

High Honors Chemistry
Final Exam Information
2024-2025
Mr. Sachetta & Mrs. Kurzman

Final Exam Format: 70 multiple choice questions (1 point each). The 1st 20 questions are mandatory and cover the entire year. The remaining 50 come from 10 out of 13 topics of your choosing. Each topic has 5 MC questions.

Topics include:

- Atomic Structure
- Periodic Table
- Bonding
- Chemical Reactions
- Stoichiometry
- Particle Interactions
- Gases
- Solution Chemistry
- Acids & Bases
- Kinetics
- Equilibrium
- Thermodynamics
- Lab Procedures

The following questions are for you to practice as you prepare for the HH Chemistry final exam.

Matter

- _____ 1. An example of a physical property is
A. reacts with acid B. luster C. neutralizes a base D. flammability
- _____ 2. Dissolving table salt (NaCl) in water is classified as a physical change because it
A. produces no new substances
B. transfers energy
C. releases heat
D. changes the properties of water
- _____ 3. The state of matter that has an indefinite shape and an indefinite volume is
A. gaseous state C. elemental state
B. liquid state D. solid state
- _____ 4. Which of the following is a diatomic element?
A. Helium B. Sulfur C. Astatine D. Hydrogen
- _____ 5. Block Q and Block Z have the same mass. Both blocks are placed into a container of pure water. Block Q floats in the water, and Block Z sinks to the bottom of the container. Which of the following statements is an accurate conclusion from this demonstration?

A. Block Z is heavier than Block Q.
B. Block Z is less dense than Block Q.
C. Block Z has a smaller volume than Block Q.
D. Block Z would float if more water were added.
- _____ 6. Pure substances include
A. elements and compounds C. elements only
B. compounds and mixtures. D. elements and mixtures
- _____ 7. Which of the following describes the separation of the components of a mixture?
A. Through electrolysis, water is split into oxygen and hydrogen
B. Butane reacts with oxygen to produce carbon dioxide and water
C. Sodium Chloride is isolated from saltwater through evaporation
D. Calcium carbonate decomposes to form calcium oxide and carbon dioxide
- _____ 8. Which of the following is NOT an example of matter?
A. air B. light C. plasma D. methane (CH₄)
- _____ 9. The substances that are chemically bound together are
A. the gases in the air
B. the elements that compose methane (CH₄)
C. dust particles in the air.
D. substances in blood

_____ 10. The table below shows the physical properties of selected metals.

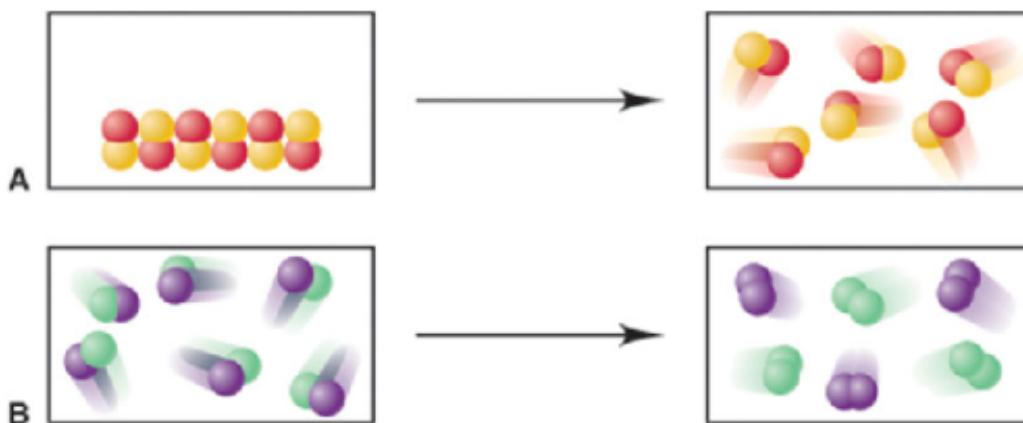
Physical Properties of Selected Metals

Metal	Molecular mass (amu)	Melting point (°C)	Boiling point (°C)	Density (g/cm³)
Bismuth	209.98	271	1560	9.80
Chromium	52.00	1857	2672	7.20
Polonium	210.05	254	962	9.40
Ruthenium	101.07	2310	3900	12.3

A cube of an unknown metal has a volume of 1.66 cm³ and a mass of 11.95 g. Based on data in the table above, what is the identity of this metal?

- A. bismuth B. chromium C. polonium D. ruthenium

For questions 11-15, use the following two choices:



_____ 11. Which show(s) a physical change?

_____ 12. Which show(s) a chemical change?

_____ 13. Which result(s) in different physical properties?

_____ 14. Which result(s) in different chemical properties?

_____ 15. Which result(s) in a change of state?

Atomic Structure

_____ 1. The atomic number of neon is 10. The atomic number for calcium is 20. Compared with a mole of neon, a mole of Calcium contains

- A. twice as many atoms
B. half as many atoms
C. an equal number of atoms
D. 20 times as many atoms

_____ 2. As the mass number of an isotope of an element increases, the number of protons

- A. increases
B. decreases
C. remains the same
D. doubles each time the mass number increase
E. not enough information is provided to answer this question.

_____ 3. Which of the following contains the most neutrons?

- A. Nitrogen – 14
B. Carbon – 14
C. Carbon – 12
D. Boron – 12
E. Oxygen – 15

_____ 4. In going from $1s^2 2s^2 2p^6 3s^2 3p^6 4s^1$ to $1s^2 2s^2 2p^6 3s^2 3p^4 4s^1$, an electron would

- A. absorb energy
B. emit energy
C. bind to another atom
D. undergo no change in energy

Use these answers for questions 5-10. Choices may be used once, more than once, or not at all.

- | | |
|----------------|----------|
| (A) Democritus | (D) |
| Rutherford | |
| (B) Dalton | (E) Bohr |
| (C) Thomson | (F) |
| Schrodinger | |

_____ 5. Developed the 1st Atomic Theory of Matter.

_____ 6. Discovered the electron.

_____ 7. Believed that all matter was composed of a smallest entity called 'atomos'.

_____ 8. Proposed that electrons have both wave and particle duality.

_____ 9. Developed the "plum pudding" model of the atom.

_____ 10. Proposed that electrons possess a certain amount of energy and must orbit the nucleus on shells.

Use these answers for questions 11 - 15. Answers may be used once, more than once, or not at all.

- (A) $1s^2 2s^2 2p^5 3s^2 3p^5$
(B) $1s^2 2s^2 2p^6 3s^2 3p^2$
(C) $1s^2 2s^2 2p^6 2d^{10} 3s^2 3p^6$
(D) $1s^2 2s^2 2p^6 3s^2 3p^4$
(E) $1s^2 2s^2 2p^6 3s^2 3p^6 4s^2 3d^3$

_____ 11. An impossible electronic configuration

_____ 12. Represents an atom that has four (4) valence electrons.

_____ 13. The ground-state configuration for the atoms of sulfur

_____ 14. Represents an atom in the excited state.

_____ 15. The ground-state configuration for the atoms of vanadium

Periodic Table

- _____ 1. The least reactive member of the alkali metals is
a. potassium b. rubidium c. cesium d. hydrogen
- _____ 2. According to Moseley, the chemical properties of elements are periodic functions of their
a. atomic size b. atomic weight c. atomic number d. isotopic weight
- _____ 3. The elements in which of the following have most nearly the same atomic radius?
(A) Be, B, C, N (B) Ne, Ar, Kr, Xe (C) Mg, Ca, Sr, Ba
(D) C, P, Se, I (E) Cr, Mn, Fe, Co
- _____ 4. Which of the following elements has characteristics of some metals and also of some nonmetals?
a. silicon (14 Si) b. calcium (20Ca) c. sulfur (16S) d. zinc (30Zn)
- _____ 5. Which of the following sections of the periodic table contains only metals?
a. period 2 b. p block c. s block d. group 2
- _____ 5. Which of the following is the same for both magnesium and strontium?
a. have similar valence electron configurations d. will react to form stable elements
b. have similar atomic radii e. have no similar chemical properties
c. have the same principal quantum number
- _____ 7. Which of the following section(s) of the periodic table contains the valence electrons?
a. s and d block b. p and d block c. s block d. s and p block
- _____ 8. An element whose ground state electron configuration ends with $s^2 p^4$ in the highest occupied energy level belongs to Group
a. 6 b. 8 c. 10 d. 16
- _____ 6. The figure below represents the periodic table and the location of four different elements on the periodic table.

[illegible]

A certain element has a ground state electron configuration of $1s^2 2s^2 2p^6 3s^2 3p^6$. Which letter in the diagram above represents the position of this element on the periodic table?

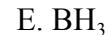
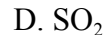
- a. W b. X c. Y d. Z

- _____ 7. Which of the following elements is the most electronegative?
(A) S (B) N (C) Ne (D) Mg (E) Na
- _____ 8. Which of the following elements has the largest atomic radius?
(A) S (B) N (C) Ne (D) Mg (E) Na
- _____ 9. Sulfur chemically resembles oxygen because they are in the same period.
a. True b. False
- _____ 10. The ionization energy generally increases as one moves from left to right across the periodic table because the effective nuclear charge increases as you move from left to right across the periodic table.
a. True b. False

Bonding

- _____ 1. Which of the following substances contains both ionic and covalent bonds?
A. CO₂ B. NH₃ C. NaNO₃ D. NaCl
- _____ 2. Which of the following properties is **not** associated with metallic bonds?
A malleability B brittleness C. ductility D. conductivity
- _____ 3. Two elements in a molecule have the same electronegativity values. Which of the following most likely holds the elements together and why?
A. an ionic bond, because electrons transfer from one element to the other
B. a nonpolar covalent bond, because the elements share electrons equally
C. a polar covalent bond, because the elements do not share electrons equally
D. an intermolecular force, because the elements do not form a chemical bond
- _____ 4. Carbon, oxygen and _____ have the possibility to form multiple covalent bonds
A. nitrogen B. iron
C. hydrogen D.
nickel E. copper
- _____ 5. Element X has an electron configuration of $1s^2 2s^2 2p^6 3s^2 3p^1$. Element X will most likely form oxides with the formula
A. X₂O B. X₂O₃ C. XO D. XO₂
- _____ 6. In which bond does the oxygen atom possess a partial positive charge?
A. O-H B. O-F C. N-O D. O-C
- _____ 12. Which of the following statements best explains why atoms bond?
A) Atoms bond to make new substances.
B) Atoms bond to become less chemically stable.
C) Atoms bond to change from a liquid to a solid.
D) Atoms bond to become more chemically stable.

The following choices are for Questions 7-10. Choices may be used once, more than once, or not at all.



_____ 7. Which molecule is polar?

_____ 8. Which molecule contains two double bonds?

_____ 9. Which molecule has two lone electron pairs?

_____ 10. Which molecule has polar bonds but is a nonpolar molecule?

_____ 11. Which of the following models **best** represents the shape of a compound with trigonal planar geometry?

A.

C.

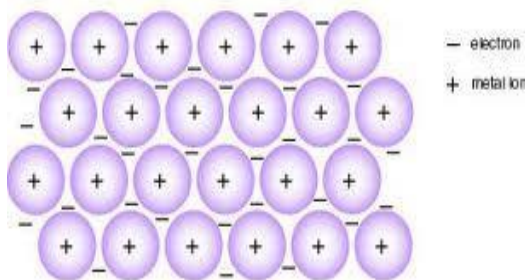
B.

D.

_____ 13. The effect of lone pairs on molecular geometry is

- A. to push other atoms closer together because lone pairs are localized on only one nucleus, so they spread out more.
- B. to allow the other atoms to be further apart because lone pairs take up less space than bonding pairs.
- C. to destabilize the molecule by creating a dipole.
- D. none, because they are just another pair of electrons.

_____ 14. The diagram below represents particles of one element.



What type of bond holds these particles together?

A) Covalent

B) Hydrogen

C) Ionic

D) Metallic

_____ 15. Palmitic acid, a component of most animal fats, has the molecular formula $\text{CH}_3(\text{CH}_2)_{14}\text{COOH}$. Which of the following is the empirical formula for palmitic acid?



Chem Rxns and Stoich

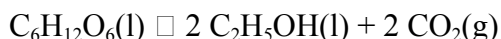
_____ 1. All of the following involve a chemical change EXCEPT

- (A) the odor of NH_3 when NH_4Cl is rubbed together with $\text{Ca}(\text{OH})_2$ powder
- (B) the formation of steam from burning H_2 and O_2
- (C) the formation of HCl from H_2 and Cl_2
- (D) the solidification of vegetable oil at low temperatures

_____ 2. When hydrocarbons burn, the products include carbon dioxide and

- (A) oxygen (B) dihydrogen monoxide (C) hydroxide (D) hydrogen

_____ 3. A balanced equation is shown below.



Which of the following statements correctly compares the mass of the reactant with the mass of the products in this equation?

- A. The mass of the reactant is half the mass of the products.
- B. The mass of the reactant is twice the mass of the products.
- C. The mass of the reactant is one-fourth the mass of the products.
- D. The mass of the reactant is the same as the mass of the products.

Questions 4–6 refer to the reactions represented below. Answer choices may be used once, more than once, or not at all. There is one answer per question.

- (A) $\text{H}_2\text{SeO}_4(\text{aq}) + 2 \text{Cl}^-(\text{aq}) + 2 \text{H}^+(\text{aq}) \rightarrow \text{H}_2\text{SeO}_3(\text{aq}) + \text{Cl}_2(\text{g}) + \text{H}_2\text{O}(\text{l})$
- (B) $\text{S}_8(\text{s}) + 8 \text{O}_2(\text{g}) \rightarrow 8 \text{SO}_2(\text{g})$
- (C) $3 \text{Br}_2(\text{aq}) + 6 \text{OH}^-(\text{aq}) \rightarrow 5 \text{Br}^-(\text{aq}) + \text{BrO}_3^-(\text{aq}) + 3 \text{H}_2\text{O}(\text{l})$
- (D) $\text{Ca}(\text{OH})_2(\text{aq}) + \text{Na}_2\text{SO}_4(\text{aq}) \rightarrow \text{CaSO}_4(\text{s}) + 2 \text{NaOH}(\text{aq})$

_____ 4. A precipitation reaction

_____ 5. A synthesis reaction

_____ 6. A combustion reaction

Particle Interactions & Gases

_____ 1. Which of the following is (are) the WEAKEST attractive force?

- A. hydrogen bonding C. polar covalent bonding
- B. covalent bonding D. ionic bonding

_____ 2. A sample of CCl_4 molecules experience

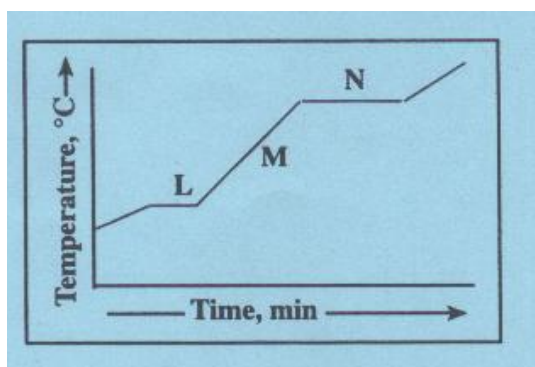
- A. hydrogen bonding C. London dispersion forces
- B. dipole-dipole forces D. Ionic bonds

_____ 3. Small drops of water tend to bead up because of

- A. high capillary action
- B. the shape of the meniscus
- C. the resistance to increased surface area
- D. low London dispersion forces

4. The properties of solids vary with their bonding. An example of this is shown by
- A. ionic solids with strong electrostatic attractions called ionic bonds, which have high melting temperatures
 - B. molecular solids with high intermolecular forces which have high melting temperatures
 - C. ionic solids with highly mobile ions which have high conductance
 - D. amorphous solids with strong London dispersion forces and high vapor pressure

5. Which of the labeled intervals represent an increase in kinetic energy?



- A. L only
- B. M only
- C. L and N only
- D. M and N only

6. The normal boiling point of water is

- A. 373 K.
- B. 173 K.
- C. 273 K.
- D. 473 K.

7. Which temperature represents absolute zero?

- A. 0 K
- B. 0 °C
- C. 273 K
- D. 273 °C

8. Which of the following best describes exothermic reactions?

- A. They always release heat.
- B. They always occur spontaneously.
- C. They never release heat.
- D. They never occur spontaneously.

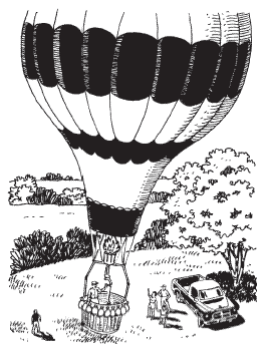
9. Which of the following substances is made of particles with the highest average kinetic energy?

- A. Fe (s) at 35 °C.
- B. Br₂ (l) at 20 °C
- C. H₂O (l) at 30° C
- D. CO₂ (g) at 25 °C

10. Which of the following characteristics of gases allows for scuba-diving tanks to contain large amounts of oxygen?

- A. Effusion
- B. Diffusion
- C. Fluidity
- D. Compressibility
- E. Expansion

11. The illustration shows a hot air balloon. The pilot can change the altitude of the balloon by changing the temperature of the gas inside the balloon. When the gas is heated, the balloon rises.



Which of the following best explains this phenomenon? Heating the gas ...

- A. reduces its pressure.
- B. decreases its density.
- C. decreases its molecular motion.
- D. reduces the frequency of the gas molecules' collisions.

_____ 12. Which of the following will definitely cause the volume of a gas to increase?

- I. decreasing the pressure with the temperature held constant
- II. increasing the pressure with a temperature decrease
- III. increasing the temperature with a pressure increase

- A. I only
- B. II only
- C. I and III only
- D. II and III only
- E. I, II, and III

_____ 13. Which of the following correctly describes molecules of two different gases if they are at the same temperature and pressure?

- A. They must have the same mass.
- B. They must have the same velocity.
- C. They must have the same average kinetic energy.
- D. They must have the same average potential energy.

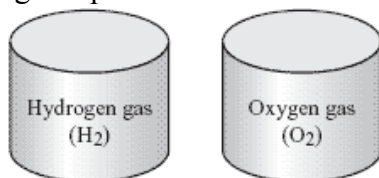
_____ 14. All of the following statements underlie the kinetic molecular theory of gases EXCEPT:

- A. Gas molecules have no intermolecular forces.
- B. Gas particles are in random motion.
- C. The collisions between gas particles are elastic.
- D. Gas particles have negligible volume.
- E. The average kinetic energy directly depends on the volume of the gas.

_____ 15. If the pressure of a gas sample is doubled at constant temperature, the volume will be

- A. 4 times the original
- B. 2 times the original
- C. 1/2 of the original
- D. 1/4 of the original
- E. 1/8 of the original

_____ 16. The two samples of gas represented below have the same volume, temperature, and pressure.



Based on this information, these two samples of gas must also have the same

- A. Chemical reactivity.
- B. Density.
- C. Mass.
- D. Number of molecules.

- _____ 17. Which of the following gases behaves most like an ideal gas at STP?
A. C_3H_8 B. NH_3 C. Ne D. HCl

Solution Chemistry

- _____ 1. When an ionic salt dissolves in water, the solute-solvent interaction is
A. hydrogen bonding C. London forces
B. ion-ion forces D. ion-dipole forces
- _____ 2. Which solute would dissolve in carbon tetrachloride, CCl_4 ?
A. SrF_2 (strontium fluoride) B. CH_3OH (methanol)
C. CH_2O (formaldehyde) D. NaCl (sodium chloride)
- _____ 3. A small amount of copper is added to silver to form sterling silver. This is
A. a chemical reaction because the metal atoms bond with each other.
B. a solution formation, with copper as the solvent and silver as the solute.
C. a solution formation, with silver as the solvent and copper as the solute.
D. a chemical reaction because the metals will exchange electrons.
- _____ 4. A mug of hot chocolate (hot chocolate mix and water) has a powdery residue on the bottom of the mug after being thoroughly mixed. The hot chocolate solution is most likely
A. saturated B. unsaturated C. supersaturated D. none of the above
- _____ 5. The table below gives information about four aqueous solutions of sodium nitrate ($NaNO_3$).

Beaker	Concentration of $NaNO_3$ (%)	Temperature ($^{\circ}C$)
1	20	0
2	20	40
3	2	80
4	2	100

- In which beaker will an additional 10 g of sodium nitrate ($NaNO_3$) dissolve at the slowest rate?
A. 1 B. 2 C. 3 D. 4

- _____ 6. Which of the following will be electrically conductive?
I. Salt dissolved in water
II. Pure water
III. Pure solid salt
A. I only B. III only C. I and II only D. I and III only E. I, II, and III

- _____ 7. Calcium hydroxide, $Ca(OH)_2$, is used as a soil conditioner in home gardens. When mixed with water, it releases hydroxide ions. Which of the following is the most likely pH for a solution of calcium hydroxide and water?
A. 1 B. 3 C. 7 D. 10

_____ 8. The table below shows pH values of some foods.

pH Values of Some Important Foods

Vegetables	pH	Citrus	pH	Dairy/Egg	pH	Starches	pH
Asparagus	5.6	Grapefruit	3.2	Butter	6.2	Bread (white)	5.5
Beans	5.5	Lemons	2.3	Cheese	5.6	Corn	6.2
Peas	6.1	Limes	1.9	Eggs (fresh)	7.8	Crackers	7.5
Spinach	5.4	Oranges	3.5	Milk	6.5	Potatoes	5.8

A patient has chronic indigestion due to an overproduction of stomach acid. Which foods should the patient avoid until the condition is resolved?

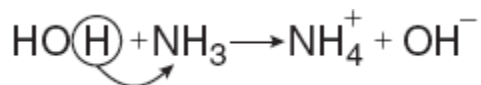
- A. vegetables B. citrus C. dairy/egg D. starches

_____ 9. Which of the following salts will hydrolyze in water to form basic solutions?

- I. NaCl
II. CuSO₄
III. K₃PO₄

- A. I only B. III only C. I and II only D. II and III only E. I, II, and III

_____ 10. A chemical equation representing the reaction of water (HOH) and ammonia (NH₃) is shown below.



Which of the following statements best explains the chemical action of the reactants in the equation?

- A. Both water and ammonia are acting as acids.
B. Both water and ammonia are acting as bases.
C. Water is acting as an acid, and ammonia is acting as a base.
D. Water is acting as a base, and ammonia is acting as an acid.

_____ 11. How does a Bronsted-Lowry acid differ from its conjugate base?

- A. The acid has one more proton C. The acid has one less proton
B. The acid has one more electron D. The acid has one less electron

_____ 12. Which of the following substances has the highest concentration of hydrogen ions in solution?

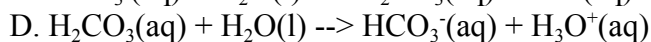
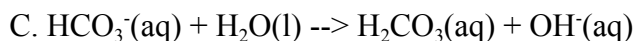
- A. bleach - pH 13 B. water - pH 7 C. tomato juice - pH 4 D. vinegar - pH 3

_____ 13. A buffer comprised of a weak acid and its conjugate base can maintain pH upon addition of small amounts of a strong base because

- A. small amounts of base do not drastically alter an aqueous solution's pH
B. the strong base is balanced by conjugate base of the buffer
C. the weak acid of the buffer reacts with the strong base to make more conjugate base
D. the strong base has a different pH than the buffer

_____ 14. The formula for carbonic acid is H₂CO₃, and the formula for hydrogen carbonate is HCO₃⁻. Together they form a buffer that is found in blood. Which of the following reactions represents what happens when excess base enters the bloodstream?

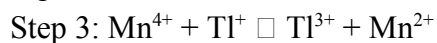
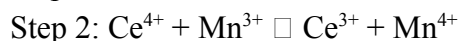
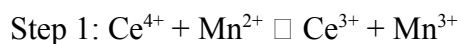
- A. HCO₃⁻(aq) + H₃O⁺(aq) → H₂CO₃(aq) + H₂O(l)
B. H₂CO₃(aq) + OH⁻(aq) → HCO₃⁻(aq) + H₂O(l)



Kinetics, Equilibrium, Thermodynamics

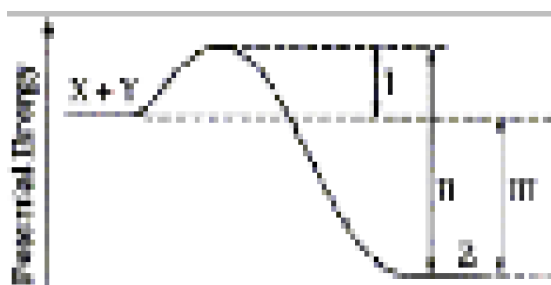
_____ 1. Which of the following best describes the role of the spark from the spark plug in an automobile engine?

- (A) The spark decreases the energy of activation for the slow step.
- (B) The spark increases the concentration of the volatile reactant.
- (C) The spark supplies some of the energy of activation for the combustion reaction.
- (D) The spark provides a more favorable activated complex for the combustion reaction.
- (E) The spark provides the heat of vaporization for the volatile hydrocarbon.



_____ 2. The proposed steps for a catalyzed reaction between Ce^{4+} and Ti^{+} are represented above. The products of the overall catalyzed reaction are

- (A) Ce^{4+} and Tl^+ (B) Ce^{3+} and Tl^{3+}
(C) Ce^{3+} and Mn^{3+} (D) Ce^{3+} and Mn^{4+}
(E) Tl^{3+} and Mn^{2+}

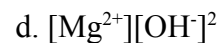
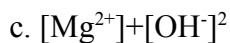
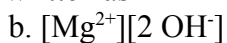
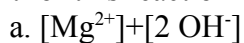


_____ 3. The energy diagram for the reaction $X + Y \rightarrow Z$ is shown above. The addition of a catalyst to this reaction would cause a change in which of the indicated energy differences?

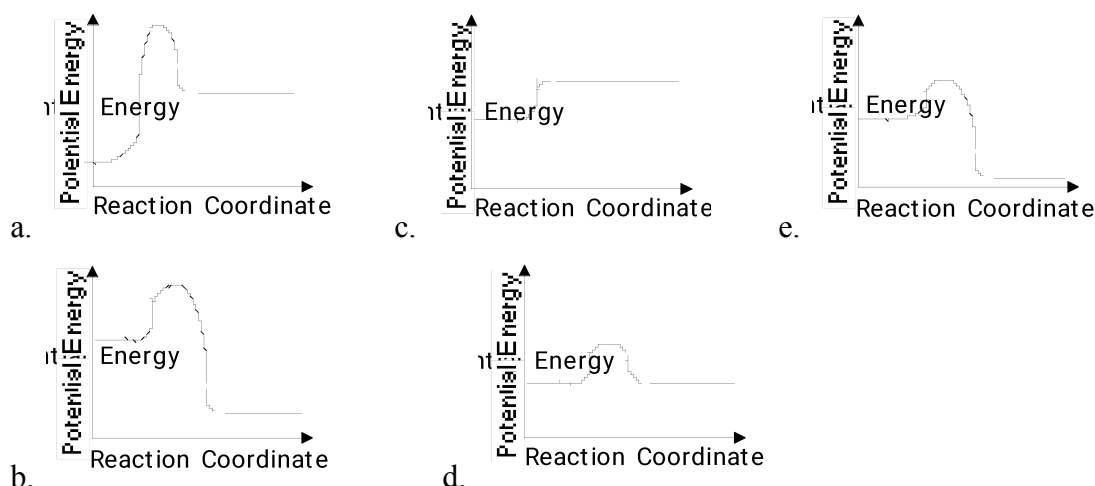
- (A) I only
(B) II only
(C) III only
(D) I and II only
(E) I, II, and III

_____ 4. Given the reaction at equilibrium: $\text{Mg}(\text{OH})_2 (\text{s}) \rightleftharpoons \text{Mg}^{2+} (\text{aq}) + 2 \text{OH}^- (\text{aq})$ The equilibrium constant for this reaction is correctly written as

- a. $[\text{Mg}^{2+}] + [2 \text{ OH}^-]$ b. $[\text{Mg}^{2+}][2 \text{ OH}^-]$ c. $[\text{Mg}^{2+}] + [\text{OH}^-]^2$ d. $[\text{Mg}^{2+}][\text{OH}^-]^2$



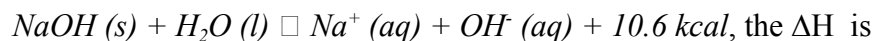
5. Which of the following is a graph that describes the pathway of reaction that is endothermic and has high activation energy?



6. Which change represents an increase in the entropy of a system?

- a. $\text{C}_6\text{H}_{12}\text{O}_6 (\text{s}) \rightarrow \text{C}_6\text{H}_{12}\text{O}_6 (\text{aq})$ c. $\text{CO}_2 (\text{g}) \rightarrow \text{CO}_2 (\text{s})$
 b. $\text{H}_2\text{O} (\text{l}) \rightarrow \text{H}_2\text{O} (\text{s})$ d. $\text{C}_2\text{H}_5\text{OH} (\text{g}) \rightarrow \text{C}_2\text{H}_5\text{OH} (\text{l})$

7. Given the reaction at 1 atm and 298 K:



- a. Negative and the reaction is spontaneous c. Positive and the reaction is spontaneous
 b. Negative and the reaction is not spontaneous d. Positive and the reaction is not spontaneous

8. When stirred in 30°C water, 5 g of powdered potassium bromide, KBr, dissolves faster than 5 g of large crystals of potassium bromide. Which of the following best explains why the powdered KBr dissolves faster?

- a. Powdered KBr exposes more surface area to water molecules than large crystals of KBr.
 b. Potassium & bromide ions in the powder are smaller than they are in the large crystal
 c. Fewer potassium & bromide ions have been separated from each other in the powder than in the crystals
 d. Powdered KBr is less dense than large crystals of KBr

Open Response Questions

Matter

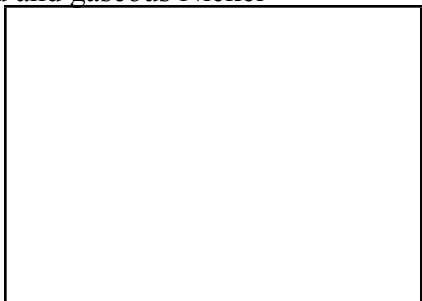
16. Mixture lab question: Let's pretend that I completed the mixture lab three times (three different samples). The first time my percentage of salt was 22%, the second it was 55%, and the third it was 56%. Assume no mistakes, and any errors affected the data in the same way for the three experiments. Why were my values different? (2pts) _____

17: Evidence of chemical changes: What are the 4 indications of chemical reactions? (5 pts)

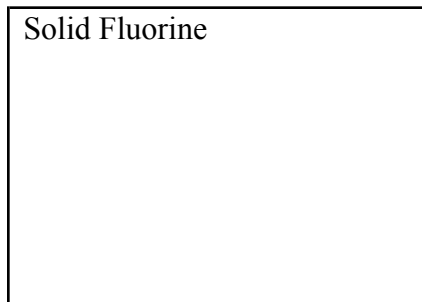
1. _____
2. _____
3. _____
4. _____

18. Draw the following samples of matter on a microscopic scale. Use different shapes when appropriate. (2pts each)

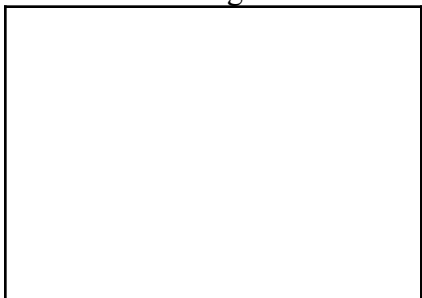
Liquid and gaseous Nickel



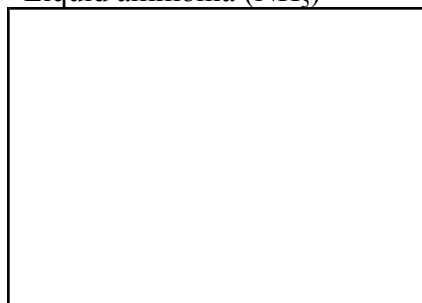
Solid Fluorine



Solid water and gaseous Helium



Liquid ammonia (NH₃)



19a. A flask has a mass of 78.23 g when empty and 593.63 g when filled with water. When the same flask is filled with concentrated sulfuric acid, H₂SO₄, its mass is 1026.57 g. What is the density of concentrated sulfuric acid? (Assume water has a density of 1.00 g/cm³ at the temperature of the measurement.) Show all work for any calculated values.

19b. Alcohol has a density of 0.80 g/mL.

Will sulfuric acid from (19a) float or sink in alcohol? _____

Will sulfuric acid from (19a) float or sink in water? _____

26. Suppose that you are the new owner of the Buccaneers Recycling Factory and you are looking for business.

An official from the city of Bedford, Mr. Taylor, tells you that they have a dump truck full of recycled materials that must be separated, and they will pay you \$5,000 if you can do it. Unfortunately, the job is made more difficult by the fact that someone has ground all of the materials into a fine powder, making it impossible to separate them by hand.

Fortunately, Mr. Taylor knows what the materials in the truck are, as well as their densities:

Material	Density (g/cm ³)
Aluminum Soda cans	2.7
Steel cans	5.7
Plastic Milk jugs	0.95
Glass Soda bottles	1.4

In your factory, you have the following materials at your disposal:

- A long conveyor belt
- A large tank that can be filled with water (density 1.0 g/ml)
- Another large tank labeled “Concentrated sugar water, density = 1.5 g/cm³”
- Several powerful magnets hanging above the conveyor belt (FYI Aluminum cans are not magnetic)
- Several nets for skimming the tanks and scooping material from the bottoms.

What property of each component will allow you to separate it from the mixture?

Aluminum Soda cans	
Steel cans	
Plastic Milk jugs	
Glass Soda bottles	

Which component should be separated first? _____

Write a **brief** outline (step 1, step 2, etc) that describes how you will separate the Glass Soda bottles from the rest of the mixture. Explain why your method would work.

Atomic Structure

16. What were the 2 major breakthroughs in the understanding of an atom based on Rutherford's Gold Foil Experiment results? Include proper vocabulary words. (3 points) _____

17. Write the appropriate electron configuration notation as indicated for each particle.

A) Exponential notation, orbital notation, and dot notation for silicon (4pts)

B) Exponential notation for Silver. (2pts)

18. Complete the following chart. (9 pts)

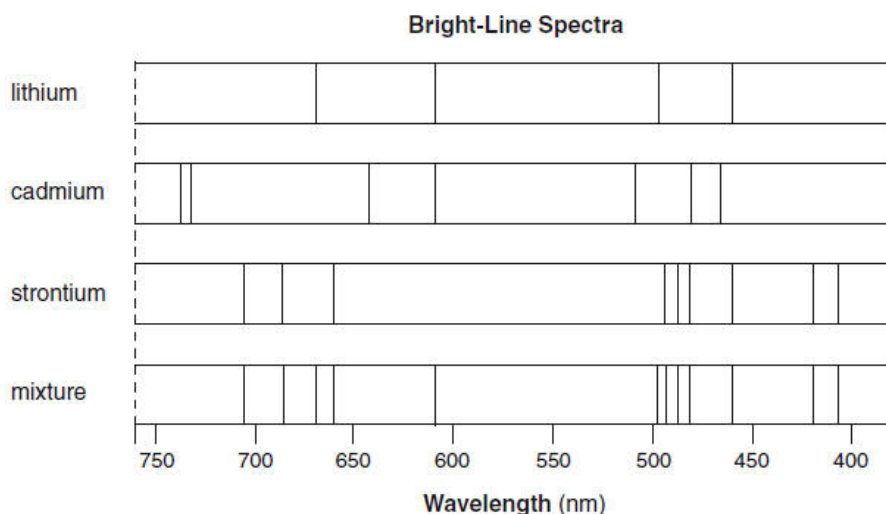
Particle	Atomic Number	Mass Number	Charge	Atom or Cation or Anion	# protons	# neutrons	# electrons	Exponential Electron Configuration
$^{44}\text{Ca}^{2+}$								

19. What is the mass of 1.55 moles of CaCO_3 ? (5 pts)

20. How many particles are contained in 46 g of fluorine? (6 pts)

21. Magnesium consists of three naturally occurring isotopes. The percent abundance of these isotopes is as follows: ^{24}Mg (78.70%), ^{25}Mg (10.13%), and ^{26}Mg (11.70%). The average atomic mass of the three isotopes is 24.3050 amu. If the atomic mass of ^{25}Mg is 24.98584 amu, and ^{26}Mg is 25.98259 amu, calculate the actual atomic mass of ^{24}Mg . Express your answer to 5 decimal places (5pts)

22. An element is found to emit a photon with energy of 3.13×10^{-19} J. Using the chart below, determine the identity of the element. Justify your answer using words and calculations. (6 pts)



Periodic Table

Directions: Write either the name or symbol of the element described in each statement on the line provided. (2 points each)

- _____ 9. Which nonmetal is a liquid at room temperature?
- _____ 10. What is the period 5 noble gas?
- _____ 11. What is the nonmetal element found in Group 14?
- _____ 12. What is the lightest alkali metal?
- _____ 13. What is the period 2 metalloid?

Directions: For #17 & 18, write the noble gas electron configuration. (5 pt, total)

17. Gold

18. Gallium

14. Use **principles of atomic structure** to answer each of the following.

a. The radius of the Ca atom is 0.197 nm; the radius of the Ca^{2+} ion is 0.099 nm. Explain why this is so based on the structure of the atom and a comparison of the data. (3 points)

	Ionization Energy (kJ/mol)	
	First	Second
K	419	3,052
Rb	403	2,633

b. Explain the difference between K and Rb in comparing their first ionization energies: (4 points)

c. Explain why there's such a drastic difference between the 1st and 2nd ionization energies of K. (4 points)

16. 12 pts total

	First Ionization Energy (kJ mol ⁻¹)	Second Ionization Energy (kJ mol ⁻¹)	Third Ionization Energy (kJ mol ⁻¹)
Element 1	1,251	2,300	3,820
Element 2	496	4,560	6,910
Element 3	738	1,450	7,730
Element 4	1,000	2,250	3,360

The table above shows the first three ionization energies for atoms of four elements from the third period of the periodic table. The elements are numbered randomly. Use the information in the table to answer the following questions.

(a) Which element is most metallic in character? Explain your reasoning. (3 points)

(b) Identify element 3. Explain your reasoning. (3 points)

(c) Write the noble gas electron configuration for an atom of element 3. (2 points)

(e) What is the chemical symbol for element 2? (1 point) _____

(f) A neutral atom of which of the four elements has the smallest radius? Why? (3 points)

BONUS: (not part of extra time allotment) The 1st ionization of Potassium is 419 kJ/mol. What minimum frequency of electromagnetic energy would be required to remove an electron from a single atom? (2 pts)

Bonding

Directions: For each of the chemical formulas listed below write the correct name. Each answer is worth 1 point.

16. CO_3 _____

17. Li_3AsO_4 _____

18. S_2P_5 _____

19. $\text{Mn}(\text{OH})_3$ _____

20. WSO_3 _____

Directions: For each of the compounds listed below write its chemical formula. Each answer is worth 1 point.

21. Silver nitride _____

22. Iron (III) hypochlorite _____

23. Triphosphorus hexabromide _____

24. Aluminum peroxide _____

25. Magnesium iodate _____

Directions: Complete the following chart. If you feel that a box doesn't warrant information, indicate by putting an "X" in the box. A blank box indicates that you do not know, and it will be marked incorrect. (16 points total)

Particle or Molecule	*Bond Type	Lewis Dot Structure	Molecular Geometry (Sketch and name)	Polarity of Molecule
26. MgCl_2				
27. CH_2O				

28. NH ₄ Cl				

(*Bond type: Ionic, non-polar covalent, polar covalent, both)

Directions: Answer the following word problems. BE SURE TO SHOW ALL WORK. NO WORK = NO CREDIT. Report your answers with the correct number of significant figures and use units.

29. The compound ethylene glycol is often used as antifreeze. It contains 38.7% carbon, 9.75% hydrogen, and the rest oxygen. The molecular mass of ethylene glycol is 62.07 g. Find the empirical and the molecular formula of ethylene glycol. (8 points)

30. What mass of Carbon can be extracted from 75.0 g of CO₂? (7 points)

33. A lab experiment was performed to determine the empirical formula of a hydrate of Na₂SO₄·XH₂O.

Mass of hydrated salt:	203.01 g
Mass of anhydrous salt after heating:	89.49 g

A. Determine the formula of the hydrate. (7 points)

B. Name the hydrate (1pts) _____

34. A 3.0 g sample of $\text{Cu}(\text{NO}_3)_2 \cdot 3\text{H}_2\text{O}$ was heated to constant mass. (8pts)

A. What is left in the evaporation dish when constant mass is reached? _____

B. What is the expected mass of the remaining substance after constant mass is established?

Chemical Reactions & Stoichiometry

Directions: Complete the word equation. Then, write the complete, balanced, chemical equation for each reaction below. Include states of matter with all reactants and products. If the reaction does not occur, write, "No reaction." Determine the reaction type for each reaction. If more than one type of reaction occurs, indicate all types.

7. Iron(II) chloride combines with potassium phosphate to produce _____

Reaction Type _____

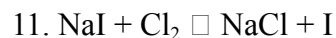
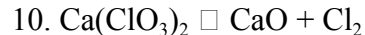
8. Chlorine gas reacts with a solution of magnesium bromide to produce _____

Reaction Type _____

9. Aluminum hydroxide decomposes with the addition of heat and produces _____

Reaction Type _____

Directions: The following reactions (#10 & #11) are incorrect. Rewrite a corrected balanced equation. No states of matter are required. (5pts)

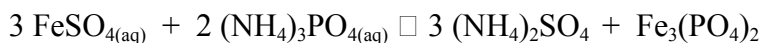


Directions: For #12 & 13 identify the missing reactant & state of matter. Then, balance the reaction (6 pts)



Directions: Answer the following questions in the spaces provided. Remember to show all your work to earn full credit. Include units and the correct number of significant figures with all answers.

14. 45.3 g of iron (II) sulfate (molar mass = 151.92g/mol) reacts with 30.7g of ammonium phosphate (molar mass = 149.12g/mol) as shown by the following balanced reaction.



A) List an appropriate observation made during the experiment that provides visual evidence of the chemical reaction.

B) Calculate the theoretical yield of the precipitate.

C) How many grams of the excess reactant remains at the conclusion of the reaction?

Particle Interactions & Gases

1. Using your knowledge of chemistry, explain why the boiling points of these three compounds between hydrogen and group 16 elements vary. (3 points)

Compound	Boiling Point
H ₂ O	100.0 °C
H ₂ S	-60.2 °C
H ₂ Se	-42.25 °C

2. Calculate the amount of heat, in calories, needed to bring 2.3 g of ice mixed with 42 g of water from 0°C to 84°C. (11 pts)

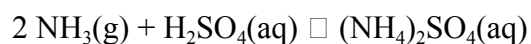
3. Which diatomic element (give its name) has a density of 7.13 g/L at STP? (6pts)

4. Rank the following gases from fastest (1) to slowest (5) molecular velocity at 300K. How many times faster is the fastest gas compared to the slowest gas? Remember to show all your work. (7 points)

_____CO₂ _____O₂ _____HF _____F₂ _____SCl₆

5. Taylor collected a sample of He and Ar via water displacement at 20. °C. The partial pressure of water vapor at 20. °C is 17.3 torr. If Taylor collected 2.2 moles of Ar and 3.3 moles of He, and the total pressure of the sample was 444 torr, what was the partial pressure of the Ar gas collected? (5 points)

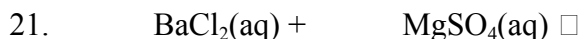
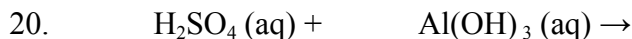
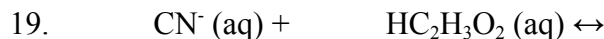
7. Ammonium sulfate, an important fertilizer, can be prepared by the reaction of ammonia with sulfuric acid according to the following balanced equation:



Calculate the volume of NH₃ (in liters) needed at 20°C and 25.0 atm to react with 150 g of H₂SO₄. (9pts)

Solution Chemistry

Directions: Complete and balance the following reactions. Include states of matter and write your final answer as a net ionic equation.



Directions: Name or write the formulas for the following acids. (1 pt. each)

22. HBr _____

24. Hydroiodic acid _____

23. H_2SO_4 _____

25. Acetic acid _____

26. In the space below, draw a picture of KBr dissolving in H_2O . (6 points)

Before dissolution:

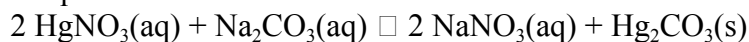
After dissolution:

Directions: Answer the following questions in the spaces provided. Show all your work to earn full credit. Report your answers with correct units and the correct number of significant figures.

27. To what volume, in milliliters, must 50.0 milliliters of 3.50 M H_2SO_4 be diluted in order to make 2.00 M H_2SO_4 ? (4 points)

28. What is the molarity of a solution that contains 5.85 g of potassium chloride (KCl) in 0.50 L of solution? (5 points)

29. Consider the balanced equation:



If 0.25 L of a 6.0 M mercury(I) nitrate solution reacts with excess sodium carbonate, what mass of mercury(I) carbonate will be produced? (7 points)

30. Determine the pH and pOH of 2.4×10^{-2} M HNO_3 . What color would this solution turn blue litmus paper? (4 pts)

31. Ocean water has a pH of 8.2. Determine the $[\text{H}_3\text{O}^+]$ and $[\text{OH}^-]$ of the water. What color would this solution turn blue litmus paper? (4 pts)

32. If 0.730 g of gaseous hydrogen monochloride is dissolved to make 2.0 liters of solution, determine the pH of the solution. (5 pts)

33. If you mix 3.33 liters of 0.500 M NaCl with 9.00 liters of 0.2777M NaCl what will the concentration of the final solution be, assuming the volumes are additive? (7 points)

Kinetics, Equilibrium, Thermodynamics

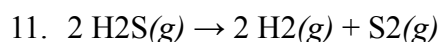
9. Given the reaction: $\text{N}_2(\text{g}) + \text{O}_2(\text{g}) + 43.2 \text{ kcal} \rightleftharpoons 2 \text{ NO}(\text{g})$, what is the heat of formation of nitrogen monoxide gas in kcal/mol? _____

10. Complete the following chart (using arrows to indicate directions) based on the reaction:



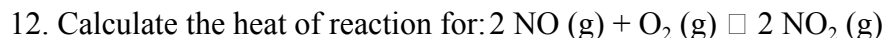
Stress	Equil. Shift	[HCl]	[O ₂]	[H ₂ O]	[Cl ₂]
Add HCl(g)		-----			
Decrease T					
Add catalyst					
Decrease P					

Calculation Directions: Perform the following calculations in the spaces provided. Show all work for partial credit.



When heated, hydrogen sulfide gas decomposes according to the equation above. A 3.40 g sample of $\text{H}_2\text{S}(\text{g})$ is introduced into an evacuated rigid 1.25 L container. The sealed container is heated to 483 K, and 3.72×10^{-2} mol of $\text{S}_2(\text{g})$ is present at equilibrium.

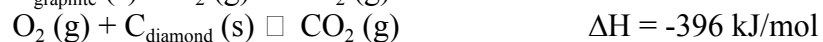
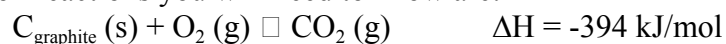
Calculate the value of the equilibrium constant, K_{eq} , for the decomposition reaction at 483 K. Is the forward or reverse reaction favored?



13. Carbon occurs in two distinct forms. It can be the soft, black material found in pencils, called graphite, or it can be the hard, brilliant gem we know as diamond. Calculate the ΔH for the conversion of graphite to diamond for the following reaction:



The combustion reactions you will need to know are:



14. Calculate the heat of reaction for $\text{C}_2\text{H}_4 + \text{HBr} \rightarrow \text{CH}_3\text{CH}_2\text{Br}$

Bond	Energy		Bond	Energy		Bond	Energy
C=C	611kJ/mol		C-H	410kJ/mol		C-Br	270 kJ/mol
C-C	350kJ/mol		H-Br	366 kJ/mol			

15. The ΔS for the reaction shown at 298 K is 0.00300 kJ/mol*K. Calculate the standard free energy for this reaction & determine whether it will occur spontaneously at 298 K.

