- *This is practice - Do NOT cheat yourself of finding out what you are capable of doing. Be sure you follow the testing conditions outlined below.*
- *DO NOT USE A CALCULATOR. You may use ONLY the green periodic table.*
- *Try to work at a pace of 1.5 min per question. Time yourself. It is important that you practice working for speed.*
- *Then when time is up, continue working and finish as necessary.*

exp	inital [A] $(mol\ L^{-1})$	inital [B] $(mol\ L^{-1})$	initial rate of formation of [C] $(mol\ L^{-1}\ sec^{-1})$
1	0.10	0.10	2.5×10^{-4}
2	0.20	0.10	5.0×10^{-4}
3	0.20	0.50	1.25×10^{-2}

1. The initial-rate data in the table above were obtained for the reaction represented below. What is the experimental rate law for the reaction.

$$A + B \rightleftarrows 2\,C$$
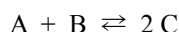
   a. $rate = k[A][B]$

   b. $rate = k[A][B]^2$

   c. $rate = k[A][B]^3$

   d. $rate = k[A]^2[B]^2$

   e. $rate = k\dfrac{[A]}{[B]}$

2. $$rate = k[A]^2$$

   For the reaction for which rate law is given above, a plot of which of the following is a straight line?
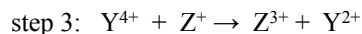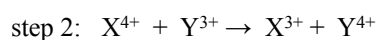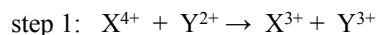
   a. $\dfrac{1}{[A]}$ versus time

   b. $[A]$ versus $\dfrac{1}{time}$

   c. $[A]$ versus time

   d. $\ln [A]$ versus time

   e. $\ln [A]$ versus $\dfrac{1}{time}$

3. $$2\,X_{(g)} + Y_{(g)} \rightleftarrows 2\,Z_{(g)}$$

   When the concentration of substance Y in the reaction above is doubled, all other factors being held constant, it is found that the rate of the reaction quadruples. The most probable explanation for this observation is that
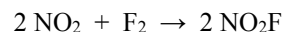
   a. substance X is not involved in any of the steps of the mechanism.

   b. substance Y is involved in the rate-determining step of the mechanism but is not involved in subsequent steps.

   c. substance Y is probably a catalyst and thus speeds up the rate of the reaction.

   d. the reactant with the smallest coefficient in the balanced equation generally has the greatest effect on the rate of the reaction.

   e. the order of the reaction with respect to Y is 2.

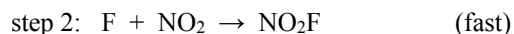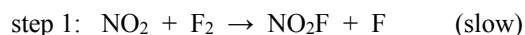4. The proposed steps for a catalyzed reaction between X^{4+} and Z^+ are represented below.

   step 1: $X^{4+} + Y^{2+} \rightarrow X^{3+} + Y^{3+}$

   step 2: $X^{4+} + Y^{3+} \rightarrow X^{3+} + Y^{4+}$

   step 3: $Y^{4+} + Z^+ \rightarrow Z^{3+} + Y^{2+}$

   The catalyst in this process is

   a. X^{4+}

   b. X^{3+}

   c. Y^{4+}

   d. Y^{2+}

   e. Z^+

5. The balanced equation for the reaction of nitrogen dioxide and fluorine is

   $$2\,NO_2 + F_2 \rightarrow 2\,NO_2F$$

   The proposed mechanism is

   step 1: $NO_2 + F_2 \rightarrow NO_2F + F$ (slow)

   step 2: $F + NO_2 \rightarrow NO_2F$ (fast)

   Which of the following are correct?

   I. The mechanism supports an experimentally determined rate law of rate = $k[NO_2]^2[F_2]$

   II. F is an intermediate

   III. The reaction is first order in F_2

   a. I only

   b. I and II only

   c. I and III only

   d. II and III only

   e. I, II, and III

6. Each of the following is true about heterogenous catalyst EXCEPT

   a. Its presence changes the rate of chemical change.

   b. It does not undergo a permanent change.

   c. It is in the same phase as the reacting particles.

   d. It's presence lowers the activation energy of the overall reaction.

   e. Its presence decreases the potential energy of the activated complex.

The Reaction below should be used for the next 3 questions

$$IO_3^- + 5I^- + 6H^+ \rightarrow 3I_2 + 3H_2O$$

7. The oxidation of iodide ions by iodate ions in acidic aqueous solution occurs according to the stoichiometry shown above. The experimentally determined rate law of the reaction is

    $$rate = k[IO_3^-] [I^-]$$

   What is the order with respect to I^- ?
    a. 1
    b. 2
    c. 3
    d. 5
    e. 6

8. According to the rate law for the reaction, an increase in the concentration of hydrogen ion has what effect on this reaction?
    a. The rate of reaction increases.
    b. The rate of the reaction decreases.
    c. The value of the rate law constant increases.
    d. The value of the rate law constant decreases.
    e. Neither the rate nor the value of the rate law constant is changed.

9. According to the rate law for the reaction, a decrease in the concentration of iodide ion has what effect on this reaction?
    a. The rate of the reaction decreases and the value of the rate law constant decreases.
    b. The rate of the reaction decreases and the value of the rate law constant remains the same.
    c. The rate of the reaction remains the same and the value of the rate law constant increases.
    d. The rate of the reaction decreases and the value of the rate law constant increases.
    e. Neither the rate nor the value of the rate law constant is changed.

10. $A_{(g)} + B_{(g)} \rightarrow C_{(g)}$

    All of the following apply to the reaction above as it is carried out at constant temperature in a sealed rigid container EXCEPT
    a. The total pressure decreases.
    b. The rate of the reaction decreases.
    c. The entropy of the system decreases
    d. The number of molecules of C decreases.
   e. The frequency of collisions between molecules A and B decreases.

11. Consider the hypothetical reaction.

    $$X_{(g)} + 2Y_{(g)} \rightarrow XY_{2(g)}$$
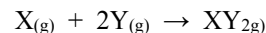
    $$\frac{\Delta[Y]}{\Delta t} = -5.0 \times 10^{-2} \text{ mol L}^{-1} \text{ sec}^{-1}$$

    What is the rate of formation of $XY_{2(g)}$
   a. $-5.0 \times 10^{2-}$ mol L^{-1} sec^{-1}
    b. $-2.5 \times 10^{2-}$ mol L^{-1} sec^{-1}
    c. 1.0×10^{-2} mol L^{-1} sec^{-1}
    d. 2.5×10^{-2} mol L^{-1} sec^{-1}
    e. 5.0×10^{-2} mol L^{-1} sec^{-1}

12. Consider the hypothetical reaction below taking place in a syringe at constant temperature. The reaction is started by placing $A_{(g)}$ and $B_{(g)}$ in the syringe.
    No chemical equilibrium is established.

    $$A_{(g)} + 2B_{(g)} \rightarrow AB_{2(g)}$$

    Which change causes an immediate increase in the partial pressure $B_{(g)}$?

    I.   addition of $B_{(g)}$ at constant volume

    II. decrease in the volume of the reaction vessel

    III. addition of $AB_{2(g)}$ at constant volume

    a. I only
    b. II only
    c. I and II only
    d. II and III only
    e. I, II, and III

13. For two first order reactions of different substances A and X

    $$A \rightarrow B \quad t_{1/2} = 30.0 \text{ min}$$
    $$X \rightarrow Y \quad t_{1/2} = 60.0 \text{ min}$$
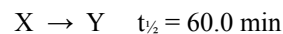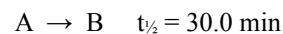
    This means that
    a. doubling the concentration of A will have ½ the effect on half-life that doubling the concentration of B will have on its half-life
    b. a certain number of grams of A will react twice as fast as the same number of grams of X
    c. a certain number of grams of X will react twice as fast as the same number of grams of A
    d. the rate constant of $A \rightarrow B$ is lower than the rate constant of $X \rightarrow Y$.
    e. 3 moles of A will react more rapidly than 3 moles of X.

Consider the reaction and its rate law given below for the next six questions.

$$2 A_{(g)} + B_{(g)} \rightarrow C_{(g)}$$
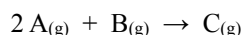
$$\text{rate} = k[A]^2[B]$$

At the beginning of one trial of this reaction
$[A] = 4.0$ and $[B] = 1.0$.

The rate of formation of C was 0.048 mole L^{-1} sec^{-1}

14. The numerical value of k, the rate constant, for this reaction is closest to
    a. 3×10^2
    b. 4×10^0
    c. 8×10^{-1}
    d. 1×10^{-2}
    e. 3×10^{-3}

15. Which is the label for k, the rate constant?
    a. $mol^2\,L^{-2}\,sec^{-1}$
    b. $L\,mol^{-1}\,sec^{-1}$
    c. $L^2\,mol^{-2}\,sec^{-1}$
    d. $L^2\,sec\,mol^{-1}$
    e. $L^2\,sec\,mol^{-2}$

16. When [B] decreases 0.4 M, what will be the value of [A]?
    a. 0.8 M
    b. 1.6 M
    c. 2.8 M
    d. 3.4 M
    e. 3.6 M

17. Which of the following describes how the rate for this trial reaction, at constant temperature, changes as [B] approaches 0.4 mol L^{-1}?
    a. The rate decreases because the concentration of the products increases.
    b. The rate remains the same because the rate constant remains the same.
    c. The rate remains the same because the temperature remains the same.
    d. The rate decreases because the concentration of the reactants decreases.
    e. The rate remains the same because the energy of activation remains the same.

18. Which applies to this reaction as it proceeds at constant temperature?
    I.   The rate of the reaction decreases.
    II. The effectiveness of collisions between reactant molecules remains the same.
    III. The frequency of collisions between reactant molecules remains the same.
    a. I only
    b. II only
    c. I and II only
    d. II and III only
    e. I, II, and III

19. Which applies to this system when its temperature increases at constant volume?
    I.   [A] decreases at a greater rate.
    II. The value for k, the rate constant, remains the same.
    III. The rate of the reaction increases.
    a. I only
    b. II only
    c. I and III only
    d. II and III only
    e. I, II, and III

20. Which applies to any reaction mechanism?
    I.   It is a list of steps that produce the overall chemical reaction.
    II. It includes only unimolecular steps.
    III. It cannot include reaction intermediates.
    a. I only
    b. II only
    c. III only
    d. I and II only
    e. I and III only

21. The first order decomposition of some radioactive isotope is 3 days. Approximately what percentage of the original substance will have decayed after 12 days have passed?
    a. 94%
    b. 88%
    c. 50%
    d. 25%
    e. 6%

Consider the information below for the next five questions.

$$5Br^-_{(aq)} + BrO_3^-_{(aq)} + 6H^+_{(aq)} \rightarrow 3Br_{2(L)} + 3H_2O_{(L)}$$
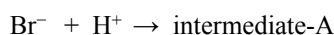
The reaction between bromide ions and bromate ions in acidic water solution occurs according to the equation above. The rate law for this reaction is known to be

$$\text{rate} = k[Br^-][BrO_3^-][H^+]^2$$

22. The overall order for this reaction is
    a. 2
    b. 3
    c. 4
    d. 6
    e. 12

23. One proposed reaction mechanism has three steps up to and including the slow step. The first step in the mechanism is

    $$Br^- + H^+ \rightarrow \text{intermediate-A}$$

    Which statement(s) must be true about this first step in the reaction mechanism?
    I.   The coefficients of the reactants must correspond to the exponents on those same terms in the overall rate law.
    II. No further step can include intermediate-A as a reactant.
    III. A subsequent step must include BrO_3^- as a reactant.
    a. I only
    b. II only
    c. III only
    d. I and II only
    e. I and III only

24. What is the effect of increasing $[H^+]$ in this reaction at a constant temperature?
    a. The value of the rate constant increases.
    b. The potential energy of the products decreases.
    c. The potential energy of the activated complex decreases.
    d. The number of collisions between H^+ and Br^- ions increases.
    e. The number of collisions between H^+ and Br^- ions decreases.

25. Which change will cause a decrease in the rate of the reaction?
    I.   addition of OH^- ions
    II. removal of H^+ ions
    III. addition of H_2O molecules
    a. I only
    b. II only
    c. I and II only
    d. II and III only
    e. I, II, and III

26. What is the effect of adding $Br_{2(L)}$ to the system? (Assume negligible change in volume.)
    I.   The mass of the system increases.
    II. The rate of reduction of BrO_3^- increases.
    III. The rate of oxidation of Br^- decreases.
    a. I only
    b. II only
    c. I and II only
    d. II and III only
    e. I, II, and III

27. The values for the change in enthalpy, ΔH, and the activation energy, E_a, for a given reaction are known. The value of E_a for the reverse reaction equals
   a. Ea for the forward reaction.
    b. $-(E_a)$ for the forward reaction.
    c. the sum of $-(\Delta H)$ and E_a
    d. the sum of E_a and ΔH
    e. the difference between ΔH and E_a

28. Which accounts for the increase in the rate of reaction when a catalyst is added to a reaction system?
    a. decrease in ΔH for the reaction
    b. increase in ΔS for the reaction
    c. increase in potential energy of the reactants
    d. increase in potential energy of the products
   e. decrease in potential energy of the activated complex

29. The rate constant for a gas phase reaction can be increased by doing which of the following?

    I.   Increasing the concentration of reactants

    II. Increasing the temperature

    III. Decreasing the size of the container

a. I only

b. II only

c. I and II only

d. I and III only

e. I, II, and III only

30. How does a catalyst increase the rate of a chemical reaction?

a. By changing the magnitude of the enthalpy change.

b. By providing a pathway for the reaction that has a lower activation energy.

c. By decreasing the potential energy of the products

d. By increasing the potential energy of the reactants

e. By giving energy to the reactants so more of them have energies greater than the activation energy.

31. Collision theory predicts all of the following EXCEPT that

a. a reaction will only occur if the collision geometry is correct

b. a reaction will not occur if the collision occurs with energy that is less than the activation energy.

c. a reaction will not occur if the reactants do not collide

d. frequency of collisions will increase with increasing temperature.

e. more successful collisions will occur for a reaction with a larger activation energy.

32. For the chemical reaction $H_2 + Br_2 \rightarrow 2HBr$, what can be said of the relative rates of consumption of the reactants when compared to the formation of product?

a. HBr will be produced at half the rate that bromine is consumed.

b. HBr will be produced at the same rate that bromine is consumed.

c. Br_2 and H_2 will be consumed at different rates.

d. HBr will be produced at twice the rate that bromine is consumed

e. It is not possible to tell anything about relative rates without the rate law.

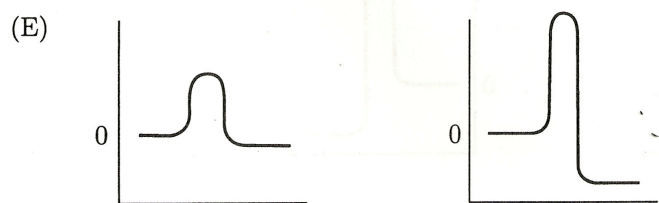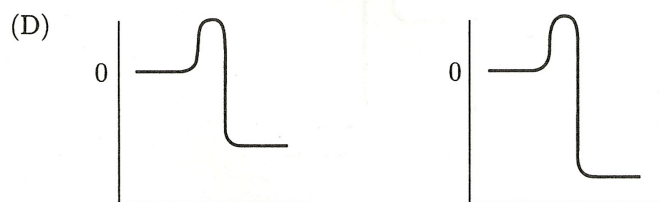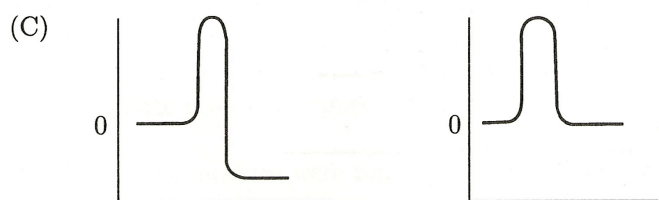33. Which energy distribution diagram represents an increase in temperature?

Before ———

After - - - - - - - - -

(A)

(B)

(C)

(D)

(E)
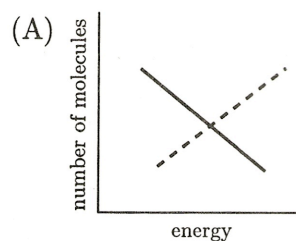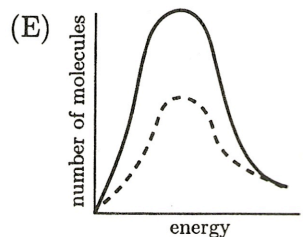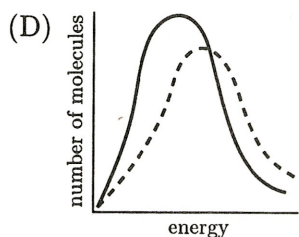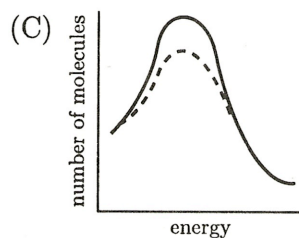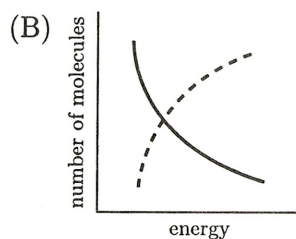
34. Which pair of potential energy/reaction coordinate diagrams represents a comparison between the same reactants where one of the pair of diagrams represents a situation that includes a catalyst?

(A)

(B)

(C)

(D)

(E)
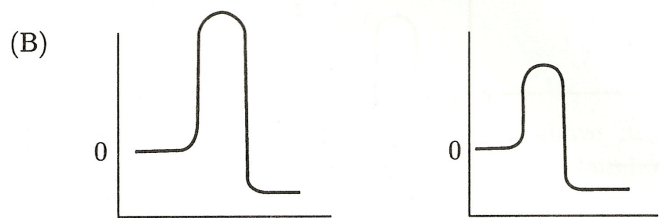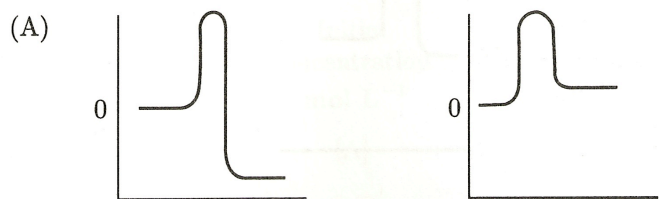
35. Which pair of potential energy/reaction coordinate diagrams represents a comparison between a reaction with high activation energy to a reaction with lower activation energy but the same heat of reaction?

(A)

(B)

(C)

(D)

(E)
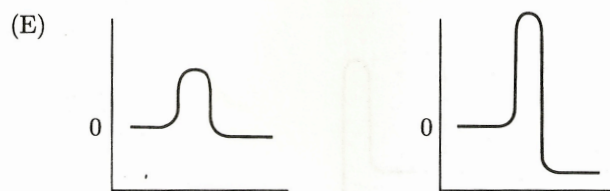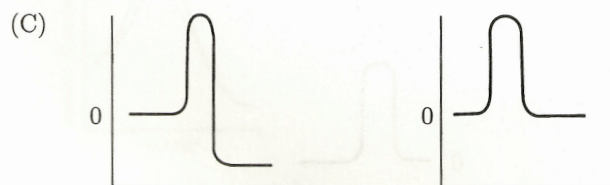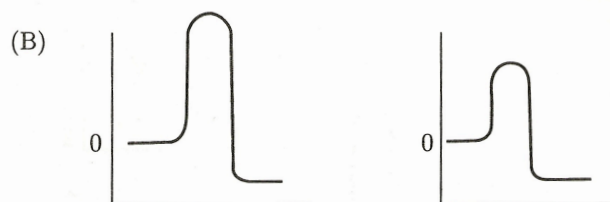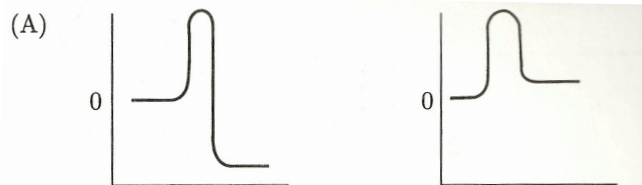
The following 4 questions refer to a reaction involving three reactants: A, B, C. Select from choices below:

(A) Rate= $k\,[A]^0$

(B) Rate= $k\,[A]^2$

(C) Rate= $k\,[A]\,[B]^3$

(D) Rate= $k\,[A]\,[B]^2\,[C]^2$

(E) Rate= $k\,[A]^2\,[B]$

36. A rate law for which the units of rate are equal to the units of the rate constant

37. A rate law for a reaction that is 3rd order overall

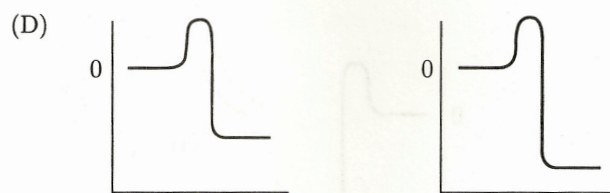38. A rate law that represents a reaction in which doubling the concentration of A and doubling the concentration of B (keeping all other variables constant) will lead to a four fold increase in the rate

39. A rate law that represent a reaction in which doubling the concentration of A and halving the concentration of B (keeping all other variables constant) will lead to a two fold increase in the rate.

The following 3 questions refer to the choices below:

(A) Reaction Mechanism

(B) Catalyst

(C) Rate-Determining step

(D) Enthalpy Change

(E) Collision Theory

40. Describes the series of steps that a chemical reaction is broken in to

41. Is present at the start of a reaction and is also present at the end of a reaction

42. The specific part of a chemical reaction that can be used to determine the rate equation

43. A sealed rigid container holds two first order reactant gases, A and B. If additional moles of gas B are added to the container while keeping the temperature constant, what can be said of the reaction under these conditions.
    a. The rate of the reaction will increase, as will the rate constant, k.
    b. the rate of the reaction will remain unchanged as will the rate constant, k.
    c. the rate of the reaction will increase but the rate constant, k, will remain unchanged.
    d. the rate of the reaction will remain unchanged but the rate constant, k, will increase.
    e. the rate of reaction will decrease as will the rate constant, k.

44. A reaction occurs in the gas phase according to the chemical equation shown below. Which statement correctly reflects the relative changes in concentrations of reactant and products in the forward reaction?
$$N_2 + 3H_2 \rightarrow 2NH_3$$
    a. $[H_2]$ decreases at the same rate $[N_2]$ decreases.
    b. $[H_2]$ decreases at ⅔ the rate $[NH_3]$ increases
    c. $[N_2]$ increases at the same rate as $[NH_3]$ decreases
    d. $[N_2]$ increases at ½ the rate $[NH_3]$ decreases
    e. $[N_2]$ decreases at ½ the rate $[NH_3]$ increases

45. For a reaction that is first order with respect to $[D]$ and second order with respect to $[E]$, which of the following will result in no change to the overall reaction rate.
    a. Doubling $[D]$ and halving $[E]$
    b. Doubling $[E]$ and halving $[D]$
    c. Doubling $[D]$ and Doubling $[E]$
    d. Increasing $[D]$ by a factor of four and halving $[E]$
    e. Increasing $[D]$ by a factor of four and dividing $[E]$ by a factor of four.

46. The rate of a chemical reaction will be increased by all of the following factors EXCEPT
    a. the presence of a high activation energy
    b. the presence of a catalyst
    c. increasing the surface area of a reactant
    d. an increase in temperature
    e. increasing the concentration of the reactants
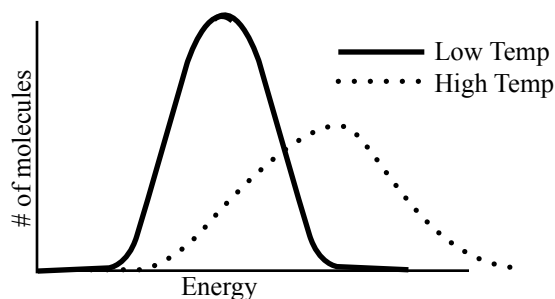
47. In the Maxwell-Boltzman distribution plot for a given reaction at two different temperatures, what can be said about the total area underneath the two curves when comparing the curve for the relatively hot temperature to the curve for the relatively low temperature.
    a. the total area under the hot curve is greater since more particles possess the minimum activation energy required.
    b. the total area under the cold curve is greater since more particles possess the minimum activation energy required
    c. the total areas are the same since the number of moles of gas does not change as a result of heating or cooling.
    d. the total areas are the same since the reaction has a fixed activation energy
    e. the total areas are the same since gases occupy the same space regardless of temperature.

48. Which of the following statements is/are true in relation to rate laws?
    I. A rate law must be determined experimentally and cannot be deduced from a chemical equation alone.
    II. Zero-order have rate constants equal to rates
    III. A "straight line" graph can be obtained for a first-order reaction by plotting the reciprocal of the concentration of reactant (y-axis) against time (x-axis)

    a. I only
    b. II only
    c. III only
    d. I and II only
    e. I,II, and III

49. If the units in the rate in a given experiment are mol L^{-1} min^{-1} and the units of all concentrations are mol L^{-1}, then the units of the rate constant associated with the rate law

    Rate= $k[A]^2[B]$:
    a. mol L^{-1} min^{-1}
    b. L^2 mol^{-2} min^{-1}
    c. mol^2 L^{-2} min^{-1}
    d. mol^{-3} L^3 min^{-1}
    e. mol^{-2} L^{-2} min^{-1}

50. For the rate law shown below, where the rate is measured in units of M s^{-1} and the concentrations of X and Y are measured in M, which of the following statements is true?

    Rate= $k[X]^2[Y]$

    I. the units of $k = M^2 s^{-1}$
    II. doubling the concentration of y while keeping all other conditions constant will not affect the rate.
    III. The reaction can be described as third-order.

    a. I only
    b. III only
    c. I and II only
    d. II and III only
    e. I, II, and III

51. For the rate law, Rate= $k[Q]^2[R]^2$,which statement is correct?
    a. The reaction is fourth order overall, and doubling both the [Q] and [R] while keeping the temperature constant will lead to a bigger k and a 16-fold increase in the rate
    b. The reaction is fourth order overall, and doubling both the [Q] and [R] while keeping the temperature constant will lead to a 16-fold increase in the rate
    c. The reaction is fourth order overall, and doubling both the [Q] and [R] while keeping the temperature constant will lead to a bigger k and an 8-fold increase in the rate
    d. The reaction is second order overall, and doubling both the [Q] and [R] while keeping the temperature constant will lead to a bigger k and a 16-fold increase in the rate
    e. The reaction is second order overall, and doubling both the [Q] and [R] while keeping the temperature constant will lead to a 16-fold increase in the rate

52. The reaction X + Y→Z has the rate law, Rate = $k[X]^2[Y]$. If the concentration of X is doubled and the concentration of Y is tripled, the rate would be increased by a factor of
    a. 2
    b. 4
    c. 5
    d. 6
    e. 12

For the next 2 questions, the proposed mechanism for a given chemical reaction is shown below.

Step 1: $A + B \rightleftharpoons F$ (fast)

Step 2: $F + A \rightarrow C + G$ (slow)

Step 3: $G + A \rightleftharpoons C + D$ (fast)
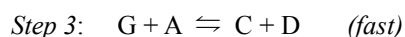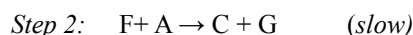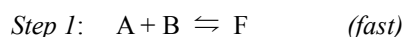
53. Which is the correct rate law?
    a.   rate = k [A]² [B]
    b.   rate = k [A] [B] [F] [G]
    c.   rate = k [A] [B]
    d.   rate = k [A]³ [B]
    e.   rate = k [A]² [B] [F]

54. Which reaction represents the overall equation?
    a. $A + B \rightleftharpoons F$
    b. $3A + B \rightarrow 2C + D$
    c. $3A + B + F + G \rightarrow 2C + D + G + F$
    d. $A + B \rightarrow C + D$
    e. $A_3 + B \rightarrow C_2 + D$

55. Which answer choice correctly matches the integrated rate law shown:

$$\frac{1}{[A]_t} = kt + \frac{1}{[A]_o}$$

    a.   A zero order reaction where a plot of
         $\frac{1}{[A]_t}$ versus t will be a straight line with slope = k

    b.   A first order reaction where a plot of
         $\frac{1}{[A]_t}$ versus t will be a straight line with slope = k

    c.   A first order reaction where a plot of
         $\frac{1}{[A]_t}$ versus t will be a straight line with slope = −k

    d.   A second order reaction where a plot of
         $\frac{1}{[A]_t}$ versus t will be a straight line with slope = k

    e.   A second order reaction where a plot of
         $\frac{1}{[A]_t}$ versus t will be a straight line with slope = −k

56. Which of the following plots will yield a straight line for a first order reaction where the slope= $-k$?
    a. ln [A] versus time
    b.   [A] versus rate
    c. $\frac{1}{[A]}$ versus time
    d.   time versus $\frac{1}{[A]}$
    e. $ln\ k$ versus time

57. The reaction of a tertiary haloalkane (represented by RX below) with hydroxide ions is found to follow the mechanism:

    Step 1 $RX \rightarrow R^+ + X^-$

    Step 2 $R^+ + OH^- \rightarrow ROH$
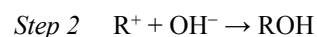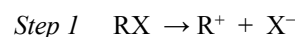
If Step 1 is found to be the slow step in the mechanism, which of the following statements is true?

    I.   The reaction will be found to be first-order with respect to RX

    II.   The reaction has an intermediate that is represented by R^+.

    III. The reaction rate is independent of the concentration of hydroxide ions.

    a.   I only
    b.   II only
    c.   III only
    d.   I and II only
    e.   I, II, and III

58. For a mechanism to be feasible, which of the following criteria must be filled?

    I.   The sum of the overall steps must add up to the overall stoichiometry of the chemical equation

    II.   The rate determining (slow step) must be the last step in the mechanism.

    III. The rate determining (slow step) must include all of the reactants that appear in the rate equation where the stoichiometric coefficients match the powers.

    a.   I only
    b.   III only
    c.   I and III only
    d.   II and III only
    e.   I, II, and III

59. Which of the following is true of all catalysts?
    a. They are used up in chemical reactions
    b. They are always transition metals
    c. They do not take part in chemical reactions.
    d. They work by increasing the activation energy of a reaction.
    e. They are present at the beginning of a a reaction and are unchanged at the end.

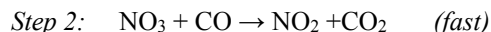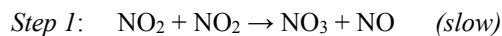The following 2 questions refer to the following equation and table below:

$$2W + 3X + Y \rightarrow Z$$
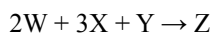
Trial	[W] mol L^{-1}	[X] mol L^{-1}	[Y] mol L^{-1}	Rate of Production of Z mol L^{-1}
1	0.001	0.001	0.001	2.1×10^{-4}
2	0.002	0.001	0.001	2.1×10^{-4}
3	0.001	0.003	0.001	6.3×10^{-4}
4	0.002	0.001	0.0005	5.25×10^{-5}

60. The rate law is:
    a. rate= k [W]^2 [X]^3 [Y]
    b. rate= k [W]^2 [X] [Y]
    c. rate= k [W] [X] [Y]
    d. rate= k [X]^3 [Y]^2
    e. rate= k [X] [Y]^2

61. The rate of change of X in Experiment 1 is:
    a. 2.1×10^{-4} mol L^{-1} min^{-1}
    b. -2.1×10^{-4} mol L^{-1} min^{-1}
    c. 6.3×10^{-4} mol L^{-1} min^{-1}
    d. -6.3×10^{-4} mol L^{-1} min^{-1}
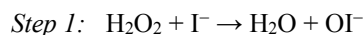   e. -4.2×10^{-4} mol L^{-1} min^{-1}

62. If tripling the concentration of a single reactant R in a multi-reactant reaction (while leaving all other conditions unchanged) leads to a nine−fold increase in rate, it can be deduced
    a. that the complete rate law is Rate= k[R]
    b. that the complete rate law is Rate= k[R]^2
    c. that the complete rate law is Rate= k[R]^3
    d. that the complete rate law is Rate= k[R]^9
    e. only that the order with respect to [R] is 2

For the next 2 questions consider the proposed mechanism shown below for the reaction between nitrogen dioxide and carbon monoxide.

Step 1: $NO_2 + NO_2 \rightarrow NO_3 + NO$ *(slow)*

Step 2: $NO_3 + CO \rightarrow NO_2 + CO_2$ *(fast)*

63. What is the Rate law for the reaction?
    a. Rate= k [NO$_2$]
    b. Rate= k [NO$_2$]^2
    c. Rate= k [NO$_2$]^2 [NO$_3$] [NO]
    d. Rate= k [NO$_2$] [NO$_3$] [NO]
    e. Rate= k [NO$_3$] [CO]

64. Identify any intermediates in the Reaction:
    a. NO$_2$ only
    b. NO$_3$ only
    c. NO$_2$ and NO$_3$
    d. NO, NO$_2$, and NO$_3$
    e. NO$_2$, NO$_3$, and NO

The following 3 questions refer to the popular demonstration called "Elephants Toothpaste" in which the mechanism is believed to be:

Step 1: $H_2O_2 + I^- \rightarrow H_2O + OI^-$

Step 2: $H_2O_2 + OI^- \rightarrow H_2O + O_2 + I^-$

65. Identify the catalyst.
    a. H$_2$O$_2$
    b. I$^-$
    c. H$_2$O
    d. OI$^-$
    e. O$_2$

66. Identify the Intermediate:
    a. H$_2$O$_2$
    b. I$^-$
    c. H$_2$O
    d. OI$^-$
    e. O$_2$

67. Which chemical equation is consistent with the mechanism provided?
    a. $2H_2O_2 \rightarrow 2H_2O + O_2$
    b. $2H_2O_2 + I^- \rightarrow 2H_2O + O_2$
    c. $\frac{1}{2} H_2O_2 + I^- \rightarrow H_2O + O_2$
    d. $\frac{1}{2} H_2O_2 + I^- \rightarrow H_2O + OI^- + O_2$
    e. $2H_2O_2 \rightarrow 2H_2O + OI^- + O_2$

68. The nuclear decay of an isotope of this element is used to measure the age of archaeological artifacts.
    a. C
    b. O
    c. N
    d. F
    e. Ne

69. If 75% of a sample of pure ^3_1H decays in 24.6 years, what is the half- life of ^3_1H
    a. 24.6 years
    b. 18.4 years
    c. 12.3 years
    d. 6.15 years
    e. 3.07 years

70. Strontium−90 decays through the emission of beta particles. It has a half- life of 29 years. How long does it take for 80 percent of a sample of strontium−90 to decay?
    a. 9.3 years
    b. 21 years
    c. 38 years
    d. 67 years
    e. 96 years

71. After 44 minutes, a sample of $^{44}_{19}K$ is found to have decayed to 25 percent of the original amount present. What is the half−life of $^{44}_{19}K$?
    a. 11 minutes
    b. 22 minutes
    c. 44 minutes
    d. 66 minutes
    e. 88 minutes

72. A sample of radioactive cadmium has a half life of 15 days. If you have a sample that originally weighed 40 g and later weighs 2.5 g. How much time elapsed between the initial and final masses?
    a. 600 days
    b. 100 days
    c. 60 days
    d. 45 days
    e. 37.5 days

73. The half-life of ^{14}C is 5570 years. How many years will it take for 90% of a sample to decompose?
    a. 5,013 years
    b. 11,000 years
    c. 18,600 years
    d. 23,000 years
    e. 50,130 years

74. Tritium decays by a first-order process that has half-life of 12.5 years. How many years will it take to reduce the radioactivity of a tritium sample to 15% of it original value?
    a. 64 yrs
    b. 54 yrs
    c. 34 yrs
    d. 24 yrs
    e. 14 yrs

75. For a first order reaction that has a half-life of 69 s at 80°C, the value of the rate constant, k, is closest to?
    a. $0.01 \ s^{-1}$
    b. $0.1 \ s^{-1}$
    c. $1 \ s^{-1}$
    d. $10 \ s^{-1}$
    e. $100 \ s^{-1}$

76. If the half-life of a reaction is independent of concentration, what is the order of the reaction?
    a. zero
    b. first
    c. second
    d. half-life is unrelated to the order of the reaction
    e. unable to be determined without knowing starting concentrations

77. A particular nuclear decay has a rate constant of 0.00346 min^{-1} What is the half-life?
    a. 3.3 hours
    b. 1.6 hours
    c. 0.0012 min
    d. 0.0024 min
    e. 0.0050 min

78. The half-life of ^{99}Tc is 6.00 hours. If it takes exactly 12.00 hours for the manufacturer to deliver a ^{99}Tc sample to a hospital, how much must be shipped in order for the hospital to receive 10.0 mg?
    a. 40.0 mg
    b. 30.0 mg
    c. 20.0 mg
    d. 15.0 mg
    e. 4.0 mg

1. b   Use the table to check the relationship between concentration changes and rate changes. $\dfrac{rate_2}{rate_1} = \dfrac{k_2}{k_1}\left(\dfrac{concA_2}{concA_1}\right)^x\left(\dfrac{concB_2}{concB_1}\right)^y$

   and substitute to find the order of A $\dfrac{5\times10^{-4}}{2.5\times10^{-4}} = \dfrac{k_2}{k_1}\left(\dfrac{0.20}{0.10}\right)^x\left(\dfrac{0.10}{0.10}\right)^y$ thus $2 = (2)^x$ and x = 1, thus first order with respect to

   A. To solve for order of B use trials 3/2 $\dfrac{125\times10^{-4}}{5\times10^{-4}} = \dfrac{k_2}{k_1}\left(\dfrac{0.20}{0.20}\right)^1\left(\dfrac{0.50}{0.10}\right)^y$ thus $25 = (5)^y$ which means y = 2, thus second

   order with respect to reactant B

2. a   The order of the reaction indicates which plot will give a straight line. Since you are told second order, it is the plot of
   $\dfrac{1}{[A]}$ *vs time* that will be a straight line.

3. e   Second order: $[conc \times 2]^2$ = rate $\times4$

4. d   A catalyst is a chemical that gets used up during an early step, but returns as a product during a later step.

5. d   Since the first step is the slow step, the stoichiometry of that step results in the order of the reaction, thus it s first order for both NO_2 and F_2. Also, F is an intermediate because it is a product of one step, but gets used up in a subsequent step.

6. c   "Same phase" meaning liquid vs solid vs gas, heterogeneous catalyst are in a different phase than the reactants they are catalyzing.

7. a   It doesn't get much easier than this! Remember, the rate law gives us the order, not the stoichiometry of the balanced equation.

8. e   No effect on the rate since the reaction is zero order with respect to H^+

9. b   While the rate changes, the rate constant will remain constant. Rate constants only change when temperature changes or in the presence of a catalyst. Rate constants do not change with concentration or pressure changes.

10. d The pressure decreases because two molecules are converted into one. The rate of all reactions decrease over time. The entropy decreases because fewer molecules result from the reaction. Of course the number of C molecules will increase during the reaction. Since the concentration of A and B will decrease over the course of the reaction, their collisions will decrease.

11. d The formation of the product is half of the rate of the loss of Y. It is correct to change the sign to positive, because we are representing the formation of product, and the negative sign on the reactant to represent loss.

12. c Since it is stated that equilibrium is not established, there is no significant reverse reaction, thus adding product does not cause the formation of more B.

13. e Half life is an indication of reaction rate. Shorter half life indicates faster reactions.

14. e Given the rate law, insert the values given and solve for k; $0.048 = k[4]^2[1]$

15. c Since the reaction is third order overall, with a molarity cubed, M^3, the rate constant must have M^{-2} as well as the sec^{-1}. Remember that M^{-2} is the same as L^2mol^{-2}. Time is always in the denominator of every rate constant, and molarity will be in the denominator raised to one power less than the overall order of the reaction.

16. c You could make a RICE table for this reaction. since B becomes 0.4 and it started at 1, it must have reacted 0.6 to get there. The 2:1 stoichiometry means that A will have reacted 1.2, resulting in a final quantity of 2.8 (4 − 1.2 = 2.8).

17. d Concentration of reactants always decrease over the course of all reactions.

18. c As the concentrations of the reactants decrease over the course of a reaction, the frequency of collisions will decrease, but the effectiveness of the collisions will remain the same, as that is a function of the molecules themselves, the temperature, and the presence of any catalyst.

19. c The reaction will proceed at a faster rate, so the loss of A will be a t a greater rate. The rate constant changes at different temperatures. It increases at higher temps and decreases at lower temps.

20. a Yup, it's a list of steps.

21. a 12 days is 4 half lives, the amount decayed will be 100>50>25>12.5>6.25% remains, thus 94% of the original material will have decayed.

22. c Add the individual orders of each reactant to get the overall order.

23. c The coefficients of mechanism steps can be used to write the rate law of the individual steps but the high coefficients in the overall reaction, are certainly not likely to correspond to the order of the reaction with respect to each reactant. Intermediate-A must be a reactant in a later step, just as BrO_3^- must also show up in a later step in or before the slow step.

24. d Increasing concentration always increases collision frequency, but may not always increase rate if a reaction is zero order with respect to the increasing reactant.

25. e Addition of OH^- will react with H^+ reducing its concentration. Removal of H^+ will decrease the rate. Addition of H_2O will dilute the reactants causing the reaction rate to decrease.

26. a Br_2 is a liquid so it will have no effect on the reaction rate since the concentration will remain constant for a pure liquid regardless of how much is in the container.

27. c   Consider the graph to the right and values of Ea and ΔH to answer the question.

28. e   The addition of a catalyst provides an alternative reaction pathway, with a modified or different activated complex that has lower potential energy. This lowers the activation energy, E_a, thus increasing the reaction rate.

29. b   Changing the temperature will change the rate constant. Changing concentration and size of container will change the rate, but not the rate constant.

30. b   An alternative pathway.

31. e   Higher activation energy is a higher hump, and is harder to get over, making for fewer successful collisions.

32. d   The stoichiometry of the overall reaction will give us answers to the questions about comparative rates of formation of products compared to loss of reactants.

33. d   The curve shifts to the right and flattens out, making for more molecules under the curve that will have the minimum energy required for successful reaction collisions.

34. b   Same ΔH, but a lower activation energy.

35. b   Reactant and products at same level on both graphs, but a lower hump to represent a lower activation energy.

36. a   For a zero order reaction, the units on the rate constant must be that same as the units on rate, M/time.

37. e   Add the exponents to get the overall order.

38. b   Second order with respect to A would cause the rate to quadruple when the concentration of A doubles. Since B is zero order, changing it's concentration would not affect the rate, thus the overall effect is caused only by A

39. e $rate = k[A]^2[B]$ *thus* $[2]^2[0.5]$ would cause the rate to simply double.

40. a   by definition

41. b   A substance that you start with but also finish with.

42. c   Also know as the "slow" step.

43. c   The rate will increase doe to the concentration increase, but the rate constant will remain the same.

44. e   The stoichiometry will give us relative comparisons of the rates of the chemicals in the reaction.

45. d $rate = k[D][E]^2$ *thus* $[4][0.5]^2 = 1$, *the same*

46. a   A high activation energy is what makes a reaction slower, harder to get over the "energy hump."

47. c   Heating a material in a sealed container, would not change the number of molecules present.

48. d   Rate laws are all experimentally determined, and zero order has no concentration factor so rate = k, and lastly item III would only be true for second order.

49. b   Two of the three molarity units in the rate expression, must cancel out and thus must be contained as units on the rate constant.

50. b   Add the individual orders to determine the overall order. For item I, the units would be $M^{-2}s^{-1}$, and doubling Y would double the rate.

51. b   Changing concentrations will not affect the rate constant.

52. e $rate = k[X]^2[Y]$ *thus* $[2]^2[3] = 12$

53. a   Since the second step is the slow step, cross off the intermediate, and gather all the reactants in the first and second steps.

54. b   Just add up the equations, canceling out items, just like Hess' Law.

55. d   See that the equation is a y = mx + b set up.

56. a   This is a memorize.

57. e   Since the first step is the rate-determining step, only RX shows up in the rate law. An intermediate is a molecule that shows up as a product in one step, but is used up as a reactant in a subsequent step. Since the hydroxide ions are in the mechanism after the ate-determining step, the hydroxide must be zero order and do not affect the rate of the reaction.

58. a   The three criteria are (1) the sum of the steps must add to the total reaction, like Hess' Law, (2) the molecularity must be reasonable unimolecular or bimolecular and rarely termolecular, and (3) the mechanism must correlate with the experimentally observed rate law.

59. e   The definition of a catalyst, unlike a reactant, the catalyst does not get used up.
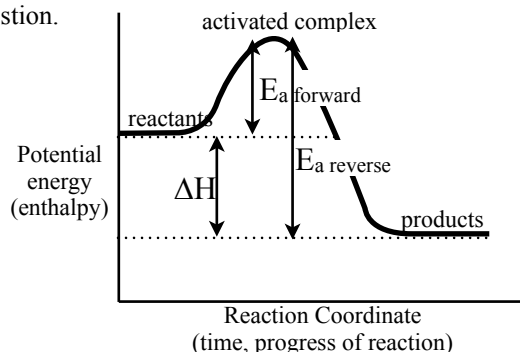
60. e   Trials 1 to 2, (X, Y stay constant) W doubled, but no change in rate, tells us that W is zero order. Trials 1 to 3, (W, Y stay constant) X is tripled and the rate is tripled, tell us X is first order. Trials 4 to 1 (W, X stay constant) Y is doubled and rate is quadrupled (watch out for the ×10 exponents) tell us that Y is second order.

61. d   Since the rate is given as production of Z, the change of X would be triple due to the 3 in the stoichiometry, and since X is a reactant, the rate of change should be represented as negative.

62. e   We can not know the entire rate law, only that the order is second with respect to the reactant.

63. b   Since the first step is the slow step, we can deduce the rate law from the stoichiometry of that step. You could write the rate law as Rate = k $[NO_2]$ $[NO_2]$ which is the same as Rate = k $[NO_2]^2$

64. b   Remember that intermediates are produced in one step and then consumed in a later step. Only NO_3 meets this criteria.

65. b   Remember that a catalyst is a chemical that is put in as a reactant, but is produced again as a product.

66. d   Intermediates are produced in one step and then consumed in a later step.

67. a   Cross of intermediates and catalysts to get the overall equation.

68. a   Perhaps you learned about carbon−14 dating in biology class or math class.

69. c   If 75% of a sample has decayed, this means 25% is remaining. Starting with 100%, this would mean two half-lives. Since the total time was 24.6 years, dived by two half-lives to get each half life as 12.3 years.

70. d   80 % decayed means 20% remaining, thus 100% > 50% > 25% > 12.5%   Thus somewhere between the second and third half life, but closer to 2 than 3 half lives. Thus the best option without a calculator would be 67 years.

71. b   Again, 100% > 50% > 25% is two half lives, thus each one must be 22 minutes long

72. c   Same quick method: 40g > 20 g > 10 g > 5 g > 2.5 g is four half lives, thus 4 × 15 is 60 days

73. c   Consider the decay 100% > 50% > 25% > 12.5%, thus just over 3 half lives occur. Looking over the answer options, c should be an easy pick.

74. c   Again, you have to guesstimate here since you do not have a calculator, and you are in between two half lives. To end with 15% remaining means somewhere between the second and third half life. 100% > 50% > 25% > 12.5%

75. a   Beware the 80ºC distractor. Simply use the half life equation on your formula sheet $t_{halflife} = \dfrac{0.693}{k}$.

76. b   Only first order equations have a half life independent of concentration. Both zero and second, the original concentration must be known to know the half life. Since concentration constantly changes during a a reaction, the half life would also constantly change for zero and second, and thus half life for those orders is not particularly useful.

77. a   Use the equation $t_{halflife} = \dfrac{0.693}{k}$ and substitute: $t_{halflife} = \dfrac{0.693}{0.00346}$. Look for the easy math and solve for ~200 which is just over 3 hours.

78. a   For this problem you must work backwards. If delivery takes 12 hours, that's two half lives. To have 10 mg remaining, work backwards 10 << 20 << 40 mg must be sent.