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 NAME: APPLIED COLLOID AND SURFACE CHEMISTRY	**COURSE CODE**: ACS701S
SESSION: JULY 2022	**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 **[27]**

(a) Define briefly the following concepts: *surface tension*; *work of adhesion*; *work of cohesion*. (6)

(b) Surface active agents are classified according to the nature of their head (polar) groups. Discuss this statement using the four classifications of surfactants. (8)

(c) In the following table are the surface tensions (γ) of the dodecyldimethylammonium chloride (DDA, $C_{12}H_{25}NH(CH_3)_2Cl$) in water solutions as function of concentration (i) without NaCl and (ii) with 0.2 M NaCl.

(i) Without NaCl Conc DDA/mM	γ /mNm^{-1}	(ii) With 0.2 NaCl	γ /mNm^{-1}
0.01	72	0.01	72
0.08	71.5	0.015	70
0.3	71	0.05	66
1	68	0.16	58
2	64	0.4	52
3	58	0.9	46
5	52	1.5	40
9.5	45	2.5	35
11	41	3.9	34
14	37.5	5.0	34
20	37.5	40	34
40	37.5		

Explain why:

(i) values of surface tensions drop rapidly when concentration of DDA rise above 1 mM (without NaCl). (2)

(ii) values of surface tensions don't change when concentration of DDA rise above 14 mM (without NaCl). (2)

(iii) addition of 0.2 M NaCl affects the surface tension. (2)

(d) Why does the molar conductance of a solution of an ionic surface agent decrease above the critical micelle concentration (cmc)? (3)

(e) An experiment to study the spreading of benzene on water gave the following surface and interfacial tension data in the table below.

	γ_{water} (mNm^{-1})	$\gamma_{benzene}$ (mNm^{-1})
Initial	72.8	28.9
Final	62.2	28.8
$\gamma_{water/benzene}$ = 35 mNm^{-1}		

Explain the spreading behaviour of benzene on water using the concept of spreading coefficient. (5)

QUESTION 2 **[14]**

(a) Define the term **Krafft temperature** of a surfactant? Why is the Kraft temperature not observed for non-ionic surfactants? (3)

(b) Using a schematic diagram,and quoting appropriate equations, show how the results might be analysed to yield
  (i) the Gibbs surface excess concentration, and;
  (ii) the area occupied by one surfactant molecule in a surface monolayer.
(6)

(c) Briefly describe how insoluble monolayers are studied using the Langmuir trough. (5)

QUESTION 3 **[17]**

(a) Formulation chemistry is the mixing of compounds/substances that do not react with each other but produce a mixture with the desired characteristics/properties to suit a particular application/use. As a formulator for detergents and household cleaners manufacturing company, you propose to the purchasing department the following ingredients that are necessary: ***sodium hypochlorite, carboxymethylcellulose, sodium carbonate and dodecylbenzene sulphonate***. State in one or two words the function of each ingredient. (4)

(b) Derive the Kelvin equation below relating the vapour pressure over a tiny droplet with that of the same amount of liquid with a flat surface:

$$RT\ln\frac{P_2}{P_1} = \frac{2\gamma V_m}{r} \qquad (9)$$

(c) 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. (4)

QUESTION 4 [16]

(a) When a drop of an insoluble liquid, such as oil, is placed on a clean liquid, such as water, it may behave in one of the three ways. Name the three behaviour scenarios possible. (3)

(b) State the wetting properties of a liquid on a solid when the contact angle, θ, is: (4)
- (i) 0°C
- (ii) 75°C
- (iii) 150°C
- (iv) 180°C

(c) To improve the wetting properties of a liquid, what additive is normally used? Explain briefly your answer. (2)

(d) Consider three different liquids mercury (Hg), water, and decane having surface tensions of 484, 72.8 and 24 mNm^{-1}, respectively. State the differential wetting properties or behaviour of these liquids on planar surfaces of the following materials whose surface energies are given in brackets: magnesium oxide, MgO ($\gamma = 1200\ mNm^{-1}$), silica, SiO_2 ($\gamma = 307\ mNm^{-1}$), polyethylene ($\gamma = 31\ mNm^{-1}$) and polytetrafluoroethylene, PTFE ($\gamma = 18\ mNm^{-1}$). (7)

QUESTION 5 [26]

(a) Describe the origins of van der Waals attraction interaction potentials acting between colloidal particles. (6)

(b) On the same well-labelled diagram, show schematically the variation of the total pair potential, $V_T = V_A + V_R$, with particle separation, h, for the following:
- (i) A stable sol
- (ii) A marginally stable sol
- (iii) An unstable sol

(6)

(c) State the conditions to be met if sterically stabilised dispersions are to be prepared. Give examples of various types of polymer structures that may be used. For a stable sterically stabilised dispersion of spherical particles, show schematically on the same well-labelled diagram the variation of the potentials, V_{total}, V_{steric} and $V_{van\ der\ Waals}$ with particle separation, h. (10)

(d) In paints and coatings formulations, **bridging flocculation** and **depletion flocculation** must be controlled. What do you understand by these two terms? (4)

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)		=	$1.602 \times 10^{-19}\ J$