Reactions at the Interfaces 2010. Examination questions

1. Surface tension. Origin of surface tension. Force at the interface. The Young-Laplace equation (derivation).
2. The Kelvin equation (derivation). Consequences of Kelvin equation
3. Nucleation theory
4. Techniques for measuring surface tension.
5. Gibbs model of interface. Surface excess. Relative adsorption.
6. Gibbs adsorption isotherm (derivation). Adsorption of electrolyte. Deviations from Gibbs isotherm.
7. Double-layer structure. Poisson-Boltzmann theory. Derive linearized PB equation (low potentials, planar interface).
8. The Grahame equation. Capacity of the double layer.
9. Electrocapillarity. Lippmann equation.
10. Mechanism of surface charge formations (mercury, AgI, oxides, mica, semiconductors). Measuring surface charge density.
11. Electroosmosis and streaming potential.
12. Electrophoresis and sedimentation potential.
13. The origin of Van der Waals force. Derive vdWaals force between two planes.
14. Relation of Hamaker constant and surface energy. Deryagin approximation.
15. Double layer force.
16. DLVO theory. Its application to stability of colloids. Non-DLVO forces.
17. Contact angle, wetting and spreading. Young equation. Wetting of inhomogeneous and rough surfaces (Wenzel and Cassie-Baxter laws).
18. Solid surfaces: Defects, Relaxation and Reconstruction. Describing surfaces and adsorbate structures.
19. Shape of crystal. Wulff equation and construction rule.
20. Main techniques to study surface structure and composition. Spectroscopy with inner and outer electrons.
21. Physi- and Chemi-sorption. Adsorption isotherms. Langmuir model.
22. Adsorption isotherms. BET model.
23. Potential theory of Polanyi.
24. Mechanisms of heterogeneous catalysis. Kinetics of reactions involving adsorbate.
25. Main surface modification techniques. Mechanism of surface silanization.
26. Friction: Amontons' and Coulomb's law and their possible origin. Static, dynamic and rolling friction.
27. Measurement of friction. Tomlinson's model of microscopic friction. Lubricated friction regimes.
28. Surfactants. Adsorption of surfactants on the surface. CMC. Thermodynamics of micelle formation.
29. Micelle structure: geometrical consideration. Optimal head group area.
30. Macroemulsion. Formation and evolution.
31. Microemulsions. Energetics and structures.
32. Floating monolayers. LB trough. Surface pressure isotherms. Principal phases in monolayer.
33. Experimental techniques to study LB monolayers. Monolayers transfer.

34. Donnan potential.
35. From surface tension measurements on aqueous solutions of butanol, it was found that the slope of the graph of surface tension against concentration was –0.156 mN m^2 mol^{-1} at a bulk concentration of 6.40 mol m^{-3}. Calculate the adsorption at this concentration and state any assumptions made.
36. The cmc of hexadecyl trimethyl ammonium bromide in water occurs at 0.96 mmol kg^{-1} and 38.6 mN m^{-1}. A solution of concentration 0.56 mmol kg^{-1} has a surface tension of 47.4 mN m^{-1}. Calculate the adsorption at a concentration of 0.63 mmol kg^{-1} and state the assumptions made.
37. After equilibration the Donnan potential across a membrane separating a solution of a negatively charged polyelectrolyte and a solution of sodium chloride is found to be 45 mV (with the polyelectrolyte solution at the lower potential). Calculate the ratio of sodium ion concentrations in the two solutions. (Ignore any osmotic movement).
38. Use the Kelvin equation to calculate the radius of an open-ended tube within which capillary condensation of nitrogen at 77 K and a relative pressure of 0.75 might be expected. Assume that prior adsorption of nitrogen has formed a layer 0.9 nm thick coating the inside of the tube. For nitrogen at 77 K the surface tension is 8.85 mN m^{-1} and the molar volume is 34.7 cm^3 mol^{-1}.
39. For an electrophysiological experiment you form an electrode from a 5 cm long platinum wire (0.4 mm diameter) by bending it in the shape of a spiral. Calculate the total capacitance of the diffuse electric double layer for aqueous solutions of a monovalent salt at concentrations of 0.1 and 0.001 M. Assume a low surface potential.
40. For a microfluidic application, a capillary of 10μm radius and 5 cm length was fabricated in glass. The zeta potential of this glass in 0.01 M KCl aqueous solution at neutral pH is -30 mV. A potential of 5 V is applied along the capillary. How fast and in which direction does the liquid flow?
41. Identical spherical particles of radius 80nm are dispersed in aqueous medium containing 3mM of sodium chloride, T=298K. The effective Hamaker constant is $1x10^{-19}$ J and the dielectric constant of the medium is 80.10. The free space permittivity is $8.85x10^{12}$ F/m. Calculate Debye length for the diffuse layer around each particle. Electrophoretic measurements give value of 45 mV for the ζ-potential. Calculate the interaction energy. Do the particle attract of repulse from each other?
42. Explain the figure below: