NAMIBIA UNIVERSITY
OF SCIENCE AND TECHNOLOGY

FACULTY OF HEALTH, NATURAL RESOURCES AND APPLIED SCIECNCES

SCHOOL OF NATURAL AND APPLIED SCIENCES

DEPARTMENT OF BIOLOGY, CHEMISTRY AND PHYSICS

QUALIFICATION: BACHELOR OF SCIENCE	
QUALIFICATION CODE: 07BOSC	**LEVEL:** 7
COURSE NAME: APPLIED COLLOID AND SURFACE CHEMISTRY	**COURSE CODE:** ACS701S
SESSION: JULY 2023	**PAPER:** THEORY
DURATION: 3 HOURS	**MARKS:** 100

SUPPLEMENTARY/SECOND OPPORTUNITY EXAMINATION QUESTION PAPER	
EXAMINER(S)	**Prof Habauka M Kwaambwa**
MODERATOR:	**Prof Edet F Archibong**

INSTRUCTIONS
1. Answer ALL the FIVE questions 2. Write clearly and neatly 3. Number the answers clearly 4. All written work must be done in bule or black ink 5. No books, notes and other additional aids are allowed 6. Mark all answers clearly with their respective question numbers

PERMISSIBLE MATERIALS

Non-programmable Calculators

ATTACHMENT

List of Useful Constants

THIS QUESTION PAPER CONSISTS OF 5 PAGES (Including this front page and List of Useful Constants)

QUESTION 1 **[26]**

(a) Explain briefly what you understand by the following terms:
Colloid particle, lyophilic colloid (2)

(b) Characterise the following colloids in terms of what the dispersed phase (gas, liquid, solid) and dispersion medium ((gas, liquid, solid) are:
(i) Smoke, Dust
(ii) Fire-extinguisher foam
(iii) Fog, Liquid sprays
(iv) Milk, Mayonnaise, Emulsion

(c) The surface tensions of the liquids mercury, water and n-hexadecane, in mNm^{-1}, are 485, 72.8 and 27.46, respectively. Explain the differences. (4)

(d) How does the temperature and presence of impurities affect the surface tension of liquids? (3)

(e) For a dilute aqueous solution of surfactant, the Gibbs adsorption isotherm may be written as follows:

$$\Gamma_s = -\frac{c_s}{RT}\frac{d\gamma}{dc_s}$$

(i) In this equation, what do the symbols Γ_s and c_s stand for? (2)
(ii) Use the values of the slope from the plot of γ versus $\ln c_s$ (linearised form) below the critical micelle concentration and at 25°C, to calculate the area per molecule, A_s, at the interface for both surfactants: (6)

	Slope/mNm^{-1}
C12EO6	- 6.856
$C12H25OSO_3^- Na^+$	- 20.56

(f) Which system of aqueous surfactant solutions in each pairs given below would give rise to lower critical micelle concentration? Explain your answer briefly. (5)
(i) dodecyldimethylammonium chloride with no added salt **versus** dodecyldimethylammonium chloride in 0.20 M aqueous NaCl?
(ii) dodecyltrimethylammonium bromide (C_{12}TAB) **versus** cetyltrimethylammonium bromide (C_{16}TAB)?

QUESTION 2 **[18]**

(a) The initial spreading coefficient, $S_{B/A}$ is reported to be 36.0 mNm^{-1} for *n*-heptanol on water at 20°C. The surface tensions of *n*-heptanol, γ_B, and water, γ_A at 20°C are 26.0 mNm^{-1} and 72.8 mNm^{-1}, respectively. Calculate the interfacial tension of *n*-heptanol and water, γ_{AB}. (3)

(b) At 20°C, the surface tension of oleic acid, γ_B, is 32.5 mNm^{-1} and the interfacial tension of oleic acid and water, γ_{AB}, is 15.5 mNm^{-1}. Solely based on this data and in (a) above, which liquid between oleic acid and *n*-heptanol would you recommend for water evaporation control? Show clearly your reasoning. (5)

(c) Derive the expression (in terms of the appropriate work of adhesion, W_a, and work of cohesion, W_c) for the spreading coefficient for a substance C at the interface between two liquids A and B. (5)

(d) The effect of an impurity on spreading of oil on water depends on whether it is in the oil or aqueous phase. Explain this statement. (5)

QUESTION 3 **[18]**

The linear form BET equation is given by:

$$\frac{P/P_o}{V\left(1-P/P_o\right)} = \frac{1}{V_m C} + \frac{(C-1)P}{V_m C P_o}$$

(a) State what the symbols in the equation represent. (4)

(b) State any **three** assumptions involved in the derivation of the BET adsorption isotherm. (3)

(c) Show how the equation above may be used to determine V_m and C. (5)

(d) State any **three** criticisms of the BET adsorption isotherm model. (3)

(e) If the monolayer capacity of the nitrogen gas adsorbed on 1 g silica gel was found to be 121.7 cm^3 (stp). Calculate the specific surface area for silica gel, taking the molecular area of nitrogen as 16.2 x 10^{-20} m^2. (3)

QUESTION 4 **[10]**

(a) Using combining relations based on the Hamaker constants of pure materials (A_i), calculate the composite Hamaker constants for the following interacting systems:

(i) Quartz-Octane-Quartz

(ii) CaF_2-Octane-Quartz

Given:

Material	**A_i x 10^{-20} J**
Quartz	3.7
n-Octane	4.5
CaF_2	7.0

(6)

(b) Discuss the implications in colloid stability of positive and negative composite Hamaker constants of the type A_{131} and A_{132}. (4)

QUESTION 5 **[28]**

(a) Electrostatic interactions (due to surface charge) are important in colloid stability of colloidal dispersions. There are several mechanisms by which colloid particles may acquire charge. Briefly describe these mechanisms. (10)

(b) State as briefly as possible the origins of van der Waals attraction, steric and depletion interaction potentials acting between colloidal particles. (6)

(c) On the same well-labelled diagram, show schematically the variation of the he variation of the van der Waals potential (V_A), electrostatic potential (V_R) and total pair potential, $V_T = V_A + V_R$, with particle separation, h, for a stable colloidal dispersion. For such a stable, label clearly the primary minimum, primary maximum and secondary minimum. On the same schematic diagram of the pair potential, V_T, as function of particle distance, h, between two spherical colloidal particles, show the influence of electrolyte concentration (i.e. κ) at fixed Ψ_d. (6)

(d) Briefly explain the significance in colloid stability of the primary minimum, primary maximum and secondary minimum of V_T in (c) above. (6)

END OF EXAM QUESTIONS

USEFUL CONSTANTS:

Universal Gas constant	R	=	$8.314\ J\ K^{-1}\ mol^{-1}$
Boltzmann's constant,	k	=	$1.381 \times 10^{-23}\ J\ K^{-1}$
Planck's constant	h	=	$6.626 \times 10^{-34}\ J\ s$
Debye-Huckel's constant,	A	=	$0.509\ (mol\ dm^{-3})^{1/2}$ or $mol^{-0.5}kg^{0.5}$
Faraday's constant	F	=	$96485\ C\ mol^{-1}$
Mass of electron	m_e	=	$9.109 \times 10^{-31}\ kg$
Velocity of light	c	=	$2.998 \times 10^{8}\ m\ s^{-1}$
Avogadro's constant	N_A	=	6.022×10^{23}
1 electron volt (eV)		=	$1.602 \times 10^{-19}\ J$