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Enzyme Kinetics & Inhibition (Km, Vmax, Inhibitors)

Study Guide — Enzymology

Pre-med/IB-level conceptual practice on enzyme kinetics: meaning of Km and Vmax, saturation, enzyme concentration vs substrate concentration, catalytic efficiency, and how different inhibitor types (competitive, noncompetitive, uncompetitive, mixed, irreversible, allosteric) change kinetics and graphs. Built to teach the concepts through tricky, realistic scenarios (no heavy calculations).

60 items — Study Guide with Answers

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1 **Which statement best defines Vmax for an enzyme-catalyzed reaction?**

A The fastest speed possible at any temperature

B The reaction rate when [S] = Km

C The reaction rate when all enzyme active sites are effectively saturated with substrate ✓

D The substrate concentration at which the enzyme is half saturated

E The maximum amount of product that can ever be formed

▶ **Explanation:** Vmax is the maximum initial rate achieved at saturating substrate, when the enzyme is working at full capacity (active sites occupied most of the time). It's a rate, not a product amount, and it depends on enzyme amount and catalytic speed.

2 **Which statement best defines Km (Michaelis constant) for a simple Michaelis–Menten enzyme?**

A The substrate concentration at which v = Vmax/2 ✓

B The maximum rate of the reaction

C The enzyme concentration at which v = Vmax/2

D The substrate concentration at which v = Vmax

E The number of active sites on the enzyme

▶ **Explanation:** Km is defined as the substrate concentration that gives half the maximal rate (Vmax/2) under Michaelis–Menten assumptions. It is not the same thing as Vmax or enzyme concentration.

3 **If the substrate concentration equals Km, what fraction of Vmax is the reaction rate (v) approximately?**

A 1/4 of Vmax

B **1/2 of Vmax** ✓

C 3/4 of Vmax

D Equal to Vmax

E Cannot be predicted without kcat

▶ **Explanation:** By definition, Km is the [S] where v = Vmax/2. This is a core interpretation point for understanding kinetic curves.

4 A student says: 'Km is the substrate concentration where the enzyme is fully saturated.' Which is the best correction?

A Correct: Km is where the enzyme is saturated

B Incorrect: Km is where the reaction stops

C **Incorrect: Km is where v = Vmax/2, not full saturation** ✓

D Incorrect: Km equals Vmax always

E Correct, but only at high temperature

▶ **Explanation:** Km corresponds to half-maximal rate, not full saturation. Full saturation occurs at substrate concentrations much greater than Km.

5 Which change most directly increases Vmax (without changing the enzyme's intrinsic chemistry)?

A Decreasing substrate concentration

B **Increasing enzyme concentration** ✓

C Adding a competitive inhibitor

D Lowering temperature slightly below optimum

E Lowering pH far from optimum

▶ **Explanation:** Vmax is proportional to the total active enzyme present (and kcat). Adding more enzyme increases total catalytic capacity. Inhibitors and poor conditions usually reduce apparent activity rather than increasing Vmax.

6 **If you double the enzyme concentration while keeping substrate concentration fixed at a very high level (saturating), what happens to the initial rate?**

A It stays the same because substrate is saturating

B **It approximately doubles** ✓

C It halves because the enzyme is diluted

D It becomes independent of enzyme concentration

E It becomes zero because the enzyme competes with itself

▶ **Explanation:** At saturating substrate, the rate is near Vmax, and Vmax [enzyme]. Doubling enzyme roughly doubles Vmax and thus doubles the saturating-rate.

7 **At very low substrate concentration compared with Km, what mainly controls the reaction rate?**

A Only the pH of the solution

B Only the temperature of the solution

C **Primarily the substrate concentration (rate rises roughly proportionally with [S])** ✓

D Only Vmax (rate is flat and saturated)

E Only the amount of product already formed

▶ **Explanation:** When [S] Km, the enzyme is far from saturation and the rate is approximately proportional to [S]. Saturation/plateau behavior occurs at [S] Km.

8 **At very high substrate concentration compared with Km, what mainly limits the reaction rate?**

A Substrate diffusion into the enzyme is always limiting

B **The enzyme's catalytic capacity (approaching Vmax)** ✓

C The substrate concentration, which continues to increase rate linearly

D The reaction must stop because enzyme is saturated

E Only Km

▶ **Explanation:** When [S] Km, active sites are occupied most of the time, so adding more substrate barely increases rate. The limiting factor becomes enzyme turnover (kcat) and enzyme amount (Vmax).

9 **Which statement about Km is most accurate for students at this level?**

A **Lower Km usually corresponds to higher apparent substrate affinity (enzyme reaches half Vmax at lower [S])** ✓

B Lower Km always means higher Vmax

C Km is the same as enzyme concentration

D Km is the maximum possible rate

E Km has units of time

▶ **Explanation:** Km has units of concentration. A smaller Km means half-maximal rate occurs at lower [S], often interpreted as higher affinity in basic models (though Km is not always exactly the dissociation constant).

10 **A student measures a lower Vmax after accidentally using half as much enzyme as intended. What happens to Km (assuming conditions are otherwise identical)?**

A Km increases

B Km decreases

C **Km stays the same** ✓

D Km becomes zero

E Km becomes infinite

▶ **Explanation:** Changing enzyme concentration changes Vmax (capacity) but does not change Km for a given enzyme-substrate pair under the same conditions. Km is tied to enzyme–substrate interaction/kinetics, not how much enzyme you used.

11 **Which statement correctly describes a competitive inhibitor?**

A It binds only to the enzyme–substrate complex

B **It binds the active site and competes with substrate, so high [S] can reduce its effect** ✓

C It decreases Km and decreases Vmax

D It decreases Vmax but does not affect Km

E It permanently destroys the enzyme by covalent bonding (always)

▶ **Explanation:** Competitive inhibitors compete with substrate for the active site, so adding more substrate can outcompete the inhibitor. In classic competitive inhibition, Vmax stays the same but apparent Km increases.

12 **In classic competitive inhibition, which kinetic change is expected?**

A Vmax decreases; Km decreases

B Vmax decreases; Km unchanged

C **Vmax unchanged; Km increases (apparent)** ✓

D Vmax increases; Km increases

E Vmax unchanged; Km decreases

▶ **Explanation:** Competitive inhibitors make it harder for substrate to bind, so more substrate is needed to reach half Vmax (Km increases). With enough substrate, the enzyme can still reach its original maximal capacity (Vmax unchanged).

13 A drug decreases the reaction rate at low substrate concentration, but at very high substrate concentration the reaction still reaches the same Vmax as without the drug. The drug is most likely a:

A **Competitive inhibitor** ✓

B Pure noncompetitive inhibitor

C Uncompetitive inhibitor

D Irreversible inhibitor

E Denaturing agent that unfolds the enzyme

▶ **Explanation:** If Vmax is unchanged but more substrate is needed to get the same rate, that matches competitive inhibition. Noncompetitive/irreversible inhibition reduces Vmax because active enzyme capacity is reduced.

14 Which statement best describes a pure noncompetitive inhibitor (classic model)?

A It binds only at the active site

B It binds only to the enzyme–substrate complex

C **It reduces Vmax without changing Km (apparent)** ✓

D It increases Vmax and decreases Km

E It is always irreversible

▶ **Explanation:** In pure noncompetitive inhibition, the inhibitor reduces catalytic capacity (Vmax decreases) but does not change substrate affinity for the active site (Km unchanged). It typically binds at a different site and can bind E and ES equally.

15 **A student adds an inhibitor and finds that no matter how much substrate is added, the reaction cannot reach the original Vmax. Which inhibitor type best fits?**

A Competitive inhibition

B **Noncompetitive (or irreversible) inhibition** ✓

C Competitive inhibition only at low temperature

D No inhibition is occurring

E Increased enzyme concentration

▶ **Explanation:** If Vmax is reduced, increasing substrate cannot restore the original maximum rate. This happens with noncompetitive (and mixed/uncompetitive) inhibition and with irreversible inhibitors that reduce the amount of active enzyme.

16 **Uncompetitive inhibitors are defined by which binding behavior?**

A Bind only to free enzyme (E)

B **Bind only to the enzyme–substrate complex (ES)** ✓

C Bind only to the active site and mimic substrate

D Bind covalently and permanently

E Bind DNA instead of the enzyme

▶ **Explanation:** Uncompetitive inhibitors bind only after substrate has bound (to ES), often 'locking' the complex and preventing product formation. This causes both apparent Vmax and apparent Km to decrease.

17 **In classic uncompetitive inhibition, the typical kinetic changes are:**

A Vmax unchanged; Km increases

B Vmax decreases; Km unchanged

C Vmax decreases; Km increases

D **Vmax decreases; Km decreases** ✓

E Vmax increases; Km decreases

▶ **Explanation:** Uncompetitive inhibition lowers Vmax because some ES is trapped and cannot form product. It also lowers apparent Km because removing ES shifts the equilibrium, making the enzyme appear to bind substrate more readily (needs less [S] for half Vmax).

18 **A student notices that adding more substrate does NOT overcome an inhibitor, but increasing enzyme concentration partially restores the maximal rate. Which inhibitor type is most consistent with this observation (conceptually)?**

A Competitive inhibition

B **Noncompetitive inhibition** ✓

C Uncompetitive inhibition

D No inhibition

E Substrate activation

▶ **Explanation:** In noncompetitive inhibition, adding substrate doesn't restore Vmax because catalytic capacity is reduced. Increasing total enzyme can raise overall capacity (more active enzyme molecules available), partially restoring maximal rate.

19 **Mixed inhibition is best recognized by which general pattern?**

A Km always decreases and Vmax always increases

B Vmax decreases, and Km changes (can increase or decrease depending on inhibitor preference for E vs ES) ✓

C Vmax unchanged and Km unchanged

D Vmax increases while Km stays the same

E Only Km increases while Vmax decreases to zero always

▶ **Explanation:** Mixed inhibitors can bind both E and ES but with different affinities. That always reduces Vmax (less effective catalysis), while Km shifts depending on whether the inhibitor prefers E (Km ↑) or ES (Km ↓).

20 **Which feature most strongly suggests an inhibitor is irreversible (at this level)?**

A Its effect disappears when substrate concentration is raised high enough

B It binds the enzyme through weak, easily reversible interactions only

C Enzyme activity does not recover after removing free inhibitor, because the enzyme has been permanently inactivated ✓

D It increases Km but not Vmax

E It binds only to the ES complex

▶ **Explanation:** Irreversible inhibitors permanently inactivate enzyme molecules (often by covalent modification). Washing/removing free inhibitor does not restore activity because the enzyme itself has been changed.

21 **An irreversible inhibitor reduces the number of active enzyme molecules. What kinetic change is most expected (qualitatively)?**

A **Vmax decreases; Km (of the remaining active enzyme) is usually unchanged** ✓

B Vmax increases; Km decreases

C Only Km increases; Vmax unchanged

D Only Km decreases; Vmax unchanged

E Both Vmax and Km always increase

▶ **Explanation:** If you permanently remove active enzyme, total catalytic capacity drops, lowering Vmax. Km reflects binding/kinetics of the active enzyme molecules that remain and often does not change just because fewer enzymes exist.

22 **A teacher says: 'Competitive inhibitors always look like the substrate.' Which response is best?**

A Always true: competitive inhibitors must be identical to the substrate

B **Mostly true at this level: competitive inhibitors often resemble the substrate enough to bind the active site, but they don't have to be identical** ✓

C False: competitive inhibitors always bind to an allosteric site

D False: competitive inhibitors bind only to ES

E True only for enzymes in mitochondria

▶ **Explanation:** Competitive inhibitors bind the active site, so they often resemble the substrate or transition state, but they do not need to be identical. 'Substrate-like' is a helpful heuristic, not an absolute rule.

23 **Which statement best captures why a competitive inhibitor increases the apparent Km?**

A It permanently destroys half the enzyme molecules

B It makes the enzyme bind substrate more tightly

C **It makes it harder for substrate to occupy the active site, so more substrate is needed to reach half-maximal rate** ✓

D It makes the enzyme faster at turning substrate into product

E It changes temperature of the reaction mixture

▶ **Explanation:** Competitive inhibitors compete for the active site. As a result, to achieve the same fraction of active sites occupied by substrate, a higher substrate concentration is required—so apparent Km increases.

24 **A noncompetitive inhibitor reduces Vmax. Conceptually, the best reason is that it:**

A Prevents substrate from ever binding to the enzyme

B **Reduces the fraction of enzyme molecules that can successfully catalyze product formation (even if substrate can bind)** ✓

C Makes substrate concentration lower

D Turns the enzyme into a substrate

E Increases the enzyme's affinity so much that the reaction stops

▶ **Explanation:** Noncompetitive inhibition reduces effective catalytic capacity: some enzyme molecules become catalytically ineffective due to inhibitor binding. Even at high substrate, you can't restore the original Vmax.

25 **You compare two enzymes acting on the same substrate. Enzyme A has a lower Km than enzyme B, but both have the same Vmax at the same enzyme concentration. Which conclusion is most reasonable?**

A **Enzyme A reaches half-maximal rate at lower substrate concentration** ✓

B Enzyme A always makes more product per second at saturating substrate

C Enzyme A must have a higher Vmax

D Enzyme B has higher substrate affinity than enzyme A

E Enzyme A cannot be inhibited

▶ **Explanation:** Lower Km means Vmax/2 is reached at lower [S], so enzyme A becomes effective at lower substrate levels. At saturating [S], both approach the same Vmax here, so A does not necessarily have a higher saturating rate.

26 **Which statement best explains why Vmax depends on enzyme concentration?**

✓ **A More enzyme means more active sites available, increasing total catalytic capacity**

B More enzyme automatically increases substrate concentration

C Vmax is fixed by temperature only and cannot change

D More enzyme reduces reaction rate by crowding out substrate

E Enzyme concentration affects Km but not Vmax

▶ **Explanation:** At saturation, each enzyme molecule can work at its own turnover rate. Total rate equals (rate per enzyme) × (number of enzyme molecules), so more enzyme raises Vmax.

27 **A student measures Vmax and Km for an enzyme. Then they add more enzyme and repeat. What changes?**

A Vmax increases; Km stays the same ✓

B Vmax stays the same; Km increases

C Vmax decreases; Km decreases

D Both Vmax and Km increase

E Both Vmax and Km decrease

▶ **Explanation:** Adding more enzyme increases maximum capacity (Vmax). Km is an interaction/kinetic constant for the enzyme-substrate pair and does not change simply because you have more enzyme molecules.

28 **A classic Michaelis–Menten curve (v vs [S]) approaches a plateau at high [S]. The best explanation is:**

A Substrate is destroyed at high concentration

B The enzyme becomes saturated, so adding substrate doesn't significantly increase the fraction of occupied active sites ✓

C The enzyme begins producing substrate instead of product

D The reaction becomes endothermic

E The buffer runs out of ions

▶ **Explanation:** At high [S], most enzyme active sites are occupied, so the rate is limited by enzyme turnover rather than substrate availability, producing a plateau at Vmax.

29 **Which experimental change would help you distinguish a competitive inhibitor from a noncompetitive inhibitor without doing any calculations?**

A Change the color of the test tube

B Increase substrate concentration to very high levels and see whether the same Vmax can still be reached ✓

C Measure pH once at the beginning only

D Measure the mass of the enzyme protein

E Use a different brand of pipette

▶ **Explanation:** Competitive inhibition can be overcome by high substrate (Vmax restored). Noncompetitive inhibition cannot restore original Vmax by adding substrate. This is a conceptual diagnostic test.

30 **A reaction shows the same Km but a smaller Vmax after adding an inhibitor. Which inhibitor type is the best match (classic patterns)?**

A Competitive

B **Pure noncompetitive** ✓

C Uncompetitive

D Competitive irreversible

E Substrate

▶ **Explanation:** Pure noncompetitive inhibition reduces Vmax (lower capacity) while leaving Km unchanged (no change in substrate affinity at the active site in the classic model). Competitive changes Km, not Vmax.

31 **A reaction shows both a smaller Vmax and a smaller Km after adding an inhibitor. Which inhibitor type is the best match (classic patterns)?**

A Competitive

B Pure noncompetitive

C **Uncompetitive** ✓

D Competitive irreversible

E Activator

▶ **Explanation:** Uncompetitive inhibitors bind ES only, reducing Vmax and decreasing apparent Km. This 'down-and-left' shift is a key pattern students often forget.

32 **An inhibitor decreases Vmax and increases Km. Which label best fits?**

A Competitive inhibition

B Pure noncompetitive inhibition

C Uncompetitive inhibition

D Mixed inhibition with preference for free enzyme (E) ✓

E No inhibition is happening

▶ **Explanation:** If Vmax decreases and Km increases, the inhibitor reduces catalytic capacity and also reduces effective substrate binding (or shifts equilibrium). That matches mixed inhibition where inhibitor binds E more strongly than ES.

33 **An inhibitor decreases Vmax and decreases Km. Which label best fits?**

A Competitive inhibition

B Pure noncompetitive inhibition

C Mixed inhibition with preference for ES ✓

D Competitive inhibition only at low [S]

E Enzyme activation

▶ **Explanation:** If Vmax decreases, capacity is reduced. If Km also decreases, the inhibitor likely stabilizes ES (binds ES more strongly than E), making substrate appear to bind more readily while still slowing catalysis—consistent with mixed inhibition favoring ES (uncompetitive is an extreme case).

34 **A student claims: 'If an inhibitor lowers Km, it must be an activator because lower Km means better.' Which is the best correction?**

A Correct: lower Km always means faster reaction at all substrate concentrations

B **Incorrect: Km can decrease even when the inhibitor makes Vmax smaller, so overall catalysis can still be worse** ✓

C Correct: lower Km always increases Vmax

D Incorrect: Km cannot change with inhibitors

E Correct only in the presence of oxygen

▶ **Explanation:** A lower apparent Km does not guarantee higher rates overall. In uncompetitive/mixed inhibition, Km can decrease while Vmax also decreases, meaning the reaction can be slower despite the lower Km.

35 **Which statement best distinguishes an allosteric inhibitor from a competitive inhibitor?**

A Allosteric inhibitors always bind covalently

B **Allosteric inhibitors bind at a site other than the active site and change enzyme activity by altering conformation** ✓

C Competitive inhibitors bind only to ES

D Allosteric inhibitors increase Vmax by definition

E Competitive inhibitors can never be overcome by high substrate

▶ **Explanation:** Allosteric regulation involves binding at a distinct regulatory site that changes enzyme shape/function. Competitive inhibitors bind the active site and compete with substrate; their effect can often be reduced by high [S].

36 **Feedback inhibition in a metabolic pathway is best described as:**

A An enzyme in the pathway inhibiting the next enzyme in line by cutting it

B **The final product inhibits an early enzyme, slowing the pathway when product is abundant** ✓

C A substrate inhibiting itself by becoming toxic

D Only competitive inhibition by the substrate

E A process found only in bacteria

▶ **Explanation:** Feedback inhibition is a control strategy: when enough end product accumulates, it inhibits an earlier step (often allosterically), preventing unnecessary resource use.

37 A student adds a competitive inhibitor and then doubles enzyme concentration (keeping inhibitor concentration the same). Which outcome is most likely?

A Competitive inhibition disappears completely at all substrate concentrations

B Vmax increases (more enzyme), but a higher substrate concentration is still needed to reach half of that Vmax ✓

C Km must return exactly to its original value

D Vmax decreases because more enzyme binds more inhibitor

E The reaction becomes zero because inhibitor is amplified

▶ **Explanation:** More enzyme raises Vmax. Competitive inhibition still shifts the curve right: you still need more substrate to reach half-max rate (apparent Km remains higher than without inhibitor).

38 Two experiments use the same enzyme and conditions. In experiment 2, the enzyme is partially denatured by heat (some enzymes lose proper shape). What is the most likely kinetic effect?

A Vmax increases because heat adds energy

B Vmax decreases because fewer functional enzymes remain active ✓

C Km always decreases because heat increases collisions

D Km always increases and Vmax always increases

E Km becomes undefined and the reaction becomes photosynthesis

▶ **Explanation:** Denaturation reduces the number of functional enzyme molecules and/or their catalytic ability, lowering Vmax. Km may change unpredictably depending on how binding is affected, but the clearest expectation is reduced maximal capacity.

39 **A student thinks Vmax is a 'fixed property of the enzyme molecule' and cannot change. Which is the best correction?**

A Correct: Vmax cannot change in any experiment

B **Incorrect: Vmax depends on enzyme concentration and conditions; changing the amount of enzyme changes Vmax** ✓

C Incorrect: Vmax is defined as Km/2

D Correct, unless substrate concentration is low

E Correct, unless you change the pH of the substrate only

▶ **Explanation:** Vmax for a reaction mixture depends on how much active enzyme is present (and environmental conditions affecting kcat). If you add more enzyme or inactivate enzyme, Vmax changes.

40 **Which scenario best demonstrates that competitive inhibition can be overcome?**

A Adding more inhibitor restores normal activity

B **Raising substrate concentration restores the same Vmax as without inhibitor** ✓

C Lowering substrate concentration restores Vmax

D Heating the enzyme restores Vmax permanently

E Removing enzyme from the solution restores activity

▶ **Explanation:** Competitive inhibitors and substrate compete for the same site. At high substrate, substrate occupancy dominates and the same maximal rate (Vmax) can be achieved.

41 **Which scenario best demonstrates that noncompetitive inhibition cannot be overcome by substrate?**

A Increasing substrate concentration makes the inhibitor more effective

B Increasing substrate concentration restores the original Vmax

C **Even at very high substrate concentration, the maximum rate stays lower than before inhibitor was added** ✓

D The inhibitor effect disappears when substrate is removed

E The inhibitor increases Vmax

▶ **Explanation:** Noncompetitive inhibition reduces catalytic capacity. Substrate can still bind, but some enzymes are ineffective, so Vmax is lowered and cannot be restored simply by adding more substrate.

42 **A student sees two Michaelis–Menten curves. Curve 2 is shifted to the right compared to curve 1 but reaches the same plateau. What is the best interpretation?**

A Vmax decreased; Km decreased

B **Vmax unchanged; Km increased** ✓

C Vmax increased; Km decreased

D Vmax decreased; Km unchanged

E Both Vmax and Km are unchanged

▶ **Explanation:** A right shift with the same plateau means you need more substrate to reach the same rates (Km ↑) but the maximal capacity is unchanged (Vmax same), consistent with competitive inhibition or reduced affinity without capacity loss.

43 **A student sees two Michaelis–Menten curves. Curve 2 plateaus at a lower rate than curve 1 but reaches half-max at the same substrate concentration. Best interpretation?**

- A **Vmax decreased; Km unchanged** ✓
- B Vmax unchanged; Km increased
- C Vmax increased; Km unchanged
- D Vmax decreased; Km decreased
- E Vmax unchanged; Km decreased

▶ **Explanation:** A lower plateau indicates Vmax decreased. If the substrate concentration at half-max rate is unchanged, Km is unchanged. This is the classic pure noncompetitive pattern.

44 **Which statement about the relationship between Km and enzyme–substrate binding is most accurate?**

- A Km is always exactly equal to the dissociation constant (Kd) of ES
- B Km has no relationship at all to binding
- C **Km often correlates with binding/affinity in simple models, but it is not always identical to Kd because it also reflects catalytic steps** ✓
- D Km is determined only by temperature, not by enzyme structure
- E Km is the same for all enzymes

▶ **Explanation:** At this level, Km is commonly used as an 'apparent affinity' measure, but strictly it is a kinetic constant that can reflect both binding and conversion steps. So it can correlate with affinity without being identical to Kd in all cases.

45 **Which change would most likely increase the reaction rate at a fixed substrate concentration that is far below Km?**

A **Increasing enzyme concentration** ✓

B Decreasing enzyme concentration

C Adding a noncompetitive inhibitor

D Decreasing substrate concentration further

E Denaturing half the enzyme

▶ **Explanation:** When [S] Km, rate is sensitive to both substrate and enzyme concentration. Increasing enzyme increases the number of catalytic sites and increases rate, even though the enzyme is not saturated.

46 **Which statement about enzyme saturation is correct?**

A At saturation, the enzyme is permanently bound to substrate and cannot release product

B **At saturation, most active sites are occupied most of the time, so adding more substrate has little effect on rate** ✓

C At saturation, Km becomes zero

D At saturation, competitive inhibitors become more effective

E At saturation, the reaction must stop immediately

▶ **Explanation:** Saturation means enzyme active sites are largely occupied, so the rate approaches Vmax and becomes less responsive to increases in substrate concentration.

47 **A student plots 1/v vs 1/[S] (Lineweaver–Burk) and sees that with an inhibitor, the y-intercept increases but the x-intercept stays the same. Which classic inhibitor pattern does this suggest?**

A Competitive inhibition

B **Pure noncompetitive inhibition** ✓

C Uncompetitive inhibition

D No inhibition

E Activation

▶ **Explanation:** On a Lineweaver–Burk plot, the y-intercept is 1/Vmax. If it increases, Vmax decreased. If the x-intercept (−1/Km) stays the same, Km is unchanged. That matches pure noncompetitive inhibition.

48 **On a Lineweaver–Burk plot, competitive inhibition typically causes lines to intersect at the:**

A x-axis (same x-intercept)

B **y-axis (same y-intercept)** ✓

C origin (0,0)

D They are parallel and never intersect

E random points depending on temperature only

▶ **Explanation:** Competitive inhibition leaves Vmax unchanged, so 1/Vmax (the y-intercept) stays the same. Km increases, changing the slope and x-intercept, so lines cross at the y-axis.

49 **On a Lineweaver–Burk plot, uncompetitive inhibition is classically recognized because the inhibitor and no-inhibitor lines are:**

A **Parallel (same slope) with different intercepts** ✓

B Intersecting at the y-axis

C Intersecting at the x-axis

D Always overlapping exactly

E Only vertical

▶ **Explanation:** Uncompetitive inhibition decreases both Vmax and Km proportionally, so Km/Vmax (the slope) stays the same, producing parallel lines with shifted intercepts.

50 **A student adds an inhibitor and finds the Michaelis–Menten curve shifts DOWN (lower plateau) and also shifts LEFT (half-max reached at lower [S]). What is the best match?**

A Competitive inhibition

B Pure noncompetitive inhibition

C **Uncompetitive inhibition** ✓

D Enzyme concentration doubled

E Substrate concentration decreased

▶ **Explanation:** Down means Vmax decreased; left means apparent Km decreased. This is the hallmark pattern for uncompetitive inhibition (binds ES only).

51 **Which explanation best fits why competitive inhibition does not change Vmax?**

A Because competitive inhibitors speed up catalysis at high [S]

B **Because at saturating substrate, substrate outcompetes inhibitor for the active site, so the enzyme can still achieve its full catalytic capacity** ✓

C Because competitive inhibitors bind covalently

D Because Vmax depends only on Km

E Because inhibitors cannot bind enzymes at all

▶ **Explanation:** At very high [S], most enzyme active sites are occupied by substrate rather than inhibitor, so the maximum rate (Vmax) can still be reached. The inhibitor mainly affects how much substrate is required to reach that rate.

52 **An inhibitor binds equally well to free enzyme (E) and enzyme–substrate complex (ES) but does not affect substrate binding strength. Which label best describes it?**

A Competitive inhibitor

B **Pure noncompetitive inhibitor** ✓

C Uncompetitive inhibitor

D Irreversible inhibitor

E Substrate analog that binds only to the active site

▶ **Explanation:** Pure noncompetitive inhibition is the special case of mixed inhibition where inhibitor binds E and ES equally, leaving Km unchanged while reducing Vmax.

53 **Which statement about 'enzyme efficiency' is most accurate at this level?**

A **An enzyme is more effective at low substrate if it has a low Km and/or high catalytic rate** ✓

B Only Vmax matters, because Km is never used

C Only Km matters, because Vmax is always the same

D Efficiency increases when inhibitors are added

E Efficiency is the same as the pH of the solution

▶ **Explanation:** At low substrate, enzymes with lower Km reach useful rates sooner, and enzymes with higher turnover can process substrate faster. Many courses summarize efficiency via 'high activity at low [S],' conceptually tied to Km and catalytic speed.

54 **Two enzymes have the same Km. Enzyme X has a higher Vmax than enzyme Y in the same experiment. The best explanation is that enzyme X:**

A Has higher substrate affinity

B Is present at higher effective concentration and/or has a higher turnover rate (kcat) ✓

C Must have a higher Km

D Is inhibited competitively

E Has fewer active sites

▶ **Explanation:** Vmax depends on total active enzyme and how fast each active site can catalyze (kcat). Same Km means similar half-saturation behavior, but different Vmax reflects capacity/turnover differences.

55 **A student adds a noncompetitive inhibitor and then increases substrate concentration 100×. The rate increases somewhat but still plateaus below the original Vmax. Why can the rate still increase at first?**

A Because noncompetitive inhibitors turn into competitive inhibitors at high substrate

B Because some enzyme molecules remain uninhibited and can process more substrate as [S] rises, but total capacity is still lower ✓

C Because substrate destroys inhibitor molecules automatically

D Because Vmax is independent of inhibitors

E Because the enzyme becomes a transporter at high substrate

▶ **Explanation:** Even with noncompetitive inhibition, there are still active enzyme molecules that respond to increased substrate—so the rate rises. But because effective catalytic capacity is reduced, the maximal plateau stays below the original Vmax.

56 **Which inhibitor type is MOST likely to show a stronger inhibitory effect at higher substrate concentrations (because it binds ES rather than E)?**

A Competitive

B **Uncompetitive** ✓

C Competitive irreversible

D No inhibitor

E A substrate

▶ **Explanation:** Uncompetitive inhibitors bind only to ES, so as [S] increases and more ES forms, there are more binding targets for the inhibitor—making the inhibition more pronounced relative to low [S].

57 **A student wants to reduce the effect of a competitive inhibitor without changing substrate concentration. Which change is most likely to help?**

A Add more inhibitor

B Remove substrate entirely

C Decrease enzyme concentration

D **Lower inhibitor concentration (dilution/removal)** ✓

E Add oxygen

▶ **Explanation:** Competitive inhibition depends on inhibitor occupancy of the active site. If you cannot increase substrate, the most direct way to reduce inhibition is to reduce inhibitor availability/concentration.

58 **Which statement about 'raising substrate concentration' is a common trap?**

A It can overcome competitive inhibition

B It can restore Vmax in competitive inhibition

C It always restores Vmax no matter the inhibitor type ✓

D It increases reaction rate when [S] is far below Km

E It has little effect when [S] is far above Km

▶ **Explanation:** Only competitive inhibition is classically 'overcome' by increasing substrate. Noncompetitive, uncompetitive, mixed, and irreversible inhibition reduce Vmax and cannot be fully fixed by substrate alone.

59 Which real-world example is MOST consistent with an irreversible inhibitor conceptually (enzyme permanently inactivated)?

A A molecule that binds weakly to the active site and is easily washed away

B A molecule that covalently modifies the active site and permanently reduces active enzyme amount ✓

C A substrate molecule that binds and becomes product

D A molecule that increases substrate concentration

E A molecule that changes the color of the buffer

▶ **Explanation:** Irreversible inhibitors inactivate enzymes (often covalently), lowering functional enzyme concentration and thus lowering Vmax. The key concept is permanence—activity does not recover after removal.

60 A student compares two inhibitors. Inhibitor A increases Km but does not change Vmax. Inhibitor B decreases Vmax but does not change Km. Which pairing is correct?

A A = uncompetitive; B = competitive

B A = competitive; B = pure noncompetitive ✓

C A = irreversible; B = competitive

D A = pure noncompetitive; B = competitive

E A = mixed; B = uncompetitive

▶ **Explanation:** Competitive inhibition increases apparent Km without changing Vmax. Pure noncompetitive inhibition decreases Vmax without changing Km. Recognizing these signature patterns is central to mastering enzyme inhibition.