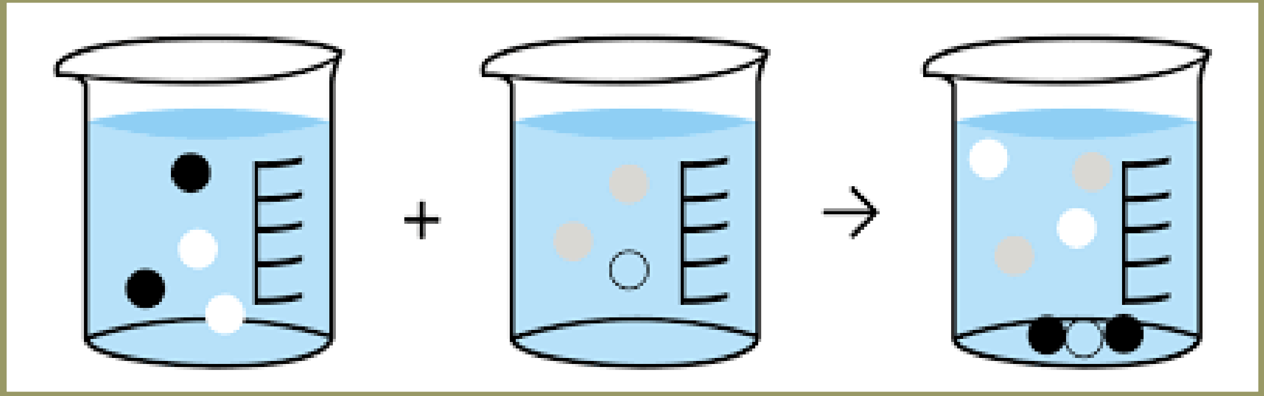

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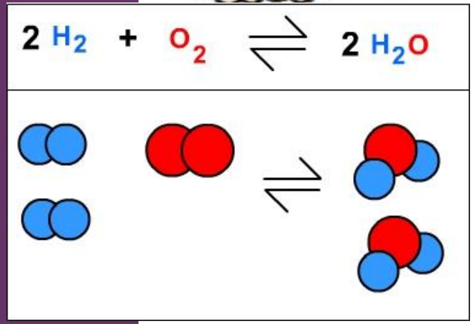
Big Idea #3

Chemical Reactions

Changes in matter involve the rearrangement and/or reorganizations of atoms and/or the transfer of electrons.



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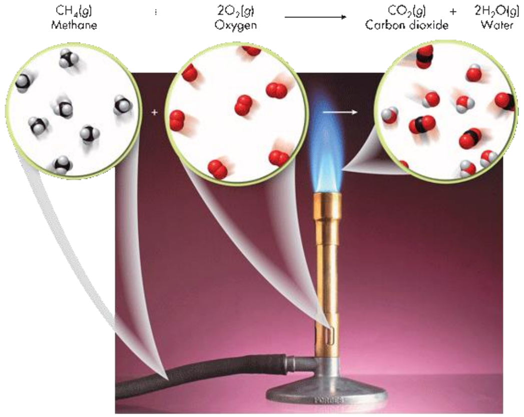
Source

Types of Chemical Reactions

Video

Combustion

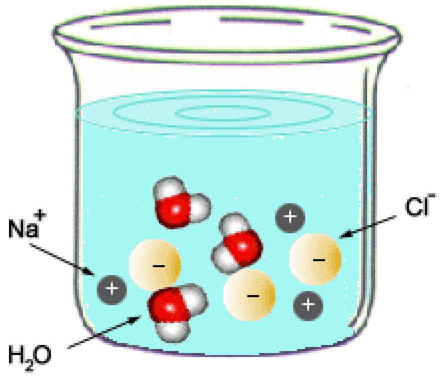
$C_xH_x + O_2 \rightarrow CO_2 + H_2O$



C. *Pearson Chemistry*. Boston, MA: Pearson, 2012. Print.

Acid-Base (Neutralization)

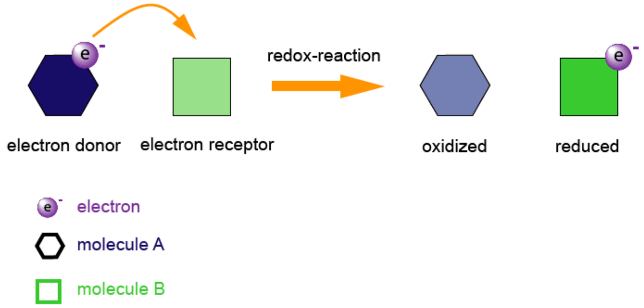
$HA + BOH \rightarrow H_2O + BA$



Oxidation-Reduction

$A^+ + e^- \rightarrow A$

$B \rightarrow B + e^-$



Precipitation

AB (aq) + CD (aq) $\rightarrow$ AD (aq) + CB (s)

LO 3.1: Students can translate among macroscopic observations of change, chemical equations, and particle views.

Source

Types of Chemical Reactions

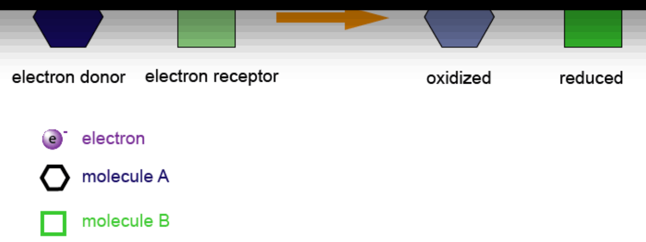
Combustion
$C_xH_x + O_2 \rightarrow CO_2 + H_2O$

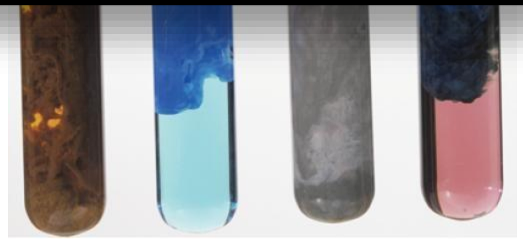
Acid-Base (Neutralization)
$HA + BOH \rightarrow H_2O + BA$

1) **2015 AP® CHEMISTRY FREE-RESPONSE QUESTIONS**

3. Potassium sorbate, $KC_6H_7O_2$ (molar mass 150. g/mol) is commonly added to diet soft drinks as a preservative. A stock solution of $KC_6H_7O_2(aq)$ of known concentration must be prepared. A student titrates 45.00 mL of the stock solution with 1.25 *M* HCl(*aq*) using both an indicator and a pH meter. The value of K_a for sorbic acid, $HC_6H_7O_2$, is 1.7×10^{-5}.

(a) Write the net-ionic equation for the reaction between $KC_6H_7O_2(aq)$ and HCl(*aq*).





LO 3.1: Students can translate among macroscopic observations of change, chemical equations, and particle views.

Source

Types of Chemical Reactions

Combustion

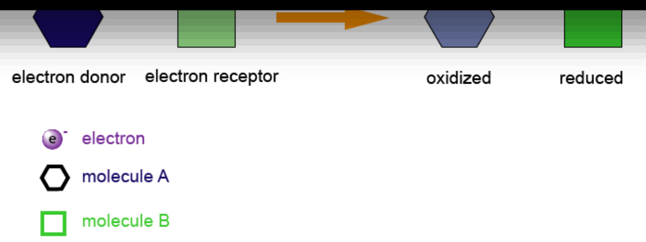
$C_xH_x + O_2 \rightarrow CO_2 + H_2O$

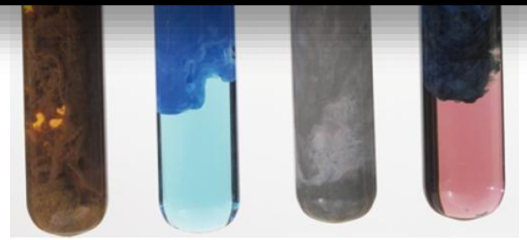
Acid-Base (Neutralization)

$HA + BOH \rightarrow H_2O + BA$

1) **2015 AP® CHEMISTRY FREE-RESPONSE QUESTIONS**

$H^+ + C_6H_7O_2^- \rightleftarrows HC_6H_7O_2$	1 point is earned the net-ionic equation.





LO 3.1: Students can translate among macroscopic observations of change, chemical equations, and particle views.

Source

Types of Chemical Reactions

Combustion

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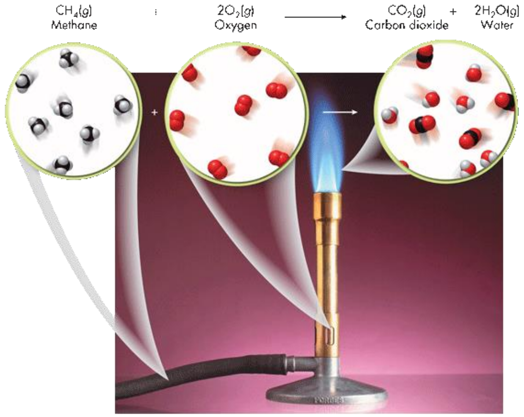

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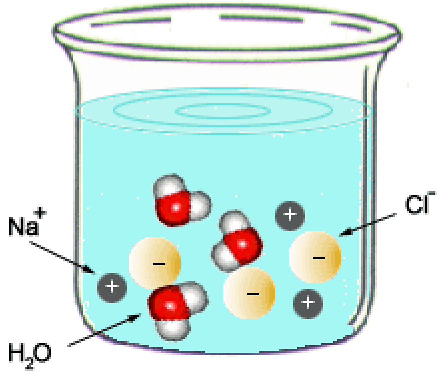
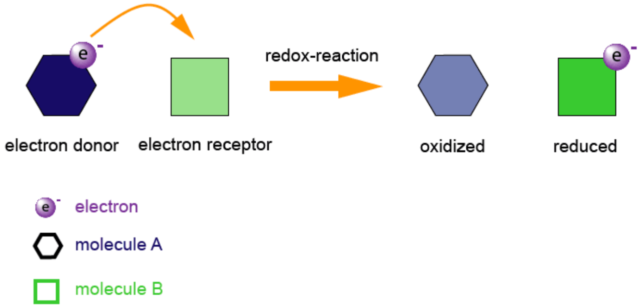


[Video]

Oxidation-Reduction

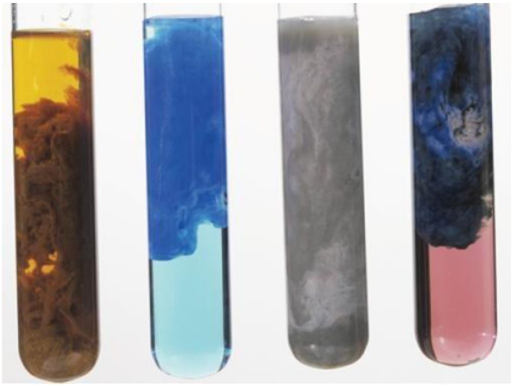
$A^+ + e^- \rightarrow A$

$B \rightarrow B + e^-$



Precipitation

$AB\ (aq) + CD\ (aq) \rightarrow AD\ (aq) + CB\ (s)$



LO 3.1: Students can translate among macroscopic observations of change, chemical equations, and particle views.

Balanced Equations

Source

Complete Molecular: $AgNO_3\,(aq) + KCl\,(aq) \longrightarrow AgCl\,(s) + KNO_3\,(aq)$

Complete Ionic : $Ag^+(aq) + NO_3^-(aq) + K^+(aq) + Cl^-(aq) \longrightarrow AgCl\,(s) + K^+(aq) + NO_3^-(aq)$

Net Ionic : $Ag^+(aq) + Cl^-(aq) \longrightarrow AgCl\,(s)$

Video

Quizlet

TABLE 4.2 Solubility Rules for Common Ionic Compounds in Water at 25°C

Soluble Compounds	Insoluble Exceptions
Compounds containing alkali metal ions (Li^+, Na^+, K^+, Rb^+, Cs^+) and the ammonium ion (NH_4^+)	
Nitrates (NO_3^-), bicarbonates (HCO_3^-), and chlorates (ClO_3^-)	
Halides (Cl^-, Br^-, I^-)	Halides of Ag^+, Hg_2^{2+}, and Pb^{2+}
Sulfates (SO_4^{2-})	Sulfates of Ag^+, Ca^{2+}, Sr^{2+}, Ba^{2+}, Hg_2^{2+}, and Pb^{2+}
Insoluble Compounds	**Soluble Exceptions**
Carbonates (CO_3^{2-}), phosphates (PO_4^{3-}), chromates (CrO_4^{2-}), sulfides (S^{2-})	Compounds containing alkali metal ions and the ammonium ion
Hydroxides (OH^-)	Compounds containing alkali metal ions and the Ba^{2+} ion

Spectator ions should not be included in your balanced equations.

Remember, the point of a Net Ionic Reaction is to show only those ions that are involved in the reaction. Chemists are able to substitute reactants containing the same species to create the intended product.

You only need to memorize that compounds with nitrate, ammonium, halides and alkali metals are soluble.

LO 3.2: The student can translate an observed chemical change into a balanced chemical equation and justify the choice of equation type (molecular, ionic, or net ionic) in terms of utility for the given circumstances.

Source

+

Making Predictions

2)

a. Solid copper carbonate is heated strongly:

Click reveals answer and explanation.

b. What evidence of a chemical change would be observed with this reaction?

Video

Click reveals answer and explanation.

c. What is the percent yield of CO_2 if you had originally heated 10.0g $CuCO_3$ and captured 3.2g CO_2 ?

Click reveals answer and explanation.

d. How could you improve your percent yield?

Click reveals answer and explanation.

LO 3.3: The student is able to use stoichiometric calculations to predict the results of performing a reaction in the laboratory and/or to analyze deviations from the expected results.

Source

Making Predictions

2)

a. Solid copper carbonate is heated strongly:

$CuCO_3$ (s) → CuO (s) + CO_2 (g)

b. What evidence of a chemical change would be observed with this reaction?

Video

One would observe a color change and evolution of a gas

c. What is the percent yield of CO_2 if you had originally heated 10.0g $CuCO_3$ and captured 3.2g CO_2 ?

Step 1: Find the Theoretical Yeild
10.0g $CuCO_3$ x(1mol/123.555g) x (1mol CO_2 /1 mol$CuCO_3$) X 44.01gCO_2/mol = 3.562 gCO_2

Step 2: Find Percent Yield
(3.2 g / 3.562 g) * 100 = 89.8 % → 90% with correct sig figs

d. How could you improve your percent yield?
-reheat the solid, to see if there is any further mass loss
-make sure you have pure $CuCO_3$

LO 3.3: The student is able to use stoichiometric calculations to predict the results of performing a reaction in the laboratory and/or to analyze deviations from the expected results.

Source

+

Limiting Reactants – D.A.

3)

$Al_2S_3 + 6\ H_2O \longrightarrow 2Al(OH)_3 + 3\ H_2S$

15.00 g aluminum sulfide and 10.00 g water react

a) Identify the Limiting Reactant

Click reveals answer and explanation.

b) What is the maximum mass of H_2S which can be formed from these reagents?

Click reveals answer and explanation.

c) How much excess reactant is left in the container?

Click reveals answer and explanation.

Video
Sim
pHet

***Dimensional Analysis is not the only way to solve these problems. You can also use BCA tables (modified ICE charts), which may save time on the exam →*

LO 3.4: The student is able to relate quantities (measured mass of substances, volumes of solutions, or volumes and pressures of gases) to identify stoichiometric relationships for a reaction, including situations involving limiting reactants and situations in which the reaction has not gone to completion.

+

Limiting Reactants – D.A.

Source

3)

Al_2S_3 + 6 H_2O ---> 2$Al(OH)_3$ + 3 H_2S

15.00 g aluminum sulfide and 10.00 g water react

a) Identify the Limiting Reactant

15.00g Al_2S_3 x (1mol/ 150.158 g) x (6mol H_2O/1mol Al_2S_3) x (18g/mol H_20) = 10.782 g H_20 needed

10g H_20 x (1mol/ 18.015 g) x (1 mol Al_2S_3 / 6mol H_2O) x (150.158 g/mol) = 13.892g Al_2S_3 needed

H_20 is limiting, because we need more than we were given

Video

Sim

pHet

b) What is the maximum mass of H_2S which can be formed from these reagents?

Theoretical Yield

10.00 g H_20 x (1mol/ 18.015 g) x (3/6) x (34.0809 g/mol) = 9.459 g H_2S produced

c) How much excess reactant is left in the container?

15.00 g – 13.892 g = 1.11g Al_2S_3

***Dimensional Analysis is not the only way to solve these problems. You can also use BCA tables (modified ICE charts), which may save time on the exam →*

LO 3.4: The student is able to relate quantities (measured mass of substances, volumes of solutions, or volumes and pressures of gases) to identify stoichiometric relationships for a reaction, including situations involving limiting reactants and situations in which the reaction has not gone to completion.

Source

Limiting Reactants – BCA Table

3) Alternative technique

15.00 g aluminum sulfide and 10.00 g water react according to the following equation:

$$Al_2S_3 + 6\ H_2O \dashrightarrow 2Al(OH)_3 + 3\ H_2S$$

a) Identify the Limiting Reactant

Video

Click reveals answer and explanation.

b) What is the maximum mass of H_2S which can be formed from these reagents?

Click reveals answer and explanation.

c) How much excess reactant is left in the container?

Click reveals answer and explanation.

LO 3.4: The student is able to relate quantities (measured mass of substances, volumes of solutions, or volumes and pressures of gases) to identify stoichiometric relationships for a reaction, including situations involving limiting reactants and situations in which the reaction has not gone to completion.

Source

Limiting Reactants – BCA Table

3) Alternative technique

15.00 g aluminum sulfide and 10.00 g water react according to the following equation:

$$Al_2S_3 + 6\ H_2O \text{ ---> } 2Al(OH)_3 + 3\ H_2S$$

a) Identify the Limiting Reactant

Video

15.00g Al_2S_3 x (1mol/ 150.158 g) = .100mol
10g H_20 x (1mol/ 18.015 g) = .555

Complete the table *using the molar relationships*

Water is the limiting reactant.

	Al_2S_3	6 H_2O	2$Al(OH)_3$	3 H_2S
Before	.0999	.5551	0	0
Change	-.0925	-.5551	+ .1850	+ .2775
After	.0074	0	.1850	.2775

b) What is the maximum mass of H_2S which can be formed from these reagents?

0.2775 mol H_2S x (34.0809 g/mol) = 9.459 g H_2S produced

c) How much excess reactant is left in the container?

.0074mol Al_2S_3 x 150.158 g/mol = 1.11g Al_2S_3

LO 3.4: The student is able to relate quantities (measured mass of substances, volumes of solutions, or volumes and pressures of gases) to identify stoichiometric relationships for a reaction, including situations involving limiting reactants and situations in which the reaction has not gone to completion.

Source

+

Experimental Design

4)

Synthesis

a. A sample of pure Cu is heated in excess pure oxygen. Design an experiment to determine quantitatively whether the product is CuO or Cu_2O.

Video

Click reveals basic steps

Decomposition $CaCO_3(s) \rightarrow CaO(s) + CO_2(g)$

b. Design a plan to prove experimentally that this reaction illustrates conservation of mass.

Click reveals basic steps

LO3.5: The student is able to design a plan in order to collect data on the synthesis or decomposition of a compound to confirm the conservation of matter and the law of definite proportions.

+ Source

Experimental Design

4) **Synthesis**

a. A sample of pure Cu is heated in excess pure oxygen. Design an experiment to determine quantitatively whether the product is CuO or Cu_2O.

Video

Find the mass of the copper. Heat in oxygen to a constant new mass. Subtract to find the mass of oxygen that combined with the copper. Compare the moles of oxygen atoms to the moles of original copper atoms to determine the formula.

Decomposition $CaCO_3(s) \rightarrow CaO(s) + CO_2(g)$

b. Design a plan to prove experimentally that this reaction illustrates conservation of mass.

Find the mass of calcium carbonate and seal it in a rigid container. Evacuate the container of remaining gas. Heat the container and take pressure readings (this will be the pressure exerted by the CO_2). Using PV=nRT, calculate the moles of carbon dioxide gas present in the container and compare it to the molar relationships afforded by the balanced chemical equation.

LO3.5: The student is able to design a plan in order to collect data on the synthesis or decomposition of a compound to confirm the conservation of matter and the law of definite proportions.

Source

Data Analysis

5)

When tin is treated with concentrated nitric acid, and the resulting mixture is strongly heated, the only
remaining product is an oxide of tin. A student wishes to find out whether it is SnO or SnO_2.

Mass of pure tin 5.200 grams.
Mass of dry crucible 18.650 g
Mass of crucible + oxide after first heating 25.500 g
Mass after second heating 25. 253 g
Mass after third heating 25. 252 g

Video

How can you use this data, and the law of conservation of mass, to determine the formula of the product?

Click reveals answer and explanation.

LO 3.6: The student is able to use data from synthesis or decomposition of a compound to confirm the conservation of matter and the law of definite proportions.

+

[Source](#)

Data Analysis

5)

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Mass of dry crucible 18.650 g
Mass of crucible + oxide after first heating 25.500 g
Mass after second heating 25. 253 g
Mass after third heating 25. 252 g

[Video](#)

How can you use this data, and the law of conservation of mass, to determine the formula of the product?

1) Determine the number of moles of tin. 5.200/118.7 = 0.0438 moles. Sn

2) Subtract the mass of the crucible from the mass after the third heating. 25.252-18.650 = 6.602 g SnO_x

3) Subtract the mass of tin from the mass of oxide to get the mass of oxygen. 6.602-5.200 = 1.402 grams of oxygen.

4) Calculate the moles of oxygen atoms, and divide by the moles of tin atoms to get the formula ratio.

1.402 g/16.00 g/mol of atoms = 0.0876 moles. 0.0876/0.0438 = 2.00

The formula must be SnO_2.

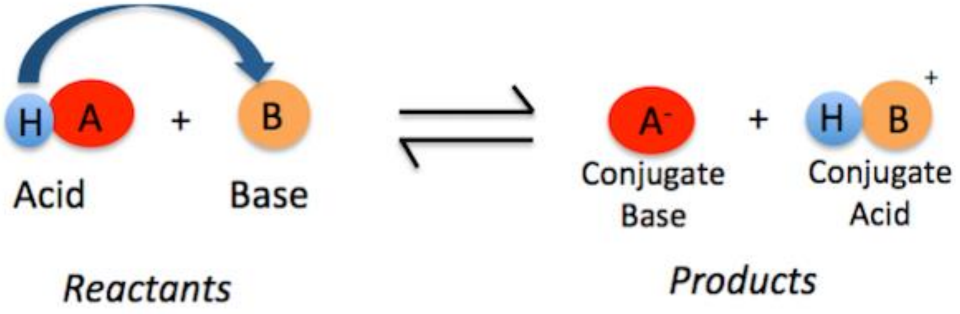
LO 3.6: The student is able to use data from synthesis or decomposition of a compound to confirm the conservation of matter and the law of definite proportions.

Source

Bronsted-Lowery Acids & Bases

According to Bronsted-Lowery (B.L.) an acid is a "proton donor" and a base is a "proton acceptor." The proton here is shown as a hydrogen.

The acid's conjugate base is the anion.
The base's conjugate acid now has the proton (hydrogen ion).



Video
Quizlet

- Hydrogen fluoride: A Brønsted–Lowry acid

$$HF(aq) + H_2O(l) \rightleftharpoons H_3O^+(aq) + F^-(aq)$$

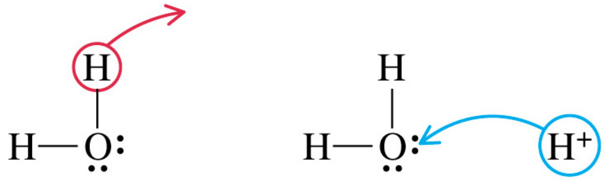
Acid	Base	Conjugate acid	Conjugate base

- Ammonia: A Brønsted–Lowry base

$$NH_3(aq) + H_2O(l) \rightleftharpoons NH_4^+(aq) + OH^-(aq)$$

Base	Acid	Conjugate acid	Conjugate base

Amphoteric nature of water
Water acts as both an acid & a base.



H_2O as an acid H_2O as a base

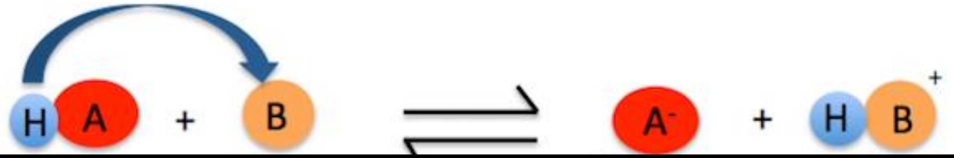
$$H_2O \leftrightarrow H^+ + OH^-$$
$$2H_2O \leftrightarrow H_3O^+ + OH^-$$

LO 3.7: The student is able to identify compounds as Bronsted-Lowry acids, bases and/or conjugate acid-base pairs, using proton-transfer reactions to justify the identification.

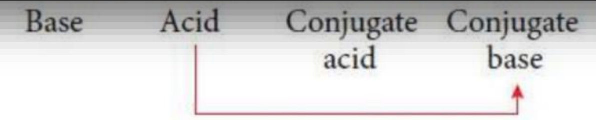
[Source]

+ Bronsted-Lowery Acids & Bases

6) According to Bronsted-Lowery (B.L.) an acid is a "proton donor" and a base is a "proton acceptor." The proton here is shown as a hydrogen.



It is an acid-base reaction. The weak acid $HC_2H_3O_2$ reacts with the weak base HCO_3^- with $HC_2H_3O_2$ donating a proton. OR It is an acid-base reaction. No solid precipitates, so it is not a precipitation reaction. None of the oxidation numbers change, so it is not a redox reaction.	1 point is earned for identifying the reaction as acid-base. 1 point is earned for the justification.



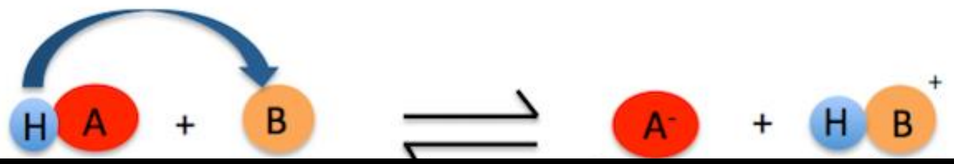
LO 3.7: The student is able to identify compounds as Bronsted-Lowry acids, bases and/or conjugate acid-base pairs, using proton-transfer reactions to justify the identification.

Source

+

Bronsted-Lowery Acids & Bases

6) According to Bronsted-Lowery (B.L.) an acid is a "proton donor" and a base is a "proton acceptor.“ The proton here is shown as a hydrogen.

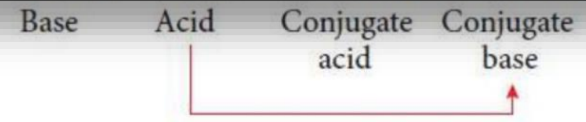


2016 AP® CHEMISTRY FREE-RESPONSE QUESTIONS

$$NaHCO_3(s) + HC_2H_3O_2(aq) \rightarrow NaC_2H_3O_2(aq) + H_2O(l) + CO_2(g)$$

2. A student designs an experiment to study the reaction between $NaHCO_3$ and $HC_2H_3O_2$. The reaction is represented by the equation above. The student places 2.24 g of $NaHCO_3$ in a flask and adds 60.0 mL of 0.875 *M* $HC_2H_3O_2$. The student observes the formation of bubbles and that the flask gets cooler as the reaction proceeds.

   (a) Identify the reaction represented above as an acid-base reaction, precipitation reaction, or redox reaction. Justify your answer.



LO 3.7: The student is able to identify compounds as Bronsted-Lowry acids, bases and/or conjugate acid-base pairs, using proton-transfer reactions to justify the identification.

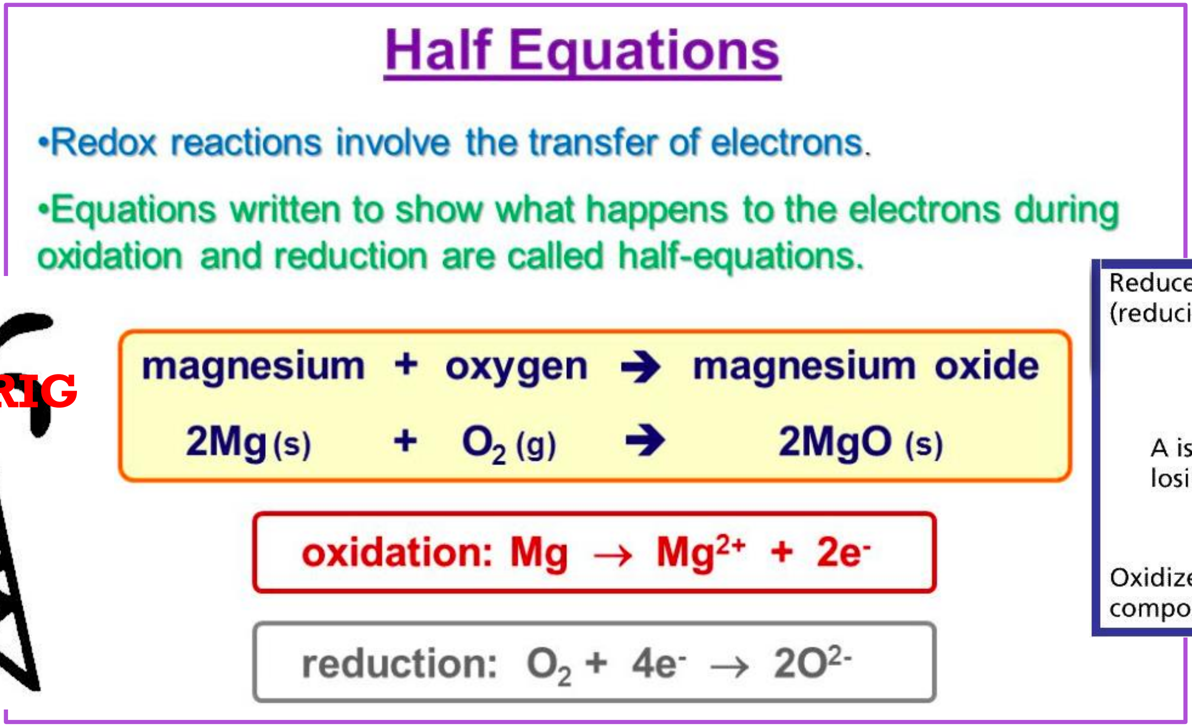
Redox Reactions

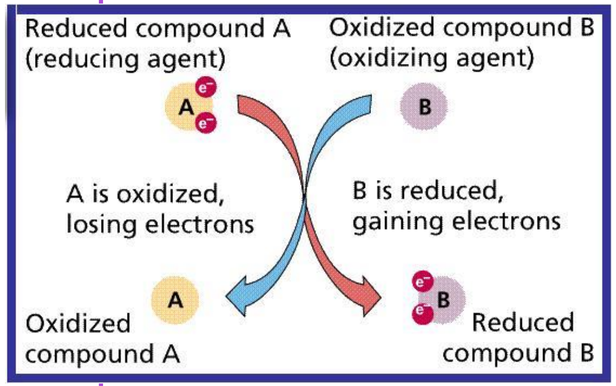
+

[Source]

- When an electron is transferred, it is called a ***redox reaction***. When something is reduced, the RED part of redox, it gains electrons. You may have a difficult time with this definition because when something is reduced, it usually means that it is losing something. In this case, it is a reduction in charge. Remember, electrons are negatively charged so if something is being reduced, it's getting more negatively charged by receiving more electrons. The other reaction that is coupled with this is called *oxidation*--the "OX" part of redox. Whenever something is reduced, the electron it gains has to come from somewhere. The oxidation is the loss of an electron, so if an atom is oxidized it loses its electron to another atom. And these are always coupled reactions. If one molecule is oxidized, another molecule must be reduced and vice versa: the electron must go somewhere.

[Video]





LO 3.8: The student is able to identify redox reactions and justify the identification in terms of electron transfer

Redox Reactions

[Source]

+

- When an electron is transferred, it is called a ***redox reaction***. When something is reduced, the RED part of redox, it gains electrons. You may have

7)

Question:

Zinc ions will react with aluminum metal according to the following chemical reaction:

$$2\ Al_{(s)} + 3\ Zn^{2+}{}_{(aq)} \rightarrow 2Al^{3+}{}_{(aq)} + 3\ Zn_{(s)}$$

Based on this chemical reaction how many moles of electrons would be transferred when 1.0 mol of Zn^{2+} ions are consumed?

a. 6.0 moles
b. 3.0 moles
c. 2.0 moles
d.1.0 moles
e. 0.33 moles

LO 3.8: The student is able to identify redox reactions and justify the identification in terms of electron transfer

Redox Reactions

Source

- When an electron is transferred, it is called a ***redox reaction***. When something is reduced, the RED part of redox, it gains electrons. You may have [redacted]

7) [redacted]

Question:

Zinc ions will react with aluminum metal according to the following chemical reaction:

$$2\ Al_{(s)} + 3\ Zn^{2+}_{(aq)} \rightarrow 2Al^{3+}_{(aq)} + 3\ Zn_{(s)}$$

[redacted]

Answer:

The correct answer is "c" 2.0 moles. For each Zn^{2+} ion 2 electrons are needed to convert it in to a Zn atom. If we are consuming 1 mole of Zn^{2+} we will need to transfer 2 moles of electrons.

[redacted]

LO 3.8: The student is able to identify redox reactions and justify the identification in terms of electron transfer

+

Redox Titrations

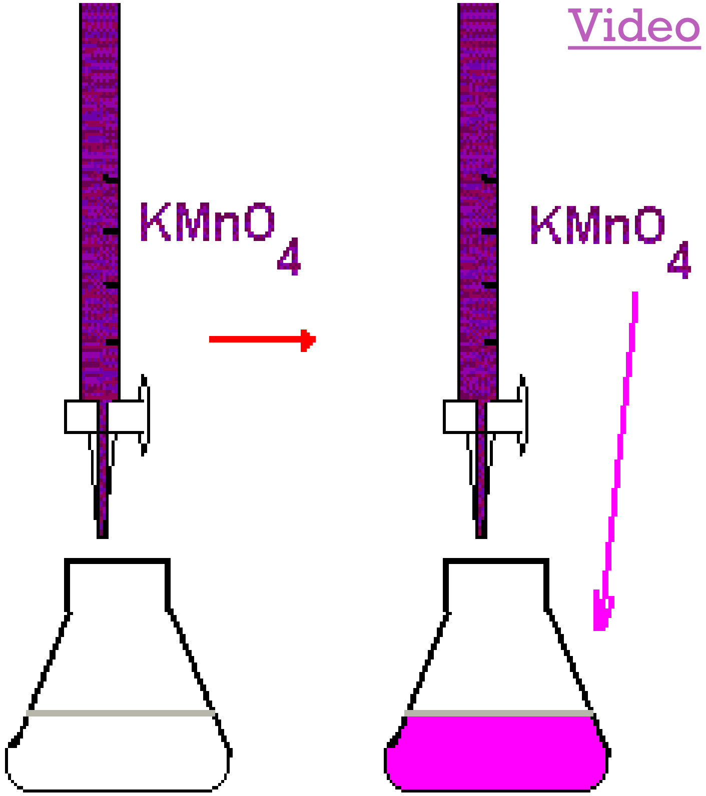
Source

A redox titration (also called an oxidation-reduction titration) can accurately determine the concentration of an unknown analyte by measuring it against a standardized titrant. A common example is the redox titration of a standardized solution of potassium permanganate ($KMnO_4$) against an analyte containing an unknown concentration of iron (II) ions (Fe^{2+}). The balanced reaction in acidic solution is as follows:

$$MnO_4^- + 5Fe^{2+} + 8H^+ \rightarrow 5Fe^{3+} + Mn^{2+} + 4H_2O$$

In this case, the use of $KMnO_4$ as a titrant is particularly useful, because it can act as its own indicator; this is due to the fact that the $KMnO_4$ solution is bright purple, while the Fe^{2+} solution is colorless. It is therefore possible to see when the titration has reached its endpoint, because the solution will remain slightly purple from the unreacted $KMnO_4$

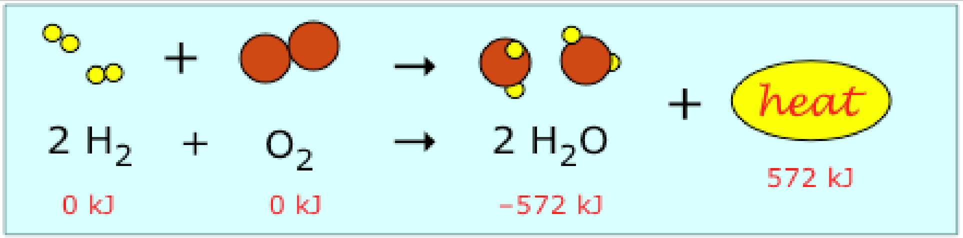
Video



LO 3.9: The student is able to design and/or interpret the results of an experiment involving a redox titration

Evidence of Chemical Change

Source



An exothermic chemical reaction rearranges electrons and nuclei to a lower potential energy configuration; the excess energy is liberated as heat.

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Chemical Changes:

Production of a gas:
$2KClO_{3\ (s)} + heat \rightarrow 2KCl_{\ (s)} + 3O_{2\ (g)}$

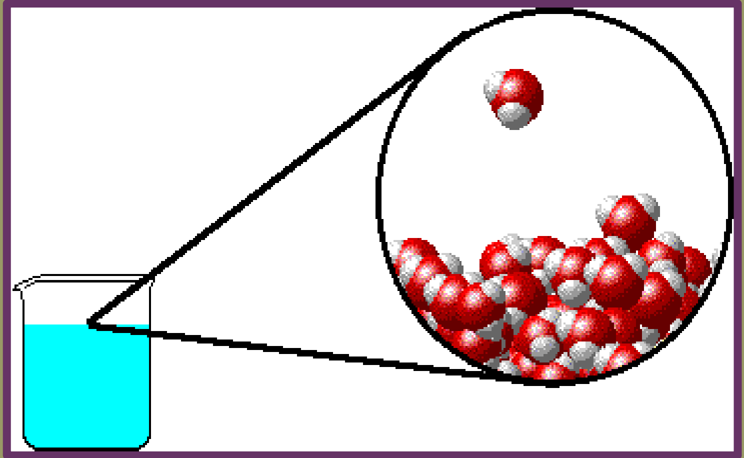
Formation of a precipitate:
$AgNO_3)_{\ (aq)} + KCl_{\ (aq)} \rightarrow AgCl_{\ (s)} + 2KNO_{3\ (aq)}$

Change in color:
Two white solids react to produce a mixture of a yellow and a white solid when shaken forcefully!
$Pb(NO_3)_{2\ (s)} + 2KI_{\ (s)} \rightarrow PbI_{2\ (s)} + 2KNO_{3\ (s)}$

Production of heat*:
$2\ Mg_{\ (s)} + O_{2\ (s)} \rightarrow 2MgO_{\ (s)} + heat$
*can also include the absorption of heat

Physical Changes:

may produce similar visible evidence (i.e. boiling water creates "bubbles," but bonds are not broken and reformed. No new substances are made.



LO 3.10: Evaluate the classification of a process as a physical, chemical, or ambiguous change based on both macroscopic observations and the distinction between rearrangement of covalent interactions and noncovalent interactions.

Evidence of Chemical Change

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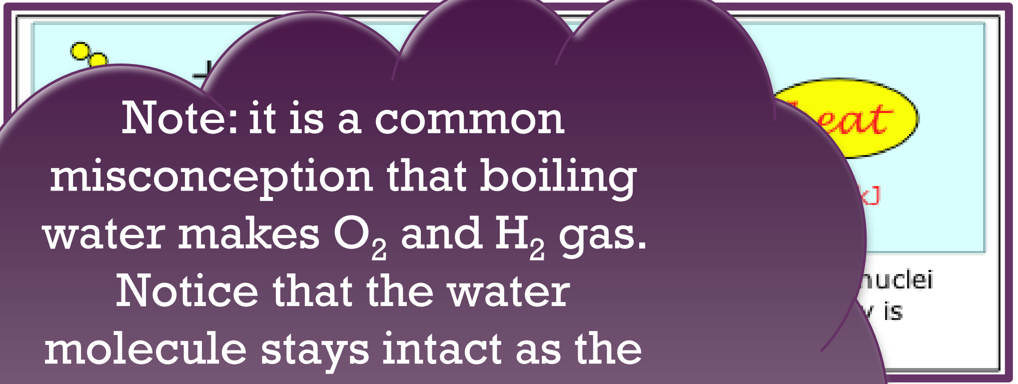

Note: it is a common misconception that boiling water makes O_2 and H_2 gas. Notice that the water molecule stays intact as the water boils. Covalent bonds are not broken with during this phase change- only intermolecular attractions (hydrogen bonds) between water molecules.

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Chemical Ch

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Formation of a

$AgNO_{3})_{(aq)}$ + KC

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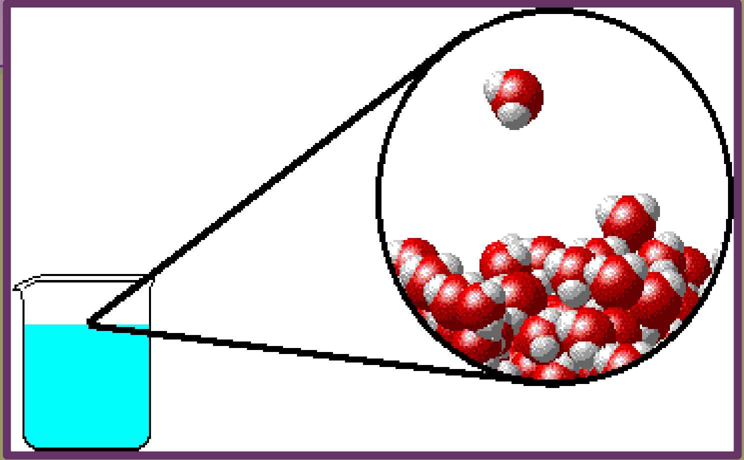

LO 3.10: Evaluate the classification of a process as a physical, chemical, or ambiguous change based on both macroscopic observations and the distinction between rearrangement of covalent interactions and noncovalent interactions.

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Energy Changes

- Chemical reactions involve the formation of new products
- Bonds between atoms or ions in the reactants must be BROKEN (the enthalpy of the system is increasing … ENDOTHERMIC process)
- Bonds are then FORMED between atoms or ions to make the producsts of the reaction. (the enthalpy of hte system is decreasing…EXOTHERMIC process)

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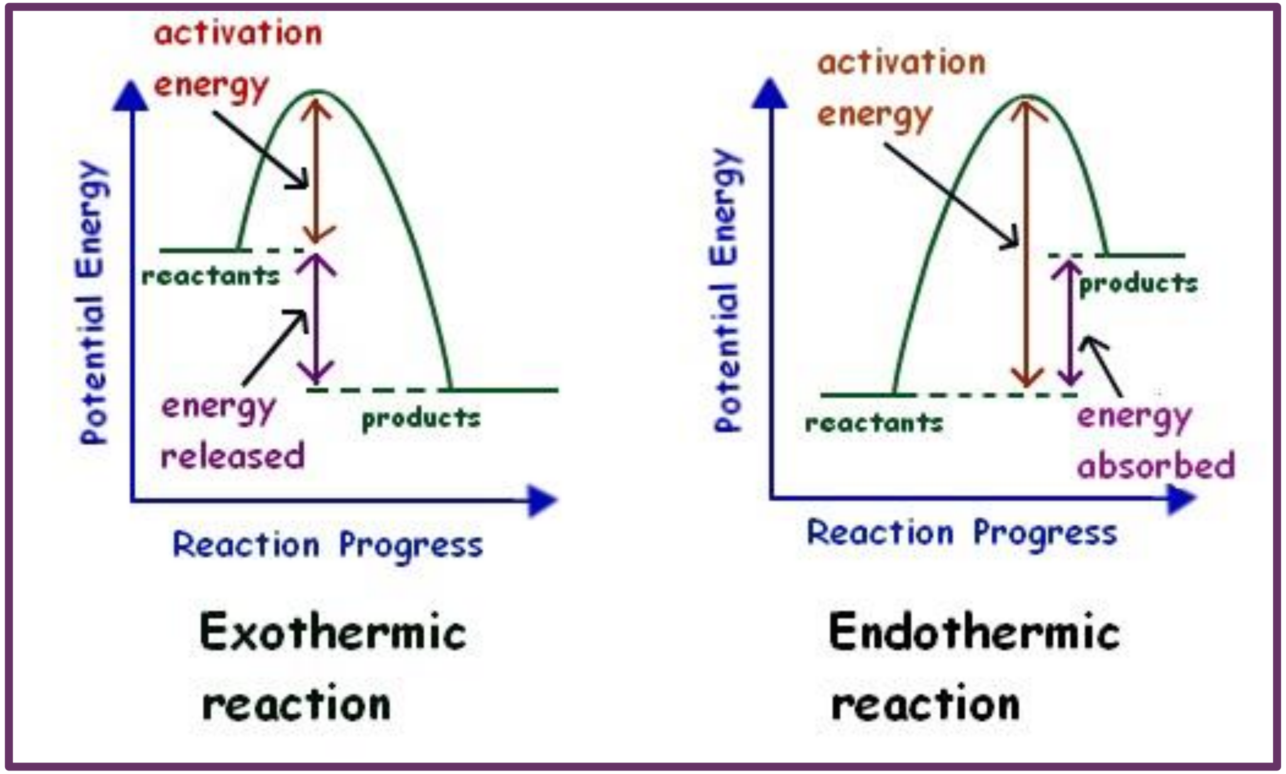

LO 3.11: The student is able to interpret observations regarding macroscopic energy changes associated with a reaction or process to generate a relevant symbolic and/or graphical representation of the energy changes.

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8)

Galvanic Cell Potential

Question:

The following question is based on combining the three different half cells listed below:

Half Cell 1: $Sn^{2+} + 2e^- \longrightarrow Sn$

Half Cell 2: $Ag^+ + e^- \longrightarrow Ag$

Half Cell 2: $Cr^{3+} + 3e^- \longrightarrow Cr$

Galvanic Cell	Half Cells	Reaction	$E°_{cell}$ (V)
X	1 & 2	$Sn + 2Ag^+ \longrightarrow 2Ag + Sn^{2+}$	0.94
Y	2 & 3	$Cr + 3Ag^+ \longrightarrow 3Ag + Cr^{3+}$	1.54
Z	1 & 3	$2Cr + 3Sn^{2+} \longrightarrow 3Sn + 2Cr^{3+}$	?

What is the cell potential of galvanic cell Z?

a. 0.26 V

b. 0.60 V

c. 2.48 V

d. 5.90 V

Click reveals answer and explanation.

Source

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LO 3.12: Make qualitative or quantitative predictions about galvanic or electrolytic reactions based on half-cell reactions and potentials and/or Faraday's laws.

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Z	1 & 3	$2Cr + 3Sn^{2+} \longrightarrow 3Sn + 2Cr^{3+}$	?

What is the cell potential of galvanic cell Z?

a. 0.26 V

b. 0.60 V

c. 2.48 V

d. 5.90 V

Answer:

The correct answer is "b", 0.60 V. The potential of cell Z can be calculated by combining cells X and Y. Cell X needs to be reversed changing it's potential from 0.94 to -0.94, then the reactions of the reversed X and Y will combine to give cell Z. So the value -0.94 from the reversed cell X can be added to the potential of cell Y, giving a value of 0.60 for cell Z. It is important to note that even though cell X would need to be multiplied by 3 and cell Y would need to be multiplied by 2 in order to produce cell Z those changes do not effect the voltage of either cell.

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LO 3.12: Make qualitative or quantitative predictions about galvanic or electrolytic reactions based on half-cell reactions and potentials and/or Faraday's laws.

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Redox Reactions and Half Cells

9)

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Z	1 & 3	$2Cr + 3Sn^{2+} \longrightarrow 3Sn + 2Cr^{3+}$	?

In galvanic cells X and Z, which of the following takes place in half cell 1?

a. Oxidation occurs in both cell X and cell Z.
b. Reduction occurs in both cell X and cell Z.
c. Oxidation occurs in cell X and reduction in cell Z.
d. Reduction occurs in cell X and oxidation in cell Z.

Video

Video

LO 3.13: The student can analyze data regarding galvanic or electrolytic cells to identify properties of the underlying redox reactions

Source

Redox Reactions and Half Cells

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Galvanic Cell	Half Cells	Reaction	$E°_{cell}$ (V)
X	1 & 2	$Sn + 2Ag^+ \longrightarrow 2Ag + Sn^{2+}$	0.94

Answer:
The correct answer is "c", oxidation occurs in cell X and reduction in cell Z. In galvanic cell X the tin is losing electrons to form the Sn^{2+} ion, this is oxidation. In galvanic cell Z the Sn2+ is gaining electrons to form Sn, this is reduction.

Video

Video

LO 3.13: The student can analyze data regarding galvanic or electrolytic cells to identify properties of the underlying redox reactions

2016 FRQ #3

10) ▪ This question drew heavily from Big Idea #3

While cleaning up after the experiment, the student wishes to dispose of the unused solid I_2 in a responsible manner. The student decides to convert the solid I_2 to $I^-(aq)$ anion. The student has access to three solutions, $H_2O_2(aq)$, $Na_2S_2O_3(aq)$, and $Na_2S_4O_6(aq)$, and the standard reduction table shown below.

Half reaction	$E°$ (V)
$S_4O_6^{2-}(aq) + 2\,e^- \rightarrow 2\,S_2O_3^{2-}(aq)$	0.08
$I_2(s) + 2\,e^- \rightarrow 2\,I^-(aq)$	0.54
$O_2(g) + 2\,H^+(aq) + 2\,e^- \rightarrow H_2O_2(aq)$	0.68

(e) Which solution should the student add to $I_2(s)$ to reduce it to $I^-(aq)$? Circle your answer below. Justify your answer, including a calculation of $E°$ for the overall reaction.

$H_2O_2(aq)$ $Na_2S_2O_3(aq)$ $Na_2S_4O_6(aq)$

(f) Write the balanced net-ionic equation for the reaction between I_2 and the solution you selected in part (e).

2016 FRQ #3

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(e) Which solution should the student add to $I_2(s)$ to reduce it to $I^-(aq)$? Circle your answer below. Justify your answer and include a calculation of $E°$ for the overall reaction.

$H_2O_2(aq)$ $Na_2S_2O_3(aq)$ $Na_2S_4O_6(aq)$

[$Na_2S_2O_3(aq)$ should be circled.] The reaction between $S_2O_3^{2-}(aq)$ and $I_2(s)$ will be thermodynamically favorable because $E°$ for the reaction is positive ($E° = 0.54 - 0.08 = +0.46$ V), from which it follows that $\Delta G°$ is negative because $\Delta G° = -nFE°$.	1 point is earned for the correct choice. 1 point is earned for a correct justification.

(f) Write the balanced net-ionic equation for the reaction between I_2 and the solution you selected in part (e).

$I_2 + 2\,S_2O_3^{2-} \rightarrow 2\,I^- + S_4O_6^{2-}$	1 point is earned for the correct equation.

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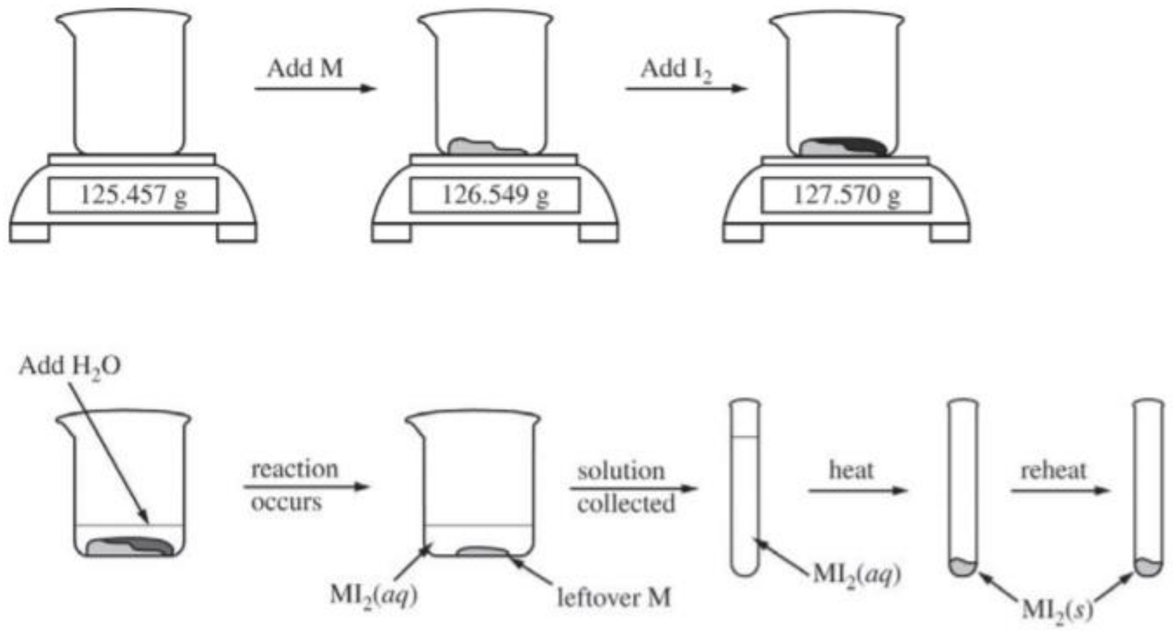
3. To determine the molar mass of an unknown metal, M, a student reacts iodine with an excess of the metal to form the water-soluble compound MI_2, as represented by the equation above. The reaction proceeds until all of the I_2 is consumed. The $MI_2(aq)$ solution is quantitatively collected and heated to remove the water, and the product is dried and weighed to constant mass. The experimental steps are represented below, followed by a data table.



Data for Unknown Metal Lab	
Mass of beaker	125.457 g
Mass of beaker + metal M	126.549 g
Mass of beaker + metal M + I_2	127.570 g
Mass of MI_2, first weighing	1.284 g
Mass of MI_2, second weighing	1.284 g

(a) Given that the metal M is in excess, calculate the number of moles of I_2 that reacted.

(b) Calculate the molar mass of the unknown metal M.

2016 F

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3. To determine the molar mass of an unknown metal, M, a student reacts iodine with an excess of the metal to form the water-soluble compound MI_2, as represented by the equation above. The reaction proceeds until all of the I_2 is consumed. The $MI_2(aq)$ solution is quantitatively collected and heated to remove the water, and the product is dried and weighed to constant mass. The experimental steps are represented below, followed by a

(a) Given that the metal M is in excess, calculate the number of moles of I_2 that reacted.

$127.570 - 126.549 = 1.021 \text{ g } I_2$ $1.021 \text{ g } I_2 \times \dfrac{1 \text{ mol } I_2}{253.80 \text{ g } I_2} = 0.004023 \text{ mol } I_2$	1 point is earned for the number of moles.

(b) Calculate the molar mass of the unknown metal M.

Number of moles of I_2 = number of moles of M $1.284 \text{ g } MI_2 - 1.021 \text{ g } I_2 = 0.263 \text{ g M}$ Molar mass of M = $\dfrac{0.263 \text{ g M}}{0.004023 \text{ mol M}} = 65.4 \text{ g/mol}$	1 point is earned for the number of grams of M. 1 point is earned for the molar mass.

Mass of MI_2, second weighing	1.284 g

(a) Given that the metal M is in excess, calculate the number of moles of I_2 that reacted.

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