Chemical Reactions
4.1 Introduction for Reactions
4.2 Net Ionic Equations
4.3 Representations of Reactions
4.4 Physical and Chemical Changes
Worksheet Key

1) The following questions pertain to the formation of an $Al(NO_3)_3$ solution.
   a. Write the balanced chemical equation for the dissolving of aluminum nitrate in water.

$Al(NO_3)_{3(s)} \rightarrow Al^{3+}_{(aq)} + 3\ NO_3^-{}_{(aq)}$

   b. Is the dissolving of aluminum nitrate in water a chemical process, a physical process, or both? Justify your answer.

The dissolving of aluminum nitrate in water can be classified as a chemical process and a physical process. Chemical process involve the breaking and/or formation of chemical bonds. Ionic bonds between Al^{3+} and NO_3^- are broken during the dissolving process. Physical process involve changes in intermolecular forces. Ion-dipole intermolecular forces are established during the dissolving of aluminum nitrate.

2) The following questions pertain to the melting of ice.
   a. Write a balanced chemical equation for the melting of a pure sample of ice, H_2O.

$H_2O(s) \rightarrow H_2O(l)$

   b. Is the melting ice to create liquid water a chemical process, a physical process, or both? Justify your answer.

Melting ice is a phase change, which is a physical process. Physical process involve changes in intermolecular forces. In this case, hydrogen bonds are weakened.

3) Two solutions at 25°C are mixed. The temperature of the combined solution increases to 32°C and a white precipitate forms. Has a chemical change occurred or has a physical change occurred? Justify your answer.

A chemical change has occured. Changes in temperature and the formation of precipitates are indications of chemical changes.

4) A piece of paper catches on fire and burns. Has a chemical change occurred or has a physical change occurred? Justify your answer.

A chemical change has occured. The production of heat and light are indications of

chemical changes.

5) Classify each of the following processes as a physical change, a chemical change, or both. Justify your answer by identifying the types of intermolecular or intramolecular forces that are involved in each of the following processes and describing what happens to those forces while the processes are occurring.

a. $CO_2(s) \rightarrow CO_2(g)$

Physical change. London dispersion forces in solid carbon dioxide are overcome, generating individual CO_2 molecules.

b. $CO_2(g) \rightarrow C(s) + O_2(g)$

Chemical change. Covalent bonds in the CO_2 molecule are broken.

c. $NH_2F(l) \rightarrow NH_2F(g)$

Physical change. London dispersion forces and H-bonds in liquid NH_2F are overcome, generating individual gaseous NH_2F molecules.

d. $NaCl\ (s) \rightarrow Na^+(aq) + Cl^-(aq)$

Dissolving an ionic compound in water can be classified as a physical change and a chemical change. Ionic bonds are broken (chemical change) and ion-dipole intermolecular forces between water and the ions are formed (physical change).

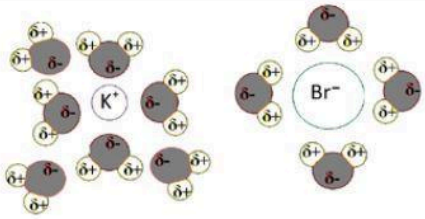
e. $NH_2F(l) \rightarrow \frac{1}{2}\ N_2(g) + H_2(g) + \frac{1}{2}\ F_2(g)$

Chemical change. Covalent bonds in the NH_2F molecule are broken and new covalent bonds are formed.

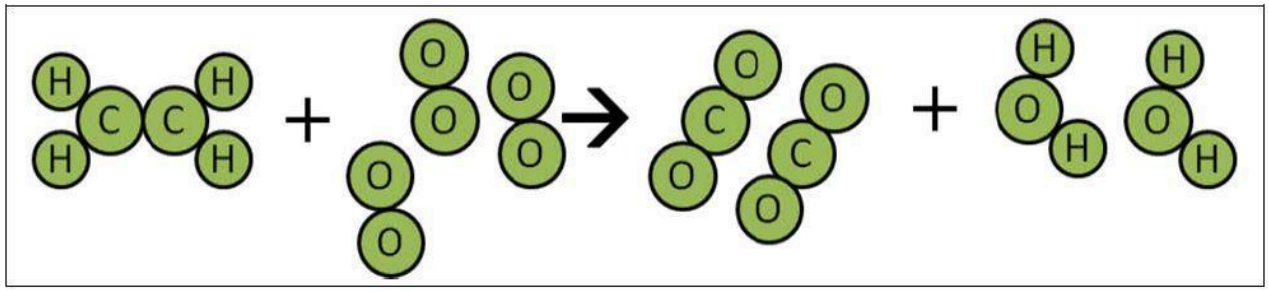
f. $H_2O(s) \rightarrow H_2O(l)$

Physical change. London dispersion and H-bonds in solid water are stretched to produce liquid water.

6) Draw a representation that shows the interactions between the solute and solvent in an aqueous solution of potassium bromide. Use space-filling or ball-and-stick models for the solvent molecules.



7) C_2H_4 reacts with O_2 to form CO_2 and water.
   a. Make a particulate drawing which shows that atoms are conserved during this reaction.



   b. Use your drawing to explain why all atoms were conserved during this reaction.

One C_2H_4 molecule reacted with three O_2 molecules to form two CO_2 molecules and two water molecules. The reactant side of the equation has two carbon atoms and the product side of the equation has two carbon atoms. The reactant side of the equation has four hydrogen atoms and the product side of the equation has four hydrogen atoms. The reactant side of the equation has six oxygen atoms and the product side of the equation has six oxygen atoms. The atoms formed new molecules, but they were all conserved.

   c. Use your drawing to explain how the law of conservation of mass applies to this reaction.

All of the atoms that were contained in the reactant molecules are present in the product molecules. No atoms were lost and no atoms were gained in this reaction. The mass of these atoms is constant, so no mass was lost or gained in the chemical reaction.

8) Balance the following chemical equations.
   a. $2\ AlBr_3 + 3\ K_2SO_4 \rightarrow 6\ KBr + Al_2(SO_4)_3$
   b. $C_3H_8 + 5\ O_2 \rightarrow 3\ CO_2 + 4\ H_2O$
   c. $FeCl_3(aq) + 3\ NaOH(aq) \rightarrow Fe(OH)_3(s) + 3\ NaCl(aq)$
   d. $Ba^{2+} + S^{2-} \rightarrow BaS(s)$
   e. $4\ P + 5\ O_2 \rightarrow 2\ P_2O_5$
   f. $S_8 + 12\ O_2 \rightarrow 8\ SO_3$
   g. $2\ H_2O + O_2 \rightarrow 2\ H_2O_2$
   h. $2\ Cu + O_2 \rightarrow 2\ CuO$
   i. $Pb(NO_3)_2 + 2\ NaI \rightarrow PbI_2(s) + 2\ NaNO_3$
   j. $8\ ZnS + 4\ O_2 \rightarrow 8\ ZnO + S_8$
   k. $C_7H_6O_3 + 7\ O_2 \rightarrow 7\ CO_2 + 3\ H_2O$
   l. $2\ Na + ZnI_2 \rightarrow 2\ NaI + Zn$
   m. $V_2O_5 + 5\ Ca \rightarrow 5\ CaO + 2\ V$
   n. $C_{12}H_{22}O_{11} + 12\ O_2 \rightarrow 12\ CO_2 + 11\ H_2O$

o. $N_2 + 3\ H_2 \rightarrow 2\ NH_3$
p. $2\ KClO_3 \rightarrow 2\ KCl + 3\ O_2$

9) Aqueous solutions of potassium chloride and silver nitrate are mixed and a silver chloride precipitate forms.
   a. Write the balanced molecular equation for this reaction.

$$AgNO_{3(aq)} + KCl_{(aq)} \rightarrow AgCl_{(s)} + KNO_{3(aq)}$$

   b. Write the balanced complete ionic equation for this reaction.

$$Ag^+_{(aq)} + NO_3^-{}_{(aq)} + K^+_{(aq)} + Cl^-{}_{(aq)} \rightarrow AgCl_{(s)} + K^+_{(aq)} + NO_3^-{}_{(aq)}$$

   c. Write the net ionic equation for this reaction.

$$Ag^+_{(aq)} + Cl^-_{(aq)} \rightarrow AgCl_{(s)}$$

10) A solution of iron (II) nitrate is poured into a sodium sulfide solution and a iron (II) sulfide precipitate forms.
   a. Write the balanced molecular equation for this reaction.

$$Fe(NO_3)_{2(aq)} + Na_2S_{(aq)} \rightarrow FeS_{(s)} + 2\ NaNO_{3(aq)}$$

   b. Write the balanced complete ionic equation for this reaction.

$$Fe^{2+}_{(aq)} + 2\ NO_3^-{}_{(aq)} + 2\ Na^+_{(aq)} + S^{2-}_{(aq)} \rightarrow FeS_{(s)} + 2\ Na^+_{(aq)} + NO_3^-{}_{(aq)}$$

   c. Write the balanced net ionic equation for this reaction.

$$Fe^{2+}_{(aq)} + S^{2-}_{(aq)} \rightarrow FeS_{(s)}$$

11) A solution of lithium carbonate is poured into a solution of calcium nitrate and a white precipitate forms.
   a. Write the balanced molecular equation for this reaction.

$$Ca(NO_3)_{2\,(aq)} + Li_2CO_{3(aq)} \rightarrow CaCO_{3(s)} + 2\ LiNO_3$$

   b. Write the balanced net ionic equation for this reaction.

$$Ca^{2+}_{(aq)} + CO_3^{2-}{}_{(aq)} \rightarrow CaCO_{3(s)}$$