Instructions

1. Do not open the exam until you are told to start.

2. This exam is closed note and closed book. You are not allowed to use any outside material while taking this exam.

3. Use the spaces provided to write down your answers. To receive full credit, you must show all work. Do not write answers on any other pieces of paper. If you need more room, write on the back of the exam and be sure to include a note describing where the work is located.

4. When solving numerical problems, make sure you include the proper units in your final answer.

5. If a question asks for a response in sentence or paragraph form, make sure you respond in that format.

6. Useful data for the exam and a periodic table are provided on the last page of the exam. Carefully tear out these sheets if you wish.

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Multiple Choice
Unless otherwise directed, choose the single best answer for each question.

1. A 2.500 M NaOH solution contains 0.3650 moles of NaOH. What is the volume (mL) of the solution?
   a.) 6849 mL  
b.) 146.0 mL  
c.) 912.5 mL  
d.) 250.0 mL  
e.) None of the above.

2. What is the volume of one mole of CO$_2$(g) at STP?
   a.) 1.000 L  
b.) 22.41 L  
c.) 44.00 L  
d.) 44.00 g  
e.) 24.50 L

3. Using the balanced chemical equation shown below, calculate the number of moles of O$_2$ that must react to produce 6.0 moles of CO$_2$.
   \[ \text{C}_2\text{H}_4(g) + 3\text{O}_2(g) \rightarrow 2\text{CO}_2(g) + 2\text{H}_2\text{O}(g) \]
   a.) 4.0 moles  
b.) 7.5 moles  
c.) 9.0 moles  
d.) 15 moles  
e.) None of the above.

4. In a can of Pepsi™, the sugar dissolved in the soda is a ___________ and water is the ___________.
   a.) solute, solvent  
b.) solvent, solute  
c.) solution, solute  
d.) solvent, solution  
e.) solvent, solvent

5. A 20.00 mL solution of 0.3000 M H$_2$SO$_4$ is titrated with a 0.2500 M solution of KOH. What volume of KOH must be added to react with all of the H$_2$SO$_4$?
   a.) 24.00 mL  
b.) 12.00 mL  
c.) 48.00 mL  
d.) 90.00 mL  
e.) None of the above
The diagram below depicts the collection of N\(_2\)(g), O\(_2\)(g), and Ar(g) over water. Use the diagram to answer the following three questions.

Temperature of gases and water = 50.00\(^\circ\)C

6. If the partial pressure of N\(_2\) is 0.24 atm., the partial pressure of O\(_2\) is 0.50 atm., and the partial pressure of Ar is 0.49 atm., what is the mole fraction of O\(_2\)(g) in the mixture of gases?

a.) 1.23  
b.) 0.50  
c.) 0.41  
d.) 0.37  
e.) None of the above.

7. If the temperature of the water and gas is increased to 80.00\(^\circ\)C, what will happen to the total pressure exerted by the gases?

a.) The pressure will decrease.  
b.) The pressure will increase.  
c.) The pressure will remain constant.  
d.) It is impossible to tell what will happen to the total pressure.

8. If 2.00 moles of O\(_2\)(g) are added to the container, what will happen to the frequency of collisions between the gas particles?

a.) The frequency of collisions will decrease.  
b.) The frequency of collisions will increase.  
c.) The frequency of collisions will not change.  
d.) It is impossible to tell what will happen to the frequency of collisions.

9. A 5.95-g sample of AgNO\(_3\) is reacted with excess BaCl\(_2\) according to the equation below.

\[
2\text{AgNO}_3(\text{aq}) + \text{BaCl}_2(\text{aq}) \rightarrow 2\text{AgCl}(s) + \text{Ba(NO}_3)_2(\text{aq})
\]

If 3.49 g of AgCl is obtained from the reaction, what is the percent yield of AgCl?

a.) 34.8%  
b.) 58.7%  
c.) 46.3%  
d.) 69.5%  
e.) None of the above.
10. A solution is prepared by dissolving 7.31 g of Na$_2$SO$_4$ in enough water to make 225 mL of solution. What is the molarity of sodium ions?

a.) 0.0325 M  
b.) 0.000229 M  
c.) 0.229 M  
d.) 0.457 M  
e.) None of the above.

11. For which of the following changes is it not clear whether the volume of a particular sample of an ideal gas will increase or decrease?

a.) increase the temperature and decrease the pressure  
b.) keep the temperature constant and decrease the pressure  
c.) increase the temperature and increase the pressure  
d.) increase the temperature and keep the pressure constant  
e.) decrease the temperature and increase the pressure

12. What volume (L) of 18.0 M H$_2$SO$_4$ is required to prepare 12.0 L of 0.156 M H$_2$SO$_4$?

a.) 0.00187 L  
b.) 0.0520 L  
c.) 0.208 L  
d.) 0.104 L  
e.) None of the above.

13. Magnesium burns in air according to the balanced chemical equation shown below. How many moles of O$_2$ are consumed when 0.770 moles of magnesium combust?

2Mg(s) + O$_2$(g) $\rightarrow$ 2MgO(s)

a.) 0.0317  
b.) 2.60  
c.) 0.770  
d.) 1.54  
e.) 0.385
Use the diagram below to answer the following question.

14. Which diagram above represents the situation in which the pressure of the collected gas is less than atmospheric pressure?
   a.) diagram A  
   b.) diagram B  
   c.) diagram C  
   d.) diagrams A and B  
   e.) None of the diagrams.

15. Using the balanced chemical equation below, calculate the volume (mL) of 3.00 M HCl that is required to react with 0.250 moles of Zn.
   \[ \text{Zn(s)} + 2\text{HCl(aq)} \rightarrow \text{ZnCl}_2(\text{aq}) + \text{H}_2(\text{g}) \]
   a.) 1090 mL  
   b.) 750. mL  
   c.) 833 mL  
   d.) 167 mL  
   e.) None of the above.

16. What is the volume of a helium balloon that contains 2.50 moles of He at 27°C and 1.10 atm.?
   a.) 5.04 L  
   b.) 22.4 L  
   c.) 34.8 L  
   d.) 56.0 L  
   e.) 61.5 L

17. A 5.25 g sample of argon gas occupies 6.35 L at 328.15 K and 0.892 atm. What volume will the sample of argon occupy at 293.15 K and 1.05 atm.?
   a.) 1.96 L  
   b.) 5.46 L  
   c.) 4.82 L  
   d.) 6.10 L  
   e.) None of the above.
Gaseous N₂O and O₂ can combine to form N₂O₅(g). Use the balanced chemical equation and the diagrams below to answer the following question.

\[ \text{N}_2\text{O}(g) + 2\text{O}_2(g) \rightarrow \text{N}_2\text{O}_5(g) \]

18. Based on the identity and numbers of molecules present before the reaction, which compound is the limiting reagent?
   
   a.) N₂O  
   b.) O₂  
   c.) N₂O₅  
   d.) All of the reactants are used up so there is no limiting reactant.  
   e.) Impossible to tell.

19. A sample of H₂ gas is collected over water at 30.00°C in a small container. If 0.0435 moles of H₂ is collected and the volume of the H₂ is 2.63 L, what is the total pressure inside the container holding the H₂(g)?
   
   a.) 0.411 atm.  
   b.) 0.453 atm.  
   c.) 0.370 atm.  
   d.) 0.0407 atm.  
   e.) None of the above.
20. In the table below, the name or formula for a chemical compound is given. Fill in the table with the corresponding name or formula of the chemical compound. (6 points)

<table>
<thead>
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<th>NAME</th>
<th>FORMULA</th>
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<td>HIO₃</td>
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<td>aluminum hydroxide</td>
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<tr>
<td>Sr(C₂H₃O₂)₂</td>
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</table>

21. One of the steps in the commercial process for converting ammonia to nitric acid is the conversion of NH₃ to NO and H₂O as indicated by the balanced chemical equation shown below.

\[
4 \text{NH}_3(g) + 5 \text{O}_2(g) \rightarrow 4 \text{NO}(g) + 6 \text{H}_2\text{O}(g)
\]

Molar Mass (g/mole)  17.0306  31.9988  30.0061  18.0153

a.) If you start with 2.25 g of NH₃ and 3.75 g of O₂, what mass of H₂O will you generate? (12 points)

b.) How much of each reactant will be left after the reaction is complete? (5 points)
22. A 27.52 mL sample of citric acid is titrated with 0.3651 M NaOH. The balanced titration reaction is shown below.

\[
\text{H}_3\text{C}_6\text{H}_5\text{O}_7(\text{aq}) + 3\text{NaOH}(\text{aq}) \rightarrow 3\text{H}_2\text{O}(\text{l}) + \text{Na}_3\text{C}_6\text{H}_5\text{O}_7(\text{aq})
\]

a.) If the titration requires 35.26 mL of the NaOH solution to reach the equivalence point, how many moles of \(\text{H}_3\text{C}_6\text{H}_5\text{O}_7\) were in the original citric acid solution? (7 points)

b.) What was the molarity of the original \(\text{H}_3\text{C}_6\text{H}_5\text{O}_7\) solution? (2 points)

c.) If the end point of the titration was dark pink in color, would the value for the calculated molarity be too large, too small, or unaffected? (3 points)

23. Phosphorus trichloride (PCl\(_3\)) can decompose to form solid phosphorus (P\(_4\)) and chlorine gas. The balanced chemical equation for the decomposition is shown below.

\[
4\text{PCl}_3(\text{l}) \rightarrow \text{P}_4(\text{s}) + 6\text{Cl}_2(\text{g})
\]

If the pressure of the Cl\(_2\)(g) that is collected is equal to 1.25 atm at a temperature of 307.5 K and it has a volume of 0.0567 L, what is the mass of P\(_4\)(s) that is also produced during the decomposition? (5 points)
### Conversion Factors, Constants, and Periodic Table

**Avogadro’s Number:** $6.022 \times 10^{23}$ particles/mole

**Pressure Conversion:** $760 \text{ mmHg} (\text{torr}) = 1 \text{ atm}$

**Ideal Gas Constant:** $0.08206 \frac{\text{L} \cdot \text{atm}}{\text{mol} \cdot \text{K}}$

**62.36 \frac{\text{L} \cdot \text{mmHg}}{\text{mol} \cdot \text{K}}**

**8.314 \frac{\text{J}}{\text{mol} \cdot \text{K}}**

**Temperature conversion:** $T [\text{K}] = 273.15 + T [\text{°C}]$

**Percent Yield:** $\% \text{ yield} = \frac{\text{actual yield}}{\text{theoretical yield}} \times 100\%$

**Gas Equations:** $P_A = P_{\text{tot}} \cdot \chi_A$

**PV = nRT**

### Vapor Pressure of Water at Various Temperatures

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### Compound | Molar Mass (g/mole)
---|---
AgCl | 143.3209
AgNO₃ | 169.8731
Na₂SO₄ | 142.043
P₄ | 123.8950

### Periodic Table

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