MACHAKOS UNIVERSITY

University Examinations for 2022/2023 Academic Year

SCHOOL OF PURE AND APPLIED SCIENCES

DEPARTMENT OF PHYSICAL SCIENCES

FIRST YEAR SECOND SEMISTER EXAMINATION FOR

BACHELOR OF SCIENCE TELECOMMUNICATION AND INFORMATION TECHNOLOGY

BACHELOR OF SCIENCE (FOOD NUTRITION AND DIETETICS)

BACHELOR OF EDUCATION (SPECIAL NEEDS)

BACHELOR OF SCIENCE (MATHEMATICS)

BACHELOR OF EDUCATION (SCIENCE)

SCH 103: INTRODUCTION TO CLASSICAL ANALYSIS AND SEPARATION TECHNIQUES

DATE: 14/4/2023 **TIME: 8:30 – 10:30 AM**

INSTRUCTIONS:

- The paper consists of **TWO** sections.
- Section **A** is **Compulsory**.
- Answer any **two** questions from section **B**.

- **Relevant Tables (Periodic table, t-test, and Q-test) and Statistical formula are presented after the questions.**

SECTION A (COMPULSORY)

QUESTION ONE (30 MARKS)

a) Explain the difference between the following terms:

i) Sample mean and Population mean (2 marks)

ii) Molarity and Molality (2 marks)

iii) Base line and Solvent front in chromatography (2 marks)

iv) Heterogeneous sample and homogenous sample (2 marks)

b) Describe the separation principle of each of the following mixture separation methods and state two applications for each method.

i) Fractional distillation (3 marks)

ii) Centrifugation (3 marks)

c) An optimum assay shows that the paracetamol content of a pain-relieving tablet is 117 μmol/dl. Assume you have developed a new assay that gave the following values for replicate analyses: 123, 125, 117, 121, 126 μmol/dl.

(i) Using Q-test (95 % confidence level) determine whether the 117 μmol/dl is an outlier? **N/B. Show your workings.** (5 marks)

(ii) Can you be 95 % confident that your result differs from the "known" m value? **N/B. Show your workings.** (5 marks)

d) Briefly explain how the column and flow-rate affect the plate height (6 marks)

SECTION B: ATTEMPT ANY TWO QUESTIONS

QUESTION TWO (20 MARKS)

a) State **four (4)** disadvantages of titrimetric analysis over gravimetric analysis. (4 marks)

b) 9.7 g of a mixture of Potassium hydroxide and Potassium chloride was dissolved to make one litre solution. 20.0 cm^3 of this solution required 25.0 cm^3 of 0.12 M hydrochloric acid for completed neutralization.

i) Define neutralization titration? (1 mark)

ii) Explain the component of the mixture that does not react with the acid. (2 marks)

iii) Calculate the percentage by mass of Potassium chloride in the mixture. (6 marks)

c) Six samples were analyzed using two methods, New and Standard methods. Determine whether these two methods differ significantly at 90 % confidence level for the following individual samples from 1 to 6 as shown on the table below. (7 marks)

Given that, $\bar{d} = \frac{\sum d_i}{n_i}$, $s_d = \sqrt{\frac{\sum (d_i - \bar{d})^2}{n-1}}$, $t_{calculated} = \frac{|\bar{d}|}{s_d}\sqrt{n}$

Sample	Standard Method	New Method
1	10.5	10.2
2	11.9	12.7
3	8.7	8.6
4	16.9	17.5
5	10.9	11.2
6	11.1	11.5

QUESTION THREE (20 MARKS)

a) Hydrocarbons in the cabin of an automobile were measured during trips at the Machakos bus terminus and trips along Nairobi - Thika highway. The total concentrations of the toluene hydrocarbon were:

Machakos: $30.2 \pm 30\ \mu g/m^3$ (29 measurements)

Nairobi-Thika: $45.4 \pm 25\ \mu g/m^3$ (27 measurements)

Do these results differ significantly at 95 %? Show your workings clearly

Given that, $s_{pooled} = \sqrt{\frac{s_1^2(n_1 - 1) + s_2^2(n_2 - 1)}{n_1 + n_2 - 2}}$ (10 marks)

b) Determine the molarity and molality of 45.0 wt% NaOH. (The **density** of a substance is the mass per unit volume). Given that the density of the NaOH is 2.13 g/mL. (10 marks)

QUESTION FOUR (20 MARKS)

a) Define the following terms.

(i) Plate Height (1 mark)

(ii) Retention time as used in chromatography (1 mark)

(iii) Elution (1 mark)

b) The five major considerations/steps followed in choosing a Gas chromatography as a method of sample analysis are: (i) The goal of the analysis, (ii) Sample preparation, (iii) Type of detector, (iv) Choice of Column, and (v) Injection method. Describe briefly the first three steps, (i to iii) (9 marks)

c) 10.0 g of hydrated potassium carbonate (IV) $K_2CO_3.xH_2O$ on heating leaves 7.93 g of the anhydrous salt.

i) How many moles of anhydrous salt are there in 10 g of the hydrate? (2 marks)

ii) Calculate the mass of water of crystallization in the hydrated salt (2 marks)

iii) Determine the number of moles of water present in the hydrated K_2CO_3? (2 marks)

iv) How many moles of water are present in the hydrate for every one mole of K_2CO_3 that is the value of x.? (2 marks)

QUESTION FIVE (20 MARKS)

a) Describe the separation principle of each of the following analytical techniques and state two applications for each method.

i) Ion Exchange chromatography (3 marks)

ii) Fractional Crystallization (3 marks)

iii) Ultra-filtration (3 marks)

iv) Reverse Osmosis (3 marks)

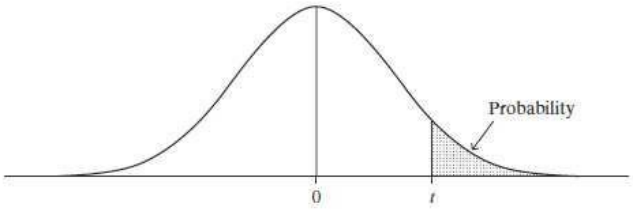
b) List an example of one case that we studied for comparison of means and write equation used in this case (3 marks)

c) A factory uses 63.0 kg of 68 % pure nitric (V) acid per day to produce an ammonium fertilizer for an agricultural county. If the density of the acid is 1.42 gcm^{-3}, calculate:

(i) the concentration of the acid used in moles per litre. (3 marks)

(ii) the volume of ammonia gas at r.t.p used. (H = 1.0, N = 14.0, O = 16.0, one mole of gas = 24 dm^{-3} at r.t.p) (2 marks)

TABLE B: t Distribution Critical Values



	Confidence Level					
	80%	90%	95%	98%	99%	99.8%
	Right-Tail Probability					
df	$t_{.100}$	$t_{.050}$	$t_{.025}$	$t_{.010}$	$t_{.005}$	$t_{.001}$
1	3.078	6.314	12.706	31.821	63.656	318.289
2	1.886	2.920	4.303	6.965	9.925	22.328
3	1.638	2.353	3.182	4.541	5.841	10.214
4	1.533	2.132	2.776	3.747	4.604	7.173
5	1.476	2.015	2.571	3.365	4.032	5.894
6	1.440	1.943	2.447	3.143	3.707	5.208
7	1.415	1.895	2.365	2.998	3.499	4.785
8	1.397	1.860	2.306	2.896	3.355	4.501
9	1.383	1.833	2.262	2.821	3.250	4.297
10	1.372	1.812	2.228	2.764	3.169	4.144
11	1.363	1.796	2.201	2.718	3.106	4.025
12	1.356	1.782	2.179	2.681	3.055	3.930
13	1.350	1.771	2.160	2.650	3.012	3.852
14	1.345	1.761	2.145	2.624	2.977	3.787
15	1.341	1.753	2.131	2.602	2.947	3.733
16	1.337	1.746	2.120	2.583	2.921	3.686
17	1.333	1.740	2.110	2.567	2.898	3.646
18	1.330	1.734	2.101	2.552	2.878	3.611
19	1.328	1.729	2.093	2.539	2.861	3.579
20	1.325	1.725	2.086	2.528	2.845	3.552
21	1.323	1.721	2.080	2.518	2.831	3.527
22	1.321	1.717	2.074	2.508	2.819	3.505
23	1.319	1.714	2.069	2.500	2.807	3.485
24	1.318	1.711	2.064	2.492	2.797	3.467
25	1.316	1.708	2.060	2.485	2.787	3.450
26	1.315	1.706	2.056	2.479	2.779	3.435
27	1.314	1.703	2.052	2.473	2.771	3.421
28	1.313	1.701	2.048	2.467	2.763	3.408
29	1.311	1.699	2.045	2.462	2.756	3.396
30	1.310	1.697	2.042	2.457	2.750	3.385
40	1.303	1.684	2.021	2.423	2.704	3.307
50	1.299	1.676	2.009	2.403	2.678	3.261
60	1.296	1.671	2.000	2.390	2.660	3.232
80	1.292	1.664	1.990	2.374	2.639	3.195
100	1.290	1.660	1.984	2.364	2.626	3.174
∞	1.282	1.645	1.960	2.326	2.576	3.091

Source: "Table of Percentage Points of the t-Distribution." Computed by Maxine Merrington, Biometrika, 32 (1941): 300. Reproduced by permission of the Biometrika trustees.

CRITICAL VALUES OF Q FOR REJECTION OF OUTLIER

Numberof observations	Q (95% Confidence)
4	0.829
5	0.710
6	0.625
7	0.568
8	0.526
9	0.493
10	0.466
11	0.444
12	0.425
15	0.384
20	0.342

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
1 **H** 1.0079																	2 **He** 4.0026
3 **Li** 6.941	4 **Be** 9.0122											5 **B** 10.811	6 **C** 12.011	7 **N** 14.007	8 **O** 15.999	9 **F** 18.998	10 **Ne** 20.180
11 **Na** 22.990	12 **Mg** 24.305											13 **Al** 26.982	14 **Si** 28.086	15 **P** 30.974	16 **S** 32.065	17 **Cl** 35.453	18 **Ar** 39.948
19 **K** 39.098	20 **Ca** 40.078	21 **Sc** 44.956	22 **Ti** 47.867	23 **V** 50.942	24 **Cr** 51.996	25 **Mn** 54.938	26 **Fe** 55.845	27 **Co** 58.933	28 **Ni** 58.693	29 **Cu** 63.546	30 **Zn** 65.409	31 **Ga** 69.723	32 **Ge** 72.64	33 **As** 74.922	34 **Se** 78.96	35 **Br** 79.904	36 **Kr** 83.798
37 **Rb** 85.468	38 **Sr** 87.62	39 **Y** 88.906	40 **Zr** 91.224	41 **Nb** 92.906	42 **Mo** 95.94	43 **Tc** (98)	44 **Ru** 101.07	45 **Rh** 102.91	46 **Pd** 106.42	47 **Ag** 107.87	48 **Cd** 112.41	49 **In** 114.82	50 **Sn** 118.71	51 **Sb** 121.76	52 **Te** 127.60	53 **I** 126.90	54 **Xe** 131.29
55 **Cs** 132.91	56 **Ba** 137.33	57-71 *	72 **Hf** 178.49	73 **Ta** 180.95	74 **W** 183.84	75 **Re** 186.21	76 **Os** 190.23	77 **Ir** 192.22	78 **Pt** 195.08	79 **Au** 196.97	80 **Hg** 200.59	81 **Tl** 204.38	82 **Pb** 207.2	83 **Bi** 208.98	84 **Po** (209)	85 **At** (210)	86 **Rn** (222)
87 **Fr** (223)	88 **Ra** (226)	89-103 #	104 **Rf** (261)	105 **Db** (262)	106 **Sg** (266)	107 **Bh** (264)	108 **Hs** (270)	109 **Mt** (268)	110 **Ds** (281)	111 **Rg** (272)	112 **Uub** (285)	113 **Uut** (284)	114 **Uuq** (289)	115 **Uup** (288)	116 **Uuh** (291)		118 **Uuo** (294)

* Lanthanide series	57 **La** 138.91	58 **Ce** 140.12	59 **Pr** 140.91	60 **Nd** 144.24	61 **Pm** (145)	62 **Sm** 150.36	63 **Eu** 151.96	64 **Gd** 157.25	65 **Tb** 158.93	66 **Dy** 162.50	67 **Ho** 164.93	68 **Er** 167.26	69 **Tm** 168.93	70 **Yb** 173.04	71 **Lu** 174.97
# Actinide series	89 **Ac** (227)	90 **Th** 232.04	91 **Pa** 231.04	92 **U** 238.03	93 **Np** (237)	94 **Pu** (244)	95 **Am** (243)	96 **Cm** (247)	97 **Bk** (247)	98 **Cf** (251)	99 **Es** (252)	100 **Fm** (257)	101 **Md** (258)	102 **No** (259)	103 **Lr** (262)