

# 2023 Ap Chem Frq

AP® Chemistry 2023 Free-Response Questions

Begin your response to **QUESTION 1** on this page.

**CHEMISTRY**  
**SECTION II**

**Time—1 hour and 45 minutes**

**7 Questions**

**Directions:** Questions 1–3 are long free-response questions that require about 23 minutes each to answer and are worth 10 points each. Questions 4–7 are short free-response questions that require about 9 minutes each to answer and are worth 4 points each.

For each question, show your work for each part in the space provided after that part. Examples and equations may be included in your responses where appropriate. For calculations, clearly show the method used and the steps involved in arriving at your answers. You must show your work to receive credit for your answer. Pay attention to significant figures.

1. Answer the following questions related to manganese compounds.

(a) Manganese has several common oxidation states.

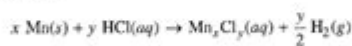
(i) Write the complete electron configuration for an Mn atom in the ground state.



(ii) When manganese forms cations, electrons are lost from which subshell first? Identify both the number and letter associated with the subshell.

4s

A student performs an experiment to produce a manganese salt of unknown composition,  $Mn_xCl_y(aq)$ , and determine its empirical formula. The student places a sample of  $Mn(s)$  in a beaker containing excess  $HCl(aq)$ , as represented by the following equation.



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## 2023 AP Chem FRQ: A Comprehensive Guide to Mastering the Free Response Questions

The AP Chemistry exam looms large, and for many students, the free-response questions (FRQs) are the most daunting part. This comprehensive guide will dissect the 2023 AP Chem FRQs, providing insights into common question types, effective strategies for tackling them, and valuable tips to maximize your score. We'll cover everything from understanding the scoring rubric to developing effective problem-solving techniques, ensuring you're well-prepared to conquer these crucial questions.

# Understanding the 2023 AP Chemistry FRQ Structure

The AP Chemistry exam features six free-response questions, typically encompassing various topics covered throughout the year. These questions test your ability to apply concepts, analyze data, and communicate your understanding clearly and concisely. Unlike multiple-choice questions, FRQs demand a deeper understanding and require you to show your work, justifying your answers with appropriate reasoning and calculations.

## #### Key Question Types in the 2023 AP Chem FRQs:

**Equation Writing and Balancing:** Expect questions requiring you to write and balance chemical equations, often involving stoichiometry calculations and reaction prediction. Practice balancing equations under time pressure to improve accuracy and speed.

**Stoichiometry and Limiting Reactants:** Mastering stoichiometric calculations is crucial. Be prepared to determine limiting reactants, theoretical yields, and percent yields. Remember to show all your work clearly and include units.

**Equilibrium Calculations:** Equilibrium problems are a staple of AP Chemistry FRQs. Be comfortable with calculating equilibrium constants ( $K$ ), using ICE tables, and applying Le Chatelier's principle.

**Acid-Base Chemistry:** Understand acid-base equilibria, pH calculations, titration curves, and buffer solutions. Knowing how to work with weak acids and bases is essential.

**Thermochemistry:** Questions involving enthalpy changes ( $\Delta H$ ), entropy changes ( $\Delta S$ ), and Gibbs free energy ( $\Delta G$ ) are common. Understand the relationships between these thermodynamic properties and their applications.

**Electrochemistry:** This topic often features in FRQs, covering topics like cell potentials, Nernst equation calculations, and electrochemical cells. Practice drawing diagrams and calculating cell potentials under various conditions.

**Descriptive Chemistry:** These questions test your qualitative understanding of chemical properties and reactions. You might be asked to explain trends in the periodic table, predict reaction products, or explain observed phenomena.

**Organic Chemistry:** While not always heavily emphasized, organic chemistry principles often appear in the FRQs, covering topics such as nomenclature, functional groups, and reaction mechanisms.

## Strategies for Mastering the 2023 AP Chem FRQs

### #### 1. Thorough Content Review:

A solid understanding of all AP Chemistry concepts is paramount. Rely on your textbook, class notes, and reputable online resources to solidify your knowledge base before tackling practice FRQs.

#### #### 2. Practice, Practice, Practice:

The key to success is consistent practice. Work through as many past AP Chemistry FRQs as possible. Focus on understanding the reasoning behind the answers, not just getting the correct numerical results.

#### #### 3. Develop a Systematic Approach:

Develop a consistent approach for solving FRQs. Start by carefully reading the question, identifying the key concepts involved, and outlining your strategy before beginning calculations.

#### #### 4. Show Your Work:

Even if you're unsure of the final answer, showing your work can earn you partial credit. Clearly demonstrate your thought process, including units and significant figures.

#### #### 5. Master the Scoring Rubric:

Familiarize yourself with the AP Chemistry scoring rubric. Understanding how points are awarded can help you prioritize your efforts and focus on the most crucial aspects of each question.

#### #### 6. Time Management:

Practice answering FRQs under timed conditions to simulate the exam environment. Allocate your time efficiently to ensure you attempt all questions within the allotted time.

#### #### 7. Seek Feedback:

Review your practice FRQs with a teacher, tutor, or study group to identify areas for improvement and refine your problem-solving techniques.

## Analyzing Past 2023 AP Chem FRQs (Hypothetical Example)

Since the actual 2023 FRQs are confidential for a period, we can't provide specific examples here. However, a typical question might ask you to analyze experimental data on a reaction's rate to determine the rate law and calculate the rate constant. You would need to demonstrate your knowledge of kinetics, including the method of initial rates and understanding of reaction orders. Another might involve calculating the pH of a buffer solution after the addition of a strong acid or base. Remember to always show your work and clearly explain your reasoning.

## Conclusion

Conquering the 2023 AP Chem FRQs requires a combination of solid content knowledge, effective strategies, and consistent practice. By following these tips and dedicating yourself to thorough preparation, you can significantly improve your chances of achieving a high score on the exam.

Remember, success hinges on understanding the underlying principles, not just memorizing formulas. Practice diligently, and you'll be well-equipped to tackle these challenging questions with confidence.

## FAQs

1. Where can I find past AP Chemistry FRQs for practice? The College Board website is the official source for past exam questions, but many prep books and online resources also offer practice FRQs.
2. How much weight do FRQs carry in the final AP Chemistry score? The free-response section constitutes a significant portion of your overall AP Chemistry score. The exact weighting can vary slightly from year to year, but it's crucial to perform well on these questions.
3. What if I make a mistake in a calculation within an FRQ? Showing your work is crucial. Even with an incorrect final answer, you can earn partial credit for demonstrating a correct understanding of the underlying concepts and procedures.
4. Is it better to attempt all FRQs or focus on the ones I know best? Attempting all FRQs is generally recommended, as you might earn some points even if you don't fully understand the question. However, ensure you allocate your time effectively.
5. What are some common mistakes students make on AP Chemistry FRQs? Common mistakes include failing to show work, neglecting units, ignoring significant figures, and not clearly communicating their reasoning. Thorough practice and careful review can help minimize these errors.

**2023 ap chem frq: ASAP Chemistry: A Quick-Review Study Guide for the AP Exam** The Princeton Review, 2019-02-12 Looking for sample exams, practice questions, and test-taking strategies? Check out our extended, in-depth AP chem prep guide, *Cracking the AP Chemistry Exam!* LIKE CLASS NOTES—ONLY BETTER. The Princeton Review's ASAP Chemistry is designed to help you zero in on just the information you need to know to successfully grapple with the AP test. No questions, no drills: just review. Advanced Placement exams require students to have a firm grasp of content—you can't bluff or even logic your way to a 5. Like a set of class notes borrowed from the smartest student in your grade, this book gives you exactly that. No tricks or crazy stratagems, no sample essays or practice sets: Just the facts, presented with lots of helpful visuals. Inside ASAP Chemistry, you'll find: • Essential concepts, terms, and functions for AP Chem—all explained clearly & concisely • Diagrams, charts, and graphs for quick visual reference • A three-pass icon system designed to help you prioritize learning what you MUST, SHOULD, and COULD know in the time you have available • Ask Yourself questions to help identify areas where you might need extra attention • A resource that's perfect for last-minute exam prep and for daily class work Topics covered in ASAP Chemistry include: • Atomic structure • Covalent bonding & intermolecular forces • Thermochemistry • Acids & bases ... and more!

**2023 ap chem frq: CliffsNotes AP Chemistry 2021 Exam** Angela Woodward Spangenberg, 2020-09-29 CliffsNotes AP Chemistry 2021 Exam gives you exactly what you need to score a 5 on the exam: concise chapter reviews on every AP Chemistry subject, in-depth laboratory investigations, and full-length model practice exams to prepare you for the May 2021 exam. Revised to even better

reflect the new AP Chemistry exam, this test-prep guide includes updated content tailored to the May 2021 exam. Features of the guide focus on what AP Chemistry test-takers need to score high on the exam: Reviews of all subject areas In-depth coverage of the all-important laboratory investigations Two full-length model practice AP Chemistry exams Every review chapter includes review questions and answers to pinpoint problem areas.

**2023 ap chem frq: Princeton Review AP Calculus AB Prep 2021** The Princeton Review, 2020-08 Make sure you're studying with the most up-to-date prep materials! Look for the newest edition of this title, The Princeton Review AP Calculus AB Prep, 2022 (ISBN: 9780525570554, on-sale August 2021). Publisher's Note: Products purchased from third-party sellers are not guaranteed by the publisher for quality or authenticity, and may not include access to online tests or materials included with the original product.

**2023 ap chem frq: 5 Steps to a 5: AP Chemistry 2023 Elite Student Edition** Mary Millhollon, Richard H. Langley, 2022-08-01 AP Teachers' #1 Choice! Ready to succeed in your AP course and ace your exam? Our 5 Steps to a 5 guides explain the tough stuff, offer tons of practice and explanations, and help you make the most efficient use of your study time. 5 Steps to a 5: AP Chemistry Elite is more than a review guide, it's a system that has helped thousands of students walk into test day feeling prepared and confident. Everything you Need for a 5: 3 full-length practice tests that align with the latest College Board requirements Hundreds of practice exercises with answer explanations Comprehensive overview of all test topics Proven strategies from seasoned AP educators Why the Elite edition? 200+ pages of additional AP content 5-minute daily activities to reinforce critical AP concepts AP educators love this feature for bellringers in the classroom! Study on the Go: All instructional content in digital format (for both computers and mobile devices) Interactive practice tests with answer explanations A self-guided study plan with daily goals, powerful analytics, flashcards, games, and more A Great In-class Supplement: 5 Steps is an ideal companion to your main AP text Includes an AP Chemistry Teacher's Manual that offers excellent guidance to educators for better use of the 5 Steps resources

**2023 ap chem frq: Chemistry 2e** Paul Flowers, Richard Langely, William R. Robinson, Klaus Hellmut Theopold, 2019-02-14 Chemistry 2e is designed to meet the scope and sequence requirements of the two-semester general chemistry course. The textbook provides an important opportunity for students to learn the core concepts of chemistry and understand how those concepts apply to their lives and the world around them. The book also includes a number of innovative features, including interactive exercises and real-world applications, designed to enhance student learning. The second edition has been revised to incorporate clearer, more current, and more dynamic explanations, while maintaining the same organization as the first edition. Substantial improvements have been made in the figures, illustrations, and example exercises that support the text narrative. Changes made in Chemistry 2e are described in the preface to help instructors transition to the second edition.

**2023 ap chem frq: 5 Steps to a 5: AP Chemistry 2021 Elite Student Edition** John T. Moore, Richard H. Langley, 2020-10-01 MATCHES THE LATEST EXAM! In this hybrid year, let us supplement your AP classroom experience with this multi-platform study guide. The immensely popular 5 Steps to a 5 AP Chemistry Elite Student Edition has been updated for the 2020-21 school year and now contains: 3 full-length practice exams (available both in the book and online) that reflect the latest exam "5 Minutes to a 5" section—a 5-minute activity for each day of the school year that reinforces the most important concepts covered in class Up-to-Date Resources for COVID 19 Exam Disruption Access to a robust online platform Comprehensive overview of the AP Chemistry exam format Hundreds of practice exercises with thorough answer explanations Proven strategies specific to each section of the test A self-guided study plan including flashcards, games, and more online

**2023 ap chem frq: Barron's AP Psychology with CD-ROM** Robert McEntarffer, Allyson J. Weseley, 2010-02-01 This updated manual presents one diagnostic test and two full-length practice tests that reflect the actual AP Psychology Exam in length, subject matter, and difficulty. All test

questions are answered and explained. It also provides extensive subject review covering all test topics. Topics reviewed include research methods, the biological basis of behavior, sensation and perception, states of consciousness, learning, cognition, personality, abnormal psychology, and treatment of disorders. This manual also presents an overview of the test, extra multiple-choice practice questions, test-taking tips, and an analysis of the test's essay question with a sample essay. Enclosed with the manual is a CD-ROM that presents two more practice tests with answers, explanations, and automatic scoring, as well as extensive subject review.

**2023 ap chem frq:** Barron's AP Biology Deborah T. Goldberg, 2017-08-30 Barron's AP Biology is one of the most popular test preparation guides around and a "must-have" manual for success on the Biology AP Test. In this updated book, test takers will find: Two full-length exams that follow the content and style of the new AP exam All test questions answered and explained An extensive review covering all AP test topics Hundreds of additional multiple-choice and free-response practice questions with answer explanations This manual can be purchased alone, or with an optional CD-ROM that includes two additional practice tests with answers and automatic scoring

**2023 ap chem frq:** Sterling Test Prep AP Chemistry Practice Questions Test Prep Sterling, 2018-06-06 Practice questions with detailed explanations for all topics tested on AP Chemistry. Electronic and atomic structure of matter; Periodic table; Chemical bonding; States of matter: gases, liquids, solids; Solution chemistry; Acids and bases; Stoichiometry; Equilibrium and reaction rates; Thermochemistry; Electrochemistry

**2023 ap chem frq:** *The Electron in Oxidation-reduction* De Witt Talmage Keach, 1926

**2023 ap chem frq:** *AP Chemistry Crash Course Book + Online* Adrian Dingle, 2014-02-21 REA's Crash Course for the AP\* Chemistry Exam - Gets You a Higher Advanced Placement\* Score in Less Time Completely Revised for the New 2014 Exam! Crash Course is perfect for the time-crunched student, the last-minute studier, or anyone who wants a refresher on the subject. Are you crunched for time? Have you started studying for your Advanced Placement\* Chemistry exam yet? How will you memorize everything you need to know before the test? Do you wish there was a fast and easy way to study for the exam AND boost your score? If this sounds like you, don't panic. REA's Crash Course for AP\* Chemistry is just what you need. Our Crash Course gives you: Targeted, Focused Review - Study Only What You Need to Know Fully revised for the 2014 AP\* Chemistry exam, this Crash Course is based on an in-depth analysis of the revised AP\* Chemistry course description outline and sample AP\* test questions. It covers only the information tested on the new exam, so you can make the most of your valuable study time. Our targeted review focuses on the Big Ideas that will be covered on the exam. Explanations of the AP\* Chemistry Labs are also included. Expert Test-taking Strategies This Crash Course presents detailed, question-level strategies for answering both the multiple-choice and essay questions. By following this advice, you can boost your score in every section of the test. Take REA's Online Practice Exam After studying the material in the Crash Course, go to the online REA Study Center and test what you've learned. Our practice exam features timed testing, detailed explanations of answers, and automatic scoring analysis. The exam is balanced to include every topic and type of question found on the actual AP\* exam, so you know you're studying the smart way. Whether you're cramming for the test at the last minute, looking for extra review, or want to study on your own in preparation for the exams - this is the study guide every AP\* Chemistry student must have. When it's crucial crunch time and your Advanced Placement\* exam is just around the corner, you need REA's Crash Course for AP\* Chemistry!

**2023 ap chem frq:** **SAT Subject Test: Chemistry Crash Course** Adrian Dingle, 2013-07-02 SAT\* Chemistry Subject Test Crash Course - Gets You a Higher Score in Less Time Our Crash Course is perfect for the time-crunched student, the last-minute studier, or anyone who wants a refresher on the subject. Are you crunched for time? Have you started studying for your SAT\* Chemistry Subject Test yet? How will you memorize everything you need to know before the exam? Do you wish there was a fast and easy way to study for the test AND raise your score? If this sounds like you, don't panic. SAT\* Chemistry Crash Course is just what you need. Crash Course gives you: Targeted, Focused Review - Study Only What You Need to Know The Crash Course is based on an

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**2023 ap chem frq:** ACS General Chemistry Study Guide , 2020-07-06 Test Prep Books' ACS General Chemistry Study Guide: Test Prep and Practice Test Questions for the American Chemical Society General Chemistry Exam [Includes Detailed Answer Explanations] Made by Test Prep Books experts for test takers trying to achieve a great score on the ACS General Chemistry exam. This comprehensive study guide includes: Quick Overview Find out what's inside this guide! Test-Taking Strategies Learn the best tips to help overcome your exam! Introduction Get a thorough breakdown of what the test is and what's on it! Atomic Structure Electronic Structure Formula Calculations and the Mole Stoichiometry Solutions and Aqueous Reactions Heat and Enthalpy Structure and Bonding States of Matter Kinetics Equilibrium Acids and Bases Solubility Equilibria Electrochemistry Nuclear Chemistry Practice Questions Practice makes perfect! Detailed Answer Explanations Figure out where you went wrong and how to improve! Studying can be hard. We get it. That's why we created this guide with these great features and benefits: Comprehensive Review: Each section of the test has a comprehensive review created by Test Prep Books that goes into detail to cover all of the content likely to appear on the test. Practice Test Questions: We want to give you the best practice you can find. That's why the Test Prep Books practice questions are as close as you can get to the actual ACS General Chemistry test. Answer Explanations: Every single problem is followed by an answer explanation. We know it's frustrating to miss a question and not understand why. The answer explanations will help you learn from your mistakes. That way, you can avoid missing it again in the future. Test-Taking Strategies: A test taker has to understand the material that is being covered and be familiar with the latest test taking strategies. These strategies are necessary to properly use the time provided. They also help test takers complete the test without making any errors. Test Prep Books has provided the top test-taking tips. Customer Service: We love taking care of our test takers. We make sure that you interact with a real human being when you email your comments or concerns. Anyone planning to take this exam should take advantage of this Test Prep Books study guide. Purchase it today to receive access to: ACS General Chemistry review materials ACS General Chemistry exam Test-taking strategies

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**2023 ap chem frq: America's Lab Report** National Research Council, Division of Behavioral and Social Sciences and Education, Center for Education, Board on Science Education, Committee on High School Laboratories: Role and Vision, 2006-01-20 Laboratory experiences as a part of most U.S. high school science curricula have been taken for granted for decades, but they have rarely been carefully examined. What do they contribute to science learning? What can they contribute to science learning? What is the current status of labs in our nation's high schools as a context for learning science? This book looks at a range of questions about how laboratory experiences fit into U.S. high schools: What is effective laboratory teaching? What does research tell us about learning in high school science labs? How should student learning in laboratory experiences be assessed? Do all students have access to laboratory experiences? What changes need to be made to improve laboratory experiences for high school students? How can school organization contribute to effective laboratory teaching? With increased attention to the U.S. education system and student outcomes, no part of the high school curriculum should escape scrutiny. This timely book investigates factors that influence a high school laboratory experience, looking closely at what currently takes place and what the goals of those experiences are and should be. Science educators, school administrators, policy makers, and parents will all benefit from a better understanding of the need for laboratory experiences to be an integral part of the science curriculum-and how that can be accomplished.

**2023 ap chem frq: College Admission 101** The Princeton Review, Robert Franek, 2018-06-12 This friendly, helpful Q&A book from the editor-in-chief of The Princeton Review presents simple answers to your toughest questions about the college admissions process, figuring out financial aid, and getting into the university of your choice! As The Princeton Review's chief expert on education, Robert Franek frequently appears on ABC, CBS, NBC, and FOX to share his insider expertise on the college admissions process. Each year, he travels to high schools across the country, advising thousands of anxious students and parents on how to turn their college hopes into reality. Now, with College Admission 101, the best of Rob's wisdom has finally been collected in one place! From standardized tests to financial aid, Rob provides straightforward answers to 60+ of the questions he hears most often, including: · Should I take the ACT or SAT? · When should I start my college research? · How many schools should I apply to? · Will applying Early Decision or Early Action give me a leg up? · Which extracurricular activities do colleges want to see? · How does the financial aid process work? · What's more important: GPA or test scores?

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- 6 Practice Exams (3 in the book + 3 online)
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- Flashcards, games, social media support, and more

**2023 ap chem frq: Piezoelectric Energy Harvesting** Alper Erturk, Daniel J. Inman, 2011-04-04

The transformation of vibrations into electric energy through the use of piezoelectric devices is an exciting and rapidly developing area of research with a widening range of applications constantly materialising. With *Piezoelectric Energy Harvesting*, world-leading researchers provide a timely and comprehensive coverage of the electromechanical modelling and applications of piezoelectric energy harvesters. They present principal modelling approaches, synthesizing fundamental material related to mechanical, aerospace, civil, electrical and materials engineering disciplines for vibration-based energy harvesting using piezoelectric transduction. *Piezoelectric Energy Harvesting* provides the first comprehensive treatment of distributed-parameter electromechanical modelling for piezoelectric energy harvesting with extensive case studies including experimental validations, and is the first book to address modelling of various forms of excitation in piezoelectric energy harvesting, ranging from airflow excitation to moving loads, thus ensuring its relevance to engineers in fields as disparate as aerospace engineering and civil engineering. Coverage includes: Analytical and approximate analytical distributed-parameter electromechanical models with illustrative theoretical case studies as well as extensive experimental validations Several problems of piezoelectric energy harvesting ranging from simple harmonic excitation to random vibrations Details of introducing and modelling piezoelectric coupling for various problems Modelling and exploiting nonlinear dynamics for performance enhancement, supported with experimental verifications Applications ranging from moving load excitation of slender bridges to airflow excitation of aeroelastic sections A review of standard nonlinear energy harvesting circuits with modelling aspects.

**2023 ap chem frq: Asimov on Chemistry** Isaac Asimov, 1975 Essays samlet under overskrifterne: Inorganic chemistry, Nuclear chemistry, Organic chemistry, Biochemistry, Geochemistry, General

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**2023 ap chem frq: *AP Calculus AB Prep Plus 2020 & 2021*** Kaplan Test Prep, 2020-02-04

Kaplan's AP Calculus AB Prep Plus 2020 & 2021 is revised to align with the latest exam. This edition

features more than 1,000 practice questions in the book and online, complete explanations for every question, and a concise review of high-yield content to quickly build your skills and confidence. Test-like practice comes in 8 full-length exams, 11 pre-chapter quizzes, 11 post-chapter quizzes, and 22 online quizzes. Customizable study plans ensure that you make the most of the study time you have. We're so confident that AP Calculus AB Prep Plus offers the guidance you need that we guarantee it: after studying with our online resources and book, you'll score higher on the exam—or you'll get your money back. To access your online resources, go to [kaptest.com/moreonline](https://www.kaptest.com/moreonline) and follow the directions. You'll need your book handy to complete the process. The College Board has announced that the 2021 exam dates for AP Calculus AB will be May 4, May 24, or June 9, depending on the testing format. (Each school will determine the testing format for their students.)

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**2023 ap chem frq: "I Love Learning; I Hate School"** Susan D. Blum, 2016-01-13 Frustrated by her students' performance, her relationships with them, and her own daughter's problems in school, Susan D. Blum, a professor of anthropology, set out to understand why her students found their educational experience at a top-tier institution so profoundly difficult and unsatisfying. Through her research and in conversations with her students, she discovered a troubling mismatch between the goals of the university and the needs of students. In *I Love Learning; I Hate School*, Blum tells two intertwined but inseparable stories: the results of her research into how students learn contrasted with the way conventional education works, and the personal narrative of how she herself was transformed by this understanding. Blum concludes that the dominant forms of higher education do not match the myriad forms of learning that help students—people in general—master meaningful and worthwhile skills and knowledge. Students are capable of learning huge amounts, but the ways higher education is structured often leads them to fail to learn. More than that, it leads to ill effects. In this critique of higher education, infused with anthropological insights, Blum explains why so much is going wrong and offers suggestions for how to bring classroom learning more in line with appropriate forms of engagement. She challenges our system of education and argues for a reintegration of learning with life.

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