

# Quantitative Problems in Anesthesia

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## 1 Don't cry over spilt sevoflurane

While setting up the OR you accidentally drop a 250 mL bottle of sevoflurane. It shatters when it hits the ground.

1. Assuming the OR is a sealed container of dimensions  $25 \cdot 20 \cdot 10$  ft, what is the steady-state concentration,  $c_{ss}$  of sevoflurane in the room (in ppm)?

Room temperature is  $25^\circ\text{C}$ , the density of sevoflurane is  $1.52$  g/mL and its molecular weight is 200.

2. If the ventilation system is on and operating at the industry-standard flow rate of 15 room volume exchanges per hour, how long will it take before the concentration in the room falls below 2 ppm, the OSHA ceiling on occupational exposure to volatile anesthetics?

3. What is the initial rate of change in concentration (in ppm/min)?

## 2 Fun with E-cylinders

If a full  $O_2$  E cylinder (1900 psi) contains 660 L of  $O_2$  at STP, what is the radius of the cylinder in terms of its height,  $r(h)$  ?

## 3 IV infusion kinetics

An intravenous infusion of a drug with concentration  $c_d$  mg/ml is started with a syringe pump. The infusion line is piggybacked to a continuously dripping carrier fluid with a three-way stopcock. The distance between the stopcock and the tip of the IV catheter is the dead volume,  $V$ . The carrier flows at a rate

$Q_c$  ml/min and the drug is infused at a rate  $Q_d$ .<sup>1</sup>

1. What is the steady-state drug concentration  $c_{ss}$  at the tip of the catheter?
2. If the drug traverses  $V$  with a discrete 'head' (*Plug-Flow*), how long does it take for the drug to reach the patient's bloodstream?
3. If the drug mixes uniformly within  $V$  at all times (*Well-Mixed*), how long does it take for the drug concentration to reach 95% of steady-state?

## 4 I smell sevo!

An anesthesia delivery system at steady-state is delivering 8% sevoflurane with a total fresh gas flow  $Q$ . Prior to intubation, the mask is taken off the patient and exposed to the environment. Let  $V$  be the dead volume of the breathing system (includes the breathing circuit, breathing bag, and internal plumbing distal to the vaporizer).

1. How much wasted sevoflurane gas,  $W$ , is delivered into the OR environment in  $t$  minutes?
2. As you take off the mask you turn the sevoflurane vaporizer off. Now how much sevoflurane gas,  $W$ , is delivered into the OR environment in  $t$  minutes?
3. Now, instead of turning off the vaporizer, you turn off the fresh gas flow. How much sevoflurane gas,  $W$ , is delivered into the OR environment in  $t$  minutes?

## 5 Anesthesia at high altitude

You take an anesthesia machine up to 10,000 ft ( $P_{atm} = 500$  mmHg) and set the vaporizer (calibrated at sea level) to deliver 2.1% sevoflurane (vapor pressure 160 mm). What concentration of sevoflurane gets delivered? What is the relative potency?

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<sup>1</sup>Adapted from Lovich et al, The Impact of Carrier Flow Rate and Infusion Set Dead-Volume on the Dynamics of Intravenous Drug Delivery. *Anesth Analg* 2005;100:1048-55.