《工程化学》教学大纲

一、基本信息

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| 课程名称：工程化学 | 英文课程名称：Engineering Chemistry |
| 课程代码：100307E004 | 总学分：3 |
| 总学时：48 | 理论学时：44 |
| 实验学时：4 | 上机学时：0 |
| 开课学院：工学院 | 适用专业：安全工程、勘查工程与技术 |
| 课程性质：必修 | 先修课程：高等数学 |

二、课程简介

工程化学以现代化学的基本原理和知识为主，对化学的许多分支学科所涵盖的基本内容做了较整体的阐述和研讨。本课程以化学热力学基本原理为主线探讨化学平衡、相平衡、电化学等学科方面的内容，并简要讨论化学动力学基本原理。主要内容有化学热力学、化学平衡、水溶液中的离子平衡、相平衡、氧化还原反应和电化学、界面化学、化学动力学等内容；此外了解化学实验的特点，对化学实验方法有基本的认识。

三、教学目标

本课程是非化工类专业本科生的一门基础课，目的主要是使非化工类专业的本科生掌握必需的化学基本知识、基本理论及实验的基本技能，培养学生用化学的观点分析和解决实际问题的能力，为以后的学习工作奠定良好的化学基础。要求学习本课程后，应达到以下基本要求：

（1）正确理解工程化学课程中涉及的化学热力学、化学平衡、水溶液中的离子平衡、相平衡、电解质溶液、氧化还原反应和电化学、界面化学、化学动力学的基本概念和基本原理。

（2）能够进行基本的化学实验操作，能够对实验结果进行分析和处理。

（3）具备分析问题和解决问题的能力。

（4）具有较强的团队合作能力与表达能力，具有自主学习的能力。

四、教学内容与学习要求

（可按章节顺序或教学单元顺序编写，要详细说明具体教学内容、教学重点和难点，应清楚地表达知识、技能的范围和深度，充分反映课程的知识和技能要求，体现课程特点。）

| **章节/教学单元** | | **教学内容、重点、难点** | **学时** | **学习要求** |
| --- | --- | --- | --- | --- |
| **绪论** |  | 化学的地位和作用、课程性质、课程安排、学习方法等。 | 1 | ☑理解 |
| **第一章**  **化学热力学基础** | 1.1理想气体状态方程 | 理想气体状态方程，分压定律，实际气体，气体液化及临界状态。 | 1 | ☑记忆  ☑理解  ☑应用 |
| 1.2热力学第一定律与热化学 | 物系，环境，状态，状态函数，功，热，过程与可逆过程，热力学能。热力学第一定律，焓，热容，等压反应热，等容反应热，盖斯定律，标准摩尔生成焓，标准摩尔燃烧焓，反应热与温度的关系。 | 6 | ☑记忆  ☑理解  ☑应用  ☑综合分析 |
| 1.3热力学第二定律与化学反应方向、限度 | 热力学第二定律，熵和熵判据，理想气体熵变的计算。凝聚态物质PVT变化熵的计算；相变化过程熵变计算，环境熵变计算 | 8 | ☑记忆  ☑理解  ☑应用  ☑综合分析 |
| 1.4热力学第三定律与热力学重要函数 | 热力学第三定律与标准摩尔熵，标准摩尔反应熵。吉布斯函数，判断化学反应自发方向的判据，化学反应的标准摩尔吉布斯函数变。标准平衡常数表达式，平衡组成计算，标准平衡常数与温度的关系。 | 4 | ☑理解  ☑应用  ☑综合分析 |
| **第二章**  **化学动力学** | 第一节 反应速率及速率方程 | 反应速率，反应速率方程式，反应级数，反应速率常数，速率方程的积分形式。 | 2 | ☑记忆  ☑理解  ☑应用 |
| 第二节 温度对反应速率的影响 | 阿伦尼乌斯公式，活化能。 | 1.5 | ☑记忆  ☑理解  ☑应用 |
| 第三节 催化反应 | 催化剂，催化反应的一般机理，催化剂特性。 | 0.5 | ☑记忆  ☑理解  ☑应用 |
| **第三章**  **水溶液中的离子平衡** | 第一节 稀溶液依数性 | 溶液的分类，溶液浓度的表示方法，拉乌尔定律，理想溶液和实际溶液，稀溶液依数性。 | 1 | ☑理解  ☑应用 |
| 第二节 水溶液中酸碱平衡 | 酸碱质子理论，弱酸、弱碱的解离平衡及计算，同离子效应、缓冲溶液及应用。酸碱指示剂。  电解质溶液：  强电解质溶液的活度、活度系数。 | 4 | ☑记忆  ☑理解  ☑应用  ☑综合分析 |
| 第三节 难溶电解质的多相离子平衡 | 多相离子平衡和标准溶度积，溶度积规则及应用(沉淀生成与溶解、分布沉淀和沉淀转化)。 | 3 | ☑记忆  ☑理解  ☑应用 |
| **第四章**  **氧化还原反应和电化学** | 第一节 氧化还原反应 | 氧化剂，还原剂，氧化还原反应方程式配平。 | 1 | ☑记忆  ☑理解  ☑应用 |
| 第二节原电池 | 电池反应与电池图式，电极类型，原电池电动势，可逆电池，可逆电池热力学 | 3 | ☑记忆  ☑理解  ☑应用  ☑综合分析 |
| 第三节电极电势 | 标准电极电势，电极电势的能斯特方程，电极电势的应用(比较氧化剂、还原剂相对强弱，判断氧化还原反应方向和程度)。 | 4 | ☑记忆  ☑理解  ☑应用  ☑综合分析 |
| **第六章**  **界面现象** | 第一节 表面张力 | 表面张力，表面功和表面吉布斯函数。 | 1 | ☑记忆  ☑理解  ☑应用 |
| 第二节 纯液体的表面现象 | 液体对固体的润湿作用，弯曲液面的附加压力，毛细管现象，开尔文公式。 | 1 | ☑记忆  ☑理解  ☑应用 |
| 第三节 溶液的表面吸附 | 溶液的表面吸附现象，表面活性剂的定义、结构特点及分类，表面活性剂的重要作用。 | 2 | ☑理解  ☑应用 |

注：在“学习要求”一栏补充选项，可以多选，无要求可不填，也可自定要求。**记忆，**指能从记忆库中找到相关的知识、概念、术语或材料与当前的信息进行比较、确认，能记住并能不加理解的列出、描述这些知识、概念、术语或材料；**理解，**指能对所学的内容作归纳、分类、解释、总结、推断和一定程度的发挥；**应用，**指能选择正确的程序应用、实施所学到的内容，并能进行必要的计算或决断；**综合分析，**指能将所学的内容分解并找出它们的相互关系和构成，或能计划、创造、建造、有改变的重构，或能作评论、总结、估计、预测、评估、论证和答辩。

实验内容

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **序号** | **实验项目名称** | **主要内容** | **主要仪器名称** | **仪器台套数** | **每组人数** | **实验类型** | **实验类别** | **学时** |
| 1 | 实验室安全教育 | 讲解实验室安全知识、注意事项 | / | / | / | / | / | 1 |
| 2 | 表面张力测定—最大压差法 | 测定正丁醇水溶液的表面张力，了解表面张力的影响因素，了解溶液表面的吸附作用。 | 最大压差法测表面张力装置 | 20 | 2 | 验证性 | 基础实验 | 3 |

注：实验类型指演示性、验证性、综合性、设计性、创新性。实验类别指基础实验、专业基础实验、专业实验。

五、教学方法

本课程以“夯实基础、强化实验、培养能力”为教学理念，倡导基础理论与实验操作相结合。包括两个主要教学环节，即课堂理论教学和实验。

**1．课堂理论教学**

教师讲授课程要求的基本概念和基本理论；同时，设计讨论性问题，引导学生思考，通过师生互动交流，得到合理的认识。在这一环节，学生以听课为主。

教学材料包括教材及教学PPT。

**2．实验**

学生通过本课程可以巩固、扩大和加深课堂所学的理论知识，了解化学实验的特点，初步学会常用仪器的使用。

六、考核方式

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| --- | --- |
| 是否排考 | 是 |
| 考核形式 | 笔试（闭卷） |
| 成绩评定方式 | 百分制 |
| 过程成绩/% | 30% |
| 实验成绩/% | 10% |
| 结课考试成绩/% | 60% |

七、教材与参考书

**（一）教材**

《现代化学基础》，第四版，胡忠鲠主编，高等教育出版社，2014，ISBN：9787040409444。

**（二）参考书目或文献**

1、《普通化学》，第五版，浙江大学普通化学教研组主编，高等教育出版社，2002，ISBN：9787040107630。

2、《物理化学》上、下册，第四版，天津大学物理化学教研室所编，高等教育出版社，2001，ISBN：9787040101638。

3、《无机化学》，第四版，大连理工大学无机化学教研室编，高等教育出版社，2004，ISBN：9787040094633。

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|  | 制定人：梅述钘 |
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|  | 制（修）订时间：2024年2月 |

**《Engineering Chemistry》Syllabus**

**I. Basic Information**

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| --- | --- |
| Course Name: Engineering Chemistry | Name in Chinese: 工程化学 |
| Course No.: 100307E004 | Total Credits: 3 |
| Total Hours: 48 | Lecture Hours: 44 |
| Lab Hours: 4 | Computer Lab Hours: 0 |
| Offering College: Department of Engineering | Corresponding Majors: Safety engineering, Prospecting technology and Engineering |
| Course Type: Required | Prerequisite: Advanced mathematics |

**II. Course Introduction**

Engineering chemistry to the basic principles of modern chemistry and knowledge-based, many branches of chemistry covered by the basic content of a more comprehensive exposition and discussion. This course focuses on the basic principles of chemical thermodynamics, including chemical equilibrium, phase equilibria and electrochemistry, and briefly discusses the basic principles of chemical kinetics. The main contents of chemical thermodynamics, chemical balance, aqueous solution in the ion balance, phase equilibrium, oxidation and reduction reactions and electrochemistry, interface chemistry, chemical kinetics and so on; In addition to understand the characteristics of chemical experiments on chemical experiment methods are basic Understanding.

**III. Course Objective**

Engineering Chemistry is a basic course for non-chemical undergraduates. The main purpose is to make non-chemical undergraduate students master the necessary basic knowledge of chemistry, basic theory and experimental basic skills, students with chemical point of view to analyze and solve practical problems, in order to lay the foundation for future study of good chemistry basis. Requirements After completing this course, you should meet the following basic requirements:

（1）The basic concepts and basic principles of chemical thermodynamics, chemical equilibrium, ion balance, phase equilibrium, electrolyte solution, redox reaction and electrochemistry, interfacial chemistry and chemical kinetics in Engineering chemistry are correctly understood.

（2）Can carry on the basic chemistry experiment operation, can carry on the analysis and the processing to the experiment result.

（3）Have the ability to analyze problems and solve problems.

（4）Have strong ability of teamwork and expression, with self-learning ability.

**IV. Contents and Requirements**

| **Chapter/Unit** | | **Contents and Key Points** | **hrs** | **Requirements** |
| --- | --- | --- | --- | --- |
| Introduction |  | The status and role of chemistry, the nature of the curriculum, the curriculum, and the learning methods. | 1 | ☑Comprehension |
| Chapter 1  The basis of chemical thermodynamics | 1.1 Equation of state of ideal gas | The state equation of ideal gas, Dalton's partial-pressure laws, real gas, gas liquefaction and critical state. | 1 | ☑Memory  ☑Comprehension  ☑Application |
| 1.2 The first law of thermodynamics and thermochemistry: | System, surroundings, state, state function, heat, work, process and reversible process, thermodynamic energy. The first law of thermodynamics, enthalpy, heat capacity, isobaric reaction heat, isochoric reaction heat, hess′s law, standard molar enthalpy of formation, standard molar enthalpy of combustion, the relation between reaction heat and temperature. | 6 | ☑Memory  ☑Comprehension  ☑Application  ☑Comprehensive Analysis |
| 1.3 The second law of hermodynamics and the direction and limit of chemical reaction: | The second law of thermodynamics, entropy and entropy criterion, calculation of entropy change of ideal gas. Calculation of PVT change entropy of condensed matter; Phase change process entropy change calculation, environmental entropy change calculation | 8 | ☑Memory  ☑Comprehension  ☑Application  ☑Comprehensive Analysis |
| 1.4 Third law of thermodynamics and important functions of thermodynamics | Third law of thermodynamics and standard molar entropy, standard molar reaction entropy. Gibbs function, the criterion for determining the spontaneous direction of a chemical reaction, the standard molar Gibbs function change of a chemical reaction. Expression of standard equilibrium constant, calculation of equilibrium composition, relationship between standard equilibrium constant and temperature. | 4 | ☑Memory  ☑Comprehension  ☑Application  ☑Comprehensive Analysis |
| Chapter 2  Chemical Kinetics | 2.1 Reaction rate and rate equation of chemical reaction: | Rate of chemical reaction , rate equation of chemical reaction, reaction order, rate constant, integral rate equation. | 2 | ☑Memory  ☑Comprehension  ☑Application |
| 2.2 The effect of temperature on rate of reaction: | Arrhenius equation, activation energy. | 1.5 | ☑Memory  ☑Comprehension  ☑Application |
| 2.3 Catalytic reaction: | Catalyst, general mechanism of catalytic reaction, the character of catalyst.。 | 0.5 | ☑Memory  ☑Comprehension  ☑Application |
| Chapter 3  Ionic equilibrium in aqueous solution | 3.1 Colligative Properties of Dilute Solution | Categories of solution, representing methods of solution concentration, Raoult's law , ideal solution and real solution, colligative properties of dilute solution. | 1 | ☑Comprehension  ☑Application |
| 3.2 Acid-base balance in aqueous solution | Proton theory of acid base, dissociation equilibrium and calculation of weak acid and base, isoionic effect, buffer solution and application. Acid base indicator.  Electrolyte solution:  Activity and activity coefficient of strong electrolyte solution. | 4 | ☑Memory  ☑Comprehension  ☑Application  ☑Comprehensive Analysis |
| 3.3 The quilibrium of precipitation and dissolution: | Multiphase ionic equilibrium and standard solubility product, the solubility-product rule and applications(precipitation generation and dissolution, steps of precipitation , the transfer of precipitation). | 3 | ☑Memory  ☑Comprehension  ☑Application |
| Chapter 4  redox reaction and electrochemistry | 4.1 Redox reaction: | Oxidizing agent, reducing agent, balancing oxidation-reduction equation. | 1 | ☑Memory  ☑Comprehension  ☑Application |
| 4.2 Galvanic cell | Cell reaction and notation of galvanic cell, electrode types, electromotive forces of galvanic cell, reversible cell, thermodynamics of reversible cell. | 3 | ☑Memory  ☑Comprehension  ☑Application  ☑Comprehensive Analysis |
| 4.3 Electrode potential | Standard electrode potential, Nernst equation of electrode potential, applications of electrode potential(comparing oxidizability intensity between oxidants and reducing agents,judging direction and degree of redox reaction ). | 4 | ☑Memory  ☑Comprehension  ☑Application  ☑Comprehensive Analysis |
| Chapter 6  Interfacial phenomena | 6.1 Surface tension | Surface tension, surface work, Gibbs function of specific surface. | 1 | ☑Memory  ☑Comprehension  ☑Application |
| 6.2 The superficial phenomenon of the pure liquid | The solid's surface wetness, additional pressure on curved surface, the capillary phenomenon, Kelvin’s equation. | 1 | ☑Memory  ☑Comprehension  ☑Application |
| 6.3 Surface adsorption of solution | Surface adsorption phenomenon in solution, definition, molecular structure and classification of surfactant, the role of surfactant. | 2 | ☑Comprehension  ☑Application |

**Lab Contents**

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **No.** | **Project** | **Contents** | **Apparatus** | **Units** | **Students/Group** | **Lab Type** | **Lab Category** | **hrs** |
| 1 | Laboratory safety education | Laboratory safety knowledge and precautions | / | / | / | / | / | 1 |
| 2 | Determination of surface tension - Maximum differential pressure method | Determination of the surface tension of aqueous solution of n-butanol to understand the surface tension of the factors to understand the adsorption surface of the solution. | Maximum differential pressure method for measuring surface tension | 20 | 2 | Verification | Basic Experiment | 3 |

**V. Teaching Method**

This course aims to "consolidate the foundation, strengthen the experiment, training capacity" for the teaching philosophy, advocate the combination of basic theory and experimental operation. Including two main teaching links, namely classroom theory teaching and experiment.

**1．Classroom theory teaching**

Teachers to teach the basic requirements of the basic concepts and basic theory; the same time, the design of discussion issues, and guide students to think, through interaction between teachers and students to get a reasonable understanding. In this part, students to lectures.

Teaching materials include teaching materials and teaching PPT.

**2．Experiment**

Through this course students can consolidate, expand and deepen the theoretical knowledge learned in the classroom, understand the characteristics of chemical experiments, the initial use of commonly used instruments.

**VI. Evaluation**

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| --- | --- |
| Whether to arrange the examination | Yes |
| Examination form | Written examination (closed-book exam) |
| Evaluation method | Percentage |
| Usually exercises/% | 30% |
| Experiment/% | 10% |
| Final exam result/% | 60% |

**VII. Textbook and Reference**

**(1) Textbook**

"Modern Chemistry Foundation", edited by Hu Zhonggeng, Higher Education Press.

**(2) Reference**

1、"General Chemistry", Fifth Edition, edited by Zhejiang University, Higher Education Press.

2、"Physical Chemistry", fourth edition, compiled by Tianjin University, Higher Education Press.

3、"Inorganic Chemistry", fourth edition, Department of Inorganic Chemistry, Dalian University of Science and Technology, Higher Education Press.