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Biochemistry: Enzyme Kinetics & Inhibition

Printable Flashcards — Pre-Med Biology

Michaelis-Menten kinetics, K_m and V_{max} , competitive, noncompetitive, uncompetitive, mixed and irreversible inhibition, Lineweaver-Burk plots, allosteric enzymes, and exam calculations.

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

159 cards — Printable Flashcards

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1

Michaelis-Menten kinetics is basically about how... changes with substrate concentration.

2

v_0 (initial velocity) means...

3

V_{max} means...

4

K_m is defined as the substrate concentration where...

5

What does a LOW K_m usually mean (in plain words)?

6

What does a HIGH K_m usually mean (in plain words)?

7

Trap: K_m is the maximum rate. True or false?

8

Trap: V_{max} is a substrate concentration. True or false?



2

The reaction rate measured right at the start, before conditions change much.

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1

Enzyme reaction rate (initial velocity, v_0).

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4

$$v_0 = V_{max}/2.$$

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3

The maximum rate the enzyme can reach when substrate is saturating.

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6

You need more substrate to get the enzyme going fast (lower apparent affinity).

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5

The enzyme reaches high speed at low substrate -> it 'grabs' substrate well (higher apparent affinity).

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8

False.

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7

False.

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9

Units check: K_m has the same units as...

10

Units check: V_{max} has the same units as...

11

Michaelis-Menten equation (the one they love):

12

Michaelis-Menten: $v = \frac{V_{max}[S]}{K_m + [S]}$.

13

At $[S] = K_m$, the velocity is $V_{max}/2$.

14

Substrate concentration at which $v = V_{max}/2$ is called:

15

At very low substrate ($[S] \ll K_m$), the rate is approximately...

16

At very high substrate ($[S] \gg K_m$), the rate is approximately...



10

Reaction rate (velocity).

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9

Substrate concentration ([S]).

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12

Michaelis-Menten: $v = (V_{max}[S]) / (K_m + [S])$.

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11

$v = (V_{max} [S]) / (K_m + [S])$.

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14

K_m

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13

At $[S] = K_m$, the velocity is $V_{max}/2$.

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16

V_{max} (it plateaus).

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15

Proportional to $[S]$ (almost linear).

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17

First-order in $[S]$ means...

18

Zero-order in $[S]$ means...

19

Trap: at saturating substrate, the enzyme goes faster and faster forever. True or false?

20

What increases V_{max} (cleanest way)?

21

Trap: adding more enzyme changes K_m . True or false?

22

If you double enzyme concentration, what happens to V_{max} and K_m ?

23

A Michaelis-Menten v vs $[S]$ graph is usually shaped like a...

24

How do you visually find K_m on a v vs $[S]$ plot?



18

Rate doesn't change much when [S] changes (rate ~ constant).

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17

Rate changes when [S] changes (rate ~ [S]).

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20

Increase enzyme concentration.

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19

False.

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22

V_{max} doubles; K_m stays the same.

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21

False.

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24

Find $V_{max}/2$ on the y-axis, go to the curve, then down to the x-axis.

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23

Hyperbola (rises fast, then levels off).

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25

Low $[S]$ ($\ll K_m$): v is roughly
proportional to $[S]$. High $[S]$
($\gg K_m$): v approaches V_{max} .

26

If $[S] \gg K_m$, the reaction rate is close to:

27

Enzyme inhibitor =

28

Reversible inhibitor means...

29

Irreversible inhibitor means...

30

Where can inhibitors bind (big categories)?

31

Trap: all inhibitors bind the
active site. True or false?

32

The exam-friendly question: 'Can
adding more substrate fix it?' This is
mostly asking: competitive or not?



26

Vmax

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25

Low [S] ($\ll K_m$): v is roughly proportional to [S]. High [S] ($\gg K_m$): v approaches Vmax.

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28

It binds and unbinds (enzyme can recover when inhibitor is removed).

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27

Anything that decreases enzyme activity (slows the rate).

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30

Active site (competitive) or elsewhere/allosteric site (noncompetitive/mixed).

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29

It permanently inactivates the enzyme (often by covalent binding).

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32

Yes -> competitive. No -> usually noncompetitive/uncompetitive/irreversible.

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31

False.

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33

Competitive inhibition can be overcome by high $[S]$; noncompetitive/uncompetitive generally cannot.

34

Competitive inhibitor binds the enzyme's...

35

Competitive inhibition effect on V_{max} :

36

Competitive inhibition effect on K_m (apparent):

37

One-sentence memory for competitive inhibition:

38

Why does competitive inhibition increase K_m (logic)?

39

Why doesn't competitive inhibition change V_{max} (logic)?

40

Graph clue (v vs $[S]$) for competitive inhibition:



34

Active site (competes with substrate).

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33

Competitive inhibition can be overcome by high [S]; noncompetitive/uncompetitive generally cannot.

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36

K_m increases.

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35

V_{max} stays the same.

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38

Because the enzyme spends time with inhibitor in the active site, so you need more substrate to occupy the enzyme.

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37

K_m up, V_{max} same.

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40

Same V_{max} plateau, curve shifts to the right.

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39

Because at very high [S], substrate wins the competition and saturates the enzyme.

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41

Lineweaver-Burk clue for competitive inhibition ($1/v$ vs $1/[S]$):

42

Trap: competitive inhibition decreases V_{max} . True or false?

43

Scenario: adding lots of substrate brings the rate back to normal. What inhibitor type screams 'me'?

44

Competitive inhibition: apparent K_m increases, V_{max} unchanged.

45

Inhibitor type that increases K_m but keeps V_{max} the same:

46

Noncompetitive inhibitor binds...

47

Noncompetitive inhibition effect on V_{max} :

48

Noncompetitive inhibition effect on K_m (classic pure case):



42

False.

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41

Same y-intercept ($1/V_{max}$), x-intercept moves toward 0 (K_m increases).

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44

Competitive inhibition: apparent K_m increases, V_{max} unchanged.

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43

Competitive inhibition.

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46

An allosteric site (not the active site) and reduces enzyme activity.

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45

Competitive

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48

K_m stays the same.

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47

V_{max} decreases.

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49

One-sentence memory for noncompetitive inhibition:

50

Why can't adding more substrate fix pure noncompetitive inhibition?

51

Graph clue (v vs $[S]$) for noncompetitive inhibition:

52

Lineweaver-Burk clue for pure noncompetitive inhibition:

53

Trap: noncompetitive inhibition increases K_m . True or false (pure case)?

54

Scenario: V_{max} dropped, K_m looks unchanged. Most likely inhibitor type?

55

Pure noncompetitive inhibition: $\{c1::V_{max} \text{ decreases}\}$, $\{c2::K_m \text{ unchanged}\}$.

56

Inhibitor type that decreases V_{max} but leaves K_m unchanged (pure case):



50

Because the problem isn't substrate binding
- it's that the enzyme's activity is reduced.

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49

V_{max} down, K_m same.

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52

Same x-intercept ($-1/K_m$),
higher y-intercept ($1/V_{max}$).

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51

Lower V_{max} plateau; curve doesn't
reach original max even at high $[S]$.

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54

Noncompetitive (pure).

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53

False.

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56

Noncompetitive

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55

Pure noncompetitive inhibition:
 V_{max} decreases, K_m unchanged.

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57

Uncompetitive inhibitor binds only to...

58

Uncompetitive inhibition effect on V_{max} :

59

Uncompetitive inhibition effect on K_m (apparent):

60

One-sentence memory for uncompetitive inhibition:

61

Can increasing $[S]$ overcome uncompetitive inhibition?

62

Graph clue (v vs $[S]$) for uncompetitive inhibition:

63

Lineweaver-Burk clue for uncompetitive inhibition:

64

Trap: uncompetitive inhibition leaves K_m unchanged. True or false?



58

V_{max} decreases.

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57

The enzyme-substrate complex (ES), not the free enzyme.

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60

K_m down, V_{max} down (both down).

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59

K_m decreases.

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62

Lower V_{max} AND the curve shifts left (half-max at lower $[S]$).

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61

No (and it can even make inhibition stronger, because more ES forms).

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64

False.

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63

Parallel lines (same slope).

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65

Scenario: V_{max} decreased and K_m decreased. Most likely inhibitor type?

66

Uncompetitive inhibition: apparent V_{max} decreases and K_m decreases (both down).

67

Inhibitor type that decreases BOTH K_m and V_{max} :

68

Mixed inhibition means...

69

Mixed inhibition effect on V_{max} :

70

Mixed inhibition effect on K_m :

71

Quick identification: V_{max} decreases AND K_m increases. That pattern is most consistent with...

72

Lineweaver-Burk clue for mixed inhibition (general):



66

Uncompetitive inhibition: apparent V_{max} decreases and K_m decreases (both down).

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65

Uncompetitive inhibition.

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68

Inhibitor can bind both free enzyme (E) and ES, but not equally.

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67

Uncompetitive

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70

K_m changes (can go up or down).

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69

V_{max} decreases.

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72

Lines intersect left of the y-axis (not on axes).

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71

Mixed inhibition (not pure noncompetitive).

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73

Trap: mixed inhibition is the same thing as uncompetitive. True or false?

74

Mixed inhibition: V_{max} decreases and K_m changes (up or down).

75

Inhibitor type that decreases V_{max} and changes K_m (not necessarily up or down):

76

Irreversible inhibitor does what to the enzyme?

77

Classic effect of irreversible inhibition on V_{max} :

78

Classic effect of irreversible inhibition on K_m (for the remaining active enzymes):

79

Can increasing substrate overcome irreversible inhibition?

80

How could a cell recover from irreversible inhibition (concept)?



74

Mixed inhibition: V_{max} decreases
and K_m changes (up or down).

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73

False.

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76

It permanently inactivates it (often covalently).

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75

Mixed inhibition

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78

K_m often stays the same.

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77

V_{max} decreases (less active enzyme available).

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80

Make new enzyme (or add more enzyme in a lab).

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79

No.

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81

Trap: irreversible inhibition is just 'very strong competitive inhibition'. True or false?

82

Suicide inhibitor means...

83

If you see a drug that 'covalently' binds an enzyme, what kind of inhibition is that usually?

84

Irreversible inhibition usually lowers V_{max} because it reduces the amount of active enzyme.

85

Inhibition type where the enzyme is permanently inactivated (often covalent):

86

Allosteric enzyme means...

87

Allosteric enzymes often show a v vs $[S]$ curve that's...

88

Cooperativity (simple) means...



82

An inhibitor that the enzyme starts to process, then it gets stuck and permanently inactivates the enzyme.

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81

False.

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84

Irreversible inhibition usually lowers V_{max} because it reduces the amount of active enzyme.

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83

Irreversible.

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86

Its activity is regulated by molecules binding at a site other than the active site.

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85

Irreversible inhibition

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88

Binding one substrate molecule changes how easily the next one binds.

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87

Sigmoidal (S-shaped), not hyperbolic.

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89

Trap: every enzyme follows Michaelis-Menten. True or false?

90

For an allosteric enzyme, people often use $K_{0.5}$ instead of K_m . $K_{0.5}$ means...

91

Allosteric activator typically shifts the sigmoidal curve...

92

Allosteric inhibitor typically shifts the sigmoidal curve...

93

Feedback inhibition is when...

94

Trap: feedback inhibition is competitive inhibition at the active site. True or false?

95

Allosteric enzymes often show $\{\{c1::sigmoidal\}\}$ (S-shaped) kinetics instead of classic $\{\{c2::hyperbolic\}\}$ Michaelis-Menten curves.

96

S-shaped (sigmoidal) v vs [S] curve usually suggests:



90

The substrate concentration where $v = V_{max}/2$ (for the sigmoidal curve).

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89

False.

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92

Right (more substrate needed for a given rate).

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91

Left (less substrate needed for a given rate).

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94

False (usually).

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93

The final product of a pathway inhibits an earlier enzyme (often allosterically).

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96

An allosteric/cooperative enzyme

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95

Allosteric enzymes often show sigmoidal (S-shaped) kinetics instead of classic hyperbolic Michaelis-Menten curves.

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97

k_{cat} (turnover number) is basically...

98

Relationship you might see: $V_{max} =$

99

If k_{cat} increases (same $[E]$),
what happens to V_{max} ?

100

Catalytic efficiency is often summarized as...

101

Trap: V_{max} is an inherent constant
of the enzyme and doesn't depend
on enzyme amount. True or false?

102

At saturating substrate: $\{c1::V_{max}\}$
 $= \{c2::k_{cat}\} * \{c3::[E]_{total}\}$.

103

Turnover number (substrates converted
per enzyme per second at saturation):

104

Lineweaver-Burk plot is a graph of...



98

$k_{cat} * [E]_{total}$.

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97

How many substrate molecules one enzyme site can convert to product per second when fully saturated.

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100

k_{cat}/K_m (higher = better at low substrate).

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99

V_{max} increases.

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102

At saturating substrate: $V_{max} = k_{cat} * [E]_{total}$.

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101

False.

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104

$1/v$ versus $1/[S]$.

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103

k_{cat}

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105

On a Lineweaver-Burk plot, the y-intercept equals...

106

On a Lineweaver-Burk plot, the x-intercept equals...

107

On a Lineweaver-Burk plot, the slope equals...

108

Competitive inhibition on Lineweaver-Burk: lines intersect at the...

109

Pure noncompetitive inhibition on Lineweaver-Burk: lines intersect at the...

110

Uncompetitive inhibition on Lineweaver-Burk gives...

111

Mixed inhibition on Lineweaver-Burk typically intersects...

112

Trap: if y-intercept increases on Lineweaver-Burk, V_{max} increased. True or false?



106

$-1/K_m$.

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105

$1/V_{max}$.

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108

Y-axis.

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107

K_m/V_{max} .

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110

Parallel lines.

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109

X-axis.

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112

False.

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111

Left of the y-axis (not on the axes).

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113

Lineweaver-Burk: y-intercept = $\{c1::1/V_{max}\}$, x-intercept = $\{c2::-1/K_m\}$, slope = $\{c3::K_m/V_{max}\}$.

114

In a Lineweaver-Burk plot, the y-intercept equals:

115

K_m increases, V_{max} unchanged.
Name the inhibition.

116

V_{max} decreases, K_m unchanged.
Name the inhibition (classic).

117

K_m decreases, V_{max} decreases. Name the inhibition.

118

K_m increases, V_{max} decreases.
Name the inhibition.

119

Competitive vs noncompetitive in one question: which one changes K_m ?

120

Competitive vs noncompetitive in one question: which one changes V_{max} ?



114

$1/V_{max}$

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113

Lineweaver-Burk: y-intercept = $1/V_{max}$,
x-intercept = $-1/K_m$, slope = K_m/V_{max} .

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116

Noncompetitive inhibition (pure) OR
irreversible inactivation (kinetically similar).

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115

Competitive inhibition.

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118

Mixed inhibition.

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117

Uncompetitive inhibition (classic).

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120

Noncompetitive changes
 V_{max} ; competitive doesn't.

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119

Competitive changes K_m ;
pure noncompetitive doesn't.

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121

If two v vs $[S]$ curves have the SAME V_{max} but different K_m , the inhibitor is most likely...

122

If two v vs $[S]$ curves have different V_{max} , competitive inhibition is...

123

If an inhibitor binds ONLY the ES complex, what happens when you increase $[S]$?

124

If a question says 'inhibitor binds at active site and resembles substrate', that's almost always...

125

If a question says 'inhibitor binds allosteric site and changes enzyme shape', that's most likely...

126

Pattern ID: $K_m \uparrow + V_{max} \text{same}$
 \rightarrow competitive. $K_m \text{same} + V_{max} \downarrow \rightarrow$ noncompetitive (pure).

127

Pattern ID: $K_m \downarrow + V_{max} \downarrow \rightarrow$ uncompetitive. $K_m \uparrow + V_{max} \downarrow \rightarrow$ mixed.

128

Inhibition where increasing substrate can overcome the inhibitor:



122

Unlikely (competitive keeps V_{max}).

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121

Competitive.

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124

Competitive inhibition.

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123

You can form more ES, which gives the inhibitor more targets (so you don't rescue the enzyme).

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126

Pattern ID: K_m up + V_{max} same \rightarrow competitive.
 K_m same + V_{max} down \rightarrow noncompetitive (pure).

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125

Noncompetitive or mixed inhibition (allosteric).

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128

Competitive inhibition

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127

Pattern ID: K_m down + V_{max} down \rightarrow uncompetitive. K_m up + V_{max} down \rightarrow mixed.

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129

If $[S] = K_m$, what fraction of V_{max} is the rate?

130

If $[S] = 9K_m$, the rate is about what fraction of V_{max} ?

131

If $[S] = K_m/9$, the rate is about what fraction of V_{max} ?

132

Speed check: $K_m = 4 \text{ mM}$, $V_{max} = 80$. At $[S]=4 \text{ mM}$, $v = ?$

133

Speed check: $K_m = 5$, $V_{max} = 100$. At $[S]=5$, $v = ?$

134

Speed check: $K_m = 5$, $V_{max} = 100$. At $[S]=15$, $v = ?$

135

Speed check: $K_m = 10$, $V_{max} = 60$. At $[S]=30$, $v = ?$

136

If you know $v/V_{max} = [S]/(K_m + [S])$, then at $[S]=K_m$ the fraction is...



130

About 9/10 of V_{max} ($0.9 V_{max}$).

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129

1/2 of V_{max} .

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132

40 (same units as V_{max}).

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131

About 1/10 of V_{max} ($0.1 V_{max}$).

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134

75.

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133

50.

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136

$K_m / (K_m + K_m) = 1/2$.

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135

45.

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137

If $[S]$ is huge compared to K_m , v/V_{max} is close to...

138

If $[S]$ is tiny compared to K_m , v is approximately...

139

Fraction trick: $v/V_{max} = [S]/(K_m + [S])$. So if $[S] = nK_m$, then $v/V_{max} = n/(n+1)$.

140

$K_m = 8 \text{ mM}$, $V_{max} = 120$. At $[S] = 8 \text{ mM}$, $v =$

141

At $[S] = K_m$, about what fraction of enzyme active sites are occupied (basic M-M idea)?

142

Trap: K_m tells you how fast the enzyme is. True or false?

143

Trap: lower K_m ALWAYS means higher binding affinity. True or false?

144

If an enzyme has a very low K_m , it reaches high speed when substrate is...



138

$$v = (V_{max}/K_m) * [S].$$

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137

1 (so $v \sim V_{max}$).

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140

60

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139

Fraction trick: $v/V_{max} = [S]/(K_m + [S])$. So if $[S] = nK_m$, then $v/V_{max} = n/(n+1)$.

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142

False.

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141

About half.

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144

Low (it doesn't need much substrate).

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143

Careful: usually yes in simple exam questions, but not always in real life.

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145

If an enzyme has a very high K_m , it really speeds up only when substrate is...

146

V_{max} is limited by what at saturation?

147

If temperature goes way above optimum, enzyme rate drops because...

148

Trap: denaturation changes K_m and V_{max} the same way as competitive inhibition. True or false?

149

pH changes can mess with enzyme activity because...

150

Trap: inhibitors always decrease V_{max} . True or false?

151

If an inhibitor increases K_m , what happened to 'apparent affinity'?

152

If an inhibitor lowers V_{max} , what happened to effective enzyme activity?



146

How fast the enzyme can turn over substrate (kcat) and how much enzyme you have.

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145

High.

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148

False.

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147

The enzyme denatures (shape breaks).

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150

False.

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149

They change charges on amino acids -
> active site shape/chemistry changes.

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152

It decreased (less working enzyme or slower catalysis).

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151

It decreased (needs more substrate).

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153

Trap: inhibitors change the equilibrium constant (K_{eq}) of the reaction. True or false?

154

At saturation, the limiting factor is $\{c1::enzyme\}$ (amount + turnover), not substrate.

155

Classic competitive inhibitor example: malonate inhibits...

156

Real-life logic: ethanol is used as an antidote for methanol poisoning because ethanol...

157

Aspirin is often taught as an example of...

158

Penicillin is a classic example of...

159

If a question says 'substrate analogue inhibitor', the first inhibition type to suspect is...



154

At saturation, the limiting factor is enzyme (amount + turnover), not substrate.

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153

False.

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156

Competitively occupies alcohol dehydrogenase, slowing methanol conversion to toxic products.

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155

Succinate dehydrogenase (competitive with succinate).

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158

An irreversible inhibitor of a bacterial enzyme (cell wall synthesis).

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157

Irreversible inhibition (covalent modification) of an enzyme (COX).

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159

Competitive inhibition.

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