



SNACC

SOCIETY FOR NEUROSCIENCE
IN ANESTHESIOLOGY AND CRITICAL CARE



NEURO QUIZ-33

APPLIED PHYSICS - 1

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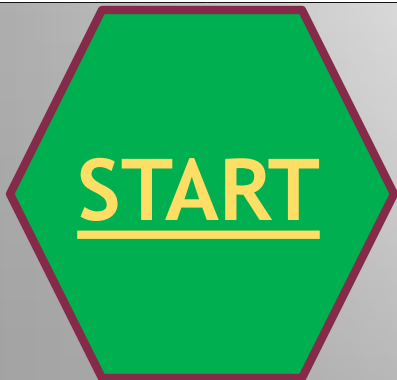
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1. DURING A CRANIOTOMY UNDER MEP MONITORING, THE TECHNICIAN QUESTIONS THE RELIABILITY OF THE GAS MONITOR. WHICH OF THE FOLLOWING IS NOT TRUE OF THE INFRARED GAS ANALYZER?

- A. Water vapor interferes with the measurement
- B. The sampled gas can be returned back to the breathing circuit
- C. It is based on Beer-Lambert law
- D. Gases such as Helium and Xenon cannot be measured

Next Question

1.A. WATER VAPOR INTERFERES WITH THE MEASUREMENT



TRY AGAIN

- ⦿ Molecules with two or more dissimilar atoms absorb infrared (IR) radiation
- ⦿ Water vapor (H_2O) can absorb IR and interfere with measurement
- ⦿ Therefore these monitors have a water-trap

Next Question

1.B. THE SAMPLED GAS CAN BE RETURNED BACK TO THE BREATHING CIRCUIT



TRY AGAIN

- In a Mass Spectrometer, the sample of gas is ionized using an electron gun. These charged molecules are then accelerated through a magnetic field and the charged gas molecules are deflected depending on their mass, and thus identified
- This ionized gas sample cannot be returned to the patient
- The gas sample in an infrared analyzer can be returned to the patient circuit

[Next Question](#)

1.C. IT IS BASED ON BEER-LAMBERT LAW



TRY AGAIN

- The infrared analyzer is based on the **Beer-Lambert** law, which states that the quantity of light absorbed by a substance dissolved in a fully transmitting solvent is directly proportional to the concentration of the substance and the path length of the light through the solution

[Next Question](#)

1.D. GASES SUCH AS HELIUM AND XENON CANNOT BE MEASURED



CORRECT!

- Molecules with two or more dissimilar atoms absorb infrared (IR) radiation and different molecules have distinct IR absorption spectra.
- Helium and Xenon, being mono-atomic, cannot be measured by infrared gas analyzer

[Back to Question](#)

[Next Question](#)

2. STANDARD MACHINE CHECK IN CERTAIN ANESTHESIA MACHINES INCLUDE CALIBRATION OF THE OXYGEN MONITOR. OXYGEN IN A GAS MIXTURE CAN BE MEASURED BY ALL THE FOLLOWING, EXCEPT

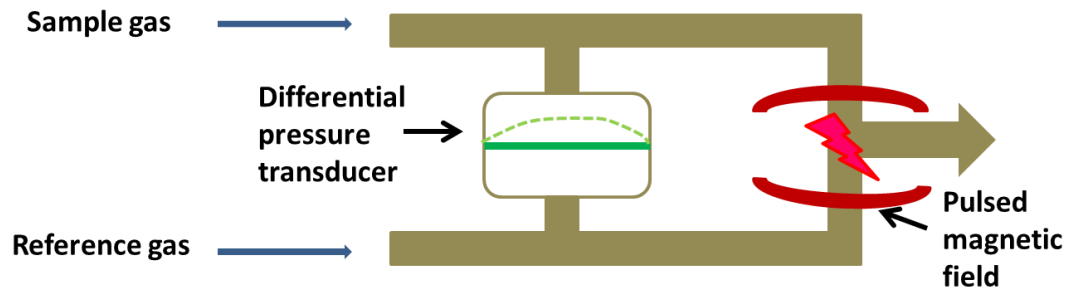
- A. Paramagnetic analyzer
- B. Galvanic Cell analyzer
- C. Polarographic analyzer
- D. Infrared gas analyzer

2.A. PARAMAGNETIC ANALYZER



[TRY AGAIN](#)

- Oxygen, because of its unpaired electron in the outer orbit, is ‘paramagnetic’ (attracted towards a magnetic field), while most other gases used in anesthesia are ‘diamagnetic’ or repels from a magnetic field
- This property is used to measure oxygen in most modern anesthesia machines



[Next Question](#)

2.B. GALVANIC CELL ANALYZER



TRY AGAIN

- The galvanic or the fuel cell is similar to the Clark Polarographic electrode, except that it generates its own voltage without any external power source
- It consists of a gold cathode and a lead anode immersed in potassium hydroxide solution
- It is used to measure the inspired oxygen % in certain anesthesia machines

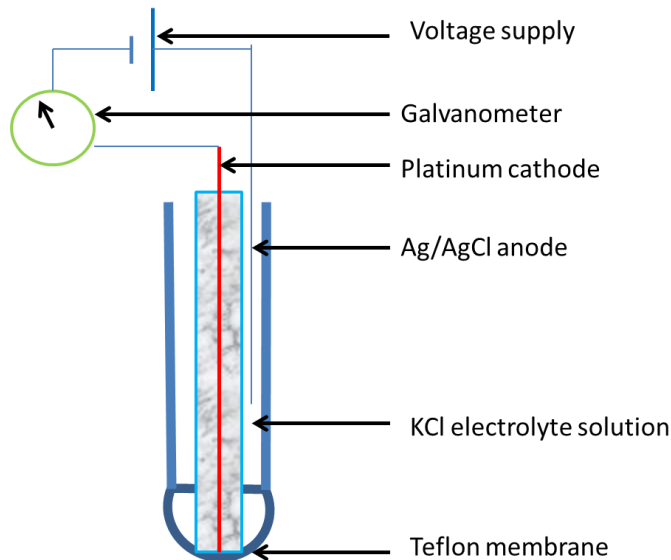


Next Question

2.C. POLAROGRAPHIC ANALYZER



TRY AGAIN



- Polarographic (Clark) Oxygen electrode can measure oxygen in blood or a gas sample
- The Teflon membrane is oxygen permeable
- Cathode: $O_2 + 2H_2O + 4e^- = 4OH^-$
- Electrolyte: $KCl + OH^- = KOH + Cl^-$
- Anode: $Ag + Cl^- = AgCl + e^-$

Next Question

2.D. INFRARED GAS ANALYZER



CORRECT!

- ⦿ Molecules with two or more dissimilar atoms absorb infrared (IR) radiation
- ⦿ Oxygen, nitrogen, helium, xenon, and argon do not absorb IR radiation and cannot be measured by this technique

[Back to Question](#)

[Next Question](#)

3. DURING A LAMINECTOMY, THE RESIDENT ATTRIBUTES A LOW SPO2 TO LOW BODY TEMPERATURE. THE PULSE OXIMETER IS BASED ON WHICH PHYSICAL PRINCIPLE?

- A. Boyle's Law
- B. Dalton's Law
- C. Beer-Lambert Law
- D. Bernoulli principle

3.A. BOYLE'S LAW



TRY AGAIN

⊙ **Boyle's Law** - The **Pressure** of a fixed mass of gas at constant temperature is *inversely proportional* to its **Volume** (PV is a constant)

⊙ **Application:**

- If the volume of a cylinder (V_1) and the gauge pressure (P_1) is known, the volume of gas (V_2) that will be available at atmospheric pressure (P_2) can be calculated. [$P_1V_1 = P_2V_2$]
- A cylinder of oxygen of volume 5L and pressure 1900 *psi* will give 660L of oxygen at 14.7 *psi* (760 mmHg)

Next Question

3.B. DALTON'S LAW



TRY AGAIN

- Dalton's Law - Pressure exerted by a mixture of gases is the sum of the partial pressures exerted by each gas
- The partial pressure exerted by each gas is proportional to its concentration in the mixture
- Application:
 - A 2% sevoflurane in a gas mixture exerts a partial pressure of 15 mmHg (2% of 760mmHg)

Next Question

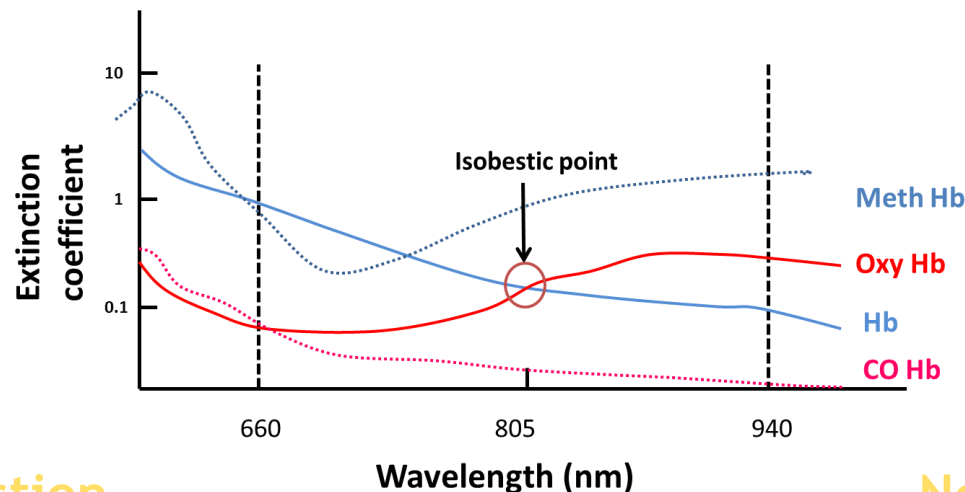
3.C. BEER-LAMBERT LAW



CORRECT!

- The Beer-Lambert law states that the quantity of light absorbed by a substance dissolved in a fully transmitting solvent is directly proportional to the concentration of the substance and the path length of the light through the solution

Absorption spectrum of different forms of Hemoglobin



[Back to Question](#)

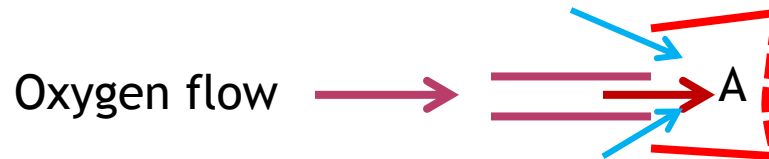
[Next Question](#)

3.D. BERNOULLI PRINCIPLE



TRY AGAIN

- In fluid dynamics, *Bernoulli's principle* states that an increase in the speed of a fluid occurs simultaneously with a decrease in pressure or a decrease in the fluid's potential energy
- Application:
 - Oxygen flow through a venturi mask drops the pressure beyond the nozzle (A) and entrains air to provide a fixed performance oxygen mask



Venturi mask

Next Question

4. DURING A ROUTINE MACHINE CHECK, THE ANESTHESIA TECHNICIAN COMMENTS THAT THE N_2O CYLINDER IS NEARLY EMPTY. THE FOLLOWING STATEMENT ABOUT NITROUS OXIDE (N_2O) CYLINDER IS FALSE

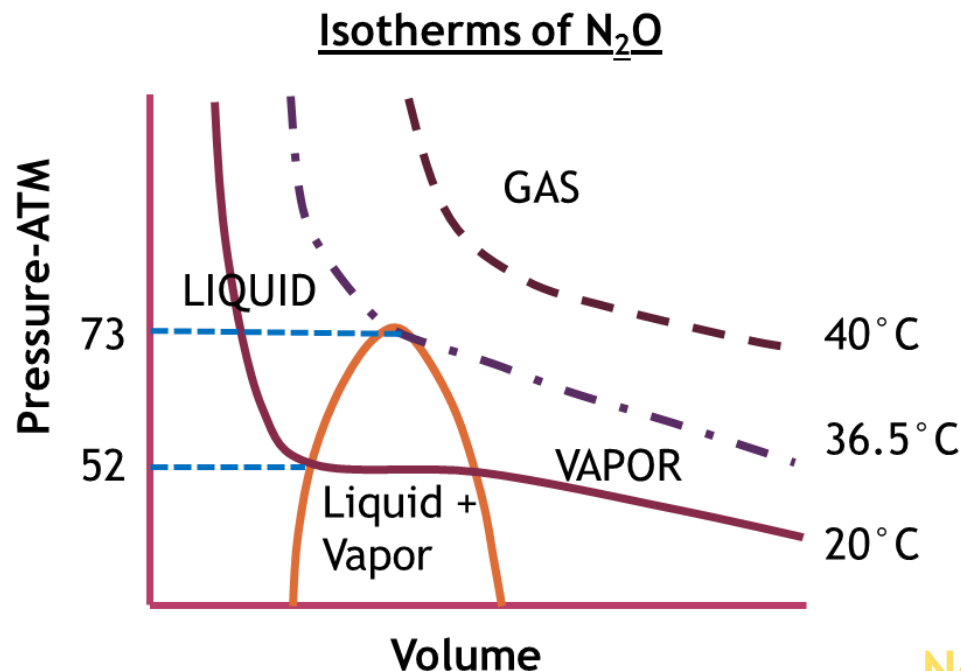
- A. The critical temperature of N_2O is $36.5^\circ C$
- B. The gauge pressure does not change with normal usage
- C. The gauge pressure of ~ 50 ATM is the critical pressure of N_2O
- D. The volume of N_2O available in a cylinder is calculated by weighing the cylinder and applying Avogadro's law

4.A. THE CRITICAL TEMPERATURE OF N_2O IS $36.5^\circ C$



[TRY AGAIN](#)

- Critical temperature is the temperature above which a gas cannot be liquefied, irrespective of the magnitude of pressure applied to it



[Next Question](#)

4.B. THE GAUGE PRESSURE DOES NOT CHANGE WITH NORMAL USAGE



TRY AGAIN

- ⦿ N_2O cylinder contains both liquid and vapor and the gauge shows the saturated vapor pressure of N_2O at 20°C - 50 atm
- ⦿ As long as there is liquid N_2O in the cylinder the pressure would be same, provided the temperature is 20°C , which it is with normal usage

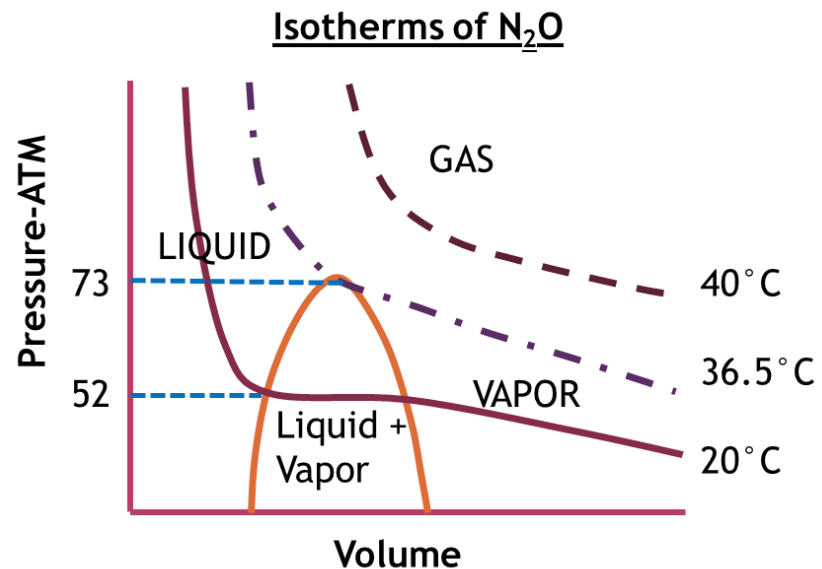
[Next Question](#)

4.C. THE GAUGE PRESSURE OF ~50 ATM IS THE CRITICAL PRESSURE OF N_2O



CORRECT!

- The saturated vapor pressure of N_2O at $20^\circ C$ is about 50 ATM
- The critical pressure (pressure needed to liquefy the gas at its critical temperature) of N_2O is about 73 ATM



[Back to Question](#)

[Next Question](#)

4.D. THE VOLUME OF N_2O AVAILABLE IN A CYLINDER IS CALCULATED BY WEIGHING THE CYLINDER AND APPLYING AVOGADRO'S LAW



TRY AGAIN

- *Avogadro's Law* - 1 mole (gm mol wt) of any gas occupies 22.4L at $0^\circ C$ & 760 mmHg; and has 6.02×10^{23} molecules (*Avogadro's number*)
- 44gm (mol.wt) of N_2O would occupy 22.4L
- Weight of cylinder containing N_2O minus the tare weight of cylinder would give the weight of N_2O in the cylinder

[Next Question](#)

5. BEFORE TRANSFERRING AN INTUBATED PATIENT TO THE NEURO ICU, THE ANESTHESIA RESIDENT CHECKS THE OXYGEN CYLINDER. WHICH OF THE STATEMENT ABOUT OXYGEN STORAGE IS FALSE?

- A. The pressure in a full oxygen cylinder, irrespective of the size, is about 137 atm
- B. The pressure in a liquid oxygen storage tank is approximately 2000psi
- C. The amount of oxygen in a cylinder can be calculated using Boyle's law
- D. Normal oxygen cylinder does not contain any liquid oxygen even under freezing conditions (-40° C)

5.A. THE PRESSURE IN A FULL OXYGEN CYLINDER, IRRESPECTIVE OF THE SIZE, IS ABOUT 137 ATM



TRY AGAIN

- Oxygen cylinders are filled up to a pressure of about 2000 psi with is 137 atm ($137 \times 101 \text{ kPa}$)
- Oxygen and air are stored as compressed gases, and therefore the volume can be calculated if the pressure in the cylinder is known

5.B. THE PRESSURE IN A LIQUID OXYGEN STORAGE TANK IS APPROXIMATELY 2000 PSI



CORRECT!

- Oxygen is stored at -170°C , which is lower than the critical temperature of -119°C and the Saturated Vapor Pressure at that temperature is about **7 atm (102 psi)**
- Oxygen in a vacuum insulated evaporator (VIE) hold about 1500L of liquid oxygen, which converts to 860 times that volume at $20^{\circ}\text{C}/760\text{mmHg}$



[Back to Question](#)

[References](#)

5.C. THE AMOUNT OF OXYGEN IN A CYLINDER CAN BE CALCULATED USING BOYLE'S LAW



TRY AGAIN

⊙ **Boyle's Law** - The **Pressure** of a fixed mass of gas at constant temperature is *inversely proportional* to its **Volume** (PV is a constant)

⊙ **Application:**

- If the volume of a cylinder (V_1) and the gauge pressure (P_1) is known, the volume of gas (V_2) that will be available at atmospheric pressure (P_2) can be calculated. [$P_1V_1 = P_2V_2$]
- A cylinder of oxygen of volume 5L and pressure 2000 *psi* will give 680L of oxygen at 14.7 *psi* (760 mmHg)

References

5.D. NORMAL OXYGEN CYLINDER DOES NOT CONTAIN ANY LIQUID OXYGEN EVEN UNDER FREEZING CONDITIONS (-40°C)



TRY AGAIN

- Critical temperature is the temperature above which a gas cannot be liquefied, irrespective of the magnitude of pressure applied to it
- Critical temp of oxygen is -119°C

References

REFERENCES

1. Davis PD, Kenny GNC. Basic Physics and Measurement in Anaesthesia. 5th Edition, Butterworth-Heinemann. New Delhi. 2005
2. Dorsch JA, Dorsch SE. Understanding anesthesia equipment. 5th Edition, Lippincott Williams & Wilkins, Philadelphia 2008

GO TO QUESTION - 1 2 3 4 5