Appendix 12c

REVIEW
to occupy the academic position:

"Professor"	
"Associate Professor"	X
	one of the academic positions indicated shall be marked with the sign "X"

Candidates to occupy the position:

1	Assist. Prof.	Dr.	Vasil	Ivanov	Karastoyanov	UCTM
№	academic position	scientific degree	name	middle name	last name	workplace

Scientific area:

4.0	Natural Sciences, Mathematics and Informatics
code	name

Professional area:

4.2	Chemical sciences
code	name

Scientific specialty:

Physical Chemistry

The competition has been announced:

23	19.03.2024	Physical Chemistry	Chemical Technologies
in SG issue	date	for the needs of the Department	Faculty

The review was written by:

Prof.	DSc	Vessela	Tsvetanova	Tsakova-Stancheva	Institute of Physical Chemistry, BAS
academic position	scientific degree	name	middle name	last name	workplace

1. Review for the candidate:

Assist. Prof.	Dr.	Vasil	Ivanov	Karastoyanov
academic position	scientific degree	name	middle name	last name

1.1. Completion of the provided documents:

A) The competition documents are in full compliance with the Regulations	3 points	**X**

B) The documents are complete but do not fully comply with the requirements of the Regulations	2 points	
C) The documents are not completed in accordance with the requirements of the Regulations	0 points	
		one of the answers given is marked with the sign "X"

Missing documents and violated requirements must be described if response C is marked.

1.2. Meeting the minimum requirements under the Regulations:

A) The candidate meets the minimum requirements	20 points	**X**
B) The candidate doesn't meet the minimum requirements	0 points	
		one of the answers given is marked with the sign "X"

It must be filled in if answer B is marked. The publication activity of the candidate is analyzed. The response of the results achieved (quoted) is analyzed.
The candidate participates in the competition with six publications equivalent to a habilitation thesis, published in reputable international journals such as Electrochimica Acta, Corrosion Science, Colloids & Interfaces, etc., which carry 135 points with a required minimum of 100 points. Additionally, 10 publications have been submitted which carry 220 points against the required minimum of 200 points. The number of citations of the works entered in the competition is 157 (314 points) and exceeds the national minimum requirement of 25 citations (50 points) by a considerable margin. It is worth noting the significant citation rate (145 citations in total) of works 1-3, which are part of the candidate's habilitation thesis. With the published papers, citations and the PhD Dissertation submitted in the competition, the number of points for indicators A, B, C and D (of the Regulations for the Implementation of the Law for the Development of Academic Staff in the Republic of Bulgaria) of the candidate is 669 and exceeds markedly the minimum national requirements of 400 points.

1.3. Relevance of scientific and / or applied research:

A) The research is relevant. Part of the research is pioneering (no results are known on the topic by other authors)	7 points	**X**
B) Research is relevant. Results from other authors are known for each of the topics and / or applications studied.	5 points	
C) Most of the research is relevant, but also some results are presented that have no scientific and / or applied value	3 points	
D) The smaller part of the research is relevant	2 points	
E) Research is not relevant	0 points	

		one of the answers given is marked with the sign "X"

The evaluation of the relevance of the research must be substantiated.
The papers, equivalent to a habilitation thesis, relate to the challenging area of research and modelling of corrosion processes in various structural materials (stainless steels, zirconium-niobium alloys and nickel-based high chromium alloy) used in first and second loops of nuclear reactors. Their relevance stems from the high safety requirements of these facilities and the consequent need for detailed knowledge and control of the corrosion processes and water chemistry regimes used in these systems. The main part of the remaining papers included in the candidate's application is devoted to modelling the processes of formation of barrier oxide layers and dissolution of various transition metals such as Ti, Mo, Nb and W. The research follows an original approach based on the application of multiple electrochemical and other analytical methods (so-called multi-method approach), where independent experimental measurements are used to parameterize and validate the proposed quantitative kinetic models. The models developed and validated in this way make it possible to enrich the current understanding of oxidation processes and of the barrier and electronic properties of oxide layers formed on metals and alloys of this group. The publications devoted to the research of steel and modified titanium oxides as potential photocatalysts for photoelectrochemical decomposition of water address the relevant topic of finding suitable photoanodes with sufficient efficiency in the visible part of light. An essential aspect of the research is the endeavour to use, as far as possible, widely available materials and relatively simple and reproducible procedures for the preparation of the relevant oxides. The experimental procedures for electrochemical modification of titanium oxide substrates are original and lead to the preparation of oxide (molybdenum or copper) layers with suitable photosensitive properties.

1.4. Knowledge of the problems subject of research:

A) The candidate knows in detail the achievements of other authors on the researched topics and/or applications	6 points	**X**
B) The candidate is partially familiar with the achieved results on the researched topics and / or applications	4 points	
C) The candidate has no prior knowledge of the status of the researched problems	0 points	
		one of the answers given is marked with the sign "X"

The evaluation must be substantiated if answer C is marked.
The works presented by the candidate in the competition for associate professor are collective, most often in co-authorship with two established Bulgarian electrochemists. All publications are clearly and logically written, contain a detailed description of previous research and a convincing justification of the objectives set and the ways to achieve them. This implies that the candidate is familiar with the achievements of other authors on the topics of the research presented.

1.5. Type of research:

A) Theoretical	4 points	
B) Applied	4 points	**X**

C) Theoretical with application elements	4 points	
D) It does not correspond to the level specified in the Act for the Development of the Academic Staff in the Republic of Bulgaria and the Regulations	0 points	
		one of the answers given is marked with the sign "X"

The level of research must be substantiated if answer D is marked.
The research is of an applied nature, although the solution of the applied objectives is in all cases based on the development of models requiring an excellent knowledge of the theory of oxide layer formation and a thorough understanding of the theory of the electrochemical impedance spectroscopy.

1.6. Objectives of the research:

A) Realistic and of scientific and / or applied interest	8 points	**X**
B) Realistic, but not of scientific and / or applied interest	4 points	
C) Unattainable (unrealistic)	0 points	
		one of the answers given is marked with the sign "X"

Objectives must be specified. The type of the set objectives must be justified.
The objectives set in all the studies presented are realistic, have a clear practical focus and can be summarised as follows: - validation of a model describing the passive state of steel used in the first loop of nuclear reactors in simulated pressurized water reactor conditions - establishing the role of the water chemistry regime on the corrosion of a nickel-based high chromium alloy used in modern steam generators under simulated hot-functional test, depending on the water chemistry regime of the process - establishing the mechanism of oxide layer growth and corrosion of zirconium-niobium alloys used as fuel claddings of nuclear power plants - establishing the mechanism of corrosion erosion and slag formation of steel used in the second loop of nuclear power plants in the temperature range 100-240^{o} C - parameterisation of kinetic models for the growth of oxide films on titanium and titanium alloy, as well as on molybdenum, and comparative assessment of the corrosion properties of pure and alloyed titanium materials - preparation of metal oxide photocatalytic materials absorbing light in the visible spectrum with a view to applications for photoelectrochemical decomposition of water.

1.7. Methods of research:

A) Adequate to research and set scientific objectives and /or applications	8 points	**X**
B) Partially appropriate, enabling part of the scientific objectives and / or applications to be achieved	4 points	

C) Inappropriate methods	0 points	
		one of the answers given is marked with the sign "X"

Methods must be specified. The type of methods used is justified.
The main experimental method applied in all studies is electrochemical impedance spectroscopy. In a number of cases, this method has been combined with analytical data obtained ex-situ by X-ray photoelectron spectroscopy, glow discharge optical electron spectroscopy, scanning electron microscopy, reflectance spectroscopy in the ultraviolet, visible and near-infrared regions, etc. Other electrochemical methods used include the combined galvanostatic-tensiostatic method, measurement of photocurrent transients and of photovoltammetric curves. In some cases, quantum mechanical calculations using Density functional theory (DFT) have been used to model the adsorption of water or other solution components on the substrates under investigation.   An important methodological approach in the papers equivalent to habilitation thesis is the experimentation in conditions close to the operational ones. For this purpose special electrochemical cells were designed and constructed as well as a laboratory re-circulation loop for conducting electrochemical measurements at temperatures up to 350 °C and pressures up to 15 MPa.   The approach used to model the oxide layer growth processes and the corrosion processes depending on the operational regimes of different types of steels and other metals and alloys is based on the mixed conduction model developed at an earlier stage by Bojinov et al. In all cases, however, the problem of multiple parameters required to obtain quantitative data has been addressed by validation or calibration based on independent experimental results.   In general, well-chosen combinations of modern experimental, theoretical, and computational methods appropriate to the particular problems of a given study have been applied.

1.8. Candidate research contributions:

A) With lasting scientific and / or applied response, they form the basis for new research and applications	20 points	**X**
B) They are of significant scientific and / or applied interest, complete and / or summarize previous research	16 points	
C) They are of scientific and / or applied interest	12 points	
D) Lack of significant contributions	8 points	
E) Lack of contributions	0 points	
		one of the answers given is marked with the sign "X"

Contributions must be specified. The type of results achieved must be justified.
The main contributions of the publications presented in the competition can be summarized as follows: 1) Based on the theory of mixed conductivity of oxide films and combined experimental data from impedance spectroscopy and X-ray photoelectron spectroscopy, the corrosion process for steel used in the first loop of nuclear reactors has been described (paper 1). Using the same approach, the water chemistry regime (i.e., LiOH and H_3BO_3 concentrations) for hot cladding of steam generators using alloy 690 was optimized (Paper 3). On the basis of the developed models of corrosion processes in conditions simulating the operational characteristics in the first loop of nuclear power plants (NPP),

software for the prediction of radioactivity accumulation was created and implemented at Kozloduy NPP in 2010. 2) A kinetic model of oxidation of zirconium-niobium alloys, which are used as fuel cladding in the first-loop heat carrier of nuclear power plants, was developed. The model is based on the theory of mixed conductivity and the conjugate current approach and allows equations to be derived for the increase in oxide thickness and the amount of hydrogen incorporated as a function of time, temperature and the water chemistry regime of the process (papers 2 and 5). The developed model has served for a software implemented in the Kozloduy NPP operation in 2021. 3) Based on electrochemical impedance spectroscopy data and the mixed conduction theory, a model for corrosion erosion and slag formation in the second loop of pressurized water nuclear power plants is developed. The predictions of the model are applicable to quantify the kinetics of sludge formation and consolidation and used to create a software implemented in the operation of Kozloduy NPP (papers 4 and 6). 4) On the basis of electrochemical impedance spectroscopy data, photocurrent transients measured in the Ti/TiO_2/ethylene glycol/H_2O/NH_4F system, combined with X-ray photoelectron spectroscopy data, a quantitative model for oxide layer growth and dissolution of titanium and a titanium alloy (containing molybdenum, niobium and aluminium) in fluoride-containing electrolytes has been parameterized (papers 12-15). The oxide film on titanium alloy was found to exhibit better protective and at the same time inferior electronic properties compared to that on titanium (papers 14 and 15). The developed model was also applied to the case of oxidation of molybdenum in concentrated phosphoric acid by considering a multistep transpassive dissolution reaction (paper 13). 5) Experimental procedures have been developed for the formation of oxide layers on austenitic steel (paper 11) and for electrochemical deposition of molybdenum oxides (paper 9) and copper oxides (paper 16) on titanium oxide substrates,resulting in photocatalytic materials with improved light absorption in the visible spectrum and potential applications for photoelectrochemical decomposition of water. The contributions (1-3) concerning the study of corrosion processes of structural materials used in first and second loop of nuclear power plants are undoubtedly of important practical importance and lasting effect, as evidenced by the software products implemented for control of technological regimes in the operation of Kozloduy NPP. It is essential to note that practically significant results have been obtained on the basis of sophisticated multi-parametric models, justified using independent data from appropriately selected experimental measurements. The significant response in the international scientific literature to these studies is further evidence of the enduring interest in the results obtained and of their high scientific and applied value. The model for oxide film growth and dissolution of titanium and titanium alloys (4) demonstrates in practice the solution of the problem of the large number of parameters required for a complete quantitative description of these processes by using an approach combining experimental data from suitably chosen measurement methods. This approach could be adapted, developed and applied to describe oxide layer formation and concomitant processes on other metal substrates. Finally, the contributions (5) concerning photocatalytic materials with improved absorption in the visible light spectrum, investigated in relation to photoelectrochemical decomposition of water, highlight opportunities for the development of photocatalysts with enhanced efficiency and practical applicability. The contributions are in all cases original, have both practical value in relation to the solution of specific problems and at the same time outline a methodological approach for quantitative modelling of the processes of oxide film formation and dissolution on metal substrates using a combination of in-situ and ex-situ measurement methods.

1.9. Participation of the candidate in the achievement of the presented results:

A) The candidate has at least an equal participation in the submitted papers	8 points	X
B) The candidate has at least an equal participation in most of the submitted papers	7 points	

C) The candidate has a secondary participation in most of the submitted papers	4 points	
D) The candidate participation is unnoticeable	0 points	
		one of the answers given is marked with the sign "X"

Critical notes must be provided if one of the items C or D is marked.
In the candidate's publications it is noted that his contribution as a co-author is in conducting the research and validating the measurements. According to my personal impressions, Dr. Karastoyanov is an excellent experimentalist who has a detailed knowledge of the use of various electrochemical techniques. He has been also involved in the design of special electrochemical cells and systems that allow research to be performed in conditions close to those operating for the construction materials used in nuclear recators. Therefore, I believe that Dr. Karastoyanov has had at least an equal participation in the works presented, and most likely a leading part with respect to a significant portion of the electrochemical research.

1.10. Pedagogical activity:

A) The candidate has effective and sufficient pedagogical activity at the university. The textbooks issued are modern and useful (they meet the requirements of the Regulations). The work with undergraduate and doctoral students is at a high professional level.	8 points	**X**
B) The candidate has sufficient pedagogical activity at the university. The textbooks issued satisfy the requirements of the Regulations.	6 points	
C) The pedagogical activity and / or textbooks issued are insufficient (do not meet the requirements of the Regulations)	0 points	
		one of the answers given is marked with the sign "X"

Critical notes must be provided if one of the items B or C is marked.
During the last three academic years, Dr. Karastoyanov has given lectures in seven different disciplines, six of which for Master's students and one for Bachelor's students. The lecture courses focus on the modern field of hydrogen energy and hydrogen technology. The candidate is an independent author of the textbook "PRACTICAL COURSE IN FUEL ELEMENTS TECHNOLOGY".

1.11. Critical notes:

A) Lack of critical notes	8 points	**X**
B) Critical notes of a technical nature	7 points	
C) Critical notes that would partially improve the results achieved in a small part of the research	5 points	
D) Critical notes that would partially improve the results achieved in most of the research	3 points	

E) Significant critical notes	0 points	
		one of the answers given is marked with the sign "X"

Critical notes must be provided if one of the answers C, D or E is marked.

1.12. Conclusion

A) The evaluation of the candidate's activity is **POSITIVE**	This evaluation is assigned to a total number of at least 65 points	**X**
B) The evaluation of the candidate's activity is **NEGATIVE**	This evaluation is assigned to a total number below 65 points	
		one of the answers given is marked with the sign "X"

To be filled in if requested by the reviewer
The research and teaching activities of Dr. Karastoyanov testify to an established scientist and teacher with proven high competence in the study of corrosion processes of construction materials, oxide film formation and accompanying dissolution processes of metals and alloys with important practical applications. His scientific metrics significantly exceed the requirements for the academic position of Associate Professor as defined in the Regulations to the Law for the Development of Academic Staff in the Republic of Bulgaria, and he scores the maximum of 100 points in the indicators of the UCTM scorecard. Therefore, I give a positive assessment of the activity of Dr. Vasil Karastoyanov and support with deep conviction his candidacy for the position of Associate Professor in the Department of Physical Chemistry of UCTM.

03.07.2024	The review was written by:	
date		signature