

1. Which idea of John Dalton is no longer considered part of the modern view of atoms?
- A Atoms are extremely small.
  - B Atoms of the same element have identical masses.
  - C Atoms combine in simple whole number ratios to form compounds.
  - D Atoms of different elements can combine in different ratios to form different compounds.
2. Which **best** describes the current atomic theory?
- A Atoms consist of electrons circling in definite orbits around a positive nucleus.
  - B Atoms are composed of electrons in a cloud around a positive nucleus.
  - C Atoms can easily be split, at which time they become radioactive.
  - D An atom's mass is determined by the mass of its neutrons.
3. What is the nuclear composition of uranium-235?
- A 92 electrons + 143 protons
  - B 92 protons + 143 electrons
  - C 143 protons + 92 neutrons
  - D 92 protons + 143 neutrons
4. Which **best** describes the relationship between subatomic particles in any neutral atom?
- A The number of protons equals the number of electrons.
  - B The number of protons equals the number of neutrons.
  - C The number of neutrons equals the number of electrons.
  - D The number of neutrons is greater than the number of protons.
5. What is the name of the compound  $\text{PbO}_2$ ?
- A lead oxide
  - B lead(II) oxide
  - C lead oxide(II)
  - D lead(IV) oxide

6. What is the name of  $\text{HCl} (aq)$ ?
- A chloric acid  
B hydrochloric acid  
C hydrogen chloride  
D perchloric acid
7. What is the chemical formula for calcium nitrate?
- A  $\text{CaNO}_3$   
B  $\text{Ca}(\text{NO}_2)_2$   
C  $\text{Ca}(\text{NO}_3)_2$   
D  $\text{Ca}_3\text{N}_2$
8. Which is the correct formula for dinitrogen pentoxide?
- A  $\text{N}_4\text{O}$   
B  $\text{NO}_2$   
C  $\text{N}_2\text{O}_5$   
D  $\text{NO}_4$
9. If the volume of an 18.5-g piece of metal is  $2.35 \text{ cm}^3$ , what is the identity of the metal?
- A iron  
B lead  
C nickel  
D zinc
10. Which substance listed in the table is a liquid at  $27^\circ\text{C}$ ?

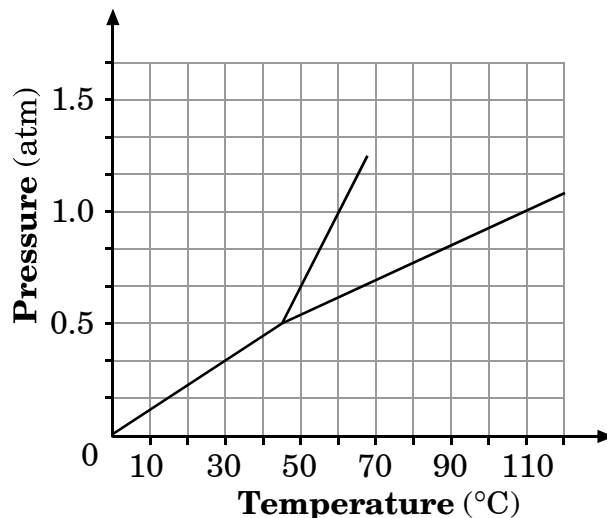
	<b>Melting Point</b>	<b>Boiling Point</b>
<b>I</b>	$28^\circ\text{C}$	$140^\circ\text{C}$
<b>II</b>	$-10^\circ\text{C}$	$25^\circ\text{C}$
<b>III</b>	$20^\circ\text{C}$	$140^\circ\text{C}$
<b>IV</b>	$-90^\circ\text{C}$	$14^\circ\text{C}$

- A I  
B II  
C III  
D IV

11. Which will increase the solubility of **most** solid solutes?
- A decreasing the temperature
  - B decreasing the amount of solvent at constant temperature
  - C increasing the amount of solute at constant temperature
  - D increasing the temperature
12. What happens to the pressure of a constant mass of gas at constant temperature when the volume is doubled?
- A The pressure is doubled.
  - B The pressure remains the same.
  - C The pressure is reduced by  $\frac{1}{2}$ .
  - D The pressure is reduced by  $\frac{1}{4}$ .
13. The total pressure in a closed vessel containing  $\text{N}_2$ ,  $\text{O}_2$  and  $\text{CO}_2$  is 30 atm. If the partial pressure of  $\text{N}_2$  is 4 atm, and the partial pressure of  $\text{O}_2$  is 6 atm, what is the partial pressure of  $\text{CO}_2$ ?
- A 20 atm
  - B 30 atm
  - C 40 atm
  - D 50 atm
14. What is the pressure, in atmospheres, exerted by a 0.100-mol sample of oxygen in a 2.00-L container at  $273^\circ\text{C}$ ?
- A  $4.48 \times 10^{-1}$  atm
  - B  $2.24 \times 10^0$  atm
  - C  $1.12 \times 10^3$  atm
  - D  $2.24 \times 10^3$  atm
15. What type of bonding is associated with compounds that have the following characteristics:
- high melting points
  - conduct electricity in the molten state
  - solutions conduct electricity
  - normally crystalline solids at room temperature.
- A covalent
  - B ionic
  - C hydrogen
  - D metallic

16. Which is a unique characteristic of the bonding between metal atoms?
- A Atoms require additional electrons to reach a stable octet.
  - B Atoms must give away electrons to reach a stable octet.
  - C Atoms share valence electrons only with neighboring atoms to reach a stable octet.
  - D Delocalized electrons move among many atoms creating a sea of electrons.
17. Which pair of elements would **most likely** bond to form a covalently bonded compound?
- A sodium and fluorine
  - B barium and chlorine
  - C phosphorus and oxygen
  - D magnesium and sulfur
18. Based on the VSEPR theory, what is the molecular geometry of a molecule of  $\text{PI}_3$ ?
- A linear
  - B tetrahedral
  - C trigonal planar
  - D trigonal pyramidal

19. Consider this phase diagram:



At what temperature does the normal boiling point occur?

- A 45°C
- B 60°C
- C 100°C
- D 110°C

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20. What happens when energy is removed from liquid water?

- A Molecules slow down, and more hydrogen bonds are formed.
- B Molecules slow down, and more hydrogen bonds are broken.
- C Molecules move faster, and more hydrogen bonds are formed.
- D Molecules move faster, and more hydrogen bonds are broken.

## End of Goal 2 Sample Items

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## Chemistry Goal 2

### Sample Items Key Report

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- 1 Objective: 2.01**  
Analyze the historical development of the current atomic theory.  
a. Early contributions: Democritus and Dalton.  
b. The discovery of the electron: Thomson and Millikan.  
c. The discovery of the nucleus, proton and neutron: Rutherford and Chadwick.  
d. The Bohr model.  
e. The quantum mechanical model.  
**Thinking Skill:** Analyzing **Correct Answer:** B
- 2 Objective: 2.01**  
Analyze the historical development of the current atomic theory.  
a. Early contributions: Democritus and Dalton.  
b. The discovery of the electron: Thomson and Millikan.  
c. The discovery of the nucleus, proton and neutron: Rutherford and Chadwick.  
d. The Bohr model.  
e. The quantum mechanical model.  
**Thinking Skill:** Knowledge **Correct Answer:** B
- 3 Objective: 2.02**  
Examine the nature of atomic structure.  
a. Subatomic particles: protons, neutrons, and electrons.  
b. Mass number and/or Atomic number.  
c. Isotopes.  
**Thinking Skill:** Applying **Correct Answer:** D
- 4 Objective: 2.02**  
Examine the nature of atomic structure.  
a. Subatomic particles: protons, neutrons, and electrons.  
b. Mass number and/or Atomic number.  
c. Isotopes.  
**Thinking Skill:** Applying **Correct Answer:** A
- 5 Objective: 2.03**  
Apply the language and symbols of chemistry.  
a. Name compounds using the IUPAC conventions.  
b. Write formulas of simple compounds from their names.  
**Thinking Skill:** Applying **Correct Answer:** D
- 6 Objective: 2.03**  
Apply the language and symbols of chemistry.  
a. Name compounds using the IUPAC conventions.  
b. Write formulas of simple compounds from their names.  
**Thinking Skill:** Applying **Correct Answer:** B
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## Chemistry Goal 2

### Sample Items Key Report

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- 7 Objective: 2.03**  
Apply the language and symbols of chemistry.  
a. Name compounds using the IUPAC conventions.  
b. Write formulas of simple compounds from their names.  
**Thinking Skill:** Applying **Correct Answer:** C
- 8 Objective: 2.03**  
Apply the language and symbols of chemistry.  
a. Name compounds using the IUPAC conventions.  
b. Write formulas of simple compounds from their names.  
**Thinking Skill:** Applying **Correct Answer:** C
- 9 Objective: 2.04**  
Identify substances using their physical properties:  
a. Melting points and/or Boiling points.  
b. Density.  
c. Solubility.  
**Thinking Skill:** Applying **Correct Answer:** A
- 10 Objective: 2.04**  
Identify substances using their physical properties:  
a. Melting points and/or Boiling points.  
b. Density.  
c. Solubility.  
**Thinking Skill:** Analyzing **Correct Answer:** C
- 11 Objective: 2.04**  
Identify substances using their physical properties:  
a. Melting points and/or Boiling points.  
b. Density.  
c. Solubility.  
**Thinking Skill:** Analyzing **Correct Answer:** D
- 12 Objective: 2.05**  
Analyze the basic assumptions of kinetic molecular theory and its applications:  
a. Ideal Gas Equation.  
b. Combined Gas Law.  
c. Dalton's Law of Partial Pressures.  
**Thinking Skill:** Analyzing **Correct Answer:** C
- 13 Objective: 2.05**  
Analyze the basic assumptions of kinetic molecular theory and its applications:  
a. Ideal Gas Equation.
-

## Chemistry Goal 2 Sample Items Key Report

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- b. Combined Gas Law.
- c. Dalton's Law of Partial Pressures.

**Thinking Skill:** Applying **Correct Answer:** A

**14 Objective: 2.05**

Analyze the basic assumptions of kinetic molecular theory and its applications:

- a. Ideal Gas Equation.
- b. Combined Gas Law.
- c. Dalton's Law of Partial Pressures.

**Thinking Skill:** Applying **Correct Answer:** B

**15 Objective: 2.06**

Assess bonding in metals and ionic compounds as related to chemical and physical properties.

**Thinking Skill:** Analyzing **Correct Answer:** B

**16 Objective: 2.06**

Assess bonding in metals and ionic compounds as related to chemical and physical properties.

**Thinking Skill:** Applying **Correct Answer:** D

**17 Objective: 2.07**

Assess covalent bonding in molecular compounds as related to molecular geometry and chemical and physical properties.

- a. Molecular.
- b. Macromolecular.
- c. Hydrogen bonding and other intermolecular forces (dipole/dipole interaction, dispersion).
- d. VSEPR theory.

**Thinking Skill:** Analyzing **Correct Answer:** C

**18 Objective: 2.07**

Assess covalent bonding in molecular compounds as related to molecular geometry and chemical and physical properties.

- a. Molecular.
- b. Macromolecular.
- c. Hydrogen bonding and other intermolecular forces (dipole/dipole interaction, dispersion).
- d. VSEPR theory.

**Thinking Skill:** Analyzing **Correct Answer:** D

**19 Objective: 2.08**

Assess the dynamics of physical equilibria.

- a. Interpret phase diagrams.
- b. Factors that affect phase changes.

**Thinking Skill:** Analyzing **Correct Answer:** D

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## Chemistry Goal 2

### Sample Items Key Report

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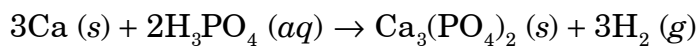
- 20**      **Objective:**      **2.08**  
Assess the dynamics of physical equilibria.  
a. Interpret phase diagrams.  
b. Factors that affect phase changes.  
**Thinking Skill:**      Analyzing      **Correct Answer:**      A

1. The compound formed between element X and oxygen has the chemical formula  $X_2O$ . Which element would X **most likely** represent?
- A Fe  
B Zn  
C Ag  
D Sn
2. Which electron configuration represents a transition element?
- A  $1s^2 2s^2 2p^3$   
B  $1s^2 2s^2 2p^6 3s^2$   
C  $1s^2 2s^2 2p^6 3s^2 3p^6 4s^2 3d^7$   
D  $1s^2 2s^2 2p^6 3s^2 3p^6 4s^2 3d^{10} 4p^4$
3. Given the electronic configuration of  $1s^2 2s^2 2p^4$ , how many electrons does this element have in its outer level?
- A 2  
B 4  
C 6  
D 8
4. Which correctly lists four atoms from smallest to largest radii?
- A I, Br, Cl, F  
B F, I, Br, Cl  
C Si, P, S, Cl  
D Cl, S, P, Si
5. Which **best** explains why cations are smaller than the atoms from which they are formed?
- A The metallic atom gains electrons, causing a larger effective nuclear pull.  
B The metallic atom loses electrons, resulting in loss of an entire energy level.  
C The nonmetallic atom gains electrons, causing a larger effective nuclear pull.  
D The nonmetallic atom loses electrons, resulting in loss of an entire energy level.

6. Which have the lowest electronegativities?
- A alkali metals
  - B halogens
  - C rare earth elements
  - D transition metals
7. How many moles are in 59.6 grams of  $\text{BaSO}_4$ ?
- A 0.256 mole
  - B 3.91 moles
  - C 13.9 moles
  - D 59.6 moles
8. What is the volume of two moles of hydrogen gas at STP?
- A 44.8 L
  - B 22.4 L
  - C 11.2 L
  - D 2.00 L
9. How many molecules are contained in 55.0 g of  $\text{H}_2\text{SO}_4$ ?
- A 0.561 molecule
  - B 3.93 molecules
  - C  $3.38 \times 10^{23}$  molecules
  - D  $2.37 \times 10^{24}$  molecules
10. If a sample of magnesium has a mass of 60. g, how many moles of magnesium does the sample contain?
- A 1.1 moles
  - B 1.2 moles
  - C 2.0 moles
  - D 2.5 moles
11. How many grams of KCl are necessary to prepare 1.50 liters of a 0.500-M solution of KCl?
- A 224 g
  - B 74.6 g
  - C 56.0 g
  - D 24.9 g

12. What is the molarity of a solution containing 20.0 g of sodium hydroxide dissolved in 1.00 L of solution?
- A 0.500 M  
B 0.400 M  
C 0.300 M  
D 0.200 M
13. Analysis shows a compound to be, by mass, 43.8% N, 6.2% H, and 50.0% O. Which is a possible molecular formula for the substance?
- A  $\text{NH}_4\text{NO}_2$   
B  $\text{NH}_4\text{NO}_3$   
C  $\text{NH}_3\text{OH}$   
D  $\text{N}_2\text{OH}$
14. A compound has an empirical formula of  $\text{CH}_2\text{O}$  and a molecular mass of 180 g. What is the compound's molecular formula?
- A  $\text{C}_3\text{H}_6\text{O}_3$   
B  $\text{C}_6\text{H}_{12}\text{O}_6$   
C  $\text{C}_6\text{H}_{11}\text{O}_7$   
D  $\text{C}_{12}\text{H}_{22}\text{O}_{11}$
15. What is the percent by mass of iron in the compound  $\text{Fe}_2\text{O}_3$ ?
- A 70%  
B 56%  
C 48%  
D 30%
16. Metallic sodium reacts violently with water to form hydrogen and sodium hydroxide according to the balanced equation:
- $$2\text{Na} + 2\text{H}_2\text{O} \rightarrow 2\text{NaOH} + \text{H}_2$$
- How many moles of hydrogen gas are generated when 4.0 moles of sodium react with excess water?
- A 1.0 mole  
B 2.0 moles  
C 3.0 moles  
D 4.0 moles

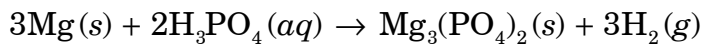
17. Consider this reaction:



How many moles of calcium are required to produce 60.0 g of calcium phosphate?

- A 0.145 mole  
B 0.194 mole  
C 0.387 mole  
D 0.581 mole
- 
18. According to the equation  $2\text{H}_2\text{O (l)} \rightarrow 2\text{H}_2 \text{ (g)} + \text{O}_2 \text{ (g)}$ , what mass of  $\text{H}_2\text{O}$  is required to yield 22.4 L of  $\text{O}_2$  at STP?
- A 12 g  
B 18 g  
C 24 g  
D 36 g

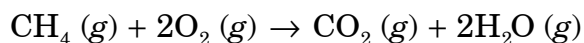
19. Consider this reaction:



How many grams of magnesium phosphate should be produced if 5.40 grams of magnesium react with excess phosphoric acid?

- A 1.80 grams
  - B 19.5 grams
  - C 58.4 grams
  - D 175 grams
- 

20. Methane ( $\text{CH}_4$ ) is burned in oxygen according to this balanced chemical equation:



What volume of carbon dioxide is formed when 9.36 liters of methane are burned in excess oxygen at STP?

- A 9.36 L
- B 15.0 L
- C 18.7 L
- D 22.4 L

## End of Goal 3 Sample Items

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## Chemistry Goal 3

### Sample Items Key Report

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- 1 Objective: 3.01**  
Analyze periodic trends in chemical properties and use the periodic table to predict properties of elements.  
a. Groups (families), Periods, and representative elements (main group) and transition elements.  
b. Electron configuration and energy levels.  
c. Ionization energy, atomic and ionic radii, and/or electronegativity.  
**Thinking Skill:** Applying **Correct Answer:** C
- 2 Objective: 3.01**  
Analyze periodic trends in chemical properties and use the periodic table to predict properties of elements.  
a. Groups (families), Periods, and representative elements (main group) and transition elements.  
b. Electron configuration and energy levels.  
c. Ionization energy, atomic and ionic radii, and/or electronegativity.  
**Thinking Skill:** Analyzing **Correct Answer:** C
- 3 Objective: 3.01**  
Analyze periodic trends in chemical properties and use the periodic table to predict properties of elements.  
a. Groups (families), Periods, and representative elements (main group) and transition elements.  
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**Thinking Skill:** Applying **Correct Answer:** C
- 4 Objective: 3.01**  
Analyze periodic trends in chemical properties and use the periodic table to predict properties of elements.  
a. Groups (families), Periods, and representative elements (main group) and transition elements.  
b. Electron configuration and energy levels.  
c. Ionization energy, atomic and ionic radii, and/or electronegativity.  
**Thinking Skill:** Organizing **Correct Answer:** D
- 5 Objective: 3.01**  
Analyze periodic trends in chemical properties and use the periodic table to predict properties of elements.  
a. Groups (families), Periods, and representative elements (main group) and transition elements.  
b. Electron configuration and energy levels.  
c. Ionization energy, atomic and ionic radii, and/or electronegativity.
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## Chemistry Goal 3 Sample Items Key Report

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	<b>Thinking Skill:</b>	Analyzing	<b>Correct Answer:</b>	B
<b>6</b>	<b>Objective:</b>	<b>3.01</b>		
	Analyze periodic trends in chemical properties and use the periodic table to predict properties of elements.			
	a. Groups (families), Periods, and representative elements (main group) and transition elements.			
	b. Electron configuration and energy levels.			
	c. Ionization energy, atomic and ionic radii, and/or electronegativity.			
	<b>Thinking Skill:</b>	Organizing	<b>Correct Answer:</b>	A
<b>7</b>	<b>Objective:</b>	<b>3.02</b>		
	Apply the mole concept, Avogadro's number and conversion factors to chemical calculations.			
	a. Particles to moles, mass to moles, and/or volume of a gas to moles			
	b. Molarity of			
	c. Empirical and molecular			
	d. Percent composition.			
	<b>Thinking Skill:</b>	Applying	<b>Correct Answer:</b>	A
<b>8</b>	<b>Objective:</b>	<b>3.02</b>		
	Apply the mole concept, Avogadro's number and conversion factors to chemical calculations.			
	a. Particles to moles, mass to moles, and/or volume of a gas to moles			
	b. Molarity of			
	c. Empirical and molecular			
	d. Percent composition.			
	<b>Thinking Skill:</b>	Applying	<b>Correct Answer:</b>	A
<b>9</b>	<b>Objective:</b>	<b>3.02</b>		
	Apply the mole concept, Avogadro's number and conversion factors to chemical calculations.			
	a. Particles to moles, mass to moles, and/or volume of a gas to moles			
	b. Molarity of			
	c. Empirical and molecular			
	d. Percent composition.			
	<b>Thinking Skill:</b>	Applying	<b>Correct Answer:</b>	C
<b>10</b>	<b>Objective:</b>	<b>3.02</b>		
	Apply the mole concept, Avogadro's number and conversion factors to chemical calculations.			
	a. Particles to moles, mass to moles, and/or volume of a gas to moles			
	b. Molarity of			
	c. Empirical and molecular			

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## Chemistry Goal 3

### Sample Items Key Report

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d. Percent composition.

**Thinking Skill:** Applying

**Correct Answer:** D

11 **Objective:** 3.02

Apply the mole concept, Avogadro's number and conversion factors to chemical calculations.

a. Particles to moles, mass to moles, and/or volume of a gas to moles

b. Molarity of

c. Empirical and molecular

d. Percent composition.

**Thinking Skill:** Applying

**Correct Answer:** C

12 **Objective:** 3.02

Apply the mole concept, Avogadro's number and conversion factors to chemical calculations.

a. Particles to moles, mass to moles, and/or volume of a gas to moles

b. Molarity of

c. Empirical and molecular

d. Percent composition.

**Thinking Skill:** Applying

**Correct Answer:** A

13 **Objective:** 3.02

Apply the mole concept, Avogadro's number and conversion factors to chemical calculations.

a. Particles to moles, mass to moles, and/or volume of a gas to moles

b. Molarity of

c. Empirical and molecular

d. Percent composition.

**Thinking Skill:** Applying

**Correct Answer:** A

14 **Objective:** 3.02

Apply the mole concept, Avogadro's number and conversion factors to chemical calculations.

a. Particles to moles, mass to moles, and/or volume of a gas to moles

b. Molarity of

c. Empirical and molecular

d. Percent composition.

**Thinking Skill:** Applying

**Correct Answer:** B

15 **Objective:** 3.02

Apply the mole concept, Avogadro's number and conversion factors to chemical calculations.

a. Particles to moles, mass to moles, and/or volume of a gas to moles

b. Molarity of

## Chemistry Goal 3 Sample Items Key Report

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- c. Empirical and molecular
- d. Percent composition.

**Thinking Skill:** Applying

**Correct Answer:** A

**16 Objective: 3.03**

Calculate quantitative relationships in chemical reactions (stoichiometry).

- a. Moles of each species in a
- b. Mass of each species in a
- c. Volumes of gaseous species in a reaction.

**Thinking Skill:** Applying

**Correct Answer:** B

**17 Objective: 3.03**

Calculate quantitative relationships in chemical reactions (stoichiometry).

- a. Moles of each species in a
- b. Mass of each species in a
- c. Volumes of gaseous species in a reaction.

**Thinking Skill:** Applying

**Correct Answer:** D

**18 Objective: 3.03**

Calculate quantitative relationships in chemical reactions (stoichiometry).

- a. Moles of each species in a
- b. Mass of each species in a
- c. Volumes of gaseous species in a reaction.

**Thinking Skill:** Applying

**Correct Answer:** D

**19 Objective: 3.03**

Calculate quantitative relationships in chemical reactions (stoichiometry).

- a. Moles of each species in a
- b. Mass of each species in a
- c. Volumes of gaseous species in a reaction.

**Thinking Skill:** Applying

**Correct Answer:** B

**20 Objective: 3.03**

Calculate quantitative relationships in chemical reactions (stoichiometry).

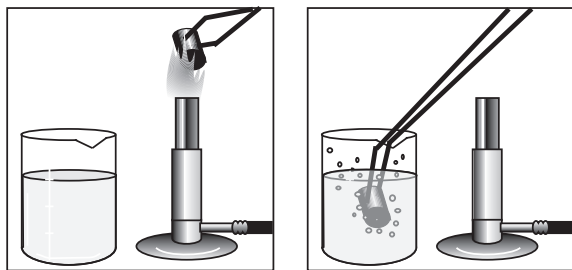
- a. Moles of each species in a
- b. Mass of each species in a
- c. Volumes of gaseous species in a reaction.

**Thinking Skill:** Integrating

**Correct Answer:** A

1. Consider the spectrum for the hydrogen atom. In which situation will light be produced?
- A Electrons absorb energy as they move to an excited state.
  - B Electrons release energy as they move to an excited state.
  - C Electrons absorb energy as they return to the ground state.
  - D Electrons release energy as they return to the ground state.
2. Which statement regarding red and green visible light is correct?
- A The speed of green light is greater than that of red light.
  - B The wavelength of green light is longer than that of red light.
  - C The energy of green light is lower than that of red light.
  - D The frequency of green light is higher than that of red light.
3. Which color of light would a hydrogen atom emit when an electron changes from the  $n = 5$  level to the  $n = 2$  level?
- A red
  - B yellow
  - C green
  - D blue
4. What energy level transition is indicated when the light emitted by a hydrogen atom has a wavelength of 103 nm?
- A  $n = 2$  to  $n = 1$
  - B  $n = 3$  to  $n = 1$
  - C  $n = 4$  to  $n = 2$
  - D  $n = 5$  to  $n = 2$

5. A piece of metal is heated in a Bunsen burner flame and then immersed in a beaker of cool water.



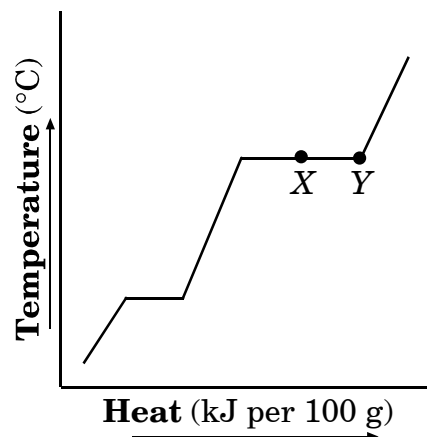
Which statement *best* describes the effect of the temperature changes on the kinetic energy of the particles?

- A Kinetic energy of metal atoms decreases in the flame.
- B Kinetic energy of water molecules increases when the heated metal is immersed.
- C Kinetic energy of water molecules decreases when the heated metal is immersed.
- D Kinetic energy of metal atoms increases when immersed in the cooler water.

6. The gases helium, neon, and argon are in separate containers at  $55^{\circ}\text{C}$ . Which is true about the kinetic energy of the gases?

- A Helium has the lowest mass and therefore greatest kinetic energy.
- B They each have a different kinetic energy.
- C Argon has the greatest mass and therefore the greatest kinetic energy.
- D They all have the same average kinetic energy.

7. This is a heating curve for a substance.



Between points X and Y, which would be observed?

- A Solid and liquid will be present.
- B Only vapor will be present.
- C Liquid and vapor will be present.
- D Only liquid will be present.

8. An open container of water is brought to a boil and heated until all of the water is converted to water vapor. Which describes the changes in the water molecules?
- A The molecules speed up and move farther apart.
- B The molecules speed up and move closer together.
- C The molecules slow down and move farther apart.
- D The molecules slow down and move closer together.
9. 6.00 g of gold was heated from 20.0°C to 22.0°C. How much heat was applied to the gold?
- A 1.55 J
- B 15.5 J
- C 17.0 J
- D 32.5 J
10. A student has a beaker containing 55 g of water at 100°C. How much heat is needed to convert the water to steam?
- A 120,000 J
- B 18,000 J
- C 2,200 J
- D 330 J

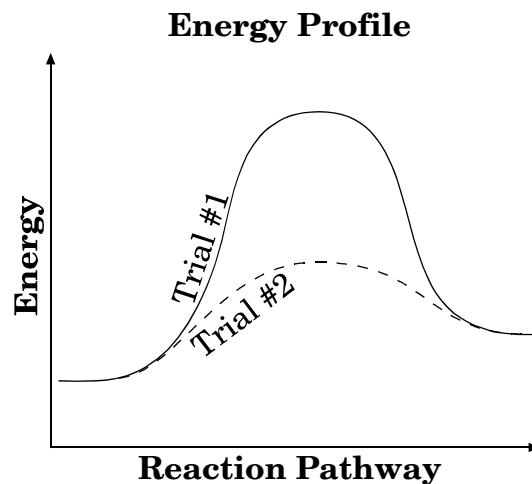
11. How many grams of ice will melt at 0°C if the ice absorbs 420. J of energy?
- A 0.186 g
- B 0.795 g
- C 1.26 g
- D  $5.38 \times 10^4$  g
12. An 18.0-g piece of an unidentified metal was heated from 21.5°C to 89.0°C. If 292 J of heat energy was absorbed by the metal in the heating process, what was the identity of the metal?

**Specific Heat Table**

Substance	Specific Heat
Aluminum	0.90 J/g•°C
Calcium	0.65 J/g•°C
Copper	0.39 J/g•°C
Gold	0.13 J/g•°C
Iron	0.46 J/g•°C
Mercury	0.14 J/g•°C
Silver	0.24 J/g•°C

- A calcium
- B copper
- C iron
- D silver

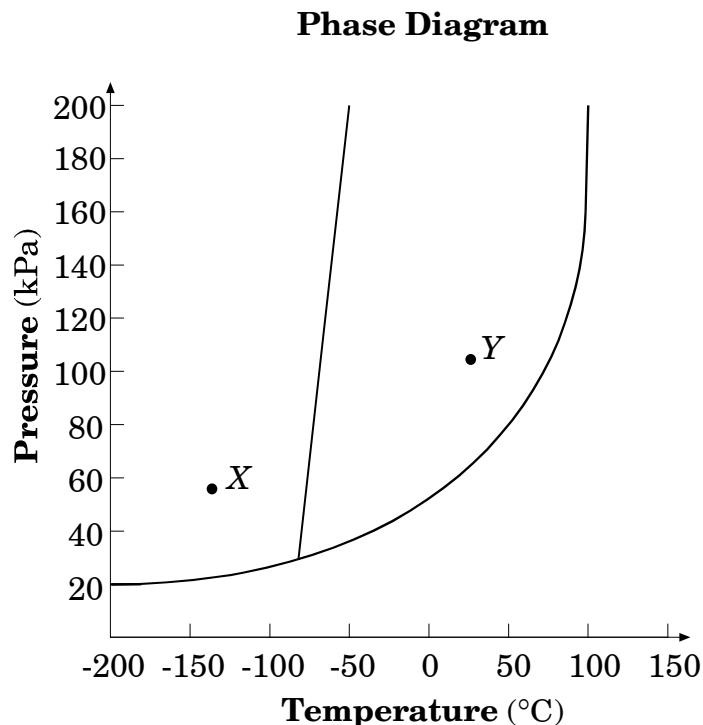
13. This graph represents the change in energy for two laboratory trials of the same reaction.



Which factor could explain the energy difference between the trials?

- A Heat was added to trial #2.
- B A catalyst was added to trial #2.
- C Trial #1 was stirred.
- D Trial #1 was cooled.

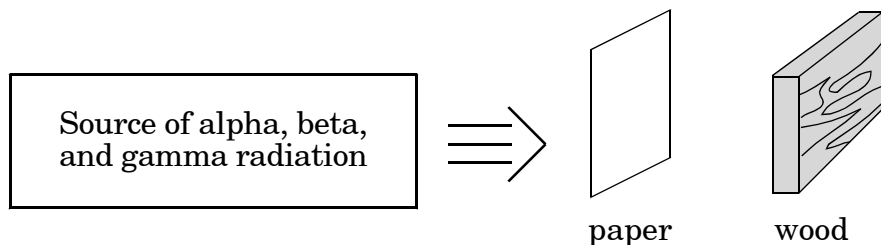
14. Consider this phase diagram.



What process is occurring when a substance changes from point X ( $-130^{\circ}\text{C}$  and 50 kPa) to point Y ( $30^{\circ}\text{C}$  and 100 kPa)?

- A boiling
  - B freezing
  - C melting
  - D sublimation
- 
15. When a chemical cold pack is activated, it becomes cool to the touch. What is happening in terms of energy?
- A An exothermic reaction is occurring, absorbing cold from its surroundings.
  - B An exothermic reaction is occurring, releasing heat to its surroundings.
  - C An endothermic reaction is occurring, releasing cold to its surroundings.
  - D An endothermic reaction is occurring, absorbing heat from its surroundings.

16. Consider this diagram:



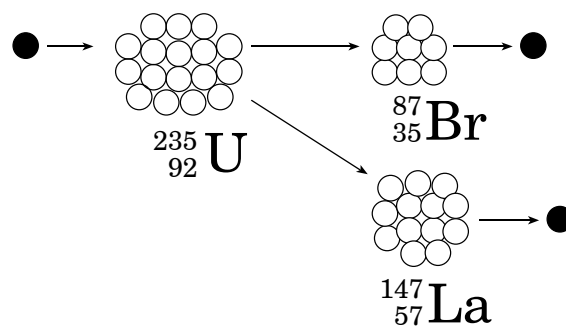
Which of the three types of radiation will penetrate the paper and wood?

- A alpha, beta, gamma
- B alpha and beta only
- C gamma only
- D beta only

17. The half-life of phosphorus-32 is 14.30 days. How many milligrams of a 20.00 mg sample of phosphorus-32 will remain after 85.80 days?

- A 3.333 mg
- B 0.6250 mg
- C 0.3125 mg
- D 0.1563 mg

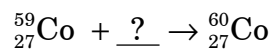
18. In the figure below, what type of nuclear activity is represented?



- A fission
- B fusion
- C alpha emission
- D beta emission

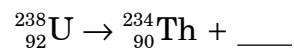


19. Which particle will complete this reaction?



- A electron
- B neutron
- C nucleus
- D proton

20. Which will complete this equation?



- A  ${}_{-1}^0e$
- B  ${}^0_0\gamma$
- C  ${}^1_1\text{H}$
- D  ${}^4_2\text{He}$

### End of Goal 4 Sample Items

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# Chemistry Goal 4

## Sample Items Key Report

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- 1**      **Objective:**    **4.01**  
Analyze the Bohr model in terms of electron energies in the hydrogen atom.  
a. The spectrum of electromagnetic  
b. Emission and absorption of electromagnetic energy as electrons change energy levels.  
**Thinking Skill:**    Applying                                **Correct Answer:**    D
- 2**      **Objective:**    **4.01**  
Analyze the Bohr model in terms of electron energies in the hydrogen atom.  
a. The spectrum of electromagnetic  
b. Emission and absorption of electromagnetic energy as electrons change energy levels.  
**Thinking Skill:**    Applying                                **Correct Answer:**    D
- 3**      **Objective:**    **4.01a**  
Analyze the Bohr model in terms of electron energies in the hydrogen atom.  
a. The spectrum of electromagnetic energy.  
**Thinking Skill:**    Analyzing                                **Correct Answer:**    D
- 4**      **Objective:**    **4.01**  
Analyze the Bohr model in terms of electron energies in the hydrogen atom.  
a. The spectrum of electromagnetic  
b. Emission and absorption of electromagnetic energy as electrons change energy levels.  
**Thinking Skill:**    Analyzing                                **Correct Answer:**    B
- 5**      **Objective:**    **4.02**  
Analyze the law of conservation of energy, energy transformation, and various forms of energy involved in chemical and physical processes.  
A. Differentiate between heat and  
b. Analyze heating and cooling  
c. Calorimetry, heat of fusion and heat of vaporization  
d. Endothermic and exothermic processes including interpretation of potential energy. Diagrams (energy vs. reaction pathway), enthalpy and activation energy.  
**Thinking Skill:**    Applying                                **Correct Answer:**    B
- 6**      **Objective:**    **4.02**  
Analyze the law of conservation of energy, energy transformation, and various forms of energy involved in chemical and physical processes.  
A. Differentiate between heat and  
b. Analyze heating and cooling  
c. Calorimetry, heat of fusion and heat of vaporization  
d. Endothermic and exothermic processes including interpretation of potential energy. Diagrams (energy vs. reaction pathway), enthalpy and activation energy.  
**Thinking Skill:**    Applying                                **Correct Answer:**    D
-

## Chemistry Goal 4

### Sample Items Key Report

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- 7 Objective: 4.02**  
Analyze the law of conservation of energy, energy transformation, and various forms of energy involved in chemical and physical processes.  
A. Differentiate between heat and  
b. Analyze heating and cooling  
c. Calorimetry, heat of fusion and heat of vaporization  
d. Endothermic and exothermic processes including interpretation of potential energy. Diagrams (energy vs. reaction pathway), enthalpy and activation energy.  
**Thinking Skill:** Analyzing **Correct Answer:** C
- 8 Objective: 4.02**  
Analyze the law of conservation of energy, energy transformation, and various forms of energy involved in chemical and physical processes.  
A. Differentiate between heat and  
b. Analyze heating and cooling  
c. Calorimetry, heat of fusion and heat of vaporization  
d. Endothermic and exothermic processes including interpretation of potential energy. Diagrams (energy vs. reaction pathway), enthalpy and activation energy.  
**Thinking Skill:** Applying **Correct Answer:** A
- 9 Objective: 4.02**  
Analyze the law of conservation of energy, energy transformation, and various forms of energy involved in chemical and physical processes.  
A. Differentiate between heat and  
b. Analyze heating and cooling  
c. Calorimetry, heat of fusion and heat of vaporization  
d. Endothermic and exothermic processes including interpretation of potential energy. Diagrams (energy vs. reaction pathway), enthalpy and activation energy.  
**Thinking Skill:** Applying **Correct Answer:** A
- 10 Objective: 4.02**  
Analyze the law of conservation of energy, energy transformation, and various forms of energy involved in chemical and physical processes.  
A. Differentiate between heat and  
b. Analyze heating and cooling  
c. Calorimetry, heat of fusion and heat of vaporization  
d. Endothermic and exothermic processes including interpretation of potential energy. Diagrams (energy vs. reaction pathway), enthalpy and activation energy.  
**Thinking Skill:** Applying **Correct Answer:** A
- 11 Objective: 4.02**  
Analyze the law of conservation of energy, energy transformation, and various forms of energy involved in chemical and physical processes.  
A. Differentiate between heat and
-

## Chemistry Goal 4

### Sample Items Key Report

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b. Analyze heating and cooling  
c. Calorimetry, heat of fusion and heat of vaporization  
d. Endothermic and exothermic processes including interpretation of potential energy.  
Diagrams (energy vs. reaction pathway), enthalpy and activation energy.  
**Thinking Skill:** Applying **Correct Answer:** C

**12 Objective: 4.02**  
Analyze the law of conservation of energy, energy transformation, and various forms of energy involved in chemical and physical processes.  
A. Differentiate between heat and  
b. Analyze heating and cooling  
c. Calorimetry, heat of fusion and heat of vaporization  
d. Endothermic and exothermic processes including interpretation of potential energy.  
Diagrams (energy vs. reaction pathway), enthalpy and activation energy.  
**Thinking Skill:** Analyzing **Correct Answer:** D

**13 Objective: 4.03**  
Assess reaction rates and factors that affect reaction rates.  
**Thinking Skill:** Applying **Correct Answer:** B

**14 Objective: 4.01**  
Analyze the Bohr model in terms of electron energies in the hydrogen atom.  
a. The spectrum of electromagnetic  
b. Emission and absorption of electromagnetic energy as electrons change energy levels.  
**Thinking Skill:** Analyzing **Correct Answer:** C

**15 Objective: 4.02**  
Analyze the law of conservation of energy, energy transformation, and various forms of energy involved in chemical and physical processes.  
A. Differentiate between heat and  
b. Analyze heating and cooling  
c. Calorimetry, heat of fusion and heat of vaporization  
d. Endothermic and exothermic processes including interpretation of potential energy.  
Diagrams (energy vs. reaction pathway), enthalpy and activation energy.  
**Thinking Skill:** Knowledge **Correct Answer:** D

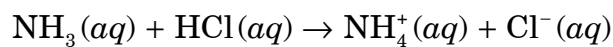
**16 Objective: 4.04**  
Analyze nuclear energy.  
A. Radioactivity: characteristics of alpha, beta and gamma  
b. Decay equations for alpha and beta  
c. Half-life and fission and  
d. Fission and fusion.  
**Thinking Skill:** Analyzing **Correct Answer:** C



1. Consider this reaction:
- $$\text{NH}_3(g) + \text{HCl}(g) \rightarrow \text{NH}_4\text{Cl}(s)$$
- Which type of reaction does this equation represent?
- A combustion
  - B decomposition
  - C single replacement
  - D synthesis
2. Which equation represents a single replacement reaction that can occur?
- A  $\text{F}_2 + 2\text{NaCl} \rightarrow 2\text{NaF} + \text{Cl}_2$
  - B  $\text{Cl}_2 + 2\text{NaF} \rightarrow 2\text{NaCl} + \text{F}_2$
  - C  $\text{Cu} + 2\text{NaCl} \rightarrow \text{CuCl}_2 + 2\text{Na}$
  - D  $\text{Zn} + 2\text{NaF} \rightarrow \text{ZnF}_2 + 2\text{Na}$
3. What products are formed when the metal potassium is added to water?
- A K and  $\text{H}_2\text{O}$
  - B KOH and  $\text{H}_2\text{O}$
  - C  $\text{K}_2\text{O}$  and  $\text{H}_2$
  - D KOH and  $\text{H}_2$
4. When  $\text{Na}_2\text{O}$  reacts with  $\text{H}_2\text{O}$ , what is produced?
- A  $\text{HNaO}_2$
  - B  $\text{Na} + \text{H}_2\text{O}$
  - C  $\text{NaO} + \text{H}_2$
  - D NaOH
5. Which equation is correctly balanced?
- A  $\text{Cu} + \text{H}_2\text{SO}_4 \rightarrow \text{CuSO}_4 + \text{H}_2\text{O} + \text{SO}_2$
  - B  $2\text{Na} + 2\text{H}_2\text{O} \rightarrow 2\text{NaOH} + \text{H}_2$
  - C  $2\text{Fe} + 3\text{O}_2 \rightarrow \text{Fe}_2\text{O}_3$
  - D  $4\text{Cu} + \text{S}_8 \rightarrow 8\text{Cu}_2\text{S}$
6. What coefficients are required to balance this equation?
- $$\_ \text{Fe}_2\text{O}_3 + \_ \text{CO} \rightarrow \_ \text{Fe} + \_ \text{CO}_2$$
- A 2, 6, 3, 6
  - B 1, 3, 2, 3
  - C 1, 1, 2, 2
  - D 1, 1, 2, 1

7. An aqueous solution of silver nitrate is added to an aqueous solution of iron(II) chloride. Which is the net ionic equation for the reaction that occurs?
- A  $\text{AgNO}_2(aq) + \text{FeCl}(aq) \rightarrow \text{AgCl}(s) + \text{FeNO}_2(aq)$
- B  $2\text{AgNO}_3(aq) + \text{FeCl}_2(aq) \rightarrow 2\text{AgCl}(s) + \text{Fe}(\text{NO}_3)_2(aq)$
- C  $2\text{Ag}^{+1}(aq) + \text{NO}_3^{-1}(aq) + \text{Fe}^{+2}(aq) + \text{Cl}_2(g) \rightarrow 2\text{AgCl}(s)$
- D  $2\text{Ag}^{+}(aq) + 2\text{Cl}^{-}(aq) \rightarrow 2\text{AgCl}(s)$
- 
8. Which example indicates that a chemical change has occurred?
- A When two aqueous solutions are mixed, a precipitate is formed.
- B As ammonium nitrate dissolves in water, it causes the temperature of the water to decrease.
- C Alcohol evaporates when left in an open container.
- D Water is added to blue copper(II) chloride solution. The resulting mixture is lighter blue in color.

9. Consider this chemical equation:



In this reaction, why is the ammonia considered a base?

- A  $\text{NH}_3$  increases the hydronium ion concentration.
- B  $\text{NH}_3$  decreases the hydroxide ion concentration.
- C  $\text{NH}_3$  accepts a proton.
- D  $\text{NH}_3$  donates a proton.

10. Phenolphthalein is an indicator that turns pink when added to a basic solution. In which solution would phenolphthalein turn pink?

- A NaOH
- B HCl
- C  $\text{H}_2\text{O}$
- D NaCl

11. A water sample was found to have a pH of 6 at  $25^\circ\text{C}$ . What is the hydroxide concentration in the water sample?

- A  $1 \times 10^{-8} M$
- B  $6 \times 10^{-8} M$
- C  $1 \times 10^{-6} M$
- D  $6 \times 10^{-6} M$

12. What is the pH of a solution of KOH with a hydroxide concentration of  $[\text{OH}] = 1 \times 10^{-4} M$ ?

- A -10
- B -4
- C 4
- D 10

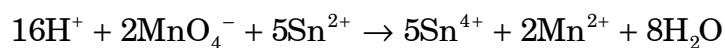
13. In a titration experiment, if 30.0 mL of an HCl solution reacts with 24.6 mL of a 0.50-M NaOH solution, what is the concentration of the HCl solution?

- A 0.41 M
- B 0.61 M
- C 1.5 M
- D 370 M



14. What is the oxidation number of the chromium atom in the  $\text{Cr}_2\text{O}_7^{2-}$  ion?
- A -6
- B -4
- C +4
- D +6
- 

15. Consider this oxidation-reduction reaction:



Which represents the oxidation half-reaction?

- A  $\text{Sn}^{4+} + 2\text{e}^- \rightarrow \text{Sn}^{2+}$
- B  $\text{Mn}^{6+} + 4\text{e}^- \rightarrow \text{Mn}^{2+}$
- C  $\text{Sn}^{2+} \rightarrow \text{Sn}^{4+} + 2\text{e}^-$
- D  $\text{Mn} \rightarrow \text{Mn}^{2+} + 2\text{e}^-$
- 

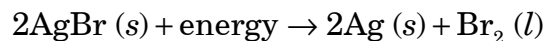
16. This balanced equation represents a chemical reaction:



Which substance undergoes reduction?

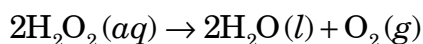
- A  $\text{Ag}^0$
- B  $\text{H}^+$
- C  $\text{N}^{5+}$
- D  $\text{O}^{2-}$
-

17. Consider this chemical equation:



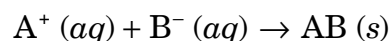
Which is true about the reaction?

- A Silver is reduced.
  - B Bromine is reduced.
  - C Silver loses electrons.
  - D Bromine gains electrons.
18. Consider this balanced chemical equation:



Which will increase the rate of the reaction?

19. For the reaction



increasing the temperature increases the rate of the reaction. Which is the **best** explanation for this happening?

- A The pressure increases, which in turn increases the production of products.
- B The concentration of reactants increases with an increase in temperature.
- C The average kinetic energy increases, so the likelihood of more effective collisions between ions increases.
- D Systems are more stable at high temperatures.

20. Which statement explains why the speed of some reactions is increased when the surface area of one or all the reactants is increased?
- A increasing surface area changes the electronegativity of the reactant particles
  - B increasing surface area changes the concentration of the reactant particles
  - C increasing surface area changes the conductivity of reactant particles
  - D increasing surface area enables more reactant particles to collide

### **End of Goal 5 Sample Items**

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## Chemistry Goal 5

### Sample Items Key Report

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- 1 Objective: 5.01**  
Evaluate various types of chemical reactions.  
a. Analyze reactions by types: Single replacement, double replacement (including acid-base neutralization), decomposition, synthesis, and combustion of simple  
b. predict products  
**Thinking Skill:** Applying **Correct Answer:** D
- 2 Objective: 5.01**  
Evaluate various types of chemical reactions.  
a. Analyze reactions by types: Single replacement, double replacement (including acid-base neutralization), decomposition, synthesis, and combustion of simple  
b. predict products  
**Thinking Skill:** Analyzing **Correct Answer:** A
- 3 Objective: 5.01**  
Evaluate various types of chemical reactions.  
a. Analyze reactions by types: Single replacement, double replacement (including acid-base neutralization), decomposition, synthesis, and combustion of simple  
b. predict products  
**Thinking Skill:** Analyzing **Correct Answer:** D
- 4 Objective: 5.01**  
Evaluate various types of chemical reactions.  
a. Analyze reactions by types: Single replacement, double replacement (including acid-base neutralization), decomposition, synthesis, and combustion of simple  
b. predict products  
**Thinking Skill:** Analyzing **Correct Answer:** D
- 5 Objective: 5.02**  
Apply the law of conservation of matter to the balancing of chemical equations.  
**Thinking Skill:** Applying **Correct Answer:** B
- 6 Objective: 5.02**  
Apply the law of conservation of matter to the balancing of chemical equations.  
**Thinking Skill:** Analyzing **Correct Answer:** B
- 7 Objective: 5.02**  
Apply the law of conservation of matter to the balancing of chemical equations.  
**Thinking Skill:** Analyzing **Correct Answer:** D
- 8 Objective: 5.03**  
Identify the indicators of chemical change:
-

## Chemistry Goal 5

### Sample Items Key Report

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- a. Formation of a
- b. Evolution of a
- c. Color
- d. Absorption or release of heat.

**Thinking Skill:** Applying

**Correct Answer:** A

**9 Objective: 5.04**

Identify the physical and chemical behaviors of acids and bases.

- a. General properties of acids and
- b. Ionization and the degree of dissociation (strengths) of acids and bases.
- c. Indicators, acid-base titration, and/or ionization and the degree of dissociation (strengths) of acids and
- d. Concentration and dilution of acids and bases, and/or pH and
- e. Acid-base
- f. pH and pOH.

**Thinking Skill:** Analyzing

**Correct Answer:** C

**10 Objective: 5.04**

Identify the physical and chemical behaviors of acids and bases.

- a. General properties of acids and
- b. Ionization and the degree of dissociation (strengths) of acids and bases.
- c. Indicators, acid-base titration, and/or ionization and the degree of dissociation (strengths) of acids and
- d. Concentration and dilution of acids and bases, and/or pH and
- e. Acid-base
- f. pH and pOH.

**Thinking Skill:** Knowledge

**Correct Answer:** A

**11 Objective: 5.04**

Identify the physical and chemical behaviors of acids and bases.

- a. General properties of acids and
- b. Ionization and the degree of dissociation (strengths) of acids and bases.
- c. Indicators, acid-base titration, and/or ionization and the degree of dissociation (strengths) of acids and
- d. Concentration and dilution of acids and bases, and/or pH and
- e. Acid-base
- f. pH and pOH.

**Thinking Skill:** Applying

**Correct Answer:** A

**12 Objective: 5.04**

Identify the physical and chemical behaviors of acids and bases.

- a. General properties of acids and
- b. Ionization and the degree of dissociation (strengths) of acids and bases.
- c. Indicators, acid-base titration, and/or ionization and the degree of dissociation

## Chemistry Goal 5

### Sample Items Key Report

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(strengths) of acids and

d. Concentration and dilution of acids and bases, and/or pH and

e. Acid-base

f. pH and pOH.

**Thinking Skill:** Applying

**Correct Answer:** D

**13 Objective: 5.04**

Identify the physical and chemical behaviors of acids and bases.

a. General properties of acids and

b. Ionization and the degree of dissociation (strengths) of acids and bases.

c. Indicators, acid-base titration, and/or ionization and the degree of dissociation (strengths) of acids and

d. Concentration and dilution of acids and bases, and/or pH and

e. Acid-base

f. pH and pOH.

**Thinking Skill:** Applying

**Correct Answer:** A

**14 Objective: 5.05**

Analyze oxidation/reduction reactions with regard to the transfer of electrons.

a. Assign oxidation numbers to elements in REDOX reactions, and /or assess the practical applications of oxidation and reduction

b. Identify the elements oxidized and

c. Write simple half

d. Assess the practical applications of oxidation and reduction reactions.

**Thinking Skill:** Analyzing

**Correct Answer:** D

**15 Objective: 5.05**

Analyze oxidation/reduction reactions with regard to the transfer of electrons.

a. Assign oxidation numbers to elements in REDOX reactions, and /or assess the practical applications of oxidation and reduction

b. Identify the elements oxidized and

c. Write simple half

d. Assess the practical applications of oxidation and reduction reactions.

**Thinking Skill:** Analyzing

**Correct Answer:** C

**16 Objective: 5.05**

Analyze oxidation/reduction reactions with regard to the transfer of electrons.

a. Assign oxidation numbers to elements in REDOX reactions, and /or assess the practical applications of oxidation and reduction

b. Identify the elements oxidized and

c. Write simple half

d. Assess the practical applications of oxidation and reduction reactions.

**Thinking Skill:** Analyzing

**Correct Answer:** C

## Chemistry Goal 5

### Sample Items Key Report

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- 17 Objective: 5.05**  
Analyze oxidation/reduction reactions with regard to the transfer of electrons.  
a. Assign oxidation numbers to elements in REDOX reactions, and /or assess the practical applications of oxidation and reduction  
b. Identify the elements oxidized and  
c. Write simple half  
d. Assess the practical applications of oxidation and reduction reactions.  
**Thinking Skill:** Analyzing **Correct Answer:** A
- 18 Objective: 5.05**  
Analyze oxidation/reduction reactions with regard to the transfer of electrons.  
a. Assign oxidation numbers to elements in REDOX reactions, and /or assess the practical applications of oxidation and reduction  
b. Identify the elements oxidized and  
c. Write simple half  
d. Assess the practical applications of oxidation and reduction reactions.  
**Thinking Skill:** Analyzing **Correct Answer:** C
- 19 Objective: 5.06**  
Assess the factors that affect the rates of chemical reactions:  
a. The nature of the reactants.  
b. Temperature.  
c. Concentration.  
d. Surface Area  
e. Catalyst.  
**Thinking Skill:** Analyzing **Correct Answer:** C
- 20 Objective: 5.06**  
Assess the factors that affect the rates of chemical reactions:  
a. The nature of the reactants.  
b. Temperature.  
c. Concentration.  
d. Surface Area  
e. Catalyst.  
**Thinking Skill:** Analyzing **Correct Answer:** D