Review for Unit Test 4: Reaction Rates (Chapter 6)

Objectives:

1. Be able to define or explain the following terms: enthalpy, exothermic, endothermic, reaction rate, average rate, instantaneous rate, initial rate, activation energy, activated complex, reaction intermediates, rate determining step, reaction mechanism, catalyst (homogeneous and heterogeneous), inhibitor, and half-life.

2. Know several properties that can be used to measure the rate of a chemical reaction.

3. Given a rate graph, calculate instantaneous and average reaction rates.

4. Given a chemical equation and a reaction rate for one species, use stoichiometry (mole ratios) to predict the corresponding rates for the other reactants and products.

5. Use collision theory to **explain** the effect of temperature, surface area, concentration, and catalysts on reaction rates.

6. Explain how catalysts and inhibitors work. What is the effect of a catalyst on E_a and ΔH?

7. Predict how the nature of the reactants will affect the rate of a chemical reaction. In general, homogeneous gas or aqueous systems with small, charged particles (such as simple ions) react very quickly. Heterogeneous systems that include solid reactants or reactants with large, uncharged particles tend to react more slowly.

8. Interpret values for the reaction rate constant "k", E_a, and ΔH. Which of these values are affected by temperature? Understand the relationship between E_a and reaction rate.

9. Draw and interpret potential energy diagrams for the progress of a chemical reaction. Be able to label E_a forward and reverse, ΔH forward and reverse, activated complexes and reaction intermediates.

10. Determine the rate law expression for a reaction from experimental concentration and rate data. Be sure you report the correct units for the rate law constant.

11. Use the rate law expression for a reaction to calculate the rate of a reaction when you are given specific concentrations of reactants. Predict the effect of changing the concentration of various reactants on the reaction rate.

12. Given the mechanism for a reaction, activation energies and enthalpy changes (ΔH), graph the potential energy diagram for the reaction and identify the rate-determining step, overall activation energy, overall enthalpy change and overall reaction equation for the reaction.

13. Given a reaction mechanism and rate data for the elementary steps, evaluate whether or not a given rate law equation for the reaction is probable.

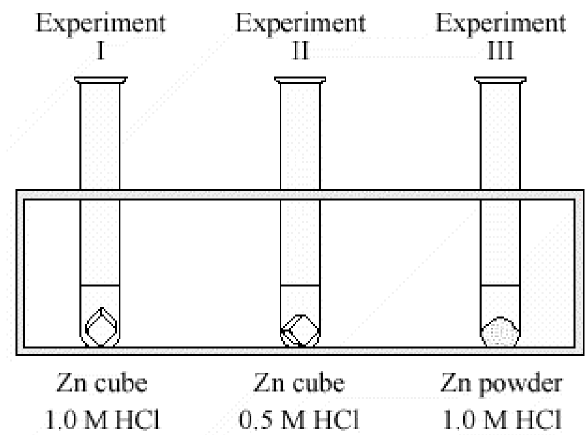
14. Given the Rate Law and "k" for a first order reaction, be able to calculate the half-life. Given the half-life for a first order reaction, calculate "k".

Practice Multiple Choice Questions:

1. The slowest of the following reactions is:
a) $H^+ (aq) + OH^- (aq) \rightarrow H_2O (l)$
b) $Ag^+ (aq) + Cl^- (aq) \rightarrow AgCl (s)$
c) $Cu (s) + 2 Ag^+ (aq) \rightarrow Cu^{2+} (aq) + 2 Ag (s)$
d) $3 Ba^{2+} (aq) + 2 PO_4^{3-} (aq) \rightarrow Ba_3(PO_4)_2 (s)$

2. At 25°C, which of the following reactions is fastest?
a) $H_2 (g) + I_2 (g) \rightarrow 2 HI (g)$
b) $C_6H_{12}O_6 (s) + O_2 (g) \rightarrow 6 CO_2 (g) + 6 H_2O (v)$
c) $5 C_2O_4^{2-} (aq) + 2 MnO_4^{1-} (aq) + 16 H^+ (aq) \rightarrow 10 CO_2 (g) + 2 Mn^{2+} (aq) + 8 H_2O (l)$
d) $Pb^{2+} (aq) + 2 I^{1-} (aq) \rightarrow PbI_2 (s)$

3. Consider the experiment shown to the right. Each involves equal masses of zinc and 10.0 mL of acid. The rate of reaction in order from fastest to slowest is:
a) III > II > I
b) II > I > III
c) III > I > II
d) I > II > III



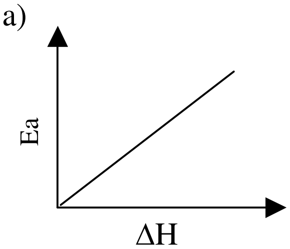
4. When a positive catalyst is added to a reaction:

I.	the heat of reaction increases
II.	a new reaction mechanism is provided
III.	E_a for the reaction increases
IV.	the rates of both the forward and reverse reactions increase

a) II and III only
b) I, II and IV only
c) II, III and IV only
d) II and IV only

5. Identify the **INCORRECT** statement below concerning chemical kinetics:
a) the rate of a chemical reaction changes with time
b) the rate of a chemical reaction is affected by the temperature of the system
c) the rate law of a chemical reaction depends on molar coefficients of the overall reaction
d) the rate law expresses how reaction rate varies with the concentration of reactants

6. Which of the following shows the relationship between E_a and ΔH for a reaction?

a)


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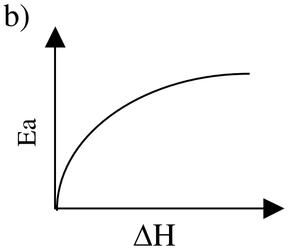

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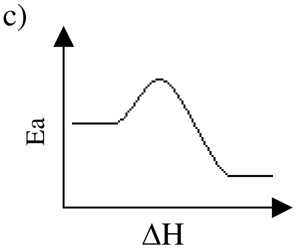

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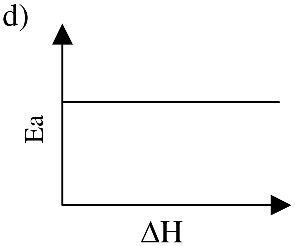


7. Which of the following could be used as units for the rate of a reaction?

a) mL/s
b) g/min
c) mol/L•s
d) all of the above

8. Increasing the temperature of a reaction increases reaction rate by:

I.	increasing the frequency of the collisions
II.	increasing the kinetic energy of the collisions
III.	decreasing the E_a of the reaction

a) I only
b) I and II only
c) I and III only
d) II and III only

9. Which of the following could be used to measure the rate of the following reaction in a **closed** system:

$2\ N_2O_5\ (l)$	$\rightarrow$	$4\ NO_2\ (g)$	+	$O_2\ (g)$
colourless		brown		colourless

I.	change in mass
II.	change in gas pressure
III.	change in intensity of colour
IV.	change in pH

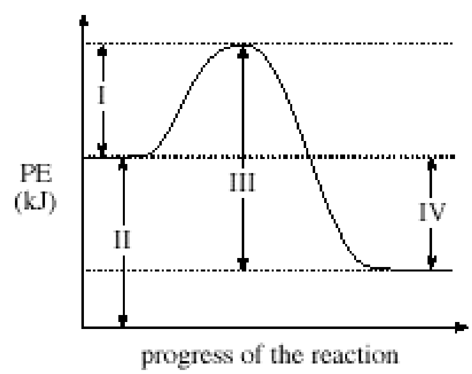
a) I and II only
b) II and III only
c) I, II and III only
d) III and IV only

10. Consider the reaction: $N_{2(g)} + 3\ H_{2(g)} \rightarrow 2NH_{3(g)}$. If the rate of formation of NH_3 is 4.0×10^{-4} mol/s, then the rate of consumption of H_2 is:

a) 1.2×10^{-3} mol/s
b) 2.0×10^{-4} mol/s
c) 4.0×10^{-4} mol/s
d) 6.0×10^{-4} mol/s

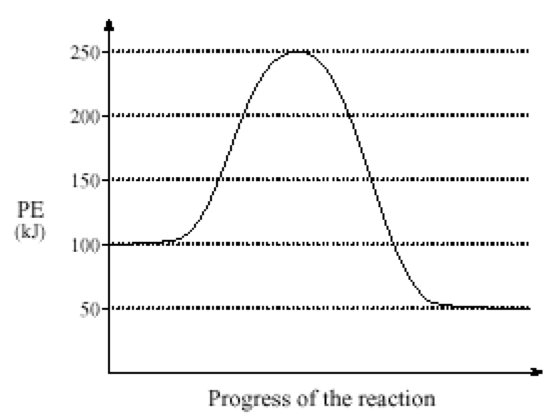
11. Consider the potential energy diagram to the right:
Which of the following represents the heat of reaction, ΔH, for the forward reaction?

a) I
b) II
c) III
d) IV



12. Consider the potential energy diagram to the right:
Which of the following describes the forward reaction?

a) E_a = 250 kJ, ΔH = +50 kJ
b) E_a = 200 kJ, ΔH = +50 kJ
c) E_a = 150 kJ, ΔH = –50 kJ
d) E_a = 250 kJ, ΔH = –50 kJ

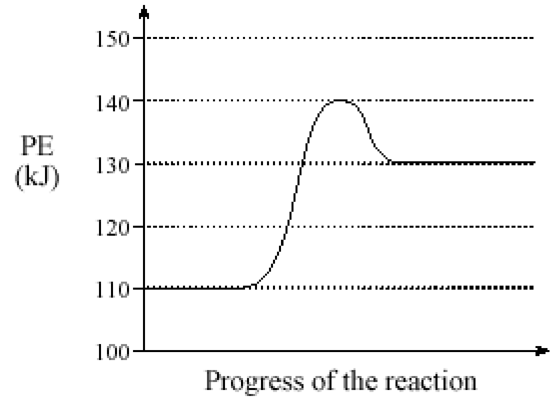


13. The average kinetic energy of colliding particles can be increased by:

I.	increasing the temperature
II.	adding a catalyst
III.	increasing the reactant concentration

a) I only
b) I and II only
c) I and III only
d) I, II and III

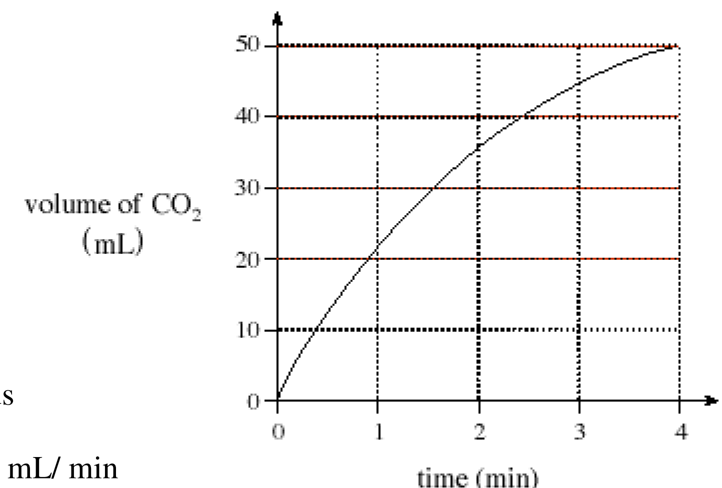
14. Consider the potential energy diagram for a reversible reaction shown to the right:



a) for the reverse reaction: $E_a = 10$ kJ, $\Delta H = -20$ kJ
b) for the forward reaction: $E_a = 10$ kJ, $\Delta H = +10$ kJ
c) for the reverse reaction: $E_a = 10$ kJ, $\Delta H = -30$ kJ
d) for the reverse reaction: $E_a = 30$ kJ, $\Delta H = +30$ kJ

15. Which of the following reactions is the slowest at SATP?
a) $2\ NaOCl\ (aq) \rightarrow 2\ NaCl\ (aq) + O_2\ (g)$
b) $Ca^{2+}\ (aq) + 2\ OH^{1-}\ (aq) \rightarrow Ca(OH)_2\ (s)$
c) $N_2O_5\ (g) \rightarrow NO_2\ (g) + NO_3\ (g)$
d) $Cu\ (s) + S\ (s) \rightarrow CuS\ (s)$

$CaCO_{3(s)} + 2HCl_{(aq)} \rightarrow CaCl_{2(aq)} + CO_{2(g)} + H_2O_{(\ell)}$



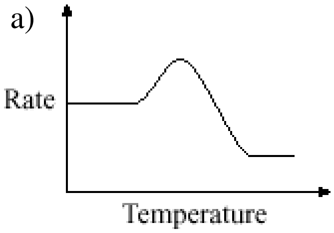
16. Consider the graph to the right:
Which of the following time periods will have the fastest reaction rate?
a) in the period from 0 to 1 minute
b) in the period from 0 to 2 minutes
c) in the period from 1 – 2 minutes
d) the instantaneous rate at 2 minutes

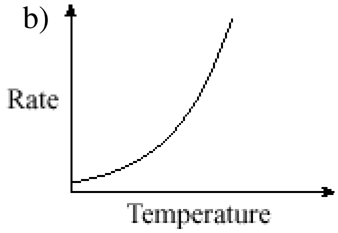
17. From the graph in question 16, the instantaneous reaction rate at 2.0 min is approximately:
a) 36 mL/min
b) 11 mL/min
c) 18 mL/ min
d) 0.056 mL/min

18. From the graph in question 16, the average rate of reaction in the first 3.0 minutes is approximately:
a) 45 mL/min
b) 12 mL/min
c) 15 mL/min
d) 0.067 mL/min

19. In the overall reaction given by: $H_2(g) + 2\ ICl(g) \rightarrow I_2(g) + 2\ HCl(g)$
a) the concentrations of all species are changing by the same amount at all times
b) the concentration of HCl increases equally as fast as I_2
c) the concentration of H_2 decreases at the same rate as ICl
d) the concentration of HCl increases twice as fast as I_2

20. For the exothermic reaction: $CH_4\ (g) + 2\ O_2\ (g) \rightarrow CO_2\ (g) + 2\ H_2O\ (v) + \text{heat}$
Which of the following diagrams shows the relationship between rate and temperature?

a)


b)


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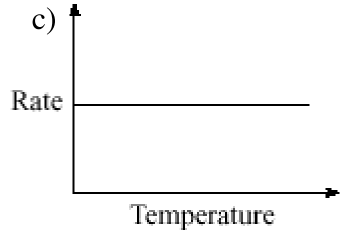
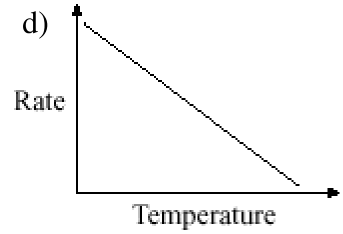
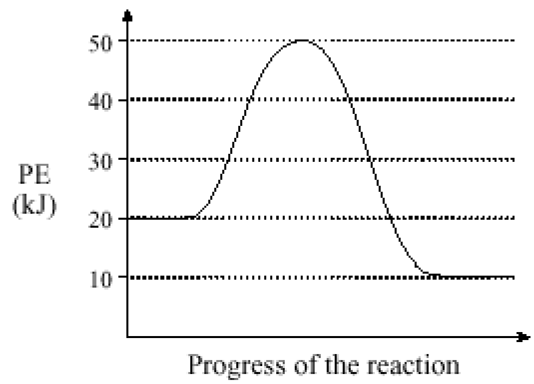


d)


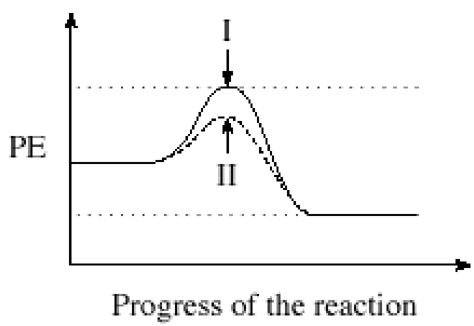
21. A substance that increases the rate of a chemical reaction and may be recovered unchanged at the end of the reaction is a(n):
a) reaction intermediate
b) activated complex
c) product
d) catalyst

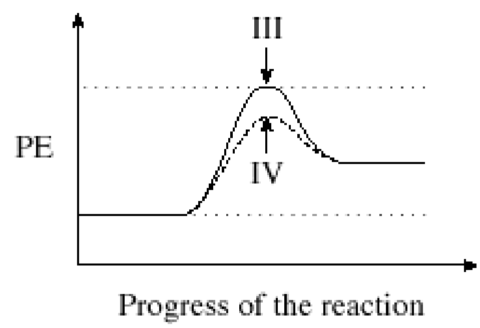
22. Consider the potential energy diagram to the right. Which of the following describes this reaction?
a) for the forward reaction: $E_a = 30$ kJ, $\Delta H = +10$ kJ
b) for the reverse reaction: $E_a = 30$ kJ, $\Delta H = -10$ kJ
c) for the reverse reaction: $E_a = 40$ kJ, $\Delta H = +10$ kJ
d) for the forward reaction: $E_a = 40$ kJ, $\Delta H = -10$ kJ



23. Referring to the graph in question 22, which of the following statements describes the potential energy of the reacting particles as they approach each other at constant temperature?
a) kinetic energy is constant but potential energy increases
b) kinetic energy is constant but potential energy decreases
c) kinetic energy increases but potential energy is constant
d) kinetic energy decreases but potential energy is constant

24. Which of the following potential energy curves represents a catalyzed endothermic reaction in the forward direction?
a) I
b) II
c) III
d) IV





25. Consider the reaction: $Mg_{(s)} + 2\ HCl_{(aq)} \rightarrow H_{2(g)} + MgCl_{2(aq)}$
The rate of this reaction increases when more magnesium is added. This change is due to:
a) an increase in the surface area
b) addition of a catalyst
c) an increase in the concentration of the reactants
d) a change in the nature of the reactants

Answer Q 26 – 28 regarding the reaction mechanism below:

Step 1	$ClO^- + H_2O \rightarrow HClO + OH^-$
Step 2	$I^- + HClO \rightarrow HIO + Cl^-$
Step 3	$HIO + OH^- \rightarrow IO^- + H_2O$

26. The overall reaction for the mechanism is:
 a) $ClO^{1-} + I^{1-} + H_2O \rightarrow Cl^{1-} + IO^{1-} + H_2O$
 b) $ClO^{1-} + H_2O + I^{1-} + HClO + HIO + OH^{1-} \rightarrow HClO + OH^{1-} + HIO + Cl^{1-} + IO^{1-} + H_2O$
 c) $ClO^{1-} + I^{1-} \rightarrow Cl^{1-} + IO^{1-}$
 d) $HIO + OH^{1-} \rightarrow IO^{1-} + H_2O$

27. In this reaction, the catalyst is:
 a) ClO^{1-}
 b) IO^{1-}
 c) H_2O
 d) HClO

28. In this reaction, HIO is a(n):
 a) catalyst
 b) reaction intermediate
 c) activated complex
 d) transition state

29. Activation energy can be described as the:
 a) the energy difference between the reactants and products
 b) the energy of motion
 c) the energy difference between the reactants and the activated complex
 d) the energy provided by a catalyst

30. The rate law for a chemical reaction is given by: Rate = $k[IO_3^-][I^-]^2[H^+]^2$. Which statement is true?
 a) this reaction is first order with respect to IO_3^- and third order overall
 b) this reaction is second order with respect to I^- and 3rd order overall
 c) this reaction is first order with respect to IO_3^- and fifth order overall
 d) this reaction is third order with respect to H^+

31. Which of the following changes occur when the temperature of a reaction is increased?

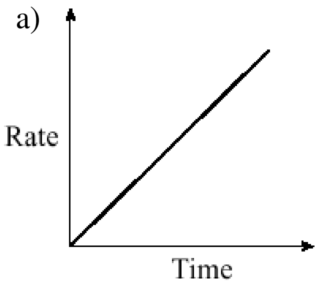
I.	ΔH of the reaction increases
II.	Frequency of the collisions increases
III.	Kinetic energy of the reactants increases

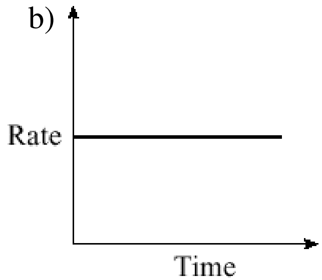
 a) I and II only
 b) I and III only
 c) II and III only
 d) I, II and III

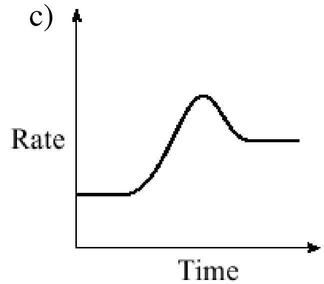
32. Which of the following statements is true about an activated complex?
 a) it is unstable and has high potential energy
 b) it is stable and has high potential energy
 c) it is unstable and has low potential energy
 d) it is stable and has low potential energy

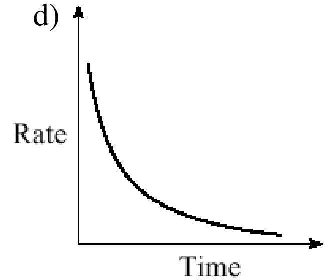
33. As the surface area of a solid reactant increases:
a) time for the reaction decreases and rate decreases
b) time for the reaction increases and rate decreases
c) time for the reaction decreases and rate increases
d) time for the reaction increases and rate increases

34. Consider this reaction: $2\ H_2O_2\ (l) \rightarrow 2\ H_2O\ (l) + O_2\ (g)$
Which graph shows the relationship between rate of consumption of H_2O_2 and time?

a)


b)


c)


d)


35. A catalyst changes the rate of a reaction by:
a) changing the ΔH for the reaction
b) increasing the temperature
c) providing the required activation energy
d) providing an alternative reaction mechanism

36. The rate of a chemical reaction is equal to the slope of a graph with the axes labelled:
a) x – axis: mass and y-axis: time
b) x – axis: time and y-axis: rate
c) x – axis: volume of gas and y-axis: time
d) x – axis: time and y-axis: concentration

37. Consider the following mechanism for a reaction:
Which of the following statements is correct?
a) HBr is a product
b) HOBr is a catalyst
c) HOOBr is a reaction intermediate
d) H_2O is a catalyst

Step 1	$HBr + O_2 \rightarrow HOOBr$
Step 2	$HBr + HOOBr \rightarrow 2HOBr$
Step 3	$2HBr + 2HOBr \rightarrow 2H_2O + 2Br_2$

38. Consider the following reaction: $Zn_{(s)} + 2\ HCl_{(aq)} \rightarrow ZnCl_{2(aq)} + H_{2(g)}$
Which of the following instruments could be used to monitor the rate of the reaction in an **open** system?

I. an electronic balance (scale)
II. a pressure gauge
III. a pH meter

a) I and II only
b) II and III only
c) I and III only
d) I, II and III

39. For the reaction: $2\ N_2O_5\ (g) \rightarrow 4\ NO_2\ (g) + O_2\ (g)$
If NO_2 is produced at a rate of 48 mL per minute, at what rate is O_2 produced?
a) 9.6 mL/min
b) 24 mL/min
c) 12 mL/min
d) 190 mL/min

Answer questions 40 – 42 about the following reaction mechanism:
The decomposition of ozone in the upper atmosphere may happen according to the mechanism:

$$O_3 + Cl \rightarrow ClO + O_2 \quad \text{(slow)}$$
$$ClO + O_3 \rightarrow Cl + O_2 + O_2 \quad \text{(fast)}$$

40. The chemical equation for the overall reaction is:
a) $2\,O_3 + Cl + ClO \rightarrow ClO + Cl + 3\,O_2$
b) $2\,O_3 + Cl_2O \rightarrow Cl_2O + 3\,O_2$
c) $2\,O_3 \rightarrow 3\,O_2$
d) $ClO + O_3 \rightarrow Cl + O_2 + O_2$

41. Which of the following rate laws is consistent with this proposed mechanism?
a) Rate = $k[O_3][Cl]$
b) Rate = $k[O_3]^2[ClO]^0$
c) Rate = $k[O_3]^2[O_2]^3$
d) Rate = $k[O_2][Cl]$

42. In the proposed mechanism:
a) ClO is a reaction intermediate and Cl acts as a catalyst
b) Cl is a reaction intermediate and OCl acts as a catalyst
c) both Cl and OCl are reaction intermediates and there is no catalyst
d) both Cl and OCl are catalysts and there is no reaction intermediate

43. The reaction: $A_2 + 2\,B \rightarrow 2AB$ is first order with respect to A_2. The units for the rate constant “k” are:
a) 1/s or s^{-1}
b) L / (mol • s) or $L \cdot mol^{-1} \cdot s^{-1}$
c) mol / (L • s) or $mol \cdot L^{-1} \cdot s^{-1}$
d) $L^2 / (mol^2 \cdot s)$ or $L^2 \cdot mol^{-2} \cdot s^{-1}$

44. For the rate expression, rate = $k\,[A]^3[B]^2$, if the concentration of A is doubled, the rate will:
a) increase by 3x
b) increase by 4x
c) increase by 8x
d) increase by 9x

45. For the reaction: $HCO_2H\,(aq) + Br_2\,(aq) \rightarrow 2\,H^{1+}\,(aq) + 2\,Br^{1-}\,(aq) + CO_2\,(g)$
The rate law has been experimentally determined to be: rate = $k\,[Br_2]$. Which of the following is the most likely the rate-determining step for this reaction?
a) $HCO_2H\,(aq) + Br_2\,(aq) \rightarrow HCO_2HBr_2$
b) $Br_2 + H_2O\,(l) \rightarrow H_2Br_2O\,(aq)$
c) $Br_2\,(aq) \rightarrow 2\,Br\,(aq)$
d) there is no way to predict the rate determining step from this information

46. For the proposed mechanism:

$$NO_2(g) + F_2(g) \rightarrow NO_2F(g) + F(g) \quad \text{(slow)}$$
$$F(g) + NO_2(g) \rightarrow NO_2F(g) \quad \text{(fast)}$$

The rate law for the overall reaction is:
a) rate = $k\,[NO_2]\,[F]$
b) rate = $k\,[NO_2]^2$
c) rate = $k\,[NO_2F]\,[F]$
d) rate = $k\,[NO_2]\,[F_2]$

47. For the reaction: H_2O_2 (aq) + 3 I^{1-} (aq) + 2 H^+ (aq) → I_3^{1-} (aq) + 2 H_2O (l), the following rate data were measured:

Trial	Initial $[H_2O_2]$	Initial $[I^{1-}]$	Initial rate of formation of I_3^{1-} (aq) mol/L·s
1	0.100	0.100	1.15×10^{-4}
2	0.100	0.200	2.30×10^{-4}
3	0.200	0.100	2.30×10^{-4}
4	0.200	0.200	4.60×10^{-4}

The rate law for this reaction is

a) rate = k $[H_2O_2]$ $[I^{1-}]$
b) rate = k $[H_2O_2]^0$ $[I^{1-}]$
c) rate = k $[H_2O_2]$ $[I^{1-}]^0$
d) rate = k $[H_2O_2]^2$ $[I^{1-}]^2$

48. The rate law for the reaction 2 NO + O_2 → 2 NO_2 is rate= k$[NO]^2[O_2]$.
At 25°C, k=7.1 X 10^9 $L^2 mol^{-2}s^{-1}$. What is the rate of reaction when [NO] = 0.0010 mol/L and $[O_2]$=0.034 mol/L?

a) 2.4×10^2 mol/L•s
b) 1.2×10^{22} mol/L•s
c) 2.4×10^3 mol/L•s
d) 1.2×10^5 mol/L•s

49. Given the reaction: A + B → C + D, the reaction will most likely occur at the greatest rate if A and B represent:

a) non-polar molecular compounds in the solid phase
b) ionic compounds in the solid phase
c) solutions of non-polar molecular compounds
d) solutions of ionic compounds

50. Which of the following statements best describes the relative rates of these two reactions:

I $Ag^+(aq) + I^-(aq) \rightarrow AgI(s)$
II $4\ Fe(s) + 3\ O_2(g) \rightarrow 2\ Fe_2O_3(s)$

a) reaction II is faster than reaction I
b) reaction I and II are both fast
c) reaction I and II are both slow
d) reaction I is faster than reaction II

51. The units for the rate constant, k, in a second order reaction are:

a) 1/s or s^-1
b) L / (mol • s) or L • mol^{-1} • s^{-1}
c) mol / (L • s) or mol • L^{-1} • s^{-1}
d) L^2 / (mol^2 • s) or L^2 • mol^{-2} • s^{-1}

52. A reaction has the following rate law expression: rate = k$[A][B]^2$. The overall reaction is:

a) unimolecular
b) bimolecular
c) termolecular
d) ½ order

53. The decomposition of hydrogen peroxide (H_2O_2) is a first order reaction. The value for "k" at 20ºC is 1.80×10^{-5} s^{-1}. What is the half-life for this reaction?

a) 1.80×10^{-5} s
b) 3.85×10^4 s
c) 0.693 s
d) 1.44 s

54. The half-life for the first order decomposition of N_2O_5 (g) at 55ºC is 410 s. Calculate the value of k for this reaction at this temperature.

a) 410 s^{-1}
b) 2.4×10^{-3} s^{-1}
c) 1.7×10^{-3} s^{-1}
d) 590 s^{-1}

55. The rate of the reaction: C_2H_2 (g) + 2 H_2 (g) → C_2H_6 (g) is relatively slow at room temperature. When a piece of platinum is put into the system, the rate of reaction increases considerably. Platinum is a:

a) negative, homogeneous catalyst
b) positive, homogeneous catalyst
c) negative, heterogeneous catalyst
d) positive, heterogeneous catalyst

56. A reaction is being studied by a university professor. He discovers that the half-life for the reaction at 25ºC is 12.5 minutes and the value of "k" at this temperature is 0.05544 min^{-1}. This reaction is:

a) zero order
b) first order
c) ½ order
d) it is impossible to know from this data

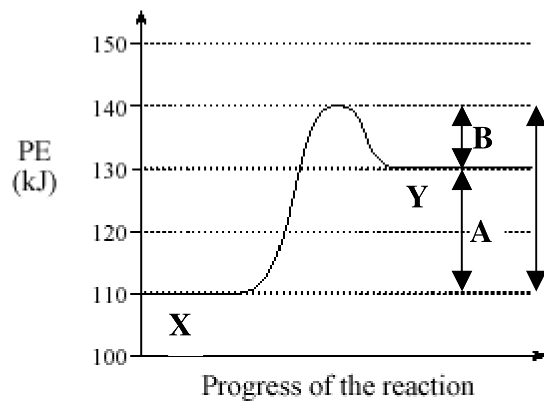
57. Ammonium nitrite, NH_4NO_2, decomposes in solution:

$$NH_4NO_2\ (aq) \rightarrow N_2\ (g) + 2\ H_2O\ (l)$$

The concentration of NH_4NO_2 at the beginning of an experiment was 0.500 M. After 3.0 hours, it was 0.432 M. What is the average rate of decomposition of NH_4NO_2 during this time interval?

a) 0.068 mol / L • hr
b) 0.14 mol / L • hr
c) 0.023 mol / L • hr
d) 0.17 mol / L • hr

58. Which statement is true about the reaction profile shown to the right?



a) Letter A represents the enthalpy change for the reaction X → Y and C is the activation energy for the reaction Y → X
b) Letter B represents the enthalpy change for the reaction X → Y and C is the activation energy for the reaction X → Y
c) Letter A represents the enthalpy change for the reaction X → Y and C is the activation energy for the reaction X → Y
d) Letter B represents the enthalpy change for the reaction X → Y and C is the activation energy for the reaction Y → X

59. Which statements is/are true for the reaction: A + B_2 + C → AB + CB, given that rate = $1.62 \times 10^6\ [A][B_2]^2$

I) the reaction rate is very fast
II) the value for ΔH is large and positive
III) the value for Ea is relatively small
IV) the rate-determining step for this reaction is termolecular
V) if the concentration of [C] is increased, the reaction rate will increase

a) I and II only
b) II, IV and V only
c) I, III and IV only
d) IV only

60. A reacts with B in a one-step reaction to give AB. The rate constant "k" for the reaction is 2.0×10^{-3} L / (mol · s). If 0.50 mole of A and 0.30 mol of B are placed in a 0.50 litre vessel, what is the initial rate of the reaction?

a) 3.0×10^{-4} mol / L · s
b) 1.2×10^{-3} mol / L · s
c) 1.5×10^{-4} mol / L · s
d) 7.5×10^{-5} mol / L · s

Be prepared to provide full written answers to following types of questions:

1. The following data were collected for the reaction $SO_2Cl_2 \rightarrow SO_2 + Cl_2$ at a constant temperature:

Time (s)	**$[SO_2Cl_2]$ (mol/L)**	**$[SO_2]$ (mol/L)**
0	0.100	0.000
10	0.082	
20	0.067	
30	0.055	
40	0.045	
50	0.037	
60	0.030	
70	0.025	
80	0.020	

a) Following all graphing conventions, graph concentration of SO_2Cl_2 and SO_2 versus time.
b) For SO_2Cl_2, determine the **instantaneous** rates of the reaction at t=20 seconds and t=60 seconds.
c) Determine the **average** rate of reaction during the first 30 seconds of the reaction.
d) What happens to the rate of the reaction as the reaction proceeds? Explain why.
e) How many elementary steps will there most likely be in the reaction mechanism for this reaction?

2. The rate law for the reaction $2\ NO + O_2 \rightarrow 2\ NO_2$ is rate = $k[NO]^2[O_2]$.
At 25°C, $k = 7.1 \times 10^9\ L^2\ mol^{-2}s^{-1}$.

a) What is the overall order for this reaction?
b) Is the activation energy for this reaction high or low?
c) If the temperature is increased, what will happen to the value of k?
d) If the concentration of NO is doubled, what will happen to the reaction rate?
e) If the concentrations of both NO and O_2 are doubled, how will the reaction rate change?
f) Which will cause the rate to increase more: doubling [NO] or tripling $[O_2]$?
g) What is the rate of reaction when [NO] = 0.0010 mol/L and $[O_2]$=0.034 mol/L?

3. For the following reactions, suggest a variable that could be used to measure reaction rate:

a) $HCl\ (aq) + KOH\ (aq) \rightarrow KCl\ (aq) + H_2O\ (l)$
b) $C_6H_{12}O_6\ (s) + 6\ O_2\ (g) \rightarrow 6\ CO_2\ (g) + 6\ H_2O\ (g)$
c) $S\ (s) + O_2\ (g) \rightarrow SO_2\ (g)$
d) $SO_2\ (g) + H_2O\ (l) \rightarrow H_2SO_3\ (aq)$
e) propene gas + $KMnO_4$ (aq) $\rightarrow$ 1,2-propanediol (l) (look back to your organic unit)

4. Consider the reaction: $BrO_3^-(aq) + 5\ Br^-(aq) + 8\ H^+(aq) \rightarrow 3\ Br_2(l) + H_2O(l)$
The initial rate of the reaction has been measured at the reactant concentrations shown:

Trial	**[BrO_3^-]** (mol/L)	**[Br^-]** (mol/L)	**[H^+]** (mol/L)	**Initial rate** (mol/L·s)
1	0.10	0.10	0.10	8.0
2	0.20	0.10	0.10	16
3	0.10	0.20	0.10	16
4	0.10	0.10	0.20	32

a) Determine "k" and the rate law for this reaction.
b) Is the activation energy for this reaction high or low?
c) What is the order of the reaction with regard to reactant **BrO_3^-**?
d) What is the order of the reaction with regard to reactant **Br^-**?
e) What is the order of the reaction with regard to reactant **H^+** ?
f) What is the overall order of this reaction?
g) What would be the initial rate (in mol/L·s) if the concentrations of all three reactants is 0.20 mol/L?

5. Suggest an explanation for each of the following observations.
a) The reaction $Ag\ (s) + \frac{1}{2} I_2\ (s) \rightarrow AgI\ (s)$ is very slow.
b) The rate of reaction for $Ag^+(aq) + I^-(aq) \rightarrow AgI\ (s)$ is very high.
c) The rate of reaction for $Ag^+\ (aq) + \frac{1}{2} I_2\ (s) \rightarrow AgI\ (s)$ is low.
d) The rate of reaction of liquid octene with bromine is very low.

6. For the reaction: $2\ NO\ (g) + 2\ H_2\ (g) \rightarrow N_2\ (g) + 2\ H_2O\ (l)$, the rate law is rate = $k[NO]^2[H_2]$

Does the following proposed mechanism (below) agree with this rate law? Explain.

(1) $2\ NO\ (g) + H_2\ (g) \rightarrow N_2\ (g) + H_2O\ (l) + \frac{1}{2} O_2\ (g)$ slow
(2) $H_2\ (g) + \frac{1}{2} O_2\ (g) \rightarrow H_2O\ (l)$ fast

7. A reacts with 2 B in a one-step reaction to give AB_2.
a) Write the rate law for this reaction.
b) If the initial rate of formation of AB_2 is 2.0×10^{-5} M/s and the initial concentrations of A and B are 0.30 M, what is the value of the rate constant "k" at this temperature?

8. A mixture of natural gas and air does not react appreciably at room temperature. When a piece of platinum metal is inserted into the mixture, it explodes. Why?

9. If you wish to dissolve a lump of sugar in water, what are three ways you could increase the rate at which the sugar dissolves? Explain why each procedure is effective.

10. Use the Kinetic Molecular Theory to explain why reaction rates vary with temperature.

11. For the reaction: 4 HBr (g) + O_2 (g) → 2 H_2O (g) + 2 Br_2 (l), the reaction mechanism is:

(1)	HBr (g) + O_2 (g) → HOOBr (g)	slow	exothermic
(2)	HOOBr (g) + HBr (g) → 2 HOBr (g)	fast	endothermic
(3)	2 HOBr (g) + 2 HBr (g) → 2 H_2O (g) + 2 Br_2 (l)	fast	exothermic

a) What is the rate-determining step for this reaction? Explain.
b) **Sketch** a potential energy diagram for this reaction mechanism.
c) In general terms, compare the E_a values for each of the elementary steps.
d) Is the rate law: rate = k $[HBr]^4 [O_2]^1$ reasonable for the reaction? Explain.
e) What would be the effect on the reaction rate of increasing the concentration of HOBr ?
f) Suggest two variables that could be used to measure the rate of this reaction.

12. The following represent the elementary steps in a reaction mechanism.

$X_2 + Y \rightarrow XY + X$	$\Delta H = -30$ kJ	$E_a = 70$ kJ
$XY + Z \rightarrow XZ + Y$	$\Delta H = 10$ kJ	$E_a = 90$ kJ
$X + Z \rightarrow XZ$	$\Delta H = -15$ kJ	$E_a = 20$ kJ

a) Assume that the enthalpy of the reactants is 50 kJ. Sketch an energy profile for this mechanism.
b) What is the rate-determining step for this reaction?
c) Write the equation for the overall reaction.
d) Find the values of ΔH and E_a for the overall reaction.
e) Identify one reaction intermediate in the reaction. How do you know it is a reaction intermediate?
f) Identify one catalyst in the reaction. How do you know it is a catalyst?

Optional Textbook Questions:
Page 309: questions 5 – 9 (read question 10- it's cool but not testable)
Page 311- 313: questions 2 – 7a, 8a, 9 – 19, 21 (just explain the difference), 23
Page 316 – 319: questions 7 – 10, 22 – 26, 32a, 33