PHARMARECALL™

PHARMACOKINETICS

Formula & Exam Pearls

A concise, exam-focused guide to core equations, worked calculations and common traps.

How to use this sheet

Identify the quantity requested, write the equation first, convert units, substitute values, and check that the answer is plausible. These formulas describe standard models; real patients may not behave exactly as the models predict.

Concept	Remember
Clearance (CL)	Volume of plasma cleared of drug per unit time.
Volume of distribution (Vd)	Apparent volume relating amount of drug in the body to plasma concentration.
Half-life (t1/2)	Time for concentration or amount to fall by 50% during the relevant elimination phase.
AUC	Area under the plasma concentration–time curve; a measure of systemic exposure.
Bioavailability (F)	Fraction of an administered dose reaching systemic circulation unchanged.

Core principle: clearance determines the maintenance dose rate needed to sustain a target concentration; Vd and clearance together determine elimination half-life.

1. Core pharmacokinetic formulas

Concept	Formula	Exam note
Absolute bioavailability	F = (AUC oral × Dose IV) / (AUC IV × Dose oral)	Assumes comparable clearance and linear kinetics.
Apparent volume of distribution	Vd = Amount of drug in body / Plasma concentration	Common units: L or L/kg.
Clearance	CL = Rate of elimination / Plasma concentration	Common units: L/h or mL/min.
First-order elimination rate	Rate = CL × C	Rate falls as concentration falls.
Half-life	t1/2 = 0.693 × Vd / CL	One-compartment, first-order model; use consistent units.
Elimination rate constant	k = 0.693 / t1/2	Units are inverse time, e.g. 1/h.
Amount remaining	At = A0 × e^(-kt)	For first-order elimination.
Concentration remaining	Ct = C0 × e^(-kt)	For the same first-order elimination phase.
Loading dose	LD = (Target concentration × Vd) / F	For IV administration, F = 1.
IV maintenance infusion rate	Rate = Target Css × CL	For IV infusion, F = 1.
Maintenance dose per interval	Dose = (Target average Css × CL × tau) / F	tau is the dosing interval; linear kinetics assumed.
AUC after IV dose	AUC = Dose / CL	For linear pharmacokinetics.
AUC after extravascular dose	AUC = F × Dose / CL	F is systemic bioavailability.
Time to steady state	Usually about 4–5 half-lives	Independent of dose in linear kinetics.

Symbols: AUC = area under the curve; Css = steady-state concentration; F = bioavailability as a fraction (e.g. 80% = 0.8); tau = dosing interval. Use a consistent time unit throughout.

2. Worked calculations

Example 1 — Half-life

A drug has Vd = 40 L and CL = 5 L/h. Calculate its elimination half-life.

t1/2 = 0.693 × Vd / CL = 0.693 × 40 L / 5 L/h = 5.54 h.

Example 2 — Loading dose

Target concentration = 10 mg/L; Vd = 30 L; oral bioavailability F = 0.75. Calculate the theoretical oral loading dose.

LD = (10 mg/L × 30 L) / 0.75 = 400 mg.

This is a mathematical estimate; formulation, absorption, therapeutic window and clinical context matter.

Example 3 — IV maintenance infusion rate

Target Css = 4 mg/L and CL = 3 L/h. Calculate the infusion rate.

Rate = Css × CL = 4 mg/L × 3 L/h = 12 mg/h.

Example 4 — Dose adjustment when clearance falls

A patient is stable on 300 mg/day. If clearance falls to 75% of its previous value and the target concentration remains unchanged, estimate the new daily dose under linear kinetics.

New dose = 300 mg/day × 0.75 = 225 mg/day. This proportional rule assumes unchanged bioavailability and linear pharmacokinetics.

Example 5 — Fraction remaining after half-lives

After 3 half-lives, fraction remaining = (1/2)^3 = 1/8 = 12.5%. Therefore, 87.5% has been eliminated, assuming first-order elimination.

3. High-yield exam pearls

1. Bioavailability is entered as a fraction: use 0.6 for 60%.

2. For IV administration, F = 1 (100%).

3. Loading dose depends primarily on target concentration and Vd; maintenance dose rate depends primarily on target concentration and clearance.

4. A larger Vd tends to increase half-life if clearance is unchanged.

5. Higher clearance tends to shorten half-life if Vd is unchanged.

6. In linear pharmacokinetics, doubling the dose generally doubles AUC and average steady-state concentration.

7. Steady state is approached after about 4–5 half-lives; increasing the dose does not usually make steady state arrive faster.

8. At steady state, average rate of drug input equals average rate of drug elimination.

9. AUC reflects systemic exposure; after an IV dose in linear kinetics, AUC = Dose/CL.

10. Vd is an apparent, not necessarily anatomical, volume.

11. First-order elimination removes a constant fraction per unit time; zero-order elimination removes a constant amount per unit time.

12. After each first-order half-life, the amount or concentration halves: 100% → 50% → 25% → 12.5% → 6.25%.

13. Only unbound drug is generally available to cross membranes and interact with targets, but clinical effects depend on the whole pharmacokinetic context.

14. A trough concentration is usually sampled immediately before the next dose; interpret it in relation to the dosing regimen.

15. With nonlinear, capacity-limited pharmacokinetics, dose changes can produce disproportionate concentration changes.

Elapsed time	Fraction remaining	Percentage remaining
1 half-life	1/2	50%
2 half-lives	1/4	25%
3 half-lives	1/8	12.5%
4 half-lives	1/16	6.25%
5 half-lives	1/32	3.125%

4. Common calculation traps

Trap	How to avoid it
Mixing units	Convert units first. For example, mg/L × L/h gives mg/h.
Using percentage instead of fraction	Enter F = 0.8, not 80, for 80% bioavailability.
Confusing dose with dose rate	Dose is an amount (mg); dose rate is amount per time (mg/h or mg/day).
Using the wrong bioavailability	For IV administration, F = 1. Account for F for extravascular routes when relevant.
Assuming half-life is always fixed	t1/2 = 0.693 × Vd/CL applies to the relevant first-order model; disease, interactions and nonlinear kinetics can alter behaviour.
Applying linear rules to saturable elimination	With capacity-limited metabolism, proportional dose–concentration relationships may fail.
Ignoring the dosing interval	For dose per oral interval, include tau when calculating from average target Css.
Rounding too early	Keep several digits during calculations; round the final answer sensibly and include units.

5. Rapid comparison: first-order vs zero-order

Feature	First-order elimination	Zero-order elimination (idealised)
Amount eliminated per unit time	Varies with concentration	Constant while pathway is saturated
Fraction eliminated per unit time	Constant	Varies with concentration
Half-life	Usually constant under stable conditions	Not constant in the same way
Concentration–time profile	Exponential decline	Approximately linear decline over the saturated range
Dose increases	Often proportional concentration increase	May cause disproportionate concentration increase

Clinical and exam reminder

Use these equations to understand principles and solve educational problems. Individual dosing decisions require drug-specific prescribing information, patient factors, therapeutic drug monitoring where indicated, and current clinical guidance. This sheet is a revision aid, not a substitute for clinical judgement.

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