

Surface Physics - Exam

You are allowed a calculator and an A4 sheet (both sides) of notes (text, formula, diagrams) with you to the exam.

All problems are worth six points. Points for each sub-question are given in the margin. Where numerical answers are required, remember to give them with the appropriate units. Read the problems carefully before answering.

Problem I

Consider a crystal with FCC structure with cubic lattice constant d .

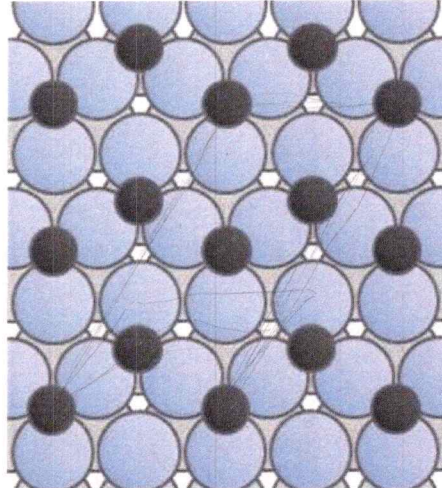
- a) Draw sketches of the lattice and surfaces with (100)-, (210)-, and (111)-terminations. *2 pt*
- b) Which of the three surfaces is expected to have the highest surface energy and why? *2 pt*
- c) Sketch the LEED pattern of the three surfaces (indicate only first order spots) *2 pt*

Problem II

- a) Explain the concepts chemisorption and physisorption. Which interactions cause them? *2 pts*
- b) In a few sentences, explain the operating principles of the following techniques, what is the main information one can obtain with them and why they are surface sensitive: ARPES and AFM *4 pts*

Problem III

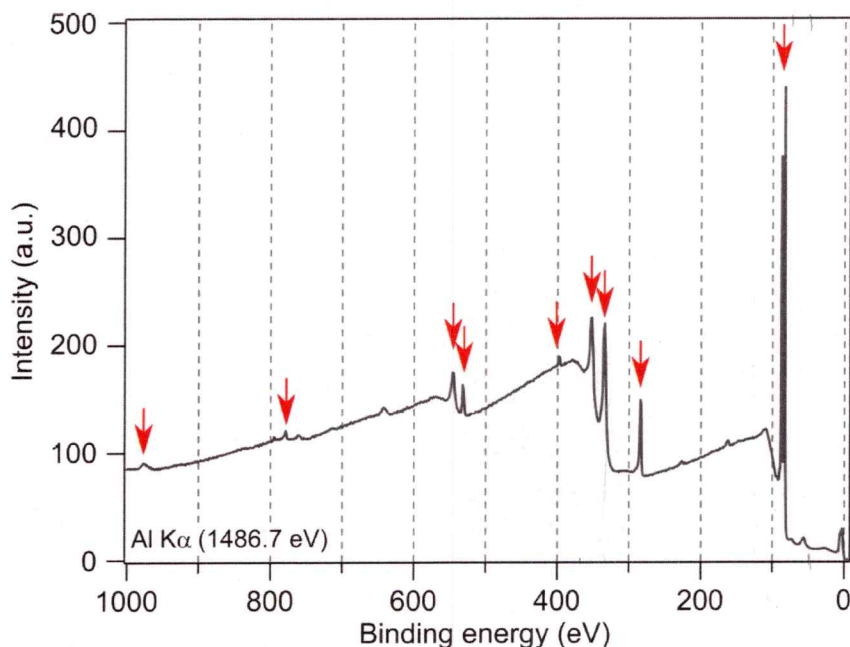
The figure below shows a schematic of nitric oxide (NO, dark spheres) adsorption structure on Ni(111) surface (surface atoms indicated in blue).



- a) Give the Wood's and matrix notations of the adsorption structure. *2 pts*
- b) What are the main adsorption sites on a (111)-terminated fcc surface?
What is the adsorption site of NO in the above image? *2 pts*
- c) Which factors influence the molecular adsorption geometry on the surface? *2 pts*

Problem IV

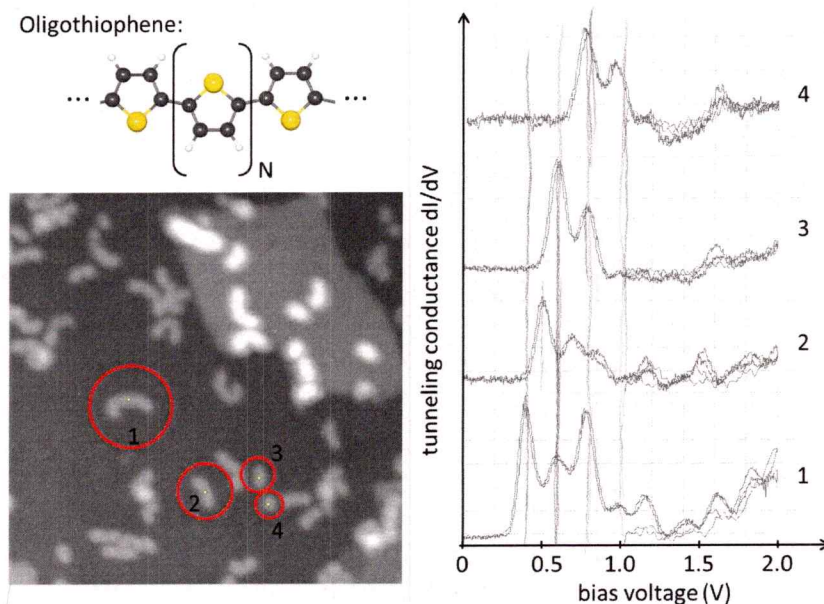
Below is a photoelectron spectrum measured with Al $K\alpha$ radiation at 1486.6 eV



- a) Concentrate on the transitions marked with red arrows. Identify the transitions based on the table of binding energies (last page). *4 pts*
- b) Which of the following is most likely the sample structure (justify your choice): monolayer of cobalt sulphide on silver substrate, 10 nm film of copper oxide on a gold substrate, one monolayer of cobalt porphyrin (molecule with a structure formula of $C_{20}H_{14}CoN_4$) on Au substrate, cobalt nitride (Co_2N) monolayer on gold substrate, 2 nm film of cobalt oxide on copper substrate? *2 pts*

Problem V

The figure below shows the structure of oligothiophene, an STM image with several oligothiophene molecules with different lengths and dI/dV spectra measured on the four highlighted molecules.



- Explain what is measured in the dI/dV tunneling spectrum and what information can be obtained on a molecular system. *3 pts*
- Why does the first feature on the dI/dV spectra shift from molecule to another? *1 pts*
- Given the molecular lengths (38 Å, 21 Å, 15 Å, 10 Å), estimate the effective mass of electrons in oligothiophene. *2 pts*

binding energies in eV

Element	1s	2s	2p _{1/2}	2p _{3/2}	3s	3p _{1/2}	3p _{3/2}	3d _{3/2}	3d _{5/2}	4s	4p _{1/2}	4p _{3/2}
C	284.2											
N	409.9	37.3										
O	543.1	41.6										
S	2472	230.9	163.6	162.5								
Co	7709	925.1	793.2	778.1	101	58.9	59.9					
Cu	8979	1096.7	952.3	932.7	122.5	77.3	75.1					
Ag	25514	3806	3524	3351	719	603.8	573	374	368.3	97	63.7	58.3
Au	80725	14353	13734	11919	3425	3148	2743	2291	2206	762.1	642.7	546.3
	4d _{3/2}	4d _{5/2}	4f _{5/2}	4f _{7/2}	5s	5p _{1/2}	5p _{3/2}					
Au	353.2	335.1	87.6	84	107.2	74.2	57.2					

