



**NAMIBIA UNIVERSITY  
OF SCIENCE AND TECHNOLOGY**

**FACULTY OF HEALTH, NATURAL RESOURCES AND APPLIED SCIENCES**

**SCHOOL OF NATURAL AND APPLIED SCIENCES**

**DEPARTMENT OF BIOLOGY, CHEMISTRY AND PHYSICS**

<b>QUALIFICATION:</b> BACHELOR OF SCIENCE	
<b>QUALIFICATION CODE:</b> 07BOSC	<b>LEVEL:</b> 7
<b>COURSE CODE:</b> ACS701S	<b>COURSE NAME:</b> APPLIED COLLOID AND SURFACE CHEMISTRY
<b>SESSION:</b> JUNE 2023	<b>PAPER:</b> THEORY
<b>DURATION:</b> 3 HOURS	<b>MARKS:</b> 100

<b>FIRST OPPORTUNITY EXAMINATION QUESTION PAPER</b>	
<b>EXAMINER(S)</b>	Prof Habauka M. Kwaambwa
<b>MODERATOR:</b>	Prof Edet F. Archibong

<b>INSTRUCTIONS</b>	
<ol style="list-style-type: none"><li>1. Answer ALL the FIVE questions</li><li>2. Write clearly and neatly</li><li>3. Number the answers clearly</li><li>4. All written work must be done in blue or black ink</li><li>5. No books, notes and other additional aids are allowed</li><li>6. Mark all answers clearly with their respective question numbers</li></ol>	

**PERMISSIBLE MATERIALS**

Non-programmable Calculators

**ATTACHMENT**

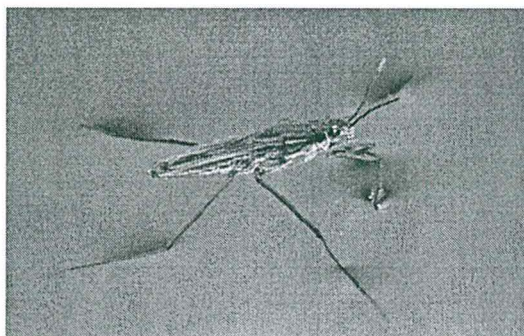
List of Useful Constants

**THIS QUESTION PAPER CONSISTS OF 7 PAGES** (Including this front page and List of Useful Constants)

**QUESTION 1**

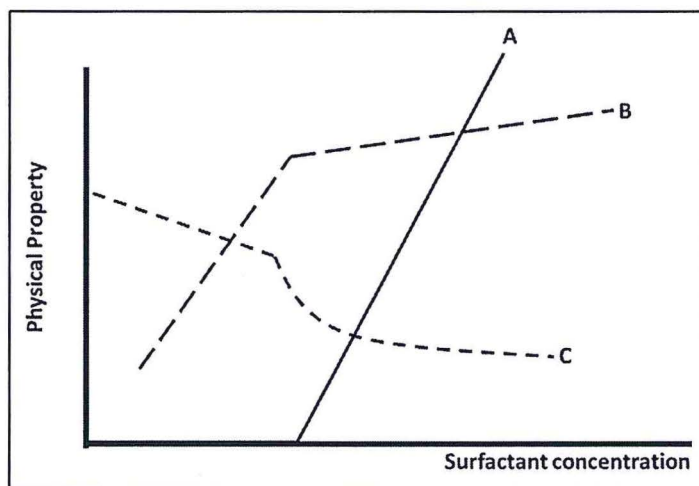
**[26]**

- (a) Name the phenomenon exhibited in Figure 1.1 below in relation to colloid science and state its origin. (2)



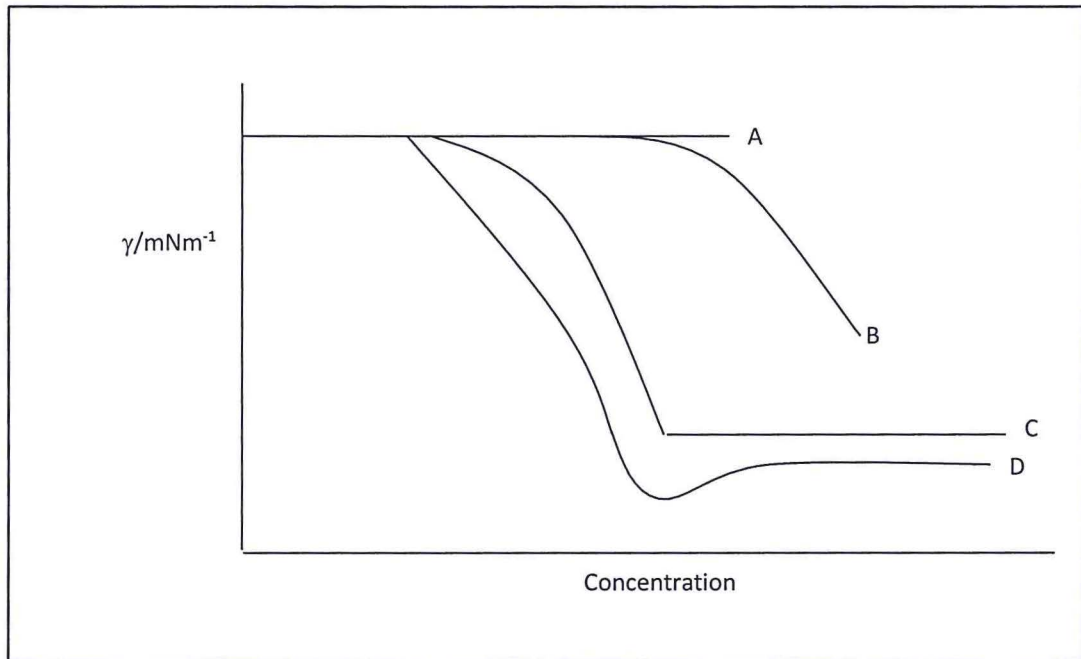
**Figure 1.1:** Pond skater “walking” on water

- (b) If the insect in Figure 1.1 is “crawling” on water in a bucket, how can you make it sink? Explain briefly your answer. (3)
- (c) Arrange the following liquids in increasing order of surface tension and explain your answer: Water, Mercury (Hg), Octane, Hexane, Octanol (3)
- (d) What is generally the effect of temperature on the surface tension phenomenon? State briefly your reason. (2)
- (e) The Figure 2 shows the variation of some physical properties of surfactant solutions with concentration. Identify which one represents the behaviour of the following observed behaviour and explain briefly your answer: (9)
- (i) Molar conductivity
  - (ii) Solubilisation
  - (iii) Osmotic pressure



**Figure 1.2:** Physical properties of surfactant solutions as a function of concentration

- (f) One of the plots in Figure 1.2 resembles that of the variation of **turbidity** with surfactant concentration. Identify which one and explain briefly the observed for this particular physical property. (3)
- (g) In Figure 1.3 below, each of the lines represents the variation of surface tension ( $\gamma$ ) concentration below. Which of the plots in the graph below represents: (4)
- Cetyltrimethylammonium bromide?
  - Sodium dodecyl sulphate with n-dodecanol?
  - Potassium chloride?
  - Moringa oleifera* seeds protein or most proteins in general?



**Figure 1.3:** Variation of surface tension with solute concentration

**QUESTION 2**

**[26]**

- Define the terms **Krafft temperature,  $T_K$** , and **Cloud point** as used in colloid chemistry. (2)
- 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)
- Using well-labelled schematic diagram, illustrate how solubility of surfactants varies with temperature, indicating clearly the position  $T_K$  and critical micelle concentration (CMC). (4)
- State whether the Krafft temperature,  $T_K$ , would **increase, decrease** or **not change** after the following changes: (5)
  - Increasing chain length of the surfactant.
  - Branching of the hydrophobic part of the surfactant

- (iii) Addition of NaCl to an ionic surfactant
  - (iv) Unsaturation (double bonds) of the hydrophobic part of the surfactant
  - (v) Insertion of EO groups between alkyl chain and the head group
- (e) For a non-ionic surfactant, X, at moderate concentrations, the surface tension (mN/m) at 298 K, based on the Gibbs adsorption isotherm equation, is given by:
- $$\gamma = 0.62 - 8.4 \ln c$$
- where c is the concentration in mM.
- (i) Determine the surface excess and area per molecule ( $\text{\AA}^2$ ). (4)
  - (ii) Suppose similar experiments were carried out for two other surfactants A and B, the sign of surface excess obtained for A was opposite to that obtained for X whereas for B it was found to be zero. State the type of adsorption exhibited or implied by each surfactant. (3)
  - (iii) If the area of headgroup is  $20 \text{\AA}^2$ , comment on the result obtained in (i) above. (2)
- (f) Given a solid (S) and liquid (L), calculate the contact angle,  $\theta$ , and deduce which of the following occurs: **Perfect wetting**, **Partial wetting**, **Non-wetting** or **Perfectly not wetted** (4)
- (i)  $\gamma_S = 18.5 \text{ mNm}^{-1}$ ,  $\gamma_L = 72.8 \text{ mNm}^{-1}$  and  $\gamma_{SL} = 91.3 \text{ mNm}^{-1}$
  - (ii)  $\gamma_S = 307 \text{ mNm}^{-1}$ ,  $\gamma_L = 45 \text{ mNm}^{-1}$  and  $\gamma_{SL} = 262 \text{ mNm}^{-1}$

### QUESTION 3

[20]

The non-linear form of the Langmuir equation for the adsorption a gas on a solid takes the form:

$$V = \frac{V_m aP}{1 + aP}$$

- (a) State any **three** assumptions involved in the derivation of the Langmuir adsorption isotherm equation for molecules at the gas/liquid interface. (3)
- (b) How is this equation modified to account for:
  - (i) Competitive adsorption on an adsorbent of two gases A and B without dissociation? (2)
  - (ii) Adsorption of gas A which dissociates into two species? (2)
- (c) Show how the linear form of the Langmuir equation above may be used to determine the constants. (5)
- (d) One student of mine recently used Moringa seed shells activated carbon to remove methylene blue (MB) from water, fitted the data to the linear form of the Langmuir equation for adsorption from solution given below and found the slope and intercept to be  $0.0295 \text{ g mg}^{-1}$  and  $0.2573 \text{ g}^2 \text{ L}^{-1} \text{ mg}^{-1}$ , respectively. Determine the values for **monolayer capacity** (adsorption capacity) and **a** in the Langmuir equation under the experimental conditions used. (4)

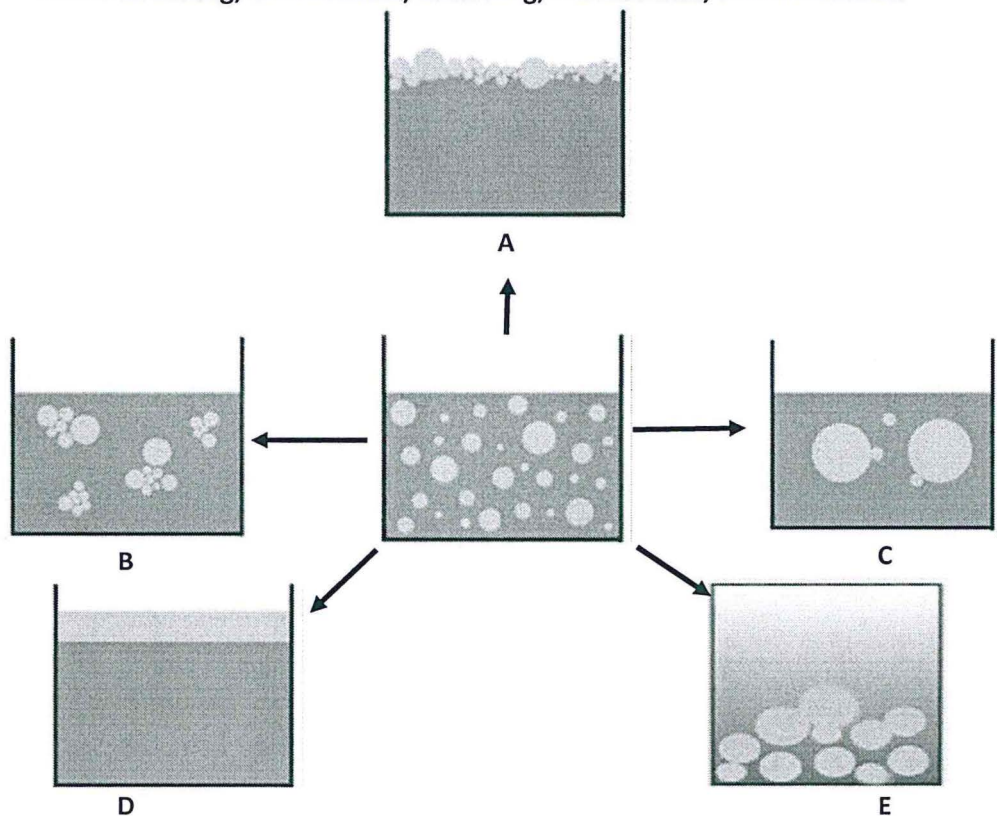
$$\frac{c}{q_e} = \frac{1}{q_{\max} a} + \frac{c}{q_{\max}}$$

- (e) Under the conditions used in (d) above, determine the specific surface area (in  $\text{m}^2\text{g}^{-1}$ ) of the Moringa seed shells activated carbon (Molecular weight of MB is  $319.85 \text{ g/mol}$  and the area adsorbed by per molecule of methylene blue is taken as  $130 \text{ \AA}^2$ ). (4)

#### QUESTION 4

[28]

- (a) Match the colloid instability mechanisms (A-E) shown in the diagram to the following terms: **Breaking, Coalescence, Creaming, Flocculation, Sedimentation** (5)



- (b) Compare and contrast the **Depletion flocculation** and **Bridging flocculation** as used in colloid stability. (3)
- (c) State briefly the effect on van der Waals attraction,  $V_A$ , if the particles are immersed in medium instead of *a vacuo*? (1)
- (d) Several methods are applied in practice to control settling and formation of dilatant “clays” in colloidal dispersions such as pharmaceuticals, paints, agrochemicals and cosmetics. State whether each of the following **promotes stability** or **promotes instability** of such dispersions: (5)
- (i) Increase concentration of a colloidal dispersion

- (ii) Viscosity of dispersion medium changed from 10 mPas to 100 mPas
  - (iii) Prepare colloid particles of size 100 nm instead of 500 nm
  - (iv) van der Waals forces changed from - 20 kJ/mol to - 100 kJ/mol
  - (v) Effective composite Hamaker constant of an interacting system of colloidal particles changed from  $4.34 \times 10^{-21}$  J to  $1.28 \times 10^{-20}$  J
  - (vi) Hamaker constant of the dispersion medium is manipulated such that it is equal to that of the particles, i.e.  $A_{\text{dispersion medium}} = A_{\text{particles}}$
- (e) The technique of manipulating the Hamaker constant of the dispersion medium to that of the particles is called **contrast matching** in Small-angle Neutron Scattering (SANS). How is this done in practice? (2)
- (f) The WINGOC wastewater treatment plant in Windhoek is based on a multiple barrier system and one of stages involves dosing of ferric chloride ( $\text{FeCl}_3$ ). What is this stage called? How is the pH of the water adjusted after this stage? (2)
- (g) There are several mechanisms which colloidal particles acquire charge. Answer the following questions based on one of the mechanisms.
- (i) The solubility product for AgBr is  $K_{sp} = [\text{Ag}^+][\text{Br}^-]$ . The AgBr particles in aqueous dispersion are negatively charged. What does this mean? (2)
  - (ii) As a Colloid Scientist, explain how you can manipulate AgBr particles so that you have a dispersion with zero charged AgBr particles and another with positively charged AgBr particles. (2)
  - (iii) What would the effect of adding  $\text{KNO}_3$ , if any, to negatively charged AgI particles? Give a reason for your answer. (2)
- (h) Apart from the above mechanism in (g), **isomorphous substitution** is another mechanism particles acquire charge. Deduce the resulting charge of clay particles if metal X (valency =  $4^+$ ) replaces metal M (valency =  $3^+$ )? (1)
- (i) Using combining relations based on the Hamaker constants of pure materials ( $A_i$ ), calculate the composite Hamaker constant for interacting system of Mica-Benzene-Teflon. Comment on the result. (3)

Given:

Material	$A_i \times 10^{20}$ J
Mica	13.5
Teflon	3.8
Benzene	5.0

**END OF EXAM QUESTIONS**

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**USEFUL CONSTANTS:**

Universal Gas constant	R	=	8.314 J K <sup>-1</sup> mol <sup>-1</sup>
Boltzmann's constant,	k	=	1.381 x 10 <sup>-23</sup> J K <sup>-1</sup>
Planck's constant	h	=	6.626 x 10 <sup>-34</sup> J s
Debye-Huckel's constant,	A	=	0.509 (mol dm <sup>-3</sup> ) <sup>1/2</sup> or mol <sup>-0.5</sup> kg <sup>0.5</sup>
Faraday's constant	F	=	96485 C mol <sup>-1</sup>
Mass of electron	m <sub>e</sub>	=	9.109 x 10 <sup>-31</sup> kg
Velocity of light	c	=	2.998 x 10 <sup>8</sup> m s <sup>-1</sup>
Avogadro's constant	N <sub>A</sub>	=	6.022 x 10 <sup>23</sup>
1 electron volt (eV)		=	1.602 x 10 <sup>-19</sup> J

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