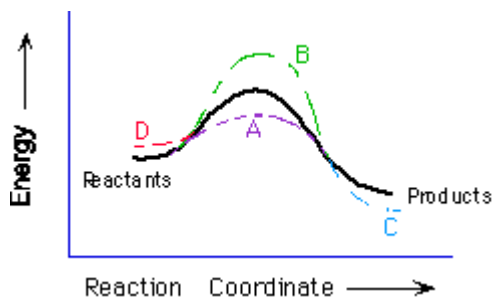


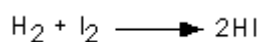
# Worksheet- Kinetics and Mechanism

1. (Catalysts) Which curve illustrates the effect of a catalyst on the reaction diagram, given that it speeds up the rate of a reaction?

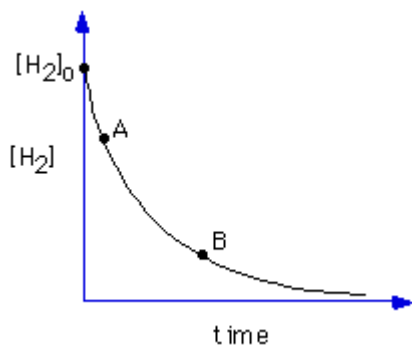
A, B, C, D



2. For the reaction:



The dependence of the concentration of  $\text{H}_2$  on time is shown below.



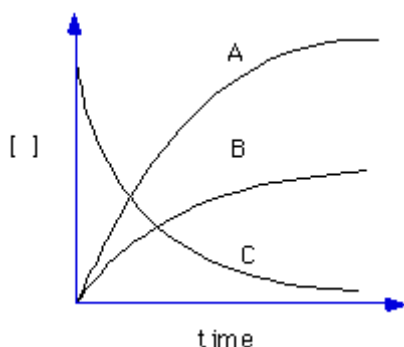
Is the reaction rate faster at point A or point B?

A, B, both rates are the same

3. For the reaction:

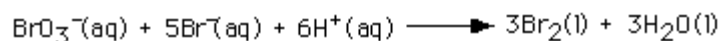


Each of the following curves corresponds to one of the species in the reaction shown above. Which curve represents the time dependence of the concentration of  $\text{O}_2$ ?



A, B, C

4. For the reaction:



The following initial rate data were obtained:

Experiment	$[\text{BrO}_3^-]_0$	$[\text{Br}^-]_0$	$[\text{H}^+]_0$	Relative Initial Rate
1	0.10M	0.10M	0.10M	1
2	0.20M	0.10M	0.10M	2
3	0.20M	0.20M	0.10M	4
4	0.10M	0.10M	0.20M	4

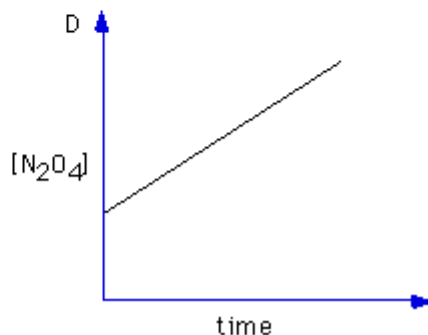
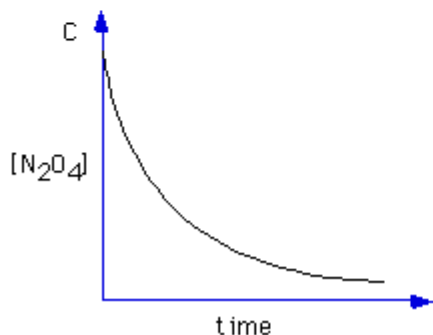
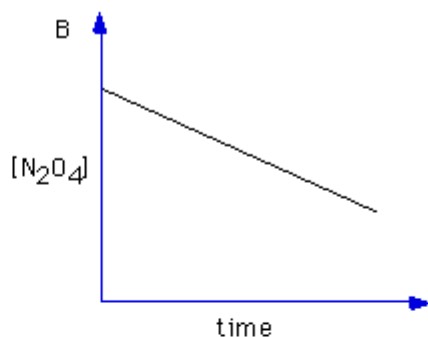
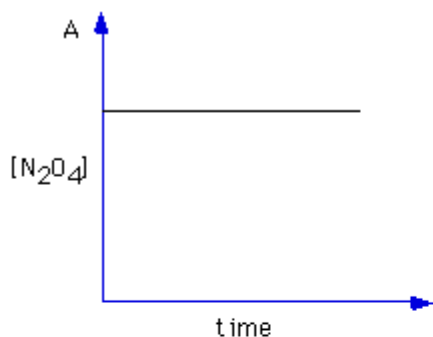
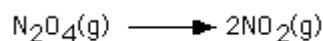
Which of the following rate laws is correct?

A. Rate =  $k[\text{BrO}_3^-]^1[\text{Br}^-]^2[\text{H}^+]^1$

B. Rate =  $k[\text{BrO}_3^-]^1[\text{Br}^-]^1[\text{H}^+]^2$

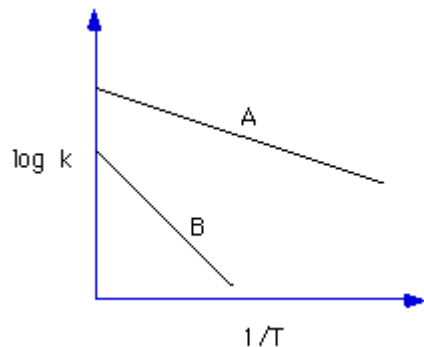
A, B

5. Which graph best describes the following reaction if it is first order in  $\text{N}_2\text{O}_4$ ?



A, B, C, D

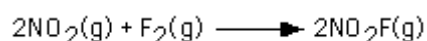
6. The diagram below shows Arrhenius plots for two chemical reactions. Which reaction has the larger activation energy?



A, B

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7. The empirical rate law for the reaction



is  $\text{Rate} = k[\text{NO}_2][\text{F}_2]$ .

Which of the following mechanisms is consistent with this rate law?

A)  $\text{NO}_2(\text{g}) + \text{F}_2(\text{g}) \rightleftharpoons \text{NO}_2\text{F}(\text{g}) + \text{F}(\text{g})$  fast

$\text{NO}_2(\text{g}) + \text{F}(\text{g}) \longrightarrow \text{NO}_2\text{F}(\text{g})$  slow

B)  $\text{NO}_2(\text{g}) + \text{F}_2(\text{g}) \rightleftharpoons \text{NO}_2\text{F}(\text{g}) + \text{F}(\text{g})$  slow

$\text{NO}_2(\text{g}) + \text{F}(\text{g}) \longrightarrow \text{NO}_2\text{F}(\text{g})$  fast

C)  $\text{F}_2(\text{g}) \rightleftharpoons \text{F}(\text{g}) + \text{F}(\text{g})$  slow

$2\text{NO}_2(\text{g}) + 2\text{F}(\text{g}) \longrightarrow 2\text{NO}_2\text{F}(\text{g})$  fast

A, B, C

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8. Which of the following is true of a catalyst?

It changes the equilibrium constant

It speeds up only the rate of the forward reaction

It is consumed in the course of the reaction

It lowers the activation energy for a reaction

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9. What is rate?

(A) The time rate of change in the concentrations of reactants

(B) The time rate of change in the concentration of products

(C)  $\text{rate} = [\text{A}][\text{B}]$

(D) None of the above

10. What is meant by the total rate of a reaction?

(A) The forward rate of the reaction

- (B) The reverse rate of the reaction
- (C) The sum of the forward and reverse rates of the reaction
- (D) None of the above

11. Which of the following rate laws could describe a third order reaction?

- (A) rate = 3
- (B) rate = k [A]
- (C) rate = k [A]<sup>2</sup>
- (D) rate = k [A] [B] [C]

12. What are the units for k in a zeroth order reaction?

- (A) M / s
- (B) None
- (C) s<sup>-1</sup>
- (D) M

13. If a reaction requires two moles of a single reagent to produce one mole of product, what is the ratio of the rate of product formation to the rate of reactant consumption?

- (A) 2 : 1
- (B) 1 : 2
- (C) 1 : 1
- (D) Cannot be determined

14. What is initial rate?

- (A) Zero, there can be no rate when time equals zero for a reaction
- (B) The rate of a reaction measured near the end of the reaction
- (C) The rate of a reaction measured at a time as close to zero as possible
- (D) None of the above

15. For a reaction with four (4) reagents, how many experiments are necessary to determine the order of the reaction when using the method of initial rates?

- (A) 2
- (B) 3
- (C) 4
- (D) 5

16. When the concentration of a reagent, A, is tripled (holding the concentrations of all other species constant), the rate increases by a factor of 1.74. What is the order of the reaction in A

- (A) 1 / 2
- (B) 1
- (C) 3
- (D) 2

17. When the concentrations of both reactants A and B are doubled the rate increases by a factor of 8. The reaction is second order in B. Determine the order of the reaction in A.

- (A) Second
- (B) First
- (C) Third
- (D) Not enough information provided to solve the problem

18. What variable in the rate law can you not determine using the method of initial rates?

- (A) k
- (B) The order of the reaction
- (C) None
- (D) rate

19. Under what circumstances should you not use the method of initial rates to determine the rate law for a reaction?

- (A) Very fast reactions
- (B) Colored reactions
- (C) Clear, colorless reactions
- (D) Very slow reactions

20. Which of the following is a technique used to stop a reaction for analysis?

- (A) Quenching
- (B) Photoelectron spectroscopy
- (C) NMR
- (D) Method of initial rates

21. By what factor would the rate increase when a second order reactant's concentration is tripled?

- (A) 3
- (B) 9
- (C) 2
- (D) 6

22. What is the advantage of using the method of integrated rates as opposed to the method of initial rates?

- (A) It's more accurate
- (B) There is no advantage
- (C) You need to only perform one reaction
- (D) It's a more secure way of finding out the rate law

23. What plot generates a straight line for a zero order reaction?

- (A)  $1 / [A]$  versus time
- (B)  $\ln [A]$  versus time
- (C) No plot
- (D)  $[A]$  versus time

24. What data is required to perform the method of integrated rates?

- (A) The concentration of a reactant or product at certain times
- (B) The absorbance of a reactant or product at certain times
- (C) Initial rate and the concentrations of all the reactants
- (D) Rate and time

25. What plot creates a straight line for a second order reaction?

- (A)  $\ln [A]$  versus time
- (B)  $1 / [A]$  versus time
- (C)  $[A]$  versus time
- (D) None of the above

26. What is the slope of the line created by a plot of  $1 / [A]$  versus time for a second order reaction?

- (A)  $-k$
- (B) 2
- (C)  $2k$
- (D)  $-E_a / R$

27. How many experiments are necessary to perform the method of integrated rates for a third order reaction in A?

- (A) Two
- (B) Three
- (C) Four
- (D) One

28. What plot gives a straight line for a first order reaction?

- (A)  $\ln [A]$  versus time
- (B)  $[A]$  versus time
- (C)  $1 / [A]$  versus time
- (D) None of the above

29. What is the slope of the line for a plot of  $\ln [A]$  versus time for a first order reaction?

- (A)  $k$
- (B)  $-k$
- (C)  $-E_a / R$
- (D)  $1 / k$

30. The concentration of A reduces from 1.0 M to 0.50 M in 25.2 minutes. If A decomposes by a first order reaction, what is the half-life of the decomposition of A?

- (A) 50.4 minutes
- (B) 12.8 minutes
- (C) 25.5 minutes

(D) 96 minutes

31. If the half-life of a first order reaction is 10 s, how long does it take to decrease the initial concentration of a reactant by 94%?

(A) 12 s

(B) 18 s

(C) 96 s

(D) 40.6 s

32. Which order of reaction has a half-life that does not depend on the concentration of the reagents?

(A) First

(B) Second

(C) Third

(D) Zero

33. What is a half-life?

(A) The time it takes for one-half of the products to be produced

(B) The time it takes for one-half of the limiting reagent to be consumed

(C) Half of the time the reaction takes to go to completion

(D) 40 years old

34. How many collisions can take place during an elementary step?

(A) Two

(B) Three

(C) One

(D) Four

35. Why is a tetramolecular reaction unlikely?

(A) It is not unlikely. It is the most common type of elementary step.

(B) Four atoms can never collide simultaneously to produce a reaction.

(C) Molecular collisions are all unlikely.

(D) The odds of having four molecules collide at exactly the same place at the same time are exceedingly small.

36. What is an intermediate?

(A) A substance that is both created and consumed during a chemical reaction that does not appear in the overall balanced reaction.

(B) A substance that speeds up the rate of a reaction without being changed.

(C) A reactant

(D) A product

37. Which of the following is a property of a mechanism?

(A) Each elementary step represents more than one collision.

(B) The sum of the elementary steps must equal the overall balanced equation.

- (C) The mechanism gives approximately the same rate law as determined by experiment.
- (D) The mechanism is experimentally determined.
38. What is the limit on the number of elementary steps in a mechanism?
- (A) 3
- (B) 4
- (C) There is no limit.
- (D) 5
39. A mechanism...
- (A) is experimentally determined.
- (B) is a series of reactions.
- (C) is not valid because it cannot be proven.
- (D) can never be proven.
40. What is the rate-determining step?
- (A) The slowest step in a mechanism
- (B) The fastest step in a mechanism
- (C) A fictional reaction added to every mechanism
- (D) None of the above
41. What is a reaction coordinate?
- (A) The length of the breaking bond
- (B) A "dummy variable" so composed as to best describe the progress of a reaction
- (C) The angle of attack
- (D) None of the above
42. What is the highest point on a reaction coordinate diagram?
- (A) An intermediate
- (B) The products
- (C) The transition state
- (D) The reactants
43. What is the vertical axis on the reaction coordinate diagram?
- (A) Size
- (B) Distance
- (C) Angle
- (D) Energy
44. What determines the number of minima between reactants and products?
- (A) The number of elementary steps
- (B) The molecularity of an elementary step
- (C) The energy of the transition state

(D) The stoichiometry of the reaction

45. In a multi-step reaction, how can you tell from the reaction coordinate diagram what the rate determining step is?

- (A) The step with the highest activation energy
- (B) The step whose transition state has the highest energy
- (C) The step with the most stable intermediate product
- (D) The step with the least stable intermediate product

46. What is the activation energy of a reaction whose rate doubles with a 15°C increase in temperature?

- (A) 52.9 kJ / mol
- (B) 12 kJ / mol
- (C) 35.8 kJ / mol
- (D) 39 kJ / mol

47. Which of the following is the Arrhenius equation?

- (A) rate = k [A] [B]
- (B) PV = nRT
- (C)  $k = \ln 2 / t$
- (D)  $k = f p e^{-E_a / RT}$

48. What is the difference between rate and the rate constant?

- (A) The rate of a reaction depends on the concentrations of reactants, whereas the rate constant is concentration-independent and measures the intrinsic reactivity of a reaction.
- (B) They are the same.
- (C) The rate is independent of temperature whereas the rate constant, according to the Arrhenius equation, is strongly dependent on temperature.
- (D) None of the above

49. What does the difference between the height of the products and that of the reactants on a reaction coordinate diagram represent?

- (A) The rate of the reaction
- (B) The free energy change of the reaction
- (C) The rate constant
- (D) Absolutely nothing; the choice of height is arbitrary

50. Which species is placed on the left in a reaction coordinate diagram?

- (A) Products
- (B) Intermediates
- (C) Reactants
- (D) Transition states

51. What is a substance that speeds up the rate of a reaction without being chemically altered called?

- (A) Reactant

- (B) Product
- (C) Intermediate
- (D) Catalyst

52. What type of catalyst is in the same phase as the reagents?

- (A) Homogeneous
- (B) Heterogeneous
- (C) Spiked
- (D) Trenchant

53. Which of the following is not true about the action of a catalyst?

- (A) It speeds up a reaction
- (B) It is present in the balanced equation for the reaction it catalyzes
- (C) It lowers the activation energy of the reaction
- (D) It is involved in the mechanism of the reaction

54. How much of a catalyst is needed to catalyze a reaction?

- (A) 1 equivalent
- (B) 10 equivalents
- (C) Less than 1 equivalent
- (D) More than 1 equivalent

55. What does a catalyst do to the free energy change of a reaction?

- (A) Increases it
- (B) Decreases it
- (C) Alters it unpredictably
- (D) Absolutely nothing

56. What is meant by the statement that one only needs a sub-stoichiometric amount of a catalyst to catalyze a reaction?

- (A) Only a small amount of catalyst is necessary to catalyze the reaction
- (B) Catalysts must be dissolved in order to work
- (C) Catalysts must be exposed to air to work
- (D) Catalysts are involved in the overall balanced equation

57. What happens to the rate of a reaction when more catalyst is added to a reaction that is zero order?

- (A) Increases
- (B) Nothing
- (C) Decreases
- (D) Cannot be predicted

58. Which of the following would not increase the rate of a first order reaction?

- (A) Increased concentrations

- (B) Increased temperature
- (C) Stirring
- (D) Addition of a catalyst