13 Aug. 2017

MINISTRY OF SCIENCE, RESEARCH AND TECHNOLOGY
NATIONAL ORGANIZATION
FOR
EDUCATIONAL TESTING

22th National and the 10th International Chemistry Olympiad
Summer 2017
Iran

Analytical Chemistry, I&II, and Instrumental Analysis

Time: 90 minutes

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Question No.	Points for each question	Signature	total score (out of 100)
1	/10		
2	/10		
3	/20		
4	/10		
5	/15		
6	/15		
7	/20		

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10th International Olympiad
Summer 2017

Do NOT write here

First name:

Last name:

Exam title:

Exam data:

13 Aug. 2017

1- What is the relative percent error in H_3O^+ Concentration at pH 5.00 that is equal to 0.01 of unit error in pH?

2- **In a solution involving the following equilibria**

$$M + L \rightleftarrows ML \qquad K_1 = [ML]/[M][L]$$

$$ML + L \rightleftarrows ML_2 \qquad K_2 = [ML_2]/[ML][L]$$

Prove that the maximum concentration of ML occurs under the conditions where $[L] = (K_1 K_2)^{-1/2}$

3- Is it possible to remove 99% of a 2.5μM CuY^{2-} impurity from a 1.0 mM CoY^{2-} solution at pH 4.0 without reducing any cobalt in controlled – potential electrolysis? (Use 0.06 as the slope of the Nernst eq.)

($E^{\circ}_{Co^{2+}/Co} = -0.277V$, $E^{\circ}_{Cu^{2+}/Cu} = +0.337V$)

($K_{CoY^{2-}} = 2.5\times10^{16}$, $K_{CuY^{2-}} = 6.25\times10^{18}$, $\alpha_4 = 4\times10^{-9}$)

(Y is EDTA, and the total concentration of free EDTA is 10 mM)

4- **The expression for fluorescence intensity is:**

$F=KQ_e\ P_0\ 2.303\varepsilon bC$

Where k is an instrumental light – collection factor, Q_e is quantum efficiency P_o is radiant power of the excitation source, and ε, b and C are the same as in the Beer-Lambert Law. Which term or terms in this expression are affected by the sample temperature? Will raising the temperature of a sample increase or decrease the fluorescence intensity? Explain your answer.

5- **Iron concentrations can be measured by forming iron(II) orthophenanthroline complexes, which have a peak absorption at 508 nm. In one solution, orthophenanthroline is added to 50.0 mL of waste water and diluted to 100.0 mL. A second solution contains 50.0 mL of the same water sample, orthophenanthroline, and 10.0 mL of a 5.550×10^{-4} M iron standard.**
Absorbance measurements at 508 nm in a 1.00-cm sample cell for these two solutions were 0.955 and 1.088, respectively. What is the iron concentration in the water sample in μg / mL (or ppm) with correct number of significant figures?
Fe = 55.85 g/mole

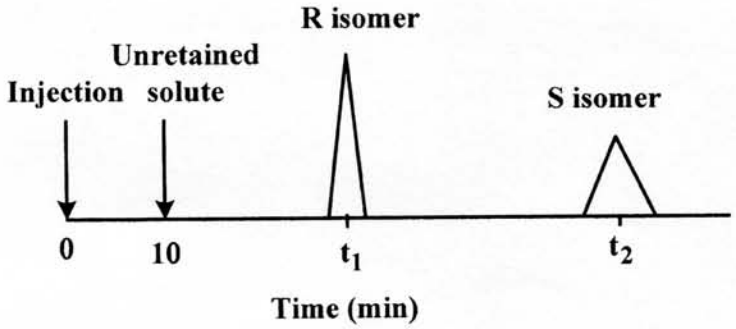
6- For the separation of optical isomers by HPLC, a mixture of R and S enantiomers is eluted with 20% (vol / vol) 2-propanol in hexane into a column with length 50 cm. The R enantiomer is eluted before the S enantiomer, with the following chromatographic parameters: R (Resolution) = 7.7; K'_R (Capacity factor for R isomer) = 1.35 and a (Separability factor) = 4.53. A schematic chromatogram is shown below.

a) Find t_1, t_2 and $\bar{w}$ (the average width of the two peaks at their base) with units of minutes.

b) Calculate the number of theoretical plates in the column for elation of S isomer and the height equivalent to a theoretical plate (H.E.T.P.) in this case;

c) Find the retention volumes for R and S isomers, when the flow rate of mobile phase is $5\,mL\,min^{-1}$. What is the volume of mobile phase?

d) What are the mean linear velocity of the migration of each isomers?



7- **Answer to the following questions.**

a) Most metals are in an ionic form in a solution, whereas in a flame the emission from neutral atoms is observed. To go from ions to atoms, from where do these electrons come?

b) For the alkali metals such as Na, K and Li, many of the atomic species present in a flame are ionized. In these cases, why is ionic emission not stronger than atomic emission?

c) Which would be superior the Dc-Arc or the high – voltage Spark as an electrical discharge source for the spectrometric analysis of a disk of a very inhomogeneous alloy? Explain and justify your answer.