Unit 3 Review – Chemical Reactions

We will start with the easiest topic and work our way to the most complex.

Evidence of a Chemical Reaction – There are 6 pieces of evidence that can occur to let you know a reaction has occurred.

- Gas bubbles form
- A solid precipitate forms
- A change in energy to the system, it's endothermic or exothermic
- A permanent color change
- A permanent odor change
- Formation of water

Types of Reactions – You will need to be able to identify the 5 different types of chemical reactions on sight. It's fairly easy if you know what to look for within each type of reaction.

- Synthesis: You know that a reaction is synthesis when there is only **one product!** There cannot be 2 different substances on the product side of the reaction.
  - Ex. $4\ Fe\ (s) + 3\ O_2\ (g) \rightarrow \mathbf{2\ Fe_2O_3\ (s)}$
- Decomposition: You know that a reaction is decomposition when there is only **one reactant**! There cannot be 2 different substances on the reactant side of the reaction.
  - Ex. $\mathbf{H_2CO_3\ (aq)} \rightarrow CO_2\ (g) + H_2O\ (l)$
- Single – Replacement: You know that a reaction is single – replacement when you see that **one element replaces another** in a reaction.
  - Ex. $\mathbf{Li}\ (s) + \mathbf{Ca}(NO_2)_2\ (aq) \rightarrow \mathbf{Ca}\ (s) + 2\ \mathbf{Li}NO_2\ (aq)$
- Double – Replacement: You know that a reaction is double- replacement when two ionic compounds switch ions with each other. The outer two ions go together and the inner two ions go together.
  - Ex. $\mathbf{Be}Cl_2\ (aq) + Ag_2\mathbf{SO_4}\ (aq) \rightarrow \mathbf{BeSO_4}\ (aq) + 2\ AgCl\ (s)$
- Combustion: This is a very specific reaction. You know it's a combustion reactions if you have a hydrocarbon and oxygen gas as reactants and carbon dioxide gas and water vapor as products.
  - Ex. $C_4H_9OH\ (l) + 6\ O_2\ (g) \rightarrow 4\ CO_2\ (g) + 5\ H_2O\ (g)$

Try to identify these reactions. They are not balanced.

1. $AlCl_3 + Na_2SO_4 \rightarrow Al_2(SO_4)_3 + NaCl$ double-replacement
2. $Zn + S_8 \rightarrow ZnS$ synthesis
3. $H_2SO_4 + Fe \rightarrow H_2 + FeSO_4$ single-replacement
4. $C_5H_{12} + O_2 \rightarrow H_2O + CO_2$ combustion
5. $Al_2S_3 \rightarrow Al + S_8$ decomposition
6. $Li_2CO_3 + MgCl_2 \rightarrow LiCl + MgCO_3$ double-replacement
7. $Fe + O_2 \rightarrow FeO$ synthesis
8. $Zn + HBr \rightarrow H_2 + ZnBr_2$ single-replacement
9. $C_5H_{10}O_4 + O_2 \rightarrow CO_2 + H_2O$ combustion
10. $MgO \rightarrow Mg + O_2$ decomposition

* Acid-Base - special type of double-replacement. One reactant has to be an acid (start w/ H) & the other has to be a hydroxide

$HA + BOH \rightarrow H_2O + BA$

Law of Conservation of Mass -

11. What is the definition? mass cannot be created or destroyed in chemical reactions

Balancing Chemical Equations – the goal of balancing is to satisfy the Law of Conservation of Mass. You MUST have the same number of atoms of each element on both sides of the arrow or yield sign. The ONLY way to do this is through multiplying by COEFFICIENTS. Remember that coefficients multiply through to every element in the compound!

Balance these equations below:

12. 2 $AlCl_3$ (aq) + 3 Na_2SO_4 (aq) → $Al_2(SO_4)_3$ (s) + 6 NaCl (aq)

Al 1×2 (SO_4) ×3 | Al 2 (SO_4) 3
Cl 3×6 | Cl ×6
Na 2×6 | Na ×6

13. 8 Zn (s) + S_8 (s) → 8 ZnS (s)

Zn ×8 | Zn ×8
S 8 | S ×8

14. H_2SO_4 (aq) + Fe (s) → H_2 (g) + $FeSO_4$ (aq)

already balanced

H 2 (SO_4) 1 Fe 1 | H 2 (SO_4) 1 Fe 1

15. C_5H_{12} (l) + 8 O_2 (g) → 6 H_2O (g) + 5 CO_2 (g)

C 5 | C ×5
H 12 | H ×12
O ×16 | O 3×16

16. 8 Al_2S_3 (s) → 16 Al (s) + 3 S_8 (s)

Al ×16 | Al ×16
S 3×24 | S 8×24

17. Li_2CO_3 (aq) + $MgCl_2$ (s) → 2 LiCl (aq) + $MgCO_3$ (aq)

Li 2 (CO_3) 1 Mg 1 Cl 2 | Li ×2 (CO_3) 1 Mg 1 Cl ×2

18. 2 Fe (s) + O_2 (g) → 2 FeO (s)

Fe ×2
O 2

Fe ×2
O ×2

19. $Zn\ (s) + 2\ HBr\ (aq) \rightarrow H_2\ (g) + ZnBr_2\ (aq)$

Zn	1	Zn	1
H	1	H	2
Br	1	Br	2

20. $2\ C_5H_{10}O_4\ (l) + 11\ O_2\ (g) \rightarrow 10\ CO_2\ (g) + 10\ H_2O\ (g)$

C	~~5~~ 10	C	10
H	~~10~~ 20	H	~~2~~ 20
O	~~6~~ 30	O	~~3~~ 30

21. $2\ MgO\ (s) \rightarrow 2\ Mg\ (s) + O_2\ (g)$

Mg	~~+2~~	Mg	~~+2~~
O	~~12~~	O	2

Writing Skeleton Equations – For many, this is the hardest part of this unit. Why? Simply, because you have to know how to write formulas, know which substances are reactants, know which ones are products, and all their states of matter. Then placing them in the correct order in the equation.

If you don't know how to write formulas, for you need a refresher, I STRONGLY suggest you go back to your unit 3 notes and check things out. Use the formula writing flowchart provided to you on the blog, www.mysciteacher.com. USE your brain, you can do this!

Example: Solid sodium hydroxide reacts with a solution of calcium sulfate to produce a sodium sulfate solution and a precipitate of calcium hydroxide

Reactants: sodium hydroxide (s) & calcium sulfate (aq)
Products: sodium sulfate (aq) & calcium hydroxide (s)

Word Equation

Sodium hydroxide (s) + calcium sulfate (aq) → sodium sulfate (aq) + calcium hydroxide (s)

All 4 of these substances are ionic compounds, which means we have to criss – cross ions when we write the formulas.

Writing the formulas:

Sodium hydroxide	Na^{1+}	OH^{1-}	becomes	$NaOH$
Calcium sulfate	Ca^{2+}	SO_4^{2-}	becomes	$CaSO_4$
Sodium sulfate	Na^{1+}	SO_4^{2-}	becomes	Na_2SO_4
Calcium hydroxide	Ca^{2+}	OH^{1-}	becomes	$Ca(OH)_2$

Skeleton Equation

$NaOH\ (s) + CaSO_4\ (aq) \rightarrow Na_2SO_4\ (aq) + Ca(OH)_2\ (s)$

Example: A common middle school science fair experiment is to put eggs in vinegar. The reaction is: Solid calcium carbonate reacts with a solution of acetic acid to produce a solution of calcium acetate, carbon dioxide gas, and water.

Reactants: calcium carbonate (s) and acetic acid (aq)
Products: calcium acetate (aq), carbon dioxide (g), and water (l)

Word Equation

Calcium carbonate (s) + acetic acid (aq) → calcium acetate (aq) + carbon dioxide (g) + water (l)
Ionic **oxyacid** **ionic** **type III** **type III**

Writing the Formulas

Calcium carbonate	Ca^{2+}	CO_3^{2-}	becomes	$CaCO_3$
Acetic acid	H^{1+}	$C_2H_3O_2^{1-}$	becomes	$HC_2H_3O_2$
Calcium acetate	Ca^{2+}	$C_2H_3O_2^{1-}$	becomes	$Ca(C_2H_3O_2)_2$
Carbon dioxide	CO_2			
Water	H_2O			

Skeleton Equation

$CaCO_3\ (s) + HC_2H_3O_2\ (aq) \rightarrow Ca(C_2H_3O_2)_2\ (aq) + CO_2\ (g) + H_2O\ (l)$

Try writing skeleton equations for these reactions.

22. Aqueous ammonium chloride reacts with a solution of sodium hydroxide to produce water, ammonia (nitrogen trihydride) gas, and a solution of sodium chloride.

$R_1 + R_2 \rightarrow P_1 \quad P_2 \quad P_3$

balanced $NH_4Cl(aq) + NaOH(aq) \rightarrow H_2O(l) + NH_3(g) + NaCl(aq)$

23. Solid sodium hydroxide reacts with a phosphoric acid solution to form water and a solution of sodium phosphate.

$R_1 + R_2 \rightarrow P_1 + P_2$

$3\,NaOH(s) + H_3PO_4(aq) \rightarrow 3H_2O(l) + Na_3PO_4(aq)$

24. When heated, solid carbon reacts with oxygen gas to form carbon monoxide gas.

$R_1 + R_2 \rightarrow P_1$

$2\,C(s) + O_2(g) \rightarrow 2CO(g)$

25. Solid silver (I) sulfate reacts with copper metal to produce a solution of copper (II) sulfate and silver metal.

$Ag_2SO_4(s) + Cu(s) \rightarrow CuSO_4(aq) + 2Ag(s)$

26. Ethane gas is burned in the presence of oxygen gas to produce carbon dioxide gas and water vapor.

$2C_2H_6(g) + 7O_2(g) \rightarrow 4CO_2(g) + 6H_2O(g)$

27. Solid lead (IV) oxide decomposes into solid lead (II) oxide and oxygen gas.

$2PbO_2(s) \rightarrow 2PbO(s) + O_2(g)$

28. A solution of lithium sulfite reacts with a solution of hydrochloric acid to produce a solution of lithium chloride, water, and sulfur dioxide precipitate.

$Li_2SO_3(aq) + 2HCl(aq) \rightarrow 2LiCl(aq) + H_2O(l) + SO_2(s)$

29. Solid calcium oxide and solid diphosphorous pentoxide react to form calcium phosphate solid.

$3CaO(s) + P_2O_5(s) \rightarrow Ca_3(PO_4)_2(s)$

30. Aqueous solutions of potassium carbonate and barium chloride react to produce potassium chloride solution and a precipitate of barium carbonate.

$K_2CO_3(aq) + BaCl_2(aq) \rightarrow 2KCl(aq) + BaCO_3(s)$

31. Ammonia (nitrogen trihydride) gas reacts with oxygen to produce gaseous nitrogen monoxide and steam.

$4NH_3(g) + 5O_2(g) \rightarrow 4NO(g) + 6H_2O(g)$

32. Solid copper in the Statue of Liberty reacted with oxygen gas in the air to create a green copper (II) oxide coating.

$2Cu(s) + O_2(g) \rightarrow 2CuO(s)$

Predicting Products – based on the type of reaction and the reactants, predict the products for the reaction, write the skeleton equation and balance.

Single – Replacement

33. $2Ag\,(s) + CuSO_4\,(aq) \rightarrow Cu + Ag_2SO_4$

metal replaces metal

34. $AlCl_3\,(aq) + 3Cs\,(s) \rightarrow Al + 3CsCl$

metal replaces metal

Double – Replacement

35. $2KCl\,(s) + Mg(OH)_2\,(aq) \rightarrow 2KOH + MgCl_2$

36. $6LiBr\,(s) + Co_2(SO_3)_3\,(aq) \rightarrow 3Li_2SO_3 + 2CoBr_3$

Synthesis

37. $H_2\,(g) + S\,(s) \rightarrow H_2S$

balanced

38. $Be\,(s) + Cl_2 \rightarrow BeCl_2$

balanced

Decomposition

39. $2Na_2O\,(s) \rightarrow 2Na + O_2$

break apart into elements

40. $2AlCl_3$ (s) → $2Al + 3Cl_2$

Acid – Base special kind of double-replacement

41. H_2SO_4 (aq) + $2KOH$ (s) → $2H_2O + K_2SO_4$

42. $3HBr$ (aq) + $Fe(OH)_3$ (s) → $3H_2O + FeBr_3$

Combustion products are $CO_2 + H_2O$

43. C_5H_{12} (l) + $8O_2$ (g) → $5CO_2 + 6H_2O$

44. $2CH_3OH$ (aq) + $3O_2$ (g) → $2CO_2 + 4H_2O$