Strathmore
UNIVERSITY

SCHOOL OF COMPUTING AND ENGINEERING SCIENCES
BACHELOR OF SCIENCE IN ELECTRICAL AND ELECTRONICS ENGINEERING
END OF SEMESTER EXAMINATION
CHE 1101 : CHEMISTRY

DATE: April 2021 Time: 3 Hours

Instructions

1. This examination consists of **FIVE** questions (1 to 5) with sub-questions.
2. Answer **Question 1 (COMPULSORY)** and any other **TWO** questions.
3. One pocket calculator per-student is allowed as long it is used in "exam-mode".
4. All other electronic devices are to be kept at a distance and shutdown in your bags**.**

Fig 1: Michel-Eugène Chevreul, "On the simultaneous contrast of colours" 1839

Question 1) Absorption and pH color Indicators [30 marks]

I) The absorption spectrum A = f(λ) of a solution of iodide I2 is given below:

a) What are the steps to follow to carry out a dosage by calibration of this iodide solution? [**3 Marks**]
b) Why is it necessary to carry out the absorbance zeroing on the spectrophotometer before making the measurements? [**3 Marks**]
c) What will the calibration curve look like? [**3 Marks**]
d) What law does it obey? [**3 Marks**]

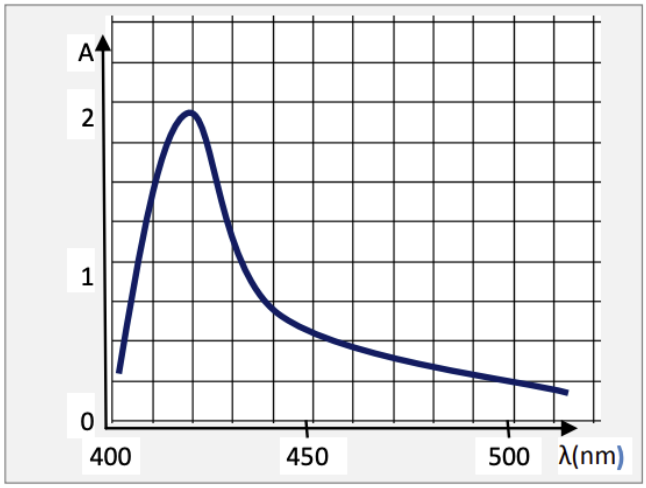
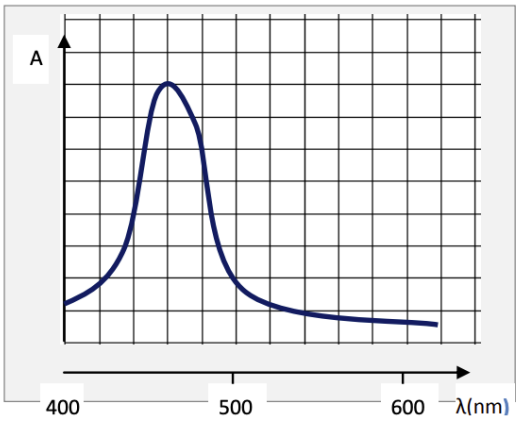


Fig. 3: Absorption of iodine solution.

II) Methyl orange is a colour indicator used in the acid-base dosages.

The color of this indicator in aqueous solution depends on the pH: Methyl orange is red for a lower pH at 4.4 and yellow for a pH above 6.2. The absorption spectrum of an aqueous solution (called S) of Methyl orange at a fixed pH is presented here.

a) What is the wavelength in nm of maximum absorption of solution S? [**3 Marks**]
b) Considering this absorption wavelength of this solution, what would be the color of S? [**4 Marks**]
c) What is the domain of pH of the prepared solution S? [**2 Marks**]



d) What would the absorption spectrum look like if the solution had been prepared at pH = 2? [**4 Marks**]

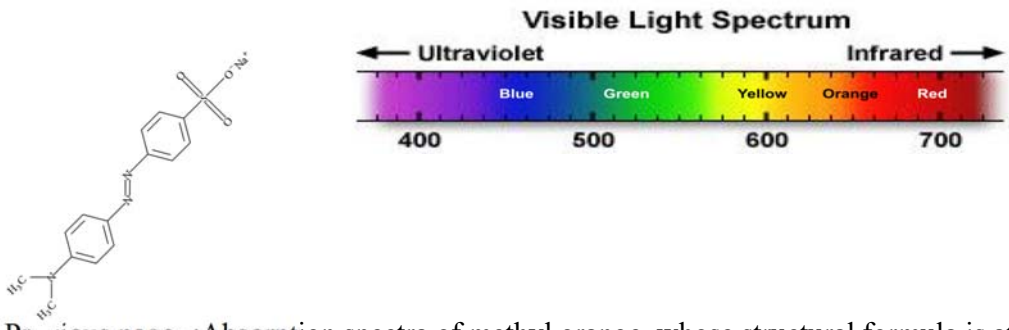


Fig 2: Previous page -:Absorption spectra of methyl orange, whose structural formula is at the top left of this page, as a function of the wavelength in nm. The here presented visible light spectrum is only for naming.

e) Methyl orange changes color at the pKa 3.47 in water at 25 °C, explain what is a pKa and write the two semi-developed structural formulas (Acid/Basic) of this pH indicator on a pH scale. [**5 Marks**]

Question 2) Exercise on dissolution [15 Marks]

The Calcium sulfate also called "gypsum plaster" when hydrated has à formula $CaSO_4$. It has a dissolution constant Ks1 = 2E-5. Ammonium chloride is an inorganic compound with the formula NH_4Cl and a white crystalline salt it has a dissolution constant Ks2 = 3E1. Those salts supposedly anhydrous. If you pour a solid mixture of ten grams of $CaSO_4$ and ten grams of NH_4Cl in 10 cL of pure water which of this solid material is likely to remain solid, how much of it?

a) Write the dissolution equation of each salt [**2 Marks**].
b) Based on the fact that the moles of $CaSO_4$ are of molar mass M1 = 136.14 $g \cdot mol^{-1}$ and those NH_4Cl of M2 = 53.49 $g.mol^{-1}$ calculate the number of mols of each salt in 10 grams. [**2 Marks**]
c) Give the nature and the amount of all possible ions in solution. [**2 Marks**]
d) Whose salt is likely to remain solid? [**2 Marks**]
e) Calculate what the mass of the remaining solids in 10 cL of water [**2 Marks**]
f) Redo the same but this time consider 1 L of pure water. [**2 Marks**]

Question 3: Exercise on Acidity [15 Marks]

An acid dissociation constant, Ka, (also known as acidity constant, or acid-ionization constant) is a quantitative measure of the strength of an acid in solution. It is modelled by the following simplified chemical reaction. The equilibrium constant for this reaction is called Ka.

$$HA(aq) \rightleftharpoons A^-(aq) + H^+(aq)$$

$$Ka = \frac{[A^-][H^+]}{[HA]}$$

a) The acidity constant here is taken to be Ka =1.4E-20, At the equilibrium [HA] is 0.10 mol.L^{-1}, and [A$^-$] is 1.6E-21 mol.L^{-1}. How much is [H_3O^+] then? [**3 Marks**]
b) Find the pH [**2 Marks**]
c) Develop the sum: "pKa+log([A-]/[HA])" [**2 Marks**]
d) What is the link between dissociation constant and acidity constant here ?[**3 Marks**]
e) The follow compound has a dissociation constant Ka = 1.74E-5 explain what acid-base couples are defined and how to calculate the amount of the produced anion when the acid has a concentration of 1M.[**5 Marks**]

$$CH_3COOH(aq) + OH^-(aq) \rightleftharpoons CH_3COO^-(aq) + H_2O(l)$$

Question 4: Exercise on equation reaction [15 Marks]

Bi_2S_3 dissolves in water according to the following reaction:

$$Bi_2S_3(s) \rightleftharpoons 2\,Bi^{3+}(aq) + 3S^{2-}(aq)$$

for which the solubility product, Ksp at room temperature, is given by Ksp=1.6E-72.

a) At room temperature how many moles of Bi_2S_3 will dissolve in 3.673E6 Litres of water? [**2 Marks**]
b) How many ions Bi^{3+} will be present in the solution? [**3 Marks**]
c) Use an advancement table to express the quantity of matter that is being transformed into Sulphur anion. [**10 Marks**]

Question 5: Exercise on experimental methods [15 Marks]

a) Atomic aluminium vapour is deposited on the mirror surface. Give the chemical symbol of Aluminium and its atomic number. [**2 Marks]**

b) Achieving a stable, pinhole-free, ultra-thin (<3 nm) overcoat would allow protected aluminium mirrors to approach the ideal aluminium intrinsic reflectivity in the challenging, but spectrally-rich, wavelength spectrum of 90-115 nm range. What is the name for this electromagnetic wave range? [**3 Marks]**

c) Considering that aluminium is heated in a filament and then sent to the plates where where the mirrors stands are located give an explanation of the schematic of figure 3. Where is located the aluminium source, and where is located the mirror? [**3 Marks]**

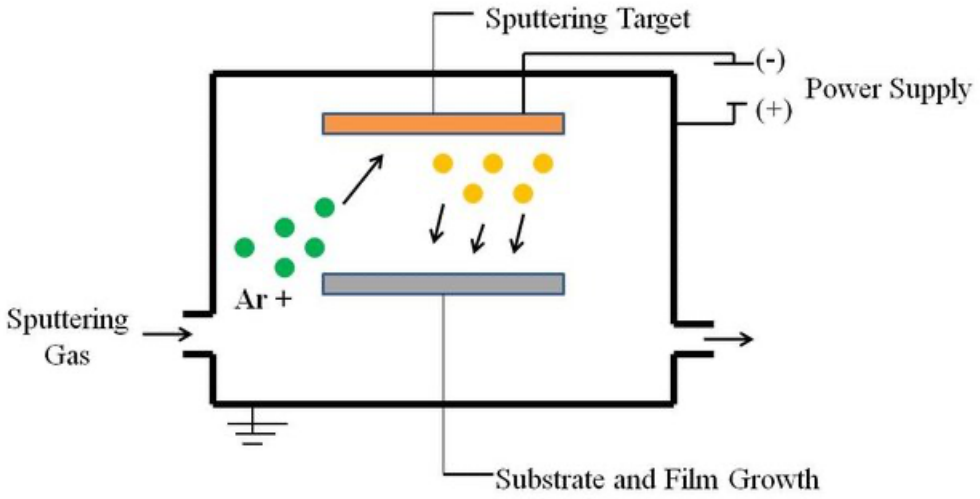


Fig. 3: Schematics of the pulsed DC Magnetron Sputtering Setup (Studies on Nanostructure Aluminium Thin Film Coatings Deposited using DC magnetron Sputtering Process Muralidhar Singh M, IOP 2016)

d) Considering the Van der Waals radius of an Aluminium atom is 184 pm what is the maximum number of these atoms are arranged in the layer deposited on the mirror surface. [**2Marks]**

e) Draw a rechargeable battery first as a generator, your schematic should indicate clearly where is the cathode and the anode. Is this convention the same when the battery serves for storing energy (accumulator) ? [**2Marks]**

f)The of the Aluminium ion formed after the impact is it an Anion or a Cation ? This device (-) pole contains the aluminium bombed by the charged Argon. Why is it called a cathode ? Justify and check this consistent with the last answer [**3Marks]**