Name _____KEY_____.

Last 5 digits of Student Number: XXX – X ___ – ___ ___ ___ ___
(may be the same as your social security number)

Chem 103
Sample Examination #2

This exam consists of nine (9) pages, including this cover page. Be sure your copy is complete before beginning your work. If this test packet is defective, ask for another one.

A copy of the Periodic Table will be distributed with the exam on a separate piece of paper. You may use the back side of the Periodic Table as scratch paper. No work on scratch paper will be graded or collected.

DO NOT WRITE BELOW THIS LINE

Part 1 (out of 50):

Part 2

Problem 1 (out of 14):

Problem 2 (out of 14):

Problem 3 (out of 14):

Part 3 (out of 8):

TOTAL (out of 100):

Disclaimer:
This is a copy of a typical Exam 2 given in Chem 103 during the academic year. Your test will be different. This test is being posted to give you a sense of the format, style, scope and level of a typical test on this material. This test may have questions on topics that may not be covered on your exam. Moreover, your test may have questions on topics not covered in this practice exam. Posting this test in no way limits the format, style, scope and level of the test that you will take. Do not limit your preparation to the material in this practice exam.

Part I. Multiple-Choice or Short Response

Point values of questions are indicated in curly brackets {…}.

1. {8 pts; 4 pts each} Complete the reactions and write balanced net ionic equations for the reactions that occur when the following are mixed together. Indicate all states (*s*, *l*, *g*, or *aq*).

a) $AgNO_3\,(aq) + MgBr_2\,(aq) \rightarrow$

$AgNO_{3(aq)} \rightarrow Ag^+_{(aq)} + NO_3^-{}_{(aq)}$

$MgBr_{2\,(aq)} \rightarrow Mg^{2+} + 2Br^-_{(aq)}$

$2Ag^+_{(aq)} + 2NO_3^-{}_{(aq)} + Mg^{2+}_{(aq)} + 2Br^-_{(aq)} \rightarrow 2AgBr_{(s)} + 2NO_3^-{}_{(aq)} + Mg^{2+}_{(aq)}$

$Ag^+_{(aq)} + Br^-_{(aq)} \rightarrow AgBr_{(s)}$

b) $NH_4Br\,(aq) + KOH\,(aq) \rightarrow$

$NH_4Br_{(aq)} \rightarrow NH_4^+{}_{(aq)} + Br^-_{(aq)}$

$KOH_{(aq)} \rightarrow K^+_{(aq)} + OH^-_{(aq)}$

$NH_4^+{}_{(aq)} + Br^-_{(aq)} + K^+_{(aq)} + OH^-_{(aq)} \rightarrow NH_{3(aq)} + H_2O_{(l)} + K^+_{(aq)} + Br^-_{(aq)}$

$NH_4^+{}_{(aq)} + OH^-_{(aq)} \rightarrow NH_{3(aq)} + H_2O_{(l)}$

2. {5 pts} Identify the type of reaction by writing the corresponding letter beside each reaction.

A. combustion reaction
B. precipitation reaction
C. acid-base reaction
D. gas-forming reaction
E. redox reaction

A	$2\,C_6H_5COOH + 15\,O_2 \rightarrow 14\,CO_2 + 6\,H_2O$
C	$Ba(OH)_2 + 2\,HCl \rightarrow BaCl_2 + 2\,H_2O$
E	$Fe_2O_3 + 3\,CO \rightarrow 2\,Fe + 3\,CO_2$
D	$MgCO_3 + HNO_3 \rightarrow Mg(NO_3)_2 + H_2O + CO_2$
B	$Pb(NO_3)_2 + Na_2SO_4 \rightarrow PbSO_4 + NaNO_3$

3. {3 pts} How many <u>milliliters</u> of a 0.996 M solution of $CaCl_2$ (m.w. 110.98) are needed to obtain 2.531 g of $CaCl_2$?

$$V \cdot C = \frac{m}{MW} \qquad V = \frac{m}{(MW)(C)}$$

$$V = \left(\frac{2.531\ g}{1}\right)\left(\frac{1\ mol}{110.98\ g}\right)\left(\frac{1\ L}{0.996\ mol}\right)\left(\frac{1000\ mL}{1\ L}\right) = 22.3\ mL$$

4. {4 pts} What are the concentrations of the following ionic species in a 1.23 M solution of $Al(NO_3)_3$? $Al(NO_3)_{3\,(aq)} \rightarrow Al^{3+}_{(aq)} + 3\,NO_3^-{}_{(aq)}$

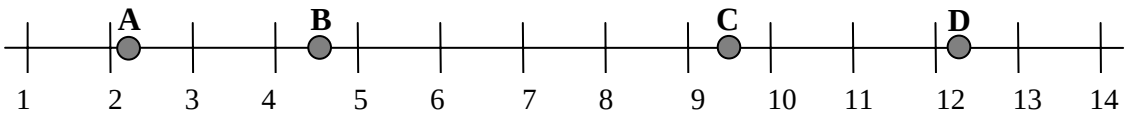
a) $[Al^{3+}]$ = 1.23 M $\left(1.23\ \frac{mol}{L}\ Al(NO_3)_3\right)\left(\frac{1\ mol\ Al^{3+}}{1\ mol\ Al(NO_3)_3}\right)$

b) $[NO_3^-]$ = 3(1.23) = 3.69 M $\left(1.23\ \frac{m}{L}\ Al(NO_3)_3\right)\left(\frac{3\ mol\ NO_3^-}{1\ mol\ Al(NO_3)_3}\right)$

5. {3 pts} Circle which of the following is *soluble* in water. (All the others are below the threshold of solubility, and are considered mostly insoluble.)

$PbCl_2$ $Ag_2C_2O_4$ $FePO_4$ (**$MgSO_4$**) BaS

6. {5 pts} Use the letters A, B, C, and D on the pH scale below to answer the questions.



- Which is a weak acid? B
- Which is a strong acid? A
- Which is a weak base? C
- Which is a strong base? D
- Identify the pH's of two solutions that could be combined, in equal volumes, to produce a neutral solution.

pH (B) = 4.5

pH (C) = 9.5

$$\frac{4.5 + 9.5}{2} = 7$$

7. {3 pts} Calculate the pH of a solution that has $[H^+] = 2.1 \times 10^{-10}$ M.

$pH = -\log [2.1 \times 10^{-10}] = 9.68$

8. {3 pts} What is the oxidation number of Mn in $KMnO_4$?

$+1 + x + 4(-2) = 0$

$x = +7$

9. {4 pts} Given this reaction

$$5\ C_2O_4^{2-}(aq) + 2\ MnO_4^-(aq) + 16\ H^+(aq) \rightarrow 2\ Mn^{2+}(aq) + 10\ CO_2(g) + 8\ H_2O(l)$$

Identify which species is:

- Oxidized? $C_2O_4^{2-}$
- Reduced? MnO_4^-
- The oxidizing agent? MnO_4^-
- The reducing agent? $C_2O_4^{2-}$

10. {4 pts} Identify the sign of the enthalpy change of the system as positive (+) or negative (-) for each of these systems, and very briefly explain why.

a) The system is the chemicals that undergo this change:
$C_5H_{12}(g) + 8\ O_2(g) \rightarrow 5\ CO_2(g) + 6\ H_2O(l)$

ΔH_{sys} is (circle one) positive (negative)
because:
Combustion generates heat.

b) Perspiring cools down your body. Liquid water on your skin undergoes the change, $H_2O(l) \rightarrow H_2O(g)$. Consider the water on your skin to be the system.

ΔH_{sys} is (circle one) (positive) negative
because:
Heat is absorbed to effect the l → g phase change.

11. {4 pts} Determine the standard enthalpy change (in kilojoules) for the following reaction, given the standard heats of formation provided in the table that follows. Show your work to receive partial credit.

std state $\Delta H_f = 0$

$$CH_4\,(g) + 3\,Cl_2\,(g) \rightarrow 3\,HCl\,(g) + CHCl_3\,(g)$$

Substance	CH_4 (*g*)	HCl (*g*)	$CHCl_3$ (*g*)
ΔH_f^o	-74.87 kJ/mol	-92.31 kJ/mol	-103.18 kJ/mol

$H_{prod} - H_{react}$

$= \{3(-92.31) + (-103.18)\} - \{3(0) + (-74.87)\}$

prod. react.

$= -305.24$ kJ/mol

12. {4 pts} What is Green Chemistry? (Explain three principles that Green Chemistry focuses on.)

1. Prevention
2. Non-toxic
3. Atom economy

BONUS {3 pts} The atom economy can be calculated from the equation

$$\text{Atom economy} = \frac{\text{Mass of all desired products}}{\text{Mass of all reactants}} \times 100\%$$

Why is higher atom economy considered Greener?

When atom economy = 100%, waste = 0%

A higher atom economy means less waste.

Part II. Problems

Each problem is worth 14 points. Point values of parts of problems are indicated in curly brackets {…}.
Make sure to report answers to the proper significant figures. Show all work. Partial credit is possible even if your final answers are incorrect. No credit will be given, even for a correct answer, if no work is shown.

1. One way to free metallic gold (Au) from a gold-bearing rock is to treat the rock with sodium cyanide in the presence of excess oxygen, according to the reaction

$$4\ Au\ (s)\ +\ 8\ NaCN\ (aq) +\ O_2\ (g)\ +\ 2\ H_2O\ (l)\ \rightarrow\ 4\ NaAu(CN)_2\ (aq)\ +\ 4\ NaOH\ (aq)$$

If a particular rock containing gold required 254 mL of 0.0275 M NaCN solution in order for all the gold to fully react, what mass of gold (m.w. 197.0) was in the rock?

$$\left(0.275\ \frac{mol}{L}\ CN^-\right)(0.254\ L\ CN^-)\left(\frac{4\ mol\ Au}{8\ mol\ CN^-}\right)\left(\frac{197.0\ g\ Au}{1\ mol\ Au}\right)$$

$$= 0.688\ g\ Au$$

2. When 8.25 g of ammonium nitrate, NH_4NO_3 (m.w. 80.03), are added to 90.0 g of water, the temperature of the solution decreases from 26.00ºC to 19.56ºC. (Assume the heat capacity of the solution is the same as pure water. The heat capacity of water is 4.184 J/g•K.)

a) {4 pts} What is the temperature change of the solution? (Be sure to indicate the correct sign.)

$(19.56 - 26.00)^\circ C = -6.44^\circ C = -6.44\ K$

b) {4 pts} Is dissolving NH_4NO_3 in water an exothermic or endothermic change? Explain.

NH_4NO_3 absorbed heat from the surrounding water. It is endothermic with regard to NH_4NO_3.

c) {6 pts} How much heat is absorbed or released during the change? (Be sure to indicate the correct sign.)

$(-6.44\ K)(8.25_g + 90.0_g)(4.184\ J/g \cdot K)$

$= -2650\ J$

$= -2.65\ kJ$

3. The following reaction is one step in the manufacture of sulfuric acid:

$$2\ SO_2\ (g)\ +\ O_2\ (g)\ \rightarrow\ 2\ SO_3\ (g) \qquad \Delta H = -198.0\ kJ$$

a) {7 pts} If the enthalpy of formation of SO_2 (*g*) is -296.8 kJ/mol, what is the enthalpy of formation of SO_3 (*g*)? (Hint: start by writing the formation reactions for SO_2 (*g*) and SO_3 (*g*).)

$\Delta H = H_{prod} - H_{react}$

$\Delta H = 2\,(H_{SO_3(g)}) - \{2\,H_{SO_2(g)} + H_{O_2(g)}\}$

$H_{O_2(g)} = 0$ (std state)

$\frac{1}{2}\Delta H = H_{SO_3(g)} - H_{SO_2(g)}$

$H_{SO_3(g)} = H_{SO_2(g)} + 1/2\ \Delta H$

$= -296.8 + \frac{1}{2}(-198.0) = -315.8\ kJ$

b) {7 pts} How much heat (in kilojoules) is released when 7.824 g of SO_2 (*g*) (m.w. 64.07) are converted to SO_3 (*g*)?

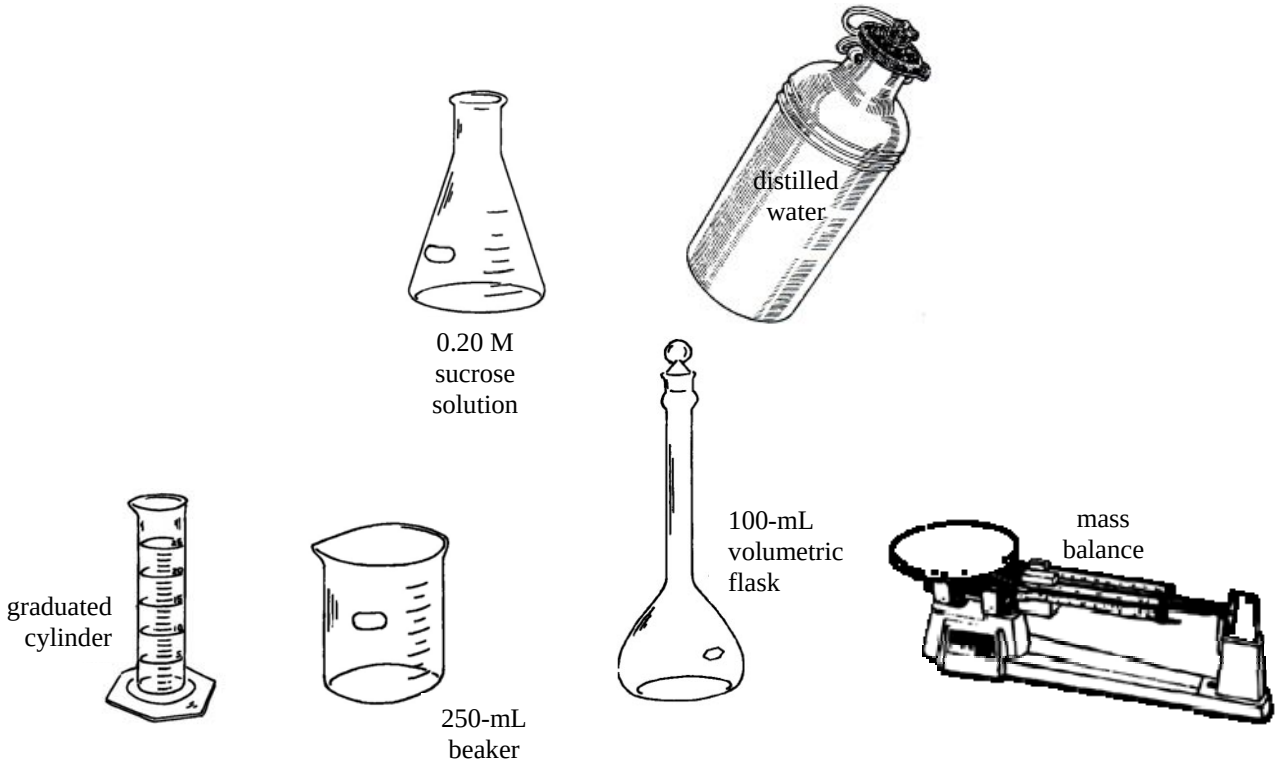
$$\left(\frac{7.824\ g\ SO_2}{64.07\ g/mol\ SO_2}\right)\left(\frac{-198.0\ kJ}{2\ mol\ SO_2}\right)$$

$= -12.09\ kJ$

Part III. Laboratory

{8 points}

Given the following laboratory materials and equipment, briefly describe **the most accurate** procedure for making a 0.020 M sucrose solution. It is not necessary to use every piece of equipment, but clearly indicate in your procedure which pieces of equipment you will use.



Less accurate

1. In the beaker, measure 1 part by volume of solution, 25 mL for example. Then add 9 parts by volume distilled water. ~~225~~ (225 mL H_2O)

OR

More accurate

2. Measure 1/10th the volume of the volumetric flask (10 mL of solution) using the graduated cylinder. Then add water to the mark on the volumetric flask.