IMPERIAL COLLEGE LONDON

M.Eng EXAMINATION IN CHEMICAL ENGINEERING 2018

PART IV

and

M.Sc. in ADVANCED CHEMICAL ENGINEERING

For Internal Students of Imperial College London

This paper is also taken for the relevant examination
for the Associateship

COLLOID AND INTERFACE SCIENCE

Thursday 3rd May 2018: 10:00-11:30

This examination is an **OPEN** note examination, which means that you can bring into the examination any **written material APART FROM TEXT BOOKS**

Answer **ALL/** questions

Question 1 carries 15 marks
Question 2 carries 35 marks
Question 3 carries 25 marks
Question 4 carries 25 marks

THIS EXAMINATION PAPER HAS SEVEN PAGES IN TOTAL
WHICH INCLUDES THIS COVER SHEET

TURN OVER FOR QUESTIONS

Question 1 **[15 marks]**

(a) Why does a drop of pentane spread when placed on water, whereas a larger hydrocarbon such as dodecane remains as a discrete droplet(s)? (Full credit will only be given when both the values of the surface/interfacial tensions and the Hamaker constants are used to illustrate your answer.)

[10 marks]

Liquid	**Surface tension $mN.m^{-1}$**	**Interfacial tension(oil water) $mN.m^{-1}$**	**Hamaker constant $X10^{20}$ J**
Water	72.8	-	4.00
Pentane	15.5	48.7	3.75
Dodecane	25.4	52.9	5.04

(b) On which of the above alkanes would a drop of water spread and why?

[5 marks]

END OF QUESTION 1

TURN OVER

Question 2 **[35 marks]**

Figure 1 shows a plot of the zeta potential distributions of [1]

i. Air bubbles stabilised by the surfactant sodium dodecyl sulfate
ii. Silica particles
iii. Alumina particles
iv. A mixture of air bubbles and alumina
v. A mixture of air bubbles and silica
vi. A mixture of silica and alumina
vii. A mixture of air bubbles silica and alumina

Explain the reasons for the potential and distributions for each of the seven cases shown in the figure,

[5 marks for each part]

[1] [The data are taken from the following reference: Wu, C, Wang, L, Harbottle, D et al. (2015) Journal of Colloid and Interface Science, 449. 339 - 408. ISSN 0021-9797]

Figure for Question 2:

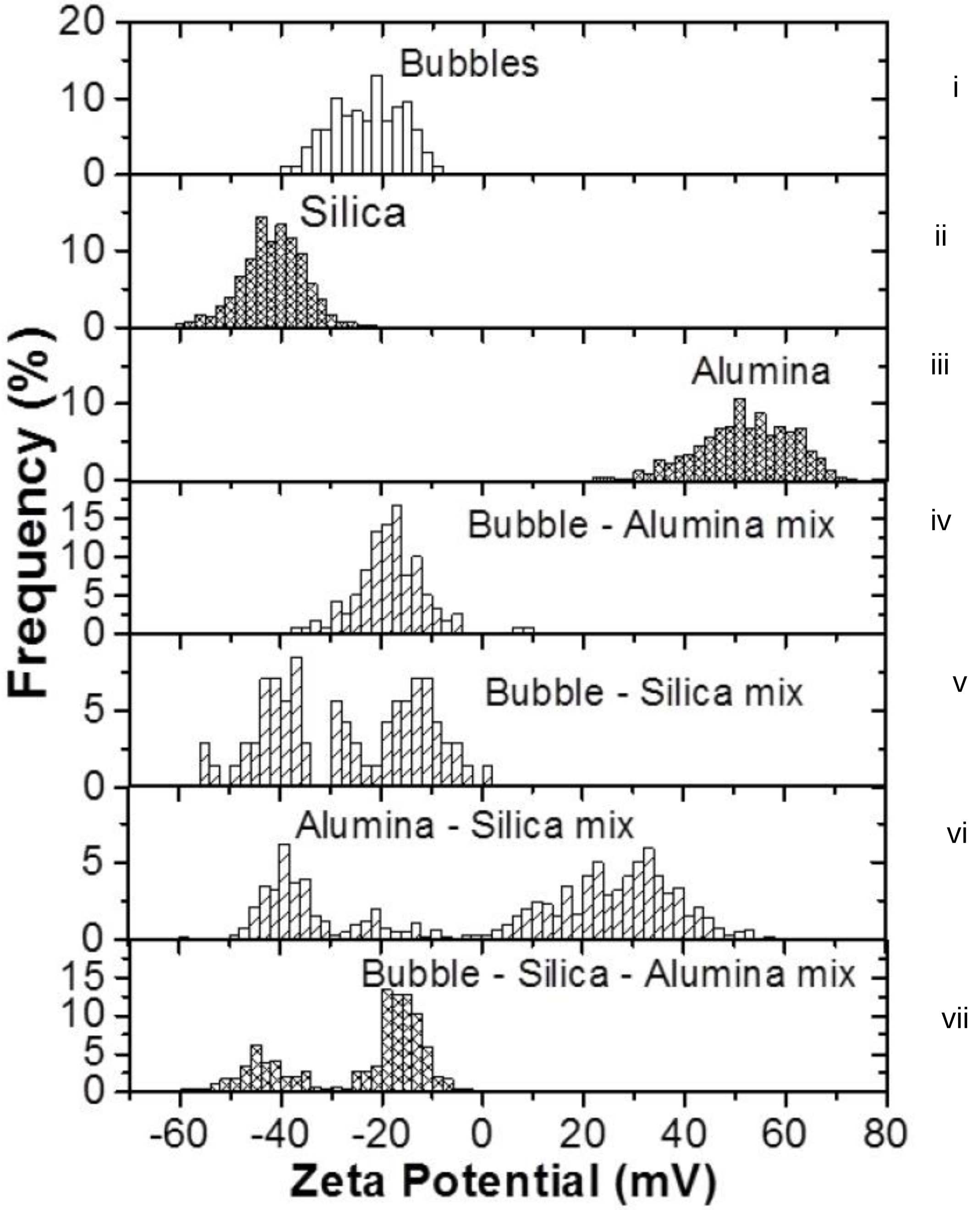

Figure 1. Zeta potential distribution of nano size alumina particle suspensions nano size silica particle suspensions and gas bubble dispersions individually or as a mixture as indicated on the figure. All measurements were performed in 0.01 mM SDS + 1 mM KCl solution at pH 6.0

END OF QUESTION 2

Question 3 **[25 marks]**

Adsorption of cationic polyelectrolytes (charged polymers) to negative surfaces such as silica and cellulose generally brings about flocculation of these solids.

a) Describe three possible mechanisms for this flocculation

[9 marks]

(b) How would the following affect the adsorption of the polyelectrolyte

(i) Polymer charge density

(ii) Polymer molecular weight

(iii) Surface charge density

(iv) Ionic strength

[16 marks]

END OF QUESTION 3

Question 4 **[25 marks]**

Figure 2, below is a plot of the surface tension as a function of $\log_{10}$ concentration of the surfactant hexadecyl trimethyl ammonium bromide (CTAB) at $25^{O}C$

(a) What is the critical micelle concentration, CMC, of the surfactant

[2 marks]

(b) Calculate the surface excess at the following concentrations

(i) $3x10^{-4}$ mol.dm^{3}.

(ii) $8x10^{-4}$ mol.dm^{3}.

(iii) $3x10^{-3}$ mol.dm^{3}.

[15 marks]

(c) A drop of an aqueous CTAB solution is placed onto a clean class surface (glass is negatively charged). What would you expect the contact angle of the droplet to be at the following concentrations of CTAB? Explain your answer

(i) $3x10^{-4}$ mol.dm^{3}.

(ii) $3x10^{-3}$ mol.dm^{3}.

[8 marks]

<u>Data for Q 4</u>

Universal Gas Constant, $R = 8.314$ J.mol^{-1}.K^{-1}
Boltzmann constant, $k = 1.38 \times 10^{-23}$ J.K^{-1}
Avogadro's number $N = 6.023 \times 10^{23}$

TURN OVER

Figures for Question 4:

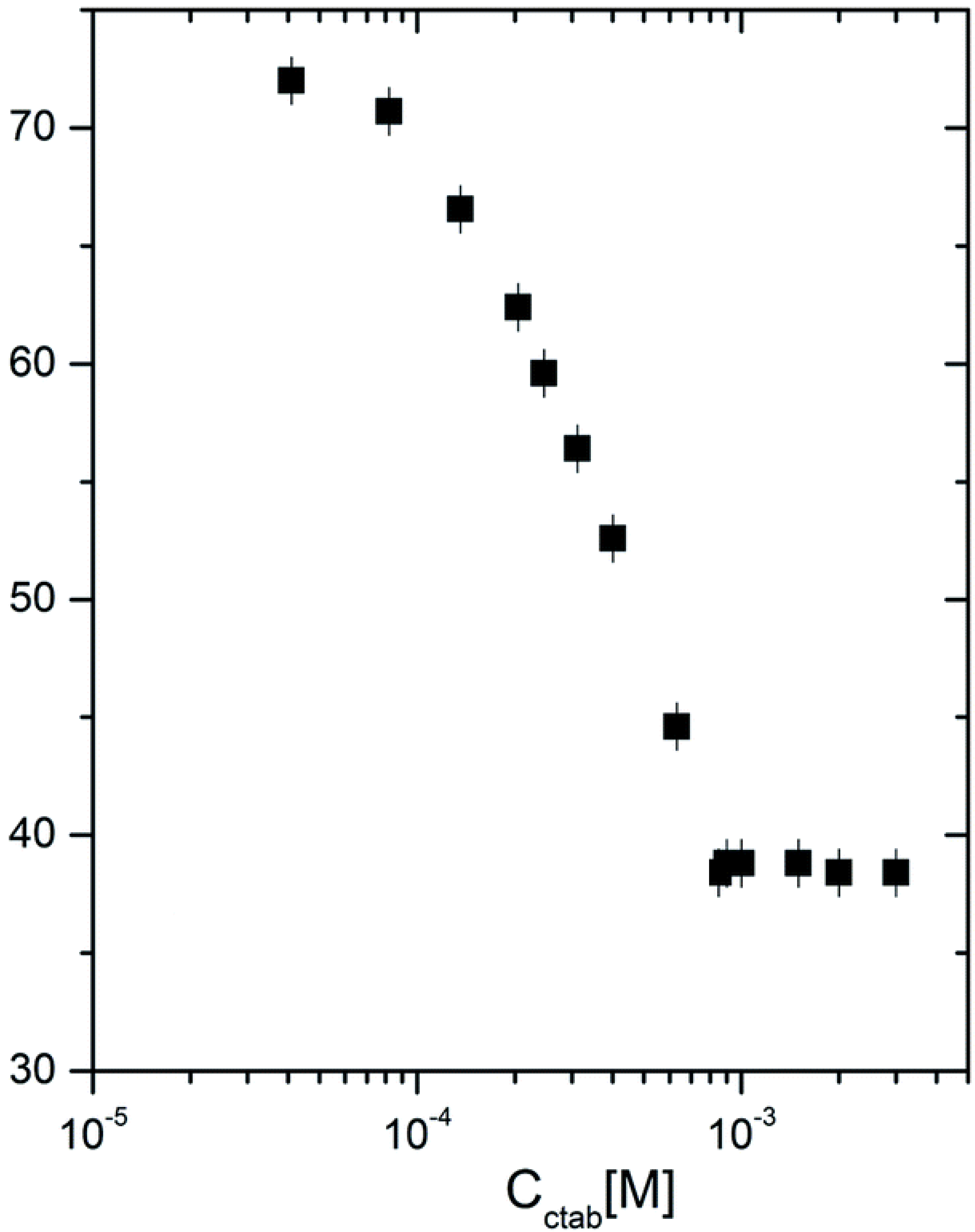

Figure 2 Equilibrium surface tension as a function of CTAB concentration at 25^{O}C,

END OF QUESTION 4

END OF PAPER