

# Michael Farabaugh's Practice Quizzes by Unit

This past year (2018-2019), I've used @[Michael Farabaugh's YouTube Practice Quizzes](#) in my class, but I've re-organized them to match the units in the order that I teach them. With Michael's permission, I am sharing these with you. I print these for my students & also post the PDF on our LMS (Learning Management System, such as the Google classroom stream) **for students to access the links found within the PDFs for them to self-monitor their work and answers.** There are link icons found **within** each PDF that are linked to Michael's YouTube video & timed to start right where those problems begin. His practice quizzes are amazing, **especially paired with his explanation** - useful is an understatement for my students [& me!] to work through these prior to a unit exam. My students will sometimes do their work on their own paper because I don't offer them much space for the FRQs.

How I use these: I first assign them during a current unit. If you would like the PDFs as individual files by unit, see the Facebook post linked [here](#). I am going to also offer them to students as targeted review prior to **The Exam**. During our review time in class, we'll review whole class weak areas, but on their own time, students can use these practice quizzes to practice their own weak areas.

The units below are **linked** to the page in this file where that unit begins. You can also sort through these files via the **bookmark icon** () found on the left.

|                                                                             |                                                                                     |                                                                           |                                                                                |                                                                          |
|-----------------------------------------------------------------------------|-------------------------------------------------------------------------------------|---------------------------------------------------------------------------|--------------------------------------------------------------------------------|--------------------------------------------------------------------------|
| <b>Unit 1</b><br>Mole, Naming,<br>Stoichiometry,<br>Formulas<br>(Pages 2-4) | <b>Unit 2</b><br>Equations,<br>Molarity, Solution<br>Stoichiometry<br>(Pages . 5-7) | <b>Unit 3</b><br>Thermochemistry<br>&<br>Thermodynamics<br>(Pages . 8-11) | <b>Unit 4</b><br>Kinetics<br>(Pages . 12-14)                                   | <b>Unit 5</b><br>General<br>Equilibrium &<br>$K_{sp}$<br>(Pages . 15-16) |
| <b>Unit 5.5</b><br>Gases & Gas<br>Equilibrium<br>(Pages . 17-20)            | <b>Unit 6</b><br>Acid-Base<br>Equilibrium<br>(Pages 21-24)                          | <b>Unit 7</b><br>Electrochemistry<br>(Pages 25-29)                        | <b>Unit 8</b><br>Atomic Structure,<br>Periodicity,<br>Bonding<br>(Pages 30-35) | <b>Unit 9</b><br>IMFs & Solid<br>Bonding<br>(Pages 36-43)                |



1. Which of the following processes requires a chemical change?

(A) Separating a sample of saltwater into water and salt  
 (B) Separating a sample of water into hydrogen and oxygen  
 (C) Separating a sample of air into nitrogen, oxygen, and other gases  
 (D) Separating a sample of green ink into a blue component and a yellow component

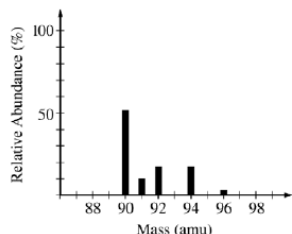
Skip #2

3. How many protons, neutrons, and electrons are present in the following ion?
- $^{56}\text{Fe}^{3+}$

|     | Protons | Neutrons | Electrons |
|-----|---------|----------|-----------|
| (A) | 26      | 30       | 23        |
| (B) | 26      | 26       | 29        |
| (C) | 26      | 30       | 29        |
| (D) | 26      | 56       | 23        |

4. Which of the following calculations is set up correctly to determine the volume (in mL) of aluminum (density = 2.7 g/mL) of a pure sample of Al that contains
- $2.0 \times 10^{24}$
- atoms?

(A)  $\frac{(2.0 \times 10^{24})(26.98)(2.7)}{(6.02 \times 10^{23})}$  (C)  $\frac{(2.0 \times 10^{24})(2.7)}{(6.02 \times 10^{23})(26.98)}$   
 (B)  $\frac{(2.0 \times 10^{24})}{(6.02 \times 10^{23})(26.98)(2.7)}$  (D)  $\frac{(2.0 \times 10^{24})(26.98)}{(6.02 \times 10^{23})(2.7)}$



5. The mass spectrum of element X is presented in the diagram above. Based on the spectrum, which of the following can be concluded about element X?

(A) X is a transition metal, and each peak represents an oxidation state of the metal.  
 (B) X contains five electron sublevels.  
 (C) The atomic mass of X is 90.  
 (D) The atomic mass of X is between 90 and 92.

| Compound | Empirical Formula | Mass of Carbon | Mass of Hydrogen |
|----------|-------------------|----------------|------------------|
| X        | CH                | 3.0 g          | 0.25 g           |
| Y        | ?                 | 6.0 g          | 1.0 g            |

6. Based on the information shown in the table above, the empirical formula for Compound Y is

(A)  $\text{C}_2\text{H}$   
 (B)  $\text{CH}_2$   
 (C)  $\text{CH}_3$   
 (D)  $\text{CH}_4$

7. The element boron has two naturally occurring isotopes:
- $^{10}\text{B}$
- and
- $^{11}\text{B}$
- . Which of the following represents the most probable data for the relative abundances of these two isotopes?

|     | Abundance of boron-10 | Abundance of boron-11 |
|-----|-----------------------|-----------------------|
| (A) | 20%                   | 80%                   |
| (B) | 40%                   | 60%                   |
| (C) | 50%                   | 50%                   |
| (D) | 80%                   | 20%                   |

8. What is the empirical formula of an oxide of chromium that is 48 percent oxygen by mass?

(A)  $\text{CrO}$   
 (B)  $\text{CrO}_2$   
 (C)  $\text{CrO}_3$   
 (D)  $\text{Cr}_2\text{O}_3$

|                                                |        |
|------------------------------------------------|--------|
| mass of crucible and lid                       | 36.0 g |
| mass of crucible, lid, and metal               | 41.0 g |
| mass of crucible, lid, and metal oxide product | 43.0 g |

9. A metallic element is heated in air until the metal reacts completely with oxygen. Given the information in the table above, the most probable formula for the metal oxide product is

(A)  $\text{MgO}$   
 (B)  $\text{CaO}$   
 (C)  $\text{K}_2\text{O}$   
 (D)  $\text{SnO}_2$

10. According to the information in the table at right, a 1.00 g sample of which of the following contains the greatest mass of oxygen?

| Compound              | Molar Mass (grams) |
|-----------------------|--------------------|
| $\text{Na}_2\text{O}$ | 62.0               |
| $\text{MgO}$          | 40.3               |
| $\text{K}_2\text{O}$  | 94.2               |
| $\text{CaO}$          | 56.1               |

(A)  $\text{Na}_2\text{O}$   
 (B)  $\text{MgO}$   
 (C)  $\text{K}_2\text{O}$   
 (D)  $\text{CaO}$

11. The empirical formula of a compound is  $\text{XF}_4$ . This compound contains 1.6 grams of X atoms for every 3.8 grams of fluorine atoms. The atomic mass of element X is most likely to be

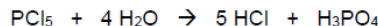
- (A) 16 amu
- (B) 32 amu
- (C) 64 amu
- (D) 128 amu

12. A sample of a compound that contains only the elements C, H, and N is completely burned in  $\text{O}_2$  to produce 44.0 g of  $\text{CO}_2$ , 45.0 g of  $\text{H}_2\text{O}$ , and some  $\text{NO}_2$ . A possible empirical formula of the compound is

- (A)  $\text{CH}_2\text{N}$
- (B)  $\text{CH}_5\text{N}$
- (C)  $\text{C}_2\text{H}_5\text{N}$
- (D)  $\text{C}_3\text{H}_3\text{N}_2$

13. A sample of solid potassium chlorate ( $\text{KClO}_3$ , FW = 122.6) was placed in a test tube and heated strongly in the presence of a catalyst until it completely decomposed. The products of the decomposition reaction are potassium chloride and oxygen gas (which escaped from the test tube). If the mass of  $\text{KClO}_3$  used in the experiment was 12.26 g, how many grams of oxygen gas were produced in this experiment?

- (A) 2.4 g
- (B) 3.2 g
- (C) 4.8 g
- (D) 6.4 g



14. In the reaction represented above, how many molecules of  $\text{PCl}_5$  are required to react completely with 18 grams of water?

- (A)  $1.5 \times 10^{23}$
- (B)  $3.0 \times 10^{23}$
- (C)  $6.0 \times 10^{23}$
- (D)  $2.4 \times 10^{24}$

15. Equal masses of  $\text{K(s)}$  and  $\text{Cl}_2(\text{g})$  are combined together and allowed to react, producing  $\text{KCl(s)}$ . The reaction proceeds until either one or both of the reactants have been completely consumed. At that point, what remains in the reaction vessel?

- (A)  $\text{KCl}$  only
- (B)  $\text{KCl}$  and  $\text{K}$  only
- (C)  $\text{KCl}$  and  $\text{Cl}_2$  only
- (D)  $\text{KCl}$ ,  $\text{K}$ , and  $\text{Cl}_2$

16. What is the limiting reactant and the theoretical yield of ammonia when 3.0 g of  $\text{H}_2$  reacts with 7.0 g of  $\text{N}_2$ ?

|     | Limiting Reactant | Theoretical Yield of $\text{NH}_3$ |
|-----|-------------------|------------------------------------|
| (A) | hydrogen          | 8.5 g                              |
| (B) | hydrogen          | 10. g                              |
| (C) | nitrogen          | 8.5 g                              |
| (D) | nitrogen          | 10. g                              |

#### CHAPTERS 1–3 PRACTICE TEST

 ←Linked at 24:13

#### FREE RESPONSE (CALCULATOR IS ALLOWED)

1. Fill in the table with the missing information. Each nuclear symbol should contain the mass number and the charge.

| Nuclear Symbol         | Charge | Protons | Neutrons | Electrons |
|------------------------|--------|---------|----------|-----------|
| $^{115}\text{In}^{3+}$ |        |         |          |           |
| $^{32}\text{P}^{3-}$   |        |         |          |           |
|                        |        | 35      | 45       | 36        |
|                        |        | 56      | 81       | 54        |

2. For each name, write the correct formula. Indicate if the substance is ionic or covalent.

| Chemical Formula | Name                 | Ionic (I) or Covalent (C)? |
|------------------|----------------------|----------------------------|
|                  | cobalt(II) carbonate |                            |
|                  | barium chlorate      |                            |
|                  | dinitrogen trioxide  |                            |
|                  | ammonium phosphate   |                            |
|                  | sulfur tetrafluoride |                            |

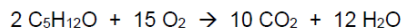
3. For each formula, write the correct name. Indicate if the substance is ionic or covalent.

| Chemical Formula                              | Name | Ionic (I) or Covalent (C)? |
|-----------------------------------------------|------|----------------------------|
| $\text{Cl}_2\text{O}_7$                       |      |                            |
| $\text{Mg}(\text{NO}_3)_2$                    |      |                            |
| $\text{K}_2\text{S}$                          |      |                            |
| $\text{PBr}_5$                                |      |                            |
| $\text{Cu}(\text{C}_2\text{H}_3\text{O}_2)_2$ |      |                            |

4. A chemist needs to determine the empirical formula of an unknown compound. This compound contains the elements C, H, N, and O.

A sample of the unknown compound with a mass of 3.8625 g was burned in excess oxygen. The reaction produced 6.8618 g of  $\text{CO}_2(g)$  and 1.7557 g of  $\text{H}_2\text{O}(g)$ .

- (a) Determine the mass, in grams, of carbon in the 3.8625 g sample of the compound.
- (b) Determine the mass, in grams, of hydrogen in the 3.8625 g sample of the compound.
- (c) When the compound is analyzed for nitrogen content only, the mass percent of nitrogen is found to be 14.14 percent. Determine the mass, in grams, of nitrogen in the 3.8625 g sample of the compound.
- (d) Determine the mass, in grams, of oxygen in the 3.8625 g sample of the compound.
- (e) Determine the empirical formula of the compound.
- (f) In another experiment, it was determined that a 8.65-g sample of this compound contained  $1.75 \times 10^{22}$  molecules. Calculate the molar mass of this compound.
- (g) Determine the molecular formula of this compound. Justify your answer.



5. Liquid pentanol undergoes complete combustion in the presence of oxygen gas according to the equation above. In a certain experiment, 7.35 mL of pentanol (density =  $0.814 \text{ g mL}^{-1}$ ) is added to 16.0 L of oxygen gas at  $150^\circ\text{C}$ . (density of  $\text{O}_2$  @  $150^\circ\text{C}$  =  $0.922 \text{ g L}^{-1}$ ).

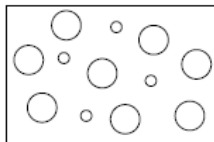
- (a) Calculate the following quantities.
- (i) moles of pentanol
- (ii) moles of oxygen gas
- (b) Identify the limiting reactant in this experiment. Justify your answer.
- (c) Calculate the theoretical yield of carbon dioxide (in grams) that could be produced from this experiment.
- (d) If the mass of carbon dioxide recovered from this experiment is 11.0 g, calculate the percent yield from this experiment.

6. In a laboratory experiment, a student obtained a sample of barium hydroxide hydrate. The number of water molecules in the hydrate formula was unknown. The formula for this compound can be written as  $\text{Ba}(\text{OH})_2 \cdot x\text{H}_2\text{O}$ , where  $x$  indicates the number of moles of water per mole of  $\text{Ba}(\text{OH})_2$ .

A sample of this hydrate was heated strongly in a crucible, in order to drive off the water of hydration. The anhydrous  $\text{Ba}(\text{OH})_2$  salt was then treated with excess sodium sulfate solution. This resulted in the formation of a white precipitate, barium sulfate. The precipitate was filtered from the solution, dried and weighed. The data table below indicates measurements recorded in this experiment.

|                                                                                        |          |
|----------------------------------------------------------------------------------------|----------|
| Mass of clean, dry crucible                                                            | 61.857 g |
| Mass of crucible + $\text{Ba}(\text{OH})_2 \cdot x\text{H}_2\text{O}$ (before heating) | 66.081 g |
| Mass of white precipitate, $\text{BaSO}_4$                                             | 3.126 g  |

- (a) Calculate the mass of the hydrate sample  $\text{Ba}(\text{OH})_2 \cdot x\text{H}_2\text{O}$  (before heating).
- (b) Write a balanced chemical equation for the reaction between barium hydroxide and sodium sulfate.
- (c) The mass of the white precipitate was 3.126 g. Calculate the number of moles of this precipitate.
- (d) Calculate the mass of the anhydrous salt,  $\text{Ba}(\text{OH})_2$ .
- (e) Calculate the mass of water that was lost in the heating process.
- (f) Calculate the value of  $x$  for the sample of  $\text{Ba}(\text{OH})_2 \cdot x\text{H}_2\text{O}$ .



1. The particle diagram above represents an aqueous solution of an ionic compound. The smaller circles represent cations and the larger circles represent anions. Water molecules are omitted for clarity. Which of the following solutes does the diagram best represent?

- (A) calcium chloride  
(B) magnesium oxide  
(C) potassium bromide  
(D) sodium sulfide

2. Which of the following choices best represents what happens when solid  $\text{NH}_4\text{NO}_3$  is dissolved into water?

- (A)  $\text{NH}_4\text{NO}_3(s) \longrightarrow \text{NH}_4\text{NO}_3(aq)$   
(B)  $\text{NH}_4\text{NO}_3(s) \longrightarrow \text{NH}_4^+(aq) + \text{NO}_3^-(aq)$   
(C)  $\text{NH}_4\text{NO}_3(s) \longrightarrow \text{NH}_3(aq) + \text{H}^+(aq) + \text{NO}_3^-(aq)$   
(D)  $\text{NH}_4\text{NO}_3(s) \longrightarrow \text{NH}_3(aq) + \text{OH}^-(aq) + \text{NO}_2^-(aq)$

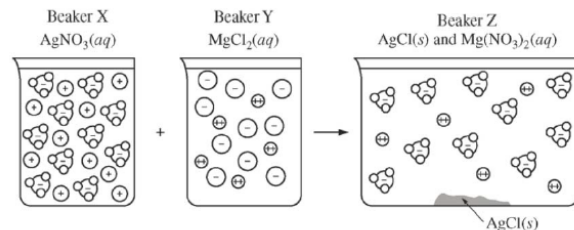
| Reaction between a solution of Compound X and a solution of $\text{K}_2\text{SO}_4$ | Reaction between a solution of Compound X and a solution of $\text{AgNO}_3$ |
|-------------------------------------------------------------------------------------|-----------------------------------------------------------------------------|
| white precipitate                                                                   | white precipitate                                                           |

3. Compound X is an ionic compound that is soluble in water. An aqueous solution of Compound X is prepared, and a few drops of this solution are tested with two separate solutions. The results of this experiment are shown in the table above. Based on this information, which of the following substances is most likely to represent the identity of Compound X?

- (A) barium chloride  
(B) sodium bromide  
(C) lead carbonate  
(D) strontium nitrate

4. Which of the following would result in the formation of a precipitate when aqueous solutions of each substance are mixed together?

- (A) mercury(I) nitrate and silver acetate  
(B) zinc chloride and aluminum sulfate  
(C) potassium sulfide and lithium phosphate  
(D) sodium iodide and lead(II) nitrate



5. Beaker X and beaker Y each contain 1.0 L of solution, as shown above. A student combines the solutions by pouring them into a larger, previously empty beaker Z and observes the formation of a white precipitate. Assuming that volumes are additive, which of the following sets of solutions could be represented by the diagram above?

|     | Beaker X              | Beaker Y              | Beaker Z                                               |
|-----|-----------------------|-----------------------|--------------------------------------------------------|
| (A) | 2.0 M $\text{AgNO}_3$ | 2.0 M $\text{MgCl}_2$ | 4.0 M $\text{Mg}(\text{NO}_3)_2$ and $\text{AgCl}(s)$  |
| (B) | 2.0 M $\text{AgNO}_3$ | 2.0 M $\text{MgCl}_2$ | 2.0 M $\text{Mg}(\text{NO}_3)_2$ and $\text{AgCl}(s)$  |
| (C) | 2.0 M $\text{AgNO}_3$ | 1.0 M $\text{MgCl}_2$ | 1.0 M $\text{Mg}(\text{NO}_3)_2$ and $\text{AgCl}(s)$  |
| (D) | 2.0 M $\text{AgNO}_3$ | 1.0 M $\text{MgCl}_2$ | 0.50 M $\text{Mg}(\text{NO}_3)_2$ and $\text{AgCl}(s)$ |

Skip #6-8

9. Which of the following represents the net-ionic equation for the reaction that occurs when solutions of acetic acid and potassium hydroxide are mixed?

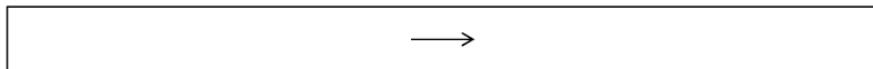
- (A)  $\text{H}^+(aq) + \text{OH}^-(aq) \longrightarrow \text{H}_2\text{O}(l)$   
(B)  $\text{H}^+(aq) + \text{KOH}(aq) \longrightarrow \text{H}_2\text{O}(l) + \text{K}^+(aq)$   
(C)  $\text{CH}_3\text{COOH}(aq) + \text{OH}^-(aq) \longrightarrow \text{H}_2\text{O}(l) + \text{CH}_3\text{COO}^-(aq)$   
(D)  $\text{CH}_3\text{COOH}(aq) + \text{KOH}(aq) \longrightarrow \text{H}_2\text{O}(l) + \text{CH}_3\text{COOK}(aq)$



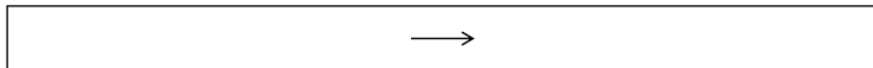
3. For each of the following, write the balanced molecular equation and the balanced net ionic equation. You do not have to write (s), (l), (g) or (aq). If no reaction occurs, write NO REACTION.

(a) Solutions of nickel(II) bromide and barium hydroxide are mixed.

molecular equation:

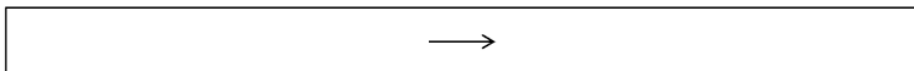


net ionic equation:

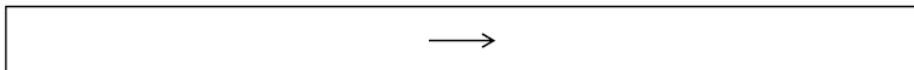


(b) Solutions of copper(II) chloride and ammonium sulfate are mixed.

molecular equation:

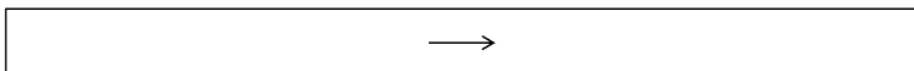


net ionic equation:

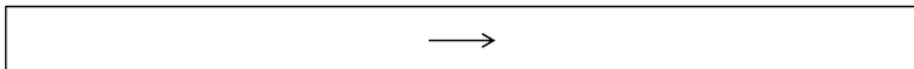


(c) Solutions of propanoic acid ( $\text{CH}_3\text{CH}_2\text{COOH}$ ) and sodium hydroxide are mixed.

molecular equation:

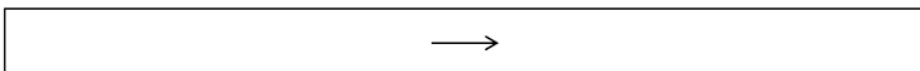


net ionic equation:

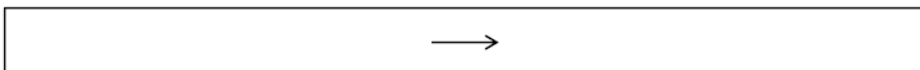


(d) Solutions of nitric acid and methylamine ( $\text{CH}_3\text{NH}_2$ ) are mixed.

molecular equation:



net ionic equation:

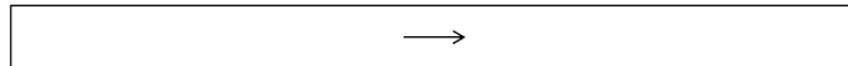


| Soluble Ionic Compounds |                                                  | Important Exceptions                                                                         |
|-------------------------|--------------------------------------------------|----------------------------------------------------------------------------------------------|
| Compounds containing    | $\text{NO}_3^-$ and $\text{CH}_3\text{CO}_2^-$   | none                                                                                         |
|                         | $\text{Cl}^-$ , $\text{Br}^-$ , and $\text{I}^-$ | compounds of $\text{Ag}^+$ , $\text{Hg}_2^{2+}$ , and $\text{Pb}^{2+}$                       |
|                         | $\text{SO}_4^{2-}$                               | compounds of $\text{Sr}^{2+}$ , $\text{Ba}^{2+}$ , $\text{Hg}_2^{2+}$ , and $\text{Pb}^{2+}$ |

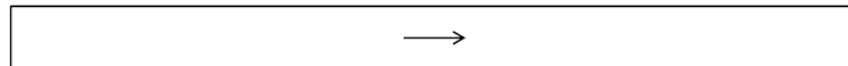
| Insoluble Ionic Compounds |                                           | Important Exceptions                                                                                            |
|---------------------------|-------------------------------------------|-----------------------------------------------------------------------------------------------------------------|
| Compounds containing      | $\text{S}^{2-}$ and $\text{OH}^-$         | compounds of $\text{NH}_4^+$ , alkali metal cations, $\text{Ca}^{2+}$ , $\text{Sr}^{2+}$ , and $\text{Ba}^{2+}$ |
|                           | $\text{CO}_3^{2-}$ and $\text{PO}_4^{3-}$ | compounds of $\text{NH}_4^+$ and alkali metal cations                                                           |

(e) Aluminum metal is added to a solution of zinc sulfate.

molecular equation:



net ionic equation:



1. A solution is prepared by combining 100.0 mL of 0.20 *M* Na<sub>2</sub>SO<sub>4</sub> with 100.0 mL of 0.50 *M* K<sub>2</sub>SO<sub>4</sub>. Which of the following choices has correctly arranged the ions in this solution in order of increasing concentration?

|     | lowest<br>concentration       | →                             | highest<br>concentration      |
|-----|-------------------------------|-------------------------------|-------------------------------|
| (A) | SO <sub>4</sub> <sup>2-</sup> | Na <sup>+</sup>               | K <sup>+</sup>                |
| (B) | Na <sup>+</sup>               | SO <sub>4</sub> <sup>2-</sup> | K <sup>+</sup>                |
| (C) | Na <sup>+</sup>               | K <sup>+</sup>                | SO <sub>4</sub> <sup>2-</sup> |
| (D) | K <sup>+</sup>                | Na <sup>+</sup>               | SO <sub>4</sub> <sup>2-</sup> |

2. A solution was prepared by dissolving 11 grams of anhydrous calcium chloride (F.W. = 110.98) into water so that the total volume is 500. mL. What is the concentration of chloride ions in this solution?

(A) 0.10 *M*  
 (B) 0.20 *M*  
 (C) 0.30 *M*  
 (D) 0.40 *M*

3. How many grams of glucose (F.W. = 180.156) are present in 500. mL of a 0.50 *M* glucose solution?

(A) 0.25 g  
 (B) 45 g  
 (C) 90. g  
 (D) 180 g

4. In order to prepare 250.0 mL of a hydrochloric acid solution that has a concentration of 0.10 *M*, how many milliliters of 10.0 *M* hydrochloric acid are needed?

(A) 0.25 mL  
 (B) 2.5 mL  
 (C) 4.0 mL  
 (D) 25 mL

5. What is the minimum volume of 2.0 *M* HNO<sub>3</sub> required to neutralize 0.50 mole of Ca(OH)<sub>2</sub> ?

(A) 200 mL  
 (B) 250 mL  
 (C) 500 mL  
 (D) 1000 mL

Skip #6

7. When Solutions #1 and #2 are combined together, silver chloride is produced. Which of the following choices would produce the greatest mass of silver chloride?

|     | Solution #1                                | Solution #2                                |
|-----|--------------------------------------------|--------------------------------------------|
| (A) | 100. mL of 0.10 <i>M</i> AgNO <sub>3</sub> | 100. mL of 0.10 <i>M</i> NaCl              |
| (B) | 100. mL of 0.10 <i>M</i> AgNO <sub>3</sub> | 100. mL of 0.20 <i>M</i> CaCl <sub>2</sub> |
| (C) | 100. mL of 0.20 <i>M</i> AgNO <sub>3</sub> | 100. mL of 0.10 <i>M</i> CaCl <sub>2</sub> |
| (D) | 100. mL of 0.30 <i>M</i> AgNO <sub>3</sub> | 100. mL of 0.10 <i>M</i> NaCl              |

8. A student was given the task of determining the mass percentage of iodide (I<sup>-</sup>) in a potassium iodide (KI) tablet. A tablet with a mass of 0.500 g was dissolved in water and treated with excess Pb(NO<sub>3</sub>)<sub>2</sub>(aq). This resulted in the formation of a yellow precipitate of PbI<sub>2</sub>(s) which was filtered, dried, and weighed. The mass of the precipitate was 0.200 g. Which of the following calculations is set up correctly to determine the mass percentage of iodide in the KI tablet?

(A)  $\frac{(0.200)(126.9)}{(461.0)(0.500)} \times 100\%$   
 (B)  $\frac{(0.200)(126.9)}{(461.0)(2)(0.500)} \times 100\%$   
 (C)  $\frac{(0.200)(2)(126.9)}{(461.0)(0.500)} \times 100\%$   
 (D)  $\frac{(0.200)(126.9)(0.500)}{(461.0)} \times 100\%$



1. A chemistry teacher needs to prepare a silver nitrate solution for a lab experiment.

(a) Calculate the mass of solid silver nitrate that is needed to prepare 500.0 mL of a 0.110 *M* silver nitrate solution. Show the setup for your calculations below. Round off your final answer to the proper number of significant figures.

(b) The experiment to be performed is based on the following chemical equation.



(i) Write a balanced molecular equation for the reaction shown above.

→

(ii) Write a balanced net-ionic equation for the reaction shown above.

→

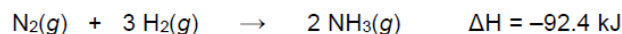
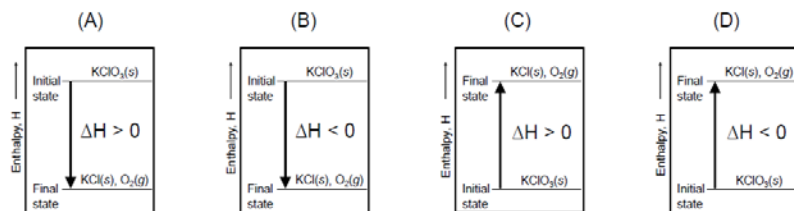
(c) In the experiment, a 1.50 g sample of zinc metal was combined with 250. mL of 0.110 *M* silver nitrate solution.

(i) Identify the limiting reactant in this experiment, and show calculations to justify your answer.

(ii) On the basis of the limiting reactant identified in part (c)(i), determine the concentration of Zn<sup>2+</sup> ions in the solution after the reaction is complete. Assume that the final volume of the solution remains unchanged.

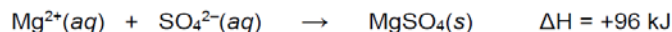


13. When solid potassium chlorate is heated in the presence of a catalyst, potassium chloride and oxygen gas are formed. Which of the following potential energy diagrams best illustrates this chemical reaction, including the change in enthalpy,  $\Delta H$ ?



14. The synthesis of ammonia is illustrated by the thermochemical equation shown above. Which of the following calculations is set up correctly to determine the mass of ammonia produced when 875 J of heat is released in this reaction?

- (A)  $\frac{(875)(92.4)(17.034)}{(1000)(2)}$  (C)  $\frac{(875)(1000)(92.4)(17.034)}{(2)}$   
 (B)  $\frac{(875)(2)(17.034)}{(1000)(92.4)}$  (D)  $\frac{(875)(1000)(2)(17.034)}{(92.4)}$



16. Use the information given in the thermochemical equation shown above to help you choose the best answer to the following question. What will happen when solid  $\text{MgSO}_4$  is dissolved completely in water at  $25^\circ\text{C}$ ?

- (A) Heat will be absorbed by the system and the temperature of the water will increase.  
 (B) Heat will be released by the system and the temperature of the water will increase.  
 (C) Heat will be absorbed by the system and the temperature of the water will decrease.  
 (D) Heat will be released by the system and the temperature of the water will decrease.



2. A chemistry teacher needs to prepare a hydrochloric acid solution for a lab experiment.

- (a) Calculate the volume of 6.0 M hydrochloric acid solution that is needed to prepare 500. mL of a 0.10 M hydrochloric acid solution. Show the setup for your calculations below. Round off your final answer to the proper number of significant figures.

- (b) The experiment that was performed in the lab involved the addition of 50. mL of 0.10 M hydrochloric acid to 50. mL of 0.10 M sodium hydroxide. The temperature of the solution increased immediately after the two solutions were combined.

- (i) The reaction between hydrochloric acid and sodium hydroxide should be classified as

(    endothermic    exothermic    ) because heat was (    absorbed    released    )

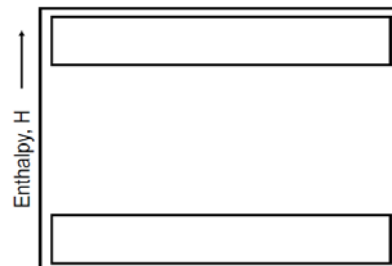
by the system. The thermometer in this experiment is considered to be part of the

(    system    surroundings    ).

- (ii) It was determined that 279 J of heat was associated with the chemicals that reacted in this experiment. Calculate the value of  $\Delta H$  (in units of kJ/mol<sub>rxn</sub>) for the reaction that occurred in this experiment. Show the setup for your calculations below. Round off your final answer to the proper number of significant figures. The sign of  $\Delta H$  should be consistent with your answer to (b)(i).

- (c) Fill in the following missing information in the enthalpy diagram below.

- The chemical formulas of the reactants and the products, listed in the appropriate boxes, according to their relative enthalpy values
- An arrow indicating the direction of the reaction, from the reactants to the products



- (d) Suppose that this experiment had been carried out by adding 50. mL of 0.20 M hydrochloric acid to 50. mL of 0.20 M sodium hydroxide.

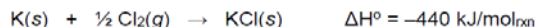
- (i) Would the magnitude of  $q$  for this experiment be less than, more than, or equal to 279 J? Justify your answer.

- (ii) Would the magnitude of  $\Delta H$  for this experiment be less than, more than, or equal to the magnitude of the  $\Delta H$  value calculated in (b)(ii)? Justify your answer.

1. In an insulated cup of negligible heat capacity, 50. g of water at 40.°C is mixed with 30. g of water at 20.°C. The final temperature of the mixture is closest to
- (A) 27°C  
(B) 30.°C  
(C) 33°C  
(D) 38°C

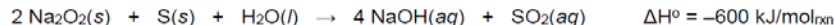
2. A 100 g sample of a metal was heated to 100°C and then quickly transferred to an insulated container holding 100 g of water at 22°C. The final temperature of the water (and the metal) was equal to 35°C. Which of the following can be concluded?

- (A) The metal temperature changed more than the water temperature did; therefore the amount of heat lost by the metal is greater than the amount of heat gained by the water.
- (B) The metal temperature changed more than the water temperature did, but the amount of heat lost by the metal is equal to the amount of heat gained by the water.
- (C) The metal temperature changed more than the water temperature did; therefore the specific heat of the metal is greater than the specific heat of the water.
- (D) The metal temperature changed more than the water temperature did, but the specific heat of the metal is equal to the specific heat of the water.



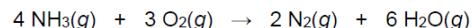
3. Based on the thermochemical equation shown above, how much heat is released or absorbed when 0.10 mol of  $\text{Cl}_2(g)$  is formed from  $\text{KCl}(s)$ ?

- (A) 44 kJ is released  
(B) 88 kJ is released  
(C) 44 kJ is absorbed  
(D) 88 kJ is absorbed



4. In a certain experiment, 7.8 g  $\text{Na}_2\text{O}_2(s)$  is mixed with 3.2 g  $\text{S}(s)$  along with excess water. Which of the following identifies the limiting reactant and the heat released, q, for this experiment?

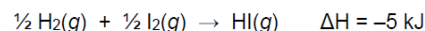
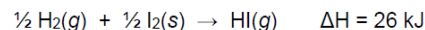
|     | Limiting Reactant       | q     |
|-----|-------------------------|-------|
| (A) | $\text{Na}_2\text{O}_2$ | 30 kJ |
| (B) | $\text{Na}_2\text{O}_2$ | 60 kJ |
| (C) | S                       | 30 kJ |
| (D) | S                       | 60 kJ |



| Substance               | $\Delta H_f^\circ$ |
|-------------------------|--------------------|
| $\text{NH}_3(g)$        | -50 kJ/mol         |
| $\text{H}_2\text{O}(g)$ | -240 kJ/mol        |

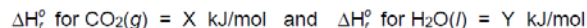
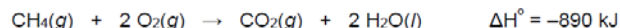
5. Based on the information in the table above, what is the value of  $\Delta H^\circ$  for the reaction represented above?

- (A) -1640 kJ  
(B) -1240 kJ  
(C) -290 kJ  
(D) -190 kJ



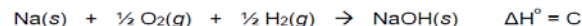
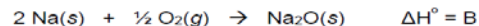
6. Based on the information above, what is the enthalpy change for the sublimation of iodine?

- (A) 21 kJ/mol  
(B) 31 kJ/mol  
(C) 42 kJ/mol  
(D) 62 kJ/mol

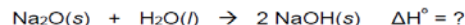


7. The value of  $\Delta H^\circ$  for the combustion of methane gas is equal to -890 kJ as shown above. The standard enthalpy of formation for  $\text{CO}_2(g)$  is equal to X kilojoules per mole. The standard enthalpy of formation for  $\text{H}_2\text{O}(l)$  is equal to Y kilojoules per mole. In terms of X and Y, the standard enthalpy of formation for methane gas is equal to

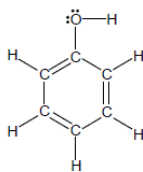
- (A)  $X + 2Y + 890$   
(B)  $X + 2Y - 890$   
(C)  $X + Y + 890$   
(D)  $X + Y - 890$



8. Based on the information above, what is the standard enthalpy change for the following reaction?



- (A)  $A + B - C$   
(B)  $A + B - 2C$   
(C)  $C - A - B$   
(D)  $2C - A - B$



1. The structural formula of phenol is shown above. Answer the following questions concerning phenol.

(a) Write a balanced chemical equation for the complete combustion of 1 mole of phenol.



(b) In a calorimetry experiment, 2.00 g of pure solid phenol is completely burned in a bomb calorimeter. The temperature of the calorimeter increased from 25.00°C to 33.62°C. The heat capacity of the calorimeter is 7.54 kJ/°C.

(i) Calculate the amount of heat (in units of kJ) that was released to the calorimeter during the combustion experiment. Show your work below in order to receive full credit.

(ii) Calculate the enthalpy change,  $\Delta H^\circ_{\text{comb}}$ , for the chemical equation you wrote in part (a) in units of kJ/mol<sub>rxn</sub>. Show your work below in order to receive full credit.

(c) Use your answer from (b)(ii) and the data in the table below to calculate the standard enthalpy of formation for phenol (in units of kJ/mol). Show your work below in order to receive full credit.

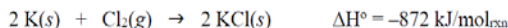
| Substance                      | Standard Enthalpy of Formation, $\Delta H^\circ_f$ (kJ/mol) |
|--------------------------------|-------------------------------------------------------------|
| $\text{CO}_2(\text{g})$        | -393.5                                                      |
| $\text{H}_2\text{O}(\text{l})$ | -285.8                                                      |
| phenol (s)                     | ?                                                           |



1. Which of the following reactions is not thermodynamically favored at low temperatures but becomes favored as the temperature increases?

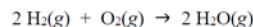
|     | Reaction                                                                                      | $\Delta H^\circ$ (kJ/mol <sub>rxn</sub> ) | $\Delta S^\circ$ (J/mol <sub>rxn</sub> ·K) |
|-----|-----------------------------------------------------------------------------------------------|-------------------------------------------|--------------------------------------------|
| (A) | $2 \text{ CO}(\text{g}) + \text{O}_2(\text{g}) \rightarrow 2 \text{ CO}_2(\text{g})$          | -566                                      | -173                                       |
| (B) | $2 \text{ H}_2\text{O}(\text{g}) \rightarrow 2 \text{ H}_2(\text{g}) + \text{O}_2(\text{g})$  | 484                                       | 90.0                                       |
| (C) | $2 \text{ N}_2\text{O}(\text{g}) \rightarrow 2 \text{ N}_2(\text{g}) + \text{O}_2(\text{g})$  | -164                                      | 149                                        |
| (D) | $\text{PbCl}_2(\text{s}) \rightarrow \text{Pb}^{2+}(\text{aq}) + 2 \text{ Cl}^{-}(\text{aq})$ | 23.4                                      | -12.5                                      |

Skip #2.



3. It is observed that the reaction shown above goes essentially to completion. Which of the following is a true statement about the thermodynamic favorability of the reaction?
- (A) The reaction is favorable and driven by an enthalpy change only.  
 (B) The reaction is favorable and driven by an entropy change only.  
 (C) The reaction is favorable and driven by both enthalpy and entropy changes.  
 (D) The reaction is unfavorable due to both enthalpy and entropy changes.
4. Which of the following processes involves the greatest increase in entropy?

- (A)  $\text{SO}_3(\text{g}) + \text{H}_2(\text{g}) \rightarrow \text{SO}_2(\text{g}) + \text{H}_2\text{O}(\text{g})$   
 (B)  $\text{N}_2(\text{g}) + 3 \text{ H}_2(\text{g}) \rightarrow 2 \text{ NH}_3(\text{g})$   
 (C)  $\text{C}_2\text{H}_2(\text{g}) + 2 \text{ H}_2(\text{g}) \rightarrow \text{C}_2\text{H}_6(\text{g})$   
 (D)  $\text{MgSO}_3(\text{s}) \rightarrow \text{MgO}(\text{s}) + \text{SO}_2(\text{g})$



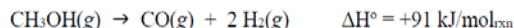
5. The reaction above is thermodynamically favorable at 25°C. What are the signs of  $\Delta H^\circ$ ,  $\Delta S^\circ$ , and  $\Delta G^\circ$ ?

|     | $\Delta H^\circ$ | $\Delta S^\circ$ | $\Delta G^\circ$ |
|-----|------------------|------------------|------------------|
| (A) | -                | +                | +                |
| (B) | +                | +                | +                |
| (C) | -                | -                | -                |
| (D) | +                | -                | -                |

Skip #6.

7. Under which of the following conditions will an exothermic reaction be thermodynamically favorable?
- (A) when  $\Delta G$  is positive  
 (B) when  $\Delta S$  is positive  
 (C) when  $\Delta S$  is negative and  $T > \frac{|\Delta H|}{|\Delta S|}$   
 (D) An exothermic reaction is thermodynamically favorable at all temperatures.
8. For which of the following processes does the value of  $\Delta S$  decrease ( $\Delta S < 0$ )?

- (A) Melting of glucose  
 (B) Evaporation of liquid bromine  
 (C) Precipitation of silver chloride  
 (D) Sublimation of carbon dioxide



9. The reaction represented above goes essentially to completion. What can be inferred about  $\Delta S^\circ$  for the reaction at 298 K?
- (A) It must be positive because the reaction is thermodynamically unfavorable at 298 K.  
 (B) It must be negative because there are more moles of products than reactants.  
 (C) It must be positive because  $\Delta G^\circ$  is negative and  $\Delta H^\circ$  is positive.  
 (D) It must be negative because  $\Delta G^\circ$  is positive and  $\Delta H^\circ$  is positive.
10. A certain reaction is thermodynamically favored at temperatures below 400. K, but it is not favored at temperatures above 400. K. The value of  $\Delta H^\circ$  for the reaction is  $-20 \text{ kJ/mol}$ . What is the value of  $\Delta S^\circ$  for the reaction? (Assume that  $\Delta H^\circ$  and  $\Delta S^\circ$  do not change with temperature.)

- (A)  $-50 \text{ J mol}^{-1} \text{ K}^{-1}$   
 (B)  $-20 \text{ J mol}^{-1} \text{ K}^{-1}$   
 (C)  $-0.050 \text{ J mol}^{-1} \text{ K}^{-1}$   
 (D)  $50 \text{ J mol}^{-1} \text{ K}^{-1}$



11. Which of the following is true for the process represented above at  $327^\circ\text{C}$  and 1 atm? The normal melting point of Pb is  $327^\circ\text{C}$ .

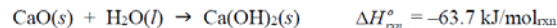
- (A)  $\Delta H = 0$   
 (B)  $T\Delta S = 0$   
 (C)  $\Delta H = T\Delta S$   
 (D)  $\Delta S < 0$

#### CHAPTER 19 PRACTICE QUIZ



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#### FREE RESPONSE – CALCULATOR IS ALLOWED

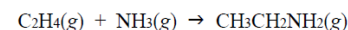


1. Calcium oxide,  $\text{CaO}(s)$ , has been proposed as a substance that can be used to heat water quickly for portable heating packs or for cooking. When placed in water,  $\text{CaO}(s)$  reacts as shown by the equation above.
- (a) A student wants to design a heating pad that could heat a 150.0 g sample of water from  $25.0^\circ\text{C}$  to  $60.0^\circ\text{C}$ . Calculate the amount of heat, in joules, that the water must absorb for its temperature to change by this amount. Assume that the specific heat capacity of the water is  $4.18 \text{ J/(g} \cdot ^\circ\text{C)}$ . Show the set-up for your calculations in order to receive full credit. Round off your answer to three significant figures.
- (b) Calculate the minimum mass of  $\text{CaO}(s)$  that the student would need to use in order to cause the temperature change described in part (a). Show the set-up for your calculations in order to receive full credit. Round off your answer to three significant figures.

- (c) The student hypothesizes that the design of the heating pad could be changed to enable it to heat 150.0 g of water from  $25.0^\circ\text{C}$  to  $90.0^\circ\text{C}$  by using a greater mass of  $\text{CaO}(s)$ .
- (i) Use the data in the table below to determine the standard entropy change,  $\Delta S_{\text{rxn}}^\circ$ , in  $\text{J/(K} \cdot \text{mol}_{\text{rxn}})$  for the reaction.

| Substance                   | Absolute Entropy at $25^\circ\text{C}$ ( $\text{J/(K} \cdot \text{mol)}$ ) |
|-----------------------------|----------------------------------------------------------------------------|
| $\text{CaO}(s)$             | 83                                                                         |
| $\text{H}_2\text{O}(l)$     | 70.                                                                        |
| $\text{Ca}(\text{OH})_2(s)$ | 40.                                                                        |

- (ii) Is the reaction thermodynamically favorable at  $90.0^\circ\text{C}$ ? Justify your answer with a calculation. Assume that both  $\Delta S_{\text{rxn}}^\circ$  and  $\Delta H_{\text{rxn}}^\circ$  are constant between  $25.0^\circ\text{C}$  and  $90.0^\circ\text{C}$ .



2. Ethylene,  $\text{C}_2\text{H}_4(g)$ , reacts with ammonia,  $\text{NH}_3(g)$ , to produce ethylamine,  $\text{CH}_3\text{CH}_2\text{NH}_2(g)$  as shown by the equation above.

| Substance                              | Enthalpy of Formation at $25^\circ\text{C}$ ( $\text{kJ/mol}$ ) | Absolute Entropy at $25^\circ\text{C}$ ( $\text{J/(K} \cdot \text{mol)}$ ) |
|----------------------------------------|-----------------------------------------------------------------|----------------------------------------------------------------------------|
| $\text{C}_2\text{H}_4(g)$              | 52.3                                                            | 219.4                                                                      |
| $\text{NH}_3(g)$                       | -46.2                                                           | 192.5                                                                      |
| $\text{CH}_3\text{CH}_2\text{NH}_2(g)$ | -47.5                                                           | 283.8                                                                      |

- (a) Use the data in the table above to help you determine each of the following quantities.

- (i)  $\Delta H_{\text{rxn}}^\circ$  (in  $\text{kJ/mol}_{\text{rxn}}$ ) for the reaction shown above  
 (ii)  $\Delta S_{\text{rxn}}^\circ$  (in  $\text{J/(K} \cdot \text{mol}_{\text{rxn}})$ ) for the reaction shown above.

- (b) Calculate the value of  $\Delta G_{\text{rxn}}^\circ$  for the reaction shown above at  $25^\circ\text{C}$ . Show the set-up for your calculations in order to receive full credit. Include units in your answer.

Skip part (c).

- (d) Calculate the temperature (in  $^\circ\text{C}$ ) at which the value of  $\Delta G_{\text{rxn}}$  would be equal to zero. Assume that both  $\Delta S_{\text{rxn}}^\circ$  and  $\Delta H_{\text{rxn}}^\circ$  do not change with temperature. Show the set-up for your calculations in order to receive full credit. Round off your answer to the nearest  $1^\circ\text{C}$ .
- (e) This reaction is thermodynamically favorable at  $25^\circ\text{C}$ . What drives this chemical reaction? Circle one of the following options.

Enthalpy only

Entropy only

Both enthalpy and entropy

- (f) Justify your selection in part (e) in terms of  $\Delta G_{\text{rxn}}^\circ$ .

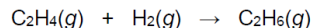
## Unit 4: Kinetics

## CHAPTER 13 – 14 PRACTICE QUIZ

MULTIPLE CHOICE – NO CALCULATOR ALLOWED



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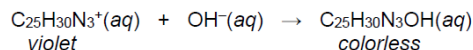
9. Which of the following will most likely increase the rate of the reaction represented above?

- (A) Decreasing the temperature of the reaction system  
 (B) Adding a heterogeneous catalyst to the reaction system  
 (C) Increasing the volume of the reaction vessel using a piston  
 (D) Removing some  $\text{H}_2(g)$  from the reaction system

| Experiment | Mass of Zinc | Form of Zinc     | Concentration of $\text{HCl}(aq)$ | Temperature of $\text{HCl}(aq)$ |
|------------|--------------|------------------|-----------------------------------|---------------------------------|
| 1          | 10.0 g       | powdered zinc    | 1.0 M                             | 25.0°C                          |
| 2          | 10.0 g       | zinc metal strip | 0.10 M                            | 25.0°C                          |
| 3          | 10.0 g       | powdered zinc    | 1.0 M                             | 50.0°C                          |
| 4          | 10.0 g       | zinc metal strip | 1.0 M                             | 25.0°C                          |

10. In a certain experiment, zinc metal reacted with hydrochloric acid. Based on the information in the table above, which of the following lists of experiments is arranged in order of increasing reaction rate?

- (A)  $2 < 1 < 4 < 3$   
 (B)  $2 < 4 < 1 < 3$   
 (C)  $2 < 4 < 3 < 1$   
 (D)  $4 < 2 < 1 < 3$



The reaction between  $\text{C}_{25}\text{H}_{30}\text{N}_3^+(aq)$  and  $\text{OH}^-(aq)$ , as represented above, is studied to determine the reaction rate. A 10.0 mL sample of 0.10 M  $\text{NaOH}(aq)$  is mixed with a 10.0 mL sample of  $2.4 \times 10^{-5}$  M  $\text{C}_{25}\text{H}_{30}\text{N}_3^+(aq)$ . A 5.0 mL sample of the reaction mixture is quickly transferred to a clean cuvette and placed in a spectrophotometer, and the progress of the reaction is measured. The data are given in the table below.

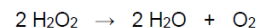
| Time (s)   | 0    | 30   | 60   | 90   | 120  | 150  | 180  | 210  | 240  | 270  | 300  |
|------------|------|------|------|------|------|------|------|------|------|------|------|
| Absorbance | 0.62 | 0.54 | 0.47 | 0.41 | 0.36 | 0.31 | 0.27 | 0.23 | 0.20 | 0.17 | 0.15 |

11. Approximately how long did it take for 75 percent of the initial amount of  $\text{C}_{25}\text{H}_{30}\text{N}_3^+(aq)$  to react?

- (A) 60 s  
 (B) 120 s  
 (C) 150 s  
 (D) 300 s

Skip #12.

Name: \_\_\_\_\_ Pd \_\_\_\_\_

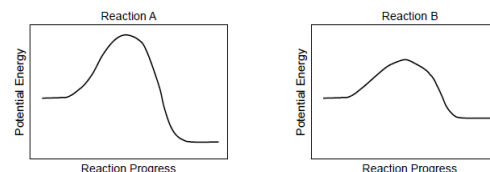


The decomposition of  $\text{H}_2\text{O}_2(aq)$  is represented by the equation above. A student monitored the decomposition of a 1.0 L sample of  $\text{H}_2\text{O}_2(aq)$  at a constant temperature of 300. K and recorded the concentration of  $\text{H}_2\text{O}_2$  as a function of time. The results are given in the table below.

| Time (s) | $[\text{H}_2\text{O}_2]$ (mol/L) |
|----------|----------------------------------|
| 0        | 2.7                              |
| 200.     | 2.1                              |
| 400.     | 1.7                              |
| 600.     | 1.4                              |

13. Which of the following statements is a correct interpretation of the data regarding how the order of the reaction can be determined?

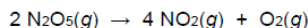
- (A) The reaction must be 1<sup>st</sup> order because there is only one reactant species.  
 (B) The reaction must be 2<sup>nd</sup> order because 2 is the coefficient of  $\text{H}_2\text{O}_2$  in the equation.  
 (C) The reaction is 1<sup>st</sup> order if the plot of  $\ln [\text{H}_2\text{O}_2]$  versus time is a straight line.  
 (D) The reaction is 1<sup>st</sup> order if the plot of  $1/[\text{H}_2\text{O}_2]$  versus time is a straight line.



14. Based on the potential energy diagrams shown above, which of the following statements is the best conclusion regarding Reaction A and Reaction B?

- (A) Reaction A is faster than Reaction B because it releases more energy.  
 (B) Reaction A is slower than Reaction B because it has a higher activation energy.  
 (C) Reaction B is slower than Reaction A because its enthalpy has a smaller magnitude.  
 (D) Reactions A and B occur at approximately the same rate because they are both exothermic reactions.

Questions 15 and 16 refer to the information below.



A sample of  $\text{N}_2\text{O}_5$  was placed in an evacuated container, and the reaction represented above occurred. The value of  $P_{\text{N}_2\text{O}_5}$ , the partial pressure of  $\text{N}_2\text{O}_5(\text{g})$ , was measured during the reaction and recorded in the table shown below.

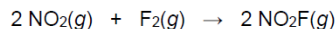
| Time (min) | $P_{\text{N}_2\text{O}_5}$ (atm) | $\ln(P_{\text{N}_2\text{O}_5})$ | $\frac{1}{P_{\text{N}_2\text{O}_5}}$ ( $\text{atm}^{-1}$ ) |
|------------|----------------------------------|---------------------------------|------------------------------------------------------------|
| 0          | 150                              | 5.0                             | 0.0067                                                     |
| 100        | 75                               | 4.3                             | 0.013                                                      |
| 200        | 38                               | 3.6                             | 0.027                                                      |
| 300        | 19                               | 2.9                             | 0.053                                                      |

15. Which of the following correctly describes the reaction?

- (A) The decomposition of  $\text{N}_2\text{O}_5$  is a zero-order reaction.
- (B) The decomposition of  $\text{N}_2\text{O}_5$  is a first-order reaction.
- (C) The decomposition of  $\text{N}_2\text{O}_5$  is a second-order reaction.
- (D) The overall reaction order is 3.

16. Based on the information in the data table above, which of the following best represents the correct numerical value and the correct units of the rate constant ( $k$ ) from this experiment?

|     | Numerical Value of $k$ | Units of $k$                      |
|-----|------------------------|-----------------------------------|
| (A) | 0.007                  | $\text{min}^{-1}$                 |
| (B) | 0.007                  | $\text{atm}^{-1} \text{min}^{-1}$ |
| (C) | 0.7                    | $\text{min}^{-1}$                 |
| (D) | 0.7                    | $\text{atm}^{-1} \text{min}^{-1}$ |



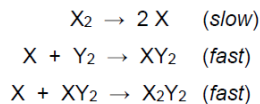
17. The rate law for the reaction represented by the equation above is  $\text{rate} = k [\text{NO}_2][\text{F}_2]$ . Which of the following could be the first elementary step of a two-step mechanism for the reaction if the first step is slow and the second step is fast?

- (A)  $\text{F}_2(\text{g}) \rightarrow 2 \text{F}(\text{g})$
- (B)  $\text{NO}_2(\text{g}) + \text{F}_2(\text{g}) \rightarrow \text{NO}_2\text{F}(\text{g}) + \text{F}(\text{g})$
- (C)  $\text{NO}_2(\text{g}) + \text{F}(\text{g}) \rightarrow \text{NO}_2\text{F}(\text{g})$
- (D)  $2 \text{NO}_2(\text{g}) + \text{F}_2(\text{g}) \rightarrow 2 \text{NO}_2\text{F}(\text{g})$

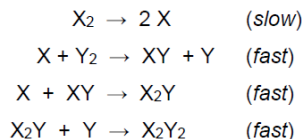


A reaction and its experimentally determined rate law are represented above. A chemist proposes two different possible mechanisms for the reaction, which are given below.

Mechanism 1

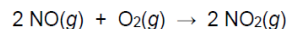


Mechanism 2

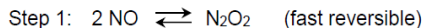


18. Based on the information above, which of the following is true?

- (A) Only mechanism 1 is consistent with the rate law.
- (B) Only mechanism 2 is consistent with the rate law.
- (C) Both mechanism 1 and mechanism 2 are consistent with the rate law.
- (D) Neither mechanism 1 nor mechanism 2 is consistent with the rate law.

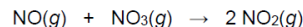


Consider the following mechanism for the reaction represented above.



19. Which of the following statements is true?

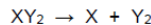
- (A) Step 1 represents a unimolecular reaction.
- (B) Increasing the concentration of  $\text{NO}$  will decrease the overall rate of the reaction.
- (C) Raising the temperature will have no effect on the numerical value of the rate constant.
- (D) The rate law that is consistent with the mechanism is  $\text{rate} = k[\text{NO}]^2[\text{O}_2]$ .



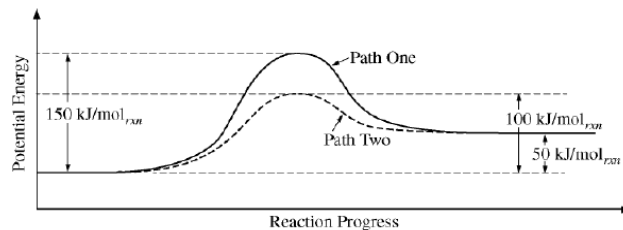
$$\text{rate} = k [\text{NO}][\text{NO}_3]$$

20. The reaction represented above occurs in a single step that involves the collision between a particle of  $\text{NO}$  and a particle of  $\text{NO}_3$ . A scientist correctly calculates the rate of collisions between  $\text{NO}$  and  $\text{NO}_3$  that have sufficient energy to overcome the activation energy. The observed reaction rate is only a small fraction of the calculated collision rate. Which of the following best explains the discrepancy?

- (A) The energy of collisions between two reactant particles is frequently absorbed by collision with a third particle.
- (B) The two reactant particles must collide with a particular orientation in order to react.
- (C) The activation energy for a reaction is dependent on the concentrations of the reactant particles.
- (D) The activation energy for a reaction is dependent on the temperature.



The equation above represents the decomposition of a compound  $XY_2$ . The diagram below shows two reaction profiles (path one and path two) for the decomposition of  $XY_2$ .



21. Which of the following most likely accounts for the difference between reaction path one and reaction path two?

- (A) A higher temperature in path one
- (B) A higher temperature in path two
- (C) The presence of a catalyst in path one
- (D) The presence of a catalyst in path two

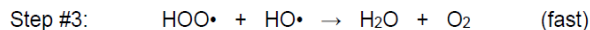
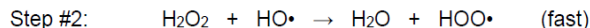
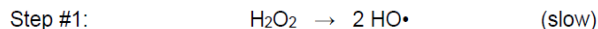
#### CHAPTER 13 – 14 PRACTICE QUIZ

#### FREE RESPONSE – CALCULATOR IS ALLOWED



←Linked, begin at 25:11

2. The decomposition of hydrogen peroxide to form water and oxygen gas is studied in a kinetics experiment. A proposed mechanism for the reaction is represented by the three equations below.

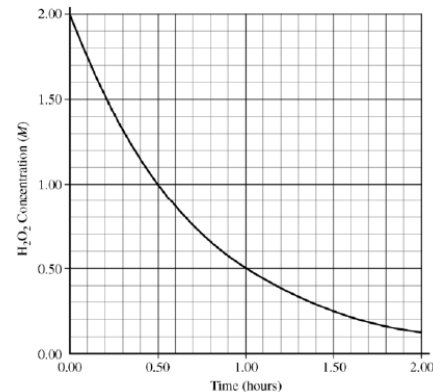


(a) Use the proposed mechanism to write the balanced equation for this decomposition reaction.

(b) Identify all of the substances that behave as intermediates in the proposed mechanism.

(c) Write the rate law that is consistent with the proposed mechanism.

The rate of the decomposition reaction was studied in an experiment, and the resulting data were plotted in the graph shown below.



(d) Information from this graph can be used to determine if the reaction is zero-order, first-order or second-order with respect to  $H_2O_2$ .

- (i) Identify the order of this reaction, based on the information in the graph.
- (ii) Justify your answer, based on the information from the graph.

(e) Is the order of the reaction (as determined from the experimental data) consistent with the rate law that was written in part (c)? \_\_\_\_\_

(f) Use the data from the graph to calculate the value of the rate constant ( $k$ ) for this reaction. Include units in your answer.

(g) The decomposition of  $H_2O_2(aq)$  is slow at 298 K, but adding a suitable catalyst to the solution increases the rate of the reaction. For each of the following quantities,

indicate whether its value in the catalyzed reaction at 298 K would be

higher than, lower than, or the same as

its value in the uncatalyzed reaction at 298 K.

For each prediction, justify your answer.

(i) The overall enthalpy change for the decomposition reaction,  $\Delta H$

(ii) The activation energy for the decomposition reaction,  $E_a$

(iii) The half-life ( $t_{1/2}$ ) of  $H_2O_2$

(iv) The rate constant,  $k$

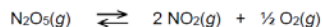
Unit 5: General Equilibrium &  $K_{sp}$ 

## CHAPTER 15 PRACTICE QUIZ

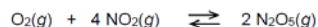
## MULTIPLE CHOICE – NO CALCULATOR ALLOWED



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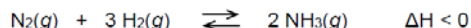


1. The equilibrium constant for the gas phase reaction above is 95 at 25°C. What is the value of the equilibrium constant for the following reaction at 25°C?



- (A)  $(95)^2$   
 (B)  $(95)^{1/5}$   
 (C)  $\frac{1}{95}$   
 (D)  $\frac{1}{95^2}$

Questions 6 – 7 refer to the following.

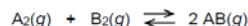


6.  $\text{NH}_3(g)$  was synthesized at 200°C in the presence of a powdered  $\text{Os}(s)$  catalyst, leading to the equilibrium system represented above. Which of the following changes would result in more  $\text{NH}_3(g)$  in the mixture after equilibrium is re-established?

- (A) Replacing the powdered  $\text{Os}(s)$  with a solid cube of  $\text{Os}(s)$  of the same total mass  
 (B) Increasing the temperature of the system to 250°C at constant pressure  
 (C) Removing some  $\text{H}_2(g)$   
 (D) Adding some  $\text{N}_2(g)$

7. In a separate experiment, the system is allowed to reach equilibrium at 200°C. Then additional  $\text{H}_2(g)$  is added to reaction vessel. Which of the following will most likely occur as the system approaches equilibrium at constant temperature?

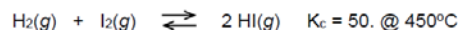
- (A)  $[\text{N}_2]$  will increase, and  $K_c$  will decrease.  
 (B)  $[\text{N}_2]$  will decrease, and  $K_c$  will increase.  
 (C)  $[\text{N}_2]$  will decrease, but  $K_c$  will remain constant.  
 (D)  $[\text{N}_2]$  will increase, but  $K_c$  will remain constant.



8. In a certain experiment, 4.00 mol each of  $\text{A}_2(g)$  and  $\text{B}_2(g)$  are placed in a 1.00 L vessel and allowed to react at constant temperature according to the equation above. Once equilibrium is reached for the reaction mixture, it is determined that the concentration of  $\text{AB}(g)$  is equal to 2.0 M. What is the value of the equilibrium constant,  $K_c$ ?

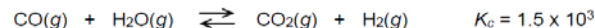
- (A)  $\frac{2}{9}$   
 (B)  $\frac{4}{9}$   
 (C) 0.50  
 (D) 1.0

Name: \_\_\_\_\_ Pd\_\_\_\_\_



9. At 450°C, 2.0 moles each of  $\text{H}_2(g)$ ,  $\text{I}_2(g)$ , and  $\text{HI}(g)$  are combined in a 1.0 L rigid container. Which of the following will occur as the system moves toward equilibrium?

- (A) More  $\text{H}_2(g)$  and  $\text{I}_2(g)$  will form.  
 (B) More  $\text{HI}(g)$  will form.  
 (C) The total pressure will decrease.  
 (D) No net reaction will occur because the number of molecules is the same on both sides of the equation.

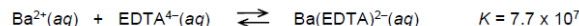


10. A 2.0 mol sample of  $\text{CO}(g)$  and a 2.0 mol sample of  $\text{H}_2\text{O}(g)$  are introduced into a previously evacuated 100. L rigid container, and the temperature is held constant as the reaction represented above reaches equilibrium. Which of the following is true at equilibrium?

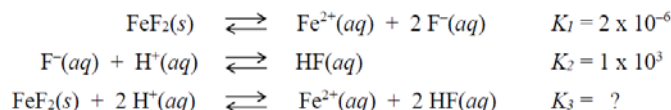
- (A)  $[\text{H}_2\text{O}] > [\text{CO}]$  and  $[\text{CO}_2] > [\text{H}_2]$   
 (B)  $[\text{H}_2\text{O}] > [\text{H}_2]$   
 (C)  $[\text{CO}_2] > [\text{CO}]$   
 (D)  $[\text{CO}] = [\text{H}_2\text{O}] = [\text{CO}_2] = [\text{H}_2]$

12. Which of the systems in equilibrium represented below will exhibit a shift to the left (toward reactants) when the pressure on the system is increased by reducing the volume of the system? (Assume that temperature is constant.)

- (A)  $\text{SF}_4(g) + \text{F}_2(g) \rightleftharpoons \text{SF}_6(g)$   
 (B)  $\text{H}_2(g) + \text{Br}_2(g) \rightleftharpoons 2 \text{HBr}(g)$   
 (C)  $\text{CaF}_2(s) \rightleftharpoons \text{Ca}^{2+}(aq) + 2 \text{F}^-(aq)$   
 (D)  $\text{SO}_2\text{Cl}_2(g) \rightleftharpoons \text{SO}_2(g) + \text{Cl}_2(g)$

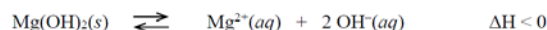


3. The polyatomic ion  $\text{C}_{10}\text{H}_{12}\text{N}_2\text{O}_8^{4-}$  is commonly abbreviated as  $\text{EDTA}^{4-}$ . The ion can form complexes with metal ions in aqueous solutions. A complex of  $\text{EDTA}^{4-}$  with the  $\text{Ba}^{2+}$  ion forms according to the equation above. A 50.0 mL volume of a solution that has an  $\text{EDTA}^{4-}(\text{aq})$  concentration of 0.30 M is mixed with 50.0 mL of 0.20 M  $\text{Ba}(\text{NO}_3)_2$  to produce 100.0 mL of solution.
- (a) Considering the value of  $K$  for the reaction, determine the concentration of  $\text{Ba}(\text{EDTA})^{2-}(\text{aq})$  in the 100.0 mL of solution. Justify your answer.
- (b) The solution is diluted with distilled water to a total volume of 1.00 L. After equilibrium has been re-established, is the number of moles of  $\text{Ba}^{2+}(\text{aq})$  present in the solution *greater than*, *less than*, or *equal to* the number of moles of  $\text{Ba}^{2+}(\text{aq})$  present in the original solution before it was diluted? Justify your answer. You should compare  $Q$  vs.  $K$  in your answer.



15. On the basis of the information above, the dissolution of  $\text{FeF}_2(\text{s})$  in acidic solution is

- (A) favorable, because  $K_2 > 1$   
 (B) favorable, because  $K_3 > 1$   
 (C) not favorable, because  $K_1 < 1$   
 (D) not favorable, because  $K_3 < 1$



16. The exothermic dissolution of  $\text{Mg}(\text{OH})_2(\text{s})$  in water is represented by the equation above. The  $K_{sp}$  of  $\text{Mg}(\text{OH})_2$  is  $1.8 \times 10^{-11}$ . Which of the following changes will increase the solubility of  $\text{Mg}(\text{OH})_2$  in an aqueous solution?

- (A) Increasing the temperature of the solution  
 (B) Decreasing the pH of the solution  
 (C) Adding NaOH to the solution  
 (D) Adding  $\text{Mg}(\text{NO}_3)_2$  to the solution

| Compound                 | $K_{sp}$              |
|--------------------------|-----------------------|
| $\text{PbCl}_2$          | $1.2 \times 10^{-5}$  |
| $\text{CuCl}$            | $1.6 \times 10^{-7}$  |
| $\text{AgCl}$            | $1.8 \times 10^{-10}$ |
| $\text{Hg}_2\text{Cl}_2$ | $1.4 \times 10^{-18}$ |

17. Based on the  $K_{sp}$  values in the table above, a saturated solution of which of the following compounds has the highest  $[\text{Cl}^{-}]$ ?

- (A)  $\text{PbCl}_2$       (B)  $\text{CuCl}$       (C)  $\text{AgCl}$       (D)  $\text{Hg}_2\text{Cl}_2$

| Compound                 | $K_{sp}$           |
|--------------------------|--------------------|
| $\text{Ag}_2\text{SO}_4$ | $1 \times 10^{-5}$ |
| $\text{PbSO}_4$          | $1 \times 10^{-8}$ |

18. A 1.0 L solution of  $\text{AgNO}_3$  and  $\text{Pb}(\text{NO}_3)_2(\text{aq})$  has a  $\text{Ag}^{+}$  concentration of 0.020 M and a  $\text{Pb}^{2+}$  concentration of 0.0010 M. A 0.0010 mol sample of  $\text{K}_2\text{SO}_4(\text{s})$  is added to the solution. Based on the information in the table above, which of the following will occur? (Assume that the volume change of the solution is negligible.)

- (A) No precipitate will form.  
 (B) Only  $\text{Ag}_2\text{SO}_4(\text{s})$  will precipitate.  
 (C) Only  $\text{PbSO}_4(\text{s})$  will precipitate.  
 (D) Both  $\text{Ag}_2\text{SO}_4(\text{s})$  and  $\text{PbSO}_4(\text{s})$  will precipitate.

19. A beaker contains 1.0 L of a saturated solution of  $\text{CaF}_2(\text{aq})$  that is in equilibrium with undissolved  $\text{CaF}_2(\text{s})$ . A chemist adds 1.0 mL of 10.0 M  $\text{KF}(\text{aq})$  to this beaker. The solution is stirred and the equilibrium is re-established. Which of the following most accurately represents the changes, if any, that have occurred in the system as a result of the addition of 1.0 mL of 10.0 M  $\text{KF}(\text{aq})$ ?

|     | The concentration of $\text{Ca}^{2+}(\text{aq})$ | The mass of $\text{CaF}_2(\text{s})$ in the beaker |
|-----|--------------------------------------------------|----------------------------------------------------|
| (A) | has decreased                                    | remains the same                                   |
| (B) | has decreased                                    | has increased                                      |
| (C) | has increased                                    | has decreased                                      |
| (D) | remains the same                                 | remains the same                                   |

3. Answer the following questions concerning magnesium hydroxide,  $\text{Mg}(\text{OH})_2$ .

- (a) A saturated solution of  $\text{Mg}(\text{OH})_2(\text{s})$  is prepared that is in equilibrium with  $\text{Mg}(\text{OH})_2(\text{s})$ . Write the solubility-product expression,  $K_{sp}$ , for  $\text{Mg}(\text{OH})_2$ .
- (b) The pH of a saturated solution of magnesium hydroxide is equal to 10.52.
- (i) Calculate the value of  $[\text{OH}^{-}]$  in this saturated solution: \_\_\_\_\_
- (ii) Calculate the value of  $[\text{Mg}^{2+}]$  in this solution: \_\_\_\_\_
- (c) Use your answers to part (b) to calculate the value of  $K_{sp}$  for  $\text{Mg}(\text{OH})_2$ . Show the set-up for your calculations in order to receive full credit.
- (d) In a different experiment, 50.0 mL of  $4.0 \times 10^{-4} \text{ M}$   $\text{Mg}(\text{NO}_3)_2$  was added to 50.0 mL of  $3.0 \times 10^{-4} \text{ M}$  NaOH. Assume that the final volume of this solution is 100.0 mL. Will a precipitate be formed in this experiment? Justify your answer by comparing the value of  $Q$  to the value of  $K_{sp}$  obtained in part (c).

## Unit 5.5: Gases &amp; Gas Equilibrium

## CHAPTER 9 – 10 PRACTICE QUIZ

## MULTIPLE CHOICE – NO CALCULATOR ALLOWED

 ←Linked at 7:26

9. Equal masses of  $\text{Ne}(g)$  and  $\text{He}(g)$  are placed in a sealed rigid container at 500 K. Which of the following statements is true about this system?

(A) The partial pressure of  $\text{Ne}(g)$  is less than the partial pressure of  $\text{He}(g)$ .  
 (B) The partial pressure of  $\text{Ne}(g)$  is equal to the partial pressure of  $\text{He}(g)$ .  
 (C) The average speed of  $\text{Ne}(g)$  particles is equal to the average speed of  $\text{He}(g)$  particles.  
 (D) The average speed of  $\text{Ne}(g)$  particles is greater than the average speed of  $\text{He}(g)$  particles.

10. Which of the following, upon reaction with excess hydrochloric acid, would produce the largest quantity of hydrogen gas?

(A) 1.0 mol Na  
 (B) 1.0 mol Mg  
 (C) 1.0 mol Al  
 (D) 1.0 mol Ca

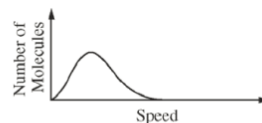
11. A gas mixture contains 14.0 g of carbon monoxide gas and 7.0 g of hydrogen gas. The total pressure of the gas mixture is 2.40 atm. What is the partial pressure of each gas in this mixture?

|     | Partial pressure of carbon monoxide gas | Partial pressure of hydrogen gas |
|-----|-----------------------------------------|----------------------------------|
| (A) | 0.15 atm                                | 2.25 atm                         |
| (B) | 0.30 atm                                | 2.10 atm                         |
| (C) | 0.60 atm                                | 1.80 atm                         |
| (D) | 1.60 atm                                | 0.80 atm                         |

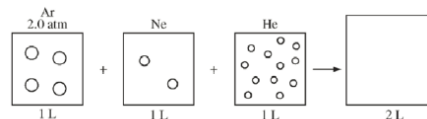
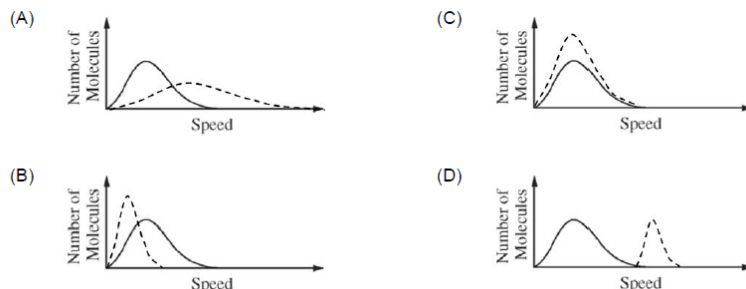
12. At which of the following temperatures and pressures would a real gas be most likely to deviate from ideal behavior?

|     | Temperature (K) | Pressure (atm) |
|-----|-----------------|----------------|
| (A) | 100             | 0.01           |
| (B) | 100             | 50             |
| (C) | 1000            | 0.01           |
| (D) | 1000            | 50             |

Name: \_\_\_\_\_ Pd \_\_\_\_\_



13. The graph above shows the speed distribution of molecules in a sample of oxygen gas at 25°C. Which of the following graphs is most likely to represent the speed distribution of the same number of molecules of hydrogen gas at 25°C (as a dashed curve)?



14. The figure above represents three sealed 1.0 L vessels, each containing a different inert gas at 298 K. The pressure of Ar in the first vessel is 2.0 atm. The ratio of the numbers of Ar, Ne, and He atoms in the vessels is 2:1:6, respectively. After all the gases are combined in a previously evacuated 2.0 L vessel, what is the total pressure of the gases at 298 K?

(A) 4.5 atm  
 (B) 6.0 atm  
 (C) 9.0 atm  
 (D) 18 atm

| Container   | A       | B       |
|-------------|---------|---------|
| Gas         | Ar      | He      |
| Temperature | 30°C    | 30°C    |
| Pressure    | 2.0 atm | 4.0 atm |

15. The information in the table above refers to two different gases in identical rigid containers A and B. Which of the following statements is true?

(A) The average kinetic energy of the gas particles in Container B is greater than the average kinetic energy of the gas particles in Container A.  
 (B) The density of the gas in Container B is greater than the density of the gas in Container A.  
 (C) The number of gas particles in Container B is greater than the number of gas particles in Container A.  
 (D) The average speed of the gas particles in Container B is less than the average speed of the gas particles in Container A.

16. Samples of  $F_2$  gas and Xe gas are mixed in a container of fixed volume. Initially, the partial pressure of the  $F_2$  gas is 8.0 atm and the partial pressure of the Xe gas is 1.7 atm. When all of the Xe gas reacted, forming a solid compound, the pressure of the unreacted  $F_2$  gas was 4.6 atm. The temperature remained constant. What is the formula of the solid compound?

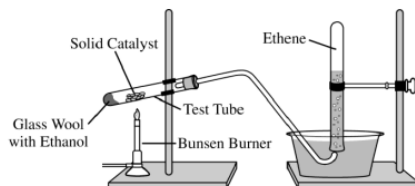
- (A)  $XeF$   
 (B)  $XeF_2$   
 (C)  $XeF_3$   
 (D)  $XeF_4$

CHAPTER 9 – 10 PRACTICE QUIZ

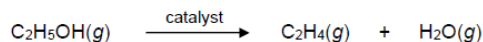


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FREE RESPONSE – CALCULATOR IS ALLOWED



2. Ethene,  $C_2H_4(g)$ , may be prepared by the dehydration of ethanol,  $C_2H_5OH(g)$ , using a solid catalyst. A setup for the lab synthesis is shown in the diagram above. The equation for the dehydration reaction is given below.



A student added a 0.200 g sample of  $C_2H_5OH(l)$  to a test tube using the setup shown above. The student heated the test tube gently with a Bunsen burner until all of the  $C_2H_5OH(l)$  evaporated and gas generation stopped. When the reaction stopped, the volume of collected gas was 85.4 mL at 625.0 torr and  $32.0^\circ\text{C}$ . (The vapor pressure of water at  $32.0^\circ\text{C}$  is 35.7 torr.)

- (a) Calculate the number of moles of  $C_2H_4(g)$

(i) that are actually produced in the experiment and measured in the gas collection tube,

(ii) and that would be produced if the dehydration reaction went to completion.

- (b) Calculate the percent yield of ethene in the experiment.

3. A sample of propane,  $C_3H_8(g)$ , is introduced into a previously evacuated rigid 5.00 L reaction vessel at  $127^\circ\text{C}$ . Then a sample of  $O_2(g)$  is introduced into the same vessel at constant temperature. This mixture of  $C_3H_8(g)$  and  $O_2(g)$  is sparked so that a complete combustion reaction occurs, producing  $CO_2(g)$  and  $H_2O(g)$ .

- (a) Write a balanced chemical equation for the complete combustion of  $C_3H_8(g)$ .

- (b) The table below represents the partial pressure of each substance, before and after the reaction occurs. Fill in the missing information in the table based on the stoichiometry of the reaction. Assume that temperature remains constant at  $127^\circ\text{C}$ .

| Substance                                                   | $C_3H_8(g)$ | $O_2(g)$  | $CO_2(g)$ | $H_2O(g)$ |
|-------------------------------------------------------------|-------------|-----------|-----------|-----------|
| Partial pressure before the reaction at $127^\circ\text{C}$ | 0.200 atm   | 1.40 atm  | 0.00 atm  | 0.00 atm  |
| Partial pressure after the reaction at $127^\circ\text{C}$  | 0.00 atm    | 0.400 atm |           |           |

- (c) Calculate the mole fraction of  $O_2(g)$  in the 5.00 L reaction vessel at  $127^\circ\text{C}$

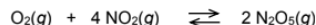
(i) before the reaction occurs,

(ii) and after the reaction occurs.

- (d) Calculate the mass of  $C_3H_8(g)$  that is consumed in the combustion reaction.

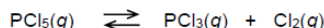


1. The equilibrium constant for the gas phase reaction above is 95 at 25°C. What is the value of the equilibrium constant for the following reaction at 25°C?



- (A)  $(95)^2$   
 (B)  $(95)^{1/2}$   
 (C)  $\frac{1}{95}$   
 (D)  $\frac{1}{95^2}$

Questions 2 – 5 refer to the following.



$\text{PCl}_5(\text{g})$  decomposes into  $\text{PCl}_3(\text{g})$  and  $\text{Cl}_2(\text{g})$  according to the equation above. A pure sample of  $\text{PCl}_5(\text{g})$  is placed in a rigid, evacuated 1.00 L container. The initial pressure of the  $\text{PCl}_5(\text{g})$  is 1.00 atm. The temperature is held constant until the  $\text{PCl}_5(\text{g})$  reaches equilibrium with its decomposition products. The figures below show the initial and equilibrium conditions of the system.

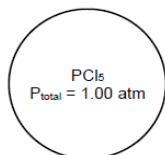


Figure 1: Initial

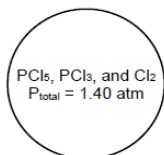
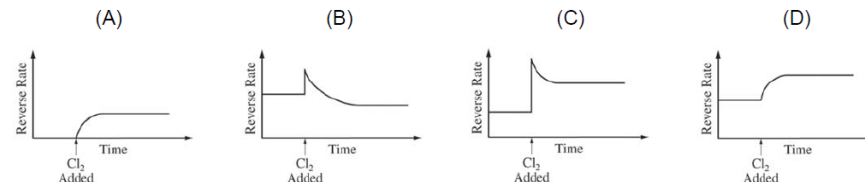


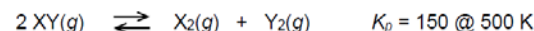
Figure 2: Equilibrium

2. As the reaction progresses toward equilibrium, the rate of the forward reaction
- (A) increases until it becomes the same as the reverse reaction rate at equilibrium  
 (B) stays constant before and after equilibrium is reached  
 (C) decreases to become a constant nonzero rate at equilibrium  
 (D) decreases to become zero at equilibrium
3. Which of the following statements about  $K_p$ , the equilibrium constant for the reaction, is correct?
- (A)  $K_p > 1$   
 (B)  $K_p < 1$   
 (C)  $K_p = 1$   
 (D) It cannot be determined whether  $K_p > 1$ ,  $K_p < 1$ , or  $K_p = 1$  without additional information.
4. A mixture of  $\text{PCl}_5(\text{g})$ ,  $\text{PCl}_3(\text{g})$ , and  $\text{Cl}_2(\text{g})$  is in a 1.00 L reaction vessel. The total pressure of the reaction system is 1.40 atm at equilibrium. Then the volume of the reaction vessel is reduced from 1.00 L to 0.50 L and equilibrium is re-established at constant temperature. What is the total pressure of the system at this point?
- (A) Less than 1.40 atm  
 (B) Greater than 1.40 atm but less than 2.80 atm  
 (C) 2.80 atm  
 (D) Greater than 2.80 atm

5. Additional  $\text{Cl}_2(\text{g})$  is injected into the system at equilibrium. Which of the following graphs best shows the rate of the reverse reaction as a function of time? (Assume that the time for injection and mixing of the additional  $\text{Cl}_2(\text{g})$  is negligible.)



6.-10. skip, begin at 14:10



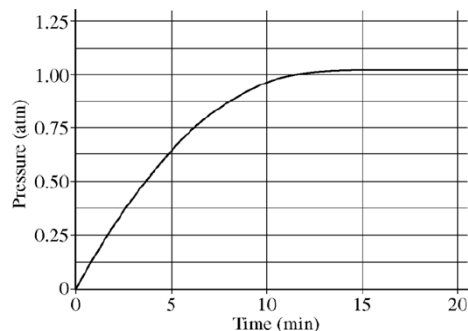
11. A certain gas,  $\text{XY}(\text{g})$ , decomposes as represented by the equation above. A sample of each of the three gases is put in a previously evacuated rigid container. The initial partial pressures of the gases are shown in the table below.

| Gas          | Initial Partial Pressure (atm) |
|--------------|--------------------------------|
| XY           | 0.10                           |
| $\text{X}_2$ | 2.0                            |
| $\text{Y}_2$ | 2.0                            |

The temperature of the reaction mixture is held constant at 500 K. In which direction, if any, will the reaction proceed?

- (A) The reaction will form more products  $\text{X}_2$  and  $\text{Y}_2$ .  
 (B) The reaction will form more reactant XY.  
 (C) The mixture is at equilibrium, so there will be no change in the partial pressure of any gas.  
 (D) The direction cannot be determined unless the volume of the container is known.

1. In a study of the decomposition of calcium carbonate, a student added a 50.0 g sample of powdered calcium carbonate to a 1.00 L rigid container. The student sealed the container, pumped out all the gases, then heated the container in an oven at 1100 K. As the container was heated, the total pressure of the carbon dioxide gas in the container was measured over time. The data are plotted in the graph below.



- (a) Write a balanced equation for the decomposition of calcium carbonate. The products are calcium oxide and carbon dioxide. Include symbols for phases of matter.

- (d) Write the expression for the equilibrium constant,  $K_p$ , for the decomposition of calcium carbonate at 1100 K.

- (b) The pressure in the container after 20 minutes of heating is equal to 1.04 atm. Calculate the number of moles of carbon dioxide gas present in the container at this point.

- (e) What is the value of  $K_p$  for this reaction at 1100 K? \_\_\_\_\_

- (c) The student repeated the experiment, but this time the student used a 100.0 g sample of powdered calcium carbonate. In this experiment, the final pressure in the container was 1.04 atm, which was the same final pressure as in the first experiment.

The student claimed that the final pressure in the container became constant during each experiment because all of the calcium carbonate had decomposed. Based on the data from these two experiments, do you agree with this claim? Explain.

- (f) After 20 minutes, additional carbon dioxide gas was injected into the container, initially raising the pressure to 1.5 atm. After 20 additional minutes at 1100 K, the final pressure in the container was recorded. Would the final pressure inside the container be less than, greater than, or equal to 1.04 atm? Explain your reasoning.

# Unit 6 Acid-Base Equilibrium Practice Quiz

CHAPTER 4 (Sections 4.1 – 4.4) PRACTICE QUIZ

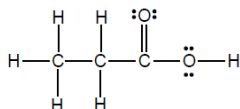
MULTIPLE CHOICE (NO CALCULATOR ALLOWED)



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6. Which of the following best describes the substance whose structural formula is shown below?

- (A) nonelectrolyte  
(B) weak acid  
(C) weak base  
(D) strong base



7. Which of the following statements concerning HF is true?

- (A) It is classified as a strong acid because it is very soluble in water.  
(B) It is classified as a weak acid because it is not very soluble in water.  
(C) It is classified as a strong acid because it is completely ionized in water.  
(D) It is classified as a weak acid because it is only partially ionized in water.

8. Solid calcium carbonate is insoluble in water, but will dissolve completely in a solution of hydrochloric acid. Which of the following represents the net-ionic equation for the reaction between solid calcium carbonate and aqueous hydrochloric acid?

- (A)  $\text{CaCO}_3(s) + 2 \text{H}^+(aq) \longrightarrow \text{Ca}^{2+}(aq) + \text{H}_2\text{O}(l) + \text{CO}_2(g)$   
(B)  $\text{CaCO}_3(s) + 2 \text{Cl}^-(aq) \longrightarrow \text{CaCl}_2(aq) + \text{CO}_2(g)$   
(C)  $\text{CO}_3^{2-}(aq) + 2 \text{H}^+(aq) \longrightarrow \text{H}_2\text{O}(l) + \text{CO}_2(g)$   
(D)  $\text{CaCO}_3(s) + 2 \text{H}^+(aq) \longrightarrow \text{Ca}^{2+}(aq) + \text{H}_2(g) + \text{CO}_2(g)$

9. Which of the following represents the net-ionic equation for the reaction that occurs when solutions of acetic acid and potassium hydroxide are mixed?

- (A)  $\text{H}^+(aq) + \text{OH}^-(aq) \longrightarrow \text{H}_2\text{O}(l)$   
(B)  $\text{H}^+(aq) + \text{KOH}(aq) \longrightarrow \text{H}_2\text{O}(l) + \text{K}^+(aq)$   
(C)  $\text{CH}_3\text{COOH}(aq) + \text{OH}^-(aq) \longrightarrow \text{H}_2\text{O}(l) + \text{CH}_3\text{COO}^-(aq)$   
(D)  $\text{CH}_3\text{COOH}(aq) + \text{KOH}(aq) \longrightarrow \text{H}_2\text{O}(l) + \text{CH}_3\text{COOK}(aq)$

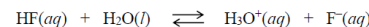
Name: \_\_\_\_\_ Pd: \_\_\_\_\_

CHAPTER 17 PRACTICE QUIZ

MULTIPLE CHOICE – NO CALCULATOR ALLOWED



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1. The dissociation of the weak acid HF in water is represented by the equation above. Which of the following choices shows what would happen to the percent ionization of HF(aq) when, in two separate experiments, 1.0 mL of distilled water and 1.0 mL 1.0 M KF(aq) are added to a 10. mL sample of 1.0 M HF(aq)?

|     | Adding 1.0 mL of distilled water to 10. mL 1.0 M HF(aq)... | Adding 1.0 mL of 1.0 M KF(aq) to 10. mL 1.0 M HF(aq)... |
|-----|------------------------------------------------------------|---------------------------------------------------------|
| (A) | would decrease the % ionization of HF(aq)                  | would decrease the % ionization of HF(aq)               |
| (B) | would decrease the % ionization of HF(aq)                  | would increase the % ionization of HF(aq)               |
| (C) | would increase the % ionization of HF(aq)                  | would decrease the % ionization of HF(aq)               |
| (D) | would increase the % ionization of HF(aq)                  | would increase the % ionization of HF(aq)               |

| Name        | Formula                           | $K_a$                | $pK_a$ |
|-------------|-----------------------------------|----------------------|--------|
| lactic acid | $\text{HC}_3\text{H}_5\text{O}_3$ | $1.4 \times 10^{-4}$ | 3.85   |

2. The table above lists information for lactic acid. A solution of 0.1 M  $\text{HC}_3\text{H}_5\text{O}_3$  has a pH of 2.4. Which of the following mixtures would create a buffer solution that has a pH of approximately 4?

- (A) A mixture of 100. mL of 0.1 M  $\text{HC}_3\text{H}_5\text{O}_3$  and 50. mL of 0.1 M NaOH  
(B) A mixture of 100. mL of 0.1 M  $\text{HC}_3\text{H}_5\text{O}_3$  and 100. mL of 0.1 M NaOH  
(C) A mixture of 100. mL of 0.1 M  $\text{HC}_3\text{H}_5\text{O}_3$  and 50. mL of 0.1 M HCl  
(D) A mixture of 100. mL of 0.1 M  $\text{HC}_3\text{H}_5\text{O}_3$  and 100. mL of 0.1 M HCl

3. A solution is prepared by adding 100 mL of 1.0 M  $\text{HC}_2\text{H}_3\text{O}_2(aq)$  to 100 mL of 1.0 M  $\text{NaC}_2\text{H}_3\text{O}_2(aq)$ . The solution is stirred and its pH is measured to be 4.73. After 3 drops of 1.0 M HCl are added to the solution, the pH of the solution is measured and is still 4.73. Which of the following equations represents the chemical reaction that accounts for the fact that acid was added but there was no detectable change in pH?

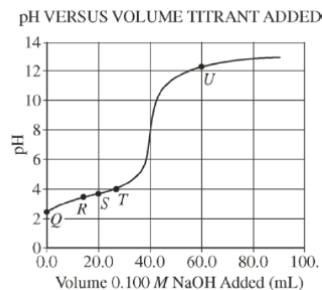
- (A)  $\text{H}_3\text{O}^+(aq) + \text{OH}^-(aq) \rightarrow 2 \text{H}_2\text{O}(l)$   
(B)  $\text{H}_3\text{O}^+(aq) + \text{Cl}^-(aq) \rightarrow \text{HCl}(g) + \text{H}_2\text{O}(l)$   
(C)  $\text{H}_3\text{O}^+(aq) + \text{C}_2\text{H}_3\text{O}_2^-(aq) \rightarrow \text{HC}_2\text{H}_3\text{O}_2(aq) + \text{H}_2\text{O}(l)$   
(D)  $\text{H}_3\text{O}^+(aq) + \text{HC}_2\text{H}_3\text{O}_2(aq) \rightarrow \text{H}_2\text{C}_2\text{H}_3\text{O}_2^+(aq) + \text{H}_2\text{O}(l)$

4. A solution contains equimolar amounts of  $\text{HOCl}(aq)$  and  $\text{NaOCl}(aq)$  and has a pH of 7.5. Five milliliters of concentrated  $\text{KOH}(aq)$  is added to this solution. Which of the following most accurately identifies the species present in greater concentration and the pH of the solution after  $\text{KOH}(aq)$  is added?

|     | Species present in greater concentration after $\text{KOH}(aq)$ is added? | pH of the solution after $\text{KOH}(aq)$ is added? |
|-----|---------------------------------------------------------------------------|-----------------------------------------------------|
| (A) | $\text{HOCl}$                                                             | $\text{pH} < 7.5$                                   |
| (B) | $\text{HOCl}$                                                             | $\text{pH} > 7.5$                                   |
| (C) | $\text{OCl}^-$                                                            | $\text{pH} < 7.5$                                   |
| (D) | $\text{OCl}^-$                                                            | $\text{pH} > 7.5$                                   |

Questions 5 – 8 refer to the diagram shown at right.

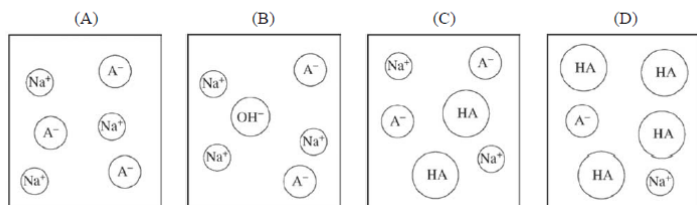
A 50.0 mL sample of an acid,  $\text{HA}$ , of unknown molarity is titrated, and the pH of the resulting solution is measured with a pH meter and graphed as a function of the volume of 0.100  $M$   $\text{NaOH}$  added.



5. At point  $R$  in the titration, which of the following species has the highest concentration?

- (A)  $\text{HA}$   
(B)  $\text{A}^-$   
(C)  $\text{H}_3\text{O}^+$   
(D)  $\text{OH}^-$

6. Which of the following is the best particulate representation of the species (other than  $\text{H}_2\text{O}$ ) that are present in significant concentrations in the solution at point  $U$  in the titration?



7. At which point on the titration curve is  $[\text{A}^-]$  closest to twice that of  $[\text{HA}]$ ?

- (A)  $R$  (B)  $S$  (C)  $T$  (D)  $U$

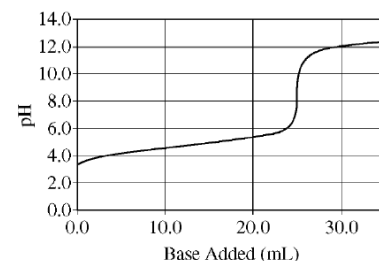
8. A student carries out the same titration, but uses an indicator instead of a pH meter. If the indicator changes color slightly past the equivalence point, what will the student obtain for the calculated concentration of the acid?

- (A) slightly less than 0.0800  $M$   
(B) slightly more than 0.0800  $M$   
(C) slightly less than 0.125  $M$   
(D) slightly more than 0.125  $M$

Questions 9 – 11 refer to the following information.

A sample of  $\text{Li}(s)$  is placed in an Erlenmeyer flask containing 100 mL of water at  $25^\circ\text{C}$ . A balloon is placed over the mouth of the flask to collect the hydrogen gas that is generated.

After all of the  $\text{Li}(s)$  has reacted with  $\text{H}_2\text{O}(l)$ , the solution in the flask is added to a clean, dry buret and used to titrate an aqueous solution of a monoprotic acid. The pH curve for this titration is shown in the diagram at right.



9. On the basis of the pH curve, the  $\text{pK}_a$  value of the acid used in the titration is closest to

- (A) 4  
(B) 5  
(C) 8  
(D) 12

10. Which of the following indicators would be the best choice for determining the end point in this titration?

|     | Indicator       | $\text{pK}_a$ | pH Range    | Acid Form | Base Form |
|-----|-----------------|---------------|-------------|-----------|-----------|
| (A) | Methyl Orange   | 4.2           | 3.1 – 4.4   | Red       | Yellow    |
| (B) | Methyl Red      | 5.0           | 4.2 – 6.2   | Red       | Yellow    |
| (C) | Thymol Blue     | 8.9           | 8.0 – 9.6   | Yellow    | Blue      |
| (D) | Alizarin Yellow | 11.0          | 10.1 – 12.0 | Yellow    | Red       |

11. Which of the following is the balanced net-ionic equation for the reaction between  $\text{Li}(s)$  and water?

- (A)  $2 \text{Li}(s) + 2 \text{H}^+(aq) \rightarrow 2 \text{Li}^+(aq) + \text{H}_2(g)$   
(B)  $2 \text{Li}(s) + 2 \text{H}_2\text{O}(l) \rightarrow 2 \text{Li}^+(aq) + 2 \text{OH}^-(aq) + \text{H}_2(g)$   
(C)  $2 \text{Li}(s) + 2 \text{H}_2\text{O}(l) \rightarrow 2 \text{LiOH}(s) + \text{H}_2(g)$   
(D)  $2 \text{Li}(s) + 8 \text{H}_2\text{O}(l) \rightarrow 2 \text{LiH}(s) + 8 \text{OH}^-(aq) + 3 \text{H}_2(g)$

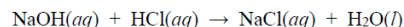
| Acid Solution | Volume of $\text{NaOH}$ Added (mL) |
|---------------|------------------------------------|
| A             | 40                                 |
| B             | 75                                 |
| C             | 115                                |
| D             | 200                                |



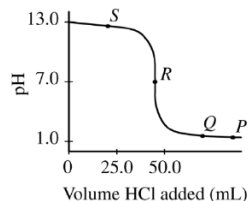
12. To maximize the yield in a certain manufacturing process, a solution of a weak monoprotic acid that has a concentration between  $0.20\text{ M}$  and  $0.30\text{ M}$  is required. Four  $100.\text{ mL}$  samples of the acid at different concentrations are each titrated with a  $0.20\text{ M}$   $\text{NaOH}$  solution. The volume of  $\text{NaOH}$  needed to reach the end point for each sample is given in the table above. Which solution is the most suitable to maximize the yield?

- (A) Solution A  
(B) Solution B  
(C) Solution C  
(D) Solution D

Questions 13 – 14 refer to the following information.



To determine the concentration of a  $\text{NaOH}(aq)$  solution, a student titrated a  $50.\text{ mL}$  sample with  $0.10\text{ M}$   $\text{HCl}(aq)$ . The reaction is represented by the equation above. The titration is monitored using a pH meter, and the experimental results are plotted in the graph below.



13. At the point labeled R on the pH curve, which of the following ions are present in the reaction mixture at a concentration greater than  $0.01\text{ M}$ ?

- (A)  $\text{Na}^+$  and  $\text{Cl}^-$  only  
(B)  $\text{Na}^+$ ,  $\text{Cl}^-$ , and  $\text{H}^+$  only  
(C)  $\text{Na}^+$ ,  $\text{Cl}^-$ , and  $\text{OH}^-$  only  
(D)  $\text{Na}^+$ ,  $\text{Cl}^-$ ,  $\text{H}^+$ , and  $\text{OH}^-$

14. One student titrated the  $\text{NaOH}(aq)$  with  $1.0\text{ M}$   $\text{HCl}(aq)$  instead of  $0.10\text{ M}$   $\text{HCl}(aq)$ . How would the student's titration curve differ from the original curve?

- (A) The initial pH would be 11 instead of 13.  
(B) The pH at the equivalence point would be 5 instead of 7.  
(C) The pH far beyond the equivalence point would be higher than in the original curve.  
(D) The pH far beyond the equivalence point would be lower than in the original curve.

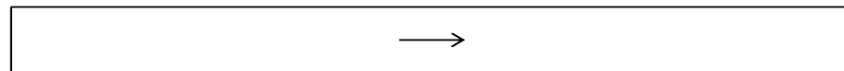
|             | Concentration and Identity of Solute |
|-------------|--------------------------------------|
| Solution #1 | $1.0\text{ M HF}$                    |
| Solution #2 | $0.80\text{ M NaF}$                  |

1. Two different aqueous solutions are represented in the table above.

- (a) The  $K_a$  value for  $\text{HF}$  is equal to  $6.8 \times 10^{-4}$ . Calculate the pH of Solution #1. Show the set-up for your calculations in order to receive full credit. Round your answer to two decimal places.
- (b) Calculate the value of  $K_b$  for the fluoride ion,  $\text{F}^-$ . Show the set-up for your calculations in order to receive full credit. Round your answer to two significant figures.
- (c) Calculate the pH of Solution #2. Show the set-up for your calculations in order to receive full credit. Round your answer to two decimal places.
- (d) Solution #3 is prepared by combining  $500.\text{ mL}$  of Solution #1 with  $500.\text{ mL}$  of Solution #2. Calculate the value of  $[\text{HF}]$  and  $[\text{F}^-]$  in Solution #3. Assume that the volume of this solution is equal to  $1.00\text{ L}$ .

$[\text{HF}] =$  \_\_\_\_\_  $[\text{F}^-] =$  \_\_\_\_\_

- (e) Calculate the pH of Solution #3. Show the set-up for your calculations in order to receive full credit. Round your answer to two decimal places.
- (f) Write a balanced net-ionic equation for the chemical reaction that would occur if a few drops of concentrated  $\text{HCl}$  solution were added to Solution #3.



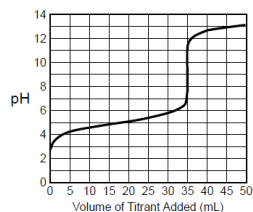
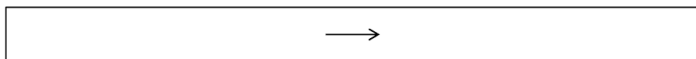
- (g) Solution #4 is prepared by adding  $4\text{ mL}$  of  $10\text{ M}$   $\text{HCl}$  to  $1.00\text{ L}$  of Solution #3. Calculate the value of  $[\text{HF}]$  and  $[\text{F}^-]$  in Solution #4. Assume that the volume of this solution is equal to  $1.00\text{ L}$ .

$[\text{HF}] =$  \_\_\_\_\_  $[\text{F}^-] =$  \_\_\_\_\_

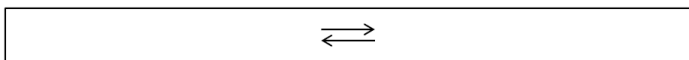
- (h) Calculate the pH of Solution #4. Show the set-up for your calculations in order to receive full credit. Round your answer to two decimal places.

2. In a certain experiment a propanoic acid ( $\text{C}_2\text{H}_5\text{CO}_2\text{H}$ ) solution is titrated with a solution of potassium hydroxide.

- (a) Write a balanced net-ionic equation for the chemical reaction between propanoic acid and potassium hydroxide.



- (b) In Trial 1 of this experiment, 25.0 mL of propanoic acid was titrated with 0.50 *M* potassium hydroxide. The pH titration curve shown above was generated for Trial 1. The volume of the titrant required to reach the equivalence point in this experiment is \_\_\_\_\_ mL.
- (c) Determine the value of  $K_a$  for propanoic acid. Justify your answer.
- (d) Calculate each of the following quantities. Show the set-up for your calculations in order to receive full credit.
- the moles of potassium hydroxide that reacted in this titration experiment
  - the concentration of the propanoic acid solution used in this titration experiment
- (e) Circle two of the following chemical substances that are present in the highest concentration in the solution at the equivalence point of the titration.
- $\text{H}_3\text{O}^+$        $\text{OH}^-$        $\text{K}^+$        $\text{C}_2\text{H}_5\text{CO}_2\text{H}$        $\text{C}_2\text{H}_5\text{CO}_2^-$
- (f) Write a balanced net-ionic equation for the chemical reaction between water and one of the substances that you circled in part (e). The equation you write should justify why the pH of the solution at the equivalence point is equal to 9.2.



| Indicator  | $\text{p}K_a$ | pH Range  | Acid Form | Base Form |
|------------|---------------|-----------|-----------|-----------|
| Methyl Red | 5.0           | 4.2 – 6.2 | Red       | Yellow    |

- (g) A second trial of this experiment is performed using the same conditions as Trial 1, except that an acid-base indicator is used instead of a pH meter. Would methyl red be an appropriate choice for an indicator in this titration? Justify your answer.

3. Answer the following questions concerning magnesium hydroxide,  $\text{Mg}(\text{OH})_2$ .

- (a) A saturated solution of  $\text{Mg}(\text{OH})_2(s)$  is prepared that is in equilibrium with  $\text{Mg}(\text{OH})_2(s)$ . Write the solubility-product expression,  $K_{sp}$ , for  $\text{Mg}(\text{OH})_2$ .

- (b) The pH of a saturated solution of magnesium hydroxide is equal to 10.52.

(i) Calculate the value of  $[\text{OH}^-]$  in this saturated solution: \_\_\_\_\_

(ii) Calculate the value of  $[\text{Mg}^{2+}]$  in this solution: \_\_\_\_\_

- (c) Use your answers to part (b) to calculate the value of  $K_{sp}$  for  $\text{Mg}(\text{OH})_2$ . Show the set-up for your calculations in order to receive full credit.

- (d) In a different experiment, 50.0 mL of  $4.0 \times 10^{-4} \text{ M}$   $\text{Mg}(\text{NO}_3)_2$  was added to 50.0 mL of  $3.0 \times 10^{-4} \text{ M}$   $\text{NaOH}$ . Assume that the final volume of this solution is 100.0 mL. Will a precipitate be formed in this experiment? Justify your answer by comparing the value of  $Q$  to the value of  $K_{sp}$  obtained in part (c).

## Unit 7 Electrochem Practice Quiz - MF

## CHAPTER 4 (Sections 4.1 – 4.4) PRACTICE QUIZ

## MULTIPLE CHOICE (NO CALCULATOR ALLOWED)

 ←Linked at 8:52


10. Which of the following statements is true regarding the reaction above?

- (A) Sulfur is being oxidized because its oxidation state changes from  $-2$  to  $+2$ .  
 (B) Hydrogen is being oxidized because its oxidation state changes from  $+1$  to  $0$ .  
 (C) Silver is being oxidized because its oxidation state changes from  $0$  to  $+1$ .  
 (D) This is not an oxidation-reduction reaction.



11. Which of the following statements is true regarding the reaction above?

- (A) Manganese is oxidized; sulfur is reduced.  
 (B) Sulfur is oxidized; manganese is reduced.  
 (C) Potassium is oxidized; hydrogen is reduced.  
 (D) Hydrogen is oxidized; potassium is reduced.

12. Which of the following choices represents a pair of substance in which carbon has the same oxidation state in each substance?

- (A)  $\text{CH}_4$  and  $\text{CH}_3\text{OH}$   
 (B)  $\text{CH}_2\text{O}$  and  $\text{CO}$   
 (C)  $\text{C}_2\text{H}_4$  and  $\text{C}_6\text{H}_6$   
 (D)  $\text{CO}_2$  and  $\text{H}_2\text{CO}_3$

13. A certain metal is added to a solution of cobalt(II) nitrate, and no visible sign of reaction occurs. When this metal is added to a solution of hydrochloric acid, bubbles appear on the surface of the metal. The identity of metal is most likely to be

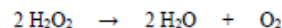
- (A) calcium  
 (B) zinc  
 (C) tin  
 (D) silver

|                |                                                                          |
|----------------|--------------------------------------------------------------------------|
| Most reactive  | $\text{Li(s)} \rightarrow \text{Li}^+(\text{aq}) + \text{e}^-$           |
|                | $\text{K(s)} \rightarrow \text{K}^+(\text{aq}) + \text{e}^-$             |
|                | $\text{Ba(s)} \rightarrow \text{Ba}^{2+}(\text{aq}) + 2\text{e}^-$       |
|                | $\text{Ca(s)} \rightarrow \text{Ca}^{2+}(\text{aq}) + 2\text{e}^-$       |
|                | $\text{Na(s)} \rightarrow \text{Na}^+(\text{aq}) + \text{e}^-$           |
|                | $\text{Mg(s)} \rightarrow \text{Mg}^{2+}(\text{aq}) + 2\text{e}^-$       |
|                | $\text{Al(s)} \rightarrow \text{Al}^{3+}(\text{aq}) + 3\text{e}^-$       |
|                | $\text{Mn(s)} \rightarrow \text{Mn}^{2+}(\text{aq}) + 2\text{e}^-$       |
|                | $\text{Zn(s)} \rightarrow \text{Zn}^{2+}(\text{aq}) + 2\text{e}^-$       |
|                | $\text{Cr(s)} \rightarrow \text{Cr}^{3+}(\text{aq}) + 3\text{e}^-$       |
|                | $\text{Fe(s)} \rightarrow \text{Fe}^{2+}(\text{aq}) + 2\text{e}^-$       |
|                | $\text{Co(s)} \rightarrow \text{Co}^{2+}(\text{aq}) + 2\text{e}^-$       |
|                | $\text{Ni(s)} \rightarrow \text{Ni}^{2+}(\text{aq}) + 2\text{e}^-$       |
|                | $\text{Sn(s)} \rightarrow \text{Sn}^{2+}(\text{aq}) + 2\text{e}^-$       |
|                | $\text{Pb(s)} \rightarrow \text{Pb}^{2+}(\text{aq}) + 2\text{e}^-$       |
|                | $\text{H}_2\text{(g)} \rightarrow 2 \text{H}^+(\text{aq}) + 2\text{e}^-$ |
|                | $\text{Cu(s)} \rightarrow \text{Cu}^{2+}(\text{aq}) + 2\text{e}^-$       |
|                | $\text{Ag(s)} \rightarrow \text{Ag}^+(\text{aq}) + \text{e}^-$           |
|                | $\text{Hg(l)} \rightarrow \text{Hg}^{2+}(\text{aq}) + 2\text{e}^-$       |
|                | $\text{Pt(s)} \rightarrow \text{Pt}^{2+}(\text{aq}) + 2\text{e}^-$       |
| Least reactive | $\text{Au(s)} \rightarrow \text{Au}^{3+}(\text{aq}) + 3\text{e}^-$       |

Name: \_\_\_\_\_ Pd\_\_\_\_\_

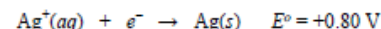
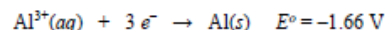
## CHAPTER 20 PRACTICE QUIZ

## MULTIPLE CHOICE – NO CALCULATOR ALLOWED

 ←Linked at 0:00


1. Which of the following statements is true concerning the reaction shown above?

- (A) Hydrogen is oxidized and oxygen is reduced.  
 (B) Oxygen is oxidized and hydrogen is reduced.  
 (C) Oxygen is both oxidized and reduced.  
 (D) No elements are oxidized or reduced; the reaction is not a redox reaction.



2. According to the standard reduction potentials given above, which of the following mathematical operations correctly calculates the standard cell potential for the reaction represented below?

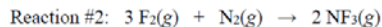
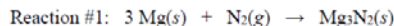


- (A)  $(-1.66 \text{ V}) + [(3)(-0.80 \text{ V})] = -4.06 \text{ V}$   
 (B)  $(+1.66 \text{ V}) + [(3)(+0.80 \text{ V})] = +4.06 \text{ V}$   
 (C)  $(-1.66 \text{ V}) + (-0.80 \text{ V}) = -2.46 \text{ V}$   
 (D)  $(+1.66 \text{ V}) + (+0.80 \text{ V}) = +2.46 \text{ V}$

| Half-reaction                                                                                        | Standard Reduction Potential at 25°C (V) |
|------------------------------------------------------------------------------------------------------|------------------------------------------|
| $\text{Li}^+(\text{aq}) + \text{e}^- \rightarrow \text{Li(s)}$                                       | $-3.05$                                  |
| $2 \text{H}_2\text{O(l)} + 2 \text{e}^- \rightarrow \text{H}_2\text{(g)} + 2 \text{OH}^-(\text{aq})$ | $-0.83$                                  |

3. A direct current is passed through a 1.00 M aqueous solution of lithium chloride (LiCl). Chlorine gas is observed as a product at the anode. Based on the information in the table above, which of the following identifies the chemical species that is formed at the cathode and gives the correct justification?

- (A)  $\text{Li(s)}$  is produced at the cathode because  $|-3.05|$  is greater than  $|-0.83|$ .  
 (B)  $\text{H}_2\text{(g)}$  is produced at the cathode because  $|-0.83|$  is less than  $|-3.05|$ .  
 (C)  $\text{Li(s)}$  is produced at the cathode because the reduction of water is more favorable than the reduction of lithium ions.  
 (D)  $\text{H}_2\text{(g)}$  is produced at the cathode because the reduction of lithium ions is more favorable than the reduction of water.



4. Which of the following statements is true concerning the two reactions shown above?

- (A)  $\text{N}_2$  is oxidized in both reactions.
- (B)  $\text{N}_2$  is reduced in both reactions.
- (C)  $\text{N}_2$  is oxidized in Reaction #1, and reduced in Reaction #2.
- (D)  $\text{N}_2$  is oxidized in Reaction #2, and reduced in Reaction #1.

Questions 5 – 7 refer to galvanic cells made from different combinations of the three half-cells described below.

Half-cell 1: strip of  $\text{Al}(s)$  in  $1.00 \text{ M Al}(\text{NO}_3)_3(aq)$

Half-cell 2: strip of  $\text{Cu}(s)$  in  $1.00 \text{ M Cu}(\text{NO}_3)_2(aq)$

Half-cell 3: strip of  $\text{Fe}(s)$  in  $1.00 \text{ M Fe}(\text{NO}_3)_2(aq)$

| Galvanic Cell | Half-cells | Cell Reaction                                                                                 | $E^\circ_{\text{cell}}$ (V) |
|---------------|------------|-----------------------------------------------------------------------------------------------|-----------------------------|
| X             | 1 and 2    | $2 \text{ Al}(s) + 3 \text{ Cu}^{2+}(aq) \rightarrow 2 \text{ Al}^{3+}(aq) + 3 \text{ Cu}(s)$ | 2.00                        |
| Y             | 1 and 3    | $2 \text{ Al}(s) + 3 \text{ Fe}^{2+}(aq) \rightarrow 2 \text{ Al}^{3+}(aq) + 3 \text{ Fe}(s)$ | 1.22                        |
| Z             | 2 and 3    | $\text{Fe}(s) + \text{Cu}^{2+}(aq) \rightarrow \text{Fe}^{2+}(aq) + \text{Cu}(s)$             | ?                           |

5. What is the standard cell potential of galvanic cell Z?

- (A) 0.26 V
- (B) 0.78 V
- (C) 2.34 V
- (D) 3.22 V

6. In galvanic cells Y and Z, which of the following takes place in half-cell 3?

- (A) Reduction occurs in both cell Y and cell Z.
- (B) Oxidation occurs in both cell Y and cell Z.
- (C) Reduction occurs in cell Y, and oxidation occurs in cell Z.
- (D) Oxidation occurs in cell Y, and reduction occurs in cell Z.

7. If the half-cell containing  $1.00 \text{ M Fe}(\text{NO}_3)_2(aq)$  in galvanic cells Y and Z is replaced with a half-cell containing  $5.00 \text{ M Fe}(\text{NO}_3)_2(aq)$ , what will be the effect on the cell voltage of the two galvanic cells?

- (A) The voltage will increase in both cells.
- (B) The voltage will decrease in both cells.
- (C) The voltage will increase in cell Y and decrease in cell Z.
- (D) The voltage will decrease in cell Y and increase in cell Z.

| Half-Reaction                                         | $E^\circ$ (V) |
|-------------------------------------------------------|---------------|
| $\text{Ag}^+(aq) + e^- \rightarrow \text{Ag}(s)$      | +0.80         |
| $\text{Cu}^{2+}(aq) + 2 e^- \rightarrow \text{Cu}(s)$ | +0.34         |
| $\text{Ni}^{2+}(aq) + 2 e^- \rightarrow \text{Ni}(s)$ | -0.28         |
| $\text{Zn}^{2+}(aq) + 2 e^- \rightarrow \text{Zn}(s)$ | -0.76         |

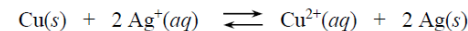
8. A standard voltaic cell is to be constructed using two different metals. Based on the standard reduction potentials listed in the table above, which combination will produce the largest cell potential?

- (A) silver and copper
- (B) silver and zinc
- (C) nickel and copper
- (D) nickel and zinc

| Half-Reaction                                           | $E^\circ$ (V) |
|---------------------------------------------------------|---------------|
| $\text{Cl}_2(g) + 2 e^- \rightarrow 2 \text{ Cl}^-(aq)$ | +1.36         |
| $\text{Br}_2(l) + 2 e^- \rightarrow 2 \text{ Br}^-(aq)$ | +1.06         |
| $\text{Fe}^{2+}(aq) + 2 e^- \rightarrow \text{Fe}(s)$   | -0.44         |
| $\text{Sn}^{2+}(aq) + 2 e^- \rightarrow \text{Sn}(s)$   | -0.14         |

9. Based on the information in the table above, which of the following reactions is favored to occur under standard conditions?

- (A)  $\text{Cl}_2(g) + \text{Fe}(s) \rightarrow 2 \text{ Cl}^-(aq) + \text{Fe}^{2+}(aq)$
- (B)  $\text{Fe}^{2+}(aq) + 2 \text{ Br}^-(aq) \rightarrow \text{Fe}(s) + \text{Br}_2(g)$
- (C)  $\text{Br}_2(l) + 2 \text{ Cl}^-(aq) \rightarrow 2 \text{ Br}^-(aq) + \text{Cl}_2(g)$
- (D)  $\text{Fe}^{2+}(aq) + \text{Sn}(s) \rightarrow \text{Fe}(s) + \text{Sn}^{2+}(aq)$



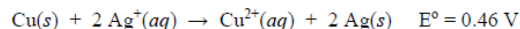
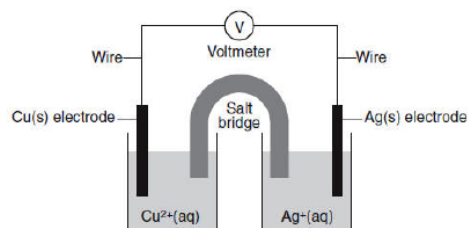
10. The equilibrium constant for the reaction above is  $4 \times 10^{15}$ . Which of the following correctly describes the standard voltage ( $E^\circ$ ) and the standard free energy change ( $\Delta G^\circ$ ) for this reaction?

- (A)  $\Delta G^\circ > 0$  and  $E^\circ < 0$
- (B)  $\Delta G^\circ > 0$  and  $E^\circ > 0$
- (C)  $\Delta G^\circ < 0$  and  $E^\circ < 0$
- (D)  $\Delta G^\circ < 0$  and  $E^\circ > 0$

## FREE RESPONSE (CALCULATOR IS ALLOWED)

11. In a certain experiment, molten  $\text{CaCl}_2$  undergoes electrolysis, and the electrical current is 12.0 amps. Which of the following calculations is set up correctly to determine the time (in seconds) required to produce 1.00 gram of calcium?

- (A)  $\frac{(2)(96485)(12.0)}{(40.08)}$
- (B)  $\frac{(2)(96485)}{(40.08)(12.0)}$
- (C)  $\frac{(96485)(12.0)}{(40.08)(2)}$
- (D)  $\frac{(96485)}{(2)(40.08)(12.0)}$



12. When the voltaic cell shown above is operated under standard conditions, the initial concentrations of  $\text{Cu}^{2+}(aq)$  and  $\text{Ag}^+(aq)$  are each equal to 1.0 M. The cell potential is equal to 0.46 V at 25°C. A few drops of concentrated hydrochloric acid,  $\text{HCl}(aq)$ , are added to the beaker containing the cathode, and a precipitate forms. Which of the following correctly predicts the effect of this change on the cell potential and gives the correct justification for it?

|     | The cell potential should be... | Justification                    |
|-----|---------------------------------|----------------------------------|
| (A) | less than 0.46 V                | $[\text{Cu}^{2+}]$ has decreased |
| (B) | more than 0.46 V                | $[\text{Cu}^{2+}]$ has decreased |
| (C) | less than 0.46 V                | $[\text{Ag}^+]$ has decreased    |
| (D) | more than 0.46 V                | $[\text{Ag}^+]$ has decreased    |

4. For each of the following reactions, identify which elements, if any, are being oxidized and which elements are being reduced. Fill in the blanks with the correct oxidation numbers for the appropriate elements before and after the reaction.

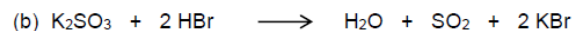
If there are no changes in oxidation number for any of the elements in the reaction, check the box to indicate that it is not an oxidation–reduction reaction.



\_\_\_\_\_ is being oxidized from \_\_\_\_\_ to \_\_\_\_\_ and

\_\_\_\_\_ is being reduced from \_\_\_\_\_ to \_\_\_\_\_

\_\_\_\_\_ This is not an oxidation–reduction reaction.



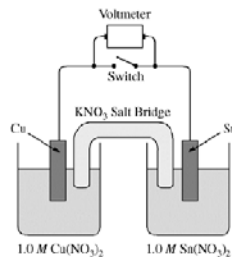
\_\_\_\_\_ is being oxidized from \_\_\_\_\_ to \_\_\_\_\_ and

\_\_\_\_\_ is being reduced from \_\_\_\_\_ to \_\_\_\_\_

\_\_\_\_\_ This is not an oxidation–reduction reaction.

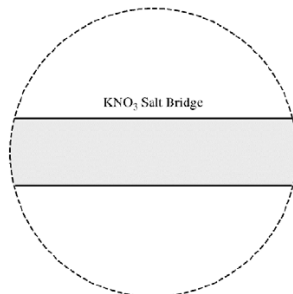


## FREE RESPONSE – CALCULATOR IS ALLOWED



1. A student is given a standard galvanic cell, represented above, that has a Cu electrode and a Sn electrode. As current flows through the cell, the student determines that the Cu electrode increases in mass and the Sn electrode decreases in mass.

- Identify the electrode at which oxidation is occurring. Explain your reasoning based on the student's observations.
- As the mass of the Sn electrode decreases, where does the mass go?
- In the expanded view of the center portion of the salt bridge shown in the diagram below, draw and label a particle view of what occurs in the salt bridge as the cell begins to operate. Omit solvent molecules and use arrows to show the movement of particles.

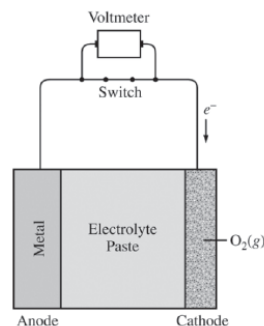


- A nonstandard cell is made by replacing the 1.0 M solutions of  $\text{Cu}(\text{NO}_3)_2$  and  $\text{Sn}(\text{NO}_3)_2$  in the standard cell with 0.50 M solutions of  $\text{Cu}(\text{NO}_3)_2$  and  $\text{Sn}(\text{NO}_3)_2$ . The volumes of solutions in the nonstandard cell are identical to those in the standard cell.
  - Is the cell potential of the nonstandard cell greater than, less than, or equal to the cell potential of the standard cell? Justify your answer.
  - Both the standard and nonstandard cells can be used to power an electronic device. Would the nonstandard cell power the device for the same time, a longer time, or a shorter time as compared with the standard cell? Justify your answer.

- (e) In another experiment, the student places a new Sn electrode into a fresh solution of 1.0 M  $\text{Cu}(\text{NO}_3)_2$ .

| Half-Reaction                                              | $E^\circ$ (V) |
|------------------------------------------------------------|---------------|
| $\text{Cu}^+(aq) + e^- \rightarrow \text{Cu}(s)$           | 0.52          |
| $\text{Cu}^{2+}(aq) + 2e^- \rightarrow \text{Cu}(s)$       | 0.34          |
| $\text{Sn}^{4+}(aq) + 2e^- \rightarrow \text{Sn}^{2+}(aq)$ | 0.15          |
| $\text{Sn}^{2+}(aq) + 2e^- \rightarrow \text{Sn}(s)$       | -0.14         |

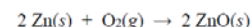
- Using information from the table above, write a net-ionic equation for the reaction between the Sn electrode and the  $\text{Cu}(\text{NO}_3)_2$  solution that would be thermodynamically favorable. Justify that the reaction is thermodynamically favorable.
- Calculate the value of  $\Delta G^\circ$  for the reaction. Include units with your answer.



2. Metal-air cells are a relatively new type of portable energy source consisting of a metal anode, an alkaline electrolyte paste that contains water, and a porous cathode membrane that lets in oxygen from the air. A schematic of the cell is shown above. Reduction potentials for the cathode and three possible metal anodes are given in the table below.

| Half Reaction                                                                                        | Potential ( $E$ ) at pH 11 and 298 K |
|------------------------------------------------------------------------------------------------------|--------------------------------------|
| $\text{O}_2(g) + 2\text{H}_2\text{O}(l) + 4e^- \rightarrow 4\text{OH}^-(aq)$                         | +0.34 V                              |
| $\text{ZnO}(s) + \text{H}_2\text{O}(l) + 2e^- \rightarrow \text{Zn}(s) + 2\text{OH}^-(aq)$           | -1.31 V                              |
| $\text{Na}_2\text{O}(s) + \text{H}_2\text{O}(l) + 2e^- \rightarrow 2\text{Na}(s) + 2\text{OH}^-(aq)$ | -1.60 V                              |
| $\text{CaO}(s) + \text{H}_2\text{O}(l) + 2e^- \rightarrow \text{Ca}(s) + 2\text{OH}^-(aq)$           | -2.78 V                              |

- (a) Early forms of metal-air cells used zinc as the anode. Zinc oxide is produced as the cell operates according to the overall equation below.



- Using the data in the table above, calculate the cell potential for the zinc-air cell.
- The electrolyte paste contains  $\text{OH}^-$  ions. On the diagram of the cell above, draw an arrow to indicate the direction of migration of  $\text{OH}^-$  ions through the electrolyte as the cell operates.



2. (b) A fresh zinc-air cell is weighed on an analytical balance before being placed in a hearing aid for use.

(i) As the cell operates, does the mass of the cell increase, decrease, or remain the same?

(ii) Justify your answer to part (b)(i) in terms of the equation for the overall cell reaction.

- (c) The zinc-air cell is taken to the top of a mountain where the air pressure is lower.

(i) Will the cell potential be higher, lower, or the same as the cell potential at the lower elevation?

(ii) Justify your answer to part (c)(i) based on the equation for the overall cell reaction and the information above.

- (d) Metal-air cells need to be lightweight for many applications. In order to transfer more electrons with a smaller mass, Na and Ca are investigated as potential anodes. A 1.0 g anode of which of these metals would transfer more electrons, assuming that the anode is totally consumed during the lifetime of a cell? Justify your answer with calculations.

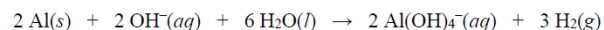
3. An electrolytic cell produces 235 g of Al(l) according to the equation above.

(a) Calculate the number of moles of electrons that must be transferred in the cell to produce 235 g of Al(l).

(b) A steady current of 152 A was used during the process. Determine the amount of time, in seconds, that was needed to produce 235 g of Al(l).

(c) Calculate the volume of CO<sub>2</sub>(g), measured at 300 K and 1.00 atm, that is produced in the process.

When Al(s) is placed in a concentrated solution of KOH at 25°C, the reaction represented below occurs.



| Half-reaction                                                                       | $E^\circ$ (V) |
|-------------------------------------------------------------------------------------|---------------|
| $\text{Al}(\text{OH})_4^-(aq) + 3 e^- \rightarrow \text{Al}(s) + 4 \text{OH}^-(aq)$ | -2.35         |
| $2 \text{H}_2\text{O}(l) + 2 e^- \rightarrow \text{H}_2(g) + 2 \text{OH}^-(aq)$     | -0.83         |

- (d) Using the table of standard reduction potentials shown above, calculate the following.

(i)  $E^\circ$ , in volts, for the formation of Al(OH)<sub>4</sub><sup>-</sup>(aq) and H<sub>2</sub>(g) at 25°C.

(ii)  $\Delta G^\circ$ , in kJ/mol<sub>rxn</sub>, for the formation of Al(OH)<sub>4</sub><sup>-</sup>(aq) and H<sub>2</sub>(g) at 25°C.

## Unit 8: Atomic Structure, Periodicity &amp; Bonding

CHAPTER 5 – 6 PRACTICE QUIZ (Sections 5.5 – 5.7, 6.1 – 6.3, 6.5 – 6.8)



←Linked at 10:26

MULTIPLE CHOICE – NO CALCULATOR ALLOWED

| Type of electromagnetic radiation | Frequency (s <sup>-1</sup> ) | Wavelength (m)      | Energy (J)          |
|-----------------------------------|------------------------------|---------------------|---------------------|
| X                                 | $3 \times 10^{21}$           | $1 \times 10^{-13}$ | $2 \times 10^{-12}$ |
| Y                                 | $3 \times 10^{14}$           | ?                   | ?                   |

9. Two types of electromagnetic radiation, X and Y, are represented in the data table above. Which of the following are the most probable values for wavelength and energy associated with Y?

(A)  $1 \times 10^{-20}$  m,  $2 \times 10^{-5}$  J  
 (B)  $1 \times 10^{-20}$  m,  $2 \times 10^{-19}$  J  
 (C)  $1 \times 10^{-6}$  m,  $2 \times 10^{-5}$  J  
 (D)  $1 \times 10^{-6}$  m,  $2 \times 10^{-19}$  J

10. Which of the following statements is most closely associated with the photoelectric effect?

(A) Light shining on a clean metal surface causes the surface to emit electrons.  
 (B) Energy is emitted by electrons as they travel from an higher energy state toward a lower energy state.  
 (C) Electrons exist only in certain discrete energy levels, which are described by quantum numbers.  
 (D) The solution to Schrodinger's equation for the hydrogen atom yields a set of wave functions called orbitals.

11. Which of the following represents the ground state electron configuration and an excited state electron configuration for the same element?

|     | Ground State          | Excited State         |
|-----|-----------------------|-----------------------|
| (A) | $1s^2 2s^2 2p^1$      | $1s^2 2s^2 2d^1$      |
| (B) | $1s^2 2s^2 2p^6$      | $1s^2 2s^2 2p^5 3s^1$ |
| (C) | $1s^2 2s^2 2p^5$      | $1s^2 2s^2 2p^6$      |
| (D) | $1s^2 2s^2 2p^6 3s^2$ | $1s^2 2s^2 2p^5 3s^3$ |

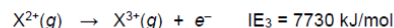
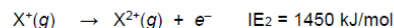
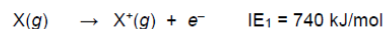
12. There are eight elements located in Period 3 of the periodic table. How many of these elements have a ground state electron configuration that contains exactly two unpaired electrons?

(A) one                      (B) two                      (C) three                      (D) four

13. When electrons are removed from an atom to form a cation, they are always removed first from the occupied orbitals having the largest principal quantum number ( $n$ ). Which of the following represents the ground state electron configuration for the  $\text{Co}^{2+}$  ion?

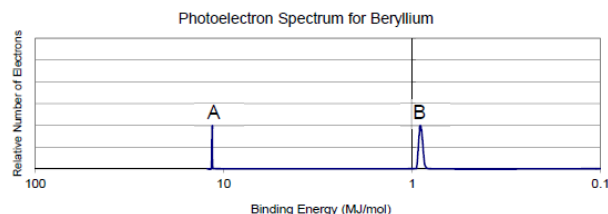
(A)  $[\text{Ar}] 3d^7$                       (B)  $[\text{Ar}] 3d^5 4s^2$                       (C)  $[\text{Ar}] 3d^6 4s^1$                       (D)  $[\text{Ar}] 3d^7 4s^2$

Name: \_\_\_\_\_ Pd \_\_\_\_\_



14. For element X represented above, which of the following is the most likely explanation for the large difference between the second and third ionization energies?

(A) The effective nuclear charge decreases with successive ionizations.  
 (B) The shielding of outer electrons increases with successive ionizations.  
 (C) The electron removed during the third ionization is, on average, much closer to the nucleus than the first two electrons were.  
 (D) The electron removed during the third ionization is located in a higher energy level than the first two electrons were.



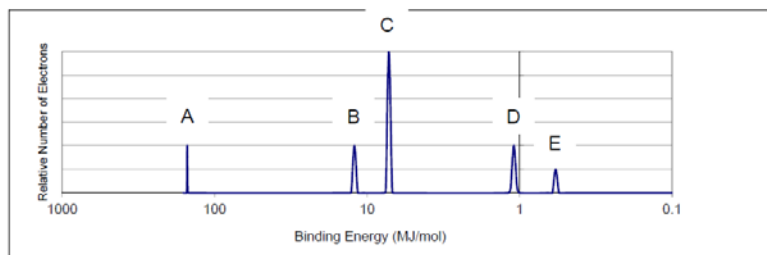
15. The diagram above represents the photoelectron spectrum for beryllium. Which of the following statements is correct concerning Peak A and Peak B?

(A) The electrons represented by Peak A require more energy to remove because they are located in a full s orbital.  
 (B) The electrons represented by Peak B require more energy to remove because they are located in a full s orbital.  
 (C) The electrons represented by Peak A require more energy to remove because they are closer to the nucleus.  
 (D) The electrons represented by Peak B require more energy to remove because they are closer to the nucleus.



2. A certain light source produces yellow light with a wavelength of 580 nm.

- Calculate the frequency of this light in units of  $\text{s}^{-1}$ . Show your work below in order to receive full credit.
- Calculate the energy of a single photon of this light in units of joules. Show your work below in order to receive full credit.
- The Br–Br bond has a bond energy of 192 kJ/mol. Does light with a wavelength of 580 nm have sufficient energy to break the Br–Br bond? Justify your answer with a calculation. Show your work below in order to receive full credit.
- A different light source that emits infrared light is shined on a sample of  $\text{Br}_2$  molecules.
  - The wavelength of infrared light is ( shorter longer ) than 580 nm.
  - The frequency of infrared light is ( lower higher ) than the frequency of yellow light.
  - Therefore, the energy associated with infrared light is ( lower higher ) than the value that was calculated in part (b) for yellow light.
  - It is likely that infrared radiation ( would wouldn't ) have sufficient energy to break the Br–Br bond.



3. The diagram shown above represents the photoelectron spectrum of a pure element.

- Write the chemical symbol for this element. \_\_\_\_\_
- Label each peak in the diagram with the name of the orbital in which the electrons are located. Identify the orbital with its principal quantum number ( $n$ ) and orbital type, such as 1s or 3p.  
A \_\_\_\_\_ B \_\_\_\_\_ C \_\_\_\_\_ D \_\_\_\_\_ E \_\_\_\_\_
- Explain why peak D is twice as high as peak E.
- Explain why peak C has a higher binding energy than peak D.



| Element   | Atomic Radius (pm) | First Ionization Energy (kJ/mol) |
|-----------|--------------------|----------------------------------|
| Calcium   | 174                | 590                              |
| Potassium | ?                  | ?                                |

- Based on periodic trends and the data in the table above, which of the following are the most probable values for atomic radius and first ionization energy for potassium?
  - 144 pm, 419 kJ/mol
  - 144 pm, 633 kJ/mol
  - 196 pm, 419 kJ/mol
  - 196 pm, 633 kJ/mol
- Which of the following properties tends to decrease as you move from top to bottom down Group 14?
  - atomic radius
  - ionization energy
  - metallic character
  - reactivity with oxygen

| Successive Values of Ionization Energy (kJ/mol) for an Element in Period 3 |       |       |       |       |       |
|----------------------------------------------------------------------------|-------|-------|-------|-------|-------|
| $I_1$                                                                      | $I_2$ | $I_3$ | $I_4$ | $I_5$ | $I_6$ |
| 578                                                                        | 1817  | 2745  | 11577 | 14830 | 18376 |

- Based on the information in the table above, what is the most likely identity of this element?
  - Mg
  - Al
  - Si
  - P
- Which of the following series is listed in order of increasing radius?

|     | smallest radius  | -----> | largest radius |
|-----|------------------|--------|----------------|
| (A) | $\text{K}^+$     | K      | Rb             |
| (B) | $\text{Ca}^{2+}$ | Ca     | Mg             |
| (C) | $\text{O}^{2-}$  | O      | S              |
| (D) | $\text{P}^{3-}$  | P      | N              |

Skip #5

- A certain substance is dissolved in water, forming a basic ( $\text{pH} > 7$ ) solution. With respect to the possible identity of the substance and its reaction with water, which of the following choices is most likely to be correct?

|     | Possible Identity of the Substance | Chemical Reaction with Water                                                   |
|-----|------------------------------------|--------------------------------------------------------------------------------|
| (A) | $\text{CO}_2$                      | $\text{CO}_2 + \text{H}_2\text{O} \rightarrow \text{H}_2\text{CO}_3$           |
| (B) | $\text{SO}_2$                      | $\text{SO}_2 + \text{H}_2\text{O} \rightarrow \text{HSO}_2^+ + \text{OH}^-$    |
| (C) | CaO                                | $\text{CaO} + \text{H}_2\text{O} \rightarrow \text{Ca}(\text{OH})_2$           |
| (D) | BaO                                | $\text{BaO} + \text{H}_2\text{O} \rightarrow \text{Ba} + \text{H}_2\text{O}_2$ |

7. A pure sample of  $\text{XCl}_3$  exists as a colorless liquid and has a boiling point of  $76^\circ\text{C}$ . Which of the following choices represents a possible identity of element X and the type of bonding present in  $\text{XCl}_3$ ?

|     | Possible Identity of Element X | Type of Bonding in $\text{XCl}_3$ |
|-----|--------------------------------|-----------------------------------|
| (A) | phosphorus                     | ionic                             |
| (B) | phosphorus                     | covalent                          |
| (C) | nickel                         | ionic                             |
| (D) | nickel                         | covalent                          |

8. Which of the following processes would release the largest quantity of energy?

- (A)  $\text{KBr}(s) \rightarrow \text{K}^+(g) + \text{Br}^-(g)$   
 (B)  $\text{MgO}(s) \rightarrow \text{Mg}^{2+}(g) + \text{O}^{2-}(g)$   
 (C)  $\text{K}^+(g) + \text{Br}^-(g) \rightarrow \text{KBr}(s)$   
 (D)  $\text{Mg}^{2+}(g) + \text{O}^{2-}(g) \rightarrow \text{MgO}(s)$

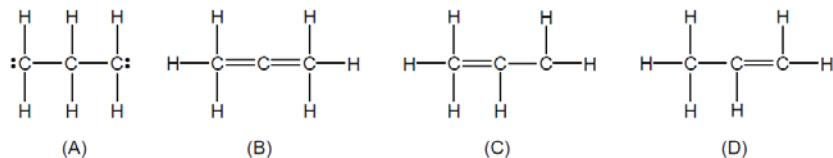
9. Which of the following bonds has the largest dipole moment?

- (A) C–N (B) P–S (C) As–F (D) Se–Br

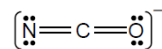
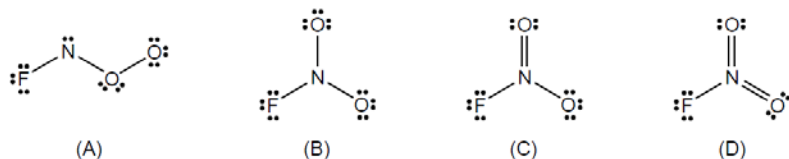
10. Which of the following molecules has a Lewis structure that is identical to nitrogen triiodide?

- (A) sulfur trioxide  
 (B) boron trichloride  
 (C) chlorine trifluoride  
 (D) arsenic tribromide

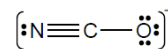
11. Which of the Lewis structures below best represents the molecule  $\text{C}_3\text{H}_6$ ?



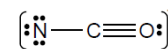
12. Which of the Lewis structures below best represents the molecule  $\text{NO}_2\text{F}$ ?



#1



#2



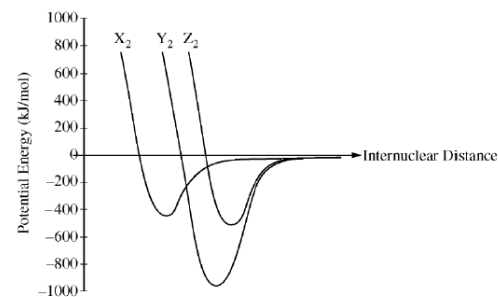
#3

13. Three different Lewis structures for the cyanate ion ( $\text{NCO}^-$ ) are shown above. Which structure, if any, is the most favorable (or dominant)?

- (A) #1, because the C–N bond length is nearly equal to the C–O bond length.  
 (B) #2, because the most electronegative atom carries the negative formal charge  
 (C) #3, because the most electronegative atom is part of a strong triple bond  
 (D) All three Lewis structures for the cyanate ion are equally favorable.

14. Which of the following series is listed in order of increasing O–O bond length (from shortest O–O bond to longest O–O bond)?

- (A)  $\text{O}_2$ ,  $\text{O}_3$ ,  $\text{H}_2\text{O}_2$   
 (B)  $\text{O}_2$ ,  $\text{H}_2\text{O}_2$ ,  $\text{O}_3$   
 (C)  $\text{O}_3$ ,  $\text{O}_2$ ,  $\text{H}_2\text{O}_2$   
 (D)  $\text{O}_3$ ,  $\text{H}_2\text{O}_2$ ,  $\text{O}_2$



15. The potential energy as a function of internuclear distance for three diatomic molecules,  $\text{X}_2$ ,  $\text{Y}_2$ , and  $\text{Z}_2$ , is shown in the graph above. Based on the data in the graph, which of the following correctly identifies the diatomic molecules,  $\text{X}_2$ ,  $\text{Y}_2$ , and  $\text{Z}_2$ ?

|     | $\text{X}_2$ | $\text{Y}_2$ | $\text{Z}_2$ |
|-----|--------------|--------------|--------------|
| (A) | $\text{H}_2$ | $\text{N}_2$ | $\text{O}_2$ |
| (B) | $\text{H}_2$ | $\text{O}_2$ | $\text{N}_2$ |
| (C) | $\text{N}_2$ | $\text{O}_2$ | $\text{H}_2$ |
| (D) | $\text{O}_2$ | $\text{H}_2$ | $\text{N}_2$ |



16. According to the data in the table below, what is the estimated value of  $\Delta H^\circ$  for the reaction shown above?

| Bond  | Average Bond Enthalpy (kJ/mol) |
|-------|--------------------------------|
| I-I   | 150                            |
| Cl-Cl | 240                            |
| I-Cl  | 210                            |

- (A) -390 kJ  
(B) -180 kJ  
(C) +180 kJ  
(D) +390 kJ

CHAPTER 4 – 5 PRACTICE QUIZ (Sections 4.5 – 4.6 & 5.1 – 5.4)

MULTIPLE CHOICE – NO CALCULATOR ALLOWED

←Linked at 11:56



12. Which of the following best describes and justifies the change in electrostatic potential energy that occurs when the two charged particles shown in the diagram above are brought closer together?

|     | Electrostatic Potential Energy | Justification                                  |
|-----|--------------------------------|------------------------------------------------|
| (A) | increases                      | the attraction between the particles increases |
| (B) | increases                      | the attraction between the particles decreases |
| (C) | decreases                      | the attraction between the particles increases |
| (D) | decreases                      | the attraction between the particles decreases |

CHAPTER 7 – 8 PRACTICE QUIZ

FREE RESPONSE – CALCULATOR IS ALLOWED

←Linked at 23:05

| Element   | 1 <sup>st</sup> Ionization energy (kJ/mol) | 2 <sup>nd</sup> Ionization energy (kJ/mol) |
|-----------|--------------------------------------------|--------------------------------------------|
| Sodium    | 496                                        | 4562                                       |
| Magnesium | 738                                        | 1451                                       |
| Potassium | 419                                        | 3052                                       |

1. The following questions refer to the information in the table above.

- (a) Write the complete electron configuration for each of the following atoms or ions.

Na \_\_\_\_\_ Na<sup>+</sup> \_\_\_\_\_

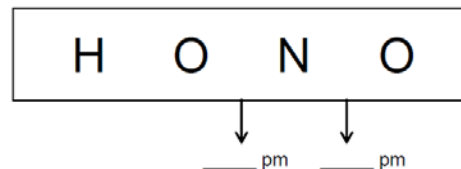
Mg \_\_\_\_\_ Mg<sup>+</sup> \_\_\_\_\_

K \_\_\_\_\_ K<sup>+</sup> \_\_\_\_\_

- (b) Explain why the 1<sup>st</sup> ionization energy of sodium is less than the 1<sup>st</sup> ionization energy of magnesium. Your answer should refer to the atomic structures of sodium and magnesium. Identify the specific orbital from which each electron is removed.
- (c) Explain why the 1<sup>st</sup> ionization energy of potassium is less than the 1<sup>st</sup> ionization energy of sodium. Your answer should refer to the atomic structures of potassium and sodium. Identify the specific orbital from which each electron is removed.
- (d) Explain why the 2<sup>nd</sup> ionization energy of sodium is higher than the 2<sup>nd</sup> ionization energy of magnesium. Your answer should refer to the electronic configurations of Na<sup>+</sup> and Mg<sup>+</sup>. Identify the specific orbital from which each electron is removed.
- (e) Which metal (Na, Mg, or K) reacts most vigorously with water? Your answer should refer to specific information from the table above and how this property is related to the reactivity of metals.

2. Answer the following questions related to nitrous acid (HNO<sub>2</sub>) and the nitrite ion (NO<sub>2</sub><sup>-</sup>).

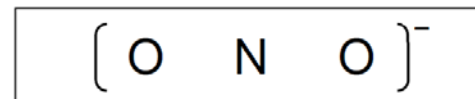
- (a) Complete the Lewis electron-dot diagram for HNO<sub>2</sub> by drawing the required number of electrons, including bonding pairs and nonbonding pairs. Each atom should have a full valence shell and a formal charge of zero.



- (b) When the HNO<sub>2</sub> molecule was analyzed, it was determined that one of the nitrogen-oxygen bonds has a length of 120 pm, and the other nitrogen-oxygen bond has a length of 146 pm.

Based on the Lewis electron dot structure that you drew in the box above, fill in the two blanks above with either a bond length of 120 pm or a bond length of 146 pm.

- (c) Complete the Lewis electron-dot diagram for the nitrite ion, NO<sub>2</sub><sup>-</sup>, by drawing the required number of electrons, including bonding pairs and nonbonding pairs.

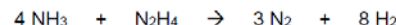


- (d) It was determined that the two nitrogen-oxygen bonds in the nitrite ion have the same length. Explain this result, using principles of chemical bonding.

- (e) Estimate the bond length of the nitrogen-oxygen bond in the nitrite ion: \_\_\_\_\_ pm

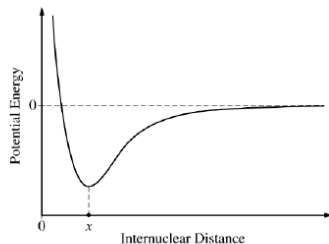
| Average Bond Enthalpies (kJ/mol) |     |
|----------------------------------|-----|
| H-H                              | 436 |
| N-H                              | 391 |
| N-N                              | 163 |
| N=N                              | 418 |
| N≡N                              | 941 |

3. Use the bond enthalpy data in the table above to estimate the value of  $\Delta H$  for the following reaction. Show your calculations below in order to receive full credit.





## MULTIPLE CHOICE – NO CALCULATOR ALLOWED



1. The potential energy of a system of two atoms as a function of their internuclear distance is shown in the diagram above. Which of the following is true regarding the forces between the atoms when their internuclear distance is  $x$  ?
- (A) The attractive and repulsive forces are balanced, so the two atoms will maintain an average internuclear distance  $x$ .
- (B) There is a net repulsive force pushing the atoms farther apart, so the atoms will continue to move farther apart from each other.
- (C) There is a net attractive force pulling the atoms closer together, so the atoms will continue to move closer together.
- (D) The diagram only shows potential energy, so it cannot be determined if the forces between the two atoms are attractive or repulsive.
2. Which of the following choices most accurately describes both the molecular geometry and the polarity for both  $\text{CO}_2$  and  $\text{SO}_2$ ?

| (A) | Substance     | Molecular Geometry | Polarity |
|-----|---------------|--------------------|----------|
|     | $\text{CO}_2$ | linear             | polar    |
|     | $\text{SO}_2$ | bent               | nonpolar |

| (C) | Substance     | Molecular Geometry | Polarity |
|-----|---------------|--------------------|----------|
|     | $\text{CO}_2$ | linear             | nonpolar |
|     | $\text{SO}_2$ | linear             | nonpolar |

| (B) | Substance     | Molecular Geometry | Polarity |
|-----|---------------|--------------------|----------|
|     | $\text{CO}_2$ | linear             | nonpolar |
|     | $\text{SO}_2$ | linear             | polar    |

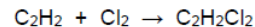
| (D) | Substance     | Molecular Geometry | Polarity |
|-----|---------------|--------------------|----------|
|     | $\text{CO}_2$ | linear             | nonpolar |
|     | $\text{SO}_2$ | bent               | polar    |

3. Which of the following statements most accurately describes boron trifluoride?
- (A) It is a nonpolar substance that contains nonpolar bonds.
- (B) It is a nonpolar substance that contains polar bonds.
- (C) It is a polar substance that contains nonpolar bonds.
- (D) It is a polar substance that contains polar bonds.
4. Which of the following choices represents the correct estimates of the bond angles in methane and water?

|     | H–C–H bond angle in $\text{CH}_4$ | H–O–H bond angle in $\text{H}_2\text{O}$ |
|-----|-----------------------------------|------------------------------------------|
| (A) | $90^\circ$                        | $180^\circ$                              |
| (B) | $109.5^\circ$                     | $105^\circ$                              |
| (C) | $109.5^\circ$                     | $109.5^\circ$                            |
| (D) | $109.5^\circ$                     | $115^\circ$                              |

5. Which of the following lists is arranged in order of increasing bond angle (i.e., from smallest bond angle to largest bond angle) ?

- (A)  $\text{NF}_3$ ,  $\text{CF}_4$ ,  $\text{BF}_3$
- (B)  $\text{NF}_3$ ,  $\text{BF}_3$ ,  $\text{CF}_4$
- (C)  $\text{CF}_4$ ,  $\text{NF}_3$ ,  $\text{BF}_3$
- (D)  $\text{CF}_4$ ,  $\text{BF}_3$ ,  $\text{NF}_3$



6. When the reaction shown above occurs, does the hybridization of the carbon atoms change?
- (A) No; the hybridization of the carbon atoms does not change.
- (B) Yes; the hybridization of the carbon atoms changes from  $\text{sp}$  to  $\text{sp}^2$ .
- (C) Yes; the hybridization of the carbon atoms changes from  $\text{sp}$  to  $\text{sp}^3$ .
- (D) Yes; the hybridization of the carbon atoms changes from  $\text{sp}^2$  to  $\text{sp}^3$ .
7. The hybridization of the carbon atoms in acetone,  $(\text{CH}_3)_2\text{CO}$ , is best described as
- (A)  $\text{sp}^2$  for all three carbon atoms
- (B)  $\text{sp}^3$  for all three carbon atoms
- (C) either  $\text{sp}$  or  $\text{sp}^2$
- (D) either  $\text{sp}^2$  or  $\text{sp}^3$
8. Which of the following molecules contains exactly three sigma ( $\sigma$ ) bonds and two pi ( $\pi$ ) bonds?
- (A)  $\text{HCN}$
- (B)  $\text{HCO}_2\text{H}$
- (C)  $\text{C}_2\text{H}_2$
- (D)  $\text{C}_2\text{H}_4$

1. (a) Fill in the missing information in the table below.

| Molecule         | Molecular Geometry | Is this Molecule Polar or Nonpolar? |
|------------------|--------------------|-------------------------------------|
| BeF <sub>2</sub> |                    |                                     |
| OF <sub>2</sub>  |                    |                                     |
| XeF <sub>2</sub> |                    |                                     |
| CF <sub>4</sub>  |                    |                                     |
| SF <sub>4</sub>  |                    |                                     |
| XeF <sub>4</sub> |                    |                                     |

- (b) Identify the bond angles for each of the following.

The F–Be–F angle in BeF<sub>2</sub> \_\_\_\_\_ The F–C–F angle in CF<sub>4</sub> \_\_\_\_\_

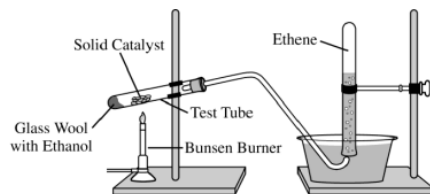
- (c) Identify the hybridization of the central atom (sp, sp
- <sup>2</sup>
- , or sp
- <sup>3</sup>
- ) for each of the following.

BeF<sub>2</sub> \_\_\_\_\_ OF<sub>2</sub> \_\_\_\_\_ CF<sub>4</sub> \_\_\_\_\_

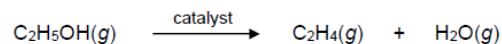
- (d) (i) Make a prediction regarding the F–O–F bond angle in OF
- <sub>2</sub>
- .

\_\_\_\_\_ The F–O–F bond angle in OF<sub>2</sub> is less than 109.5°.\_\_\_\_\_ The F–O–F bond angle in OF<sub>2</sub> is equal to 109.5°.\_\_\_\_\_ The F–O–F bond angle in OF<sub>2</sub> is greater than 109.5°.

- (ii) Justify your choice in part (d)(i) with a complete and thorough explanation.



2. Ethene, C
- <sub>2</sub>
- H
- <sub>4</sub>
- (g), may be prepared by the dehydration of ethanol, C
- <sub>2</sub>
- H
- <sub>5</sub>
- OH(g), using a solid catalyst. A setup for the lab synthesis is shown in the diagram above. The equation for the dehydration reaction is given below.



A student added a 0.200 g sample of C<sub>2</sub>H<sub>5</sub>OH(l) to a test tube using the setup shown above. The student heated the test tube gently with a Bunsen burner until all of the C<sub>2</sub>H<sub>5</sub>OH(l) evaporated and gas generation stopped. When the reaction stopped, the volume of collected gas was 85.4 mL at 625.0 torr and 32.0°C. (The vapor pressure of water at 32.0°C is 35.7 torr.)

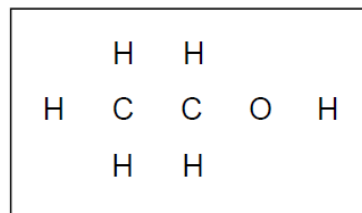
- (a) Calculate the number of moles of C
- <sub>2</sub>
- H
- <sub>4</sub>
- (g)

- (i) that are actually produced in the experiment and measured in the gas collection tube,
- (ii) and that would be produced if the dehydration reaction went to completion.

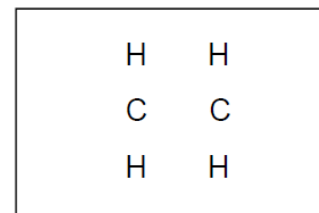
## 2.(continued)

- (b) Calculate the percent yield of ethene in the experiment.

- (c) In the boxes below, complete the Lewis electron-dot diagrams for ethene and ethanol by drawing in all of the electron pairs. Note that the diagrams below are not necessarily representative of the actual molecular geometry for either molecule.



ethanol



ethene

- (d) Identify the hybridization (sp, sp
- <sup>2</sup>
- , or sp
- <sup>3</sup>
- ) of the carbon atoms

(i) in ethanol \_\_\_\_\_

(ii) in ethene \_\_\_\_\_

- (e) Identify the predicted value for the H–C–H bond angle

(i) in ethanol \_\_\_\_\_

(ii) in ethene \_\_\_\_\_

## Unit 9: IMFs, Solid Bonding

CHAPTER 11 – 12 PRACTICE QUIZ

 ←Linked at 0:00

MULTIPLE CHOICE – NO CALCULATOR ALLOWED

| Name       | Structural Formula                                                                                                                                                                                                                  | Molar Mass (g/mol) |
|------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------|
| acetone    | $  \begin{array}{c}  \text{H} & & \text{:O:} & & \text{H} \\    & &    & &   \\  \text{H}-\text{C} & - & \text{C} & - & \text{C}-\text{H} \\    & & & &   \\  \text{H} & & & & \text{H}  \end{array}  $                             | 58.1               |
| butane     | $  \begin{array}{c}  \text{H} & \text{H} & \text{H} & \text{H} \\    &   &   &   \\  \text{H}-\text{C} & -\text{C} & -\text{C} & -\text{C}-\text{H} \\    &   &   &   \\  \text{H} & \text{H} & \text{H} & \text{H}  \end{array}  $ | 58.1               |
| 1-propanol | $  \begin{array}{c}  \text{H} & \text{H} & \text{H} & & \\    &   &   & & \\  \text{H}-\text{C} & -\text{C} & -\text{C} & - & \text{O}-\text{H} \\    &   &   & & \\  \text{H} & \text{H} & \text{H} & &   \end{array}  $           | 60.1               |

1. The table above shows the structural formulas and molar masses for three different compounds. Which of the following is a list of the compounds in order of increasing boiling points?

(A) butane < 1-propanol < acetone  
 (B) butane < acetone < 1-propanol  
 (C) 1-propanol < acetone < butane  
 (D) acetone < butane < 1-propanol

2. Which of the following statements is the most appropriate based on the physical properties of solids?

(A) Ionic solids tend to have higher melting points than molecular solids.  
 (B) Metallic solids tend to have higher melting points than covalent-network solids.  
 (C) Ionic compounds are excellent conductors of electricity in the solid phase.  
 (D) Molecular solids are excellent conductors of electricity when dissolved into water.

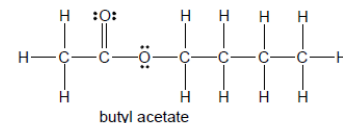
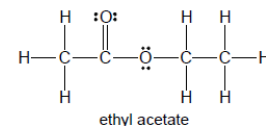
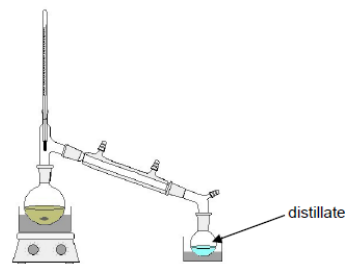
|                    |      |      |
|--------------------|------|------|
|                    | NaF  | MgO  |
| Boiling Point (°C) | 1695 | 3600 |

|                   |                 |                  |                |                 |                 |
|-------------------|-----------------|------------------|----------------|-----------------|-----------------|
|                   | Na <sup>+</sup> | Mg <sup>2+</sup> | F <sup>-</sup> | Cl <sup>-</sup> | O <sup>2-</sup> |
| Ionic Radius (pm) | 76              | 72               | 133            | 181             | 140             |

3. Based on the data in the tables above, which of the following statements provides the best prediction for the boiling point of NaCl?

(A) NaCl will have a lower boiling point than NaF because the coulombic attractions are weaker in NaCl than in NaF.  
 (B) NaCl will have a boiling point between that of NaF and MgO because the covalent character of the bonds in NaCl is intermediate between that of NaF and MgO.  
 (C) NaCl will have a higher boiling point than MgO because the ions are spaced farther apart in NaCl than in MgO.  
 (D) NaCl will have a higher boiling point than MgO because the electron cloud in NaCl is larger and more polarizable than it is in MgO.

Name: \_\_\_\_\_ Pd \_\_\_\_\_



4. A mixture containing equal numbers of moles of ethyl acetate and butyl acetate was separated using distillation. Based on the diagrams shown above, which of the following identifies the substance that would be initially present in higher concentration in the distillate and correctly explains why that occurs?

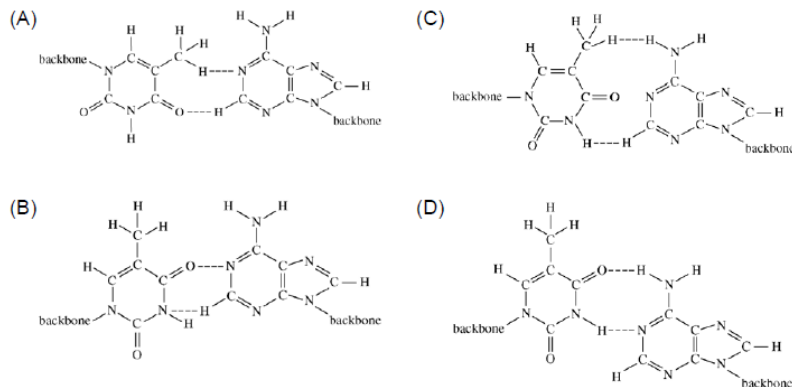
(A) Ethyl acetate, because it has fewer C–C bonds to break  
 (B) Ethyl acetate, because it has a shorter carbon chain and weaker London dispersion forces  
 (C) Butyl acetate, because it has more C–C bonds to break  
 (D) Butyl acetate, because it has a longer carbon chain and stronger London dispersion forces

| Substance                                                                                                         | Boiling Point (K) |
|-------------------------------------------------------------------------------------------------------------------|-------------------|
| $  \begin{array}{c}  \text{:Cl:} \\    \\  \text{:Cl:}-\text{C}-\text{:Cl:} \\    \\  \text{:Cl:}  \end{array}  $ | 350               |
| $  \begin{array}{c}  \text{:F:} \\    \\  \text{:F:}-\text{P}-\text{:F:} \\    \\  \text{:F:}  \end{array}  $     | 171               |

5. Which of the following statements provides the best explanation for the different boiling points shown in the table above?

(A) The London dispersion forces between CCl<sub>4</sub> molecules are stronger than the London forces between PF<sub>3</sub> molecules.  
 (B) The dipole-dipole forces between CCl<sub>4</sub> molecules are stronger than the dipole-dipole forces between PF<sub>3</sub> molecules.  
 (C) The London dispersion forces between PF<sub>3</sub> molecules are stronger than the London forces between CCl<sub>4</sub> molecules.  
 (D) The dipole-dipole forces between PF<sub>3</sub> molecules are stronger than the dipole-dipole forces between CCl<sub>4</sub> molecules.

6. Thymine and adenine form a base pair in the DNA molecule. These two bases can form a connection between two strands of DNA via two hydrogen bonds. Which of the following diagrams shows the correct representation of the hydrogen bonding (denoted by dashed lines) between thymine and adenine base pairs? (In each diagram, thymine is shown at the left and adenine is shown at the right. The bases are attached to the backbone portion of the DNA strands.)



| Substance      | Equilibrium Vapor Pressure at 20°C (torr) |
|----------------|-------------------------------------------|
| $C_6H_6(l)$    | 75                                        |
| $C_2H_5OH(l)$  | 44                                        |
| $CH_3OH(l)$    | 92                                        |
| $C_2H_6O_2(l)$ | 0.06                                      |

7. Based on the data in the table above, which of the following liquid substances has the weakest intermolecular forces?

(A)  $C_6H_6(l)$  (B)  $C_2H_5OH(l)$  (C)  $CH_3OH(l)$  (D)  $C_2H_6O_2(l)$

| Ion       | Ionic Radius (pm) |
|-----------|-------------------|
| $Zn^{2+}$ | 74                |
| $Ca^{2+}$ | 100               |
| $Ba^{2+}$ | 135               |

8. Based on the data in the table above, which of the following correctly predicts the relative strength of the attraction of  $Zn^{2+}$ ,  $Ca^{2+}$ , and  $Ba^{2+}$  ions to water molecules in a solution, from strongest to weakest, and provides the correct reason?

(A)  $Zn^{2+} > Ca^{2+} > Ba^{2+}$  because the smaller ions have a stronger coulombic attraction to water  
 (B)  $Zn^{2+} > Ca^{2+} > Ba^{2+}$  because the smaller ions are more electronegative  
 (C)  $Ba^{2+} > Ca^{2+} > Zn^{2+}$  because the larger ions are more polarizable  
 (D)  $Ba^{2+} > Ca^{2+} > Zn^{2+}$  because the larger ions are less electronegative

9. A sample of a hard, solid binary compound at room temperature did not conduct electricity as a pure solid but became highly conductive when dissolved in water. Which of the following types of interactions is most likely found between the particles in the substance?

(A) Ionic bonds  
 (B) Metallic bonds  
 (C) Covalent bonds  
 (D) Hydrogen bonds

| Element | Metallic Radius (pm) | Melting Point (°C) | Common Oxidation State |
|---------|----------------------|--------------------|------------------------|
| Au      | 144                  | 1064               | 1+, 3+                 |
| Cu      | 128                  | 1085               | 1+, 2+                 |
| Ag      | 144                  | 961                | 1+                     |

10. To make Au stronger and harder, it is often alloyed with other metals, such as Cu and Ag. Consider two alloys, one of Au and Cu and one of Au and Ag, each with the same mole fraction of Au. If the Au/Cu alloy is harder than the Au/Ag alloy, then which of the following is the best explanation based on the information in the table above?

(A) Cu has two common oxidation states, but Ag has only one.  
 (B) Cu has a higher melting point than Au has, but Ag has a lower melting point than Au has.  
 (C) Cu atoms are less polarizable than Ag atoms are; thus Cu has weaker interparticle forces.  
 (D) Cu atoms are smaller than Ag atoms; thus they interfere more with the displacement of atoms in the alloy.

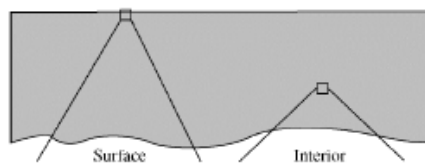
11. At room temperature  $I_2(s)$  is a molecular solid. Which of the following provides a characteristic of  $I_2(s)$  with a correct explanation?

(A) It has a high melting point because it has weak intermolecular forces.  
 (B) It is hard because it forms a three-dimensional covalent network.  
 (C) It is very soluble in water because its molecules are polar.  
 (D) It is not a good conductor of electricity because its valence electrons are localized in bonding and nonbonding pairs.

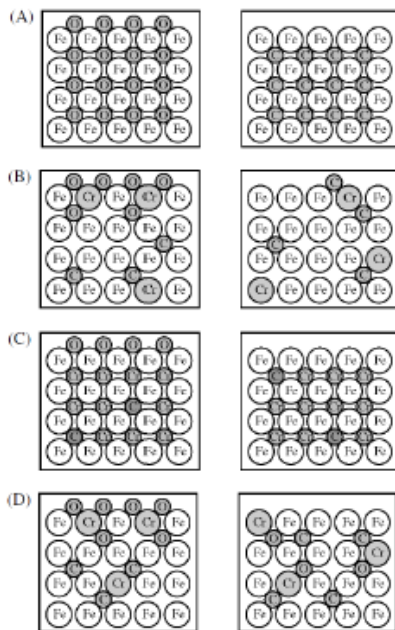
12. Which of the following processes involves breaking covalent bonds?

(A)  $C_{10}H_8(s) \rightarrow C_{10}H_8(g)$   
 (B)  $HF(l) \rightarrow HF(g)$   
 (C)  $NaCl(s) \rightarrow Na^+(aq) + Cl^-(aq)$   
 (D)  $Cl_2(g) \rightarrow 2 Cl(g)$

13. Steel is an alloy consisting of Fe with a small amount of C. Elemental Cr can be added to steel to make the steel less likely to rust; Cr atoms react with oxygen in the air to form a nonreactive layer of chromium oxide on the surface of the steel, preventing the oxidation of underlying Fe atoms. A sample of steel-chromium alloy contains 15 percent Cr by mass. Which of the following diagrams best shows a particle-level view of a surface section and an interior section of the alloy represented below at the left? (The atomic radii of the atoms involved are given in the table below at the right.)



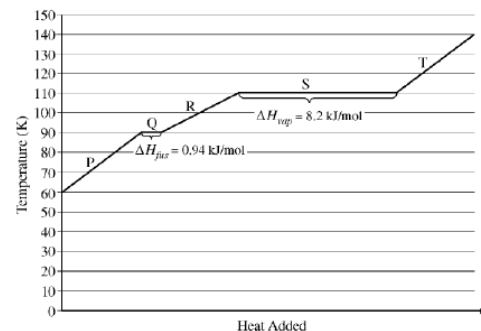
| Element | Molar Mass (g/mol) | Atomic Radius (pm) |
|---------|--------------------|--------------------|
| Fe      | 55.85              | 125                |
| Cr      | 52.00              | 127                |
| C       | 12.01              | 77                 |
| O       | 16.00              | 73                 |



| Substance | Formula                                                                                    |
|-----------|--------------------------------------------------------------------------------------------|
| Hexane    | $\text{CH}_3\text{CH}_2\text{CH}_2\text{CH}_2\text{CH}_2\text{CH}_3$                       |
| Octane    | $\text{CH}_3\text{CH}_2\text{CH}_2\text{CH}_2\text{CH}_2\text{CH}_2\text{CH}_2\text{CH}_3$ |

14. The formulas of hexane and octane are shown in the table above. Which of the following lists is arranged in order of increasing viscosity?

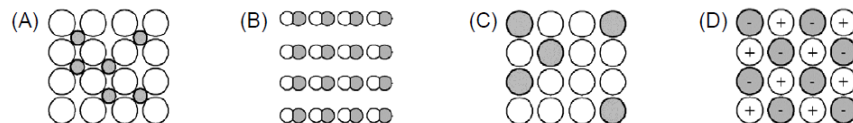
|     | Lowest viscosity | ----->        | Highest viscosity |
|-----|------------------|---------------|-------------------|
| (A) | hexane @ 25°C    | octane @ 25°C | octane @ 45°C     |
| (B) | octane @ 25°C    | hexane @ 25°C | hexane @ 45°C     |
| (C) | hexane @ 25°C    | hexane @ 45°C | octane @ 45°C     |
| (D) | hexane @ 45°C    | hexane @ 25°C | octane @ 25°C     |



15. The graph above represents the heating curve for methane ( $\text{CH}_4$ ). Which of the following best explains why more energy is required for the process occurring at 110 K than for the process occurring at 90 K?

- (A) Intermolecular attractions are completely overcome during vaporization.  
 (B) Intermolecular attractions in the solid phase are weaker than in the liquid phase.  
 (C) The electron cloud of  $\text{CH}_4$  becomes more polarizable at higher temperatures.  
 (D) The vaporization process involves a larger increase in temperature than the fusion process.

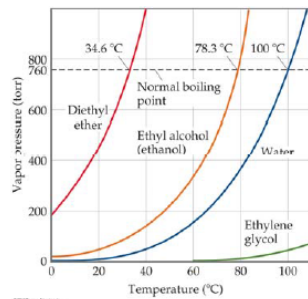
16. Which of the following diagrams best depicts an alloy of Ni and B?



17. Silicon crystals are semiconductors. Which of the following is a correct reason for the increase in the conductivity of Si crystals when a small fraction of Si atoms are replaced with those of a different element?

- (A) P atoms introduce additional mobile negative charges.  
 (B) P atoms introduce additional mobile positive charges.  
 (C) Ge atoms have more electrons than Si atoms have.  
 (D) Ge atoms are much smaller than Si atoms.

| Temperature (°C) | Vapor Pressure of Compound X (torr) |
|------------------|-------------------------------------|
| 60               | 175                                 |
| 65               | 220                                 |
| 70               | 275                                 |
| 75               | 345                                 |
| 80               | 425                                 |
| 85               | 520                                 |
| 90               | 640                                 |
| 95               | 780                                 |



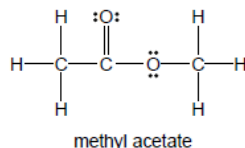
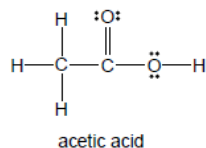
18. The table above lists the vapor pressure of Compound X at various temperatures. Based on this information as well as the information in the graph shown above, which of the following statements is most likely to be true concerning Compound X?

- (A) It experiences stronger intermolecular attractive forces than ethyl alcohol does.  
 (B) It experiences stronger intermolecular attractive forces than ethylene glycol does.  
 (C) Its boiling point is lower than the boiling point of ethyl alcohol.  
 (D) Its boiling point is higher than the boiling point of water.

#### CHAPTER 11 – 12 PRACTICE QUIZ

#### FREE RESPONSE – CALCULATOR IS ALLOWED

←Linked at 20:19



1. (a) Place a check (✓) in each of the appropriate boxes in the table below to indicate the type of intermolecular attractive forces experienced by each substance. It is possible for a substance to experience more than one type of attractive force.

| Substance      | London dispersion forces | Dipole-dipole forces | Hydrogen bonding |
|----------------|--------------------------|----------------------|------------------|
| acetic acid    |                          |                      |                  |
| methyl acetate |                          |                      |                  |

BP of acetic acid = 118°C

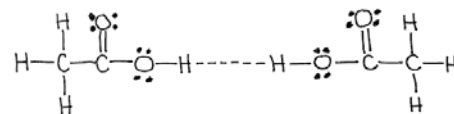
BP of methyl acetate = 57°C

- (b) Select one of the following statements that provides the best justification for the boiling point data shown above.

- \_\_\_\_\_ Methyl acetate has a larger electron cloud and is more polarizable than acetic acid is.  
 \_\_\_\_\_ Methyl acetate contains more hydrogen atoms than acetic acid, so it has more opportunities to form hydrogen bonds than acetic acid does.  
 \_\_\_\_\_ The London dispersion forces in acetic acid are stronger than the London dispersion forces in methyl acetate.  
 \_\_\_\_\_ Acetic acid experiences hydrogen bonding attractions; however, methyl acetate does not experience hydrogen bonding attractions.

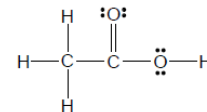
1. continued

A student drew the following diagram to indicate the strongest type of intermolecular attractive force between two acetic acid molecules.

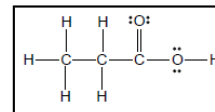


- (c) The student's drawing is incorrect. Your job is to draw the diagram correctly. The box below shows one molecule of acetic acid. Your instructions are the following.

- Draw a second molecule of acetic acid in the box below.
- Draw a dashed line (-----) to indicate the strongest type of intermolecular attractive force that exists between the two acetic acid molecules.
- Each end of the dashed line should be connected to a specific atom on each acetic acid molecule so that the attractive force between the molecules is indicated correctly.



- (d) Propanoic acid, shown at right, has a boiling point of 141°C.



- (i) Identify all the types of intermolecular forces present among the molecules in propanoic acid.

- (ii) Which of the types of intermolecular forces that you identified in part (d)(i) is most responsible for the difference in boiling points of acetic acid and propanoic acid?

| Substance  | Structural Formula                                                                                                                                                                                                                                                                                   | Vapor Pressure at 20°C (torr) |
|------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------|
| hexane     | $  \begin{array}{cccccc}  \text{H} & \text{H} & \text{H} & \text{H} & \text{H} & \text{H} \\    &   &   &   &   &   \\  \text{H}-\text{C}-\text{C}-\text{C}-\text{C}-\text{C}-\text{H} \\    &   &   &   &   &   \\  \text{H} & \text{H} & \text{H} & \text{H} & \text{H} & \text{H}  \end{array}  $ | 132                           |
| 2-hexanone | $  \begin{array}{cccccc}  \text{H} & \text{H} & \text{H} & \text{H} & \text{O} & \text{H} \\    &   &   &   &    &   \\  \text{H}-\text{C}-\text{C}-\text{C}-\text{C}-\text{C}-\text{H} \\    &   &   &   & &   \\  \text{H} & \text{H} & \text{H} & \text{H} & & \text{H}  \end{array}  $           | 10                            |

2. (a) Place a check (✓) in each of the appropriate boxes in the table below to indicate the type of intermolecular attractive forces experienced by each substance. It is possible for a substance to experience more than one type of attractive force.

| Substance  | London dispersion forces | Dipole-dipole forces | Hydrogen bonding |
|------------|--------------------------|----------------------|------------------|
| hexane     |                          |                      |                  |
| 2-hexanone |                          |                      |                  |

- (b) In terms of the relative strength of the intermolecular forces, explain why hexane has a higher vapor pressure than 2-hexanone at 20°C.

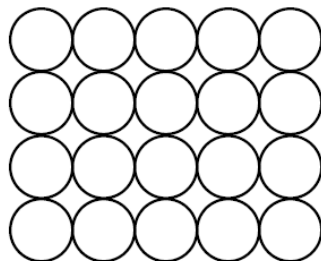
- (c) Which liquid, hexane or 2-hexanone, should have a higher boiling point?

| Element | Atomic Radius (pm) |
|---------|--------------------|
| Cu      | 135                |
| Zn      | 135                |

3. Brass is an alloy of copper and zinc. The atomic radii of the metals are given in the table above. In the diagram below, use the following symbols for atoms of copper and zinc.



- (a) Fill in the appropriate symbols in the diagram below so that it represents a particle-level diagram of a solid brass alloy that is 70 mole percent copper and 30 mole percent zinc.



- (b) Should this brass alloy be classified as an interstitial alloy or a substitutional alloy? Justify your answer.

4. The following information was collected for four different solids, labeled A through D.

| Solid | Physical Appearance             | Melting Point | Conductivity                                 | Solubility                                     |
|-------|---------------------------------|---------------|----------------------------------------------|------------------------------------------------|
| A     | white crystalline solid         | 80°C          | nonelectrolyte                               | slightly soluble in H <sub>2</sub> O (30 mg/L) |
| B     | gray crystalline solid          | 1414°C        | nonelectrolyte                               | insoluble in H <sub>2</sub> O                  |
| C     | white crystalline solid         | 770°C         | conducts electricity when dissolved in water | very soluble in H <sub>2</sub> O (344 g/L)     |
| D     | silvery-white crystalline solid | 1455°C        | conducts electricity as a solid              | insoluble in H <sub>2</sub> O                  |

- (a) Based on this information, classify each of the four substances into one of the following: metallic, ionic, covalent network, molecular

A \_\_\_\_\_ C \_\_\_\_\_

B \_\_\_\_\_ D \_\_\_\_\_

- (b) The identity of the four solids are the following (in no particular order): silicon (Si), nickel (Ni), naphthalene (C<sub>10</sub>H<sub>8</sub>), & potassium chloride (KCl). Write the most likely identity for each substance.

A \_\_\_\_\_ C \_\_\_\_\_

B \_\_\_\_\_ D \_\_\_\_\_

#### CHAPTER 13 – 14 PRACTICE QUIZ

MULTIPLE CHOICE – NO CALCULATOR ALLOWED

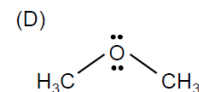
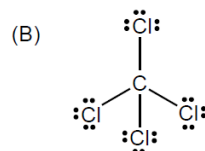
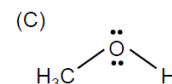
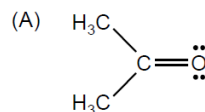
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| Ion              | Ionic Radius (pm) |
|------------------|-------------------|
| Na <sup>+</sup>  | 116               |
| Mg <sup>2+</sup> | 86                |
| K <sup>+</sup>   | 152               |
| Ca <sup>2+</sup> | 114               |

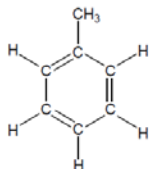
1. Based on Coulomb's law and the information in the table above, which of the following cations is most likely to have the strongest interaction with an adjacent water molecule in aqueous solution?

(A) Na<sup>+</sup> (B) Mg<sup>2+</sup> (C) K<sup>+</sup> (D) Ca<sup>2+</sup>

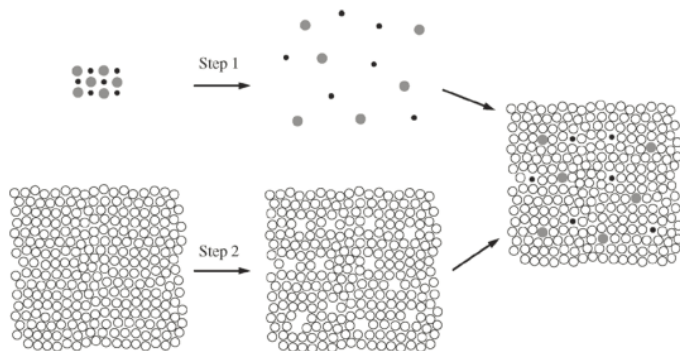
2. Which of the following molecules is least soluble in water?



3. One reason that could explain why silver chloride ( $\text{AgCl}$ ) is insoluble in water is
- (A) the London dispersion forces between water molecules are very weak
  - (B) the ion-dipole forces between  $\text{Ag}^+$  ions and water molecules are very strong
  - (C) the ionic bonds between  $\text{Ag}^+$  ions and  $\text{Cl}^-$  ions are very strong
  - (D) the covalent bonds between H atoms and O atoms are very strong



4. The structural formula of toluene ( $\text{C}_7\text{H}_8$ ) is shown above. Toluene has a rather low solubility in water (0.52 g/L @  $20^\circ\text{C}$ ). Which of the following best describes the intermolecular forces of attraction between water and toluene?
- (A) Toluene is nonpolar, so there are no attractive forces between toluene and water.
  - (B) The H atoms in toluene form weak hydrogen bonds with the O atoms in water.
  - (C) Ion-dipole forces are formed between the pi bonds of toluene and polar water molecules.
  - (D) There are London dispersion interactions between toluene and water.



5. The dissolution of an ionic solute in a polar solvent can be imagined as occurring in three steps, as shown in the figure above. In step 1, the separation between ions in the solute is greatly increased, just as will occur when the solute dissolves in the polar solvent. In step 2, the polar solvent is expanded to make spaces that the ions will occupy. In the last step, the ions are inserted into the spaces in the polar solvent. Which of the following best describes the enthalpy change,  $\Delta H$ , for each step?
- (A) All three steps are endothermic.
  - (B) All three steps are exothermic.
  - (C) Steps 1 and 2 are endothermic, and the final step is exothermic.
  - (D) Steps 1 and 2 are exothermic, and the final step is endothermic.

6. Which of the following substances has the greatest solubility in water?

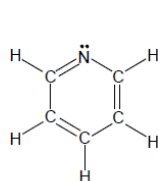
- (A)  $\text{C}_2\text{H}_5\text{OH}$
- (B)  $\text{C}_{10}\text{H}_{21}\text{OH}$
- (C)  $\text{C}_5\text{H}_{12}$
- (D)  $\text{CCl}_4$

7. When most gases dissolve in water, the process is normally exothermic. Which of the following statements best supports this fact?

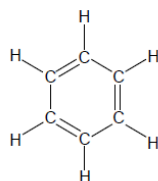
- (A) The solubility of gases in water tends to increase as the temperature is increased.
- (B) Energy is released when solvent-solvent interactions are broken.
- (C) Separation of solute particles from each other requires little or no energy.
- (D) Most gases form strong covalent bonds when they react with water.

8. Which of the following conditions would maximize the solubility of  $\text{O}_2$  in water?

|     | Partial Pressure of $\text{O}_2$ (atm) | Temperature ( $^\circ\text{C}$ ) |
|-----|----------------------------------------|----------------------------------|
| (A) | 0.5 atm                                | $5^\circ\text{C}$                |
| (B) | 5 atm                                  | $5^\circ\text{C}$                |
| (C) | 0.5 atm                                | $50^\circ\text{C}$               |
| (D) | 5 atm                                  | $50^\circ\text{C}$               |



pyridine



benzene

1. The structures of pyridine ( $C_5H_5N$ ) and benzene ( $C_6H_6$ ) are shown above.

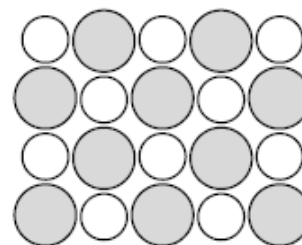
- (a) Identify all of the types of intermolecular attractive forces that could exist between the solute and solvent for each of the following mixtures. Assume that water is the solvent.

| Mixture            | Types of intermolecular attractive forces that could exist between the solute and the solvent |
|--------------------|-----------------------------------------------------------------------------------------------|
| pyridine and water |                                                                                               |
| benzene and water  |                                                                                               |

- (b) Which substance, pyridine or benzene, should have a greater solubility in water?
- (c) Justify your answer to part (b) by giving a specific reason for the difference in the strength of the intermolecular attractive forces mentioned in part (a).
- (d) In the box below, draw one molecule of water and one molecule of pyridine. Draw a dashed line (-----) to indicate the strongest type of intermolecular attractive force that exists between the two molecules. Each end of the dashed line should be connected to a specific atom on each molecule, so that the attractive force between the molecules is indicated correctly.

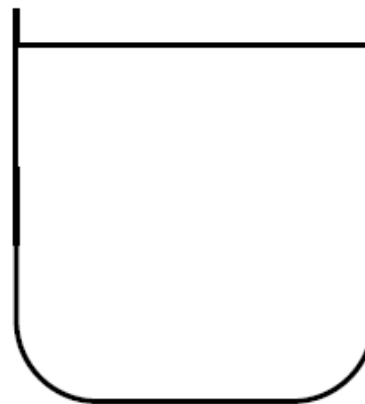


$H_2O$  molecule



$LiCl$  crystal

1. The structures of a water molecule and a crystal of  $LiCl(s)$  are represented above. A student prepares a solution by dissolving 1 g  $LiCl$  into 100 mL of water.
- (a) In the space provided below, show the interactions of the components of  $LiCl(aq)$  by making a drawing that represents the different particles present in the solution. You should base the particles in your drawing on the particles in the representations above. Include only one formula unit of  $LiCl$  and no more than ten molecules of water. Your drawing must include the following details.
- identity of the ions (symbol and charge)
  - the arrangement and proper orientation of the particles in solution



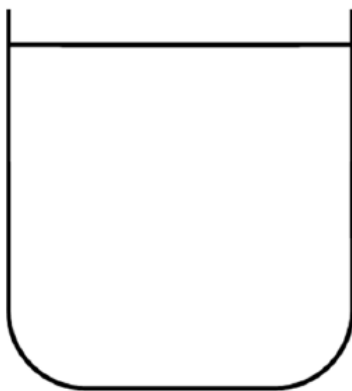
$LiCl(aq)$

- (b) Is  $LiCl(aq)$  classified as a strong electrolyte, a weak electrolyte, or a nonelectrolyte? Justify your prediction with an explanation that includes information about the drawing that you made in part (a).

2. Atoms of hydrogen, carbon, and oxygen are shown as follows.



- (a) In the space provided below, show what happens when two molecules of methanol ( $\text{CH}_3\text{OH}$ ) are dissolved completely into water. You should use the particles in the representations above to help you draw the particle diagram for  $\text{CH}_3\text{OH}(aq)$ . You do not have to draw any water molecules in your diagram.



$\text{CH}_3\text{OH}(aq)$

- (b) Is  $\text{CH}_3\text{OH}(aq)$  classified as a strong electrolyte, a weak electrolyte, or a nonelectrolyte? Justify your prediction with an explanation that includes information about the drawing that you made in part (a).