PharmaRecall™

PHARMACOKINETICS

VOLUME 1 • FOUNDATIONAL ACTIVE-RECALL CARDS

Absorption • Distribution • Metabolism • Excretion

Bioavailability • Volume of Distribution • Clearance • Half-life • Loading and Maintenance Doses

For	Medical, pharmacy, nursing and other health-science students
Study method	Active recall: attempt each answer before reading the explanation
Included	30 recall cards, core formulas, comparison tables, exam pearls and rapid-review checklist

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A focused revision resource for understanding how drug concentrations change with time and how pharmacokinetic principles inform rational dosing.

How to Use These Recall Cards

1. Read the question and attempt an answer from memory.
2. Explain the principle aloud or write a short answer.
3. Mark each card Secure, Developing or Review again.
4. Revisit difficult cards after 24 hours and again several days later.
5. Use consistent units in calculations and consult drug-specific references for clinical dosing.

Core Formula Map

Parameter	Formula
Absolute bioavailability	F = (AUC oral × Dose IV) / (AUC IV × Dose oral)
Volume of distribution	Vd = Amount of drug in body / Plasma concentration
Clearance (linear IV)	CL = IV dose / AUC
Elimination half-life	t½ = 0.693 × Vd / CL (simple first-order model)
IV loading dose	Loading dose = Target concentration × Vd
Extravascular loading dose	Loading dose = Target concentration × Vd / F
Maintenance dose rate	Target average steady-state concentration × CL / F
Maintenance dose per interval	Target average concentration × CL × interval / F

Note: These are simplified teaching relationships. Check units, assumptions, route, organ function and drug-specific guidance before applying them clinically.

Foundational Recall Cards

RECALL CARD 01 | What is pharmacokinetics?

Recall: What the body does to a drug over time: absorption, distribution, metabolism and excretion (ADME). It links a dose to drug concentrations over time.

RECALL CARD 02 | Pharmacokinetics versus pharmacodynamics

Recall: Pharmacokinetics concerns drug movement and concentration over time; pharmacodynamics concerns drug effects, mechanisms and concentration–effect relationships.

RECALL CARD 03 | Name the four ADME processes.

Recall: Absorption: entry into systemic circulation; distribution: reversible movement between blood and tissues; metabolism: chemical transformation; excretion: removal of drug or metabolites.

RECALL CARD 04 | What influences drug absorption?

Recall: Route, formulation and dissolution; lipid solubility and ionisation; surface area and blood flow; gastric emptying and transit; food; transporters; local pH; and presystemic metabolism.

RECALL CARD 05 | How does ionisation affect membrane passage?

Recall: The non-ionised form generally crosses lipid membranes more readily. Weak acids are more non-ionised at lower pH and weak bases at higher pH, but pH alone does not determine the main site of absorption.

RECALL CARD 06 | What is first-pass metabolism?

Recall: Presystemic metabolism in the intestinal wall and/or liver before a drug reaches systemic circulation; it can reduce oral bioavailability. IV, sublingual and transdermal routes avoid hepatic first-pass metabolism; rectal bypass is partial.

RECALL CARD 07 | Define bioavailability (F).

Recall: The fraction of an administered dose that reaches systemic circulation unchanged. IV bioavailability is 1 (100%); extravascular bioavailability may be lower due to incomplete absorption and presystemic loss.

RECALL CARD 08 | How is absolute bioavailability calculated?

Recall: For linear pharmacokinetics: F = (AUC oral × Dose IV) / (AUC IV × Dose oral). AUC is the area under the plasma concentration–time curve.

RECALL CARD 09 | Distinguish Cmax, Tmax and AUC.

Recall: Cmax is the maximum observed concentration; Tmax is the time to Cmax; AUC measures total systemic exposure and is commonly used to compare exposure or bioavailability.

RECALL CARD 10 | Define distribution.

Recall: Reversible transfer of drug between plasma and tissues, influenced by perfusion, permeability, lipid solubility, ionisation, protein/tissue binding, transporters and barriers such as the blood–brain barrier.

Foundational Recall Cards — continued

RECALL CARD 11 | Why does plasma protein binding matter?

Recall: Binding to albumin, alpha-1-acid glycoprotein and other proteins affects the free fraction. Unbound drug is generally available for diffusion, receptor interaction, metabolism and glomerular filtration. Displacement alone does not always cause a sustained clinical interaction.

RECALL CARD 12 | Define volume of distribution (Vd).

Recall: An apparent volume relating the amount of drug in the body to its plasma concentration: Vd = amount of drug in the body / plasma concentration. It is not necessarily an anatomical volume.

RECALL CARD 13 | Interpret a high or low Vd.

Recall: Low Vd suggests much drug remains in plasma/extracellular fluid; high Vd suggests extensive tissue distribution or tissue binding. Interpret in the context of drug properties and clinical conditions.

RECALL CARD 14 | How is Vd used for a loading dose?

Recall: Loading dose = target plasma concentration × Vd / F for an extravascular route. For IV dosing, F = 1. Check units and drug-specific recommendations.

RECALL CARD 15 | Define drug metabolism.

Recall: Chemical transformation of a drug, often to aid elimination. Metabolism can also activate prodrugs or form active or toxic metabolites. The liver is a major site, but other tissues contribute.

RECALL CARD 16 | Distinguish Phase I and Phase II metabolism.

Recall: Phase I includes oxidation, reduction and hydrolysis, often involving CYP enzymes. Phase II conjugates a drug/metabolite with endogenous groups such as glucuronide, sulfate or glutathione. The phases need not occur sequentially.

RECALL CARD 17 | What is the CYP450 system?

Recall: A family of enzymes that metabolises many drugs. Inhibition can increase substrate exposure; induction can reduce it over time. The magnitude depends on the drug, pathway, time course and therapeutic index.

RECALL CARD 18 | Enzyme induction versus inhibition

Recall: Induction increases enzyme expression/activity and often develops over days; it may lower substrate exposure. Inhibition reduces enzyme activity and may increase substrate exposure more quickly. Transporters and non-CYP enzymes also matter.

RECALL CARD 19 | Describe renal drug excretion.

Recall: Renal elimination can involve glomerular filtration of unbound drug, active tubular secretion and tubular reabsorption. Renal function, protein binding, urine flow, urine pH and transporters affect urinary excretion.

RECALL CARD 20 | Filtration, secretion and reabsorption

Recall: Filtration transfers unbound drug into the filtrate; secretion actively transports drug from blood into the tubular lumen; reabsorption returns drug from tubular fluid to blood.

Foundational Recall Cards — continued

RECALL CARD 21 | Define clearance (CL).

Recall: The apparent volume of plasma from which drug is completely removed per unit time. CL = rate of elimination / plasma concentration under the relevant conditions; total clearance combines contributing pathways.

RECALL CARD 22 | How are clearance and AUC related?

Recall: For linear IV pharmacokinetics, CL = IV dose / AUC. For extravascular dosing, dose / AUC estimates CL/F if F is unknown. If dose and F are unchanged, lower clearance increases AUC.

RECALL CARD 23 | Define elimination half-life.

Recall: The time required for concentration or amount in the body to decrease by 50% during the relevant elimination phase. In a one-compartment, first-order model: t½ = 0.693 × Vd / CL.

RECALL CARD 24 | What remains after successive half-lives?

Recall: With first-order elimination, approximately 50% remains after one half-life, 25% after two, 12.5% after three, 6.25% after four and 3.125% after five.

RECALL CARD 25 | How long to approach steady state?

Recall: With repeated dosing or constant infusion and linear first-order kinetics, about 4–5 half-lives are commonly used as an estimate. Time to steady state is generally independent of dose; steady-state concentration depends on dose rate, F and clearance.

RECALL CARD 26 | Explain first-order elimination.

Recall: A constant fraction is eliminated per unit time; the elimination rate is proportional to concentration. Half-life is usually constant within the relevant concentration range.

RECALL CARD 27 | Explain zero-order elimination.

Recall: A constant amount is eliminated per unit time when pathways are saturated; half-life is not constant. Ethanol is a common teaching example; phenytoin can show capacity-limited metabolism at relevant concentrations.

RECALL CARD 28 | Loading dose versus maintenance dose

Recall: A loading dose rapidly approaches the target concentration and depends mainly on Vd and F. Maintenance dosing replaces drug eliminated over time and depends mainly on clearance, target concentration, dosing interval and F.

RECALL CARD 29 | How is maintenance dose rate calculated?

Recall: Maintenance dose rate = target average steady-state concentration × clearance / F. For a dose per interval: dose = target average concentration × CL × dosing interval / F, assuming linear kinetics.

RECALL CARD 30 | How can organ impairment or interactions alter dosing?

Recall: Reduced renal/hepatic function may lower clearance and raise exposure, requiring drug-specific dose/interval adjustment or monitoring. Enzyme/transporter interactions can also change exposure; use prescribing guidance, clinical response and therapeutic drug monitoring where indicated.

High-Yield Comparison Tables

1. Absorption, Bioavailability and Exposure

Term	Meaning	Key point
Absorption	Movement from administration site into systemic circulation	May be incomplete; not synonymous with bioavailability
Bioavailability (F)	Fraction reaching systemic circulation unchanged	IV F = 1; extravascular F may be reduced by incomplete absorption and first-pass loss
Cmax	Maximum observed plasma concentration	Affected by absorption, distribution and elimination
Tmax	Time to Cmax	Often reflects absorption rate, but elimination also contributes
AUC	Area under concentration–time curve	Measures systemic exposure; with linear kinetics depends on dose, F and CL

2. Volume of Distribution versus Clearance

Parameter	Meaning	Main dosing implication
Vd	Apparent volume relating amount in body to plasma concentration	Major determinant of loading dose
CL	Volume of plasma cleared per unit time	Major determinant of maintenance dose rate
High Vd	Extensive tissue distribution relative to plasma	May require a larger loading dose for a given target concentration
Low CL	Slower drug removal	Can increase exposure and accumulation at the same dose rate
Half-life	Time for concentration to fall by half in the elimination phase	Helps estimate dosing interval and time to steady state

3. First-Order versus Zero-Order Elimination

Feature	First-order	Zero-order / capacity-limited
Amount eliminated per time	Varies with concentration	Approximately constant while saturated
Fraction eliminated per time	Approximately constant	Varies with concentration
Half-life	Usually constant	Not constant
Concentration decline	Exponential	Approximately linear during capacity-limited elimination
Teaching examples	Many drugs at usual concentrations	Ethanol; phenytoin can show capacity-limited metabolism

4. Loading versus Maintenance Dosing

Feature	Loading dose	Maintenance regimen
Purpose	Reach target concentration faster	Replace drug eliminated over time
Main determinant	Vd and target concentration	CL and target average steady-state concentration
Bioavailability	Divide by F for extravascular route	Divide by F for extravascular route
Clinical caveat	Consider distribution, toxicity and target	Consider organ function, interactions, response and monitoring

Exam Pearls: High-Yield Points

1. Pharmacokinetics describes concentration over time; pharmacodynamics describes effects in relation to concentration.

2. IV administration has 100% bioavailability by definition, but drug does not instantly reach all target tissues.

3. AUC is an exposure measure. For linear IV pharmacokinetics, AUC = dose / clearance.

4. Vd is an apparent volume, not necessarily a physical compartment; extensive tissue binding can produce a very large Vd.

5. Loading dose is chiefly related to Vd; maintenance dose rate is chiefly related to clearance.

6. In the simple first-order model, half-life increases when Vd increases or clearance decreases.

7. About 4–5 half-lives are commonly needed to approach steady state or near-complete elimination; clinical exceptions exist.

8. Protein-binding displacement alone does not automatically produce a sustained, clinically important interaction.

9. Enzyme induction often develops more slowly than inhibition because it may require increased enzyme synthesis.

10. Renal excretion includes filtration, secretion and reabsorption—not filtration alone.

11. Urine pH can affect reabsorption of some weak acids and bases; urine manipulation requires a specific clinical indication and protocol.

12. When F is unknown after extravascular dosing, dose/AUC estimates CL/F rather than CL alone.

13. Capacity-limited elimination can make small dose increases cause disproportionate increases in concentration.

14. Check units carefully: mg, micrograms, litres, millilitres and time units must be consistent.

15. Therapeutic drug monitoring is useful for selected drugs when concentrations can guide management.

Rapid-Review Checklist

■ I can define pharmacokinetics and explain ADME.

■ I can distinguish absorption from bioavailability and explain first-pass metabolism.

■ I can identify the meaning of Cmax, Tmax and AUC.

■ I can explain the influence of perfusion, barriers and protein binding on distribution.

■ I can define Vd and use it in a loading-dose calculation.

■ I can distinguish Phase I and Phase II metabolism.

■ I can explain enzyme induction and inhibition at a basic level.

■ I can describe filtration, tubular secretion and reabsorption.

■ I can define clearance and relate it to AUC.

■ I can calculate half-life from Vd and clearance in the simple model.

■ I can distinguish first-order from zero-order elimination.

■ I can estimate time to steady state from half-life.

■ I can calculate loading and maintenance doses with consistent units.

■ I can explain why renal/hepatic impairment and interactions may require dose adjustment.

End of Volume 1 • PharmaRecall™ Pharmacokinetics Foundational Active-Recall Cards

For educational revision. This resource does not replace official prescribing information, local protocols or patient-specific clinical judgment.