NAMIBIA UNIVERSITY
OF SCIENCE AND TECHNOLOGY

FACULTY OF HEALTH, APPLIED SCIENCES AND NATURAL RESOURCES

DEPARTMENT OF NATURAL AND APPLIED SCIENCES

QUALIFICATION: BACHELOR OF SCIENCE	
QUALIFICATION CODE: 07BOSC	**LEVEL:** 7
COURSE CODE: ACS701S	**COURSE NAME:** APPLIED COLLOID AND SURFACE CHEMISTRY
SESSION: JUNE 2022	**PAPER:** THEORY
DURATION: 3 HOURS	**MARKS:** 100

FIRST 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 6 PAGES (Including this front page and List of Useful Constants)

QUESTION 1 **[23]**

(a) Colloids can be described in terms **size, dispersed phase/dispersion medium**, and **lyophilic or lyophobic** colloids. Write briefly about this statement. (5)

(b) Surfactants are classified according to the type of the hydrophilic group. In many respects, the aqueous behaviour of dodecybetaine is closer to octyl poly(oxyethylene) glycol (Triton X-100) than to hexadecyltrimethylammonium bromide. Explain or discuss this statement. (4)

(c) Water treatment Moringa seed proteins are cationic. Arrange in increasing order of interaction of the following surfactants with Moringa seed proteins and explain briefly your answer:
Cetylpyridinium bromide; Polyoxyethylene alkyl ether, and; Sodium dodecyl sulphate.
Explain your answer. (4)

(d) There is a variety of physical properties that can be used to determine the critical micelle concentration (CMC) of a surfactant such as sodium dodecyl sulphate (SDS). On the same diagram, show the variation of the following physical quantities with SDS concentration, showing clearly the position of the CMC: (4)
   (i) Osmotic pressure
   (ii) Turbidity
   (iii) Surface tension

(e) Explain briefly the observed behaviours in (d) above. (6)

QUESTION 2 **[27]**

(a) Define the terms **solubilisation**, **Krafft temperature**, T_K, and **cloud point** as used in colloid chemistry. (6)

(b) The cloud point for TX-100 was studied as function temperature. What would you observe if the same experiment was done using sodium dodecyl sulphate (SDS)? (2)

(c) Using well-labelled schematic diagrams illustrate how (i) solubilisation varies with surfactant concentration, and; (ii) how solubility of surfactants with temperature indicating clearly the position T_K and critical micelle concentration. (7)

(d) State whether the critical micelle concentration (CMC) would **increase**, **decrease** or **not change** after the following changes: (5)
   (i) Changing the surfactant from $CH_3(CH_2)_9(OCH_2CH_2)_5OH$ to $CH_3(CH_2)_7(OCH_2CH_2)_5OH$
   (ii) Increasing the temperature
   (iii) Addition of electrolyte to an ionic surfactant
   (iv) Presence of impurity when CMC is determined by surface tension
   (v) Branching of the hydrophobic part of the surfactant

(e) A Moringa shower gel formula has the following components:

Identification	Component
A	Water
B	SDS 30%
C	Coconut diethanolamide
D	Alkyl amido propyl betaine 30%
E	Cocoamine oxide
F	NaCl
G	Perfume, colour, preservative
H	Lactic acid
J	Moringa seed oil

Match each of the following functions to corresponding letter (A-J) of the components in the table above: (7)

(i) Increases thickness by causing the surfactant to restructure into the high viscosity cylindrical micelle structures

(ii) Anionic surfactant

(iii) Thought to be a component of the skin and used to the pH compatible with that of the skin, i.e. adjust pH to 6.5

(iv) Antiaging and antifungal component

(v) Amphoteric surfactant to generate foam or cold water detergent

(vi) Nonionic surfactant that imparts excellent viscosity enhancing and foam stabilisation in anionic based systems

(vii) Foam booster surfactant

QUESTION 3 **[12]**

(a) Outline any **three** main assumptions involved in the derivation of the BET adsorption isotherm equation for molecules at the gas/liquid interface. (3)

(b) The linear BET equation is of the form:

$$\frac{p}{V(p_o - p)} = \frac{1}{V_m c} + \frac{(c-1)}{V_m c}\frac{p}{p_o}$$

(i) State what each of the quantities in this equation represents. (4)

(ii) A graphical plot of $\frac{p}{V(p_o - p)}$ against $\frac{p}{p_o}$ data for the adsorption of nitrogen gas on 1 g of sample of alumina at 77 K gave a slope of 2.88×10^{-2} cm^{-3} (s.t.p.) and an intercept of 9.87×10^{-4} cm^{-3} (s.t.p.). Calculate the specific surface area (m^2g^{-1}) for the alumina sample, taking the molecular area of nitrogen as 16.2×10^{-20} m^2. (5)

QUESTION 4 **[20]**

(a) Compare and contrast the following terms as used in colloid stability: (6)

(i) Sedimentation and Creaming

(ii) Depletion flocculation and Bridging flocculation

(b) Explain how the following factors would affect the stability of colloidal dispersions. (6)

(i) Brownian motion

(ii) Increase in particle size of colloidal particles

(iii) Decrease in medium viscosity

(c) Define the terms **point of zero charge** and **potential determining ions**. As a Colloid Scientist, use/apply these concepts to explain why AgI particles are negatively charged and how you can manipulate them so that you have a dispersion with zero charged AgI particles and another with positively charged AgI particles. (6)

(d) Apart from the above mechanism in (c), **isomorphous substitution** is another mechanism particles acquire charge. Deduce the resulting charge of clay particles if metal X (valency = 4^+) replaces metal M (valency = 3^+)? (2)

QUESTION 5 **[18]**

(a) One form of the van Waals interaction potential between two particles is given by:

$$V_A(h) = -\frac{Aa}{12h},$$

(i) State **any** two conditions under which this equation is valid. (2)

(ii) Briefly state the effect on V_A if the particles are immersed in medium instead particles instead of particles in a vacuo? (1)

(iii) What effect on V_A is observed if the Hamaker constant of the medium approaches that of the particles? (1)

(b) Using combining relations based on the Hamaker constants of pure materials (A_i), calculate the composite Hamaker constants for the following interacting systems:
(i) Polystyrene in water; (ii) SiO_2 in water, and; (iii) Polyestyrene-Water-SiO_2 (6)
Comment on the results with respect colloid stability of the systems. (3)

Given:

Material	**A_i x 10^{-20} J**
Polystyrene	7.2
SiO_2	0.8
Water	4.1

(c) On the same well-labelled diagram, show schematically the variation of the van der Waals attraction potential (V_A), electrostatic potential (V_R) and total pair potential ($V_T = V_A + V_R$) with the interparticle separation, h, for a **marginally stable** dispersion of nanoparticles indicating clearly the positions, if any, of primary minimum, primary maximum, secondary minimum and Born repulsion potential (V_B). (5)

END OF EXAM QUESTIONS

USEFUL CONSTANTS:

Universal Gas constant	R	=	8.314 J K^{-1} mol^{-1}
Boltzmann's constant,	k	=	1.381 x 10^{-23} J K^{-1}
Planck's constant	h	=	6.626 x 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 x 10^{-31} kg
Velocity of light	c	=	2.998 x 10^{8} m s^{-1}
Avogadro's constant	N_A	=	6.022 x 10^{23}
1 electron volt (eV)		=	1.602 x 10^{-19} J