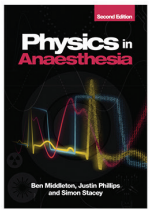
Chapter 10

Diffusion, osmosis and solubility



Self-assessment questions

These questions and answers, in both MTF and SBA formats, accompany *Physics in Anaesthesia 2e* and link back to the book for guidance.

Multiple true / false questions

For each of the following questions, mark all answers as either true or false

1. Regarding the speed of diffusion of gas across a semipermeable membrane:

a. The greater the partial pressure gradient the faster the rate of diffusion
b. The diffusion constant is inversely proportional to the solubility of the gas
c. A person with emphysema will have reduced rates of diffusion across the alveolar membrane
d. The lungs of a person with fibrosing alveolitis will have increased diffusing capacity
e. Carbon dioxide is used to measure diffusing capacity of the lung because it is highly soluble in blood

Pointer

- See Graham's law and Fick's law.

Reminder

- In emphysema the surface area of the alveolar membrane is reduced.
- In fibrosing alveolitis the diameter of the alveolar membrane is increased.

2. Regarding the relationship between the solubility, temperature and pressure of a gas in a liquid:

a. Raoult's law best describes this relationship
b. Henry's law constant is temperature dependent
c. As the temperature rises the solubility of a gas decreases
d. Solubility has no units of measurement
e. In settings where there is an increase in pressure, for example, whilst a person is diving, nitrogen is more capable of dissolving into the blood

Did you know?

- Solubility can be measured as $mol \cdot L^{-1}$ or $g \cdot 100g^{-1}$ of water.
- Conversely to gases, the solubility of solids and liquids rises with temperature, e.g. sugar dissolving in a hot cup of tea.

3. Regarding the partition coefficients of inhaled anaesthetic agents:

a. The solubility of a gas is a good model of the brain's absorption ability
b. The scale on the Meyer–Overton graph is logarithmic
c. Having a lower solubility in blood is a desired trait
d. A gas with a lower blood/gas partition coefficient will take longer to have its desired effect
e. Gases with high blood/gas partition coefficients dissolve into the blood at lower partial pressures

Reminder

- Gases with higher blood/gas partition coefficients dissolve quicker from the lungs into the blood.
- However, this happens at the expense of the gas exerting a lower partial pressure once dissolved and therefore a slower diffusion rate from blood to brain tissue.

Pointer

- See *Figure 10.6*.
- For more on logarithmic scales, see *Section 27.2*.

4. Under normal conditions, what is true regarding the diffusion of these gases across the alveolar membrane into the blood:

a. Helium hardly diffuses
b. Nitrogen hardly diffuses
c. Carbon dioxide diffuses faster than oxygen because it has a lower molecular weight
d. Carbon dioxide has a transit time across the alveolar membrane of 0.1 seconds
e. Oxygen has a transit time across the alveolar membrane of 0.3 seconds

Reminder

- Both the molecular weight and solubility affect the diffusion.
- This explains why helium hardly diffuses despite its low molecular weight and why carbon dioxide diffuses quickly despite its higher molecular weight.

Did you know?

- Helium's low molecular weight in comparison to the other normal constituents of air (nitrogen, oxygen, carbon dioxide) is the reason for the change in timbre of the voice on inhalation.
- Sound travels faster through helium than air and this leads to increased frequencies of the resonant harmonics produced by the vocal cords (see *Section 5.6*)

Single best answer questions

For each of the following questions, select the single best answer – note that more than one answer may be true but only one option represents the best answer

1. What best describes the minimum alveolar concentration (MAC) and how is it related to the partition coefficient of an inhaled anaesthetic agent?

a. The MAC is the rise in vapour pressure of a solvent and is proportional to the molar concentration of the solute
b. The MAC is a measure of relative anaesthetic potency of an inhalational gas and is inversely proportional to the oil/gas partition coefficient
c. A high oil/water partition coefficient results in a potent anaesthetic effect
d. The MAC is the concentration of vapour in the lungs required to prevent a reflex response to a skin incision in 50% of patients and it is inversely proportional to the blood/gas partition coefficient
e. A gas with a higher oil/gas partition coefficient will have lower MAC

Pointer

- Read the answers carefully.

Did you know?

- The MAC is altered by many states, both physiological and pharmacological.
- One of the more interesting examples is in humans with ginger hair where MACs are increased.

2. Salt water takes longer to come to the boil than water on its own. What best describes the reason for this difference?

a. Salt water has a higher boiling point than water
b. Raoult's law states that the rise in vapour pressure of a solvent is proportional to the molar concentration of the solvent; the salt particles increase the surface area of water molecules to evaporate leading to a higher boiling point
c. Salt water has a higher latent heat of evaporation than water
d. Vapour pressure is a non-colligative property
e. The salt particles decrease the surface area available to the water molecules to evaporate leading to a higher boiling point

Reminder

- As a colligative property, the vapour pressure of a solvent is reduced with the addition of more of a solute.

Pointer

- Think of vapour pressure as an indication of a liquid's evaporation rate.

3. Why is hypertonic saline used to treat a patient with cerebral oedema?

a. There is lower concentration of solute in this fluid in comparison to the fluid on the brain; this pressure gradient causes the movement of solvent from the blood into the brain
b. The blood will have a higher osmotic pressure than the brain tissue and thus charged ions in the saline will diffuse across the blood–brain barrier reducing the brain oedema
c. The blood will have a higher osmotic pressure than the brain tissue; water will travel from the cerebral tissue by osmosis along this concentration gradient and into the blood, reducing the oedema
d. To reduce osmosis
e. To facilitate fluid shifts

Pointer

- Major fluid shifts are important considerations in the presentation and management of a variety of pathological considerations – osmosis is the underlying principle.

Answers to questions for Chapter 10 – Diffusion, osmosis and solubility

Multiple true / false questions

The following answers are true:

1. a and c

2. b, c and e

3. a, b, c and e

4. a, b, d and e

Single best answer questions

The options below represent the single best answer, although other options may also be true:

1. b

2. e

3. c