**Name: Period: Seat#:**

**Worksheet #9**

**Directions:** Show all work in a way that would earn you credit on the AP Test! **Use binder paper to show work.**

1. Consider the rxn, 8 A + 5 B  8 C + 6 D. If [C] is increasing at the rate of 4 M/s, at what rate is [B] decreasing?

(A) 0.40 M/s (B) 2.5 M/s (C) 4.0 M/s (D) 6.4 M/s (E) -2.5 M/s

1. Consider the rxn, 5 A + 3 B  9 C + 7 D. If A is being used up at the rate of 15 M/s, how quickly is D being made?

(A) 7 M/s (B) 14 M/s (C) 21 M/s (D) 10.7 M/s (E) 1.4 M/s

1. If, at a particular moment, ammonia is formed at a rate of 0.50 M/s from the reaction
N2(g) + 3H2(g)  2 NH3(g), what is the rate of disappearance of N2 and that of H2 from the reaction?

|  |  |  |  |
| --- | --- | --- | --- |
| (A) | N2: 0.25 M/s; H2, 0.75 M/s | (B) | N2: 0.25 M/s; H2, 0.25 M/s |
| (C) | N2: 0.25 M/s; H2, 0.33 M/s | (D) | N2: 0.50 M/s; H2, 0.50 M/s |
| (E) | N2: 0.75 M/s; H2, 0.50 M/s |  |  |

1. In the reaction, CO + 3 H2  CH4 + H2O, which rate expression below is incorrect?

(A) -Δ[CO]/Δt = -Δ[H2]/3Δt (B) Δ[CH4]/Δt = Δ[H2O]/Δt

(C) -Δ[CO]/Δt = Δ[H2O]/Δt (D) -3Δ[H2]/Δt = Δ[H2O]/Δt

(E) -Δ[CO]/Δt = Δ[CH4]/Δt

1. The rate law for a chemical reaction is determined by
2. theoretical calculations.
3. measuring reaction rate as a function of concentration of reacting species.
4. determining the equilibrium constant for the reaction.
5. measuring reaction rates as a function of temperature.
6. The rate law for a chemical reaction:
7. can be determined from the stoichiometry of the overall reaction
8. can be determined from the fastest step of the mechanism
9. can only be determined by using computer simulation
10. can be determined by measuring rate as a function of reactant concentration
11. can be determined by measuring rate a function of temperature
12. The value of the rate constant of a reaction can generally be expected to

(A) be independent of temperature. (B) increase with increasing temperature.

1. decrease with increasing temperature.
2. decrease with increasing temperature only if the reaction is exothermic.
3. The following question concerns the rxn, a A + b B  c C + d D for which the reaction rate may be written,
 rate = k[A]n[B]m . Which of the following statements is true?

(A) k depends on how long the reaction has been going (B) k depends on temperature but never pressure

(C) k depends on temperature (D) k depends on [reactants]

(E) k depends on the concentration of the products

1. Some chemical reactions proceed at a rate that is proportional to the concentration of a single reactant. Such reactions

(A) are called zero order reactions. (B) are called first order reactions.

1. are called second order reactions.
2. do not occur. For a reaction to occur, at least two molecules (or ions) must collide; in this case, however, there is only one reactant
3. The rate law for a first order reaction has the form

(A) rate = *k* (B) rate = *k* [A]2 (C) rate = *k* [A] (D) rate = *k* [A][B]

1. The rate expression for a second order reaction is

(A) rate = *k* [A] (B) rate = *k* [A]2 [B] (C) rate = *k* [A] [B] (D) rate = *k* [A]2 [B]2

1. For the reaction H2O2(aq) + 3 I-(aq) + 2 H+ (aq)  I3-(aq) + 2 H2O, the rate law is rate = k[H2O2][I-]. The correct description of the order of the reaction is:
	1. First order with respect to [H2O2]; first order with respect to [I-]; first order with respect to [H+]; and second order overall.
	2. First order with respect to [H2O2]; first order with respect to [I-]; second order with respect to [H+]; and first order overall.
	3. First order with respect to [H2O2]; third order with respect to [I-]; second order with respect to [H+]; and sixth order overall.
	4. First order with respect to [H2O2]; first order with respect to [I-]; zero order with respect to [H+]; and second order overall.
2. 2A + 3D  products is 1st order in A and 2nd order in D. What is the rate law in the form, rate =

(A) k[A][D] (B) k[A]2[D]3 (C) k[A][D]2 (D) k[A]2[D] (E) k[A]2[D]2

1. The rate law for the reaction, **A** + **B**  **C** + **D**, is first order in [**A**] and second order in [**B**]. If [**A**] is halved and [**B**] is doubled, the rate of the reaction will

|  |  |  |
| --- | --- | --- |
| (A) remain the same. | (B) | be increased by a factor of 2. |
| (C) be increased by a factor of 4. | (D) | be increased by a factor of 8 |

1. The gas–phase reaction, **A**2 + **B**2  2**AB**, proceeds by collisions between **A**2 and **B**2 molecules. If the concentrations of both **A**2 and **B**2 are doubled, the reaction rate will be changed by a factor of

(A) 1/2 (B) 2 (C) 3 (D) 4 (E)

2

1. If a reaction proceeding by the mechanism, **A** + **B**  **C** + **D**, occurs at a rate *x*, and if the concentrations of **A** and **B** are both doubled, what will be the new rate of reaction?

(A) *x* (B) 2*x* (C) 4*x* (D) 8*x* (E) 16*x*

1. For the reaction between gaseous chlorine and nitric oxide, 2NO*(g)* + Cl2*(g)*  2NOCl*(g)*, doubling the concentration of chlorine doubles the rate of reaction. Doubling the concentrations of both reactants increases the rate by a factor of eight. The reaction is

(A) first order in NO, first order in Cl2. (B) first order in NO, second order in Cl2.

(C) second order in NO, second order in Cl2. (D) second order in NO, first order in Cl2.

1. The reaction, 5 A + 3 B + 2 C  products has a rate law that is 1st order in A, 1st order in B, and 2nd order in C. Which of the following changes in concentrations will have NO EFFECT upon the rate?

|  |  |  |
| --- | --- | --- |
| (A) double [A], double [B], double [C] | (B) | halve [A], double [B], double [C] |
| (C) double [A], halve [B], double [C] | (D) | double [A], double [B], halve [C] |
| (E) halve [A], double [B], halve [C] |  |  |

1. For the reaction **A** + 2**B**  **AB**2, determine the rate law given this data:

Exp. [A] [B] Rate

|  |  |  |  |
| --- | --- | --- | --- |
| 1 | 0.23 M | 0.17 M | 0.33 M/h |
| 2 | 0.46 M | 0.17 M | 0.67 M/h |
| 3 | 0.23 M | 0.51 M | 1.00 M/h |

(A) rate = *k* [A][B] (B) rate = *k* [A][B]2 (C) rate = *k* [A]2 [B] (D) rate = *k* [A]2 [B]2

1. Consider the rxn between CH3Cl and NaOH to give CH3OH and NaCl. Calculate the rate law for this rxn given the data:

|  |  |
| --- | --- |
| Experiment Init. [CH3Cl] | Init. [NaOH] Rate (M/s) |
| 1 0.36 | 0.25 3.7 |
| 2 0.72 | 0.25 7.4 |
| 3 1.44 | 0.50 29.6 |
| (A) Rate = k[CH3Cl]2[NaOH] | (B) Rate = k[CH3Cl][NaOH]2 (C) Rate = k[CH3Cl] |
| (D) Rate = k[CH3Cl]2[NaOH]2 | (E) Rate = k[CH3Cl][NaOH] |

1. The table presents data for the reaction, 2H2*(g)* + 2NO*(g)*  2H2O*(g)* + N2*(g)*. What is the rate law?

Exp. [NO] [H2] Rate

|  |  |  |  |
| --- | --- | --- | --- |
| 1 | 6.0 | 1.0 | 18 |
| 2 | 6.0 | 2.0 | 36 |
| 3 | 1.0 | 6.0 | 3 |
| 4 | 2.0 | 6.0 | 12 |

(A) rate = *k*[H2][NO] (B) rate = *k*[H2]2[NO]

(C) rate = *k*[H2]2[NO]2 (D) rate = *k*[H2][NO]2

1. Calculate the value of the rate constant in question 19:

(A) 0.12 (B) 19 (C) 27 (D) 8.4

1. For the reaction **A** + **B**  **C** these data were obtained. What is the rate law?

Exp. [A] [B] Rate

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| 1 | 0.10 M | 0.10 M |  | 0.030 M/h |  |
| 2 | 0.10 M | 0.20 M |  | 0.120 M/h |  |  |  |  |
| 3(A) | 0.20 Mrate = *k*[A][B] | 0.20 M | (B) | 0.120 M/hrate = *k*[A]2[B] | (C) | rate = *k*[A]2 | (D) | rate = *k*[B]2 |

1. Initial rate data for the reaction, 2N2O5*(g)*  4NO2*(g)* + O2*(g)* are as follows. What is the rate law:

Exp. [N2O5] [O2] Rate

|  |  |  |  |
| --- | --- | --- | --- |
| 1 | 0.15 M | 0.30 M | 46 M/s |
| 2 | 0.20 M | 0.60 M | 61 M/s |
| 3 | 0.20 M | 0.30 M | 61 M/s |

(A) rate = *k*[N2O5] (B) rate = *k*[N2O5]1[O2]2 (C) rate = *k*[[N2O5]2 (D) rate = *k*[N2O5]2[O2]

1. The data below were measured for the reaction, 2A + 2B + 2C  D. Calculate the rate law

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Exp. | [A] | [B] | [C] | rate (M/min) |  |
| 1 | 0.25 | 0.20 | 1.0 | 5.1 |  |
| 2 | 0.25 | 0.40 | 2.0 | 20.4 |  |
| 3 | 0.25 | 0.40 | 1.0 | 20.4 |  |
| 4 | 0.50 | 0.20 | 1.0 | 10.2 |  |
| (A)(D) | rate = k[A]2[B]2[C]2rate = k[A][B]2 | (B)(E) | rate = k[A][B][C]2rate = k[A][B][C] | (C) rate = k[A][B]2[C] |

1. The decomposition of diethylether at 504 C is first order with a half-life of 1570 seconds. What fraction of the original sample will remain after 4710 seconds?

(A) 1/16 (B) 1/8 (C) 1/3 (D) 1/6 (E) 1/32

1. A first order reaction has the rate law, rate = k[A]. The half life of this reaction is:

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| (A) | t1/2 = (log10 2)/k | (B) | t1/2 = | -(ln 2) / k | (C) | t1/2 = (ln 2 )/k |
| (D) | t1/2 = 1 / k[A]o | (E) | t1/2 = | (ln 2 ) x k |  |  |

1. For the rxn, 2 NOBr(g)  2 NO(g) + Br2(g), the rate law is rate = k[NOBr]2 and the rate constant is

0.80 1/Ms. What is the concentration of NOBr after 22 s if the starting concentration is 0.086 M?

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| (A) | 7.1 x 10-11 M | (B) | 8.4 x 1011 M | (C) | 0.086 M |
| (D) | 1.2 x 10-12 M | (E) | 0.034 M |  |  |

1. The reaction of cyclopropane to propene is first order, with a rate constant of 5.4 x 10-2 hr-1 at 25 C. If I start with 0.150 M cyclopropane, how much will be left after 22.0 hours?

(A) 0.0457 M (B) 0.105 M (C) 0.127 M (D) 0.492 M (E) 0 M

1. The half-life for the first-order decomposition of the radioactive nucleus, 241U is 15 seconds. If I make 50 g of this nucleus, how long will it take until I only have 6.25 g left?

(A) 30 seconds (B) 45 seconds (C) 60 seconds (D) 75 seconds (E) 90 seconds

1. The rate law for the reaction, 3 A  C is rate = 4.36 x 10–2 [A]2, where k is given as 1/Mh What is the half life for the reaction if the initial concentration of A is 0.250 M?

(A) 0.0109 h (B) 0.0629 h (C) 15.9 h (D) 91.7 h (E) 4.36 x 10-2 h

1. 2 NO2  2 NO + O2 follows second order kinetics. At 300 C, it takes 100 s for the [NO2] to drop from 0.0100 to 0.00650 M. What is the value of k in 1/Ms?

(A) 0.096 (B) 0.65 (C) 0.81 (D) 1.2 (E) 0.54

1. CH3NC  CH3CN is a first order reaction. At 230.3 C, k = 6.30 x 10–4 s–1. If I start with 0.001 M [CH3NC], how much is left after 1000 s?

(A) 0.000533 (B) 0.00234 (C) 0.00188 (D) 0.00427

1. The value of k for a particular second-order reaction is 0.47 1/Ms. If the initial concentration of the reactant is 0.25 M, how long will it take for the concentration to decrease to 0.13 mol/L?

(A) 7.9 s (B) 1.4 s (C) 3.7 s (D) 1.7 s

1. Substance **A** undergoes a first order reaction **A**  **B** with a half life of 20 min at 25 °C. If the initial concentration of **A** in a sample is 1.6 M, what will be the concentration of **A** after 80 min?

(A) 0.40 M (B) 0.20 M (C) 0.10 M (D) 0.050 M

1. The decomposition of hydrogen peroxide is a first order reaction with k = 1.06 x 10–3 min–1. How long will it take for 40% of a sample of hydrogen peroxide to decompose?

(A) 7.55 min (B) 481 min (C) 4550 min (D) 31,400 min

1. The decomposition of SOCl2 is first order. If the half life for the reaction is 4.1 h, how long would it take for the concentration of SOCl2 to drop from 0.36 M to 0.045 M?

(A) 0.52 h (B) 1.4 h (C) 12 h (D) 33 h

1. A change in temperature from 10 °C to 20 °C is found to double the rate of a given chemical reaction. How did this change affect the reacting molecules?

(A) It doubled their average velocity. (B) It doubled their average energy.

1. It doubled the number of collisions per second.
2. It doubled the pressure inside the reaction vessel.
3. It doubled the proportion of molecules possessing at least the minimum energy required for the reaction.
4. How is the activation energy Ea determined from measurements of the rate constants as a function of temperature?
5. Plot ln K as a function of 1/T, where T is measured in degrees Celsius
6. Plot K as a function of 1/T, where T is measured in degrees Kelvin
7. Plot K as a function of T, where T is measured in degrees Kelvin
8. Plot ln K as a function of 1/T, where T is measured in degrees Kelvin
9. Plot ln K as a function of T, where T is measured in degrees Celsius
10. The kinetics of the decomposition of dinitrogen pentoxide are studied at 50 C and 75 C. Which of the following statements about these studies is correct?
11. The rate at 75 C will be greater than at 50 C because the activation energy is lower at 75 C
12. The rate at 75 C will be greater than at 50 C because the # of molecules with enough energy to react increases with temp
13. The rate at 75 C will be lower than at 50 C because the molecules with higher speeds do not interact as well as the ones at lower speeds
14. The rate at 75 C will be greater than at 50 C because the concentration of a gas increases with increasing temperature
15. The rate at 75 C will be greater than that at 50 C because the activation energy is higher.
16. The Arrhenius equation, *k* = *A*e-*E*/*RT* expresses the relationship between the rate constant, *k*, and the energy of activation, *E*. The probability that colliding molecules will react
17. increases with increasing energy of activation.
18. depends only on the empirical constant, *A*.
19. increases with decreasing temperature.
20. decreases with increasing energy of activation.
21. Dinitrogen tetraoxide, N2O4, decomposes to nitrogen dioxide, NO2, in a first-order process. If *k* = 2.5 

103 s-1 at *-*5C and *k* = 3.5  104 s-1 at 25C, what is the activation energy for the decomposition?

(A) 0.73 kJ/mol (B) 58 kJ/mol (C) 140 kJ/mol (D) 580 kJ/mol

1. The decomposition of hydrogen peroxide in the presence of iodide ion is believed to occur via the mechanism below. In this mechanism, I–*(aq)* is

1. H2O2*(aq)* + I–*(aq)*  H2O*(l)* + IO–*(aq)* 2. H2O2*(aq)* + IO–*(aq)*  H2O*(l)* + O2*(g)* + I–*(aq)*

|  |  |  |
| --- | --- | --- |
| (A) a catalyst. | (B) | a reactant in the overall reaction. |
| (C) the activated complex. | (D) | a product of the overall reaction. |

1. The following mechanism has been proposed for the formation of ethylbenzene: Which substance is not an intermediate?

CH3CH2Br + AlBr3  AlBr4– + CH3CH2+ CH3CH2+ + C6H6  C6H6CH2CH3+

C6H6CH2CH3+ + AlBr4–  AlBr3 + HBr + C6H5CH2CH3

(A) AlBr3 (B) CH3CH2+ (C) AlBr4– (D) C6H6CH2CH3+

1. Consider the reaction:, 2NO2*(g)* + F2*(g)*  2NO2F*(g)*. A proposed mechanism for this reaction is shown below. What is the rate law for this mechanism?

1. NO2 + F2  NO2F + F (slow) 2. NO2 + F  NO2F (fast)

(A) rate = *k* [NO2F]2 (B) rate = *k*[NO ][F ] (C) rate = *k*[NO ] [F ] (D) rate = *k*[NO ][F]

2

[NO ]2[F ] 2 2 2 2 2

2 2

1. The reaction, 2 NO(g) + O2(g) → 2 NO2(g), has an observed rate law, rate = k[NO]2[O2]. Three possible mechanisms could be proposed for this reaction, as shown:

MECHANISM I. Second step slow. MECHANISM II. First step slow.

1. NO(g) + NO(g) → N2O2(g) 1. NO(g) + NO(g) → N2O2(g)

2. N2O2(g) + O2(g) → 2 NO2(g) 2. N2O2(g) + O2(g) → 2 NO2(g)

MECHANISM III. One step reaction, 2 NO(g) + O2(g) → 2 NO2(g) Which of these mechanisms is the most likely?

(A) I only (B) II only (C) III only (D) I and III (E) II and III

1. Consider the following mechanism of the oxidation of bromide ions by hydrogen peroxide in acid solution. Which of the rate laws in the answers is consistent with this mechanism?

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| 1. | H+ + H2O2  H2O-OH+ | Fast | 2. | H2O-OH+ + Br-  HOBr + H2O | Slow |
| 3. | HOBr + H+ + Br-  Br2 + H2O | Fast |  |  |  |
| (A) | Rate = k[H2O2][Br-][H+]2 | (B) | Rate = k[H2O2][Br-][H+] (C) Rate = k[H2O-OH+][Br-] |
| (D) | Rate = k[H2O2][Br-]2[H+]2 | (E) | Rate = k[HOBr][H+][Br-][H2O2] |

1. In a chemical rxn involving the formation of an activated complex (transition state), which step must always be exothermic?



(A) Reactants  products (B) Products  reactants

(C) Reactants  activated complex (D) Products  activated complex

(E) Activated complex  products

1. Which line in the diagram represents the activation energy for a forward reaction?

(A) A (B) B (C) C (D) D

1. Which statement concerning the reaction coordinate diagram is true?
2. The catalyst decreases the activation energy.
3. The reaction is endothermic.
4. The addition of a catalyst slows this reaction.
5. **A** and **B** have lower potential energy than **C** and **D**.
6. Consider the reaction coordinate shown below, and pick the correct statement:

(A) the point A represents at set of intermediates

(B) the energy represented by B is the activation energy

(C) there are five steps in the mechanism

(D) the second step is the rate-determining step

(E) there are four sets of intermediates in the reaction mechanism

1. The rate of a reaction in the absence of a catalyst has been measured.
The rate of the same reaction when catalyzed is 106 times faster. The activation energy for this reaction
2. is 6/*RT* kcal/mole.
3. can be calculated from the information above if the temperatures of the reactions are given.
4. is a concept that cannot be applied to chemical reactions.
5. is different in the two cases.
6. The addition of a catalyst in a chemical reaction
7. increases the concentration of products at equilibrium.
8. increases the fraction of reactant molecules with a given kinetic energy.
9. provides an alternate path with a different activation energy.
10. lowers the enthalpy change in the overall reaction.
11. Which procedure will lower the activation energy for a particular reaction?
12. subdividing the reactants
13. increasing the reactant concentrations
14. increasing the temperature
15. adding a catalyst

# *ANSWERS:*

1. B
2. C
3. A
4. D
5. B
6. D
7. B
8. C
9. B
10. C
11. C
12. D
13. C
14. B
15. D
16. C
17. D
18. D
19. A
20. E
21. D
22. D
23. D
24. A
25. D
26. B
27. C
28. E
29. A
30. B
31. D
32. E
33. A
34. A
35. C
36. B
37. C
38. E
39. D
40. B
41. D
42. B
43. A
44. A
45. B
46. A
47. B
48. E
49. A
50. A
51. D
52. D
53. C
54. D