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Chemical Kinetics Concepts Achievement Test (CKCAT)

Gultekin Cakmakci
B.Sc. (Ankara), M.A. (York), Ph.D (Leeds)
Associate Professor of Science Education

Hacettepe University
Faculty of Education
Department of Science Education
06532 Beytepe / Ankara
TURKEY
E-mail: cakmakci@hacettepe.edu.tr
http://gultekincakmakci.weebly.com/

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Related Papers:

Cakmakci, G. & Aydogdu, C. (2011). Designing and evaluating an evidence-informed instruction in chemical kinetics. *Chemistry Education Research and Practice*, *12*(1). 15-28.

Cakmakci, G., Leach, J & Donnelly, J. (2006). Students' ideas about reaction rate and its relationship with concentration or pressure. *International Journal of Science Education*, *28*(15), 1795-1815.

Cakmakci, G. (2010). Identifying alternative conceptions of chemical kinetics among secondary school and undergraduate students in Turkey. *Journal of Chemical Education*, *87*(4), 449-455.

Bektasli, B. & Cakmakci, G. (2011). Consistency of students' ideas about the concept of rate across different contexts. *Education and Science*, *36*(162), 273-287.

Cakmakci, G. (2009). Emerging issues from textbook analysis in the area of chemical kinetics. *Australian Journal of Education in Chemistry*, *70*, 31-38.

Cakmakci, G. (2005). Different ways of explanation: Descriptive/empirical vs. explanatory/theoretical. In H.E.Fischer (Ed.), *Developing Standards in Research on Science Education* (pp. 69-77). London: Taylor & Francis.

Cakmakci, G., Donnelly, J & Leach, J. (2005). A cross-sectional study of the understanding of the relationships between concentration and reaction rate among Turkish secondary and undergraduate students. In K. Boersma & O. de Jong & H. Eijkelhof & M. Goedhart (Eds.), *Research and the Quality of Science Education*. (pp. 483-497). Dordrecht: Springer.

Cakmakci, G. (2005). A cross-sectional study of the understanding of chemical kinetics among Turkish secondary and undergraduate students. Unpublished PhD Thesis. The University of Leeds, UK.

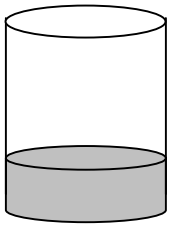
Question-1:

The following reaction occurs at room temperature (298 K):

$$Y_{(aq)} + P_{(aq)} \longrightarrow J_{(aq)}$$

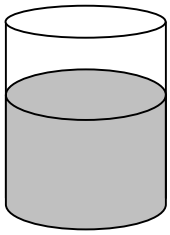
The reaction is set up under two different sets of initial conditions:

First set of conditions



Initial amount of Y= **10** mL, **2** mol/L
Initial amount of P= **10** mL, **2** mol/L

Second set of conditions



Initial amount of Y= **20** mL, **2** mol/L
Initial amount of P= **20** mL, **2** mol/L

These two identical beakers contain **different amount of** substances of Y and P. In each of the two cases compare the reaction rates.

(i) What would you say about **the rate** of these reactions?

Tick ONE box (√)

- ❑ The reaction under first set of conditions is **faster** than the reaction under second set of conditions
- ❑ The rates of reactions are **the same**
- ❑ The reaction under second set of conditions is **faster** than the reaction under first set of conditions

(ii) Explain your answer by providing reasons to support the claim you are making.

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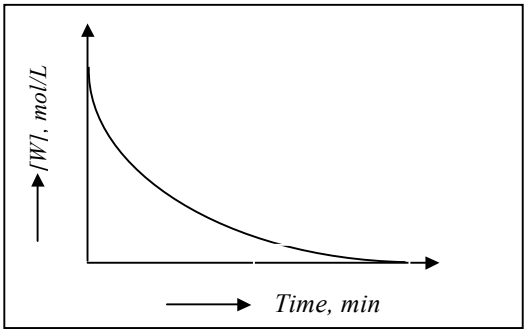
Question-2:

Consider a reaction where two chemicals 'W' and 'J' react to form 'Z'

$$W_{(aq)} + J_{(aq)} \longrightarrow Z_{(aq)}$$

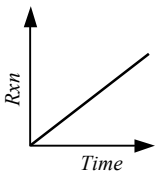
The teacher drew a graph showing how **the concentration of W** changes with **time**.



The teacher asks students to use the graph to draw a graph for the reaction rate against time.

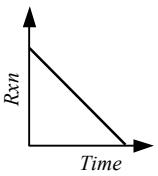
(i) How would **the reaction rate change against time?**

Tick ONE box (√)



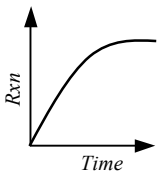
The reaction rate increases

❑ **(A)**



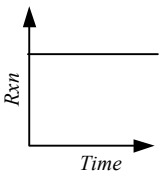
The reaction rate decreases

❑ **(B)**



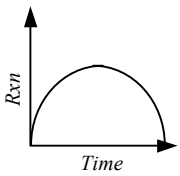
The reaction rate increases and then remains constant

❑ **(C)**



The reaction rate is constant

❑ **(D)**



The reaction rate increases and then decreases

❑ **(E)**

(ii) Explain your answer by providing reasons to support the claim you are making.

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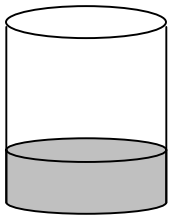
Question-3:

The following reaction occurs at room temperature (298 K):

$$T_{(aq)} + D_{(aq)} \longrightarrow R_{(aq)}$$

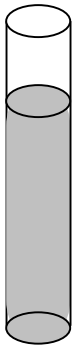
The reaction is set up under two different sets of initial conditions:

First set of conditions



Initial amount of T= **10** mL, **2** mol/L
Initial amount of D= **10** mL, **2** mol/L

Second set of conditions



Initial amount of T= **10** mL, **2** mol/L
Initial amount of D= **10** mL, **2** mol/L

Both beakers contain **same amount of** chemical species of T and D, however as can be seen from drawings the shapes of the beakers are different. In each of the two cases compare the reaction rates.

(i) What would you say about **the rate** of these reactions?

Tick ONE box (√)

- ❑ The reaction under first set of conditions is **faster** than the reaction under second set of conditions
- ❑ The rates of reactions are **the same**
- ❑ The reaction under second set of conditions is **faster** than the reaction under first set of conditions

(ii) Explain your answer by providing reasons to support the claim you are making.

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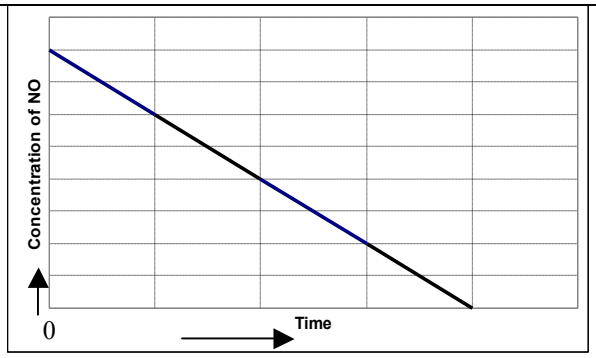
Question-4:



Some students did an experiment to find out the order of the reaction below:

$$2NO_{(g)} \xrightarrow{Pt} N_{2(g)} + O_{2(g)} \quad \Delta H < 0 \text{ (Exothermic)}$$

They measured the concentration of nitrogen monoxide (NO) regularly over time. This graph shows how the **concentration of NO** changes as time passes.

a- (i) After interpreting the graph, what would you say about this reaction? *Tick ONE box (√)*

☐ The reaction is zero order with respect to 'NO' and thus the rate expression for the reaction is: $r_{NO} = k\,[NO]^0 = k$

☐ The reaction is first order with respect to 'NO' and thus the rate expression for the reaction is: $r_{NO} = k\,[NO]^1$

☐ The reaction is second order with respect to 'NO' and thus the rate expression for the reaction is: $r_{NO} = k\,[NO]^2$

a- (ii) Explain your answer by providing reasons to support the claims you are making.

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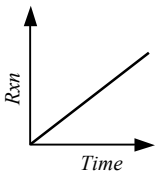
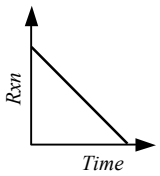
b- (i) What would you say about the rate of this reaction? How would the reaction rate change against time? *Tick ONE box (√)*



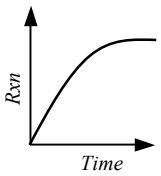
The reaction rate increases

☐ **(A)**



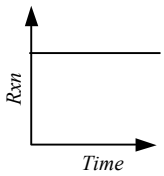
The reaction rate decreases

☐ **(B)**



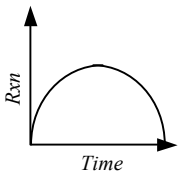
The reaction rate increases and then remains constant

☐ **(C)**



The reaction rate is constant

☐ **(D)**



The reaction rate increases and then decreases

☐ **(E)**

b- (ii) Explain your answer by providing reasons to support the claims you are making.

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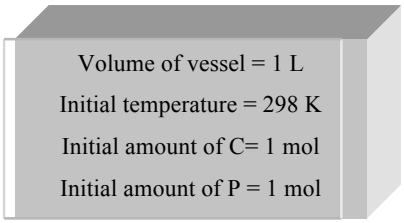
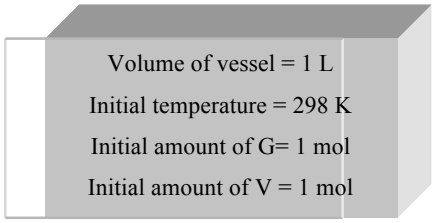
Question-5:



Reaction 1

$C_{(g)} + P_{(g)} \longrightarrow B_{(g)}$ $\Delta H < 0$ (**Exothermic**)



Reaction 2

$G_{(g)} + V_{(g)} \longrightarrow Q_{(g)}$ $\Delta H > 0$ (**Endothermic**)

These two identical vessels contain **different reactants.** In each of the two cases compare the reaction rates.

(i) What would you say about **the rate** of these reactions? *Tick ONE box (√)*

- ❑ Reaction 1 is **faster** than Reaction 2
- ❑ The rates of reactions are **the same**
- ❑ Reaction 2 is **faster** than Reaction 1
- ❑ It **is not possible to compare** the rates of these reactions, because there is not enough information given in the question.

(ii) Explain your answer by providing reasons to support the claims you are making.

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Question-6:

When a house was newly built both the hot and the cold water pipes in the kitchen were shiny. After a while, the **outside of these pipes** had become dull and rusty (covered with a thin, brown coating).

(i) What would you say about these pipes?

Tick ONE box (√)

- ❑ The outside of the cold water pipe would get rustier than the outside of the hot water pipe.
- ❑ Both water pipes would get same amount of rust on them.
- ❑ The outside of the hot water pipe would get rustier than the outside of the cold water pipe.

(ii) Explain your answer by providing reasons to support the claims you are making.

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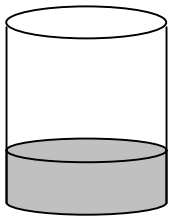
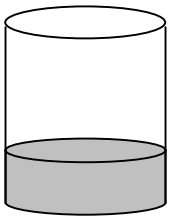
Question-7:

The chemical equations given below represent two hypothetical reactions. Consider these two reactions that have different activation energies ($\mathbf{E}_a$) occur at **the same temperature**;



Reaction 1

$Y_{(aq)} + P_{(aq)} \longrightarrow C_{(aq)}$ $\mathbf{E}_a = \mathbf{92\ kJ.mol^{-1}}$



Reaction 2

$T_{(aq)} + V_{(aq)} \longrightarrow Z_{(aq)}$ $\mathbf{E}_a = \mathbf{480\ kJ.mol^{-1}}$

(i) What would you say about **the rate** of these reactions? *Tick ONE box (√)*

- ❑ Reaction 1 is **faster** than Reaction 2
- ❑ The rates of reactions are **the same**
- ❑ Reaction 2 is **faster** than Reaction 1
- ❑ It **is not possible to compare** the rates of these reactions, because there is not enough information given in the question.

(ii) Explain your answer by providing reasons to support the claims you are making.

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Question-8:

$2NO_{(g)} + Cl_{2\,(g)} \rightleftharpoons 2NOCl_{(g)}$ $\Delta H < 0$ (**Exothermic**)

How the following condition would affect the rate of this reaction.

(i) Increasing the initial temperature of the system

- ❑ will increase **only** the rate of forward reaction
- ❑ will increase **only** the rate of reverse reaction
- ❑ will increase **both** the rate of forward and reverse reactions
- ❑ will decrease **only** the rate of forward reaction
- ❑ will decrease **only** the rate of reverse reaction
- ❑ will decrease **both** the rate of forward and reverse reactions

(ii) Explain your answer by providing reasons to support the claims you are making.

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Question-9:

The following reaction occurs at room temperature (298 K):

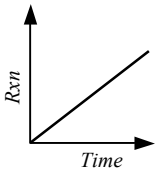
$$M_{(aq)} + Z_{(aq)} \longrightarrow G_{(aq)}$$

Some students measured the concentration of the product G regularly over time. The data is as follows:

Time (min)	Concentration of G (mol/L)
0	0
3	0.02
6	0.04
9	0.06
12	0.08

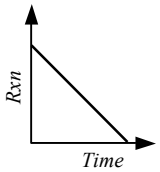
(i) How would **the reaction rate change against time?**

Tick ONE box (√)



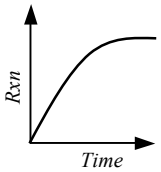
The reaction rate increases

❑ **(A)**



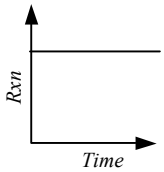
The reaction rate decreases

❑ **(B)**



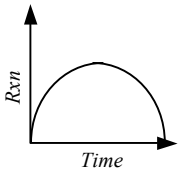
The reaction rate increases and then remains constant

❑ **(C)**



The reaction rate is constant

❑ **(D)**



The reaction rate increases and then decreases

❑ **(E)**

(ii) Explain your answer by providing reasons to support the claim you are making.

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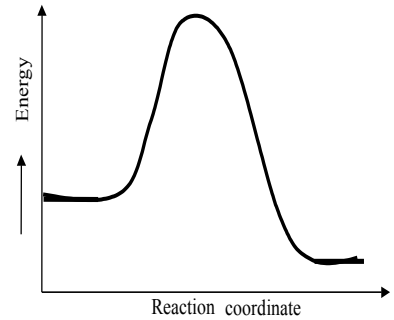
Question-10:

Consider a reaction where two chemicals 'X' and 'Y' react to form 'Q'. For this reaction, the equation for without a catalyst is presented below. The following figure shows a pathway for the uncatalysed reaction.

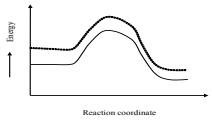
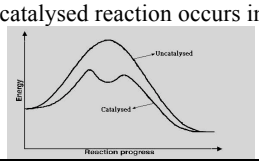
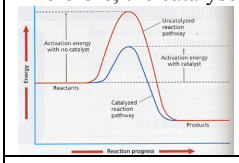
$$X_{(aq)} + Y_{(aq)} \longrightarrow Q_{(aq)} \qquad \Delta H < 0 \text{ (Ekzotermik)}$$



The equation for this reaction with 'W' catalyst is presented as follows:

$$X_{(aq)} + Y_{(aq)} \xrightarrow{W_{(aq)}} Q_{(aq)}$$

Read the following statements based on the information given above and t*ick ONE box (√)* for each statement as 'CORRECT', 'INCORRECT' or 'I DON'T KNOW'. Explain your answer by providing reasons to support the claim you are making.

Statements	**(A) CORRECT**	**(B) INCORRECT**	**(C) I DON'T KNOW**	**.....because.....**
The catalyst gives energy to the reaction, therefore it increases the activation energy (E_a) of the reaction. 				....
At the end of the reaction, the catalyst does not change.				....
During the reaction, the catalyst does not react with any of the reactants present and it does not change at the end of the reaction.				....
The catalyst changes the rate constant (k) of the reaction.				....
The catalyst changes pathways of the reaction in a way that the activation energy (E_a) of the reaction is lowered.				....
The catalyst changes the mechanism of the reaction. The catalysed reaction occurs in more than one step. 				....
The catalyst does not change the mechanism of the reaction. Therefore, the catalysed reaction also occurs in one step. 				....
The catalyst does not change the enthalpy of the reaction (ΔH).				....

This work should be cited as:
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Gultekin Cakmakci
B.Sc. (Ankara), M.A. (York), Ph.D (Leeds)
Associate Professor of Science Education

Hacettepe University
Faculty of Education
Department of Science Education
06532 Beytepe / Ankara
TURKEY
E-mail: cakmakci@hacettepe.edu.tr
http://gultekincakmakci.weebly.com/