General Anesthesia Capstone Project – General Information & Thinking Questions

You will not be able to access the "thinking questions" drop box until you score at least 80% on one take of the “information review questions”.

General Information:
Before taking the Information Review Questions, it is recommended that you review the following topics:

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Project Overview & Thinking Questions:
Surgical procedures took a major leap forward in patient comfort with the advent of anesthetic agents in the mid-1800s. The first demonstrated use of nitrous oxide was in 1844 and that of diethyl ether in 1846. While nitrous oxide is still commonly used in dental applications, diethyl ether has been supplanted by a new generation of anesthetics which offer fewer side effects and are notably non-flammable. One class of the new anesthetics is fluorinated hydrocarbons. In this capstone project, you will examine the chemistry of these fluorinated hydrocarbons, one proposal for how general anesthetics work, and how inhalation anesthetics are delivered.

Two examples of fluorinated hydrocarbon anesthetics are Isoflurane and Sevoflurane.

\[
\begin{align*}
\text{Isoflurane} & : \quad \begin{array}{c}
F \\
F \\
\text{Cl} \\
\text{F} \\
F \\
\end{array} \\
\text{Sevoflurane} & : \quad \begin{array}{c}
F \\
F \\
\text{F} \\
\text{F} \\
\text{F} \\
\end{array}
\end{align*}
\]

1.) (1.5 points) Identify the different functional groups in Isoflurane.
2.) (1.5 points) Identify the different functional groups in Sevoflurane.

In pharmacology, it is important to understand how lipophilic a drug is as well as how hydrophilic a drug is. Lipophilic means lipid loving; in other words, lipophilic compounds would want to dissolve in lipids. A related term you have learned about is hydrophilic.
3.) (3 points) Explain what characteristics of functional groups make an organic compound lipophilic and what ones make a compound hydrophilic. Explain why these characteristics are lipophilic or hydrophilic.

4.) (3 points) Based on the structures of Isoflurane & Sevoflurane and what you have learned in Modules 5 and 8 this semester, would you expect these molecules to be hydrophilic or lipophilic? Explain your answer.

One of the general characteristics of general anesthetics is that they are lipophilic compounds. The exact mode of action for general anesthetics has not been elucidated. Many hypotheses have been proposed as to how they work. One hypothesis that has been proposed is that all lipophilic compounds act as general anesthetics by dissolving in the lipophilic cell membrane of nerve cells causing the membrane to bloat and that the lipophilic compounds do not interact with any chiral receptors within the membrane, but rather it is just the quantity of compounds in the membrane that cause the effect.

Two experiments (given below) were performed to test this hypothesis. For each experiment, you will need to indicate whether it proves or disproves the hypothesis given above.

Experiment #1: An experiment run to test the hypothesis found that cyclopropane acted as a general anesthetic.

5.) (2 points) Is cyclopropane a lipophilic or hydrophilic compound?

6.) (3 points) Does the fact that cyclopropane acts as a general anesthetic support or disprove the hypothesis listed above? Explain your answer.

Experiment #2: An experiment run found that the two enantiomers of Isoflurane do not act the same as anesthetics, in that it took a smaller amount of one to produce the same anesthetic effect as the other.

7.) (2 points) What roles do chiral receptors play in biological systems?

8.) (3 points) Does the fact that the two enantiomers of Isoflurane do not act the same support or disprove the hypothesis listed above? Explain your answer.

Mode of delivery for drugs plays a very important part of the design of compounds. Inhalation anesthetics as their name implies are delivered to the body via the lungs. The anesthetic enters the lungs and is absorbed through the alveoli by passive diffusion. It then passively diffuses into the bloodstream which in turn delivers it to all tissue throughout the body, where once again the anesthetic passively diffuses into the tissue.

\[
\text{inhaled/exhaled gases} \rightleftharpoons \text{alveoli} \rightleftharpoons \text{blood} \rightleftharpoons \text{tissue}
\]

9.) (3 points) Explain why an anesthetic diffuses from the inhaled air into the lungs onward to the tissue in terms of partial pressure.
10.) (3 points) Explain why anesthetics must be continually administered to keep a patient from waking up? Hint – the anesthetics are not metabolized by the body.

11.) (3 points) Explain how an anesthesiologist can use the partial pressure of anesthetic being delivered to a patient to determine amount delivered? Hint – in chemistry, amount refers to moles.

One concern with using any drug is the potential for harmful metabolites or degradation products to occur. One concern with Sevoflurane is that it reacts with chemicals used in the absorbents that capture exhaled carbon dioxide. This reaction creates the toxic degradation product (called Compound A) shown below.

![Compound A](image)

12.) (2 points) While this exact reaction is not in your textbook, there is a similar reaction where atoms are removed to form an alkene. What type of reaction is the one in the textbook?

13.) (2 points) What atoms are removed in the reaction shown in the book?

14.) (3 points) Propose a valid balanced chemical equation for Sevoflurane forming Compound A. Your balanced chemical equation must show molecular formulas for all reactants and products involved in the reaction. For the organic molecules, remember the molecular formulas are written as $C_nH_mF_pO_q$. Think about what atoms are different between Sevoflurane and Compound A. For full credit, you must justify your proposal.

15.) (2 points) Please give constructive feedback regarding this Capstone Project. Was it worthwhile? Did it illustrate CHE 106 concepts? What did you gain/learn from doing the project that you did not learn from the modules individually? What would you keep/recommend in future semesters? What would you change? What other information would you like to convey to your instructor with respect to this project?

References: