THE EFFECTIVENESS OF INQUIRY BASED SELF-REGULATED LEARNING ON STUDENTS' UNDERSTANDING OF ALLOY

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ABSTRACT

The transition to industrial revolution 4.0 with evolving AI with resources easily available to students forces alteration in teaching and learning practices. Therefore, this study examined the effectiveness of inquiry based self-regulated learning towards students' understanding on alloy. The research design employed a quasi-experimental design consisting of control and experimental group. The sample consists of 40 students aged 16 from two intact classrooms. The research instruments were pre-test and post-test validated by two chemistry education experts. Students from the experimental group undergo inquiry based self- regulated learning while students from the control group undergo conventional teaching and learning processes. The data obtained were analysed descriptively and inferentially using t-test with the Statistical Package for the Social Sciences version 30.0. The control group obtained a mean pre-test score of 34.30 (SD = 6.72), while the experimental group scored 32.55 (SD = 6.53), indicating that both groups started with a comparable level of understanding on alloys. In post-test, the control group achieved a mean score of 58.30 (SD = 10.74), whereas the experimental group recorded a higher mean of 69.75 (SD = 11.84), demonstrating improvement in the experimental group's performance. The t-test analysis between the two groups also showed a significant improvement in the experimental group ($t = 11.91$, $p<0.01$) compared to the control group ($t=8.42$, $p<0.01$). This indicates that inquiry based self- regulated learning has a positive effect on students' understanding of alloy and has positive implications for teachers to implement in the teaching and learning process.

Keywords: effectiveness; self-regulated learning; inquiry-based learning; alloy; secondary level

INTRODUCTION

Understanding alloys is often challenging for students because it involves complex concepts, such as the interaction of different metals with different compositions that will change the properties of the metal among students (Cunha et al., 2024) and teachers (Ramchand, 2022) such as corrosion resistance, hardness of metal, electrical conductivity and appearance of the metal. Javier et al. (2019) found that students often struggle to understand corrosion and the process of metal corrosion which is a slow reaction and cannot be seen. In fact, corrosion is one of the biggest issues and an unavoidable challenge in many industries that needs prevention to minimise economic, environmental damage and extend the lifespan of critical infrastructure (Elyoussfi et al., 2023). This shows that understanding of alloys and its properties is important for students to resolve issues using science knowledge. By doing experiments, students are able to see the difference in the appearance of the metal before and after as well as also to prove the corrosion process happened.

The aim of conducting experiments is to foster as well as providing opportunities for students to master scientific skills. The purpose of experimental work is not just to enhance

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students' understanding towards concepts but also to develop students' scientific skills that can be used in problem solving and deeper understanding of nature science (Sshana & Abulibdeh, 2020) Essential scientific skills involves designing, measuring, observing, and interpreting data besides theoretical knowledge help students to gain concrete experience in learning science (Danielle, 2023). Concrete experience leads to strong understanding of the concepts that encourage students to think critically and analytically in solving everyday problems. According to Tegeh at al. (2020), the use of concrete experience can be one of the best alternatives to create a more pleasant learning environment that can enhance students' critical thinking skills. Mastery in critical and analytical thinking leads to improved scientific literacy and reasoning skills which are positively associated with higher academic achievement in science (Winata et al., 2025). Indirectly, students are able to demonstrate better understanding with improved performance in science.

Various learning styles need to be applied in the teaching and learning of science as the subject involves abstract concepts that are often difficult to understand. A study conducted by Hayat et al. (2024), the use of various different learning techniques in science classes can enhance students' critical thinking skills which helps them better understand complex and abstract concepts. Inquiry-based learning plays a vital role in developing students' scientific literacy and skills, such as questioning, investigating, and drawing conclusions (Jumaat, 2022). Parallelly, self-regulated learning empowers students to manage their own learning effectively by choosing suitable strategies (Feldman-Maggor, 2023). Currently, AI tools like ChatGPT and AI Remini are increasingly integrated into education, self-regulated learners can benefit more if they use these tools critically. The use of ChatGPT in providing information, evaluating responses and constructing learning plans provide support to students to design and conduct their own self-regulated learning properly (Tamrin, 2025). To ensure meaningful learning, students must evaluate AI-generated information carefully and apply it as a support for inquiry and reflection, rather than relying on it entirely (Susan, 2022).

Inquiry-Based Learning

Inquiry-based learning is a student-centred approach that emphasizes active participation involving five phases to discover new knowledge (Justice et al., 2007). According to Pedaste et al. (2015), there are five general phases in inquiry-based learning framework which include orientation, conceptualisation, investigation (such as experimentation, exploration and collecting data), conclusion (observation of what has been done) and discussion (interaction, reflection and exchange of opinion) which promote involvement in learning (Zhang et al., 2024). Through inquiry-based learning, students are able to enhance their manipulative skills (Bryne et al., 2023) and have the opportunity to explore freely and are able to retain the scientific concepts for a longer period of time (Hastuti et al., 2019). The inquiry process allows students to relate the abstract concepts with real-life context through experimentations which are proven to enhance conceptual understanding, encourage higher order thinking skills and improve attitudes towards learning science. Studies has shown positive impact of inquiry-based learning within the science classroom recently such as in topics including earth science (Harrell et al., 2023), astronomy (Sarah et al., 2024), acid and base (Cakiroglu et al., 2024), temperature measurement (Gerhátová et al., 2021), photosynthesis (Kamaruddin et al., 2024).

Self-Regulated Learning

In the age of information-on-demand with evolving application on AI, students need to have the capability to take charge of one learning (Wu et al., 2023; Wang et al., 2024). This allows the students to take responsibility of own path, pace and the learning process throughout for achieving meaningful education outcomes. After findings of various definition of self-regulated learning, in this study we apply Zimmerman's definition of self-regulated learning. According to (Zimmerman & Schunk, 2001) self-regulated is the degree to which students are metacognitively, motivationally and behaviourally active in participating in their learning process. Students take ownership of their learning process by taking part actively towards the individual academic success. There are three distinct phases in self-regulated learning according to Zimmerman (2002) which are the forethought phase, the performance phase,

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and the self-reflection phase. At the beginning, forethought phase requires students to analyse task given, set goals and strategize to achieve the goals. Followed by performance phase, students required to actively participate, monitor and control the learning process. Finally, the self-reflection phase requires students to evaluate their learning process.

Zimmerman (2002) believes that self-regulated learning is fundamental and essential quality need to be mastered by students for lifelong learning. Besides that, self-regulated learning motivates students to learn as students able to plan their learning and adjust the strategies as needed from time to time within the students' capability (Clearly & Zimmerman, 2004; Zimmerman & Schunk, 2012; Ng et al, 2024). This approach is also suitable to be use among the primary (Alvi & Gillies, 2023), secondary (Wang, Zhou et al., 2024) and tertiary level (Higgins et al., 2021).

Numerous studies have been conducted on self-regulated learning in science such as electrolyte solution (Wu, 2023), chemical bonding (Respati & Atun, 2023); genetic code (Ateş, 2024); and electricity (Al-Dulhani et al., 2024). However, no studies have been conducted on teaching and learning of alloy in science. Self-regulated learning widely used during the covid-19 pandemic whereby students need to take initiatives and check on their progress with minimal help from teachers (Muhabet al., 2022). Studies also being conducted on self-regulated learning by integrating technological tool such as web-based learning (Indriani, 2023), video conference (Fitriyana, 2021), ChatGPT (Lee et al.,2024; Ng et al., 2024), virtual lab (Al-Duhani etal., 2024) and flipped learning (Ateş, 2024).

Recently, there are few studies that have implement self-regulated learning in conducting experiments in physical laboratory (Kaycan & Ektem, 2019) or virtual laboratory (Reginald, 2023; Al-Duhani et al.,2024). Kayacan and Ektem, 2019 study the effectiveness of biology laboratory practices supported by self-regulated learning strategies towards students' readiness for self-directed learning. Al-Duhani et al., 2024 conduct a study to evaluate web-based virtual laboratory on students' self-regulated learning to learn electricity. However, there are no studies has been conducted on self-regulated learning through exploration after school among higher school students.

Inquiry Based Self-Regulated Learning

Understanding alloy involves concepts that is abstract and complex which requires hands-on activities for exploration also, to visualize the theoretical concept. Through exploration with hands-on activities, students are given the opportunity to explore, observe and measure, which helps transform abstract ideas into more concrete and comprehensible knowledge. Conducting hands-on activities allows students to test hypotheses, observe outcomes and confront misconceptions while also fostering creativity, problem-solving abilities and metacognitive skills. A study conducted by Yilmaz et al., (2024) showed that hands-on activity can foster students' scientific skills as well as enhance motivation and students' involvement in science learning. A suitable learning approach that meets the current needs is crucial to meet the modern challenges and demands, rather than an approach to deliver the knowledge that often cause students less actively engaged (Norlela & Shamsudin, 2020). Authentic science learning is required to allow students to do self-exploration that begins with student's curiosity then, leads to investigation and discovery (Agustini et al., 2024). Therefore, interactive activities such as practical experiments, hands-on activities, science-related games, and the use of engaging teaching aids improve students' academic achievement and attitudes toward learning compared to traditional teaching methods (Kırılmazkaya & Dal, 2022).

Inquiry based self-regulated learning integrates the principles of inquiry-based learning and self-regulated learning. Both learning strategies collectively provide active exploration of students with proper strategy to manage their cognitive, motivational and behavioural process during the inquiry. This learning process provides authentic context that is manageable by students through goal setting, implement task and reflecting the outcomes to manage any uncertainty and complexity in the task. This process helps students to delve into the activities and allow deeper understanding of alloy rather than memorizing the concepts. Inquiry based self-regulated learning able to foster not only conceptual understanding but able to inculcate

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21st century skills among students such as critical thinking, problem solving (learning skills) and initiatives (life skills). These skills are necessary for future human capital and to stay competitive with changing job market (Karaca-Atik et al., 2023).

Furthermore, self-regulated learning allows students to learn independently especially in today's era, where AI tools like ChatGPT or AI Gemini are increasingly integrated into education. Students who practice self-regulated learning can leverage AI tools more effectively. Nevertheless, students must be able to critically evaluate information, avoid overreliance on AI-generated responses while instead use these tools as support for inquiry and self-reflection (Susan, 2025). This ensures that the use of technology provides information that enhances students' critical thinking, rather than replacing their ability to think, process information and solve problems independently. Recent studies have confirmed that inquiry-based with self-regulated learning significantly improve students' positive emotions towards scaffold learning materials. (Seibert et al., 2021; Mamun, 2022; Mamun, 2023). Paul (2021) emphasized that self-conducted experiments are the most effective method for mastering scientific concepts and processes, while Rubani et al. (2018) found that students are more likely to recall and understand concepts when they perform experiments themselves. Self-regulated experiments also cultivate scientific attitudes such as critical and open thinking, inquiry skills, and respect for evidence (Pascaeka et al., 2023) while fostering curiosity through observation, planning procedures, making predictions, and forming hypotheses.

In addition, self-conducted experiments carried out at home using available materials are safer, more creative, and more innovative compared to laboratory experiments that are bound by fixed procedures. Hannah et al. (2024) stated that home-based experiments can enhance student performance by utilizing readily available resources along with teacher guidance and discussion. Therefore, this study emphasizes the effectiveness of inquiry based self-regulated learning in improving students' understanding, particularly in the subtopic of Alloys. Thus, combining inquiry-based learning with self-regulated learning methods while conducting an experiment can allow students to use their thinking skill freely by actively investigating, designing, and carrying out experiments while taking ownership of their learning process to deepen their understanding and also enhance their critical thinking skill and problem-solving skill. Experimental work bridges the gap between theoretical knowledge and practical understanding, helping students overcome difficulties and develop a deeper comprehension of the subtopic (Hayat et al., 2024).

Therefore, integrating inquiry-based self-regulated learning is an essential instructional approach to cultivate various skills and practical competencies in students, preparing them to succeed and remain competitive in the field of science, which is crucial for navigating the challenges of learning in the AI-driven era. Furthermore, a study from Tadesse et al. (2025), showed that experimental activities significantly enhance students' conceptual understanding compared to theory alone. Hence,by conducting experiments, students are able to see a concept more clearly and connect it with what they have learned, which helps improve their understanding of the concept.

The availability of laboratory manuals and practical modules in schools, which contain complete procedures for conducting experiments, can prevent students from applying their understanding, inquiry skills, and independence when performing practical activities (Ward & Wyllie, 2019). This indirectly limits students' freedom and ability to explore equipment and materials during experiments. As a result, students have limited understanding of the connection between the experiments they conduct and the theories taught by teachers, which makes it difficult for them to comprehend and retain the theories. Teaching and learning that rely on inefficient methods, such as depending solely on textbooks and teacher-centered approaches, can lead to a decline in performance (Ismail et al., 2022). It is therefore essential for teachers to provide students with opportunities and guidance to independently explore their surrounding environment and relate it to topics they are learning or have previously learned. Such practices can cultivate open-mindedness among students, enabling them to critically analyze phenomena and processes in their daily lives, rather than restricting learning to the classroom and school science laboratory alone.This way, learning is not confined only to the classroom and school science laboratory but extends to the real world.

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Furthermore, the time allocated for laboratory work is often insufficient because teachers need additional time to discuss issues that arise during practical sessions (Nur Zaitul et al., 2022). The time allocated in the school timetable is often limited to conducting experiments, especially when the procedures are lengthy. As a result, teachers may not have sufficient time to carry out in-depth discussions after students have completed the experiments. Discussions on the experimental results and the challenges encountered during the process are essential, as they allow students to learn how to solve problems and prevent the same issues from recurring in future practical sessions.

Therefore, inquiry-based self directed learning can be applied in conducting own experimentation, where students explore and develop their own procedures based on learning outcomes. According to Hastuti et al. (2019), through inquiry-based learning, students learn to organize and conduct experiments to understand and correctly learn scientific concepts, which are then retained over a long period.

METHODOLOGY

Research Design

The research design is a quasi-experimental study involving two groups of respondents, namely the control group and the experimental group, which share similar characteristics but were not randomly assigned. A quantitative approach was used.

Population and Sample of the study

The population in this study comprises Form 4 students taking Science at a secondary school in Perlis. Cluster random sampling was used, where two out of five classes were selected as the experimental and control groups. The sample consisted of 40 students where 20 students in the control group and 20 students in the experimental group. The level of learning ability and basic knowledge for each sample is the same. During the study, the experimental group conducted self-regulated experiments using inquiry-based self-regulated learning, while the control group followed conventional teaching and learning in the Science laboratory.

Research Instrument

The instruments used in this study were pre-test and post-test assessments to measure students' understanding on alloy. Both tests consisted of two sections which section A with 20 multiple-choice questions and section B with 3 structured questions. The minimum score was 0 marks (0%), while the maximum score was 40 marks (100%).

The questions were adapted from Sijil Pelajaran Malaysia (SPM) trial examination papers as well as actual past SPM questions. These were then modified appropriately to align with the content of the subtopic alloys found in the Form 4 science textbook. The items in the pre-test were carefully designed based on the cognitive levels outlined in Bloom's Taxonomy, which include remembering, understanding, applying, analysing, evaluating, and creating. This approach ensures that the test measures a wide range of cognitive abilities, from basic recall to higher-order thinking skills. Each question in the pre-test was assigned a different level of difficulty according to Bloom's Taxonomy, allowing for a more balanced and comprehensive assessment of student understanding.

Inquiry based self-regulated learning activities

The implementation of inquiry based self-regulated learning activities provides students with the opportunity to independently conduct experiments by formulating hypotheses, designing procedures, interpreting results, and utilizing materials available in their surroundings outside of class time. The results of these experiments are then discussed with teachers and peers during lessons to exchange ideas, evaluate others' findings and present their own conclusions. This study involved two science lessons for both groups. The control group conducted experiments traditionally in the laboratory, while the treatment group carried out self-

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regulated experiments at home and later brought their findings to school for discussion. Both groups completed pre-tests during the first science lesson, and daily lesson plans were prepared for each group to compare the effectiveness of the two methods.

During the first lesson, the teacher introduced students with a basic concept of alloy. After that, students answered a pre-test that contained instructions and questions to initiate students' inquiry towards corrosion resistance between alloy and pure metal. This allows students to create their own experiment outside of class hours. Then, students will bring the experiment results conducted outside class hours for the second lesson to compare with peers and make a further discussion on the result obtained. For the second lesson, during the induction set phase, the teacher asked students about their feedback and experience while conducting their own experiment at home. This can provide the teacher an insight into students' feelings whether they enjoy the process of conducting an experiment or they encounter problems while doing their own experiment. Then, the teacher divided students into groups during the idea restructuring phase so that students can carry out gallery walk activities that allow students to see and observe their classmates' results and noted the differences that can be noticed between students' result and the classmates'. Afterwards, the teacher would call groups' representatives to present their observations on the difference that they found during the gallery walk activity. With this information, teachers opened discussion with a whole class that allows students to discuss and exchange opinions from their knowledge of the experiment that they have been conducting. After that, the teacher concludes the concept from the discussion and explains the concept of corrosion resistance between alloy and pure metal to students. At the end of this phase, the teacher showed a video about superconductors in alloy application.

Next, during the idea application phase, the teacher asked students to list the characteristics of alloy that they have learned throughout the lesson and the teacher continued to explain in depth about every alloy characteristic whilst relating it with alloy application. During theclosure phase, students have been asked to fill out the exit ticket and answered a post-test given by the teacher. Class ended with a summary of what had been learned by students followed by a summary from the teacher.

After the study was conducted, data analysis was carried out using Statistical Package for Social Sciences (SPSS). Data were collected from the pre-test and post-test responses that are answered by the students in both groups. The analysis is conducted to compare the level of understanding between the control group and the treatment group.

Students in experimental group presented their note and answered post-test

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Self-conducted experiment done at home

Data Analysis

The data for this study consisted of responses from the pre-test and post-test by students in both experimental and control groups, assessing the effectiveness of self-experimentation through inquiry-based learning on understanding on alloy. Instrument validity was determined using expert percentage validation. All data were analysed using Statistical Package for Social Sciences (SPSS) version 30.0. Descriptive and inferential statistics were applied based on the study hypotheses.

RESULTS

Descriptive Analysis

Based on Table 1, the first objective was to identify the level of understanding of Form 4 students regarding alloy in the control and experimental groups, where the experimental group applied inquiry-based self-regulated learning by doing their own experiment. The mean percentage difference in the pre-test between both groups was only 1.75. This indicates that the initial level of understanding for the subtopic of alloys in both groups was the same. According to Salina (2021), when a quasi-experimental study is conducted, the level of knowledge in the experimental group and the control group must be equivalent to ensure that the research objectives can be achieved without error. However, the mean percentage difference in the post-test was 11.45, with the experimental group scoring higher than the control group.

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This indicates a significant difference, where the mean score of the experimental group was higher than that of the control group. Indirectly, this demonstrates the effectiveness of inquiry-based self-regulated learning of alloy.

Table 1.

Analysis of Students' Pre-Test and Post-Test Results on the Subtopic of Alloys

Test	Group	Sample Size, N	Mean	Standard Deviation
Pre	Control	20	34.30	6.721
	Experimental	20	32.55	6.525
Post	Control	20	58.30	10.737
	Experimental	20	69.75	11.840

Inferential Analysis

The pre-test and post-test results were analyzed inferentially using a t-test to compare the mean scores between the experimental group, which used inquiry based self-regulated learning to conduct own experiment, and the control group, which used conventional lab based science experiments.

Table 2.

t-test Analysis

Hypothesis	Variable	Group	Sample Size,N	t Value	p Value	Result
H_{01}	Pre-test	Control	20	0.84	0.41	Failed to be
		Experimental	20			Rejected
H_{02}	Pre-test	Experimental	20	-8.42	$0.08x10^{-6}$	Rejected
	Post-test		20			
H_{03}	Pre-test	Experimental	20	-11.91	$0.03x10^{-8}$	Rejected
	Post-test		20			
H_{04}	Post-test	Control	20	-3.20	0.01	Rejected
		Experimental	20			

*The significance level alpha (α) is $p < 0.05$

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In Table 2, the first hypothesis, H_{01}, states that there is no significant difference between the pre-test mean scores of the control and experimental groups. The t value was 0.84, with a p value of 0.41 ($p > 0.05$), indicating no significant difference and confirming that both groups had similar prior knowledge.

In addition, for the second hypothesis H_{02}, which states that there is no significant difference between the mean scores of the pre-test and post-test in the control group, the t value obtained was -8.42, and the significance value was $p < 0.001$ (0.08×10^{-6}). Since the p value is smaller than 0.05 ($p < 0.05$), the second hypothesis is rejected. This indicates that there is a significant difference between the mean scores of the pre-test and post-test in the control group.

The difference in mean scores between the pre-test and post-test shows an improvement in students' understanding of the subtopic alloy within the control group after conducting the difference in corrosion resistance between alloys and pure metals experiment in the school science lab. This is consistent with recent findings showing that hands-on experiments and inquiry based methods significantly improve conceptual understanding and performance in science (Tang et al., 2024). The positive change in students' level of understanding before and after the experiment suggests that the experiment had a positive effect on their knowledge regarding the topic.

In addition, for the third hypothesis H_{03}, which states that there is no significant difference between the mean scores of the pre-test and post-test in the experimental group, the analysis showed a t value of –11.91 and a significance value of $p < 0.01$ (0.03×10^{-8}). Since this p value is smaller than 0.05 ($p < 0.05$), the null hypothesis is rejected. This result indicates a statistically significant difference between the pre-test and post-test mean scores in the experimental group, suggesting that the intervention had a measurable impact on students' performance.

This significant improvement supports the idea that conducting experiments at home using readily available and easily found materials can deepen students' conceptual understanding. For example, Desmiawati et al., (2023) found that home based experiments on photosynthesis improved students' science process skills, showing that learning outside the formal laboratory can still yield positive effects. Such findings bolster the claim that hands-on, practical activities in everyday settings can be an effective way to enhance students' grasp of scientific topics like alloy.

Finally, for the fourth hypothesis, H_{04}, which states that there is no significant difference between the post-test mean scores of the control group and the experimental group, the analysis produced a t value of -3.20 with a significance value of $p = 0.01$. Since the p value is less than 0.05 ($p < 0.05$), the null hypothesis is rejected. This confirms that there is a statistically significant difference in the post-test performances between the two groups, indicating that the instructional method or learning environment had a meaningful effect on student outcomes.

This difference implies that students in the experimental group, who conducted self directed experiments at home using inquiry based self-regulated learning, achieved a higher level of understanding of the subtopic alloys than those in the control group who performed experiments in the school science laboratory. A similar result was found where Wong & Sim (2022) designed a curriculum-based laboratory kit that can be used even outside proper lab settings and reported significant improvement in post-test mean scores compared to pre-test scores among secondary school students using the kit. This supports the idea that hands-on, practical exposure even outside formal laboratory facilities can enhance students' conceptual understanding in science topics.

The analysis revealed significant improvements in both the control and experimental groups, rejecting the hypotheses that there were no differences in pre-test and post-test scores. Students in the control group, who conducted experiments in the school science laboratory, showed increased understanding of the alloys subtopic, reflecting the positive impact of hands-on lab work on cognitive development (Heni & Ghina, 2021). Likewise, the experimental group, which carried out self directed experiments at home using everyday

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materials, demonstrated enhanced comprehension, supporting findings that home based experiments effectively boost science performance (Maglajos et al., 2024). Moreover, a significant difference in post-test scores between the two groups was found, with inquiry based self-regulated learning leading to higher student understanding than traditional lab experiments. This aligns with Misbahul's (2020) assertion that inquiry learning with hands-on activities promotes better conceptual grasp and scientific skills among students.

CONCLUSION

This study demonstrates that the self-regulated experimental approach through inquiry based self-regulated learning can enhance students' understanding of the subtopic of alloys compared to traditional laboratory based experiments. Data analysis revealed a significant increase in mean scores in both the pre-test and post-test for both groups. However, the experimental group that conducted self directed experiments recorded a higher level of understanding. The results of the t-test analysis further support this finding, showing a significant difference between the control and experimental groups, thereby confirming the effectiveness of the inquiry based self-regulated learning approach in helping students better comprehend abstract concepts.

The implications of this study extend to various stakeholders. For students, this approach provides opportunities to independently explore knowledge, formulate hypotheses, design procedures and interpret experimental results, thereby enhancing higher order thinking skills and creativity. For teachers, their role shifts to that of a facilitator, guiding students' inquiry skills and ensuring that self directed experiments are conducted effectively. Post experiment discussions also improve the quality of teaching and promote more student centered learning. For schools, this approach has the potential to improve academic performance, produce more critical and creative learners, and enhance the school's reputation within the community.

Furthermore, the study proposes several recommendations for future research. These include refining the use of worksheets that stimulate student inquiry, extending the study to cover different science subtopics and various school levels, and involving a larger and more diverse sample. A combination of quantitative and qualitative methods is also recommended to provide a more comprehensive understanding of the effectiveness of this approach. Overall, inquiry based self-regulated learning has been proven not only to improve students' understanding of scientific concepts but also to contribute to the development of critical thinking and problem solving skills, which are essential for academic excellence.

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REFERENCES

Agustini, R., Meilanie, S., M., R., & Pujiastuti S., I., (2024). Enhancing critical thinking and curiosity in early childhood through inquiry-based science learning. *Aulad: Journal on Early Childhood*, *7*(3), 734-742 https://doi.org/10.31004/aulad.v7i3.780

Al-Duhani, F., Saat, R. M., & Abdullah, M. N. S. (2024). Effectiveness of web-based virtual laboratory on grade eight students' self-regulated learning. *Eurasia Journal of Mathematics, Science and Technology Education*, *20*(3), em2410.

Al Mamun, M. A., & Lawrie, G. (2023). Student-content interactions: Exploring behavioural engagement with self-regulated inquiry-based online learning modules. *Smart learning environments*, *10*(1), 1.

Alvi, E., & Gillies, R. M. (2023). Self-regulated learning (SRL) perspectives and strategies of Australian primary school students: a qualitative exploration at different year levels. *Educational Review*, *75*(4), 680-702.

Ateş, H. (2024). Designing a self-regulated flipped learning approach to promote students' science learning performance. *Educational Technology & Society*, *27*(1), 65-83.

Byrne, E. M., Jensen, H., Thomsen, B. S., & Ramchandani, P. G. (2023). Educational interventions involving physical manipulatives for improving children's learning and development: A scoping review. *Review of Education*, *11*(2), e3400.

Cakiroglu, U., & Sarialioglu, R. O. (2024). Leveraging Inquiry Learning via Digital Concept Maps: A Case of Acid and Bases Topic. *Journal of Interactive Learning Research*, *35*(1), 71-99.

Clarisa Aprilla. (2024). Teori belajar kognitif: Skill acquisition dan conditional knowledge, *Jurnal Psikologi, 1*(2), 31-37. https://doi.org/10.62872/x5f79c25

Cleary, T. J., & Zimmerman, B. J. (2004). Self-regulation empowerment program: A school-based program to enhance self-regulated and self-motivated cycles of student learning. *Psychology in the Schools*, *41*(5), 537-550.

Cunha, A., Macedo, N., Campos, J. C., Margolis, I., & Sousa, E. (2024, April). Assessing the impact of hints in learning formal specification. In *Proceedings of the 46th International Conference on Software Engineering: Software Engineering Education and Training* (pp. 151-161).

Elyoussfi, A., Outada, H., Isaad, J., Lrhoul, H., Salhi, A., & Dafali, A. (2023). Corrosion inhibitors of alloys and metals in acidic solution: A bibliometric analysis from 2010 to 2022. *Int. J. Corros. Scale Inhib*, *12*(2), 722-740

Eran Wandani, Neng Shufi Sufhia, Neni Eliawati & Imas Masitoh. (2023). Teori kognitif dan implikasinya dalam proses pembelajaran individu. *Jurnal Ilmiah Multidisiplin, 1,* https://doi.org/10.5281/zenodo.8055054

Feldman-Maggor, Y. (2023). Identifying self-regulated learning in chemistry classes–a good practice report. *Chemistry Teacher International*, *5*(2), 203-211.

Fitriyana, N., Wiyarsi, A., Sugiyarto, K. H., & Ikhsan, J. (2021). The ınfluences of hybrid learning with video conference and" chemondro-game" on students' self-efficacy, self-regulated learning, and achievement toward chemistry. *Journal of Turkish Science Education*, *18*(2), 233-248.

Danielle B. (2023). Improving scientific abilities through lab report revision in a high school investigative science learning environment classroom. *Physical Review Physics Education Research,* (19), 1-23 https://doi.org/10.1103/PhysRevPhysEducRes.19.020166

Desmiawati, D., Kaniawati, I., Anggraeni, S., & Putra, N. S. (2023). Implementation of home-based experiment on photosynthesis material to improve students' science process skill. *Journal of Science Education Research*, *7*(1), 12–20. https://doi.org/10.21831/jser.v7i1.52064

Gerard, L., Wiley, K., Debarger, A.H., Bichler, S., Bradford, A. & Linn M., C. Self-directed science learning during COVID-19 and beyond. *J Sci Educ Technol* 31, 258–271 (2022). https://doi.org/10.1007/s10956-021-09953-w

Received 01 October 2025 **Revised** 25 November 2025 **Accepted** 02 December 2025
Published 15 December 2025
Published by the Faculty of Science and Mathematics, Sultan Idris Education University

Gerhátová, Ž., Perichta, P., Drienovský, M., & Palcut, M. (2021). Temperature measurement—Inquiry-Based learning activities for third graders. *Education Sciences*, *11*(9), 506.

Hannah Zoe L. Maglajos, Ninio Benedict Y. Japos, Jehan Francisco, Grace Anne C. Rallos. (2024). Effectiveness of home-based laboratory experiments. *Psychology and Education: A Multidisciplinary Journal*, 26(4), 342-350. doi:10.5281/zenodo.13904533

Harrell, P. E., Thompson, R., & Waid, J. (2023). Using inquiry-based learning to develop Earth science pedagogical content knowledge: impact of a long-term professional development program. *Research in Science & Technological Education*, *41*(4), 1519-1538.

Hastuti, P.W., W Setianingsih & E Widodo. (2019). Integrating Inquiry Based Learning and ethnoscience to enhance students' scientific skills and Science literacy. *International Conference on Education, Science and TechnologyI, 1387.* 10.1088/1742-6596/1387/1/012059

Hayat, N., Yuliani, H., & Nastiti L., R., (2024). Meta-analysis: The influence of learning styles on critical thinking of science learning. *Jurnal Pendidikan dan Ilmu Fisika, 10*(2), 144-154 https://doi.org/10.31764/orbita.v10i2.24124

Heni Nafiqoh & Ghina Wulansuci. (2021). Experiential learning methods to improve young children's Science process skills during Covid-19 Pandemic. *5th International Conference on Early Childhood Education (ICECE 2020).* 10.2991/assehr.k.210322.004.

Higgins, N., Frankland, S., & Rathner, J. (2021). Self-regulated learning in undergraduate science. *International Journal of Innovation in Science and Mathematics Education*, *29*(1).

Indriani, N. C. L., Mustaji, M., & Mariono, A. (2023). The influence of web-based learning on students' self-regulated learning in high school chemistry learning. *International Journal of Educational Research Review*, *8*(2), 257-267.

Ismail, M. H., Fadzil, H. M., & Saat, R. M. (2022). Students' view on stem lessons: an analysis of needs to design integrated stem instructional practices through scientist-teacher-students partnership (STSP). *Malaysian Online Journal of Educational Sciences, 10*(2) 35-46

Javier, L., Perez, A. & Antonio D., L., (2019). Enhancing the teaching of corrosion to chemical-engineering students through laboratory experiments. *Journal of Chemical Education, 96*(5), 1029-1032 https://doi.org/10.1021/acs.jchemed.8b00803

Jumaat Nurul Farhana , Yazid Saupian & Noor Hidayah binti Che Lah. (2022). Pembelajaran Berasaskan Inkuiri dalam meningkatkan kemahiran literasi Sains dan pencapaian murid menerusi persekitaran pembelajaran dalam talian. *Malaysian Journal of Social Sciences and Humanities (MJSSH), 7*(1), 73 - 84.

Justice, C., Rice, J., Warry, W., Inglis, S., Miller, S., & Sammon, S. (2007). Inquiry in higher education: Reflections and directions on course design and teaching methods. *Innovative Higher Education*, *31*(4), 201-214.

Kamarudin, M. Z., Mat Noor, M. S. A., & Omar, R. (2024). 'How do plants grow?': teaching photosynthesis using digital inquiry-based science learning. *Science Activities*, *61*(3), 118-131.

Karaca-Atik, A., Meeuwisse, M., Gorgievski, M., & Smeets, G. (2023). Uncovering important 21st-century skills for sustainable career development of social sciences graduates: A systematic review. *Educational Research Review*, *39*, 100528.

Kayacan, K., & Ektem, I. S. (2019). The effects of biology laboratory practices supported with self-regulated learning strategies on students' self-directed learning readiness and their attitudes towards science experiments. *European Journal of Educational Research*, *8*(1), 313-323.

Kirilmazkaya, G., Dal., S., N., (2022). Effect on hands-on science activities on students' academic achievement and scientific attitude. *International Journal of Education and Literacy Studies, 10* (4), 56-61 http://dx.doi.org/10.7575/aiac.ijels.v.10n.4p.56

Received 01 October 2025 **Revised** 25 November 2025 **Accepted** 02 December 2025
Published 15 December 2025
Published by the Faculty of Science and Mathematics, Sultan Idris Education University

Lee, H. Y., Chen, P. H., Wang, W. S., Huang, Y. M., & Wu, T. T. (2024). Empowering ChatGPT with guidance mechanism in blended learning: Effect of self-regulated learning, higher-order thinking skills, and knowledge construction. *International Journal of Educational Technology in Higher Education*, *21*(1), 16.

Mamun, M. A. A. (2022). Fostering self-regulation and engaged exploration during the learner-content interaction process: the role of scaffolding in the online inquiry-based learning environment. *Interactive Technology and Smart Education*, *19*(4), 482-509.

McCray, K. (2007). Constructivist approach: Improving social studies skills academic achievement. Online Submission.

Misbahul Jannah. (2023). Inkuiri dalam pengajaran dan pembelajaran Sains. *Sosiologi dan Antropologi*. Universitas Islam Negeri Ar-Raniry, Banda Aceh. https://repository.ar-raniry.ac.id/id/eprint/27920

Mohammed Saif Husam & Kinyo, Laszlo. (2020). The role of constructivism in the enhancement of social studies education*. Journal of Critical Reviews.* 7. 249-256. 10.31838/jcr.07.07.41.

Muhabet, S., Irwanto, I. R. W. A. N. T. O., ALLANAS, E., & Yodela, E. (2022). Improving students' self-regulation using online self-regulated learning in chemistry. *Journal of Sustainability Science and Management*, *17*(10), 1-12.

Ng, D. T. K., Tan, C. W., & Leung, J. K. L. (2024). Empowering student self-regulated learning and science education through ChatGPT: A pioneering pilot study. *British Journal of Educational Technology*, *55*(4), 1328-1353.

Norlela Ahmad & Shamsudin Othman. (2020). Penggunaan kaedah didik hibur dalam pengajaran kemahiran membaca guru bahasa Melayu sekolah rendah. *International Journal of Education and Training (InjET), 6*(2), 1-11.

Nur Zaitul Akmar Mohamad, Nurahimah Mohd Yusoff & Norliza Kushairi. (2022). Pengendalian kerja amali dan cabaran Pembelajaran Abad Ke-21. *Malaysian Journal of Social Sciences and Humanities (MJSSH),* 7(1), 161-174. https://doi.org/10.47405/mjssh.v7i1.1229

Pascaeka, B., Bektiarso, S., & Harijanto, A., (2023). Scientific reasoning skills and scientific attitudes of students in learning physics using guided inquiry model with Vee Map. *Jurnal Penelitian Pendidikan IPA, 9(*11), 9610-9618. https://doi.org/10.29303/jppipa.v9i11.4467

Piaget, J. (1976). *The grasp of consciousness: Action and concept in the young child*. Harvard University Press.

Ramchand, M. (2022). Pedagogic content knowledge of science: A framework for practice and construct for understanding teacher preparation. *Contemporary Education Dialogue*, *19*(2), 281-303.

Respati, A. A., & Atun, S. (2023). The Effect of Electronic Modules on Self-regulated Learning and Cognitive Learning Outcomes on Chemical Bonding Material. *Jurnal Penelitian Pendidikan IPA*, *9*(5), 2489-2496.

Rusdiyana, R., Indriyanti, D., R., Hartono, H. & Isnaeni, W. (2024). The application of onine science based inquiry learning in primary schools. *Journal of Turkish Science Education, 21*(2), 293-303, 10.36681/tused.2024.016

Salina Mohmed. (2021). Keberkesanan model PLTP dalam pembelajaran kursus matematik di kolej komuniti Kuala Terengganu. ANP Journal of Social Science and Humanities, 2(2), 82-87. https://journalarsvot.com/index.php/anpjssh/article/view/81

Saputra, W. T., Rustaman, N. Y., & Rusyati, L. (2025). Exploring the Relationship between Logical Reasoning Skills, Scientific Literacy, and Academic Achievement in Science Courses Among Secondary Students: A Mixed Method Study. Jurnal Penelitian Pendidikan IPA, 11(1), 303–315.

Sarah, L. L., Utama, J. A., Suhandi, A., Rustaman, N., & Kadarohman, A. (2024). Inquiry-based astronomy in West Java secondary schools. *Physics Education*, *59*(4), 045009.

Seibert, J., Heuser, K., Lang, V., Perels, F., Huwer, J., & Kay, C. W. (2021). Multitouch experiment instructions to promote self-regulation in inquiry-based learning in school laboratories. *Journal of Chemical Education*, *98*(5), 1602-1609.

Received 01 October 2025 **Revised** 25 November 2025 **Accepted** 02 December 2025
Published 15 December 2025
Published by the Faculty of Science and Mathematics, Sultan Idris Education University

Sshana, Z.J., & Abulibdeh, E.S. (2020). Science practical work and its impact on students' science achievement. *Journal of Technology and Science Education,* 10(2), 199-215.

Susan, N., A., & Ventsislav, I., (2022). Artificial Intelligence in higher education: Challenges and opportunities. *Border Crossing, 12*(1), 1-15 https://doi.org/10.33182/bc.v12i1.2015

Tadesse, H., Tesfaye, D., H., Dawit, A., G., & Minaleshewa, A., (2025). Effect of virtual experiments compared to physical experiments on students' conceptual understanding of chemical kinetics concepts. *European Journal of STEM Education, 10*(1), 03 https://doi.org/10.20897/ejsteme/16261

Tamrin, M. F. (2025). The effectiveness of ChatGPT as learning tools in supporting self-regulated learning in students: a systematic *Educate: Jurnal Teknologi Pendidikan*, *10*(1), 127–133. https://doi.org/10.32832/educate.v10i1.18557

Tang, K., S., McLure, F., Williams, J. & Donnelly, C. (2024). Investigating the role of self-selected STEM projects in fostering student autonomy and self-directed learning. *The Australian Educational Researcher,* 51, 2355-2379 https://doi.org/10.1007/s13384-024-00696-2

Tegeh, I., M., Parwata, I., G., L., A. & Ostaviani, B., G. (2020). The observing learning activity assisted by concrete media improves student's conceptual knowledge. Indonesian of Educational Journal, 9(2), 182-192

Wang, C., Li, Z., & Bonk, C. (2024). Understanding self-regulated learning in AI-Assisted writing: A mixed methods study of postsecondary learners. *Computers and Education: Artificial Intelligence*, *6*, 100247.

Ward, A. M., & Wyllie, G. R. A. (2019). Bioplastics in the general Chemistry laboratory: building a semester-long research experience. *Journal of Chemical Education, 96*(4), 668–676. https://doi.org/10.1021/acs.jchemed.8b00666

Wu, M., Sun, D., Yang, Y., Li, M., & Sun, J. (2023). Investigating students' performance at self-regulated learning and its effects on learning outcomes in chemistry class at the senior secondary school. *International Journal of Science Education*, *45*(16), 1395-1418.

Wong H. T & Sim S. F. (2022). A curriculum-based laboratory kit for flexible teaching and learning of practical chemistry. *Chemistry Teacher International*, *4*(4) https://doi.org/10.1515/cti-2022-0014

Yanto, M. Minan Chusni & Enda Kurnia Yuningsih. (2023). Review literatur tentang persepsi Teori Konstruktivisme dalam keterampilan proses Sains. *Jurnal Ilmiah IKIP Mataram, 10*(2), 83-89.

Yilmaz, M. M., Bekirler, A., & Sigirtmac, A. D. (2024). Inspiring an Early Passion for Science: The Impact of Hands-on Activities on Children's Motivation. *ECNU Review of Education*, *7*(4), 1033-1053. https://doi.org/10.1177/20965311241265413

Zimmerman, B. J., & Schunk, D. H. (2012). Motivation: An essential dimension of self-regulated learning. In Motivation and self-regulated learning (pp. 1-30). Routledge.

Zhang, F., Brynildsrud, H., Papavlasopoulou, S., Sharma, K., & Giannakos, M. (2024). Where inquiry-based science learning meets gamification: a design case of Experiverse. *Behaviour & Information Technology, 44*(5), 1099–1121. https://doi.org/10.1080/0144929X.2024.2433058

Received 01 October 2025 **Revised** 25 November 2025 **Accepted** 02 December 2025
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APPENDIX

APPENDIX A

Pre-test

UNIVERSITI PENDIDIKAN SULTAN IDRIS

SULTAN IDRIS EDUCATION UNIVERSITY

FAKULTI SAINS DAN MATEMATIK UNIVERSITI PENDIDIKAN SULTAN IDRIS 35900 TANJUNG MALIM, PERAK

UJIAN PRA

SUBTOPIK ALOI

Arahan:

1. Kertas soalan ini mengandungi 20 halaman bercetak
2. Soalan terdiri 20 soalan objektif dan 3 soalan struktur
3. Pelajar dikehendaki menjawab kesemua soalan
4. Ruang di bawah ini perlu diisi dengan betul.
5. Jawab bahagian B pada ruang jawapan yang telah disediakan.

Section A

1. Which substance is an alloy?
   Bahan manakah merupakan satu aloi?

   A. Iron
   Besi
   B. Steel
   Keluli
   C. Copper
   Kuprum
   D. Aluminium
   Aluminium

2. Diagram 1 shows the atomic arrangement of a substance.
   Rajah 1 menunjukkan susunan atom bagi suatu bahan.

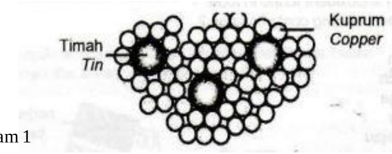


Diagram 1
Rajah 1

What is the name of the process to produce the substance?
Apakah nama proses untuk menghasilkan bahan tersebut?

A. Depolymerisation
Penyahpolimeran
B. Polymerisation
Pempolimeran
C. Vulcanisation
Pemvulkanan
D. Alloying
Pengaloian

3. Diagram 2 shows an alloy.
   Rajah 2 menunjukkan satu aloi.

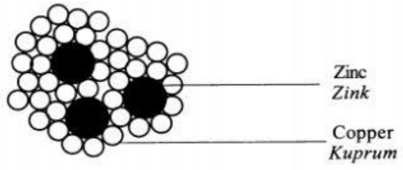


Diagram 2
Rajah 2

What is the alloy?
Apakah aloi itu?

A. Brass
Loyang
B. Steel
Keluli
C. Bronze
Gangsa
D. Pewter

4. After one year, Ahmad found that the iron gate at his house had rusted. The properties of this pure metal can be improved through the W process. trial
   What is W?
   Selepas satu tahun, Ahmad mendapati pintu pagar besi di rumahnya telah berkarat. Sifat logam tulen ini boleh dibaiki melalui proses W.
   Apakah proses W?

A. Alloying"
Pengaloian
B. Oxidation
Pengoksidaan
C. Polymerization
Pempolimeran
D. Depolymerization
Pemvulkanan

5. What is the proper material for building a lightweight, strong, and corrosion-resistant racing bicycle?
Apakah bahan yang dapat digunakan untuk membuat basikal lumba yang ringan, kuat dan tahan kakisan?
   A. Duralumin
   Duralumin
   B. Bronze
   Gangsa
   C. Steel
   Keluli
   D. Brass
   Loyang

6. What are the elements that form duralumin alloy?
Apakah unsur-unsur yang membentuk aloi duralumin?
   A. Copper and tin
   Kuprum dan timah
   B. Copper and zinc
   Kuprum dan zink
   C. Tin, antimony and copper
   Timah, antimoni dan kuprum
   D. Aluminium, copper, magnesium and manganese
   Aluminium, kuprum, magnesium dan mangan

7. Table 1 shows the composition of an alloy.
Jadual 1 menunjukkan komposisi unsur dalam sejenis aloi. (aplikasi)

Elements *Unsur*	Tin *Timah*	Copper *Kuprum*	Antimoni *Antimoni*
Percentage *Peratus*	96%	3%	1%

Table 1
Jadual 1

Which one is correct about the uses of alloy?Which of the following is true about the properties and uses of the alloy?
Antara berikut, yang manakah benar mengenai sifat serta kegunaan aloi tersebut?

	Properties *Sifat*	Uses *Kegunaan*
A	Shiny and resistant to corrosion *Berkilau dan tahan kakisan*	To make decorative item such as photo frame *Membuat barang perhiasan seperti bingkai gambar*
B	Light and strong *Ringan dan kuat*	To make frame, of aircraft and airplanes *Membuat badan pesawat dan kapal terbang*
C	Hard and resistant to corrosion *Keras dan tahan kakisan*	To make monuments, metal sculptures, coins, medals *Membuat tugu, ukiran logam, duit syiling, pingat*
D	Strong and malleable *Kuat dan mudah ditempa*	To make keys, doorknobs and musical instruments *Membuat kunci, tombol pintu dan alatan muzik*

8. Diagram 3 shows the arrangement of atoms in steel.
Rajah 3 menunjukkan susunan atom-atom dalam keluli

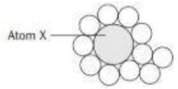
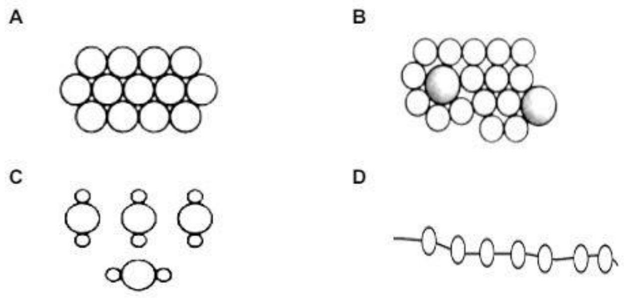


Diagram 3
Rajah 3

What is atom X?
Apakah atom X?

A. Iron
Besi
B. Carbon
Karbon
C. Copper
Kuprum
D. Bronze
Gangsa

9. Based on the following diagrams, which one illustrates the atomic structure of an alloy?
Berdasarkan rajah berikut, yang manakah menunjukkan struktur atom bagi aloi?



10. Based on the following, which one indicates the correct alloy and its composition?
Antara berikut, yang manakah menunjukkan aloi dan komposisi yang betul?

	Alloy *Aloi*	Composition *Komposisi*
A	Brass *Loyang*	Copper 75% and zinc 25% *Kuprum 75% dan zink 25%*
B	Bronze *Gangsa*	Tin 88% and copper 12% *Timah 88% dan kuprum 12%*
C	Steel *Keluli*	Carbon 99.5% and iron 0.5% Karbon 99.5% dan ferum 0.5%
D	Duralumin *Duralumin*	Aluminium 50% and copper 50% *Aluminium 50% dan kuprum 50%*

11. Diagram 4 shows the arrangement of atoms in a substance.
Rajah 4 menunjukkan susunan atom dalam suatu bahan.

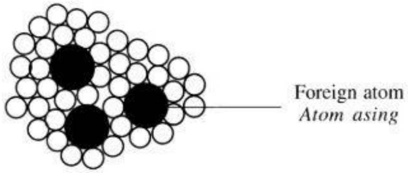


Diagram 4
Rajah 4

What is the function of foreign atoms?
Apakah fungsi atom-atom asing?

A. Soften the substance
Melembutkan bahan
B. Prevent the atoms from sliding
Menghalang atom-atom daripada menggelongsor
C. Increase the attractive force among the atoms
Meningkatkan daya tarikan antara atom
D. Decrease the melting point of the substance
Merendahkan takat lebur bahan

12. Diagram Diagram 5 shows a souvenir that made from pewter alloy.
Rajah 5 menunjukkan suatu cenderahati yang diperbuat daripada aloi piuter.

Diagram 5
Rajah 5

What is the alloy mixture that forms pewter alloy?
Apakah campuran logam yang membentuk aloi piuter?

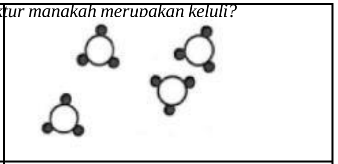
i. Iron *Besi*	iii. Copper *Kuprum*
ii. Tin *Timah*	iv. Antimoni *Antimoni*

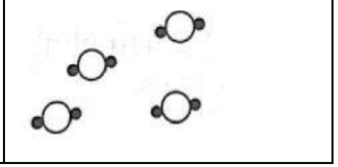
A. i, ii and iv
i, ii dan iv
B. i, iii and iv
i, iii dan iv
C. ii, iii and iv
ii, iii dan iv
D. i, ii and iii
i, ii dan iii

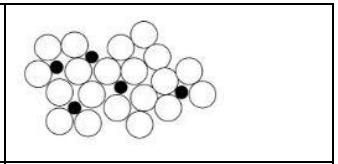
13. A group of students plans to build a remote-controlled toy helicopter.
What is the most suitable substances to be used to make the body of the helicopter?
Satu kumpulan pelajar merancang untuk membina helikopter mainan kawalan jauh.
Apakah mainan yang paling sesuai digunakan untuk membuat badan helikopter mainan tersebut?

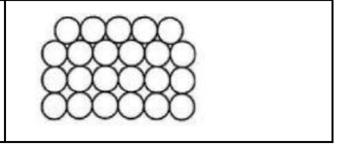
A. Iron
Besi
B. Bronze
Gangsa
C. Pewter
Piuter
D. Duralumin
Duralumin

14. Which structure represents steel?
Struktur manakah merupakan keluli?

A


B


C


D


15. An aircraft can carry many passengers at one time, For safety of the passengers, the body of aircraft needs to be built with strong material. Steel is an alloy which is very strong and used widely to build the frame of vehicles.
Kapal terbang boleh membawa ramai penumpang pada satu-satu masa. Untuk keselamatan penumpang, badan kapal terbang perlu dibina dengan bahan yang kuat. Keluli adalah sejenis aloi yang sangat kuat dan digunakan secara meluas untuk membina rangka kenderaan

Why steel cannot be used to build the body of an aircraft?
Mengapakah keluli tidak boleh digunakan untuk membina badan kapal terbang?

A. Large mass
Jisim yang besar
B. Not malleable
Tidak boleh ditempa
C. High cost
Kos yang tinggi
D. Easily corrode
Mudah terhakis

16. Which mixture will produce steel?
Campuran manakah yang akan menghasilkan keluli? (pengetahuan)

A. Tin and copper
Timah dan kuprum
B. Zinc and copper
Zink dan kuprum
C. Iron and carbon
Besi dan karbon
D. Tin and antimoni
Timah dan antimoni

17. The diagram shows a modern vehicle.
Rajah menunjukkan sebuah kenderaan moden.

What is the main characteristic of the material used to create this superconductor alloy?
Apakah ciri utama bahan yang digunakan untuk membina aloi superkondukter ini?

A. Lower magnetic field
Medan magnet yang lebih rendah
B. Low electrical resistance
Rintangan elektrik yang rendah
C. Harder structure
Struktur lebih keras
D. High energy
Tenaga yang banyak

18. Diagram 6 shows the arrangement of atoms in matter X.
Rajah 6 menunjukkan susunan atom dalam jirim X.

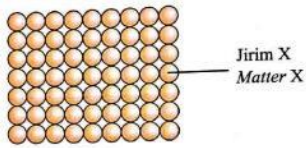


Diagram 6
Rajah 6

What is an example of a substance for matter X?
Apakah contoh bahan bagi jirim X?

A. Iron
Besi
B. Water
Air
C. Salt
Garam
D. Sugar
Gula

19. Diagram 7 shows a bridge made from material X
Rajah 7 menunjukkan jambatan yang diperbuat daripada bahan X.

Diagram 7
Rajah 7

Why is material X not used in the construction of aircrafts?
Mengapakah bahan X tidak digunakan dalam pembinaan badan kapal terbang?

A. Difficult to malleable
Sukar untuk ditempa
B. Shiny surface
Permukaan yang berkilat
C. Large mass
Jisim yang besar
D. Less attractive color
Warna yang kurang menarik

20. Diagram 8 shows the information about an alloy.
Rajah 8 menunjukkan maklumat tentang sejenis aloi.

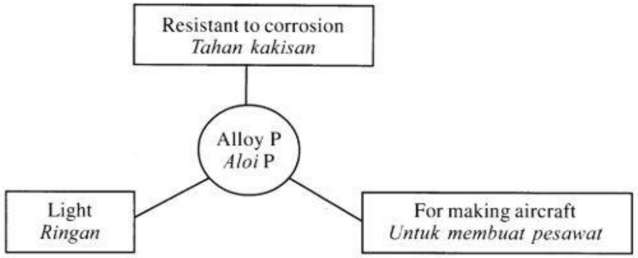


Diagram 8
Rajah 8

What is alloy P?
Apakah aloi P?

A. Brass
Loyang
B. Bronze
Gangsa
C. Pewter
Piuter
D. Duralumin
Duralumin

Section B

1. Diagram 10 shows a process producing alloy P.
Rajah 10 menunjukkan satu proses untuk menghasilkan aloi P.

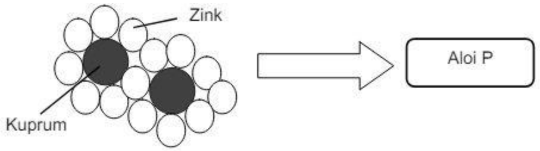


Diagram 10
Rajah 10

a. Name the process that produces alloy P.
Namakan proses yang menghasilkan aloi P [1 mark/ markah]

---

b. Describe the role of foreign atoms in alloy P materials.
Huraikan peranan atom asing dalam bahan aloi P. [2 marks/ markah]

---

c. Diagram 11 shows National Monument made from a single alloy material.
Rajah 11 menunjukkan Tugu Negara yang diperbuat dari satu bahan aloi.

Diagram 11
Rajah 11

i. What is the name of the alloy used? Justify the use of this particular alloy for The construction of the National Monument.
Apakah nama aloi yang digunakan? Wajarkan penggunaan aloi berkenaan untuk penghasilan Tugu Negara tersebut. [2 mark/ markah]

---

ii. Match the appropriate characteristics using alloy materials for the vehicles below.
Padankan ciri-ciri yang sesuai menggunakan bahan aloi untuk kenderaan di bawah [1 mark/ markah]

Can be forged *Boleh ditempa*
Shiny *Berkilat*
Lightweight *Ringan*

2. Diagram 12 shows an experiment to study the resistance towards corrosion of an alloy and a pure metal.
Rajah 12 menunjukkan suatu eksperimen untuk mengkaji ketahanan terhadap kakisan bagi aloi dan logam tulen.

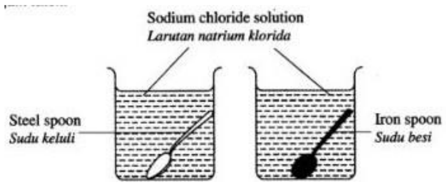


Diagram 12
Rajah 12

Table 2 shows the condition of both spoons after three days.
Jadual 2 menunjukkan keadaan kedua-dua sudu selepas tiga hari.

Types of spoon *Jenis sudu*	Condition of the spoon *Keadaan sudu*
Steel *Keluli*	…………………………………..
Iron *Besi*	Color changes *Berubah warna*

Table 2
Jadual 2

a) Based on the observation in Diagram 12, complete Table 2.
Berdasarkan pemerhatian pada Rajah 12, lengkapkan Jadual 2. [1 mark/ *1 markah*]

b) State one hypothesis for this experiment.
Nyatakan satu hipotesis bagi eksperimen ini. [1 mark/markah]

c) What is the responding variable in this experiment?
Apakah pemboleh ubah bergerak balas dalam eksperimen ini? [1 mark/markah]

d) Alloying is a process of mixing pure metal and foreign atom. Draw the arrangement of atoms in an alloy.
Pengaloian ialah proses pencampuran atom logam tulen dan atom unsur asing. Lukiskan susunan atom dalam aloi .
[2 marks/markah]

e) The following list is example of substances
Senarai berikut adalah contoh-contoh bahan

• Copper *Kuprum*	• Duralumin *Duralumin*
• Bronze *Gangsa*	• Tin *Timah*

Classify the substances into alloy and pure metal in Table 3.
Kelaskan bahan-bahan tersebut kepada aloi dan logam tulen dalam Jadual 3.

[2 marks/ markah]

Alloy *Aloi*	Pure metal *Logam tulen*

Table 3
Jadual 3

3. Diagram 13 shows the composition of steel.
Rajah 13 menunjukkan komposisi bagi keluli.

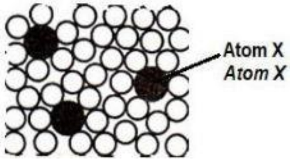


Diagram 13
Rajah 13

Table 4 shows two types of alloy with their respective compositions.
Jadual 4 menunjukkan dua jenis aloi bersama komposisi masing-masing.

Types of alloy *Jenis aloi*	Composition *Kandungan*	
Steel *Keluli*	• 99.5% iron *99.5% besi* • 0.5% atom X *0.5% atom X*	
Duralumin *Duralumin*	• 95% metal Y *95% logam Y* • 3% copper *3% kuprum*	• 1% manganese *1% mangan* • 1% magnesium *1% magnesium*

Table 4
Jadual 4

a) Based on Table 4,
Berdasarkan Jadual 4,

I. Identify atom X.
Kenal pasti atom X. [1 mark/ markah]

____

II. What is metal Y in duralumin
Apakah logam Y dalam duralumin [1 mark/ markah]

____

b) State two properties of duralumin compared to metal Y
Nyatakan dua sifat duralumin berbanding logam Y [2 marks/ markah]

1. ……………………………………………………………………………………

2. ……………………………………………………………………………………

c) Diagram 14 shows the construction of a building.
Rajah 14 menunjukkan pembinaan sebuah bangunan.

Diagram 14
Rajah 14

In your opinion, why is steel used in this building construction?
Pada pendapat anda, mengapakah pembinaan bangunan ini menggunakan keluli?
[1 marks/ markah]

____

d) Match the following alloys with their uses.
Padankan aloi berikut dengan kegunaannya.

Type of alloy *Jenis aloi*		Use *Kegunaan*
Brass *Loyang*		
Steel *Keluli*		

[2 marks / 2*markah*]

FAKULTI SAINS DAN MATEMATIK UNIVERSITI PENDIDIKAN SULTAN IDRIS 35900 TANJUNG MALIM, PERAK

ANSWER SCHEME

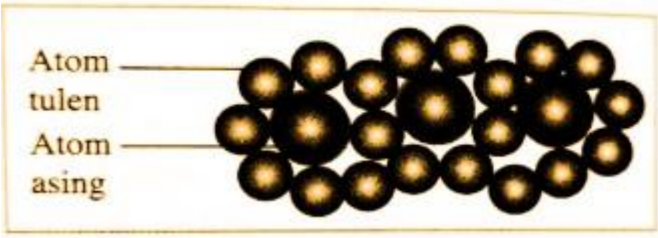
ALLOY SUBTOPIC

ANSWER SCHEME FOR SECTION A

Question No	Answer	Question No.	Answer
1	B	11	B
2	D	12	C
3	A	13	D
4	A	14	C
5	A	15	A
6	D	16	C
7	A	17	B
8	A	18	A
9	B	19	C
10	A	20	D

ANSWER SHEME FOR SECTION B

Soalan *Question*	Skema Pemarkahan *Scoring Scheme*	Markah *Mark*
1	a. Pengaloian *Alloying*	1
	b. Supaya lapisan logam tulen tidak mudah menggelongsor/tergelincir apabila dikenakan daya (1m) *Pure metal does not sliding easily/ slip when force is applied*	1
	Supaya logam tulen lebih kuat/lebih keras/lebih kukuh (1m) *Pure metal stronger/ harder/ firmer*	1
	c. Gangsa *Bronze*	1
	Wajaran- Lebih tahan karat/kakisan // lebih kukuh/kuat *Justification- Corrosion resistant// stronger/harder*	1
	d. Padanan betul pada ringan *Right match to lightweight*	1
	Jumlah	6
2	a. Tidak berubah *No change*	1
	b. Boleh menyatakan hipotesis dengan betul: *Can state correct hypothesis:* Jawapan *Answer:* 1. Sudu keluli tidak berkarat/ tiada pepejal perang/ tahan kakisan apabila direndam di dalam air garam// (1) *Stainless steel spoon does not rust/ no brown residue/ corrosion resistant when immersed in salt water* 2. Aloi tidak mudah berkarat/ tahan kakisan// (1) *Alloy not easily rust/ corrosion resistant* 3. Sudu besi mudah berkarat/ ada pepejal perang/ tidak tahan kakisan apabila direndam di dalam air garam// (1) *Iron spoon rust easily/ has brown residue/ not*	1

	corrosion resistant when immersed in salt water 4. Logam tulen mudah berkarat/ tidak tahan kakisan// (1) *Pure metal rust easily/ not corrosion resistant* Salah satu *Either one*	
	c. Kehadiran lapisan perang pada paku *The presence of brown layer on nail*	1
	d. Rajah (1) *Diagram (1)* Label (1) *Label (1)* 	1 1
	e. Aloi: Duralumin, Gangsa *Alloy: Duralumin, Bronze* Logam tulen: Kuprum, Timah *Pure metal: Copper, Tin*	1 1
	Jumlah	7
3	a. i. Karbon *Carbon* Ii. Aluminium *Aluminium* b.- Duralumin lebih kuat daripada logam Y *Duralumin stronger than metal Y* - Duralumin lebih tahan kakisan daripada logam Y *Duralumin more corrosion resistant than metal Y* c. Keluli merupakan sejenis aloi yang lebih kuat berbanding besi // (1) *Steel is an alloy that is stronger than iron* Keluli lebih kuat dan keras berbanding besi (1) *Steel is stronger and harder than iron* Salah satu *Either one*	1 1 1 1 1

	d. i)  ii) 	1 1
	Jumlah	7
	Jumlah Keseluruhan	20

APPENDIX B

Post-test

SULTAN IDRIS EDUCATION UNIVERSITY

FAKULTI SAINS DAN MATEMATIK
UNIVERSITI PENDIDIKAN SULTAN IDRIS 35900
TANJUNG MALIM, PERAK

UJIAN PASCA

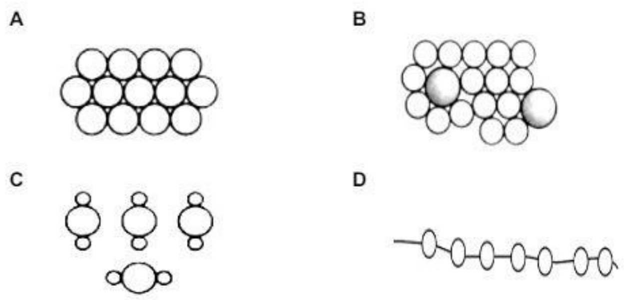
SUBTOPIK ALOI

Arahan:

1. Kertas soalan ini mengandungi 20 halaman bercetak
2. Soalan terdiri 20 soalan objektif dan 3 soalan struktur
3. Pelajar dikehendaki menjawab kesemua soalan
4. Ruang di bawah ini perlu diisi dengan betul.
5. Jawab bahagian B pada ruang jawapan yang telah disediakan.

Section A

1. Based on the following diagrams, which one illustrates the atomic structure of an alloy?
Berdasarkan rajah berikut, yang manakah menunjukkan struktur atom bagi aloi?



2. What are the elements that form duralumin alloy?
Apakah unsur-unsur yang membentuk aloi duralumin?

A. Copper and tin
Kuprum dan timah
B. Copper and zinc
Kuprum dan zink
C. Tin, antimony and copper
Timah, antimoni dan kuprum
D. Aluminium, copper, magnesium and manganese
Aluminium, kuprum, magnesium dan mangan

3. An aircraft can carry many passengers at one time, For safety of the passengers, the body of aircraft needs to be built with strong material. Steel is an alloy which is very strong and used widely to build the frame of vehicles.
Kapal terbang boleh membawa ramai penumpang pada satu-satu masa. Untuk keselamatan penumpang, badan kapal terbang perlu dibina dengan bahan yang kuat. Keluli adalah sejenis aloi yang sangat kuat dan digunakan secara meluas untuk membina rangka kenderaan

Why steel cannot be used to build the body of an aircraft?
Mengapakah keluli tidak boleh digunakan untuk membina badan kapal terbang?

A. Large mass
Jisim yang besar
B. Not malleable
Tidak boleh ditempa
C. High cost
Kos yang tinggi
D. Easily corrode
Mudah terhakis

4. Diagram 1 shows an alloy.
Rajah 1 menunjukkan satu aloi.

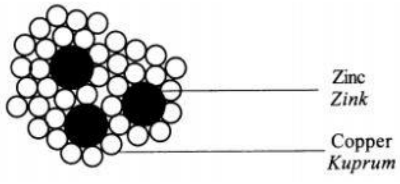


Diagram 1
Rajah 1

What is the alloy?
Apakah aloi itu?

A. Brass
Loyang
B. Steel
Keluli
C. Bronze
Gangsa
D. Pewter
Piuter

5. A group of students plans to build a remote-controlled toy helicopter.
What is the most suitable substances to be used to make the body of the helicopter?
Satu kumpulan pelajar merancang untuk membina helikopter mainan kawalan jauh.
Apakah mainan yang paling sesuai digunakan untuk membuat badan helikopter mainan tersebut?

A. Iron
Besi
B. Bronze
Gangsa
C. Pewter
Piuter
D. Duralumin
Duralumin

6. Which substance is an alloy?
Bahan manakah merupakan satu aloi?

A. Iron
Besi
B. Steel
Keluli
C. Copper
Kuprum
D. Aluminium
Aluminium

7. Which mixture will produce steel?
Campuran manakah yang akan menghasilkan keluli?

A. Tin and copper
Timah dan kuprum
B. Zinc and copper
Zink dan kuprum
C. Iron and carbon
Besi dan karbon
D. Tin and antimoni
Timah dan antimoni

8. Rajah 2 shows the information about an alloy.
Rajah 2 menunjukkan maklumat tentang sejenis aloi.

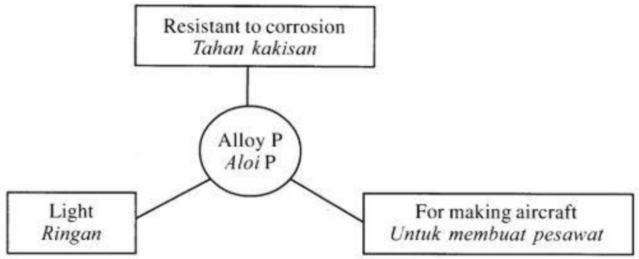


Diagram 2
Rajah 2

What is alloy P?
Apakah aloi P?

A. Brass
Loyang
B. Bronze
Gangsa
C. Pewter
Piuter
D. Duralumin
Duralumin

9. Diagram 3 shows the arrangement of atoms in a substance.
Rajah 3 menunjukkan susunan atom dalam suatu bahan.

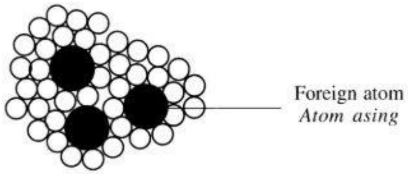


Diagram 3
Rajah 3

What is the function of foreign atoms?
Apakah fungsi atom-atom asing?

A. Soften the substance
Melembutkan bahan
B. Prevent the atoms from sliding
Menghalang atom-atom daripada menggelongsor
C. Increase the attractive force among the atoms
Meningkatkan daya tarikan antara atom
D. Decrease the melting point of the substance
Merendahkan takat lebur bahan

10. What is the suitable material for building a lightweight, strong, and corrosion-resistant racing bicycle?
Apakah bahan yang sesuai digunakan untuk membuat basikal lumba yang ringan, kuat dan tahan kakisan?
A. Duralumin
Duralumin
B. Bronze
Gangsa
C. Steel
Keluli
D. Brass
Loyang

11. The diagram shows a modern vehicle.
Rajah menunjukkan sebuah kenderaan moden.

What is the main characteristic of the material used to create this superconductor alloy?
Apakah ciri utama bahan yang digunakan untuk membina aloi superkondukter ini?

A. Lower magnetic field
Medan magnet yang lebih rendah
B. Low electrical resistance
Rintangan elektrik yang rendah
C. Harder structure
Struktur lebih keras
D. High energy
Tenaga yang banyak

12. Based on the following, which one indicates the correct alloy and its composition?
Antara berikut, yang manakah menunjukkan aloi dan komposisi yang betul?

	Alloy *Aloi*	Composition *Komposisi*
A	Brass *Loyang*	Copper 75% and zinc 25% *Kuprum 75% dan zink 25%*
B	Bronze *Gangsa*	Tin 88% and copper 12% *Timah 88% dan kuprum 12%*
C	Steel *Keluli*	Carbon 99.5% and iron 0.5% Karbon 99.5% dan ferum 0.5%
D	Duralumin *Duralumin*	Aluminium 50% and copper 50% *Aluminium 50% dan kuprum 50%*

13. Diagram 4 shows the atomic arrangement of a substance.
Rajah 4 menunjukkan susunan atom bagi suatu bahan.

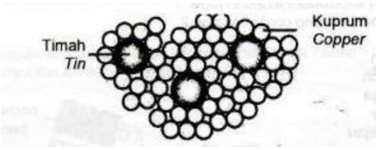


Diagram 4
Rajah 4

What is the name of the process to produce the substance?
Apakah nama proses untuk menghasilkan bahan tersebut?

A. Depolymerisation
Penyahpolimeran
B. Polymerisation
Pempolimeran
C. Vulcanisation
Pemvulkanan
D. Alloying
Pengaloian

14. Diagram 5 shows the arrangement of atoms in steel.
Rajah 5 menunjukkan susunan atom-atom dalam keluli

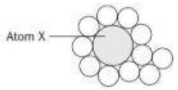


Diagram 5
Rajah 5

What is atom X?
Apakah atom X?

A. Iron
Besi
B. Carbon
Karbon
C. Copper
Kuprum
D. Bronze
Gangsa

15. Diagram 6 shows the arrangement of atoms in matter X.
Rajah 6 menunjukkan susunan atom dalam jirim X.

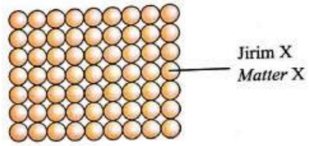


Diagram 6
Rajah 6

What is an example of a substance for matter X?
Apakah contoh bahan bagi jirim X?

A. Iron
Besi
B. Water
Air
C. Salt
Garam
D. Sugar
Gula

16. Diagram 7 shows a souvenir that made from pewter alloy.
Rajah 7 menunjukkan suatu cenderahati yang diperbuat daripada aloi piuter.

Diagram 7
Rajah 7

What is the alloy mixture that forms pewter alloy?
Apakah campuran logam yang membentuk aloi piuter?

i. Iron
Besi
ii. Tin
Timah

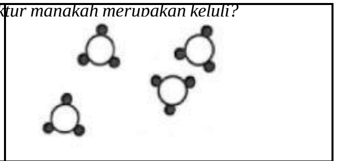
iii. Copper
Kuprum
iv. Antimoni
Antimoni

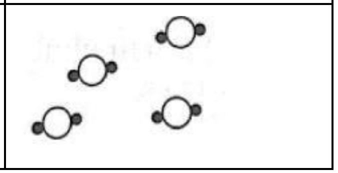
A. i, ii and iv
i, ii dan iv
B. i, iii and iv
i, iii dan iv
C. ii, iii and iv
ii, iii dan iv
D. i, ii and iii
i, ii dan iii

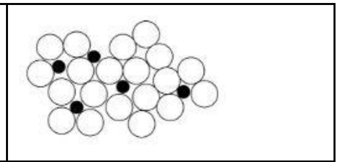
17. After one year, Ahmad found that the iron gate at his house had rusted. The properties of this pure metal can be improved through the W process. trial
What is W?
Selepas satu tahun, Ahmad mendapati pintu pagar besi di rumahnya telah berkarat. Sifat logam tulen ini boleh dibaiki melalui proses W.
Apakah proses W?

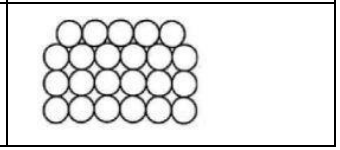
A. Alloying
Pengaloian
B. Oxidation
Pengoksidaan
C. Polymerization
Pempolimeran
D. Depolymerization
Pemvulkanan

18. Which structure represents steel?
Struktur manakah merupakan keluli?

A


B


C


D


19. Table 1 shows the composition of an alloy.
Jadual 1 menunjukkan komposisi unsur dalam sejenis aloi. (aplikasi)

Elements *Unsur*	Tin *Timah*	Copper *Kuprum*	Antimoni *Antimoni*
Percentage *Peratus*	96%	3%	1%

Table 1
Jadual 1

Which one is correct about the uses of alloy?Which of the following is true about the properties and uses of the alloy?
Antara berikut, yang manakah benar mengenai sifat serta kegunaan aloi tersebut?

	Properties *Sifat*	Uses *Kegunaan*
A	Shiny and resistant to corrosion *Berkilau dan tahan kakisan*	To make decorative item such as photo frame *Membuat barang perhiasan seperti bingkai gambar*
B	Light and strong *Ringan dan kuat*	To make frame, of aircraft and airplanes *Membuat badan pesawat dan kapal terbang*
C	Hard and resistant to corrosion *Keras dan tahan kakisan*	To make monuments, metal sculptures, coins, medals *Membuat tugu, ukiran logam, duit syiling, pingat*

D	Strong and malleable *Kuat dan mudah ditempa*	To make keys, doorknobs and musical instruments *Membuat kunci, tombol pintu dan alatan muzik*

20. Diagram 8 shows a bridge made from material X
Rajah 8 menunjukkan jambatan yang diperbuat daripada bahan X.

Diagram 8
Rajah 8

Why is material X not used in the construction of aircrafts?
Mengapakah bahan X tidak digunakan dalam pembinaan badan kapal terbang?

A. Difficult to malleable
Sukar untuk ditempa
B. Shiny surface
Permukaan yang berkilat
C. Large mass
Jisim yang besar
D. Less attractive color
Warna yang kurang menarik

Section B

1. Diagram 1 shows an experiment to study the resistance towards corrosion of an alloy and a pure metal.
Rajah 1 menunjukkan suatu eksperimen untuk mengkaji ketahanan terhadap kakisan bagi aloi dan logam tulen.

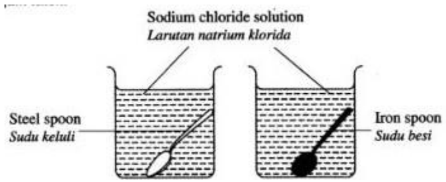


Diagram 1
Rajah 1

Table 1 shows the condition of both spoons after three days.
Jadual 1 menunjukkan keadaan kedua-dua sudu selepas tiga hari.

Types of spoon *Jenis sudu*	Condition of the spoon *Keadaan sudu*
Steel *Keluli*	…………………………………..
Iron *Besi*	Color changes *Berubah warna*

Table 1
Jadual 1

a) Based on the observation in Diagram 1, complete Table 1.
Berdasarkan pemerhatian pada Rajah 1, lengkapkan Jadual 1. [1 mark/ *1 markah*]

b) State one hypothesis for this experiment.
Nyatakan satu hipotesis bagi eksperimen ini. [1 mark/markah]

____

c) What is the responding variable in this experiment?
Apakah pemboleh ubah bergerak balas dalam eksperimen ini? [1 mark/markah]

____

d) Alloying is a process of mixing pure metal and foreign atom. Draw the arrangement of atoms in an alloy.
Pengaloian ialah proses pencampuran atom logam tulen dan atom unsur asing. Lukiskan susunan atom dalam aloi .
[2 marks/markah]

e) The following list is example of substances
Senarai berikut adalah contoh-contoh bahan

- Copper *Kuprum*
- Bronze *Gangsa*
- Duralumin *Duralumin*
- Tin *Timah*

Classify the substances into alloy and pure metal in Table 2.
Kelaskan bahan-bahan tersebut kepada aloi dan logam tulen dalam Jadual 2.
[2 marks/ markah]

Alloy *Aloi*	Pure metal *Logam tulen*

Table 2
Jadual 2

2. Table 2 shows the composition of steel.
Jadual 2 meninjukkan komposisi bagi keluli.

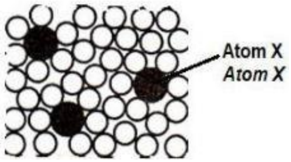


Diagram 2
Rajah 2

Table 3 shows two types of alloy with their respective compositions.
Jadual 3 menunjukkan dua jenis aloi bersama komposisi masing-masing.

Types of alloy *Jenis aloi*	Composition *Kandungan*	
Steel *Keluli*	• 99.5% iron *99.5% besi* • 0.5% atom X *0.5% atom X*	
Duralumin *Duralumin*	• 95% metal Y *95% logam Y* • 3% copper *3% kuprum*	• 1% manganese *1% mangan* • 1% magnesium *1% magnesium*

Table 3
Jadual 3

a) Based on Table 3,
Berdasarkan Jadual 3,

I. Identify atom X.
Kenal pasti atom X. [1 mark/ markah]

____

II. What is metal Y in duralumin
Apakah logam Y dalam duralumin [1 mark/ markah]

____

b) State two properties of duralumin compared to metal Y
Nyatakan dua sifat duralumin berbanding logam Y [2 marks/ markah]

1. …………………………………………………………………………………

2. …………………………………………………………………………………

c) Diagram 3 shows the construction of a building.
Rajah 3 menunjukkan pembinaan sebuah bangunan.

Diagram 3
Rajah 3

In your opinion, why is steel used in this building construction?
Pada pendapat anda, mengapakah pembinaan bangunan ini menggunakan keluli?
[1 marks/ markah]

____

d) Match the following alloys with their uses.
Padankan aloi berikut dengan kegunaannya.

Type of alloy *Jenis aloi*	Use *Kegunaan*
Brass *Loyang*	
Steel *Keluli*	

[2 marks / 2*markah*]

3. Diagram 4 shows a process producing alloy P.
Rajah 4 menunjukkan satu proses untuk menghasilkan aloi P.

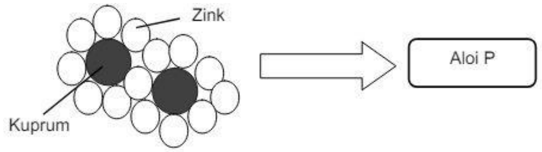


Diagram 4
Rajah 4

a. Name the process that produces alloy P.
Namakan proses yang menghasilkan aloi P [1 mark/ markah]

____

b. Describe the role of foreign atoms in alloy P materials.
Huraikan peranan atom asing dalam bahan aloi P. [2 marks/ markah]

____

c. Diagram 5 shows National Monument made from a single alloy material.
Rajah 5 menunjukkan Tugu Negara yang diperbuat dari satu bahan aloi.

Diagram 5
Rajah 5

i. What is the name of the alloy used? Justify the use of this particular alloy for The construction of the National Monument.
Apakah nama aloi yang digunakan? Wajarkan penggunaan aloi berkenaan untuk penghasilan Tugu Negara tersebut. [2 mark/ markah]

---

ii. Match the appropriate characteristics using alloy materials for the vehicles below.
Padankan ciri-ciri yang sesuai menggunakan bahan aloi untuk kenderaan di bawah [1 mark/ markah]

Can be forged *Boleh ditempa*
Shiny *Berkilat*
Lightweight *Ringan*

FAKULTI SAINS DAN MATEMATIK
UNIVERSITI PENDIDIKAN SULTAN IDRIS
35900 TANJUNG MALIM, PERAK

ANSWER

SCHEME

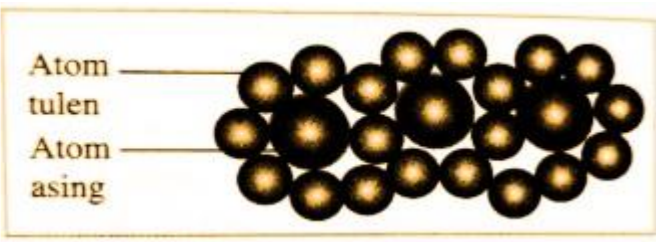
ALLOY

SUBTOPIC

ANSWER SCHEME FOR SECTION A

Question No.	Answer	Question No.	Answer
1	B	11	B
2	D	12	A
3	A	13	D
4	A	14	A
5	D	15	A
6	B	16	C
7	C	17	A
8	D	18	C
9	B	19	A
10	A	20	C

ANSWER SCHEME FOR SECTION B

Soalan *Question*	Skema Pemarkahan *Scoring Scheme*	Markah *Mark*
1	a. Tidak berubah *No change*	1
	b. Boleh menyatakan hipotesis dengan betul: *Can state correct hypothesis:* Jawapan *Answer:* 1. Sudu keluli tidak berkarat/ tiada pepejal perang/ tahan kakisan apabila direndam di dalam air garam// (1) *Stainless steel spoon does not rust/ no brown residue/ corrosion resistant when immersed in salt water* 2. Aloi tidak mudah berkarat/ tahan kakisan// (1) *Alloy not easily rust/ corrosion resistant* 3. Sudu besi mudah berkarat/ ada pepejal perang/ tidak tahan kakisan apabila direndam di dalam air garam// (1) *Iron spoon rust easily/ has brown residue/ not corrosion resistant when immersed in salt water* 4. Logam tulen mudah berkarat/ tidak tahan kakisan// (1) *Pure metal rust easily/ not corrosion resistant* Salah satu *Either one*	1
	c. Kehadiran lapisan perang pada paku *The presence of brown layer on nail*	1
	d. Rajah (1) *Diagram (1)* Label (1) *Label (1)*  	1 1

	e. Aloi: Duralumin, Gangsa *Alloy: Duralumin, Bronze* Logam tulen: Kuprum, Timah *Pure metal: Copper, Tin*	1 1
	Jumlah *Total*	7
2	a. i. Karbon *Carbon* Ii. Aluminium *Aluminium* b.- Duralumin lebih kuat daripada logam Y *Duralumin stronger than metal Y* - Duralumin lebih tahan kakisan daripada logam Y *Duralumin more corrosion resistant than metal Y* c. Keluli merupakan sejenis aloi yang lebih kuat berbanding besi // (1) *Steel is an alloy that is stronger than iron* Keluli lebih kuat dan keras berbanding besi (1) *Steel is stronger and harder than iron* Salah satu *Either one* d. i)  ii) 	1 1 1 1 1 1 1
	Jumlah *Total*	7
3	a. Pengaloian *Alloying* b. Supaya lapisan logam tulen tidak mudah menggelongsor/tergelincir apabila dikenakan daya (1m) *Pure metal does not sliding easily/ slip when force is applied*	1 1

	Supaya logam tulen lebih kuat/lebih keras/lebih kukuh (1m) *Pure metal stronger/ harder/ firmer* c. Gangsa *Bronze* Wajaran- Lebih tahan karat/kakisan // lebih kukuh/kuat *Justification- Corrosion resistant// stronger/harder* d. Padanan betul pada ringan *Right match to lightweight*	1 1 1 1
	Jumlah *Total*	6
	Jumlah Keseluruhan *Total amount*	20

APPENDIX C

Approval from the Education Policy Planning and Research Division, Ministry of Education Malaysia

KEMENTERIAN PENDIDIKAN MALAYSIA
BAHAGIAN PERANCANGAN DAN PENYELIDIKAN DASAR PENDIDIKAN
ARAS 1-4, BLOK E8
KOMPLEKS KERAJAAN PARCEL E
PUSAT PENTADBIRAN KERAJAAN PERSEKUTUAN
62604 PUTRAJAYA

TEL : 0388846591
FAKS : 0388846579

Ruj. Kami : KPM.600-3/2/3-eras(21123)
Tarikh : 8 Ogos 2024

NUR ADRIANA ATHIQAH BINTI MOHD ANUAR
NO. KP : 020502090076

NO 7, JALAN MASMUDA 5 TAMAN MASMUDA, 01000, KANGAR PERLIS
1000 KANGAR
PERLIS

Tuan,

KELULUSAN BERSYARAT UNTUK MENJALANKAN KAJIAN :
KEBERKESANAN EKSPERIMEN KENDIRI MELALUI PEMBELAJARAN BERASASKAN INKUIRI TERHADAP KEFAHAMAN PELAJAR BAGI SUBTOPIK ALOI

Perkara di atas adalah dirujuk.

2. Sukacita dimaklumkan bahawa permohonan tuan untuk menjalankan kajian seperti di bawah telah diluluskan dengan syarat :

" KELULUSAN INI BERGANTUNG KEPADA KEBENARAN PENGARAH JPN DAN PERTIMBANGAN PENTADBIR SEKOLAH. PENGUTIPAN DATA TIDAK BOLEH MENGGANGGU AKTIVITI PENGAJARAN DAN PEMBELAJARAN MURID. "

3. Kelulusan adalah berdasarkan kepada kertas cadangan penyelidikan dan instrumen kajian yang dikemukakan oleh tuan kepada bahagian ini. Walau bagaimanapun kelulusan ini bergantung kepada kebenaran Jabatan Pendidikan Negeri dan Pengetua / Guru Besar yang berkenaan.

4. Surat kelulusan ini sah digunakan bermula dari **5 Ogos 2024** hingga **31 Januari 2025**

5. Tuan dikehendaki menyerahkan senaskhah laporan akhir kajian dalam bentuk *hardcopy* bersama salinan *softcopy* berformat pdf dalam CD kepada Bahagian ini.Tuan juga diingatkan supaya mendapat kebenaran terlebih dahulu daripada Bahagian ini sekiranya sebahagian atau sepenuhnya dapatan kajian tersebut hendak diterbitkan di mana-mana forum, seminar atau diumumkan kepada media massa.

Sekian untuk makluman dan tindakan tuan selanjutnya. Terima kasih.

"BERKHIDMAT UNTUK NEGARA"

Saya yang menjalankan amanah,

Ketua Penolong Pengarah Kanan
Sektor Penyelidikan dan Penilaian Dasar
b.p. Pengarah
Bahagian Perancangan dan Penyelidikan Dasar Pendidikan
Kementerian Pendidikan Malaysia

salinan kepada:-

JABATAN PENDIDIKAN PERLIS

* SURAT INI DIJANA OLEH KOMPUTER DAN TIADA TANDATANGAN DIPERLUKAN *

APPENDIX D

Pilot Study Analysis (SPSS)

Correlations

Correlations

		PRA 1	PRA 2
PRA 1	Pearson Correlation	1	.782**
	Sig. (2-tailed)		<.001
	N	20	20
PRA 2	Pearson Correlation	.782**	1
	Sig. (2-tailed)	<.001	
	N	20	20

**. Correlation is significant at the 0.01 level (2-tailed).

APPENDIX H

Normality Test Analysis (SPSS)

Frequencies

Statistics

		MARKAH PRA RAWATAN	MARKAH PASCA RAWATAN	MARKAH PRA KAWALAN	MARKAH PASCA KAWALAN
N	Valid	20	20	20	20
	Missing	0	0	0	0
Skewness		-.348	-1.018	-.211	.367
Std. Error of Skewness		.512	.512	.512	.512
Kurtosis		-.927	.831	-1.038	-1.145
Std. Error of Kurtosis		.992	.992	.992	.992

APPENDIX E
Descriptive Analysis (SPSS)

Statistics

		MARKAH PRA RAWATAN	MARKAH PASCA RAWATAN	MARKAH PRA KAWALAN	MARKAH PASCA KAWALAN
N	Valid	20	20	20	20
	Missing	0	0	0	0
Mean		32.55	69.75	34.30	58.30
Median		33.00	73.00	35.50	58.00
Mode		30	73	38	58
Std. Deviation		6.525	11.840	6.721	10.737
Variance		42.576	140.197	45.168	115.274
Minimum		20	40	23	43
Maximum		42	85	45	75

APPENDIX F

T-test Inferential Analysis (SPSS)

Mean pre-test scores for the control group and the experiment group

T-Test

Group Statistics

	KUMPULAN	N	Mean	Std. Deviation	Std. Error Mean
MARKAH PRA	KAWALAN	20	34.30	6.721	1.503
	RAWATAN	20	32.55	6.525	1.459

Independent Samples Test

		Levene's Test for Equality of Variances		t-test for Equality of Means	
		F	Sig.	t	df
MARKAH PRA	Equal variances assumed	.151	.700	.835	38
	Equal variances not assumed			.835	37.967

Independent Samples Test

		t-test for Equality of Means			
		Significance			
		One-Sided p	Two-Sided p	Mean Difference	Std. Error Difference
MARKAH PRA	Equal variances assumed	.204	.409	1.750	2.095
	Equal variances not assumed	.204	.409	1.750	2.095

Independent Samples Test

		t-test for Equality of Means 95% Confidence Interval of the Difference	
		Lower	Upper
MARKAH PRA	Equal variances assumed	-2.490	5.990
	Equal variances not assumed	-2.490	5.990

APPENDIX G

T-test Inferential Analysis (SPSS)

Mean scores pre-test and post-test for the control group

T-Test

Paired Samples Statistics

		Mean	N	Std. Deviation	Std. Error Mean
Pair 1	MARKAH PRA KAWALAN	34.30	20	6.721	1.503
	MARKAH PASCA KAWALAN	58.30	20	10.737	2.401

Paired Samples Test

		Paired Differences			
					95% Confidence Interval of the ...
		Mean	Std. Deviation	Std. Error Mean	Lower
Pair 1	MARKAH PRA KAWALAN - MARKAH PASCA ...	-24.000	12.749	2.851	-29.967

Paired Samples Test

		Paired ...			Significance	
		95% Confidence Interval of the ...				
		Upper	t	df	One-Sided p	Two-Sided p
Pair 1	MARKAH PRA KAWALAN - MARKAH PASCA ...	-18.033	-8.419	19	<.001	<.001

APPENDIX H

Mean scores pre-test and post-test for the experiment group

T-test Inferential Analysis (SPSS)

Paired Samples Statistics

		Mean	N	Std. Deviation	Std. Error Mean
Pair 1	MARKAH PRA RAWATAN	32.55	20	6.525	1.459
	MARKAH PASCA RAWATAN	69.75	20	11.840	2.648

Paired Samples Test

		Paired Differences			
					95% Confidence Interval of the ...
		Mean	Std. Deviation	Std. Error Mean	Lower
Pair 1	MARKAH PRA RAWATAN - MARKAH PASCA RAWATAN	-37.200	13.965	3.123	-43.736

Paired Samples Test

		Paired ...			Significance	
		95% Confidence Interval of the ...				
		Upper	t	df	One-Sided p	Two-Sided p
Pair 1	MARKAH PRA RAWATAN - MARKAH PASCA RAWATAN	-30.664	-11.913	19	<.001	<.001

APPENDIX I

T-test Inferential Analysis (SPSS)

Mean scores post-test for the control group and experiment group

T-Test

Group Statistics

	KUMPULAN	N	Mean	Std. Deviation	Std. Error Mean
MARKAH PASCA	KAWALAN	20	58.30	10.737	2.401
	RAWATAN	20	69.75	11.840	2.648

Independent Samples Test

		Levene's Test for Equality of Variances		t-test for Equality of Means	
		F	Sig.	t	df
MARKAH PASCA	Equal variances assumed	.038	.847	-3.204	38
	Equal variances not assumed			-3.204	37.642

Independent Samples Test

		t-test for Equality of Means		
		Significance		
		One-Sided p	Two-Sided p	Mean Difference
MARKAH PASCA	Equal variances assumed	.001	.003	-11.450
	Equal variances not assumed	.001	.003	-11.450

Independent Samples Test

		t-test for Equality of Means		
		Std. Error Difference	95% Confidence Interval of the Difference	
			Lower	Upper
MARKAH PASCA	Equal variances assumed	3.574	-18.685	-4.215
	Equal variances not assumed	3.574	-18.687	-4.213

Daily Lesson Plan for Experiment Group
APPENDIX J

DAILY LESSON PLAN 2024			
DATE : 25/9/2024`	**DAY : WEDNESDAY**	**TIME : 1.10-2.10 PM**	**FORM : 4 BITARA**
TOTAL STUDENT : 20/25	**SUBJECT : SCIENCE**		

THEME	Exploration Elements in Nature	
TOPIC	Chemical Industry	
CONTENT STANDARD	Alloy	
LEARNING STANDARD (Learning Outcome) **Cognitive** **Affective** **Psychomotor**	**Cognitive** At the end of learning, student can: 1. Define and give example of alloy based on their elemental composition **Affective** At the end of learning, student can: 1. Identify students' level of understanding of alloy through self-conducted experiment **Psychomotor** At the end of learning, student can: 1. Explain and describe the properties of alloy orally based on the experiment that student conducted	
EXISTING KNOWLEDGE	The understanding of basic alloy concept from past class	
LESSON PHASES AND ACTIVITIES	**Activity**	
	Teacher activity	**Student activity**
STEP – **INDUCTION SET AND IDEA EXPLORATION**	- Teacher asked students to give feedback on students' experience while conducting experiment at home - Teacher explain learning objective and success criteria that must be achieved by students during today lesson - Teacher ask students to display experiment results on students' table	- Students give feedback on their experience while conducting experiment at home -Students listen teachers' explanation and prepare to start the lesson - Students show their experiment result on the table
STEP – **CONCEPT STRUCTURING AND RESTRUCTURING**	-Teacher divide students into several groups - Teacher asked students move in group to analyse experiment	- Student are in the groups that have been assigned - Student move in group to analyse experiment results from other groups (gallery walk)

TEACHING STRATEGY	
Inquiry-Based Learning	/
Constructivisme	/
Contextual Learning	
Mastery Learning	/
Problem-Based/ Project-Based Learning	/
STEM Approach	
Scientific Investigation/ Experiment	

21st CENTURY LEARNING APPROACH (PAK 21)	
Moral Values and Ethics	/
Communication	/
Collaborative	/
Creativity	/
Critical Thinking	/

PAK-21 ACTIVITIES	
Round Table	
Think Pair Share	
Group Presentation.	/
Hot Seat	
Role play	/
Gallery Walk	
Three Stray One Stay	
Declamation /Drama	/

I-THINK (THINKING MAPS)	
Circle	
Bubble	
Bridge	
Flow	/
Tree	
Multi flow	
Brace	
Double Bubble	/

HOTS (Cognitive)	
Applying (C3)	/
Analysing (C4)	/
Evaluating (C5)	
Creating (C6)	

CROSS-CURRICULAR ELEMENTS (CCE)	
Language	
Environmental Sustainability	
Moral Value	/
Science & Technology	/
Patriotism	
Creativity and Innovation	/
Entrepreneurship	
Information Technology & Communication	/

		results from other groups (gallery walk) - Teacher asked students to note the differences that student found between students' result and the result that student observe - Teacher monitor gallery walk activity in the science laboratory - Teacher choose one students from each groups to present the differences that have been noted as well as question that student wanted to ask - Teacher ask any volunteer students to answer the question and summarize the difference that happen - Teacher then explain in detail about the difference of corrosion resistance between alloy and pure metals concept and play video about superconductor in alloy application	- Student note the differences that student found between students' result and the result that student observe - Student conduct a gallery walk in groups until every group has completed their turn - The chosen student present the differences that have been noted as well as question that student wanted to ask - Volunteer student answer the question and listen to the summary delivered by the teacher - Student focus and noted some key point from teacher explanation and watch video about superconductor in alloy application
	IDEA APPLICATION	- Teacher ask student to list characteristic of alloy that student identify on a paper - Teacher write the list of characteristic of alloy given by students on whiteboard - Teacher explain in detail about alloy characteristics and relate it with application of alloy - Teacher ask student about the advantage of alloy and their importance in daily life	- Student list the characteristics of alloy on a paper - Student listen carefully to the teacher's explanation about alloy characteristics and its relation with alloy application - Student answer teacher's question
	REFLECTION AND CLOSURE	- Teacher ask student to fill the exit ticket as a reflection of students' understanding - Teacher asked students to answer post-test - Teacher ask student if there any question or confusion in today's lesson - Teacher answer students' question in a simple way and easy for student to understand	- Student fill the exit ticket as a reflection of students' understanding - Student answer post-test that given by the teacher - Student ask question about today's lesson - Student listen to teacher's explanation
BBM/ABM/TMK/INNOVATION		Semiconductor in alloy application video, Projector, Presentation slide	

Global Sustainability	
Financial Education	

ASSESSMENT AND EVALUATION	
Written Exercise	/
Oral Assessment	/
Practical Report	
Presentation	/
Other (specify) :	

ASSESSMENT TECHNIQUE	Experiment result, Post test	
REFLECTION	1. Achievement of learning objectives **Cognitive** Define and give example of alloy based on their elemental composition **Affective** Identify students' level of understanding of alloy through self-conducted experiment **Psychomotor** Explain and describe the properties of alloy orally based on the experiment that student conducted 2. Issues/ problem faced during the lesson -Lesson start a bit late because students take time to go to science laboratory 3. Suggestion/ Improvement -Ask student to be more punctual next time and advise teacher subject before to complete lesson in time given	

APPENDIX K

Daily Lesson Plan for Control Group

DAILY LESSON PLAN 2024			
DATE : 12/9/2024`	DAY : THURSDAY	TIME : 11.10-12.10 PM	FORM : 4 BISTRO
TOTAL STUDENT : 20	SUBJECT : SCIENCE		

THEME	Exploration Elements in Nature		
TOPIC	Chemical in Industries		
CONTENT STANDARD	Alloy		
LEARNING STANDARD (Learning Outcome)	At the end of learning, student can: 1. Carry out experiment to compare the characteristics of alloys with its pure metals		
EXISTING KNOWLEDGE	The understanding of basic alloy concept from past class		
LESSON PHASES AND ACTIVITIES		**Activity**	
		Teacher activity	**Student activity**
STEP	**INDUCTION SET AND IDEA EXPLORATION**	- Teacher ask question about the difference of characteristics between alloy and pure metal that have been learned - Teacher explain learning objectives and success criteria that student should achieve in today's lesson	- Student answer teachers' question in turns - Student listen to teacher explanation carefully
	CONCEPT STRUCTURING AND RESTRUCTURING	- Teacher divide students into 4 small groups - Teacher explain task that student should complete in today's lesson - Teacher assign group 1 and group 2 to conduct experiment about characteristics of pure metals and alloy in term of hardness - Teacher assign group 3 and group 4 to conduct experiment about characteristics of pure metals and alloy in term of corrosion resistant	- Student sit in the group that have been divided by teacher - Student listen teachers' instruction about today's task - Student conduct the experiment diligently and carefully in the group assigned
	IDEA APPLICATION	- After experiment completed, teacher ask group 1 representative to move to group 3 and vice versa - Teacher ask group 2 representative to move to group 4 and vice versa	- Student listen to movement instruction given by teacher - Student move to destination that have been assign - Group representatives explain experiment obtained to the group

TEACHING STRATEGY	
Inquiry-Based Learning	
Constructivisme	/
Contextual Learning	
Mastery Learning	/
Problem-Based/ Project-Based Learning	
STEM Approach	
Scientific Investigation/ Experiment	/

21st CENTURY LEARNING APPROACH (PAK 21)	
Moral Values and Ethics	/
Communication	/
Collaborative	/
Creativity	/
Critical Thinking	/

PAK-21 ACTIVITIES	
Round Table	/
Think Pair Share	
Group Presentation.	/
Hot Seat	
Role play	/
Gallery Walk	
Three Stray One Stay	
Declamation /Drama	

I-THINK (THINKING MAPS)	
Circle	
Bubble	
Bridge	
Flow	
Tree	
Multi flow	
Brace	
Double Bubble	/

HOTS (Cognitive)	
Applying (C3)	/
Analysing (C4)	/
Evaluating (C5)	
Creating (C6)	

CROSS-CURRICULAR ELEMENTS (CCE)	
Language	
Environmental Sustainability	
Moral Value	/
Science & Technology	/
Patriotism	
Creativity and Innovation	/
Entrepreneurship	
Information Technology & Communication	
Global Sustainability	

		- Teacher then ask group representatives to explain experiment result obtained to the group - Teacher ask students in the group to note the group representatives' explanation and discuss among the group - Teacher ask students to go back to their seat - Teacher explain a bit about the concept of hardness and corrosion resistance in alloy and pure metal - Teacher ask student to write practical report regarding the experiment	- Students in the group take note the group representatives' explanation and start discussion among the group - Student go back to their seat - Student listen teacher explanation about the concept of hardness and corrosion resistance in alloy and pure metal	Financial Education **ASSESSMENT AND EVALUATION** Written Exercise / Oral Assessment / Practical Report / Presentation / Other (specify) :
	REFLECTION AND CLOSURE	- Teacher ask student to fill in Traffic Light card in order to track students' performance level in today's lesson - Teacher ask student if there is any question or confusion that student want to ask - Teacher answer the question given in a simple way and easy for student to understand - Teacher ask student to answer post-test	- Student fill the Traffic Light card as a reflection of students' understanding - Student ask question about today's lesson - Student listen to teacher's explanation and take note - Student answer post-test that given by the teacher	
BBM/ABM/TMK/INNOVATION		Laptop, LCD, Text Book, Presentation Slide, Experiment Tools and Apparatus, Traffic Light Card		
ASSESSMENT TECHNIQUE		Practical Report and Post-test		
REFLECTION		4. Achievement of learning objectives - Students are able to carry out experiment successfully in comparing the characteristics of alloy and pure metal 5. Issues/ problem faced during the lesson -Lesson start a bit late because students take time to go to science laboratory 6. Suggestion/ Improvement -Ask student to be more punctual next time and advise teacher subject before to complete lesson in time given		