This practice session will walk you through a classic **One-Compartment IV Bolus** calculation. We use this model when a drug distributes so rapidly that the body behaves like a single, well-mixed tank.

The Scenario

A patient is given a **500 mg IV bolus** of "Drug X." To understand how their body handles the drug, the lab measures plasma concentrations at two different times:

- **2 hours** after injection: 15.0 mg/L
- **6 hours** after injection: 3.75mg/L

Goal: Calculate the Elimination Rate Constant (k), Half-life ($t_{1/2}$), Volume of Distribution (Vd), and total Clearance (Clt).

Step 1: Find the Elimination Rate Constant (k)

The rate constant (**k**) tells us what percentage of the drug is removed per hour. For a one-compartment model, the concentration drops exponentially. We use the formula:

$$k = \frac{\ln(C_1) - \ln(C_2)}{t_2 - t_1}$$

Calculation:

$$k = \frac{\ln(15.0) - \ln(3.75)}{6 - 2}$$

$$k = \frac{2.708 - 1.321}{4} = \frac{1.387}{4}$$

Result:

Result: $k \approx 0.347 \text{ h}^{-1}$ (This means ~35% of the drug is cleared every hour).

Step 2: Find the Half-life (t1/2)

The half-life is the time it takes for the concentration to drop by 50%. It is always related to k by the constant 0.693 (ln 2):

$$t_{1/2} = \frac{0.693}{k}$$

Calculation:

$$t_{1/2} = \frac{0.693}{0.347}$$

Result: $t_{1/2} \approx 2.0$ hours

Step 3: Find the Initial Concentration (C_0)

Since we weren't given the concentration at "Time Zero," we must back-calculate it using our k value and one of our known data points:

$$C = C_0 \cdot e^{-kt} \implies C_0 = \frac{C}{e^{-kt}}$$

Using the 2-hour data point (15 mg/L):

$$C_0 = \frac{15}{e^{-(0.347 \cdot 2)}} = \frac{15}{e^{-0.694}} = \frac{15}{0.5}$$

Result: $C_0 = 30 \text{ mg/L}$

Step 4: Find the Volume of Distribution (Vd)

Vd tells us how "diluted" the drug is in the body. If Vd is much larger than total body water (~42L), the drug is likely hiding in fat or tissues.

$$V_d = \frac{\text{Dose}}{C_0}$$

Calculation:

$$V_d = \frac{500 \text{ mg}}{30 \text{ mg/L}}$$

Result: $V_d \approx 16.7 \text{ L}$ (This drug stays mostly in the extracellular fluid).

Step 5: Find the Clearance (Cl)

Clearance is the most important clinical parameter—it tells us the volume of plasma completely cleared of drug per unit of time.

$$Cl = k \cdot V_d$$

Calculation:

$$Cl = 0.347 \text{ h}^{-1} \cdot 16.7 \text{ L}$$

Result: $Cl \approx 5.8 \text{ L/h}$

Step 6: Area Under the Curve (AUC)

AUC represents the **total drug exposure** over time. If Vd is the "space," AUC is the "total amount of time-concentration" the body experienced. For an IV bolus (one-compartment), the formula is straightforward:

$$AUC = \frac{C_0}{k}$$

Calculation using our previous data:

- Initial Concentration (C_0) = $30\ \mathrm{mg/L}$
- Elimination Rate (k) = $0.347\ \mathrm{h}^{-1}$

$$AUC = \frac{30\ \mathrm{mg/L}}{0.347\ \mathrm{h}^{-1}} \approx 86.45\ \mathrm{mg \cdot h/L}$$

Pro-Tip: You can also find AUC using Clearance. Since $Cl = \frac{\mathrm{Dose}}{AUC}$, then $AUC = \frac{\mathrm{Dose}}{Cl}$.

$$AUC = \frac{500\ \mathrm{mg}}{5.8\ \mathrm{L/h}} \approx 86.2\ \mathrm{mg \cdot h/L}$$

(Small differences are just due to rounding k and V_d earlier).

Step7: Bioavailability

Bioavailability is the fraction of the dose that actually reaches the systemic circulation.

The IV "Gold Standard"

By definition, for an **IV Bolus**, bioavailability is 100% **($F = 1.0$)**. This is because the drug is placed directly into the blood, bypassing all barriers like the gut wall or liver metabolism (first-pass effect).

How to calculate Absolute Bioavailability (F)

To find the bioavailability of a different form (like a tablet), you must compare its AUC to the IV AUC.

The Formula:

$$F = \frac{AUC_{\mathrm{oral}}/\mathrm{Dose}_{\mathrm{oral}}}{AUC_{\mathrm{IV}}/\mathrm{Dose}_{\mathrm{IV}}}$$

Practice Scenario:

Suppose you gave the same patient a **500 mg Tablet** of Drug X, and the resulting AUC_{oral} was only $43.2\ \text{mg} \cdot \text{h/L}$. Using our IV results from before:

1. **Dose-normalize:** Since both doses were $500\ \text{mg}$, we just compare the AUCs directly.
2. **Calculate:** $F = \frac{43.2}{86.4} = 0.5$
3. **Result:** Bioavailability is 50%.

Why these two matter together

Clinicians use F and AUC to switch a patient from an IV drip to a pill.

- **If $F = 1.0$ (like Levofloxacin):** The IV dose and the oral dose are the same ($500\ \text{mg}$ IV = $500\ \text{mg}$ PO).
- **If $F = 0.5$ (like our example):** You must **double** the oral dose to get the same exposure as the IV dose ($500\ \text{mg}$ IV = $1000\ \text{mg}$ PO).