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Reaction Rates & Kinetics: Rate Laws, Ea & Mechanisms

Printable Flashcards — Pre-Med Chemistry

Rate basics, collision theory, activation energy, energy diagrams, factors affecting rate, rate laws, reaction orders, determining order from data, k units, integrated rate laws, half-life, Arrhenius equation, mechanisms, and rate-determining step.

158 cards — Print double-sided, flip on long edge, then cut along dashed lines.

158 cards — Printable Flashcards

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1

Reaction rate in plain terms is...

2

Rate is the slope of what kind of graph?

3

Trap: rate is constant through the whole reaction. True or false?

4

Average rate vs instantaneous rate: what's the difference?

5

For a reactant A, the rate of disappearance is written as...

6

Trap: d[A]/dt is always the rate. True or false?

7

For a product B, the rate of formation is written as...

8

If you see a curve that gets flatter over time, that means the rate is...

2

Concentration vs time.

1

How fast concentrations change over time.

4

Average rate uses a time interval. Instantaneous rate is the slope at one exact moment (a tangent).

3

False (usually).

6

False.

5

$-d[A]/dt$ (positive number).

8

Decreasing.

7

$d[B]/dt$ (positive).

9

If the concentration-time graph is a straight line, the reaction rate is...

10

Rate is the {{c1::slope}} of a concentration vs {{c2::time}} graph.

11

Common units for reaction rate:

12

Collision theory: for a reaction to happen, particles must collide with...

13

Activation energy (Ea) is basically...

14

Trap: if a reaction is exothermic, it must be fast. True or false?

15

In an energy diagram, activation energy is the energy difference between...

16

The transition state is...

10

Rate is the slope of a concentration vs time graph.

9

Constant.

12

Enough energy and the right orientation.

11

mol/L/s (M/s)

14

False.

13

The energy barrier you must get over to react.

16

The high-energy, unstable 'in-between' arrangement at the top of the energy barrier.

15

Reactants and the transition state peak.

17

Trap: the transition state is the same as an intermediate. True or false?

18

What does increasing temperature do to reaction rate (in one sentence)?

19

Trap: temperature increases rate because it increases concentration. True or false?

20

Collision theory: collisions need enough {{c1::energy}} and the right {{c2::orientation}}.

21

Name of the energy barrier a reaction must overcome:

22

Main factors that can change reaction rate (pre-med list):

23

Why does higher concentration usually increase rate?

24

Why does higher pressure increase rate for gases?

18

It increases the fraction of molecules with enough energy to get over Ea, so rate goes up.

17

False.

20

Collision theory: collisions need enough energy and the right orientation.

19

False (mostly).

22

Concentration, temperature, surface area (solids), catalysts, and pressure (for gases).

21

activation energy

24

At the same temperature, higher pressure means more gas particles per volume -> more collisions.

23

More particles per volume -> more collisions per second.

25

Surface area: why does powdered solid react faster than a chunk?

26

Trap: increasing surface area changes the equilibrium constant K. True or false?

27

Catalyst: what does it do?

28

Trap: catalyst increases the amount of products at equilibrium. True or false?

29

Trap: catalyst gets used up, so it's a reactant. True or false?

30

In an energy diagram, a catalyst changes...

31

Why does a catalyst NOT change ΔH?

32

Trap: lowering temperature speeds up reaction by stabilizing products. True or false?

26

False.

25

More exposed particles -> more collision sites at the surface.

28

False.

27

Provides an alternative pathway with lower activation energy, so reaction is faster.

30

Activation energy (Ea), not ΔH.

29

False.

32

False.

31

ΔH depends only on reactant and product energies (state function), not the pathway.

33

Catalysts speed up reactions by lowering {{c1::Ea}} but they do NOT change {{c2::ΔH}} or K.

34

Rate law format looks like:

35

Trap: you can read m and n straight from the balanced equation. True or false?

36

k (rate constant) depends on...

37

Trap: adding more reactant increases k. True or false?

38

Reaction order (overall) is...

39

Trap: reaction order must be an integer. True or false?

40

If rate = $k[A]^2$, doubling [A] makes rate...

34

rate = $k[A]^m[B]^n$ ...

33

Catalysts speed up reactions by lowering Ea but they do NOT change ΔH or K.

36

Temperature (and catalyst), not concentration.

35

False (except for elementary steps).

38

$m + n + \ldots$ (sum of exponents in the rate law).

37

False.

40

4x bigger.

39

False.

41

If rate = $k[A]$, doubling $[A]$ makes rate...

42

If rate = $k[A]^0$, changing $[A]$ does what to rate?

43

Big exam trap: in a rate law, exponents are about...

44

Rate law: rate =
{{c1::k}}[A]^{{c2::m}}[B]^{{c3::n}} ...

45

If rate = $k[A]^3$, tripling $[A]$ changes rate by factor:

46

Experimental trick: to find order
in A, compare trials where only [A]
changes and see how rate changes.

47

Trial comparison: if doubling [A] makes
rate stay the same, order in A is...

48

Trial comparison: if doubling [A]
makes rate double, order in A is...

42

Nothing. Rate doesn't depend on [A].

41

2x bigger.

44

Rate law: rate = $k[A]^m[B]^n$ ...

43

How sensitive the rate is to concentration changes.

46

Keep B constant, change A, look at rate factor.

45

27

48

First order.

47

Zero.

49

Trial comparison: if doubling [A] makes rate quadruple, order in A is...

50

Trial comparison: if doubling [A] makes rate increase by 8x, order in A is...

51

Trap: If the coefficient of A is 2 in the balanced equation, order in A must be 2. True or false?

52

Mini data: Trial 1 [A]=0.10, rate=0.50. Trial 2 [A]=0.20, rate=2.0 (B constant). Order in A?

53

Mini data: Trial 1 [A]=0.10, rate=0.50. Trial 2 [A]=0.30, rate=1.5 (B constant). Order in A?

54

Mini data: Trial 1 [A]=0.10, rate=1.0. Trial 2 [A]=0.20, rate=1.0 (B constant). Order in A?

55

If rate = $k[A]^m[B]^n$ and you increase BOTH A and B, how do you find the new rate?

56

Order from data: doubling [A] makes rate x4 -> order in A is {{c1::2}}.

50

Third order.

49

Second order.

52

Second order in A.

51

False.

54

Zero order in A.

53

First order in A.

56

Order from data: doubling [A] makes rate x4 -> order in A is 2.

55

Multiply the factors: $(\text{factor}_A{}^m) * (\text{factor}_B{}^n)$.

57

Rate units are usually...

58

Units of k depend on...

59

For a first-order rate law (rate = k[A]), k has units of...

60

For a zero-order rate law (rate = k), k has units of...

61

For a second-order rate law like rate = $k[A]^2$, k has units of...

62

Trap: k always has units of 1/s. True or false?

63

Speed check: if your k units look wrong, what's the first thing you probably messed up?

64

Units of k for a first-order reaction:

58

Overall reaction order.

57

M/s (mol/L/s).

60

M/s.

59

1/s (s^-1).

62

False.

61

1/(M · s).

64

s^-1

63

You used the wrong order or forgot an exponent.

65

You don't always need integrated laws on pre-med, but if you do, the key one is first-order half-life:

66

Trap: first-order half-life depends on initial concentration. True or false?

67

What does 'constant half-life' usually scream?

68

First-order decay pattern: after 3 half-lives, how much is left?

69

Zero-order concentration-time graph looks like...

70

First-order concentration-time graph looks like...

71

Quick 'graph linearization' (if they ask): for first-order, a straight line happens if you plot...

72

For a first-order reaction, if k doubles, the half-life...

66

False.

65

$t1/2 = 0.693 / k$.

68

1/8 left (12.5%).

67

First-order kinetics.

70

A curve that drops fast then slows (exponential decay).

69

A straight line going down.

72

Halves.

71

ln[A] vs time.

73

First-order half-life formula:

74

Arrhenius equation (concept): k depends on temperature like...

75

From Arrhenius: if temperature increases, k usually...

76

From Arrhenius: if Ea is larger, the reaction is (usually)...

77

Trap: a catalyst increases k by increasing A only. True or false?

78

If two reactions have the same temperature and similar A, the one with smaller Ea will have...

79

Arrhenius idea: increasing {{c1::temperature}} increases k, while increasing {{c2::Ea}} decreases k.

80

Reaction mechanism is...

74

k = A e^(-Ea/RT).

73

t1/2 = 0.693/k

76

Slower at a given temperature.

75

Increases a lot.

78

Larger k (faster).

77

Usually false in the way exams mean it.

80

The step-by-step path the reaction actually takes (often multiple steps).

79

Arrhenius idea: increasing temperature increases k, while increasing Ea decreases k.

81

Elementary step means...

82

Rate-determining step (RDS) is...

83

If they say 'the first step is slow' and give a mechanism, the overall rate law usually matches...

84

Intermediate is...

85

Trap: intermediates appear in the overall balanced equation. True or false?

86

Catalyst in a mechanism is usually recognized because it...

87

Molecularity means (for an elementary step)...

88

Trap: overall reaction order equals molecularity of the overall equation. True or false?

82

The slowest step that controls
the overall reaction rate.

81

A single 'collision event' step (one step), so
its rate law DOES match its stoichiometry.

84

A species made in one step and used up in
a later step (not in the overall equation).

83

The reactants in that slow
step (with their coefficients).

86

Appears at the start and is regenerated
at the end (cancels out overall).

85

False.

88

False.

87

How many reactant particles collide
in that step (uni-, bi-, termolecular).

89

Rate-determining step = the {{c1::slowest}} step (the bottleneck).

90

On an energy diagram, ΔH is the energy difference between...

91

Trap: a lower activation energy means the reaction becomes more exothermic. True or false?

92

If an energy diagram has TWO peaks, that means...

93

For a multi-step energy diagram, the rate-determining step is the one with...

94

Trap: the highest peak is always measured from the reactants line. True or false?

95

If a catalyst is used, the energy diagram shows...

96

In an energy diagram, a catalyst lowers {{c1::Ea}} but does not change {{c2::ΔH}}.

90

Products and reactants.

89

Rate-determining step = the slowest step (the bottleneck).

92

A two-step mechanism (with an intermediate between peaks).

91

False.

94

False.

93

The largest activation energy barrier (highest peak relative to previous valley).

96

In an energy diagram, a catalyst lowers Ea but does not change ΔH.

95

A lower peak (lower Ea), but same reactant and product energy levels.

97

Kinetics tells you _____;
thermodynamics tells you _____.

98

Trap: if K is huge, the reaction
must be fast. True or false?

99

Trap: a catalyst increases K because
it helps products form. True or false?

100

If a catalyst is added to a system already at
equilibrium, what happens to concentrations?

101

If you increase temperature, does
equilibrium always shift to products?

102

Exam writer trick: they ask 'what increases rate'
and give an answer about equilibrium. Your move:

103

If rate is directly proportional to [A],
the reaction is _____ order in A.

104

If rate is proportional to $[A]^2$,
doubling [A] makes rate...

98

False.

97

Kinetics: how fast. Thermodynamics: how far (favored direction/position).

100

Nothing changes (but reactions happen faster in both directions).

99

False.

102

Ignore equilibrium talk and focus on collisions/Ea/k.

101

No.

104

4x.

103

First order.

105

If rate doesn't change when [A] changes, it's ______ order in A.

106

Rate law vs time graph trap: if [A] vs time is a straight line, likely order is...

107

If ln[A] vs time is a straight line, likely order is...

108

If 1/[A] vs time is a straight line, likely order is...

109

Rate law: rate = $k[A]^{2}[B]$. If [A] doubles and [B] halves, rate changes by factor...

110

Rate law: rate = $k[A]^{0}[B]^{3}$. If [A] triples and [B] doubles, rate changes by factor...

111

Rate law: rate = $k[A]^{1}.5$. If [A] increases by factor 4, rate changes by factor...

112

First-order half-life drill: if k = 0.693 s^-1, t1/2 =

106

Zero order.

105

Zero order.

108

Second order (in A).

107

First order.

110

8.

109

2 (it doubles).

112

1.0 s.

111

8.

113

First-order decay: if t1/2 = 10 min,
how long to reach 1/16 of original?

114

Trap: A reaction is 2nd order overall, so its
half-life is always constant. True or false?

115

You want a reaction to go faster.
The easiest 'general' knob is:

116

If the reactant is a solid, the easiest knob is often:

117

If the reactants are gases, increasing
pressure speeds it up because:

118

If a reaction is slow because of a big energy
barrier, what helps without changing equilibrium?

119

Trap: the best way to speed up a reaction is
always adding more reactant. True or false?

120

Rate law uses ______; equilibrium
constant uses ______.

114

False.

113

40 min.

116

Increase surface area (crush/grind).

115

Increase temperature.

118

A catalyst.

117

It increases effective concentration (more collisions).

120

Rate law uses concentrations during the reaction (not necessarily equilibrium). K uses equilibrium concentrations only.

119

False.

121

Can you get the rate law from the equilibrium constant expression?

122

Trap: rate law is products over reactants like K. True or false?

123

Trap: rate depends on how much product you already have. True or false (basic level)?

124

In a reversible reaction, a catalyst speeds up...

125

Trap: increasing temperature always makes equilibrium constant K bigger. True or false?

126

If a question gives you a rate law and asks 'what happens when [A] doubles?', your fastest move is:

127

Trap: if the rate is zero-order in A, that means A is not involved in the reaction. True or false?

128

Rate law exponents are found by {{c1::experiment}} (unless it's a single elementary step).

122

False.

121

No.

124

Both forward and reverse reactions.

123

Usually false for forward rate laws.

126

Use the exponent as the power on the factor.

125

False.

128

Rate law exponents are found by experiment
(unless it's a single elementary step).

127

False.

129

General rate law template:

130

Overall reaction order (for rate $= k[A]^m[B]^n$):

131

What does a catalyst change on an energy diagram?

132

At equilibrium, forward and reverse rates are:

133

A student says: 'The reaction slowed down so it must be reaching equilibrium.' What's the correction?

134

If you mix two solutions and a precipitate forms faster when you stir, stirring mainly increases rate by...

135

Why does finely divided metal react faster with acid than a metal strip?

136

Why does food spoil faster at warm temperatures (chemistry version)?

130

$m + n$

129

rate $= k[A]^m[B]^n$

132

equal

131

Activation energy (Ea)

134

Increasing mixing/contact between reactants (more effective collisions).

133

Slowing down usually just means reactants are being used up (lower concentration), not necessarily equilibrium.

136

Higher temperature increases k, so reactions (including enzyme reactions) speed up.

135

More surface area exposed to acid.

137

In a closed system, after adding a catalyst, the final amount of product is unchanged. The student thinks 'so catalyst did nothing'. Fix it:

138

For aA -> bB, 'reaction rate' is defined so everyone matches: rate =

139

Example: 2A -> B. If A disappears at 0.20 M/s, B forms at...

140

Trap: In 2A -> B, d[B]/dt = -d[A]/dt. True or false?

141

Example: 3A -> 2B. If B forms at 0.40 M/s, A disappears at...

142

Stoichiometry in rates: for aA -> bB, rate = -(1/{{c1::a}})d[A]/dt = (1/{{c2::b}})d[B]/dt.

143

Zero-order integrated form:

144

First-order integrated form:

138

-(1/a) d[A]/dt = (1/b) d[B]/dt.

137

Catalyst changed the time, not the final equilibrium/extent.

140

False.

139

0.10 M/s.

142

Stoichiometry in rates: for aA -> bB, rate = -(1/a)d[A]/dt = (1/b)d[B]/dt.

141

0.60 M/s.

144

ln[A] = ln[A]0 - kt.

143

[A] = [A]0 - kt.

145

Second-order (in A) integrated form:

146

Half-life for zero-order:

147

Half-life for second-order (rate $= k[A]^2$):

148

Pattern memory: which order has constant half-life?

149

If k has units s^-1, the reaction is likely...

150

If k has units M/s, the reaction is likely...

151

If k has units $1/(M \cdot s)$, the reaction is likely...

152

General unit rule: if overall
order = n, units of k are...

146

$t_{1/2} = [A]_0 / (2k)$.

145

$1/[A] = 1/[A]_0 + kt$.

148

First order.

147

$t_{1/2} = 1/(k[A]_0)$.

150

Zero order.

149

First order.

152

$M^{(1-n)} / s$.

151

Second order.

153

Quick: overall third-order reaction has k units of...

154

Pseudo-first-order idea (common in experiments): if B is in huge excess, then [B] is basically...

155

Trap: changing which reactant is in excess can change the observed order. True or false?

156

Initial rate means...

157

Trap: initial rate is the fastest possible rate for every reaction. True or false?

158

If they give a table labeled 'initial rates', what's the point?

154

Constant.

153

$1/(M^2 \cdot s)$.

156

The rate right at the start ($t \sim 0$), before concentrations change much.

155

True.

158

To deduce the rate law exponents by comparing trials.

157

Usually true-ish, but don't treat it as a law.