Chem. 1A Midterm 2
Version A

Name__________________________________________

Student Number _________________________________

All work must be shown on the exam for partial credit. Points will be taken off for incorrect or no units and for the incorrect number of significant figures. A non graphing calculator is allowed. On short answer problems you must show your work in order to receive credit for the problem. **If your cell phone goes off during the exam you will have your exam removed from you.**

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**Fundamental Questions**

Each of these fundamental chemistry questions is worth 4 points. **You must show work to get credit.** Little to no partial credit will be rewarded. Make sure to report answers in the correct number of significant figures and with the proper units.

1) **4 pts** A 10.00 mL sample of 2.05 M KNO₃ is diluted to a volume of 250.0 mL. What is the concentration of the diluted solution?

\[
M_iV_i = M_fV_f \\
(2.05M)(0.01000L) = M_f(0.2500L) \\
M_f = 0.0820M
\]

2) **4 pts** Identify the oxidation numbers of all of the elements in the following equation as well as indicate which element was oxidized and which was reduced.

\[
2\text{Al(s)} + 3\text{CuSO}_4(\text{aq}) \rightarrow \text{Al}_2(\text{SO}_4)_3(aq) + 3\text{Cu(s)}
\]

- **Al** 0 \( \rightarrow \) +3 lost e- Al was oxidized
- **Cu** +2 \( \rightarrow \) 0 gained e- Cu was reduced
- **S** +6 \( \rightarrow \) +6
- **O** -2

3) **4 pts** How many milliliters of 0.610 M NaOH solution are needed to neutralize 20.0 mL of a 0.245 M H₂SO₄ solution?

\[
2\text{NaOH(aq)} + \text{H}_2\text{SO}_4(\text{aq}) \rightarrow \text{Na}_2\text{SO}_4(\text{aq}) + 2\text{H}_2\text{O}
\]

\[
0.0200\text{LH}_2\text{SO}_4 \times \left( \frac{0.245\text{molH}_2\text{SO}_4}{1\text{LH}_2\text{SO}_4} \right) \times \left( \frac{2\text{molNaOH}}{1\text{molH}_2\text{SO}_4} \right) \times \left( \frac{1\text{LNaOH}}{0.610\text{molNaOH}} \right) \times \left( \frac{1000\text{mL}}{1\text{L}} \right) = 16.1\text{mlNaOH}
\]

4) **4 pts** Calculate the average kinetic energy of CH₄ molecules at 0.°C. Report answer in \( \text{molecule J} \).

\[
\left( KE \right)_\text{ave} = \frac{3}{2} \frac{RT}{\text{molecule}} = \frac{3}{2} \left( 8.3145 \frac{\text{J}}{\text{mol} \cdot \text{K}} \right) (273K) = 3.40 \times 10^{-2} \left( \frac{1\text{mol}}{6.02214 \times 10^{23} \text{molecules}} \right) = 5.65 \times 10^{-21} \frac{\text{J}}{\text{molecule}}
\]

5) **4 pts** What volume (in L) is occupied by 35.2 g of nitrogen at 35°C and 0.975 atm.

\[
P = nRT \]
\[
m = 35.2g \\
M_N₂ = 28.02 \frac{\text{g}}{\text{mol}} \\
n = 35.2g \times \left( \frac{1\text{molN}_2}{28.02\text{gN}_2} \right) = 1.26\text{molN}_2 \\
T = 35°C = 35 + 273.15 = 308K \\
V = \frac{nRT}{P} = \frac{(1.26\text{mol})(0.08206 \frac{\text{Latm}}{\text{molK}})(308K)}{(0.975\text{atm})} = 32.7L
\]

6) **4 pts** A mixture of gases contains 0.31 moles of CH₄, 0.25 moles of C₂H₆, and 0.29 moles of C₃H₈ and the total pressure of the system is 1.50 atm. What is the partial pressure of CH₄?

\[
P_{\text{CH}_4} = \frac{n_{\text{CH}_4}}{n_{\text{tot}}} P_{\text{tot}} = \frac{0.31\text{mol}}{0.31\text{mol} + 0.25\text{mol} + 0.29\text{mol}} (1.50\text{atm}) = 0.55\text{atm}
\]
Short Answer Questions

Each of the following short answer questions are worth the noted points. Partial credit will be given. Make sure to show work, report answers to the correct number of significant figures and use the proper units.

1) Write the (1) balanced molecular, (2) complete, and (3) net ionic equation for the reaction, if any, that occurs when aqueous solutions of the following are mixed. If no reaction occurs, write the balanced molecular equation only.

1a) 8 pts Ammonium sulfate and barium nitrate

\[(\text{NH}_4)_2\text{SO}_4(\text{aq}) + \text{Ba(NO}_3\text{)}_2(\text{aq}) \rightarrow 2\text{NH}_4\text{NO}_3(\text{aq}) + \text{BaSO}_4(\text{s})\]

\[2\text{NH}_4^+(\text{aq}) + 2\text{SO}_4^{2-}(\text{aq}) + 2\text{Ba}^{2+}(\text{aq}) + 2\text{NO}_3^-(\text{aq}) \rightarrow 2\text{NH}_4^+(\text{aq}) + 2\text{NO}_3^-(\text{aq}) + \text{BaSO}_4(\text{s})\]

\[\text{SO}_4^{2-}(\text{aq}) + \text{Ba}^{2+}(\text{aq}) \rightarrow \text{BaSO}_4(\text{s})\]

1b) 8 pts Sodium phosphate and potassium nitrate

\[\text{Na}_3\text{PO}_4(\text{aq}) + 3\text{KNO}_3(\text{aq}) \rightarrow 3\text{NaNO}_3(\text{aq}) + \text{K}_3\text{PO}_4(\text{aq})\]

No reaction

2) 14 Through a series of enzymatic steps, carbon dioxide and water undergo photosynthesis to produce glucose and oxygen according to the equation

\[6\text{CO}_2(\text{g}) + 6\text{H}_2\text{O}(\text{l}) \rightarrow \text{C}_6\text{H}_{12}\text{O}_6(\text{s}) + 6\text{O}_2(\text{g})\]

Given that the partial pressure of carbon dioxide in the troposphere is 0.26 Torr and that the temperature is 25°C, calculate the volume of air needed to produce 10.0 g of glucose.

Calculate moles of CO\(_2\) needed to make 10.0g C\(_6\)H\(_{12}\)O\(_6\)

\[M_{\text{C}_6\text{H}_{12}\text{O}_6} = 180.18 \, \text{g/mol}\]

\[10.0\, \text{gC}_6\text{H}_{12}\text{O}_6 \left( \frac{1\text{molC}_6\text{H}_{12}\text{O}_6}{180.18\, \text{gC}_6\text{H}_{12}\text{O}_6} \right) \left( \frac{6\text{molCO}_2}{1\text{molC}_6\text{H}_{12}\text{O}_6} \right) = 0.333\text{molCO}_2\]

Calculate volume of CO\(_2\)

\[PV = nRT\]

\[T = 25\, ^\circ\text{C} = 25 + 273.15 = 298\, \text{K}\]

\[P_{\text{CO}_2} = 0.26\text{tor} \left( \frac{1\text{atm}}{760\text{Torr}} \right) = 3.4 \times 10^{-4} \, \text{atm}\]

\[V = \frac{nRT}{P} = \left( \frac{0.333\text{mol}}{3.4 \times 10^{-4} \, \text{atm}} \right) \left( \frac{0.08206 \, \text{Latm/molK}}{298\, \text{K}} \right) = 2.40 \times 10^4 \, \text{L}\]

The volume of air and the volume of CO\(_2\) are equal because only the partial pressure of CO\(_2\) was used in the calculation and the CO\(_2\) is spread out throughout the volume of the air.
3) **14 pts** Balance the following unbalanced equation that occurs in a basic solution. In addition, identify the oxidizing and reducing agents in the reaction.

\[
\text{Cr}^{3+} (aq) + \text{MnO}_2(s) \rightarrow \text{Mn}^{2+} (aq) + \text{CrO}_4^{2-} (aq)
\]

\[
\text{Cr}^{3+} \rightarrow +6 \text{ lost e}^- \text{ Cr was oxidized}
\]

\[
\text{Cr}^{3+} \text{ is the reducing agent}
\]

\[
\text{Mn}^{4+} \rightarrow +2 \text{ gained e}^- \text{ Mn was reduced}
\]

\[
\text{MnO}_2 \text{ is the oxidizing agent}
\]

Balance oxidation \(\frac{1}{2}\) reaction

\[
\text{Cr}^{3+} \rightarrow \text{CrO}_4^{2-}
\]

\[
\text{Cr}^{3+} + 4\text{H}_2\text{O} \rightarrow \text{CrO}_4^{2-}
\]

\[
\text{Cr}^{3+} + 4\text{H}_2\text{O} + 8\text{OH}^- \rightarrow \text{CrO}_4^{2-} + 8\text{H}_2\text{O}
\]

\[
\text{Cr}^{3+} + 8\text{OH}^- \rightarrow \text{CrO}_4^{2-} + 4\text{H}_2\text{O} + 3\text{e}^-
\]

Balance reduction \(\frac{1}{2}\) reaction

\[
\text{MnO}_2 \rightarrow \text{Mn}^{2+}
\]

\[
\text{MnO}_2 \rightarrow \text{Mn}^{2+} + 2\text{H}_2\text{O}
\]

\[
\text{MnO}_2 + 4\text{H}_2\text{O} \rightarrow \text{Mn}^{2+} + 2\text{H}_2\text{O} + 4\text{OH}^-
\]

\[
\text{MnO}_2 + 2\text{H}_2\text{O} + 2\text{e}^- \rightarrow \text{Mn}^{2+} + 4\text{OH}^-
\]

\[
2(\text{Cr}^{3+} + 8\text{OH}^- \rightarrow \text{CrO}_4^{2-} + 4\text{H}_2\text{O} + 3\text{e}^-)
\]

\[
3(\text{MnO}_2 + 2\text{H}_2\text{O} + 2\text{e}^- \rightarrow \text{Mn}^{2+} + 4\text{OH}^-)
\]

\[
2\text{Cr}^{3+}(aq) + 4\text{OH}^-(aq) + 3\text{MnO}_2(aq) \rightarrow 2\text{CrO}_4^{2-}(aq) + 2\text{H}_2\text{O}(l) + 3\text{Mn}^{2+}(aq)
\]
Multiple Choice Questions
Each of the following multiple choice questions are worth 3 points. Your answers need to be filled in on the Scantron provided. Note: Your Scantrons will not be returned to you, therefore, for your records, you may want to mark your answers on this sheet. On the Scantron you need to fill in your perm number, test version, and name. Failure to do any of these things will result in the loss of 1 point. Your perm number is placed and bubbled in under the “ID number”. Do not skip boxes or put in a hyphen. In addition, leave bubbles blank under any unused boxes. The version number (A) is bubbled in under the “test form.”

1. Which gas is most dense at 1 atm and 25°C?
   A) hydrogen cyanide
   B) hydrogen sulfide
   C) nitrogen monoxide
   D) carbon monoxide
   E) nitrogen dioxide

2. What volume of 0.460 M barium nitrate solution is needed to prepare 213.0 mL of 0.268 M nitrate ion solution?
   A) 4.14×10¹ mL
   B) 1.24×10² mL
   C) 6.20×10¹ mL
   D) 3.66×10² mL
   E) 2.48×10² mL

3. A mixture of oxygen and helium is 92.3% by mass oxygen. What is the partial pressure of oxygen if atmospheric pressure is 745 Torr?
   A) 412 Torr
   B) 446 Torr
   C) 688 Torr
   D) 333 Torr
   E) 299 Torr

4. A plot of the Maxwell distribution against speed for different molecules shows that
   A) heavy molecules have a higher average speed.
   B) light molecules have a very narrow range of speeds.
   C) heavy molecules have a wide range of speeds.
   D) light molecules have a lower average speed.
   E) heavy molecules travel with speeds close to their average values.
5. Consider the following statements:
   1. Real gases act more like ideal gases as the temperature increases.
   2. When \( n \) and \( T \) are constant, a decrease in \( P \) results in a decrease in \( V \).
   3. At 1 atm and 273 K, every molecule in a sample of a gas has the same speed.
   4. At constant \( T \), \( \text{CO}_2 \) molecules at 1 atm and \( \text{H}_2 \) molecules at 5 atm have the same average kinetic energy.

Which of these statements is true?
A) 2 and 3  
B) 1 and 2  
C) 1 and 4  
D) 3 and 4  
E) 2 and 4

6. The following experiment was carried out using a newly synthesized chlorofluorocarbon. Exactly 50 mL of the gas effused through a porous barrier in 157 s. The same volume of argon effused in 76 s under the same conditions. Which compound is the chlorofluorocarbon?
A) \( \text{C}_2\text{Cl}_4\text{F}_2 \)  
B) \( \text{C}_2\text{ClF}_5 \)  
C) \( \text{C}_2\text{Cl}_2\text{F}_4 \)  
D) \( \text{C}_2\text{Cl}_5\text{F} \)  
E) \( \text{C}_2\text{Cl}_3\text{F}_3 \)

7. How many of the following compounds are soluble in water?
\( \text{Ca}_3(\text{PO}_4)_2 \), \( \text{Ba(NO}_3)_2 \), \( \text{K}_2\text{CO}_3 \), and \( \text{Cu(OH)}_2 \)
A) 1  
B) 2  
C) 3  
D) 4

8. Which of the following procedures will separate \( \text{Cu}^{2+} \) and \( \text{Ba}^{2+} \) ions?
A) Add chloride ions  
B) Add phosphate ions  
C) Add sulphate ions  
D) Add bromide ions  
E) None of these ways will separate the 2 ions
Answer Key

1. E
2. C
3. B
4. E
5. C
6. C
7. B
8. C