

**Admission Exam of the Post-Graduation Program in Chemistry
Federal University of São Carlos
Academic Master Degree and Doctoral Degree, 2/2018**

ATTENTION

PLEASE DO NOT PUT NAME ON EXAM.

ALL THE SHEETS MUST BE IDENTIFIED ONLY WITH THE CANDIDATE CODE

Question 01

The unification between thermodynamics and mechanics can be achieved by establishing equivalence between thermal and mechanical energies. The relationship between the mechanical (or electrical) energy (given in joule) with the thermal energy (given in calorie) can be obtained by performing the following experiment: consider an electrical resistance subjected to an electrical potential difference of $7 \text{ V} = 7 \text{ J C}^{-1}$ immersed in 1 kg ($\approx 1 \text{ L}$) of water. When an electrical current of $10 \text{ A} = 10 \text{ C s}^{-1}$ is passed, the water temperature rises to $1 \text{ }^\circ\text{C}$ per minute. Calculate the value of the relationship between the electrical energy with the thermal energy. Consider $c \approx 1 \text{ cal g}^{-1} \text{ }^\circ\text{C}^{-1}$.

Question 02

A solution containing carbohydrate is submitted to an enzymatic fermentation process. The evolution of the carbohydrate concentration as a function of fermentation time is shown in the following table:

Time (h)	Concentration (mol L^{-1})
0	1/15
1/12	1/30
1/6	1/60
1/4	1/120

Based on that information, calculate the reaction order and the rate constant for the fermentation process of the carbohydrate.

Question 03

Explain how it is possible to obtain an n-type or p-type semiconductor. If we wish to modify the semiconductor properties of gallium, which element would we choose: indium or phosphorus? Why?

Question 04

Ligand field theory predicts that different types of metal ions will form more stable complexes with certain types of ligands. Predict which ligands (F^- or CN^-) would form more stable complexes with the metals Cu(II) , V(III) and Cr(IV) . Explain your choices.

Question 05

How many milliliters of a 0.10 mol L^{-1} NaOH solution should be added to 50.00 mL of a 0.15 mol L^{-1} acetic acid solution to produce a buffer solution with pH equal to 4.44. K_a (Acetic Acid) = 1.8×10^{-5}

Question 06

A NaOH solution was added to a water sample which contains the following concentrations of the cations: 0.050 mol L^{-1} of Mg^{2+} and 0.010 mol L^{-1} of Ca^{2+} .

a) How is the OH^- concentration in solution when each cation start to precipitate.

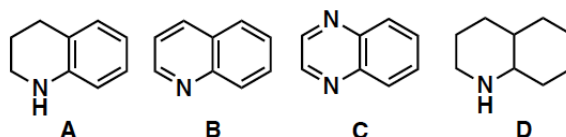
b) If the first compound to precipitate is $\text{Mg}(\text{OH})_2$, calculate the concentration of Mg^{2+} ions remaining in solution when the $\text{Ca}(\text{OH})_2$ precipitates. Consider that there is no change of volume when NaOH is added.

$$K_s \text{Mg}(\text{OH})_2 = 1.1 \times 10^{-11} \quad K_s \text{Ca}(\text{OH})_2 = 5.5 \times 10^{-6}$$

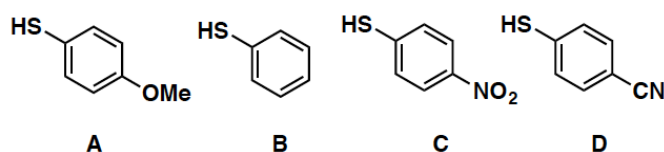
Question 07

In this question you are asked to rank the relative strengths of the series of illustrated acids and base. Use your knowledge on electronic effects as well as hybridization to rationalize it.

Part A: For the sequence of bases shown below, rank the set from strongest to weakest.



Part B: For the sequence of thiophenols shown below, rank the set from strongest to weakest acid.



Question 08

In this question you are asked to identify the major product obtained by the hydration of styrene. Provide an explanation for your choice.

