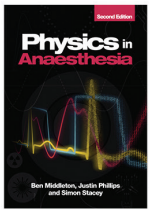
Chapter 9

The gas laws



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. At STP:

a. One mole of a gas occupies 22.4 L
b. The molecules in air follow Newton's laws of motion
c. The pressure in SI units is 101.3 Pa
d. The temperature in SI units is 373°C
e. The pressure is notably higher than that usually found at sea level

Reminder

- Standard temperature and pressure (STP) refers to conditions where the temperature is 273.15 K (or 0°C) and the atmospheric pressure is 101.3 kPa (or 760 mmHg).

Did you know?

- There are seven base units of the SI system (see *Chapter 28: Physical quantities and SI units*).

2. Oxygen is the most commonly used gas in healthcare, regarding its properties:

a. Oxygen is not an ideal gas due to its large molecular size
b. The percentage of oxygen in the air does not significantly alter at altitude
c. The partial pressure of oxygen in the air differs with altitude
d. The partial pressure of oxygen is 1% less in the alveoli than room air as a result of the increased partial pressure of water vapour
e. Boyle's law is applicable to oxygen stored at high pressure in a cylinder

Pointer

- The partial pressure of water vapour in ambient air is usually taken as 1.3 kPa.
- Humidification of inhaled air in the airways increases this partial pressure to 6.3 kPa.
- See *Chapter 7: Humidity*.

3. Regarding the gas laws:

a. At STP, the number of molecules in 10 L of oxygen is different to that in 10 L of nitrous oxide
b. The pressure law is not applicable in settings above the boiling point of a gas
c. For a fixed number of molecules of gas a smaller container will have a higher pressure
d. At higher temperatures, molecules of a gas move faster and collide with the walls of their container more often resulting in higher pressure
e. If the number of moles, pressure and temperature of a gas in a cylinder are known the volume of that gas in a cylinder can be calculated

Pointer

- Learn the gas laws well – you will be surprised how often you need them.
- The gas laws include: Avogadro's law, Dalton's law, Boyle's law, Charles's law, Gay-Lussac's (pressure) law, the Combined gas laws and the Universal gas law.

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. An occupied helium balloon climbs too high into the atmosphere and the occupants start to feel dizzy and nauseous. What best describes the reason for this?

a. There is a lower partial pressure of oxygen higher in the atmosphere causing a drop in the concentration gradient across the alveolar membrane
b. The occupants are experiencing altitude sickness
c. The occupants have inhaled helium
d. Helium has a lower density than air
e. The pressure in the balloon filled with helium is considerably greater due to its large volume

Did you know?

- Jacques Charles (Charles's law) made the first flight in a hydrogen balloon in 1783.
- Hydrogen use in hot air balloons soon fell out of fashion because the gas is so highly flammable and explosive.

2. A patient is transferred to another hospital whilst on 10 L·min^{-1} of oxygen via a NRBM and followed by another patient on 4 L·min^{-1} of oxygen via nasal cannula. If a 'full' oxygen cylinder, at a pressure 100 times that of the atmosphere and with an internal volume of 340 L, is used for each patient, how much longer can the patient on the lower flow of oxygen transfer before their cylinder empties?

a. Precisely 340 minutes
b. Precisely 85 minutes
c. Precisely 51 minutes
d. Approximately 34 minutes
e. Approximately 51 minutes

Reminder

- An oxygen cylinder at a pressure 100 times that of atmospheric pressure is capable of releasing 100 times the cylinder's volume of oxygen.

Pointer

- Be aware of this factor when transferring patients.
- You do not want to get stuck in an elevator with a patient on high flow oxygen and only one small cylinder of oxygen!
- A good way to remember the length of time you have with a full small (D) cylinder is that you've got a safe window of around 15 minutes with a patient on 15 L·min^{-1}.

3. A fixed mass of an ideal gas initially has a volume, *V*, and an absolute temperature, *T*. What are the smallest changes in volume and temperature that would double the initial pressure?

a. ½·*V* and 4·*T*
b. ¼·*V* and ½·*T*
c. 2·*V* and ¼·*T*
d. 4·*V* and 2·*T*
e. ⅛·*V* and ¼·*T*

Pointer

- This is using a combination of Boyle's law, Charles's law and the pressure law, or in other words the Combined gas law.

Answers to questions for Chapter 9 – The gas laws

Multiple true / false questions

The following answers are true:

1. a and b

2. b, c, d and e

3. c, d and e

Single best answer questions

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

1. a

2. e

3. b