STUDENTS' CONCEPTIONS AND MISCONCEPTIONS IN CHEMICAL KINETICS IN PORT HARCOURT METROPOLIS OF NIGERIA

Macson J. Ahiakwo* and Chigozirim Q. Isiguzo**
*Faculty of Technical & Science Education, Rivers State University of Science & Technology
Port Harcourt, NIGERIA
**Department of Science & Technical Education, Rivers State University of Science & Technology, Port Harcourt, NIGERIA
Corresponding Email: mcsahia@yahoo.com

ABSTRACT

The purpose of the study was to probe the conception and misconception of senior secondary (SS3) and University (US) chemistry students in chemical kinetics in Rivers State, Nigeria. The study sample was made up of 107 SS3 and 93 US students. Two main instruments were used to collect data for the study. They are the chemical kinetic calculation problem and alternative conceptions test in chemical kinetics. Overall results of the study showed that students' performance in basic chemical kinetics calculation was generally poor with the mean scores less than one point. Item analyses on the conception test revealed that about 10% of the students were able to identify the correct answers while about 90% could not identify the correct answers. The university students were superior in performance than the secondary students in the conception test. These results were discussed in the study. *[African Journal of Chemical Education—AJCE 5(2), July 2015]*

INTRODUCTION

One striking significance of import in chemical kinetics is that the derivatives can provide a model for evaluating the growth of a science education project through examination entries [1, 2, 3, 3] Although Karl Popper, T. S. Kuhn and other co-workers have argued in their own knowledge what constitutes growth in scientific knowledge, the application of the kinetic model to growth seen to provide a better measuring growth index.

One stage in science curriculum development that is relevant in this discourse is the implementation of an added portion of the curriculum arising from the growth. This is where teaching and learning is done. The impact of teaching is evidenced in the performance of the learner. It is in this vein that it is suspected that, there could be a link between a growth in a science education project and the performance of science students. It is also possible to use the kinetic model to evaluate the growth of a science education project considering the performance of the students after ascertaining their entries.

If this is the case, we expect science educators to be conversant with the principles of chemical kinetics. It becomes worrisome when some chemical educators perceive chemical kinetics and related concepts difficult to teach [4, 5]. Studies have also reported that students perceive chemical kinetics and related concepts difficult to learn [4, 5].

Cakmakci: [6] in a study carried out with upper secondary students, first year and third year university students in Turkey reported that students encounter difficulties in chemical kinetics because they are unable to differentiate reaction rate and reaction time in understanding that the reactions had the highest rate of the beginning of the reaction and the lowest at the end; confuse the chemical kinetic concepts with the thermodynamic concepts to mention a few.

Cunningham [7] also added that the trouble with some first-year college students is their problem of identifying a change that is clearly chemical as to physical in nature.

Chemical kinetics is a vital discipline to grasp in order to comprehend a chemical change in its perspective. It also provides vital skill sought for by physical chemists in particular and hence its comprehension is highly desirable [8]. Chemistry teachers, notwithstanding the difficulties encountered by the students, are making frantic efforts in making chemical kinetics less difficult and interesting to learn.

For the past ten years, chemical educators have been advocating the use of Systematic Approach to Teaching and Learning (SATL) in preparing lesson delivery for chemical concepts including chemical kinetics [9, 10]. In SATLC technique the concepts are positioned in such a way that the relations between a series of ideas and issues are made logical. The basic goal of this approach is the achievement of meaningful (deep) learning by students. In preparing lessons based on this approach and other techniques, reference is made to the previous experience or what the learner already knows.

SATL model seems to suggest that one way of teaching a learner is to use what is in the learners' memory (construct). A learner's construct of an idea or concept could be correct or incorrect. Being correct or incorrect depends on the teacher's standard by way of matching the learner's response to a task with his (teacher's) marking scheme. To the learner, the response (answer) given whether adjudged correct or incorrect by the teacher is correct. The teacher's concern is how to correct the misconception. The educator will be concerned about the significance of misconception in the learning of an individual.

According to White and Gunstone [11] there is nothing wrong with an operational definition of a complex construct like understanding, provided that we recognize that the definition is not the only possible way of measuring it. Restriction of measurement to one form, or too small a number of forms can distort the construct and lead to neglect of important aspects of it.

White and Gunstone [11] noted further that in physics, tests of understanding in Australia and America are mainly short problems which may be multiple choice objective tests (in this sense students constructs can be cued). Chemistry like physics can be tested in a similar way for understanding.

Therefore using chemical kinetics and considering secondary and university students, questions could be asked, namely,

1. What are the general performances of the students in the basic calculation involving chemical kinetics? Is there any significant difference between the mean score of the senior secondary students (SS3) and that of the university students (US) in chemical kinetics calculation?
2. What proportions of the students possess the correct conception and misconception about the questions on chemical kinetics?

METHODOLOGY

The study is of the descriptive type. A total of 409 SS3 students and 196 third year chemistry students in the University (US) in Port Harcourt Metropolis of Nigeria constituted the population of the study. The sample of the study was made up of 107 SS3 students and 93 US. These students indicated their interest to participate in the study. It was observed that the SS3 students and the year 3 university students were studying chemical kinetics at their various levels in the schools. This was what informed their inclusion in the study.

Instrument

Two main instruments were used in collecting data for the study. They are (1) chemical kinetics calculation problem (CKCP) and (2) Alternative conceptions test in chemical kinetics (ACT).

CKCP is a one-item calculation test based on elementary knowledge of chemical kinetics. Thus: when 0.5g of calcium trioxocarbonate (IV) was added to excess dilute hydrochloric acid, carbon (IV) oxide was evolved. The entire reaction took 5 minutes. What was the rate of reaction?

The stages to the solution of the problem are given as:

(a) $CaCO_{3(S)} + 2HCl(aq) \rightarrow CO_2(g) + H_2O_{(l)} + CaCl(aq)$

$CO_3^{2-}{}_{(S)} + 2H+(aq) \rightarrow CO_2(g) + H_2O_{(l)}$

(b) Rate of reaction = $\frac{mass\ of\ reactant}{time\ taken\ for\ the\ reaction}$

(c) Mass of reactant ($CaCO_3$) = 0.5g

Time taken for the completion of reaction = 5 minutes

(d) Find out amount in moles of 0.5g of $CaCO_3$, using the molar mass of $CaCO_3$, given that Ca = 40, C = 12, 0 = 16

Molar mass of $CaCO_3$ = 40 + 12 + (16 x 3)

= 40 + 12 + 48 = 100

Amount in moles of 0.5g = = $\frac{mass\ (m)}{molar\ mass\ (M)} == \frac{0.5}{100} = 0.005\ moles$

(e) Find out how many seconds in 5 minutes:

60 seconds x 5 minutes = 300 seconds

(1 minute = 60 seconds)

$\therefore$ Rate = $\frac{0.005}{300}\ mols^{-1}$

= $0.0000166 mols^{-1}$

= $1.66 \times 10^{-5}\ mols^{-1}$

From the solution of the problem, students' expected abilities in chemical kinetics problems were mapped out, these included students'

(i) ability to distinguish between a physical change and a chemical change;

(ii) ability to write balanced chemical equations to represent reactions;

(iii) ability to identify reactants and products of the reaction;

(iv) ability to write rate equation;

(v) ability to carry out simple computation involving mass of substance and time;

(vi) being able to specify the correct unit to all measurements of rate of reaction; and,

(vii) being able to identify factors influencing chemical reactions.

Alternative Conceptions Test in chemical Kinetics (ACT) was drawn up based on the identified expected students' abilities. The specification table is shown on Table 1.

Table 1: Specification Table of ACT

Students' Abilities	**Item No.**	**Total**
i. Ability to distinguish between a physical change and a chemical change	1, 2, 3,	3 items
ii. Ability to write balanced chemical equations to represent reactions	13, 14, 23, 32, 34,	5 items
iii. Ability to identify reactants and products of a reaction	16, 28, 37	3 items
iv. Ability to write rate equation	21, 22, 24, 25, 29, 36	6 items
v. Ability to carry out simple computation involving mass of substance and time	30, 31	2 items
vi. Ability to specify the correct unit of measurement of rate of reaction	26	1 item
vii. Ability to identify factors influencing chemical reactions	4, 5, 6, 7, 8, 9, 10, 11, 12, 15, 17, 18, 19, 20, 27, 33, 35, 38, 39, 40	20 items
Total	**40 items**	**40 items**

Altogether there are forty (40) items in ACT. The two instruments were given to three doctoral students in chemical education to check considering the level of the students, content and the answers to the question. The students had this assignment for two weeks to enable them do a thorough job. After this period, the investigators had a discussion with the postgraduate students with respect to the validity of the instruments. Some flaws were pointed out and a way out was suggested.

Scoring techniques were then decided. For the calculation involving chemical kinetics (using CKCP) each relevant statement, equation and computation identified in the written work of a student was scored one (1) point. For the ACT, any option chosen by the student was scored one (1) point.

The tests were then administered on thirty SS3 chemistry students in a school that was not chosen for the main study. There was first administration of the tests followed by a second administration of the tests after two weeks. A comparison of the two sets of scores of the CKCP using Pearson's Product Movement Correlation Coefficient Formula (PPMCCF) gave an r of 0.61. The scoring of the test was considered fairly reliable to be used in assessing the ability of the students to carry out calculations in chemical kinetics. For the ACT, item analyses were carried out on the first set scores which showed a mean facility value of 58% and mean discrimination index of 0.39. Computation of reliability coefficient (using PPMCCF) for the two sets of scores yielded an r of 0.68. The test was considered reliable in measuring the alternative choices of students' answers to chemical kinetics problems.

The tests were then administered to the students in their various institutions after permissions were sought from their various authorities. For each of the institutions, testing took place during a normal class period in the classrooms. So the institutions' programmes/activities were not affected by the administration of the instruments. Three teachers in the secondary school and two lectures from the university volunteered to assist in the invigilation of the students.

CKCP was administered first. Students were allowed 20 minutes. ACT was administered next after a break of 5 minutes. Students were allowed 40 minutes. It is important to note that students were supplied the answer sheets and question papers marked 001 to 107 for the secondary students and 108 to 200 for the university students. Students brought their writing materials to the examination hall.

RESULTS

These are presented according to the research questions of the study.

Research Question 1

What are the general performances of the students in the basic calculation involving chemical kinetics? Is there any significant difference between the mean score of the senior secondary students (SS3) and that of the university students (US) in chemical kinetics calculation?

Results are presented in table 2

Table 2: Mean Scores ($\bar{X}$) and standard deviations (sd) of SS3 and US students and t-test

Group	N	$\bar{X}$	Sd	df	t-value	Decision
SS3	107	0.89	0.18	198	5.19	Significant at p < .05
US	93	0.75	0.20			

Students' performance in basic chemical kinetic calculation was generally poor with the mean scores less than 1 point. It is observed in table 2 that SS3 students obtained higher mean score than the US in the basic calculation in chemical kinetics. The difference between their mean scores was significant at P < .05 (t = 5.19, df = 198).

Research Question 2

What proportions of the students possess the correct conception and misconception about the questions on chemical kinetics?

This question was answered by considering the various abilities of the students measured in the study. The results are displayed in Tables 3 to 9.

i. Students ability to distinguish between a physical change and a chemical change: Items 1, 2, 3, of the test (ACT) measured this ability. The results are shown in table 3.

Table 3: Proportion of conception and alternative conception of SS3 and US students in chemical kinetics questions

Item No.	Questions	Options	SS3(%)	US(%)
1.	Which is an example of a chemical reaction?	A. Melting of Ice	20.0	28.1
		B. The grinding of salt crystal to powder	12.5	5.8
		*C The burning of firewood	29.0	31.3
		D. The evaporation of water from the puddle	38.5	35.8
2.	Which is a chemical change?	A. Element 1 is hammered into a thin sheet	25.0	13.6
		B. Element 2 is heated and turned into a liquid	19.0	30.0
		*C Elements 3 turns a greenish colour as it sits in air	32.5	32.6
		C. Element 4 is grinded into a fire, slipping powder	23.5	23.8
3.	Which is not an example of a chemical change?	*A Boiling water	35.5	41.0
		B. Rusting water	31.5	22.0
		C. Burning wood	15.0	19.1
		D. Baking	18.0	17.9

* - correct answers (conceptions)

Task 3 revealed that over 29% of the students posses the correct conception about physical and chemical changes. About 71% possess misconceptions according to the incorrect options. Higher percentage of the University Students (US) performed better than the secondary students in distinguishing physical change from the chemical change.

ii. Students' ability to write balanced chemical equations to represent reactions: Items 13, 14, 23, 32 and 34 of ACT were used to measure the students' ability. The results are shown in Table 4.

Table 4: Proportion of conception and alternative conception of SS3 and US students in chemical kinetics questions

Item No.	Questions	Options	SS3 (%)	US (%)
13.	A mixture of powdered iron and sulphur is heated. What will be formed?	A. A single element	20.5	13.4
		B. Two other elements	12.5	14.2
		C. A solution	29.0	30.1
		*D A compound	38.0	42.3
14.	$CaCO_3(S) + 2HCl\ (aq) \rightarrow CaCl_2\ (aq) + H_2O_{(l)} + CO_2(g)$. In the reaction, the rate of reaction may be increased by ----?	*A Using powdered $CaCO_3$	12.0	16.3
		B. Using lumps of $CaCO_3$	6.0	16.3
		C. Applying high pressure	31.0	24.9
		D. Using dilute hydro-chloric acid	51.0	42.5
23.	Which of the following disciplines studies chemical reaction with respect to reaction rate, rearrangement of atoms, formation of intermediate complex?	*A Chemical kinetics	22.0	24.9
		B. Biogeography	15.0	18.2
		C. Biology	20.0	20.0
		D. Physical education	43.0	36.9
32.	Which of the following correctly represents the balanced chemical reaction between aluminum and sulphur?	*A $16Al+3S_8 \rightarrow 8Al_2\ S_3$	47.0	50.8
		B. $12Al + S_8 \rightarrow 4Al_3S_2$	13.0	13.7
		C. $8Al + S_8 \rightarrow 8AlS$	22.5	20.0
		D. $4Al + S_8 \rightarrow 4AlS_2$	17.5	15.5
34.	If additional calcium phosphate is added to the reaction mixture $2H_3PO_4 + 3Ca\ (OH)_2 \rightleftharpoons Ca_3\ (PO_4)_2 + 6H_2O$, what will happen to the overall reaction?	A. There will be no change in the overall reaction.	45.5	45.3
		B. The reaction will occur at a faster rate	18.0	20.4
		*C Less of the reactants will react in order to compensate for the increase in the amount of one of the products of reaction.	9.5	11.0
		D. More of the reactants will have to react in order to compensate for the increase in the amount of one of the products of the reaction.	27.0	23.3

* - correct answers (conceptions)

Table 4 revealed that students that possess the ability to write balanced equations constitute over 9% of the total sample. About 91% have difficulties in writing balanced equations. It was observed that more university students than the secondary students had right conception about writing balanced equations.

iii. Students ability to identify reactants and products of a reaction

Items 16, 28 and 37 were used to measure the students' ability. The results are displayed in Table 5.

Table 5: Proportion of conception and Alternative Conception of SS3 and US students in chemical kinetics questions

Item No.	**Questions**	**Options**	**SS3 (%)**	**US (%)**
16.	Which statement explains why the speed of some chemical reactions is increased when the surface area of the reactant is increased?	A. This change increases the density of the reactant particles.	52.0	36.4
		B. This change increases the concentration of the reactant particles.	38.5	29.9
		*C This change exposes more reactant particles to a possible collision	5.0	12.3
		D. This change alters the electrical conductivity of the reactant particles	4.5	21.4
28.	Two ways of reacting food with oxygen are…	*A Burning and respiration	5.0	47.3
		B. Burning and eating	12.5	10.0
		C. Energy and respiration	50.0	26.8
		D. Water and air	32.5	15.9
37.	For most irreversible reactants ….	A. The reaction rate increased with time	53.0	39.5
		*B. The reaction rate decreases with time	11.0	21.0
		C. The rate stabilizes with time	23.0	31.2
		D. The rate produces a curve with time	13.0	8.3

* - correct answers (conceptions)

For the students' ability to identify reactants and products of chemical reactions, Table 5 showed that over 5% of the students could do this, while about 95% of the students had difficulty. It was shown that more university students than the secondary students could identify reactants and products of chemical reactions.

iv. Students' ability to write rate equations: Items 21, 22, 24, 25, 29 and 36 were used to assess the students' ability. The results are shown in Table 6.

Table 6: Proportion of conception and alternative conception of SS3 and US students in chemical kinetics questions

Item No.	Questions	Options	SS3 (%)	US (%)
21	Which of the following reactions react rapidly at room temperature?	A. $2H_2 + O_2 \rightarrow 2H_2O$	21.0	33.7
		*B $H^+ + H^- \rightarrow H_2O$	29.0	29.1
		C. $C_{12}H_{22}OH \rightarrow 12C + 11H_2O$	24.5	30.0
		D. $H + OH \rightarrow H_2O$	25.5	7.2
22.	Which of the following burns easily?	A. A bar of steel	44.0	25.6
		*B Steel wool	17.5	21.3
		C. Steel sheet	14.0	36.1
		D. Steel pipe	24.5	17.0
24.	Which of these methods is not used to determine the rate of the reaction?	A. Change in amount of precipitate formed	31.0	21.9
		B. Change in intensity of colour	25.0	27.2
		*C. Change in pH value	25.0	25.0
		D. Change in total gas pressure	19.0	25.9
25.	The energy difference between the reactants and the transition state is ……………?	A. The free-energy	27.5	18.2
		B. The heat of reaction	36.0	33.7
		*C. The activation energy	21.5	25.8
		D. The kinetic energy	15.0	22.3
29.	If the temperature of a reaction is increased by the reaction will be 20^0c.	A. Two times as fast	11.5	23.1
		*B Four times as fast	25.0	19.6
		C. Twenty times as fast	32.0	40.0
		D. Unchanged because the reaction rate is not dependent on the temperature	31.5	17.3
36.	Minimum or critical amount of energy required before a chemical reaction could occur is called…?	*A. Reaction energy	17.5	17.8
		B. Effective collision	34.5	30.9
		C. Activation energy	23.5	32.1
		D. Activated complex	24.5	19.2

* - correct answers (conceptions)

The results in Table 6 revealed that over 17% of the students showed that they could write rate equations. About 83% had misconception related to the idea of rate equations. It was also found that more university students than the secondary students could write rate equations or identify related concepts.

v. Students' Ability to carry out simple computations involving mass of substance and time: Items 30 and 31 were used to assess the students' ability. The results are shown in table 7.

Table 7: Proportion of conception and alternative conception of SS3 and US students in chemical kinetics Questions

Item No.	Questions	Options	SS3 (%)	US (%)
30.	When the following reaction equation: $C_3H_8+O_2 \rightarrow CO_2 + H_2O$ is properly balanced, the amount in moles of O_2 will be…?	A. 1.5	27.5	30.1
		B. 3.5	55.0	33.1
		C. 3.0	7.5	15.8
		*D. 5.0	10 .0	21.0
31.	When the equation: $C_6H_{14} + O_2 \rightarrow CO_2 + H_2O$ is properly balanced, the amount in moles of O_2 will be…?	A. 1.5	39.5	37.2
		B. 13	11.5	13.8
		*C. 19	9.5	6.9
		C. 38	39.5	42.1

* - correct answers (conceptions)

Table 7 showed that over 9% of the students had the correct conception as regards computations involving mass and time.

vi. Students' ability to specify the correct unit of measurement of rate of reaction: Item 26 was used to measure the students' ability. The result is shown in Table 8.

Table 8: Proportion of conception and alternative conception of SS3 and US students in chemical kinetics questions

Item No.	Questions	Options	SS3 (%)	US (%)
26	The unit of rate of chemical reaction is…?	A. $moldm^{-3}s^{-1}$	7.5	11.0
		B. $mol^{-1}s^{-1}$	13.5	26.9
		*C. $mol\ s^{-1}$	18.5	39.0
		D. $Smol^{-1}$	60.5	23.1
31.	When the equation: $C_6H_{14} + O_2 \rightarrow CO_2 + H_2O$ is properly balanced, the amount in moles of O_2 will be	A. 1.5	39.5	37.2
		B. 13	11.5	13.8
		*C. 19	9.5	6.9
		D. 38	39.5	42.1
* - correct answers (conceptions)				

It is shown in table 8 that over 18% of the students could specify the correct unit in measurement involving reaction rate. About 82% of the students are unable to do this. Higher percentage of the university students than of secondary students is able to state the correct units of reaction rates.

vii. Students' ability to identify factors influencing chemical reactions: Items 4, 5, 6, 7, 8, 9, 10, 11, 12, 15, 17, 18, 19, 20, 27, 33, 35, 38, 39, and 40 were used to assess the students' ability. The results are shown in Table 9.

Table 9: Proportion of conception and alternative Conception of SS3 and US students in Chemical Kinetics Questions

Item No.	Questions	Options	SS3 (%)	US (%)
4.	Why does a catalyst cause a reaction to proceed faster?	A. They are more collisions per second only.	22.5	22.1
		B. The collisions occur with greater energy only	36.5	33.3
		*C. The activation is lowered only		
		D. There are more collisions per second	24.0	23.9
		and collisions are of greater energy	17.0	20.7
5.	What happens to a catalyst in a reaction?	*A. It is unchanged	48.5	48.0
		B. It is incorporated into the products	7.5	12.6
		C. It is incorporated into the	4.0	12.6

		reactants D. It evaporated away	40.0	26.8
6.	A catalyst works by...?	A. Lowering the activation energy barrier B. Shifting the equilibrium position towards the product C. Changing the temperature of the reactants D. Changing the particle size of the reactants.	32.5 27.5 30.0 10.0	31.1 33.5 19.3 16.1
7.	When oil is burning the reaction will...?	*A. Only release energy B. Only absorb energy C. Neither absorb nor release energy D. Sometimes release and sometimes absorb depending on the oil	50.0 11.5 5.0 33.5	35.3 19.7 7.6 11.5
8.	What drives chemical reactions?	*A. Energy B. Activation energy C. Electrons D. Physical conditions	27.5 31.0 22.0 19.5	28.0 30.8 19.2 22.0
9.	You store food in a fridge to prevent spoilage. What factor are you applying to show the rate of reaction?	A. Nature of reactant B. Isolation of reactant C. Avoid catalyst *D. Temperature	48.5 45.0 5.0 1.5	48.5 26.3 11.9 13.3
10.	The purpose of striking a match against the side of the box to light the match is......	A. To supply the activation energy *B To supply the free energy of the reaction C. To supply the heat of reaction D. To catalyze the reaction.	51.3 20.0 15.0 13.7	49.1 36.8 9.1 5.0
11.	Rate of chemical reaction depends on the following except...	*A. Rate at which gas is evolved. B. Rate at which product is formed C. Rate at which colour of reaction change D. Rate at which reactant diminish.	20.0 50.0 11.5 18.5	30.2 35.1 9.3 25.4
12.	Reaction rears when the colliding reactant particles.	A. Have energy less than the energy barrier B. Have energy equal or greater than the energy barrier *C. Have energy less than effective collision D. Have energy greater than that of the product.	31.0 25.0 23.5 20.5	23.2 24.3 29.0 23.5

15.	Which statement describes characteristics of an endothermic reaction?	A. The sign of H is positive and the products have less potential energy than the reactants.	3.5	11.7
		*B The sign of H is positive and the products have more potential energy than the reactant.	19.0	17.2
		C. The sign of H is negative and the product have less potential energy than the reactants		
		D. The sign of H is negative, and the products have more potential energy than the reactants.	25.0	24.7
			52.5	46.4
17.	Which conditions will increase the rate of a chemical reaction?	A. Decrease temperature and increase concentration of reactants	27.5	18.6
		B. Decrease temperature and increase concentration of products	19.5	15.8
		C. Increase temperature and decrease concentration of reactants	20.5	29.6
		*D. Increase temperature and increase concentration of reactants.		
			32.5	36.0
18.	In a chemical reaction, a catalyst changes the....?	A. Potential energy of the products	15.0	11.7
		B. Potential energy of the reactants.	8.0	19.9
		C. Heat of reaction	27.0	16.3
		*D. Activation energy	50.0	52.1
19.	Which procedure will increase the solubility of KCl in water?	A. Stirring the solute and solvent mixture	12.5	7.9
		*B. Increasing the surface area of the solute	24.0	26.3
		C. Raising the temperature of the solvent		
		D. Increasing the pressure on the surface of the solvent.	32.5	32.1
			31.0	33.7
20.	Reactions are generally faster at high temperature because the ...	A. Activation energy increases	48.5	34.7
		B. Energy of the product is lowered	5.5	11.1
		C. Energy of the reactant decreases	20.5	28.6
		*D. Number of effective collision		

		increases	25.5	25.6
27.	Why does a catalyst cause a reaction to proceed faster?	A. There are more collisions per second only	25.0	17.3
		B. The collision occurs with greater energy only	10.0	15.3
		*C. The activation is lowered only		
		D. There are more collisions per second and collisions are of	35.0	37.5
		greater energy	30.0	29.9
33.	Which of the following would not increase the rate of reaction?	A. Raising the temperature	31.0	35.1
		B. Adding a catalyst		
		C. Increasing the surface	42.0	20.3
		area of a solid reactant	7.0	11.2
		*D. None of the above		
			20.0	33.4
35.	Which of the following statements about chemical kinetics is not correct?	*A. The higher the activation energy, the faster the reaction	10.5	16.2
		B. The lower the activation, the faster the reaction		
		C. The higher the temperature, the faster the reaction	24.0	24.3
		D. The activation of a catalyst lowers the activation energy	15.5	16.0
			50.0	43.5
38.	What do we do to increase the surface area of the reactant?	A. Breaking them into chips	42.0	37.4
		*B. Subjecting the reactants to higher pressure	10.5	12.0
		C. Altering the direction of the reaction		
		D. Using reactant to different densities.	15.0	27.1
			32.5	23.5
39.	Which of the following does not affect the rate of a chemical reaction between non-gaseous reactants?	A. Concentration of reactants.	27.5	23.2
		B. Pressure	24.0	23.8
		C. Temperature	31.5	29.9
		D. Presence of a catalyst	17.0	23.1
40.	Temperature affects rate of reaction exception...?	A. Increase in frequency of collision.	29.5	35.3
		B. That it burns the reactants with reckless heating.	20.0	17.6
		C. It increases the kinetic energies of the reactant	32.5	24.9
		*D. The number of effective collision of the reaction	18.0	22.2

* - correct answers (conceptions)

Table 9 revealed that apart from item 9 concerning temperature as one of the factors influencing rate of reaction over 10% of the students were able to identify the various factors affecting chemical kinetics. About 90% of the students had misconceptions related to chemical kinetics factors. More university students than the secondary students had correct conceptions about the factors influencing rate of reactions. These findings need to be discussed.

DISCUSSION OF FINDINGS

Generally, students' performance in basic chemical kinetic calculation was poor with the mean scores less than one point. Cakmakci [6] and Cunningham [7] have reported the difficulties students have in learning concepts and related concepts of chemical kinetics. The nature of chemical reaction in chemical kinetics involving breaking and making of bonds and election transfer is such that the students can hardly conceptualize. This problem is recurrent as the students' progress from the secondary schools to the tertiary institutions.

Overall analyses (Tables 3-9) of the conception test revealed that about 10% of the students are able to identify the correct answers while about 90% could not identify the correct answers. This further suggests the degree of difficulty encountered by the students in learning chemical kinetics, the importance of this concept notwithstanding.

There is an issue that is noteworthy as to the performance of the secondary students and the university students. Namely, the senior secondary students were significantly better than the university students (Table 2) in carrying out elementary calculations in chemical kinetics. This may not be surprising because the chemistry course in chemical kinetics is more complex than the fundamentals at the senior secondary level. Generally the test items were elementary and at the fundamental level which the university students have studied long time ago and must have been overtaken by forgetfulness. The senior secondary students had an edge over the university students and so performed better than them. However, item analyses of the conception test showed the superiority was displayed by the university students in their better performance than the secondary students.

It behaves on the chemical educators to query the poor performance of the secondary students considering the fact that they are to pass into the higher institutions to study chemistry and have to come across chemical kinetics. Considering the results of the study, further research will be carried out to determine how the differential in the students' performance could be used to determine growth in chemical knowledge.

REFERENCES

1. Tebbuti, M. J. & Atherton, M. A. (1979). A "reaction kinetics" model for the growth of curriculum projects. *Journal of curriculum studies* 11(2), 159-166.
2. Tebbuti, M. J. (1978). The growth and eventual impact of curriculum development projects in science and mathematics. *Journal of curriculum studies* 10(1), 61 - 73.
3. Atherton, M. A. & Lawrence, J. K. (1970). *An experimental introduction to reaction kinetics*. Longman.
4. Onwu, G. O. & Ahiakwo, M. J. (1986). A study of pupils' perception of topic difficulties in 'O' and 'A' level chemistry in some selected Nigerian schools. *Journal of research in curriculum* 4(2), 1-13.
5. Bojczuk, M. (1979). Topic difficulties in 'O' – level and 'A' – level chemistry. *The school science review* 63(224), 545 - 551.
6. Cakmakci, G. (2010). Identifying alternative conceptions of chemical kinetics among secondary school and undergraduate students in Turkey. *Journal of Chemical Educatio*n 87(4), 449 - 455.
7. Cunningham, K. (2007). Application of reaction rate. *Journal of Chemical Education* 84(3), 430 - 433.
8. Summer, S., Shafi, A., & Naqvi, I. I. (2014). SATL model lesson for teaching effect of temperature on rate of reaction. *African Journal Of Chemical Education* 4(2) special issue (Part 1), 139 - 144.
9. Fahmy, A. F. M. & Lagowski, J. J. (2003) Systemic approach to teaching and learning chemistry (SATLC) in Egypt (1998-2011). *African Journal of Chemical Education* 2(2), 92-97.
10. Nazir, M.; Naqvi, I. I. & Khattak, R. (2013) SATL model lesson in chemical kinetics. *African Journal of Chemical Education* 3(1), 89-98.
11. White, R. & Gunstone, R. (1992). *Probing understanding*. London: Routledge Falmer Taylor & Francis Group 2-3.