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IDENTIFICATION OF MISCONCEPTIONS IN LEARNING THE CONCEPT OF THE ADSORPTION PROCESS

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Abstract

The purpose of this study was to identify misconceptions in chemistry for 1st-grade students about adsorption phenomena, including calculating adsorption isotherm models. To support this research, we give a test to level 1 students who had just entered lectures in the chemistry department. The test questions were about the concept of adsorption, adsorption isotherm models, and linearization. The results showed that there were misconceptions in 120 students. Only 44.45% of students answered the test without misconceptions, while 38.52% of students experienced misconceptions. The occurrence of misconceptions can be caused by the unequal process of understanding mathematics and chemistry when students study in senior high school. The concepts obtained by the students are different from the concepts actually explained by the experts. This research is expected to be an input for the development of improving students' abilities before entering further chemistry lectures.

Keywords: Adsorption isotherm, Adsorption, Certainty of response index (CRI), Education, Misconception.

1. Introduction

Misconceptions are prone to occur in students, especially during distance learning. Misconceptions occur because of differences in the understanding formed by students with the actual facts explained in literature [1]. To measure misconception, several diagnostic tools have been developed and used by researchers, including interviews [2]. multiple-choice tests (MCTs) [3]. word association [4], Certainty of Response Index (CRI) [5], two-tiers [6], three-tier diagnostic test [7], and four-tier diagnostic test [8]. These different diagnostic approaches for measuring misunderstandings in chemistry students have been widely utilized. Several examples are found, including misconceptions regarding redox titration, which is employed in the response index methodology. The multiple-choice exam procedure with open reasons has been used to assess misunderstandings regarding acid-base argentometric titrations among undergraduate students [9]. The three-tier exam method was used to evaluate high school pupils' knowledge of acids and bases [10]. While the interviews method was used to diagnose misconceptions on covalent and ionic bonding materials [11]. The two-tier technique was used to diagnosis misunderstandings in Separation of Matter [12]. However, no one has mentioned how to discover misunderstandings in undergraduate students studying chemistry in the research that has been published.

CRI is a measure of certainty of students' answers to the questions given. The CRI method can distinguish between students who know the concept, do not know the concept, or misconceptions [13]. The certainty of answers from students is described by the CRI value, the smaller the CRI value given by the students indicates a lack of confidence in answering questions. If students answer the question correctly and give a high CRI score then the student belongs to understands the concept, if the student answers the question incorrectly and gives a high CRI score the student have a misconception, whereas if the student answers the question incorrectly but gives a low CRI score the student classified by does not understand the concept [14].

Therefore, the purpose of this study was to identify misconceptions in level 1 undergraduate students in chemistry subjects about the concept of adsorption and its phenomena, including calculating the linearization of adsorption isotherm. In this research, we conducted a test on level 1 chemistry students. We detect misconceptions in students' understanding of mathematical chemistry concepts. Misconceptions can occur in students because of the wrong understanding of the learning obtained in high school. This research is expected to describe the students' initial mathematical chemistry abilities so that this research can be an evaluation for lecturers before students enter the world of lectures.

2. Method

In this study, we used the CRI to identify misconceptions among 120 undergraduate chemistry students in level 1. The CRI was used to detect and discriminate between pupils who had misunderstandings about the idea and those who did not understand it. The confidence/certainty with which a responder answers each question is measured by the CRI. CRI is supplied with each question to determine the amount of guessing used by pupils in answering the questions. The CRI scale in Table 1 reflects the level of confidence of the responses.

Table 1. CRI and criteria.

CRI	Criteria
0	(Totally guessed answer) 100% guessed
1	(Almost guess) guess rate between 75 - 99%
2	(Not Sure) guess rate between 50 - 74 %
3	(Sure) guess rate between 25 - 49 %
4	(Almost certain) guess rate between 1 - 24 %
5	(Certain) guess rate between 0 %

We ran a test to determine the students' misunderstandings. Each exam question had 23 multiple choice questions followed by a CRI level guess. We were able to determine students' knowledge based on their responses to the questions and the amount of guessing, namely students comprehend the idea, lucky guess, do not understand the concept, and misunderstandings, using this technique.

Table 2 shows a list of questions we gave to students. The questions given are questions about linearization and adsorption. The total number of questions given is 23 questions.

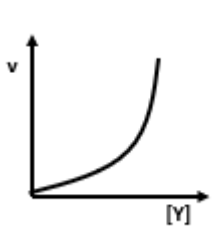
Table 2. List of questions we gave to students.

No.	Question
1	A function has an independent variable and a dependent variable. The independent variable isa variable that can be considered as input or input for the system and its value can be taken arbitrarily. While the dependent variable is a variable whose value changes as a result of changes in the value of the independent variable. The independent and dependent variable of afunction y=2x+3 is …. a. y is the independent variable and x is the dependent variable b. x is the independent variable and y is the dependent variable c. 2 is the independent variables and 3 is the dependent variables d. 2 is the dependent variables and 3 is the independent variables e. y is the independent variable and 2x + 3 is the dependent variable
2	If there is a function y=mx + C, the independent variable and the dependent variable are …. a. y is the independent variable and x is the dependent variable b. x is the independent variable and y is the dependent variable c. m is the independent variable and C is the dependent variable d. C is the independent variable and m is the dependent variable e. y is the independent variable and mx + C is the dependent variable
3	The independent variable and the dependent variable of the function P=10Q + 8 are…. a. P is the independent variable and Q is the dependent variable b. Q is the independent variable and P is the dependent variable c. 10 is the independent variables and 8 is the dependent variables d. 10 is the independent variables and 8 is the dependent variables e. P is the independent variable and 10Q + 8 is the dependent variable
4	It is known that the linear equation f(x) = ax + b. If f(2) is equal to 7 and f(5) is equal to 16,then the equation of the linear function is ....

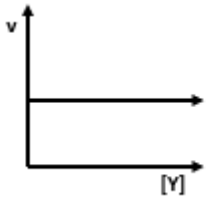
No.	Question
	a. f(x) = x + 3 b. f(x) = x – 3 c. f(x) = 3x + 1 d. f(x) = 3x – 1 e. f(x) = 3x-3
5	Known data on the results of chemical reactions:

No.	[X]	[Y]	v
1	0.2	0.2	0.0022
2	0.2	0.6	0.00198
3	0.2	0.6	0.00198

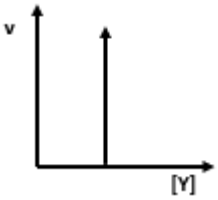
The graph that describes the functions v and [Y] is



(a)



(b)



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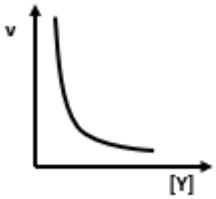
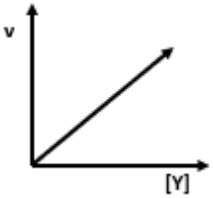


(d)



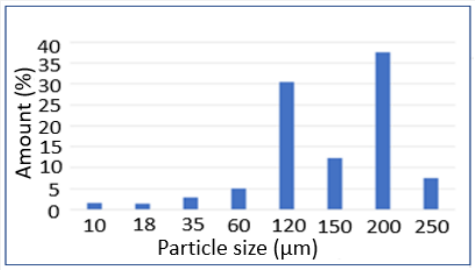
(e)

6	The following is the particle size data of pumpkin carbon after separation using a meshsieve

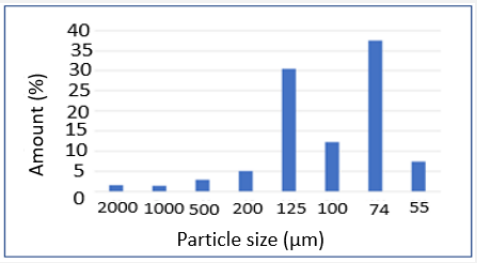
Mesh size	Convert mesh size to microns	Amount (%)
10	2000	1.49
18	1000	1.34
35	500	2.88
60	200	5.00
120	125	30.50
150	100	12.31
200	74	37.60
250	55	7.43

No.	Question
	The bar chart of the most appropriate mesh size and frequency is….

a.



b.



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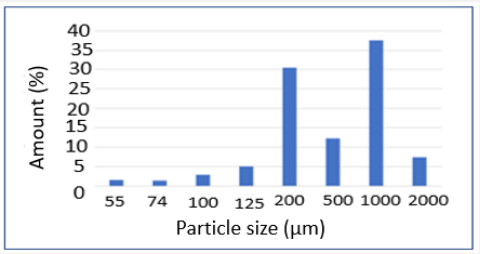
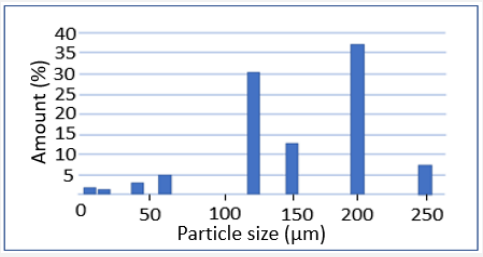
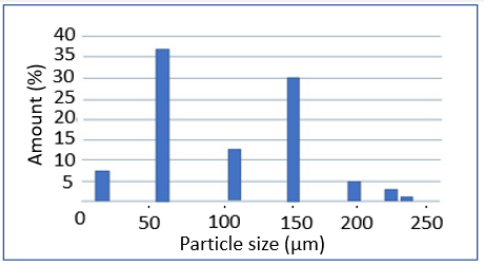


d.



e.



7	The following is the particle size data of pumpkin carbon after separation using a meshsieve…

No.	Question		
	Mesh size	**Convert mesh sizeto microns**	**Amount (%)**
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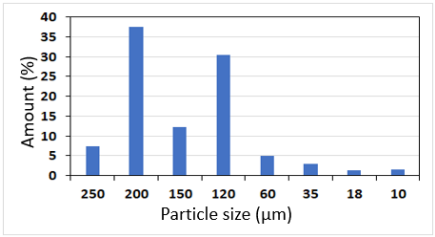
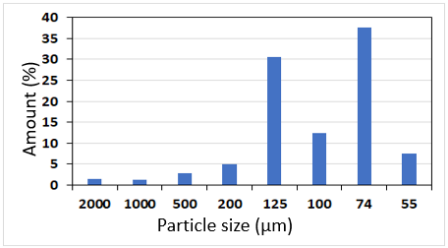
	18	1000	1.34
	35	500	2.88
	60	200	5.00
	120	125	30.50
	150	100	12.31
	200	74	37.60
	250	55	7.43

The bar chart of the micron size with the most appropriate frequency is

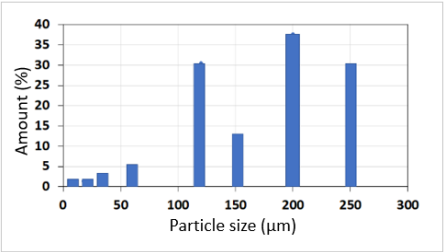
a.



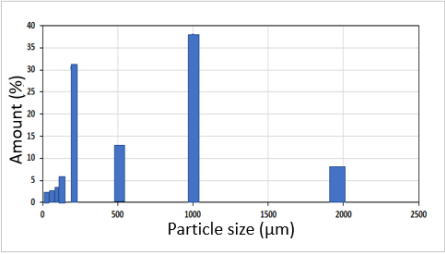
b.



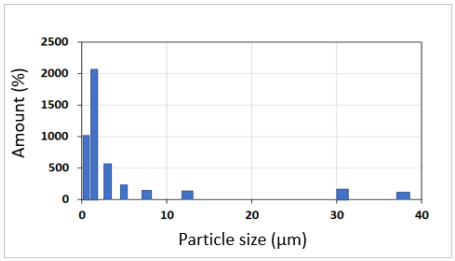
c.



d.



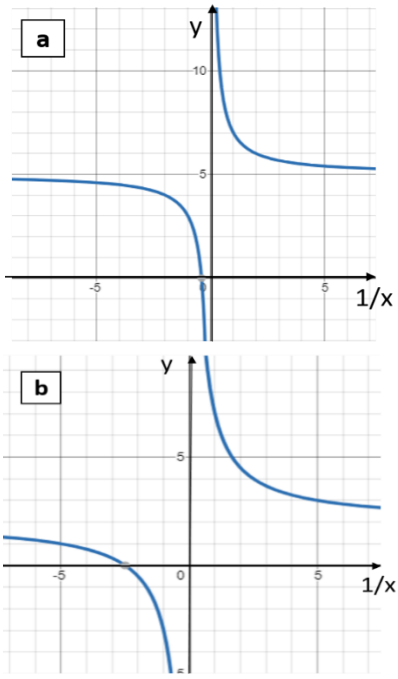
No.	Question

e. 

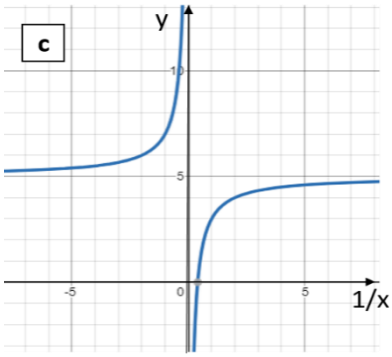
8 A linear function is a function whose independent variable has the highest power of 1. This function is said to be linear because the graph of the function in the Cartesian diagram has astraight-line curve. An example of a linear function is…

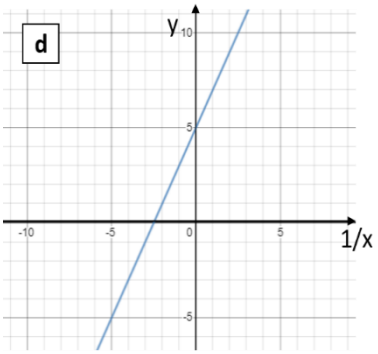
a. $2x^2 + 3x + 5 = 0$
b. $6x + y + 9 = 0$
c. $(2x + 3)(x - 2) = 0$
d. $5x^3 + 4x + 6 = 0$
e. $(3x + 1)(2x + 2) = 0$

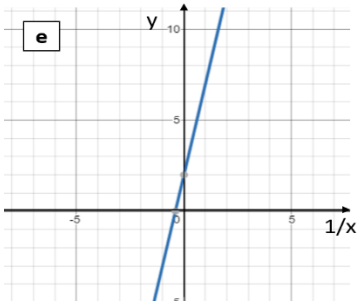
9 Known an equation $y = 2/x + 5$.The graphic image of the equation is….



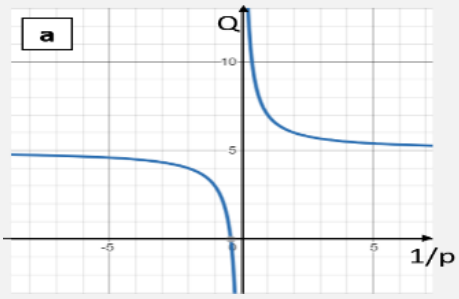
No.	Question



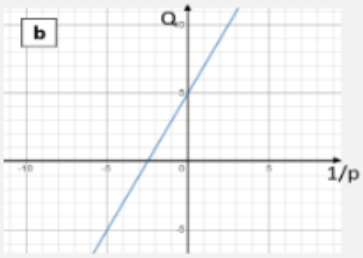


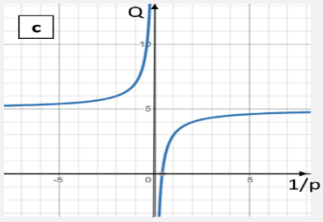


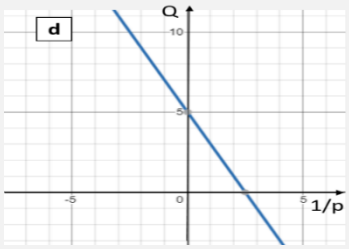
10 Know an equation Q= 2/*p* +5. If you want to make it as a linear function, then the possible graph of the equation is

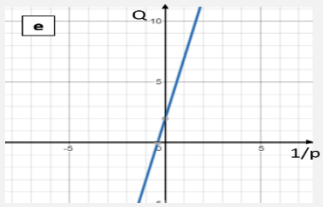


No.	Question



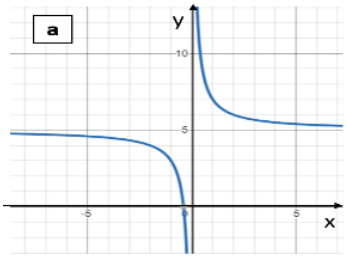


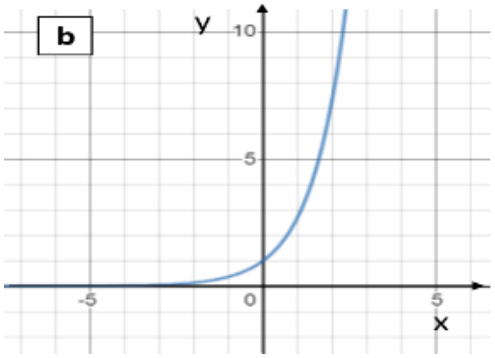
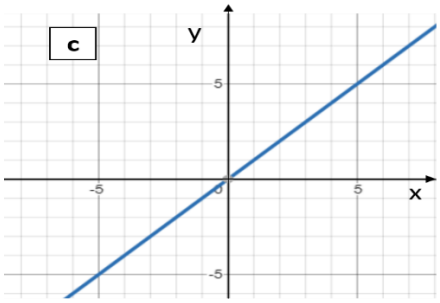
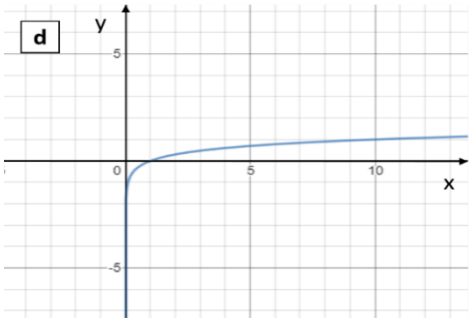
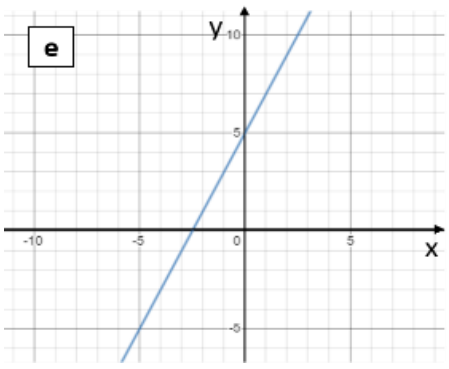




11 Know an equation y = log x + C. A possible graphic image of the equation is….

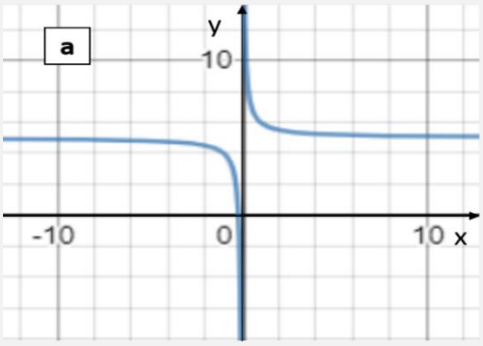
a.



No.	Question
	b. 
	c. 
	d. 
	e. 
12	Graph of from equation y = log x + 5 that is…. (x axis = log x)

No.	Question

a.



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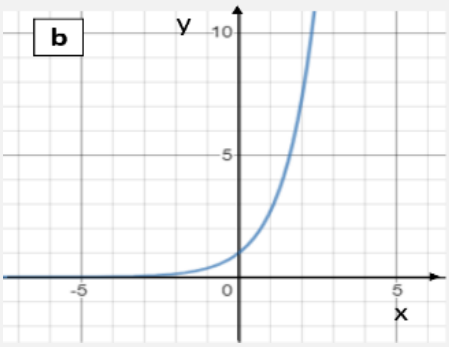

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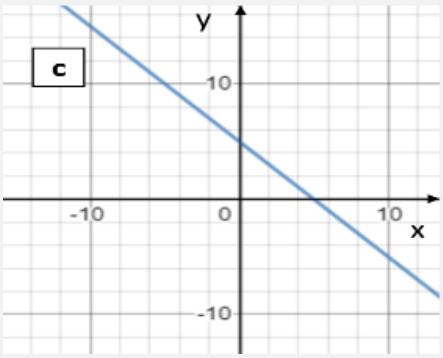
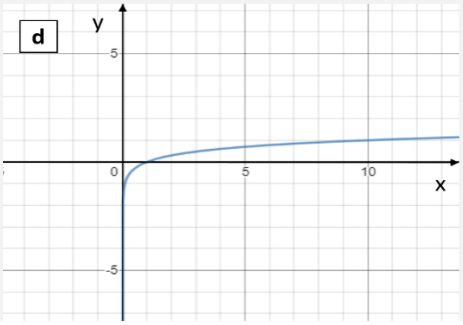
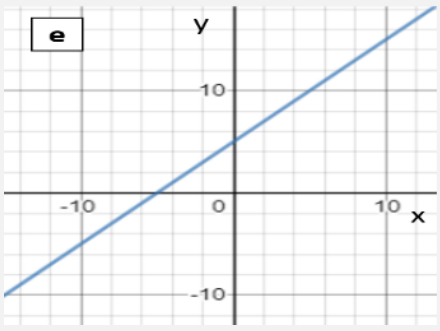


d.



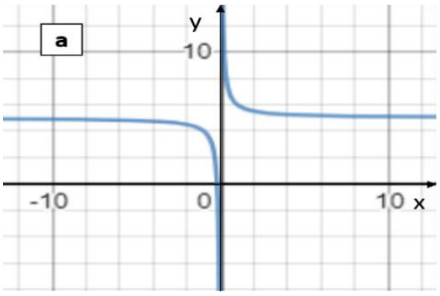
No.	Question

e.

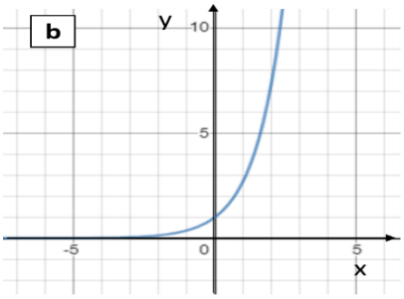


13 Graph of equation $Y= X^5+3$ is….

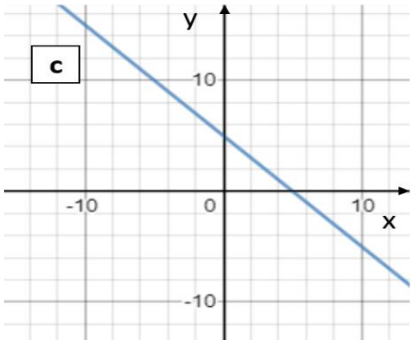
a.



b.

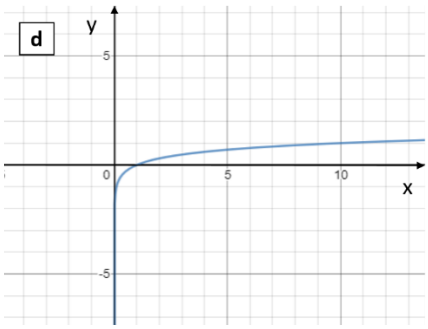


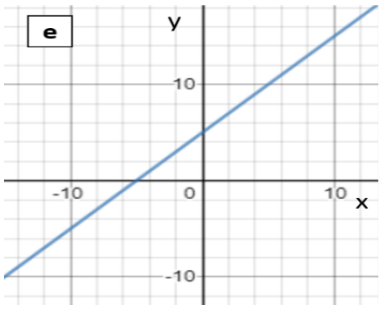
c.



d.

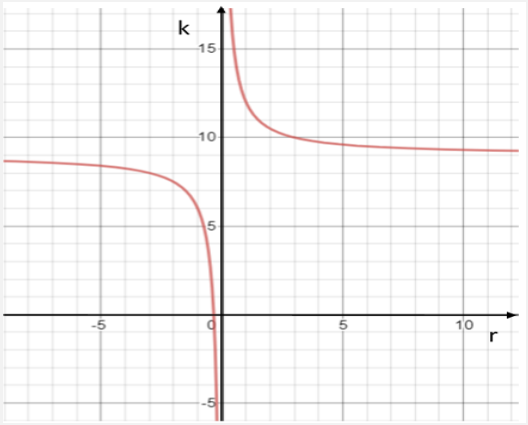
No.	Question





e.

14 Graph of equation $k = 3/r + 9$ is…



In order to produce a linear graph, the equation k can be changed to

a. $k = 3/r + 9$

b. $k-9 = 3/r$

c. $k = 3\,(1/r) + 9$

d. $r = 3/k - 9$

e. $1/k = r/3 + 9r$

15 The independent variable and the dependent variable of the function k = 7r-19 are r and k, respectively. If a curve is made, the x-axis of the equation is ….

a. k

No.	Question
	b. 7r c. r d. -19 e. 7r-19
16	When the function y=ax + b will be drawn a graph, the y-axis of the graph is …. a. y b. ax c. x d. ax + b e. b
17	A linear equation is an algebraic equation, where each term contains a constant or a constant multiplication by a single variable. This equation is said to be linear because this mathematicalrelationship can be described as a straight line in the Cartesian coordinate system, which can be written as a function y=mx+c. Given a function $\log q_e = \log q_s - (\beta\varepsilon)^2$, where q_e is the theoretical isotherm saturation capacity, β is the Dubinin-Radushkevich isotherm constant, ε is the Polanyi potential associated with the equilibrium condition. The function has the independent variable ε^2 and the dependent variable $\log q_e$. q_s and β are constants. If you want to make a linear graph of the equation, the x-axis and y-axis of the equation are …. a. axis x = $\log q_s$ and axis y= $\log q_e$ b. axis x = q_s and axis y = q_e c. axis x = ε^2 and axis y = $\log q_e$ d. axis x = ε^2 and axis y =β e. axis x =$\log q_e$ and axis y = $\log q_s$
18	Adsorption isotherm is a relationship that shows the distribution of the adsorbent between the adsorbed phase on the adsorbent surface and the bulk phase at equilibrium at a certain temperature. Several models are commonly used to explain adsorption isotherms including Freundlich, Langmuir, Temkin, Dubinin-Radushkevich, Flory-Huggin, Fowler-Guggenheim, and Hill-de Boer. It is known that the Temkin isotherm adsorption model has the equation $q_e = \beta_T(\log A_T.C_e)$ The linear equation (in the form of y=mx+c) of the adsorption model is $q_e = \beta_T(\log C_e) + (\beta_T \log A_T)$ If a graph is made, the x-axis and y-axis of the linear equation are…. a. axis x = q_e and axis y = β_T b. axis x = $\log C_e$ and axis y = q_e c. axis x = β_T and axis y = q_e d. axis x = A_T and axis y = C_e e. axis x = $\log C_e$ and axis y = q
19	It is known that the Langmuir isotherm adsorption model has the equation $q_e = \frac{q_m.K_L.C_e}{1 + K_L.C_e}$ If the X-axis is$\frac{1}{C_e}$, and the Y-axis is$\frac{1}{q_e}$, if you want to make a graph that has a straight curve as y=mx+c (linear equation) of the adsorption isotherm model is ….

No.	Question
	a. $^{C_e}/_{q_e} = \left(^{C_e}/_{q_m}\right) + \left(^{1}/_{b * q_m}\right)$ b. $^{1}/_{q_e} = \left(^{1}/_{b * q_m}\right) * \left(^{1}/_{C_e}\right) + \left(^{1}/_{q_m}\right)$ c. $^{1}/_{q_e} = \left(^{1}/_{q_m . K_L}\right) * \left(^{1}/_{C_e}\right) + \left(^{1}/_{q_m}\right)$ d. $q_e = q_m - \left(^{1}/_{b}\right) * \left(^{q_e}/_{C_e}\right)$ e. $^{q_e}/_{C_e} = b * q_m - b * q_e$
20	It is known that the Freundlich isotherm adsorption model has the equation $q_e = K_f . C_e^{1/n}$ The linear equation (in the form of y=mx+c) of the adsorption model is $log\ q_e = log\ k_f + \frac{1}{n}\ log\ C_e$. If a linear graph is made, the X-axis and Y-axis of the graph are, respectively... a. K_F and q_e b. log q_e and log K_F c. log K_F and log C_e d. log K_F and log q_e e. log q_e and log C_e
21	The linear equation (in the form y=mx+c) of the Flory-Huggins adsorption model is $log\ \left(\frac{\theta}{C_0}\right) = nFH\ log\ (1-\theta)\ +\ log\ k_{FH}$. where *nFH*, *KFH*, and C_0 are constant. The independent variable and the dependent variable from the graph of the linear equation are…. a. independent variable Log k_{FH}, dependent variable $log\ \left(\frac{\theta}{C_0}\right)$ b. independent variable *nFH*, dependent variable $log\ \left(\frac{\theta}{C_0}\right)$ c. independent variable $log\ \left(\frac{\theta}{C_0}\right)$, dependent variable *nFH* d. independent variable log (1- θ), dependent variable $log\ \left(\frac{\theta}{C_0}\right)$ e. independent variable $log\ \left(\frac{\theta}{C_0}\right)$, dependent variable log (1- θ)
22	The general equation of a linear function is y=mx+C. m represents the gradient of the line, while the constant c is the point where the line intersects the y-axis. The linear equation of theFowler–Guggenheim isotherm adsorption model is (see figure). The x-axis and y-axis of the equation are, respectively θ and log (Ce(1-θ)/Co). The gradient of the linear equation of the Fowler–Guggenheim isotherm adsorption model is… $Log\left(\frac{C_e(1-\theta)}{C_0}\right) = -log\ k_{FG} + \frac{2.\theta.W}{R.T}$ a. $Log\left(\frac{C_e(1-\theta)}{C_0}\right)$ b. θ c. $\frac{2.\theta.W}{R.T}$ d. $-log\ k_{FG}$ e. $\frac{2.W}{R.T}$
23	The general equation of a linear function is y=mx+C. The linear equation of the Hill-de Boer isotherm adsorption model is

No.	Question
	$Log\left(\frac{C_e(1-\theta)}{\theta}\right) - \frac{\theta}{1-\theta} = -log\ k_1 + \frac{k_2\theta}{R.T}$ If it is known that the y- axis, and x-axis of the adsorption model are $Log\left(\frac{C_e(1-\theta)}{\theta}\right) - \frac{\theta}{1-\theta}$ and θ then the value of constant C from the linear equation of the Hill-de Boer isotherm adsorption model is…… a. $\text{Log}\left(\frac{C_e(1-\theta)}{\theta}\right) - \frac{\theta}{1-\theta}$ b. $\frac{k_2}{R.T}$ c. $-\log k_1$ d. θ e. 1- θ

3. Results and Discussion

Table 3 describes the analysis of student test results. There are 44.35% of students have an average of correct answers, and misconceptions as much as 38.52%.

Table 3. Student misconception.

Question number	Correct (%)	Misconception (%)
1	90	10
2	60	40
3	80	40
4	90	40
5	10	73
6	40	86
7	40	70
8	60	55
9	10	33
10	30	28
11	20	27
12	20	32
13	30	43
14	30	31
15	30	60
16	50	56
17	50	36
18	80	70
19	40	23
20	50	0
21	30	6
22	20	27
23	60	0
Average	44.35	38.52

The results of the data analysis show:

(i) In the first question, there are 10% misconceptions. The misconception is caused by questions that are not too difficult, the language used is simple, some students have good knowledge when studying basic material in senior high school.

(ii) In the second question, there are 40% misconceptions. Students experience misconceptions in determining the independent variable and the dependent variable from a linear equation. This may be because students are not taught about variable components in linear equations.

(iii) In question number three there is also a 40% misconception. This problem is still discussing the independent variable and the dependent variable of an equation. These results strengthen the results obtained from the previous question regarding the occurrence of misconceptions in students about the variable components in linear equations.

(iv) In the fourth question about the equation of linear functions, students also experienced misconceptions by 40%. This misconception can be caused by students' errors in mathematical calculations. Because this question is easy but requires students to be careful in working on the problem.

(v) In question number five students have misconceptions 73%. This problem discusses the graph of the function of a chemical reaction. Misconceptions can occur because of knowledge that most students have misconceptions when studying chemical reactions in senior high school

(vi)In the sixth question, 86% of students have misconceptions. This question is used to analyse students' misconceptions about bar charts, especially writing the right scale on bar charts. Misconceptions can occur because of differences in students' understanding of the accuracy of writing scales on bar charts.

(vii) In the seventh question, students experienced a misconception of 70%, this could be due to misconceptions in understanding the making of bar charts.

(viii) In the sixth question, 55% of students have misconceptions. This can be caused because the questions presented seem easy but have a higher cognitive level, so students find it difficult to answer questions correctly and have a high level of confidence.

(ix) The ninth question shows the misconceptions that occur in students by 33%. In this problem, students are required to choose the right graph of an equation. Some students have got a good understanding of graphing a function.

(x) Question number ten shows the occurrence of misconceptions by 28%. Similar to question number 9, this question requires students to choose the right graph describing the linearity of an equation

(xi) Problem number eleven is still the same as problem numbers 9 and 10, which is about determining the right graph for a linear function. These results confirm the occurrence of misconceptions in students, which is 27%.

(xii) Question number twelve shows the occurrence of misconceptions by 32%. This problem asks students to determine the graph of an equation, this result confirms the previous result that students have misconceptions in determining the graph of a linear equation.

(xiii) Problem number thirteen discusses an equation to produce a linear graph, students experience misconceptions by 42%. This misconception in students can be caused by higher-order thinking skills that have not been obtained by students as a whole.

(xiv) In the twelfth question, 31% of students experienced misconceptions. Misconceptions can be caused by the incomplete concept of linear equation graphs that students learn in senior high school

(xv) In the fifteenth question, 60% of students have misconceptions. This can happen because the students' cognitive level is quite high and the concepts that students understand about the graph of linear equations are still quite low.

(xvi) In the sixteenth question, 56% of students had misconceptions. This can be caused because students have misconceptions in determining the components of the y-axis and x-axis in a graph

(xvii) Students experience 36% misconceptions on question number seventeen. This can be caused by the complex language of the questions, which allows for differences in understanding the meaning and questions asked.

(xviii) In the eighteenth question, 70% of students have misconceptions. This question asks the concept of adsorption isotherm, misconceptions can occur because students are not familiar with adsorption because it is not taught in senior high school.

(xix) The nineteenth question shows the misconceptions experienced by students by 23%. This is due to the clarity of the language used in the questions, good understanding of the students, and also the cognitive level of the questions that are not too high

(xx) In the twentieth question, students' misconceptions are 0%. This can be because the concepts asked are still common to students, so most students answer students completely by guessing.

(xxi) In the 21st question, students showed 6% misconceptions. This question combines the understanding of variables in linear equations with the concept of adsorption. The low understanding of students about adsorption causes most students to give a CRI score of 0 which indicates that students answer the question with 100% guessing

(xxii) In question number 22, there is a 27% misconception. This question applies knowledge about independent and dependent variables on the concept of adsorption, but the low understanding of adsorption is thought to cause misconceptions in the answers given by students.

(xxiii) In question number 23, students showed that there were no misconceptions that occurred to students. This can be caused because students do not understand the concept of adsorption in question so that most students give a CRI value of 0 which indicates that the concept in question is still unknown to students.

The results show that students have some misconceptions. The prior knowledge that students have can prevent them from learning chemical mathematics and its application in adsorption [15]. Misconceptions in some chemistry concepts have also been reported to high school students. One that

affects misconceptions in learning abstract chemistry concepts is the learning method. Students' misconceptions can be eliminated by several methods [16].

Several studies have reported preventing misconceptions in students, including by teaching chemistry concepts using analogies [15]. Misconceptions can also be eliminated with the concept of a cartoon [17]. The concept of chemistry will be easier for students to understand if it is conveyed in the form of a cartoon, but this cartoon concept is more relevant to be used for teaching elementary students. Conveying chemical concepts by making models and using them when studying is also useful for eliminating misconceptions [18]. Guiding material teaching method also effective to prevent misconception [13]. Computer-assisted teaching also has been effective in eliminating misconceptions about some chemistry concepts [19]. The problem-based learning approach also preferred to eliminate the misconception [20].

Identifying prior knowledge at the beginning of learning is important to detect misconceptions in students. If students get misconceptions, teaching must be planned in such a way as to eliminate these misconceptions. Teachers must be aware of the inadequacy of teaching methods consisting only of the transfer of information. Teachers must be able to use different teaching techniques in conveying concepts.

Based on above results, we found the effectiveness in examining the problems. However, all evaluations were done in online system. The limitations of this study need to be considered because this research was conducted when the COVID-19 outbreak occurred online or from home studies that needs additional strategies for enhancing results and comprehension [21-29]. Thus, further analyses will be done in our future research.

4. Conclusion

The purpose of this study was to identify misconceptions in level 1 undergraduate chemistry students about adsorption phenomena including making linearization curves. The results showed that there were misconceptions in 120 students who is tested. Only 44.45% of students answered the test without misconceptions, while 38.52% of students showed misconceptions. The occurrence of misconceptions can be caused by the unequal process of understanding mathematics and chemistry when students study in senior high school. The highest misconception occurs in the concept of chemical reactions and function graphs and bar charting. These misconceptions can be caused by misconceptions of understanding mathematics and chemistry when students study in senior high school wrong calculations, misconceptions in chemical reactions taught in school, and the influence of the language used on the questions. This research described the students' misconception on the mathematical chemistry abilities, this research is expected to be an evaluation for the development of improving students' abilities before entering further chemistry lectures.

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