Instructions:
- Fill in your name and student number on the scan sheet.
- Fill in the exam version number as listed above on the scan sheet.
- Write your lab section number on the “Instructor” line on the scan sheet.

Lab Sections

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- Record your answers both here and on the scan sheet. Hand in the scan sheet; take this copy of the exam with you when you leave.
- The exam contains 21 multiple-choice questions. All questions are worth 4.76 points.
- As before, exam grades will be posted on OWL once all exams have been graded.

1. What is the molarity of a solution prepared by diluting 25mL of 1.2 KOH to 1.0L?
   a. 0.03 M
   b. 3.00 M
   c. 30.00 M
   d. 0.048 M
   e. 48.00 M

2. What is the balanced net ionic equation for the result when the following two aqueous solutions are mixed? CaCl₂ (aq) and Cs₃PO₄ (aq)
   a. Ca²⁺ (aq) + 2 Cl⁻ (aq) → CaCl₂ (s)
   b. Ca²⁺ (aq) + PO₄³⁻ (aq) → CaPO₄ (s)
   c. Cs⁺ (aq) + Cl⁻ (aq) → CsCl (s)
   d. 2 Ca²⁺ (aq) + 3 PO₄³⁻ (aq) → Ca₃(PO₄)₂ (s)
   e. 3 Ca²⁺ (aq) + 2 PO₄³⁻ (aq) → Ca₃(PO₄)₂ (s)

3. The distance between two adjacent peaks of a wave is known as the _______ of the wave.
   a. frequency
   b. amplitude
   c. wavelength
   d. velocity
   e. none of the above

   Overall Equation:
   3CaCl₂(aq) + 2Cs₃PO₄(aq) → Ca₃(PO₄)₂(s) + 6Cl⁻(aq) + 6Cs⁺(aq)

   Because you need 3 Ca²⁺ ions, you need 3 CaCl₂ molecules. Because you need 2 PO₄³⁻ ions, you need 2 Cs₃PO₄ molecules.

   Total ionic equation:
   3Ca²⁺(aq) + 6Cl⁻(aq) + 6Cs⁺(aq) + 2PO₄³⁻(aq) → 6Cl⁻(aq) + 6Cs⁺(aq) + Ca₃(PO₄)₂(s)
4. Which of the following compounds is soluble in water?
   a. Li₂O → O²⁻ oxides are insoluble
   b. PbCl₂ → chlorides are usually soluble, but Pb is an exception
   c. AgNO₃ → nitrates are soluble
   d. MgCO₃ → carbonates are not soluble, Mg is not an exception
   e. None of these are soluble

In the titration of a 50.0 mL solution of H₂SO₄ of unknown concentration, it takes 30.2 mL of a 2.00 molar solution of NaOH to reach the end point. What is the molarity of the H₂SO₄ solution?

\[
\text{diprotic acid} \\
30.2 \times 10^{-3} \text{L} \times \frac{2.0 \text{mol NaOH}}{1 \text{mol H}_2\text{SO}_4} \times \frac{1 \text{mol H}_2\text{SO}_4}{2 \text{mol NaOH}} = 0.0302 \text{ mol H}_2\text{SO}_4
\]

\[
\frac{0.0302 \text{ mol H}_2\text{SO}_4}{50 \times 10^{-3} \text{L}} = 0.604 \text{ M H}_2\text{SO}_4
\]

6. What type of reaction is shown in the figure below?

\[
\begin{align*}
\text{H} & - \text{C} - \text{C} = \text{O} + \text{HCN} \rightarrow \text{CH}_3 - \text{C} - \text{OH} \\
\text{CN}
\end{align*}
\]

   a. Elimination
   b. Isomerization
   c. Addition
   d. Substitution
   e. Combustion

6. What type of reaction is shown in the figure below?

7. Exactly 15.0 mL of an NaOH solution is standardized by 22.8 mL of a 0.15 M HCl solution. Then, 43.9 mL is used to titrate 1.25 g of an unknown monoprotic acid (HA). What is the molar mass of HA (the unknown)?

\[
\begin{align*}
22.8 \times 10^{-3} \text{L} & \times \frac{0.15 \text{ mol HCl}}{1 \text{ L}} = 0.00342 \text{ mol HCl} \\
0.00342 \text{ mol HCl} & \times \frac{1 \text{ mol NaOH}}{1 \text{ mol HCl}} = 0.00342 \text{ mol NaOH} \\
0.00342 \text{ mol NaOH} & \times \frac{15 \times 10^{-3} \text{ L}}{1 \text{ mol NaOH}} = 0.228 \text{ mol NaOH} \\
43.9 \times 10^{-3} \text{ L} & \times \frac{0.228 \text{ mol NaOH}}{1 \text{ L}} \times \frac{1 \text{ mol HA}}{1 \text{ mol NaOH}} = 0.01 \text{ mol HA} \\
\frac{1.25 \text{ g HA}}{0.01 \text{ mol HA}} & = 125.0 \text{ g/mol}
\end{align*}
\]
8. What is the oxidation number of C in COCl₂?
   a. 0
   b. -2
   c. +2
   d. +4
   e. -4

   Total oxidation number = \( \sum \) of O = -2
   \[ \text{Cl is Each Cl is -1 (Cl forms a -1 ion)} \]
   Total must add up to zero, so the oxidation number of C is \( \frac{-1 \times 2 + (-2)}{-1} = +4 \)

9. Which compound listed below is not soluble in water?
   a. Na₂CO₃
   b. CuCl₂
   c. Fe(NO₃)₃
   d. BaSO₄
   e. NH₄OH

   Carbonates are not usually soluble, but Na⁺ carbonates are.
   Chloride compounds are soluble, Cu is not an exception.
   Nitrate compounds are soluble.
   Sulfates are usually soluble, but Ba compounds are an exception.
   Ammonium compounds are soluble.
   Hydroxides usually aren't, but ammonium hydroxide is an exception.

10. Which of the following has the most energy?
    a. A photon of infrared light
    b. A photon of ultraviolet light
    c. A photon of green light (550 nm)
    d. A radio wave photon
    e. None because all photons have the same energy.

11. What is the frequency of light whose wavelength is 711 nm?
    a. \( 2.80 \times 10^{-19} \text{ s}^{-1} \)
    b. \( 4.22 \times 10^{14} \text{ s}^{-1} \)
    c. \( 4.22 \times 10^5 \text{ s}^{-1} \)
    d. \( 2.10 \times 10^8 \text{ s}^{-1} \)
    e. \( 2.37 \times 10^6 \text{ s}^{-1} \)

12. What mass of I₂ is needed to prepare 50.0 mL of 1.00 M solution?
    a. 1.642 g
    b. 12.7 g
    c. 14.3 g
    d. 9.86 g
    e. none of these

   \( 50 \times 10^{-3} \text{L} \times \frac{1.0 \text{ mol}}{\text{L}} \times \frac{253.8 \text{ g}}{\text{mol}} = 12.7 \text{ g} \)

   I₂ molar mass = \( \frac{253.8 \text{ g/mol}}{2 \times 126.9 \text{ g/mol}} \)
13. A chemist places $\text{Ba(NO}_3\text{)}_2$ in one flask and $\text{Na}_2\text{SO}_4$ in another. Water is added to both flasks and the mixture in the first flask is added to the second. Which choice below describes correctly the results of this experiment?

a. Both of the compounds in the flasks dissolve when water is added and $\text{NaNO}_3$ precipitates when the contents of the flasks are mixed.

b. Both of the compounds in the flasks dissolve when water is added and $\text{BaSO}_4$ precipitates when the contents of the flasks are mixed.

c. Both of the compounds in the flasks dissolve when water is added and there is no precipitate when the contents of the flasks are mixed.

d. The $\text{Ba(NO}_3\text{)}_2$ does not dissolve in water, but the $\text{Na}_2\text{SO}_4$ does dissolve. There is no change upon mixing the contents of the flasks.

e. none of these

14. Consider mixing an aqueous solution of $\text{FeCl}_3$ with an aqueous solution of $\text{KOH}$.

$$\text{FeCl}_3\text{(aq)} + \text{KOH}\text{(aq)} \rightarrow ??$$

What spectator ions are present in this precipitation reaction?

a. $\text{Fe}^{3+}\text{(aq)}$ and $3\text{Cl}^-\text{(aq)}$

b. $\text{K}^+\text{(aq)}$ and $\text{OH}^-\text{(aq)}$

c. $\text{Fe}^{3+}\text{(aq)}$ and $3\text{OH}^-\text{(aq)}$

d. $3\text{K}^+\text{(aq)}$ and $3\text{Cl}^-\text{(aq)}$

e. $3\text{K}^+\text{(aq)}$ and $\text{Cl}^-\text{(aq)}$

15. Which aqueous solution(s) below is(are) considered basic?

i. A solution with a pH = 6

ii. A solution with $[\text{OH}^-] = 1 \times 10^{-7}\text{mm}$ $p\text{OH} = 7$ $p\text{H} = 14 - 7 = 7$ Neutral

iii. A solution with $[\text{H}_3\text{O}^+] = 1 \times 10^{-9}$ $p\text{H} = 9$ Basic

a. i only

b. ii only

c. iii only

d. i and ii

e. i and iii
16. A famous brand of sweet and sour barbecue sauce (consisting of tomato paste, water, vinegar, sugar, and secret spices) has a measured pH of 2.6. What is the hydrogen ion concentration in the sauce?

\[ [H_3O^+] = 10^{-pH} = 10^{-2.6} = 0.0025 \]

a. 0.42 M  

b. \(2.4 \times 10^{-3}\) M  

c. \(2.5 \times 10^{-3}\) M  

d. \(3.4 \times 10^{-4}\) M  

e. \(5 \times 10^{-5}\) M  

17. What species becomes oxidized and what species behaves as the reducing agent in the following oxidation-reduction reaction?

\[ 2H_2O(l) + Al(s) + MnO_4^- (aq) \rightarrow Al(OH)_4^- (aq) + MnO_2 (s) \]

a. Al becomes oxidized and Al behaves as the reducing agent.  

b. Al becomes oxidized and MnO_4^- behaves as the reducing agent.  

c. MnO_4^- becomes oxidized and MnO_4^- behaves as the reducing agent.  

d. MnO_4^- becomes oxidized and Al behaves as the reducing agent.  

e. MnO_4^- becomes oxidized and H_2O behaves as the reducing agent.  

18. What is the oxidation number of the manganese atom in the formula for the compound KMnO_4?

a. -1  

b. +1  

c. +3  

d. +5  

e. +7  

19. What ions are the products when solid Mg(ClO_4)_2 is put into water?

a. 2Mg^(2+)(aq) + ClO_4^- (aq)  

b. Mg^(2+)(aq) + 2ClO_4^- (aq)  

c. Mg^(2+)(aq) + 2ClO_4^- (aq)  

d. Mg(ClO_4)_2(s)  

e. none of these
20. Which of the following is NOT a strong electrolyte?
   a. HCl
   b. Na₂SO₄
   c. HCN
   d. KOH
   e. HNO₃

   [Note: HCN is listed as a weak acid, making it a weak electrolyte.]

21. What is the molarity of a solution prepared by dissolving 41.0 g of NaCl in 250 mL of solution?
   a. 233.0 M
   b. 0.70 M
   c. 9.50 M
   d. 2.80 M
   e. 0.003 M

   \[
   \text{NaCl molar mass} = (23.0 + 35.5) = 58.5 \text{g/mol}
   \]
   \[
   41.0 \text{g} \times \frac{1 \text{mol}}{58.5 \text{g}} = 0.70 \text{ mol}
   \]
   \[
   \frac{0.70 \text{mol}}{0.250 \text{L}} = 2.80 \text{M}
   \]