

LAST NAME: _____

FIRST NAME: _____

Student Number: _____

CHM 1311 B

Midterm #1

Fall 2015

Please keep your work covered at all times and keep your eyes on your own paper! Cheating or any appearance of cheating will result in an F in the course and possible expulsion from the university.

There are 9 pages in this test. A periodic table and data sheets are provided at the end. You may rip these pages off of the exam and use them to cover your work during the test. Any scratch work should be done on the back of these pages.

Please show all work to receive partial credit.

You have 75 minutes to complete the test.

Question	Points Possible	Points Earned
1	12	
2	6	
3	7	
4	11	
5	9	
TOTAL	45	

#1. (12 points) Short Answer Questions

a) Give the molecular formula for potassium dihydrogen phosphate:



b) What is the common name of CuO?

Cupric oxide

c) What is the name of the anion that is derived from HNO₃?

nitrate

d) If the temperature of an ideal gas is raised from 25°C to 50°C its volume will:

A) increase to double its size

B) decrease to half its size

C) neither A nor B

e) Describe one difference between an ideal gas molecule and a real gas molecule.

Real gas molecules have volume, ideal gas molecules have no volume.

Real gas molecules interact, ideal gas molecules do not interact.

f) Complete the table:

Chemical symbol	Mass number	Number of protons	Number of electrons	Number of neutrons
${}_{20}^{43}\text{Ca}^{2+}$	43	20	18	23

g) Given that the area of the earth's oceans is $3.6 \times 10^8 \text{ km}^2$, with an average depth of 3800 m, how many litres of water is in the ocean?

$$\begin{aligned} & (3.6 \times 10^8 \text{ km}^2)(3.800 \text{ km}) \left(\frac{1000 \text{ m}}{1 \text{ km}} \right)^3 \left(\frac{1000 \text{ L}}{1 \text{ m}^3} \right) \\ & = 1.4 \times 10^{21} \text{ L} \end{aligned}$$

h) How many molecules of sugar are in 1.0 mL of a 0.010 mol L⁻¹ solution?

$$\begin{aligned} N &= nN_A = cVN_A \\ &= (0.010 \text{ mol L}^{-1})(0.001 \text{ L})(6.022 \times 10^{23} \text{ molecules mol}^{-1}) \\ &= 6.0 \times 10^{18} \text{ molecules of sugar} \end{aligned}$$

i) What are the products of combustion of gasoline (assuming that gasoline is composed of compounds that only contain hydrogen and carbon)?



Question 2.

A mixture of CO₂ and Kr exerts a pressure of 0.717 bar in its container. Since Kr is expensive, you wish to recover it from the mixture. After the CO₂ is completely removed by absorption with NaOH(s), the pressure in the container is 0.256 bar.

- a) What is the mole fraction of Kr and CO₂? (2 marks)

Since the partial pressure of Kr in the original mixture is the same as the total pressure after the CO₂ is removed:

$$p_{\text{Kr}} = \chi_{\text{Kr}} p_T$$

$$\chi_{\text{Kr}} = \frac{p_{\text{Kr}}}{p_T} = \frac{0.256 \text{ bar}}{0.717 \text{ bar}} = 0.3570$$

$$\chi_{\text{CO}_2} + \chi_{\text{Kr}} = 1$$

$$\chi_{\text{CO}_2} = 1 - \chi_{\text{Kr}} = 1 - 0.3570 = 0.6430$$

Therefore the mole fraction of Kr is 0.357 and the mole fraction of CO₂ is 0.647.

- b) What is the density of the Kr if the container is at 298.15 K after the CO₂ has been removed? (2 marks)

$$d = \frac{m}{V} = \frac{pM}{RT} = \frac{(0.256 \text{ bar})(83.80 \text{ g mol}^{-1})}{(0.08314 \text{ bar L K}^{-1} \text{ mol}^{-1})(298.15 \text{ K})} = 0.865 \text{ g L}^{-1}$$

- c) Suppose the container had a small hole through which the original gas mixture can effuse. Which gas will be lost more quickly? Calculate how many times faster it will be lost. (2 marks)

$$\frac{\text{Effusion rate CO}_2}{\text{Effusion rate Kr}} = \sqrt{\frac{M_{\text{Kr}}}{M_{\text{CO}_2}}} = \sqrt{\frac{83.80 \text{ g mol}^{-1}}{44.01 \text{ g mol}^{-1}}} = 1.38$$

CO₂ will be lost more quickly – it will be lost 1.38 times more quickly than Kr.

Question 3.

a) When 0.435 g of platinum is heated in fluorine, 0.689 g of a dark red volatile solid forms. What is the empirical formula of this product? (4 marks)

$$n_{\text{Pt}} = \frac{m_{\text{Pt}}}{M_{\text{Pt}}} = \frac{0.435 \text{ g}}{195.1 \text{ g mol}^{-1}} = 0.002230 \text{ mol}$$

$$n_{\text{F}} = \frac{m_{\text{F}}}{M_{\text{F}}} = \frac{m_{\text{T}} - m_{\text{Pt}}}{M_{\text{F}}} = \frac{0.689 \text{ g} - 0.435 \text{ g}}{19.00 \text{ g mol}^{-1}} = 0.01337 \text{ mol}$$

$$\text{Pt}_{\frac{0.002230}{0.002230}} \text{F}_{\frac{0.01337}{0.002230}} = \text{PtF}_6$$

b) Suppose fluorine was a limiting reagent, such that 0.155 g of platinum remains after all the fluorine has been consumed. Calculate the percent yield of this reaction. How many grams of product would be produced? (3 marks)

$$\% \text{ yeild} = \frac{\text{actual yield}}{\text{theoretical yield}} \times 100\% = \frac{\text{actual reactant used}}{\text{reactant available}} \times 100\% = \frac{m_{\text{Pt, initial}} - m_{\text{Pt, remaining}}}{m_{\text{Pt, initial}}} \times 100\%$$

$$\% \text{ yeild} = \frac{0.435 \text{ g} - 0.155 \text{ g}}{0.435 \text{ g}} \times 100\% = 64.3\%$$

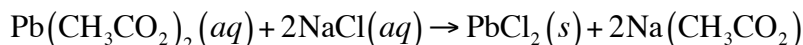
$$m_{\text{product}} = \frac{\% \text{ yeild}}{100\%} \times m_{\text{product, maximum possible}} = 0.643 \times 0.689 \text{ g}$$

$$= 0.443 \text{ g}$$

Question 4.

When an aqueous solution containing **0.250 mol** of lead(II)acetate (formula $\text{Pb}(\text{CH}_3\text{CO}_2)_2$) is added to **145 mL** of **3.65 mol/L** sodium chloride, the insoluble solid lead(II)chloride will precipitate out of the solution, with aqueous sodium acetate $\text{Na}(\text{CH}_3\text{CO}_2)$ as the other product of the reaction.

a) What is the mass of lead(II)chloride that will precipitate? (5 marks)



$$n_{\text{NaCl}} = cV = (3.65 \text{ mol L}^{-1})(0.145 \text{ L}) = 0.5292 \text{ mol}$$

$$n_{\text{PbCl}_2} = n_{\text{NaCl}} \times \frac{1 \text{ mol PbCl}_2}{2 \text{ mol NaCl}} = 0.5292 \text{ mol} \times \frac{1}{2} = 0.2646 \text{ mol}$$

Since **0.250 mol** of lead(II)acetate will form **0.250 mol** of PbCl_2 , which is smaller than the number of moles of PbCl_2 that would be produced if all the NaCl reacted, this is the limiting reagent.

$$m_{\text{PbCl}_2} = nM = (0.250 \text{ mol})(207.2 \text{ g mol}^{-1} + 2 \times 35.45 \text{ g mol}^{-1}) = (0.250 \text{ mol})(278.1 \text{ g mol}^{-1}) = 69.5 \text{ g}$$

b) What is the total number of moles of ions that will remain in solution after the reaction is complete? (5 marks)

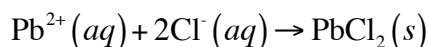
Since lead(II)acetate is limiting, the only ions that will remain in the solution are from excess NaCl and $\text{Na}(\text{CH}_3\text{CO}_2)$.

$$\begin{aligned} n_{\text{NaCl, excess}} &= n_{\text{NaCl, initial}} - n_{\text{NaCl, reacted}} \\ &= n_{\text{NaCl, initial}} - n_{\text{PbCl}_2} \times \frac{2 \text{ mol NaCl}}{1 \text{ mol PbCl}_2} \\ &= (0.5292 \text{ mol}) - (0.250 \text{ mol}) \times \frac{2 \text{ mol NaCl}}{1 \text{ mol PbCl}_2} \\ &= 0.0292 \text{ mol} \end{aligned}$$

$$n_{\text{Na}(\text{CH}_3\text{CO}_2)} = n_{\text{PbCl}_2} \times \frac{2 \text{ mol Na}(\text{CH}_3\text{CO}_2)}{1 \text{ mol PbCl}_2} = (0.250 \text{ mol}) \times \frac{2 \text{ mol Na}(\text{CH}_3\text{CO}_2)}{1 \text{ mol PbCl}_2} = 0.500 \text{ mol}$$

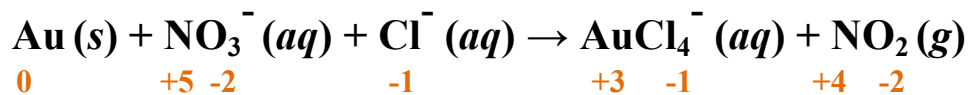
$$\begin{aligned} n_{\text{total ions}} &= n_{\text{Na}(\text{CH}_3\text{CO}_2)} \times \frac{2 \text{ mol ions}}{1 \text{ mol Na}(\text{CH}_3\text{CO}_2)} + n_{\text{NaCl, excess}} \times \frac{2 \text{ mol ions}}{1 \text{ mol NaCl}} \\ &= 0.500 \text{ mol} \times \frac{2 \text{ mol ions}}{1 \text{ mol Na}(\text{CH}_3\text{CO}_2)} + 0.0292 \text{ mol} \times \frac{2 \text{ mol ions}}{1 \text{ mol NaCl}} \\ &= 1.06 \text{ mol} \end{aligned}$$

c) Write the balanced net ionic equation for this reaction. Be sure to indicate the phases for each reactant and product. (1 mark)



Question 5.

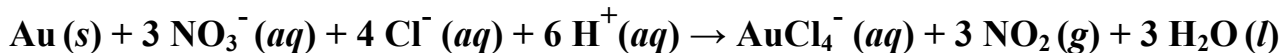
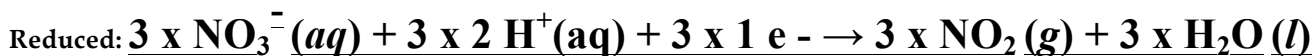
For the following reaction in aqueous solution:



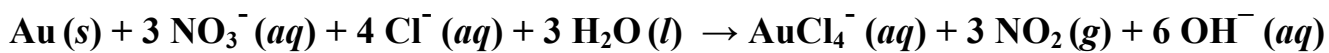
- a) Write the oxidation numbers below each element in the reaction above. (3 marks)
- b) Based on your answer in a), which compound is the oxidizing agent in this reaction? (1 mark)

NO_3^- is the oxidizing agent (it gains electrons).

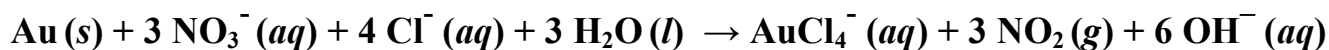
- c) Balance this equation in basic solution (5 marks).



In base solution:



Final balanced chemical equation:



Constants and Conversion Factors

$$\begin{array}{llll}
 1 \text{ mmHg} = 1 \text{ torr} & 760 \text{ mmHg} = 1 \text{ atm} & 1 \text{ atm} = 101.325 \text{ kPa} & 1 \text{ atm} = 1.013125 \text{ bar} \\
 1 \text{ cm}^3 = 1 \text{ mL} & 1 \text{ dm}^3 = 1000 \text{ mL} = 1 \text{ L} & & 1 \text{ m}^3 = 1000 \text{ L} \\
 1 \text{ cm} = 10 \text{ mm} & 1 \text{ m} = 10^6 \mu\text{m} = 10^3 \text{ mm} & & 1 \text{ km} = 1000 \text{ m}
 \end{array}$$

Avogadro's Number	N	$6.022 \times 10^{23} \text{ mol}^{-1}$
Atomic mass unit	u	$1.66054 \times 10^{-27} \text{ kg}$
Gas constant	R	$8.31451 \text{ J} \cdot \text{K}^{-1} \cdot \text{mol}^{-1}$
	R	$8.31451 \text{ kPa} \cdot \text{L} \cdot \text{K}^{-1} \cdot \text{mol}^{-1}$
	R	$0.08206 \text{ atm} \cdot \text{L} \cdot \text{K}^{-1} \cdot \text{mol}^{-1}$
	R	$8.31451 \text{ m}^3 \text{ Pa} \cdot \text{K}^{-1} \cdot \text{mol}^{-1}$
	R	$0.0831451 \text{ bar L} \cdot \text{K}^{-1} \cdot \text{mol}^{-1}$

Equations

$$T(\text{in K}) = T(\text{in } ^\circ\text{C}) + 273.15 \text{ K}$$

$$n = \frac{m}{M}$$

$$\% \text{ Yield} = \frac{\text{actual yield}}{\text{theoretical yield}}$$

$$c(\text{mol/L}) = \frac{n}{V}$$

$$c_1 V_1 = c_2 V_2$$

$$pV = nRT$$

$$\frac{p_1 V_1}{T_1} = \frac{p_2 V_2}{T_2}$$

$$p_T = p_1 + p_2 + p_3 + \dots$$

$$p_A = X_A \times p_T$$

$$X_A = \frac{n_A}{n_T}$$

$$d = \frac{m}{V} = \frac{p \cdot M}{RT}$$

$$E_K = \frac{1}{2} m v^2$$

$$u_{rms} = \sqrt{\frac{3RT}{M}}$$

$$\frac{\text{Rate A}}{\text{Rate B}} = \sqrt{\frac{M_B}{M_A}}$$

$$\left(p + \frac{n^2 a}{V^2} \right) (V - nb) = nRT$$

