) + H_3PO_4(aq) \rightarrow BaHPO_4(s) + 2H_2O(\ell)$.

14. Review Question (page 121)

Your friend has written the following balanced equation for the reaction in which aluminum and chlorine form aluminum(III) chloride:
$Al(s) + Cl(g) \rightarrow AlCl(s)$
Is this correct? If not, how would you suggest that your friend correct it?

The equation is not correct. The chemical formulas for chlorine gas and aluminum chloride are incorrect and the equation is not balanced.
The correct balanced chemical equation for this reaction is:
$2Al(s) + 3Cl_2(g) \rightarrow 2AlCl_3(s)$

Section 3.2 Synthesis Reactions and Decomposition Reactions

Solutions for Practice Problems

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21. Practice Problem (page 127)

Predict the product that is likely to form in a reaction between lithium and oxygen, and write a balanced chemical equation for the reaction.

What Is Required?

You need to predict the product and write a balanced chemical equation for the reaction between lithium and oxygen.

What Is Given?

You are given the reactants: lithium and oxygen.

Plan Your Strategy
Identify the types of elements involved and predict the product that will form.
Write the chemical formula for the product and write a balanced equation for the reaction.
Check to make sure that the ratio of the coefficients is the lowest possible ratio.
Check to make sure that the number of each kind of atom and ion is the same in the reactants and products.

Act on Your Strategy
You know this will be a synthesis reaction between a univalent metal and a non-metal to form a binary ionic compound.
The product is predicted to be lithium oxide, $Li_2O(s)$.
Skeleton equation: $Li(s) + O_2(g) \rightarrow Li_2O(s)$
Reactants: 1 Li, 2 O
Products: 2 Li^+, 1 O^{2-}
Balanced chemical equation: $4Li(s) + O_2(g) \rightarrow 2Li_2O(s)$
The ratio of the coefficients is 4:1:2. This is the lowest possible ratio.
Reactants: 4 Li, 2 O
Products: 4 Li^+, 2 O^{2-}

Check Your Solution
The overall charge on the compound lithium oxide is zero and the equation is balanced. The product is what would be expected in a synthesis reaction.
The balanced chemical equation for this reaction is:
$4Li(s) + O_2(g) \rightarrow 2Li_2O(s)$

22. Practice Problem (page 127)
Predict the product that is likely to form in a reaction between strontium and fluorine, and write a balanced chemical equation for the reaction.

What Is Required?
You need to predict the product and write a balanced chemical equation for the reaction between strontium and fluorine.

What Is Given?
You are given the reactants: strontium and fluorine.

Plan Your Strategy
Identify the types of elements involved and predict the product that will form.
Write the chemical formula for the product and write a balanced chemical equation for the reaction.
Check to make sure that the ratio of the coefficients is the lowest possible ratio.
Check to make sure that the number of each kind of atom and ion is the same in the reactants and products.

Act on Your Strategy
You know this will be a synthesis reaction between a univalent metal and a non-metal to form a binary ionic compound.
The product is predicted to be strontium fluoride, $SrF_2(s)$.
Skeleton equation: $Sr(s) + F_2(g) \rightarrow SrF_2(s)$
Reactants: 1 Sr, 2 F
Products: 1 Sr^{2+}, 2 F^-
Balanced chemical equation: $Sr(s) + F_2(g) \rightarrow SrF_2(s)$
The ratio of the coefficients is 1:1:1. This is the lowest possible ratio.
The skeleton and balanced equations are the same.

Check Your Solution
The overall charge on the compound strontium fluoride is zero and the equation is balanced. The product is what would be expected in a synthesis reaction.
The balanced chemical equation for this reaction is:
$Sr(s) + F_2(g) \rightarrow SrF_2(s)$

23. Practice Problem (page 127)
Predict the product that is likely to form in a reaction between iron and bromine, and write a balanced chemical equation for the reaction.

What Is Required?
You need to predict the product and write a balanced chemical equation for the reaction between iron and bromine.

What Is Given?
You are given the reactants: iron and bromine.

Plan Your Strategy
Identify the types of elements involved and predict the most likely product that will form.
Determine whether the metal involved, iron, is multivalent and, if so, determine its possible charges.
Write the chemical formula for the products and write balanced chemical equations for the reactions.
Check to make sure that the ratio of the coefficients in each equation is the lowest possible ratio.
Check each equation to make sure that the number of each kind of atom and ion is the same in the reactants and products.

Act on Your Strategy
You know this will be a synthesis reaction between a multivalent metal and a non-metal to form a binary ionic compound.
The possible charges on multivalent iron are Fe^{2+} and Fe^{3+}.

The predicted products are solid iron(II) bromide, $FeBr_2(s)$, and solid iron(III) bromide, $FeBr_3(s)$.
Skeleton equations:
$Fe(s) + Br_2(\ell) \rightarrow FeBr_2(s)$
$Fe(s) + Br_2(\ell) \rightarrow FeBr_3(s)$
Balanced chemical equation for solid iron(II) bromide:
$Fe(s) + Br_2(g) \rightarrow FeBr_2(s)$
Reactants: 1 Fe, 2 Br
Products: 1 Fe^{2+}, 2 Br^-
Balanced chemical equation for solid iron(III) bromide:
$2Fe(s) + 3Br_2(\ell) \rightarrow 2FeBr_3(s)$
Reactants: 2 Fe, 6 Br
Products: 2 Fe^{3+}, 6 Br^-

Check Your Solution
The overall charges on the compounds iron(II) bromide and iron(III) bromide are zero and each equation is balanced. The products are what would be expected in synthesis reactions.
The balanced chemical equation for solid iron(II) bromide is:
$Fe(s) + Br_2(\ell) \rightarrow FeBr_2(s)$
The balanced chemical equation for solid iron(III) bromide is:
$2Fe(s) + 3Br_2(\ell) \rightarrow 2FeBr_3(s)$

24. Practice Problem (page 127)
Predict the product that is likely to form in a reaction between phosphorus and hydrogen, forming gaseous phosphorus trihydride, and write a balanced chemical equation for the reaction.

What Is Required?
You need to write the balanced chemical equation for the reaction between phosphorus and hydrogen, forming gaseous phosphorus trihydride.

What Is Given?
You are given the reactants: phosphorus and hydrogen.
You are given the product: phosphorus trihydride.

Plan Your Strategy
Identify the types of elements involved in the reaction.
Write the chemical formula for the products and write a balanced chemical equation for the reaction.
Check to make sure that the ratio of the coefficients is the lowest possible ratio.
Check to make sure that the number of each kind of atom is the same in the reactants and products.

Act on Your Strategy
You know this will be a synthesis reaction between two non-metals to form a binary molecular compound.
The product is phosphorus trihydride, $PH_3(g)$.
Skeleton equation: $P(s) + H_2(g) \rightarrow PH_3(g)$
Reactants: 1 P, 2 H
Products: 1 P, 3 H
Balanced chemical equation: $2P(s) + 3H_2(g) \rightarrow 2PH_3(g)$
The ratio of the coefficients is 2:3:2. This is the lowest possible ratio.
Reactants: 2 P, 6 H
Products: 2 P, 6 H

Check Your Solution
The equation is balanced. The product is what would be expected in a synthesis reaction.
The balanced chemical equation for this reaction is:
$2P(s) + 3H_2(g) \rightarrow 2PH_3(g)$

25. Practice Problem (page 127)
Predict the product that is likely to form in a reaction between calcium and iodine, and write a balanced chemical equation for the reaction.

What Is Required?
You need to predict the product and write a balanced chemical equation for the reaction between calcium and iodine.

What Is Given?
You are given the reactants: calcium and iodine.

Plan Your Strategy
Identify the types of elements involved and predict the product that will form.
Write the chemical formula for the product and write a balanced chemical equation for the reaction.
Check to make sure that the ratio of the coefficients is the lowest possible ratio.
Check to make sure that the number of each kind of atom and ion is the same in the reactants and products.

Act on Your Strategy
You know this will be a synthesis reaction between a univalent metal and a non-metal to form a binary ionic compound.
The product is predicted to be solid calcium iodide, $CaI_2(s)$.
Skeleton equation: $Ca(s) + I_2(g) \rightarrow CaI_2(s)$

Reactants: 1 Ca, 2 I
Products: 1 Ca^{2+}, 2 I^-
Balanced chemical equation: $Ca(s) + I_2(g) \rightarrow CaI_2(s)$
The ratio of the coefficients is 1:1:1. This is the lowest possible ratio.
The skeleton and balanced equations are the same.

Check Your Solution
The overall charge on the compound calcium iodide is zero and the equation is balanced. The product is what would be expected in a synthesis reaction.
The balanced chemical equation for this reaction is:
$Ca(s) + I_2(g) \rightarrow CaI_2(s)$

26. Practice Problem (page 127)
Predict the product that is likely to form in a reaction between tin and oxygen, and write a balanced chemical equation for the reaction.

What Is Required?
You need to predict the most likely product and write a balanced chemical equation for the reaction between tin and oxygen.

What Is Given?
You are given the reactants: tin and oxygen.

Plan Your Strategy
Identify the types of elements involved and predict the most likely product that will form.
Determine whether the metal involved, tin, is multivalent and, if so, determine its possible charges.
Write the chemical formula for the products and write Balanced chemical equations for the reactions.
Check to make sure that the ratio of the coefficients in each equation is the lowest possible ratio.
Check each equation to make sure that the number of each kind of atom and ion is the same in the reactants and products.

Act on Your Strategy
You know this will be a synthesis reaction between a multivalent metal and a non-metal to form a binary ionic compound.
The possible charges on multivalent tin are Sn^{2+} and Sn^{4+}.
The predicted products are solid tin(II) oxide, SnO(s), and solid tin(IV) oxide, SnO_2 (s).
Skeleton equations:
$Sn(s) + O_2(g) \rightarrow SnO(s)$
$Sn(s) + O_2(g) \rightarrow SnO_2(s)$
Balanced chemical equation for solid tin(II) oxide: $2Sn(s) + O_2(g) \rightarrow 2SnO(s)$

Reactants: 2 Sn, 2 O
Products: 2 Sn^{2+}, 2 O^{2-}
Balanced chemical equation for solid tin(IV) oxide: $Sn(s) + O_2(g) \rightarrow SnO_2(s)$
Reactants: 1 Sn, 2 O
Products: 1 Sn^{4+}, 2 O^{2-}

Check Your Solution
The overall charges on the compounds tin(II) oxide and tin(IV) oxide are zero and each equation is balanced. The products are what would be expected in synthesis reactions.
The balanced chemical equation for solid tin(II) oxide is:
$2Sn(s) + O_2(g) \rightarrow 2SnO(s)$
The balanced chemical equation for solid tin(IV) oxide is:
$Sn(s) + O_2(g) \rightarrow SnO_2(s)$

27. Practice Problem (page 127)
Predict the product that is likely to form in a reaction between bismuth and sulfur, and write a balanced chemical equation for the reaction.

What Is Required?
You need to predict the product and write a balanced chemical equation for the reaction between bismuth and sulfur.

What Is Given?
You are given the reactants: bismuth and sulfur.

Plan Your Strategy
Identify the types of elements involved and predict the most likely product that will form.
Determine whether the metal involved, bismuth, is multivalent and, if so, determine its possible charges.
Write the chemical formula for the products and write Balanced chemical equations for the reactions.
Check to make sure that the ratio of the coefficients is the lowest possible ratio.
Check to make sure that the number of each kind of atom and ion is the same in the reactants and products.

Act on Your Strategy
You know this will be a synthesis reaction between a multivalent metal and a non-metal to form a binary ionic compound.
The possible charges on multivalent bismuth are Bi^{3+} and Bi^{5+}.
The predicted products are solid bismuth(III) sulfide, $Bi_2S_3(s)$, and solid bismuth(V) sulfide, $Bi_2S_5(s)$.

Skeleton equations:
$Bi(s) + S(s) \rightarrow Bi_2S_3(s)$
$Bi(s) + S(s) \rightarrow Bi_2S_5(s)$
Balanced chemical equation for solid bismuth(III) sulfide:
$2Bi(s) + 3S(s) \rightarrow Bi_2S_3(s)$
Reactants: 2 Bi, 3 S
Products: 2 Bi^{3+}, 3 S^{2-}
Balanced chemical equation for solid bismuth(V) sulfide:
$2Bi(s) + 5S(s) \rightarrow Bi_2S_5(s)$
Reactants: 2 Bi, 5 S
Products: 2 Bi^{5+}, 5 S^{2-}

Check Your Solution
The overall charges on the compounds bismuth((III) sulfide and bismuth(V) sulfide are zero and each equation is balanced. The products are what would be expected in synthesis reactions.
The balanced chemical equation for bismuth((III) sulfide is:
$2Bi(s) + 3S(s) \rightarrow Bi_2S_3(s)$
The balanced chemical equation for bismuth(V) sulfide is:
$2Bi(s) + 5S(s) \rightarrow Bi_2S_5(s)$

28. Practice Problem (page 127)
Predict the product that is likely to form in a reaction between aluminum and iodine, and write a balanced chemical equation for the reaction.

What Is Required?
You need to predict the product and write a balanced chemical equation for the reaction between aluminum and iodine.

What Is Given?
You are given the reactants: aluminum and iodine.

Plan Your Strategy
Identify the types of elements involved and predict the product that will form.
Write the chemical formula for the product and write a balanced chemical equation for the reaction.
Check to make sure that the ratio of the coefficients is the lowest possible ratio.
Check to make sure that the number of each kind of atom and ion is the same in the reactants and products.

Act on Your Strategy
You know this will be a synthesis reaction between a univalent metal and a non-metal to form a binary ionic compound.
The product is predicted to be solid aluminum iodide, $AlI_3(s)$.
Skeleton equation: $Al(s) + I_2(s) \rightarrow AlI_3(s)$

Reactants: 1 Al, 2 I
Products: 1 Al^{3+}, 3 I^-
Balanced chemical equation: $2Al(s) + 3I_2(s) \rightarrow 2AlI_3(s)$
The ratio of the coefficients is 2:3:2. This is the lowest possible ratio.
Reactants: 2 Al, 6 I
Products: 2 Al^{3+}, 6 I^-

Check Your Solution
The overall charge on the compound aluminum iodide is zero and the equation is balanced. The product is what would be expected in a synthesis reaction.
The balanced chemical equation for this reaction is:
$2Al(s) + 3 I_2(s) \rightarrow 2AlI_3(s)$

29. Practice Problem (page 127)
Predict the product that is likely to form in a reaction between silver and oxygen, and write a balanced chemical equation for the reaction.

What Is Required?
You need to predict the product and write a balanced chemical equation for the reaction between silver and oxygen.

What Is Given?
You are given the reactants: silver and oxygen.

Plan Your Strategy
Identify the types of elements involved and predict the product that will form.
Write the chemical formula for the product and write a balanced chemical equation for the reaction.
Check to make sure that the ratio of the coefficients is the lowest possible ratio.
Check to make sure that the number of each kind of atom and ion is the same in the reactants and products.

Act on Your Strategy
You know this will be a synthesis reaction between a univalent metal and a non-metal to form a binary ionic compound.
The product is predicted to be solid silver oxide, $Ag_2O(s)$.
Skeleton equation: $Ag(s) + O_2(g) \rightarrow Ag_2O(s)$
Reactants: 1 Ag, 2 O
Products: 2 Ag^+, O^{2-}
Balanced chemical equation: $4Ag(s) + O_2(g) \rightarrow 2Ag_2O(s)$
The ratio of the coefficients is 4:1:3. This is the lowest possible ratio.
Reactants: 4 Ag, 2 O
Products: 4 Ag^+, 2 O^{2-}

Check Your Solution
The overall charge on the compound silver oxide is zero and the equation is balanced. The product is what would be expected in a synthesis reaction.
The balanced chemical equation for this reaction is:
$4Ag(s) + O_2(g) \rightarrow 2Ag_2O(s)$

30. Practice Problem (page 127)
Predict the product that is likely to form in a reaction between nitrogen and oxygen, forming nitrogen dioxide, and write a balanced chemical equation for the reaction.

What Is Required?
You need to write a balanced chemical equation for the reaction between nitrogen and oxygen forming nitrogen dioxide.

What Is Given?
You are given the reactants: nitrogen and oxygen.
You are given the product: nitrogen dioxide.

Plan Your Strategy
Write the chemical formula for the product and write a balanced chemical equation for the reaction.
Check to make sure that the ratio of the coefficients is the lowest possible ratio.
Check to make sure that the number of each kind of atom is the same in the reactants and products.

Act on Your Strategy
You know this will be a synthesis reaction between two non-metals to form a binary molecular compound.
The product is nitrogen dioxide, $NO_2(g)$.
Skeleton equation: $N_2(g) + O_2(g) \rightarrow NO_2(g)$
Reactants: 2 N, 2 O
Products: 1 N, 2 O
Balanced chemical equation: $N_2(g) + 2O_2(g) \rightarrow 2NO_2(g)$
The ratio of the coefficients is 1:2:2. This is the lowest possible ratio.
Reactants: 2 N, 4 O
Products: 2 N, 4 O

Check Your Solution
The equation is balanced. The product is what would be expected in a synthesis reaction.
The balanced chemical equation for this reaction is:
$N_2(g) + 2O_2(g) \rightarrow 2NO_2(g)$