

Consent form and FTDICK Instrument

CONSENT FORM

We are conducting an investigation into students' understanding of chemical reaction kinetics. As you will be studying this topic we would like you to attempt the following questions and choose reasons for your answers.

The results from the investigation will be used alongside data from other students to gain a better understanding of students' understanding of reaction rates and may be published in the educational literature. The outcomes will be completely anonymous and no participants will be identifiable.

If you are happy for your results to contribute to our investigation, please tick the box below:

☐ **I am happy to take part in this investigation and for my results to contribute to the investigation**

Signed:

Date:

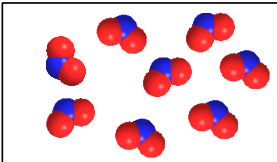
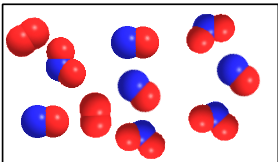
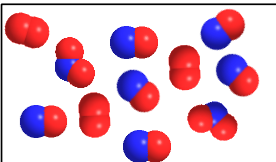
GENERAL CONFIDENCE IN CHEMISTRY

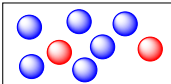
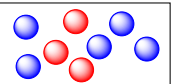
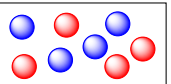
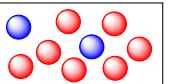
Instruction:

Before you answer the questions, please rate your confidence level in chemistry and chemical kinetics by circling the appropriate response.

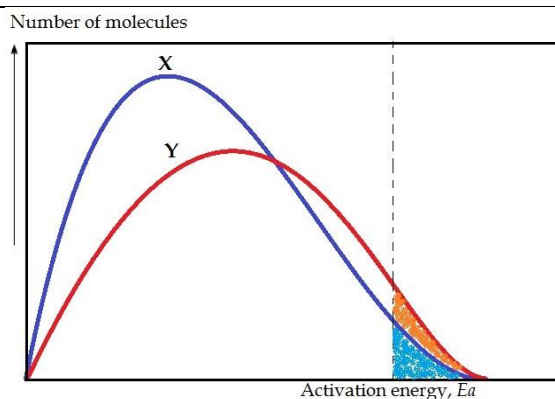
1. Please rate your overall confidence in your ability to be successful in a chemistry degree course.
1. Very unconfident 2. Not very confident 3. Average 4. Quite confident 5. Very confident
2. Please rate how confident you are in physical chemistry as compared to other areas of chemistry (for example organic/inorganic/practical)
1. Very unconfident 2. Not very confident 3. Average 4. Quite confident 5. Very confident
3. Please rate how confident you are in chemical kinetics as compared to other areas of chemistry (for example, atomic structure, acid-bases, organic nomenclature, organic mechanism, moles and concentration, etc.)
1. Very unconfident 2. Not very confident 3. Average 4. Quite confident 5. Very confident
4. Please rate how confident you are in chemical kinetics as compared to other areas of physical chemistry (for example equilibria, energy changes, gases, etc.)
1. Very unconfident 2. Not very confident 3. Average 4. Quite confident 5. Very confident

Instructions: answer the questions on the sheet about chemical kinetics. Circle the letter that represents the best answer in your view. Then circle the number that best represents how confident you are in your given answer. Don't worry if there are some questions you can't answer.

No.	Question
1.	A 64 mg sample of radioactive material decays by first order reaction. After 10 minutes two half-lives have passed. What is the mass of the sample that remains after 15 minutes? A. 24 mg B. 23 mg C. 16 mg D. 8 mg State the confidence rating of your answer 1. Very unconfident 2. Not very confident 3. Average 4. Quite confident 5. Very confident Which one of the following options is the reason for your answer to the question? A. After 10 minutes, half of the initial sample remained B. The rate of decay of this sample is a constant C. For each successive half-life, the mass change of sample is a constant D. The rate of decay of this sample increases as the mass of sample decreases E. For each successive half-life, the mass of sample decreases by a factor of 2 State the confidence rating of your answer 1. Very unconfident 2. Not very confident 3. Average 4. Quite confident 5. Very confident
2.	In a reaction represented by $K \rightarrow L + M$ the integrated rate expression is given by: $[A]_t = [A]_0 - kt$. At the start of the reaction the concentration of K is 0.8 mol dm^{-3}. If the value of the rate constant is $2 \text{ mol dm}^{-3} \text{ s}^{-1}$ determine the time taken for the concentration of K to drop to 0.4 mol dm^{-3}. A. 0.1 s B. 0.2 s C. 0.35 s D. 0.4 s State the confidence rating of your answer 1. Very unconfident 2. Not very confident 3. Average 4. Quite confident 5. Very confident Which one of the following options is the reason for your answer to the question? A. The concentration of K at its half-life is twice its initial concentration B. The concentration of K at its half-life is a half of its initial concentration C. The concentration of K at its half-life is same as its initial concentration State the confidence rating of your answer 1. Very unconfident 2. Not very confident 3. Average 4. Quite confident 5. Very confident
3.	The decomposition of nitrogen dioxide to nitric oxide and oxygen at a certain temperature is shown pictorially below and is a second order reaction and the equation for the reaction is: $2\text{NO}_2(\text{g}) \rightarrow 2\text{NO}(\text{g}) + \text{O}_2(\text{g})$  t = 10 s  t = 20 s  t =? time → The time at the final representation shown above is... A. 25 s B. 30 s C. 40 s D. 50 s State the confidence rating of your answer 1. Very unconfident 2. Not very confident 3. Average 4. Quite confident 5. Very confident

	Which one of the following options is the reason for your answer to the question? A. The value of each successive half-life is half the preceding one B. The value of $t_{1/2}$ is constant C. The rate of disappearance of this sample increases with decrease in concentration D. The value of each successive half-life is twice the preceding one. State the confidence rating of your answer 1. Very unconfident 2. Not very confident 3. Average 4. Quite confident 5. Very confident
4.	The second order reaction $\text{H}_2\text{O}_2(aq) + 3\text{I}^-(aq) + 2\text{H}^+(aq) \rightarrow 2\text{H}_2\text{O}(l) + \text{I}_3^-(aq)$ is first order in H_2O_2, first order in I^- and zero order in H^+. The rate law expression for this reaction is.... A. $\text{Rate} = k [\text{H}_2\text{O}_2] [\text{I}^-]^3 [\text{H}^+]^2$ B. $\text{Rate} = k [\text{H}_2\text{O}_2] [\text{I}^-]$ C. $\text{Rate} = k \frac{[\text{H}_2\text{O}]^2 [\text{I}_3^-]}{[\text{H}_2\text{O}_2] [\text{I}^-]^3 [\text{H}^+]^2}$ D. $\text{Rate} = k [\text{H}_2\text{O}_2]^x [\text{I}^-]^y [\text{H}^+]^z$ (x,y,z are $\neq 0$) State the confidence rating of your answer 1. Very unconfident 2. Not very confident 3. Average 4. Quite confident 5. Very confident Which one of the following options is the reason for your answer to the question? A. The values of the exponents in the rate law are obtained from the coefficients in the balanced equation B. The rate law is expressed based on the law of mass action that describes the relationship between the concentrations of the reactants and products. C. The values of the exponents in the rate law are based on the order of the reactants which are determined experimentally D. The information which is provided in the question is inadequate to determine the rate law. State the confidence rating of your answer 1. Very unconfident 2. Not very confident 3. Average 4. Quite confident 5. Very confident
5.	The reaction $\text{NO}_2(g) + \text{CO}(g) \rightarrow \text{NO}(g) + \text{CO}_2(g)$ is second order with respect to NO_2, but zero order with respect to CO. If the concentration of NO_2 increases by a factor of 2 and the concentration of CO increases by a factor of 3, the reaction rate will.... A. Increase by a factor of 36 B. Increase by a factor of 12 C. Increase by a factor of 4 D. Remain constant 1. Very unconfident 2. Not very confident 3. Average 4. Quite confident 5. Very confident Which one of the following options is the reason for your answer to the question? A. Only an increase in concentration of NO_2 affects the rate B. The higher the concentration of both reactants, the higher the rate C. The overall order of reaction is 2, therefore an increase in the concentration of both reactants increases the rate by the power of 2 D. There is no effect on the reaction rate as the order with respect to one reactant is zero State the confidence rating of your answer 1. Very unconfident 2. Not very confident 3. Average 4. Quite confident 5. Very confident
6.	For a hypothetical reaction: $\text{X} + \text{Y} \rightarrow \text{Products}$, the rate of reaction is second order with respect to X but first order with respect to Y. Four experiments are carried out with different starting concentrations represented pictorially below in the boxes A, B, C and D. Which of the starting conditions (A, B, C or D) will result in the highest rate of reaction? A  B  C  D   = X  = Y State the confidence rating of your answer

	1. Very unconfident 2. Not very confident 3. Average 4. Quite confident 5. Very confident Which one of the following options is the reason for your answer to the question? A. It has the highest concentration of the reactant which is 2nd order B. The concentrations of both reactants are the same, therefore the ratio of collisions is more favourable C. Both 1st and 2nd order reactants determine the rate D. The concentration of Y is much higher than the concentration of X and this leads to the reaction being completed faster State the confidence rating of your answer 1. Very unconfident 2. Not very confident 3. Average 4. Quite confident 5. Very confident
7.	The integrated rate law for a reaction can be expressed as $[A]_t = [A]_0 - kt$. If $[A]_0$ is the initial concentration, $[A]_t$ is the concentration at particular time, t, and k is the rate constant, then the expression of half-life for this reaction is.... A. $t_{1/2} = \frac{[A]_t}{2k}$ B. $t_{1/2} = \frac{[A]_0}{2k}$ C. $t_{1/2} = \frac{0.693}{k}$ D. $t_{1/2} = \frac{[A]_0}{k}$ State the confidence rating of your answer 1. Very unconfident 2. Not very confident 3. Average 4. Quite confident 5. Very confident Which one of the following options is the reason for your answer to the question? A. The concentration of A at its half-life is twice its initial concentration B. The concentration of A at its half-life is a half of its initial concentration C. The concentration of A at its half-life is same as its initial concentration State the confidence rating of your answer 1. Very unconfident 2. Not very confident 3. Average 4. Quite confident 5. Very confident
8.	Consider the first order reaction $X \rightarrow Y$ in which X molecules are converted to Y molecules. X is initially 2.4 mol dm⁻³ and after 10 minutes the concentration has dropped to 0.6 mol dm⁻³. Calculate the concentration of X and Y after one half life. A. X = 0.6 mol dm⁻³ & Y = 1.8 mol dm⁻³ B. X = 0.9 mol dm⁻³ & Y = 1.5 mol dm⁻³ C. X = 0.3 mol dm⁻³ & Y = 2.1 mol dm⁻³ D. X = 1.2 mol dm⁻³ & Y = 1.2 mol dm⁻³ State the confidence rating of your answer 1. Very unconfident 2. Not very confident 3. Average 4. Quite confident 5. Very confident Which one of the following options is the reason for your answer to the question? A. The concentration of X at its half-life is a half of its initial concentration B. The concentration of X is a half of its concentration at 10 minutes C. The concentration of X that react is a half the concentration that react between 0 and 10 minutes D. The half-life is reached at 10 minutes State the confidence rating of your answer 1. Very unconfident 2. Not very confident 3. Average 4. Quite confident 5. Very confident
9.	The Boltzmann distribution curves below describe the distribution of the kinetic energies of molecules.



X and Y represent the same reaction carried out at a different temperature where X is lower than Y. Which statement below is correct?

- A. X has a higher rate of reaction than Y
- B. **Y has a higher rate of reaction than X**
- C. Both reactions have the same rate
- D. There is insufficient information to determine the relative rates

State the confidence rating of your answer

1. Very unconfident 2. Not very confident 3. Average 4. Quite confident 5. Very confident

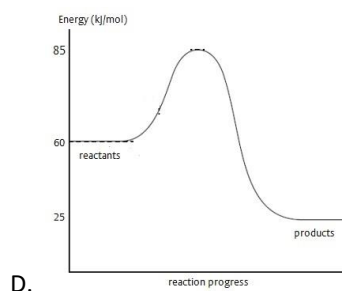
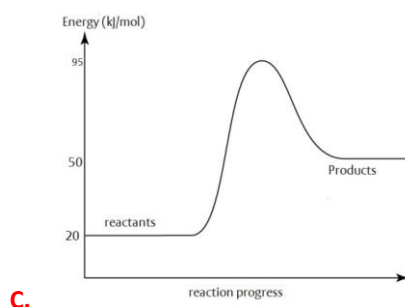
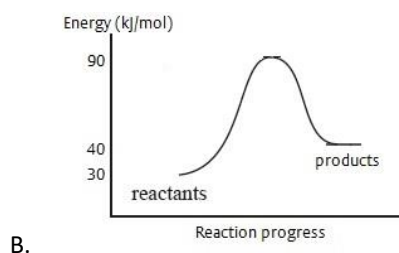
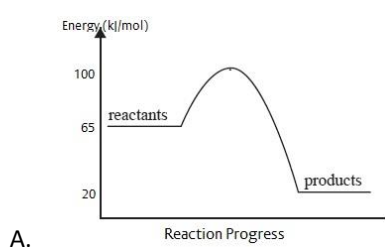
Which one of the following options is the reason for your answer to the question?

- A. This reaction has the higher activation energy
- B. The value of k and the number of molecules of both reactants are unknown
- C. **The higher the temperature, the higher the number of molecules with the activation energy (E_a)**
- D. The higher the temperature, the higher the activation energy (E_a)
- E. This reaction has the lower activation energy
- F. The value of activation energy does not determine the rate

State the confidence rating of your answer

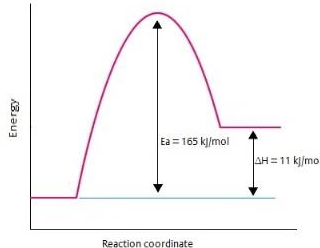
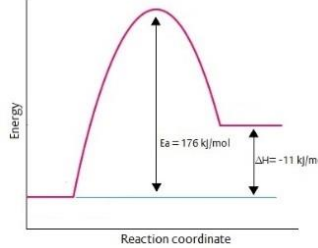
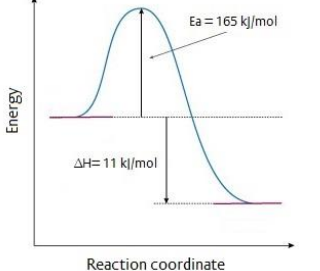
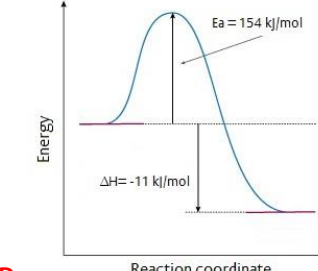
1. Very unconfident 2. Not very confident 3. Average 4. Quite confident 5. Very confident

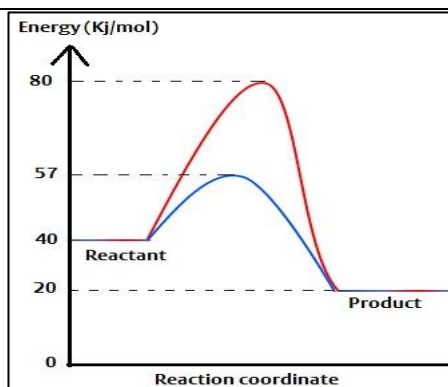
10. Consider four reactions as described in the energy profile of E_a and ΔH below. Assuming that all four reactions are carried out at the same temperature and have the same Arrhenius factor A, which reaction is the slowest....



State the confidence rating of your answer

	1. Very unconfident 2. Not very confident 3. Average 4. Quite confident 5. Very confident Which one of the following options is the reason for your answer to the question? A. The reaction has the highest energy in its transition state B. The reaction has the highest activation energy C. The reaction has the lowest energy in its transition state D. The reaction has the lowest activation energy E. The reaction is exothermic F. The reaction is endothermic State the confidence rating of your answer 1. Very unconfident 2. Not very confident 3. Average 4. Quite confident 5. Very confident
11.	The decomposition of nitrogen dioxide to nitric oxide and oxygen takes place by second order kinetics: $2\text{NO}_2(\text{g}) \rightarrow 2\text{NO}(\text{g}) + \text{O}_2(\text{g})$ At time, $t = 10 \text{ s}$ the pressure of NO_2 is 80 torr and after 5 seconds the pressure has dropped to 40 torr. Determine the time at which the pressure of NO_2 is 20 torr. A. 17.5 s B. 20 s C. 25 s D. 30 s State the confidence rating of your answer 1. Very unconfident 2. Not very confident 3. Average 4. Quite confident 5. Very confident Which one of the following options is the reason for your answer to the question? A. The value of each successive half-life is half the preceding one B. The value of $t_{1/2}$ is constant C. The rate of disappearance of this sample increases with decrease in concentration D. The value of each successive half-life is twice the preceding one. State the confidence rating of your answer 1. Very unconfident 2. Not very confident 3. Average 4. Quite confident 5. Very confident
12.	The formation of $\text{HI}(\text{g})$ follows the reaction $\text{H}_2 + \text{I}_2 \rightarrow 2\text{HI}$. This reaction may occur with the following mechanism: $\text{I}_2 \xrightleftharpoons[k_{-1}]{k_1} 2\text{I} \quad \text{fast}$ $\text{I} + \text{I} + \text{H}_2 \xrightarrow{k_2} 2\text{HI} \quad \text{slow}$ The overall rate law of this reaction is.... A. Rate = $k_2[\text{I}]^2[\text{H}_2]$ B. Rate = $k \frac{[\text{HI}]^2}{[\text{I}]^2[\text{H}_2]}$ C. Rate = $k_2 \frac{k_1}{k_{-1}} [\text{I}_2] [\text{H}_2]$ D. Rate = $k_1 [\text{I}_2] - k_{-1} [\text{I}]^2$ State the confidence rating of your answer 1. Very unconfident 2. Not very confident 3. Average 4. Quite confident 5. Very confident Which one of the following options is the reason for your answer to the question? A. The rate law is obtained directly from the slow step in the mechanism B. The rate law is obtained from the fast step in the mechanism C. The rate law is obtained from the law of mass action D. The rate law is obtained from the slow step by considering any intermediates in preceding steps State the confidence rating of your answer 1. Very unconfident 2. Not very confident 3. Average 4. Quite confident 5. Very confident

13.	The reaction $\text{NO}_2(g) + \text{NO}_3(g) \rightarrow \text{N}_2\text{O}_5(g)$ with $\Delta H = 11 \text{ kJ mol}^{-1}$ has the activation energy 165 kJ mol^{-1}. The graph below that represents the energy profile for the reverse reaction is....  A.  B.  C.  D. State the confidence rating of your answer 1. Very unconfident 2. Not very confident 3. Average 4. Quite confident 5. Very confident Which one of the following options is the reason for your answer to the question? A. The reverse reaction is endothermic and its activation energy value is lower B. The reverse reaction is exothermic and its activation energy value is lower. C. The reverse reaction is endothermic and its activation energy value is higher D. The reverse reaction is exothermic and its activation energy value is higher State the confidence rating of your answer 1. Very unconfident 2. Not very confident 3. Average 4. Quite confident 5. Very confident
14.	The energy profile below describes a catalysed and an uncatalysed pathway for a given reaction.



The value of the activation energy of the catalysed reaction is....

- A. 60 kJ mol^{-1} B. 40 kJ mol^{-1} C. 37 kJ mol^{-1} **D. 17 kJ mol^{-1}**

State the confidence rating of your answer

1. Very unconfident 2. Not very confident 3. Average 4. Quite confident 5. Very confident

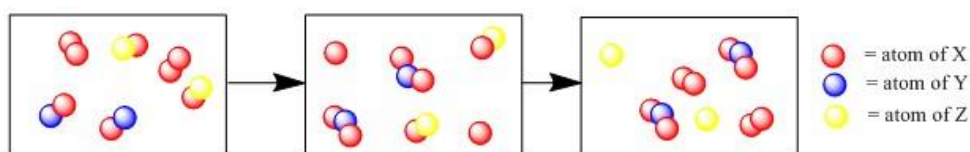
Which one of the following options is the reason for your answer to the question?

- A. The activation energy of a catalysed and an uncatalysed pathway is the same, but the mechanisms are different
 B. The activation energy of a catalysed pathway is lower than an uncatalysed one and the mechanisms are the same
C. The activation energy of a catalysed pathway is lower than an uncatalysed one and the mechanisms are different
 D. The activation energy of a catalysed pathway is higher than an uncatalysed one and the mechanisms are the same
 E. The activation energy of a catalysed pathway is higher than an uncatalysed one and the mechanisms are different
 F. The mechanism of a reaction is only changed if the temperature increases

State the confidence rating of your answer

1. Very unconfident 2. Not very confident 3. Average 4. Quite confident 5. Very confident

15. The following diagram depicts an imaginary two step mechanism of a reaction.



Based on the representation above, the substance that acts as a catalyst is....

- A. X B. XZ **C. X_2** D. XY

State the confidence rating of your answer

1. Very unconfident 2. Not very confident 3. Average 4. Quite confident 5. Very confident

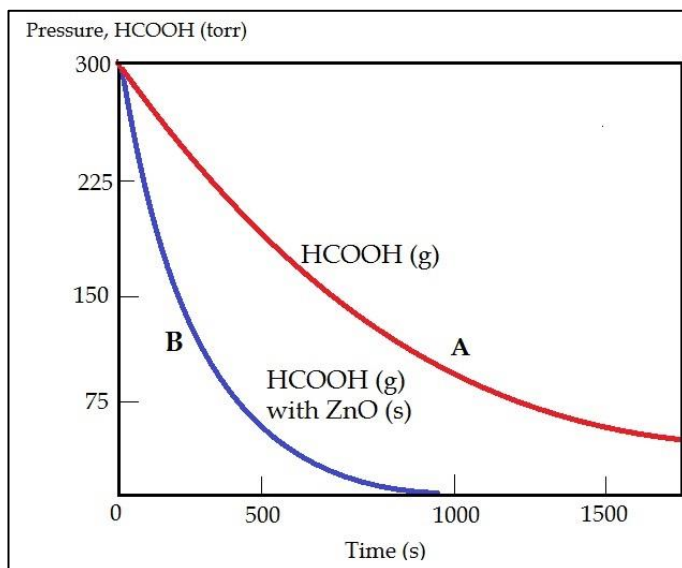
Which one of the following options is the reason for your answer to the question?

- A. The substance does not undergo a permanent chemical change and is reformed in the final product**
 B. The substance is formed in one elementary reaction and consumed in the next
 C. The substance increases the rate without being involved chemically in the reaction
 D. The substance is not present in the final product

State the confidence rating of your answer

1. Very unconfident 2. Not very confident 3. Average 4. Quite confident 5. Very confident

16. The variation in partial pressure of HCOOH for the decomposition of formic acid $\{\text{HCOOH}(g) \rightarrow \text{CO}_2(g) + \text{H}_2(g)\}$ in the gas phase as a function of time at 838 K is described in the graph below.



A graph of the partial pressure of HCOOH versus time is shown as the red curve, A. Assuming that $\text{ZnO}(s)$ is the catalyst, when a small amount of solid ZnO is added, the partial pressure of HCOOH versus time varies as shown by the blue curve, B.

Based on this information, which is the correct statement below?

- A. This is an example of homogeneous catalysis and the rate of B is higher than the rate of A
- B. This is an example of heterogeneous catalysis and the rate of B is higher than the rate of A**
- C. This is an example of homogeneous catalysis and the rate of A is higher than the rate of B
- D. This is an example of heterogeneous catalysis and the rate of A is higher than the rate of B

State the confidence rating of your answer

1. Very unconfident 2. Not very confident 3. Average 4. Quite confident 5. Very confident

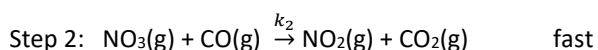
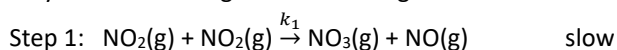
Which one of the following options is the reason for your answer to the question?

- A. HCOOH , CO_2 and H_2 are in the same phase and the presence of ZnO increases the rate
- B. HCOOH and ZnO are in different phases and the presence of ZnO decreases the rate
- C. HCOOH , CO_2 and H_2 are present in the same phase and the presence of ZnO decreases the rate
- D. HCOOH and ZnO are in different phases and the presence of ZnO increases the rate**

State the confidence rating of your answer

1. Very unconfident 2. Not very confident 3. Average 4. Quite confident 5. Very confident

17. The reaction of nitrogen dioxide and carbon monoxide $\text{NO}_2(g) + \text{CO}(g) \rightarrow \text{NO}(g) + \text{CO}_2(g)$ may occur according to the following mechanism:



If k is the overall rate constant, the rate law for this reaction is....

- A. Rate = $k[\text{NO}_2][\text{CO}]$
- B. Rate = $k[\text{NO}_2]^2$**
- C. Rate = $k[\text{NO}_3][\text{CO}]$

$$D. \text{Rate} = k \frac{[\text{NO}][\text{CO}_2]}{[\text{NO}_2][\text{CO}]}$$

State the confidence rating of your answer

1. Very unconfident 2. Not very confident 3. Average 4. Quite confident 5. Very confident

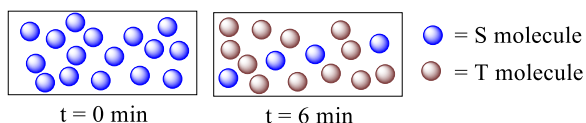
Which one of the following options is the reason for your answer to the question?

- A. **Step 1 is the rate determining step**
 B. Step 2 is the rate determining step
 C. The rate law is obtained directly from the overall reaction equation
 D. The rate law is derived from the law of mass action

State the confidence rating of your answer

1. Very unconfident 2. Not very confident 3. Average 4. Quite confident 5. Very confident

18. Consider the first order reaction $S \rightarrow T$ in which S molecules are converted to T molecules.



How many S (blue) molecules and T (brown) molecules are present at the half-life?

- A. Blue = 4 and brown = 12 B. Blue = 6 and brown = 10
 C. Blue = 2 and brown = 14 **D. Blue = 8 and brown = 8**

State the confidence rating of your answer

1. Very unconfident 2. Not very confident 3. Average 4. Quite confident 5. Very confident

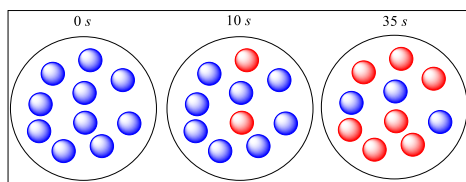
Which one of the following options is the reason for your answer to the question?

- A. The number of S molecules is a half of its initial number**
 B. The number of S molecules is a half of its number at 6 minutes
 C. The number of S molecules that react is a half the number that react between 0 and 6 minutes
 D. The half-life is reached at 6 minutes

State the confidence rating of your answer

1. Very unconfident 2. Not very confident 3. Average 4. Quite confident 5. Very confident

19. The hypothetical reaction $G \rightarrow H$ is depicted pictorially below. Each blue sphere represents 0.2 moles of G and each red sphere represents 0.2 moles of H, and the container has a volume of 1.00 L.



The number of moles of G and H respectively in the mixture after 32 s is....

- A. 1.280 mol; 0.720 mol B. 0.544 mol; 1.456 mol
C. 0.720 mol; 1.280 mol D. 1.456 mol; 0.544 mol

State the confidence rating of your answer

1. Very unconfident 2. Not very confident 3. Average 4. Quite confident 5. Very confident

Which one of the following options is the reason for your answer to the question?

- A. As time increases, the rate of conversion of G molecules to H molecules also increases
 B. As time increases, the rate of conversion of G molecules to H molecules decreases
C. The rate of conversion of G molecules to H molecules per second is a constant

State the confidence rating of your answer

1. Very unconfident 2. Not very confident 3. Average 4. Quite confident 5. Very confident

20.	The decomposition of N_2O_5 in a solvent occurs according to the following equation $\text{N}_2\text{O}_5 \rightarrow 2\text{NO}_2 + \frac{1}{2} \text{O}_2$ In the interval between 20 minutes and 40 minutes, the $[\text{N}_2\text{O}_5]$ decreases from 0.1 M to 0.080 M. Which of the following options is the correct expression of the average reaction rate? A. Rate = $\frac{d[\text{N}_2\text{O}_5]}{dt} = 0.001 \text{ M min}^{-1}$ B. Rate = $\frac{d[\text{NO}_2]}{dt} = 0.001 \text{ M min}^{-1}$ C. Rate = $\frac{d[\text{O}_2]}{dt} = 0.0005 \text{ Mmin}^{-1}$ D. Rate = $-\frac{d[\text{NO}_2]}{dt} = -0.002 \text{ Mmin}^{-1}$ State the confidence rating of your answer 1. Very unconfident 2. Not very confident 3. Average 4. Quite confident 5. Very confident Which one of the following options is the reason for your answer to the question? A. O_2 is produced twice as fast as N_2O_5 is consumed B. NO_2 is produced a half as fast as N_2O_5 is consumed C. The rate law can only be expressed by the rate of disappearance of N_2O_5 D. N_2O_5 is consumed twice as fast as NO_2 is produced E. NO_2 is consumed twice as fast as N_2O_5 is consumed F. O_2 is produced a half as fast as N_2O_5 is consumed State the confidence rating of your answer 1. Very unconfident 2. Not very confident 3. Average 4. Quite confident 5. Very confident
-----	---