



**GENERAL CHEMISTRY 2  
THIRD HOUR EXAM  
APRIL 15, 2022**

**Name** \_\_\_\_\_

**Panthersoft ID** \_\_\_\_\_

**Signature** \_\_\_\_\_

**Part 1** \_\_\_\_\_ (20 points)

**Part 2** \_\_\_\_\_ (44 points)

**Part 3** \_\_\_\_\_ (36 points)

**TOTAL** \_\_\_\_\_ (100 points)

**Do all of the following problems. Show your work.**

Unless otherwise stated, you may assume  $T = 25. ^\circ\text{C}$  in all problems.

**Part 1. Multiple choice.** Circle the letter corresponding to the correct answer. There is one and only one correct answer per problem. [4 points each]

1) Which of the following reactions is expected to go to completion?

- a) The reaction of a weak acid with a weak base
- b) The reaction of a strong acid with a weak base
- E** c) The reaction of a strong acid with a strong base
- d) Both a and b
- e) Both b and c

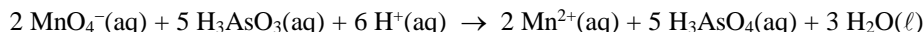
2) Which of the following methods can be used to prepare a buffer solution?

- a) Adding a monoprotic weak acid and the sodium salt of the conjugate base of the weak acid to water
- b) Partially neutralizing a solution containing a monoprotic weak acid by the addition of sodium hydroxide (NaOH), a strong soluble base
- E** c) Partially neutralizing a solution containing the sodium salt of the conjugate base of a weak monoprotic acid by the addition of hydrochloric acid (HCl), a strong monoprotic acid
- d) Both a and b
- e) Both a and b and c

3) Oxalic acid ( $\text{H}_2\text{C}_2\text{O}_4$ ) is a diprotic acid. Consider a solution of oxalic acid titrated with a solution of potassium hydroxide (KOH), a strong soluble base. How many equivalence points will be observed in the titration?

- a) 0
- b) 1
- C** c) 2
- d) 3
- e) More than 3

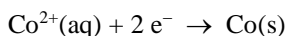
4) Permanganate ion ( $\text{MnO}_4^-$ ) can be used to titrate solutions of arsenous acid ( $\text{H}_3\text{AsO}_3$ ). The reaction that occurs is



A solution contains  $3.628 \times 10^{-3}$  moles of  $\text{H}_3\text{AsO}_3$ . To reach the equivalence point for the titration, how many moles of  $\text{MnO}_4^-$  ion must be added to the solution?

- a)  $0.726 \times 10^{-3}$  moles of  $\text{MnO}_4^-$  ion
- b)  $1.451 \times 10^{-3}$  moles of  $\text{MnO}_4^-$  ion
- B** c)  $3.628 \times 10^{-3}$  moles of  $\text{MnO}_4^-$  ion
- d)  $9.070 \times 10^{-3}$  moles of  $\text{MnO}_4^-$  ion
- e)  $18.14 \times 10^{-3}$  moles of  $\text{MnO}_4^-$  ion

5) Cobalt metal can be produced by the electrolysis of a solution containing  $\text{Co}^{2+}$  ion. The half reaction that occurs is



Electrolysis of a solution containing  $\text{Co}^{2+}$  ion is carried out for a period of 5.00 hours, using a current  $i = 2.30$  amps (1 amp = 1 C/s). How many moles of cobalt metal will be produced?

- a) 0.215 moles Co
- b) 0.429 moles Co
- A** c) 0.644 moles Co
- d) 0.858 moles Co
- e) 1.000 moles Co

**Part 2. Short answer.**

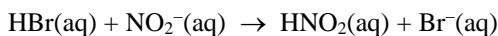
1) A buffer solution contains 0.0480 M nitrous acid ( $\text{HNO}_2$ ,  $K_a = 7.1 \times 10^{-4}$ ) and 0.0340 M nitrite ion ( $\text{NO}_2^-$ ).

a) What is the pH of the buffer solution? [8 points]

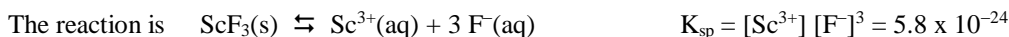
$$\text{pH} = \text{p}K_a + \log_{10}\left\{\frac{[\text{base}]}{[\text{acid}]}\right\} \quad \text{p}K_a = -\log_{10}(7.1 \times 10^{-4}) = 3.149$$

So 
$$\text{pH} = 3.149 + \log_{10}\left[\frac{(0.0340)}{(0.0480)}\right] = 3.149 + (-0.150) = 3.00$$

b) Give the balanced chemical reaction that takes place when a small amount of HBr (a strong acid) is added to the buffer solution. [4 points]



2) Scandium (III) fluoride ( $\text{ScF}_3$ , MW = 102.0 g/mol) is a slightly soluble ionic compound, with  $K_{sp} = 5.8 \times 10^{-24}$ . How many grams of scandium (III) fluoride will dissolve in 1.000 L of pure water? [10 points]



So

	Initial	Change	Equilibrium
$\text{Sc}^{3+}$	0	x	x
$\text{F}^-$	0	3x	3x

Substituting, we get

$$(x)(3x)^3 = 27x^4 = 5.8 \times 10^{-24}$$

$$x^4 = \frac{5.8 \times 10^{-24}}{27} = 2.15 \times 10^{-25} \quad x = (2.15 \times 10^{-25})^{1/4} = 6.81 \times 10^{-7}$$

Based on the ICE table, x is equal to the molar solubility for  $\text{ScF}_3$ . So the solubility by mass is

$$\text{Solubility by mass} = \frac{6.81 \times 10^{-7} \text{ mol}}{\text{L}} \frac{102.0 \text{ g}}{\text{mol}} = \underline{6.94 \times 10^{-5} \text{ g}} \text{ ScF}_3$$

Since we are adding the  $\text{ScF}_3$  to 1.000 L water, the amount that will dissolve is  $6.94 \times 10^{-5}$  g.



**Part 3. Problems.**

1) A 0.4147 g sample of a weak monoprotic acid was titrated with a 0.1273 M solution of potassium hydroxide (KOH), a strong soluble base.

a) The pH at the equivalence point for the titration will be (circle the correct answer) [4 points]

less than 7.0

equal to 7.0

**greater than 7.0**

b) After the addition of 24.86 mL of the potassium hydroxide solution, the equivalence point for the titration is reached. Based on this information, find the molecular weight of the weak monoprotic acid. [12 points]

$$\text{MW} = \frac{\text{grams acid}}{\text{moles acid}} \quad \text{grams acid} = 0.4147 \text{ g}$$

To find the moles of acid we use the information from the titration. Since the acid is weak and monoprotic, we can represent it as HA, and then write the titration reaction as



At the equivalence point, the moles of KOH is

$$\text{moles KOH} = 0.02486 \text{ L KOH} \frac{0.1273 \text{ mol KOH}}{1 \text{ soln}} = 3.165 \times 10^{-3} \text{ mol KOH}$$

Based on the balanced reaction, we may say

$$\text{moles HA} = 3.165 \times 10^{-3} \text{ mol KOH} \frac{1 \text{ mol HA}}{1 \text{ mol KOH}} = 3.165 \times 10^{-3} \text{ mol HA}$$

So the molecular weight of the weak monoprotic acid is

$$\text{MW} = \frac{0.4147 \text{ g acid}}{3.165 \times 10^{-3} \text{ mol acid}} = 131.0 \text{ g/mol}$$

2) Consider the following galvanic cell



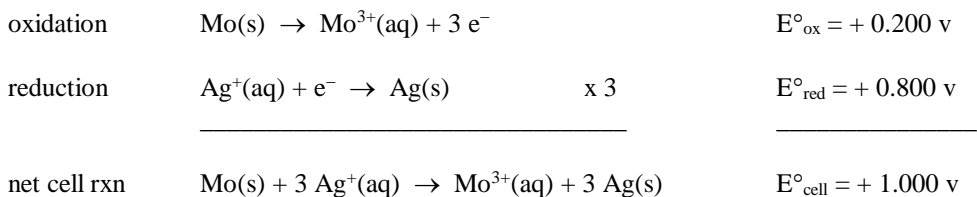
Relevant half-cell reduction reactions are given below and may be of use in doing this problem.



a) What is the oxidizing agent in the above galvanic cell? [4 points]

oxidizing agent = Ag<sup>+</sup> (The oxidizing agent is the species being reduced)

b) Give the half-cell oxidation reaction, the half-cell reduction reaction, the net cell reaction, the cell potential for standard state conditions ( $E^\circ_{\text{cell}}$ ), and the cell potential for the actual conditions ( $E_{\text{cell}}$ ) for the above galvanic cell. [16 points]



From the Nernst equation

$$E_{\text{cell}} = E^\circ_{\text{cell}} - \frac{RT}{nF} \ln Q \quad n = 3 \quad Q = \frac{[\text{Mo}^{3+}]}{[\text{Ag}^+]^3} = \frac{(0.148)}{(5.9 \times 10^{-4})^3} = 7.2 \times 10^8$$

and so  $E_{\text{cell}} = + 1.000 \text{ v} - \frac{(8.3145 \text{ J/mol}\cdot\text{K})(298.2 \text{ K})}{(3)(96485 \text{ C/mol})} \ln(7.2 \times 10^8)$

$$= + 1.000 \text{ v} - (0.175 \text{ v}) = 0.825 \text{ v}$$