UNIVERSITY OF KELANIYA - SRI LANKA

FACULTY OF SCIENCE

Bachelor of Science General Degree Examination – December 2022

Academic Year 2020/2021– Semester I

CHEMISTRY

CHEM 11622 & CHEM 11622(R) - **General Chemistry**

Number of Questions: Four (04) | Time: Two (02) hours

Number of pages: Four (04) | Answer all questions.

Q1. Answer all parts.

(A) (i) Considering the nuclear band of stability, explain briefly why lighter nuclides are stable when number of neutrons (N) are equal to number of protons (Z) while heavier nuclides are stable when N is greater than Z (N >Z) ?

(ii) Beryllium (atomic mass 9.01 amu) has ^{9}Be, ^{10}Be, and ^{7}Be isotopes. However, among these isotopes only ^{9}Be is most abundant and stable. Explain your answer using relevant balanced nuclear reactions. (25 marks)

(B) Composition analysis of a rock sample revealed the composition as 0.688 g of $^{206}_{82}Pb$ present for every 1.000 g of $^{238}_{92}U$ while rest of the elements are present in negligible amounts. If it is assumed that there are no $^{206}_{82}Pb$ present in the sample at formation,

(i) Calculate the initial mass of $^{238}_{92}U$ present in the sample

(ii) Age of the rock sample.

(^{238} U, half-life is t ½ = 4.5 x 10^{9} years) (25 marks)

(C) $^{232}_{90}Th$ undergo a series of decays yielding six (06) alpha and four (04) beta particles. Identify the final daughter nuclide at the end. (25 marks)

(D) (i) In relation to nuclear fission, state the consequences of having critical mass, subcritical mass and supercritical mass of fuel in the reactor.

(ii) Explain how a nuclear power plant controls the fission process to avoid explosion from happening.

(25 marks)

Q2. Answer all parts.

Part I

(i) Explain briefly why protons nor neutrons no longer considered as "true" elementary particles.

(ii) Protons are packed in a very small volume compared to the size of the atom. Give reasons how it is possible.

(iii) List the three types of natural radioactive emissions. (30 marks)

Part II

A). 2-Naphthylamine [$C_{10}H_9N$] (molecular weight 143.19 g mol^{-1}) is a toxic, colorless, odorless solid. A technician in a laboratory weighed 5.00 g of the above solid and dissolved it in 25.00 mL of pure methanol in a beaker and then added 225.00 mL of distilled water to prepare an aqueous solution of 2- Naphthylamine at 25 °C.

Given that the densities of pure methanol and water at 25 °C are 0.79 and 1.00 g mL^{-1} respectively and assuming that dissolving the solid does not significantly change the volume of the solvent system, calculate the concentration of 2-Naphthylamine in the solution,

(i) in units of ppm.

(ii) in units of molarity.

(iii) in units of molality. (30 marks)

B). The technician weighed 100.00 g of the above solution into a separate beaker and keeps on adding distilled water until the weight of the final solution was 300.00 g.

i. Calculate the concentration of 2-Naphthylamine in the resultant solution in units of ppm.

ii. Considering the fact that the density of the solution varies from that of pure solvents during the above dilution, will the concentration in units of molarity, reduce by the same factor as in part (i) or will it dilute by a smaller or larger factor compared to the dilution by weight? Briefly explain your answer. (20 marks)

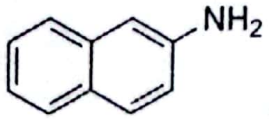
C). If the balance used by the above technician showed an error of ± 0.05 g at each weight measurement and the volume measurements had an uncertainty fraction of ± 0.2.

i. Using the concepts of significant figures and uncertainty calculations, find out the concentration of 2-Naphthylamine in the solution prepared in part A, in units of ppm.

ii. Using one example each highlight the difference between systemic errors, random errors and mistakes, that can occur in the preparation of the solution above. (20 marks)

Q3. Answer all parts.

A) An aqueous solution containing a mixture of the bases, 2-Naphtylamine (pK_a= 3.82 at 25 °C) and 1-[2-ethylamino] aniline (pK_{a1}= 4.71 and pK_{a2}= 9.673 at 25 °C) is found in a reagent bottle at room temperature.



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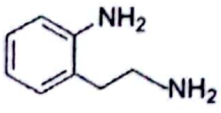

2-Naphtylamine 1-[2-ethylamino] aniline

A student takes 30.00 mL of this solution and titrates it with a standard aqueous solution of 0.20 mol L^{-1} HNO_3 using phenolphthalien as the indicator. An endpoint of 15.05 mL was achived. He then repeats the titration with methyl orange as the indicator and obtained an endpoint of 28.10 mL.

(a) Calculate (showing all steps and assumptions made) the concentration of 1-[2-ethylamino] aniline in the above solution. (35 marks)

(b) Which of the two indicators used gives the more reliable endpoint? Briefly explain your answer. (10 marks)

B). A mixture of Ca^{2+}, Zn^{2+}, Co^{2+} and Li^{+} is found in an aqueous solution. If 0.008 M aqueous Na_2EDTA solution, common metal indicators, metal masking agents and buffer solutions of pH 2.0, 4.0, 10.0 and 12.0 are found in the laboratory, explain how you would determine the concentrations of Co^{2+} and Ca^{2+} separately, in the above solution, carrying out suitable titrations. (25 marks)

C). If a new chemical bottle with the following label is found in the laboratory, using necessary calculations, briefly explain how you will prepare 250.00 mL of aqueous 0.008 M EDTA solution. You need to mention all steps and equipment that you intend to use in the answer.

(20 marks)

D). For a direct EDTA titration of a colorless aqueous solution of Zn^{2+} carried out at pH 10, a student added by mistake, methyl orange as the indicator. Realizing his mistake, he then added EBT to the same flask and continued with the titration.
What would have been the color change of the solution at the end point? (10 marks)

Q4. Answer all parts.

A). A solid mixture contains only K_2CO_3 and Na_2SO_4 (2:1 molar ratio). The molecular weights of K_2CO_3 and Na_2SO_4 are 138.21 g mol^{-1} and 142.04 g mol^{-1} respectively.

An accurately measured amount of solid mixture is dissolved in 1.00 L of distilled water to prepare a 0.70 mol L^{-1} solution of carbonate by a student. The student then gradually adds small aliquots of solid $SrCl_2$ to the solution to selectively remove the carbonate ions from the solution.

(a). Given that the solubility products of $SrCO_3$ and $SrSO_4$ are 9.3×10^{-10} and 3.2×10^{-7} $mol^2\ L^{-2}$ respectively at 25°C, using a suitable calculation find out the percentage of carbonate ions than can be removed from the solution by precipitation, without losing any sulphate ions from the solution.

(Assume that the adding of $SrCl_2$ does not alter the volume of the solution significantly).

(b). How will the pH and temperature of the solution effect the result of the above separation?

(35 marks)

B). Both MnO_2 and Mn_2O_3 in acidic media can oxidize gaseous methane into methanol, while itself undergoing reduction to Mn^{2+} ions.

$E^o_{MnO_{2(s)}/Mn^{2+}} = 1.230\ V$ $\quad$ $E^o_{Mn_2O_{3(s)}/Mn^{2+}} = 1.485\ V$ $\quad$ $E^o_{CH_3OH/CH_{4(g)}} = 0.583\ V$

Writing balanced chemical equations and using the reduction potentials given prove the above stated statement to be true under standard conditions. (35 marks)

C). 0.350 g of solid MnO_2 [MW 86.937 g mol^{-1}] and 0.650 g of solid Mn_2O_3[MW 157.87 g mol^{-1}] is added to a titration flask containing distilled water (50 mL) and 10.0 mL of dilute sulfuric acid. Gaseous methane is then slowly bubbled through the solution.

(a). Calculate the amount of methanol produced when all manganese oxides are reacted.

(b) do you need to add an indicator to the flask if you want to detect the equivalence point of the reaction? Explain your answer. (30 marks)