

CANADIAN CHEMISTRY CONTEST

CHEMISTRY

TOPIC QUESTIONS

King



6B Reaction Kinetics



KingCh

- 18) One mole of uranium-238 decays slowly. If uranium-238 decays according to first order kinetics, after how many half-lives is there likely only **one** atom of uranium-238 left?

A) 85 B) 10 C) 238 D) 41 E) 79

CCC 2020

- 25) For the reaction $2 \text{NO} (\text{g}) + \text{Cl}_2 (\text{g}) \rightarrow 2 \text{NOCl} (\text{g})$ the table below provides experimental data for 3 different reactions.

| Experiment | [NO] (mol L ⁻¹) | [Cl ₂] (mol L ⁻¹) | Initial Rate (mol L ⁻¹ s ⁻¹) |
|------------|-----------------------------|---|---|
| 1 | 0.0125 | 0.0128 | 1.14×10^{-5} |
| 2 | 0.0125 | 0.0511 | 4.55×10^{-5} |
| 3 | 0.0250 | 0.0255 | 9.08×10^{-5} |

What is the rate constant for the reaction?






A) $140 \text{ L mol}^{-1} \text{ s}^{-1}$ B) $0.0714 \text{ L mol}^{-1} \text{ s}^{-1}$ C) $5.70 \text{ L}^2 \text{ mol}^{-2} \text{ s}^{-1}$
 D) $0.562 \text{ L mol}^{-1} \text{ s}^{-1}$ E) $1.39 \text{ L}^2 \text{ mol}^{-2} \text{ s}^{-1}$

CCC 2019

- 9) For a reaction $\text{A} + \text{B} \rightarrow \text{Products}$, the rate law is: $\text{rate} = k[\text{A}][\text{B}]^2$. For containers with the same volume, which mixture would have the highest rate of reaction according to this rate law? The legend indicates which molecule is A and which is B.

Legend ● A

○ B

A)  B)  C)  D)  E) 

CCC 2018

- 21) If the rate law for an equation $\text{A} + \text{B} + \text{C} \rightarrow \text{ABC}$ is $\text{Rate} = k[\text{A}]^0[\text{B}][\text{C}]^2$ and the reactant concentration of all of the reactants doubles, by what factor does the rate of reaction increase?

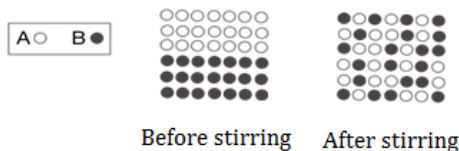
A) 3 B) 4 C) 6 D) 8 E) 10

- 14) Canada is a world-leader in the production of radionuclides such as technetium-99m ($^{99\text{m}}\text{Tc}$), which is used to diagnose bone diseases. $^{99\text{m}}\text{Tc}$ has a relative atomic mass of 98.91 amu and exhibits first-order radioactive decay with a half-life of 6.00 hours. If 8.62×10^{-12} mol of sodium pertechnetate ($\text{Na}^{99\text{m}}\text{TcO}_4$) is injected into a 75 kg adult patient, what mass of $^{99\text{m}}\text{Tc}$ would remain after 24 hours?

A) 1.46×10^{-9} g B) 2.13×10^{-10} g C) 3.66×10^{-11} g
 D) 5.33×10^{-11} g E) 9.15×10^{-11} g

CCC 2017

5) After a chemist stirs the contents of a beaker, the rate of a reaction between reactants A and B increases by a factor of four. Use the diagrams below to help you to determine the **main** reason why the rate of reaction increases.



- A) Reaction surface area increases B) Activation energy increases
 C) Reactant concentrations increase D) Total kinetic energy increases
 E) Average kinetic energy increases

24) Given the following data table for the reaction $2 A + B_2 \rightarrow 2 AB$

| [A] mol L ⁻¹ | [B ₂] mol L ⁻¹ | Rate of Reaction (mol L ⁻¹ s ⁻¹) |
|-------------------------|---------------------------------------|---|
| 0.100 | 0.100 | 0.117 |
| 0.200 | 0.100 | 0.468 |
| 0.200 | 0.200 | 0.936 |

What is the rate of reaction in mol L⁻¹ s⁻¹ if [A] = [B₂] = 0.300 mol L⁻¹?

- A) 1.87 B) 2.81 C) 3.02 D) 3.16 E) 3.51

CCC 2016

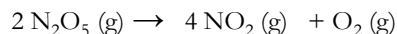
19. At a lab at the University of Toronto in 1929, Dr. Velyen Henderson and Dr. George Lucas were the first to discover the use of cyclopropane as a general anesthetic. Cyclopropane undergoes slow molecular rearrangement to propene. From the data below, determine the rate law for the reaction:

| Initial concentration of cyclopropane (mol L ⁻¹) | Rate of formation of propene (mol L ⁻¹ s ⁻¹) |
|--|---|
| 0.050 | 2.95×10^{-5} |
| 0.100 | 5.90×10^{-5} |
| 0.150 | 8.85×10^{-5} |

- A) Rate = $5.9 \times 10^{-4} \text{ s}^{-1} \times [\text{cyclopropane}]$
 B) Rate = $1.2 \times 10^{-2} \text{ L mol}^{-1} \text{ s}^{-1} \times [\text{cyclopropane}]^2$
 C) Rate = $2.4 \times 10^2 \text{ mol L}^{-1} \text{ s}^{-1} \times [\text{cyclopropane}]^2$
 D) Rate = $1.7 \times 10^3 \text{ s}^{-1} \times [\text{cyclopropane}]$
 E) Rate = $2.4 \times 10^{-1} \text{ mol L}^{-1} \text{ s}^{-1} \times [\text{cyclopropane}]^2$

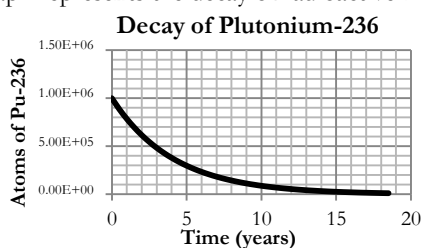
CCC 2015

7. Dinitrogen pentoxide is a strong oxidizer that is of interest for the preparation of explosives. It decomposes according to the following reaction which has a first order rate law:



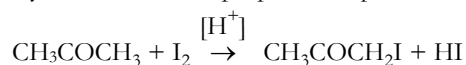
If the initial concentration of N_2O_5 is 0.100 mol L^{-1} and the rate is $4.8 \times 10^{-5} \text{ mol L}^{-1} \text{ s}^{-1}$, what is the rate constant for this process?

- A) $4.8 \times 10^{-4} \text{ s}^{-1}$ B) $4.8 \times 10^{-6} \text{ mol L}^{-1} \text{ s}^{-1}$ C) $2083 \text{ mol L}^{-1} \text{ s}^{-1}$
 D) $4.8 \times 10^{-6} \text{ s}^{-1}$ E) 2083 s^{-1}
13. The following graph represents the decay of radioactive Plutonium-236.



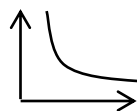
What is the half-life of Plutonium-236?

- A) 0.500 years B) 2.86 years C) 5.72 years
 D) 10.0 years E) 15.0 years
9. The acid-catalysed iodination of propanone represented by the equation

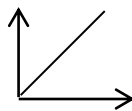


is first order with respect to hydrogen ions and to propanone and zero order with respect to iodine. Given this information which of the unlabelled graphs below is a correct representation of rate of reaction versus time for this reaction?

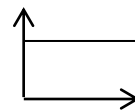
A.



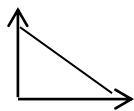
B.



C.



D.



E.



CCC 2013

CCC 2012

13. For the general reaction $L + M \rightarrow LM$ the initial rate data are given in the table below:

| [L] (mol L ⁻¹) | [M] (mol L ⁻¹) | Rate (mol L ⁻¹ s ⁻¹) |
|----------------------------|----------------------------|---|
| 0.10 | 0.10 | 0.050 |
| 0.20 | 0.10 | 0.20 |
| 0.30 | 0.30 | 0.45 |

The rate law for this reaction is:

- A. Rate = [L]¹[M]² B. Rate = [L]²[M]¹ C. Rate = [L]²[M]²
 D. Rate = [L]² E. Rate = [L]¹[M]¹

23. The average human contains about 125 grams of potassium which is a mixture of 3 isotopes: K-39, K-40 and K-41. Only potassium 40 is radioactive and its relative abundance in a sample of potassium is 0.012%. If the half life of K-40 is 1.28×10^9 years, how many K-40 atoms of the original 125 g will be present after 5.12×10^9 years?

- A. 1.41×10^{19} B. 2.26×10^{20} C. 1.13×10^{20}
 D. 5.65×10^{19} E. 2.83×10^{19}

CCC 2011

14. There has been a lot in the news about the shortage of medical isotopes. Technetium-99m is one of the isotopes in short supply because of reactor shutdowns at key production sites, one of which is in Chalk River, Ontario. Tc-99m is favoured in medical applications because it has a relatively short half-life and thus exposes patients to less radiation than some other options. From the data below determine the half-life for the decay of Tc-99m:

| Time (min) | [Tc-99m] (mol L ⁻¹) |
|------------|---------------------------------|
| 0 | 0.891 |
| 60 | 0.794 |
| 120 | 0.708 |
| 180 | 0.630 |
| 240 | 0.562 |
| 300 | 0.501 |
| 360 | 0.446 |
| 420 | 0.398 |

- A. 1 hour B. 3 hours C. 5 hours D. 6 hours E. 7 hours

15. For the reaction $aA + bB + cC \rightleftharpoons dD + eE$, the following data are available:

| [A] (mol L ⁻¹) | [B] (mol L ⁻¹) | [C] (mol L ⁻¹) | Initial Rate (mol L ⁻¹ s ⁻¹) |
|----------------------------|----------------------------|----------------------------|---|
| 0.60 | 0.60 | 0.60 | 320 |
| 0.30 | 0.60 | 0.60 | 160 |
| 0.90 | 0.15 | 0.30 | 30 |
| 0.60 | 0.15 | 0.60 | 20 |

What is the order of reaction with respect to C?

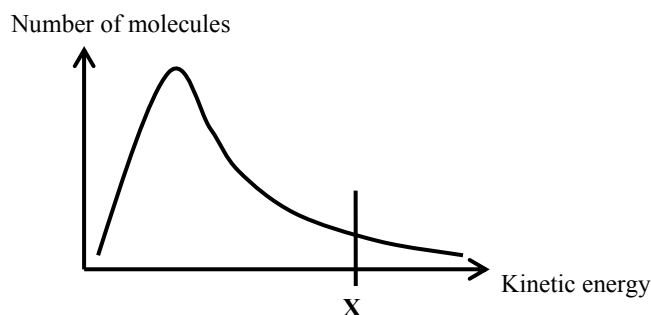
- A. Zero B. First C. Second
 D. Third E. Cannot be determined

CCC 2010

17. Some students are going to determine the rate of the following reaction:
 $2\text{MnO}_4^- (\text{aq}) + 16\text{H}^+ (\text{aq}) + 5\text{C}_2\text{O}_4^{2-} (\text{aq}) \rightarrow 2\text{Mn}^{2+} (\text{aq}) + 10\text{CO}_2 (\text{g}) + 8\text{H}_2\text{O} (\text{l})$
 Which one of the following methods of monitoring the rate would NOT be possible? Measuring the change in the:

- A. pH of the solution
 B. mass of the solution
 C. volume of gas produced
 D. amount of precipitate produced
 E. intensity of the purple colour of the solution

19. The following graph shows the relationship between the number of molecules with a particular kinetic energy (on the y axis) and the kinetic energy of these molecules (on the x axis), in a gas at a particular temperature. The gas is about to take part in a reaction for which the activation energy is E_a .

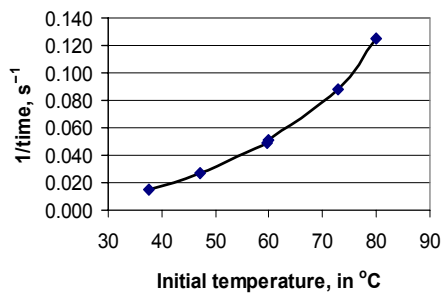


Which one of the following statements is always true?

- A. X indicates the activation energy for any reaction
 B. There are always some molecules with zero energy
 C. The value of the activation energy depends on the temperature
 D. The value of the activation energy depends on the reaction about to take place
 E. The area under the curve represents the number of molecules that have enough energy to react

CCC 2008

22. The following graph shows the effect of initial temperature on the rate of reaction for a series of experiments performed on the same reaction, with the same initial concentrations of reactants. (Note that each experiment is performed as a “clock” reaction, so it is only timed up to a certain point, and you can assume that the rate is proportional to $1/\text{time}$.)



Which one of the following statements can be correctly deduced from this graph:

- A. The reaction is exothermic
- B. The reaction is endothermic
- C. The rate of reaction increases with initial temperature
- D. The rate of reaction decreases with initial temperature
- E. The time taken for the reaction to be completed increases with initial temperature

CCC 2007