SNACC
SOCIETY FOR NEUROSCIENCE IN ANESTHESIOLOGY AND CRITICAL CARE

NEURO QUIZ-33
APPLIED PHYSICS - 1

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START

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 can 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 (H2O) 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 CAN 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

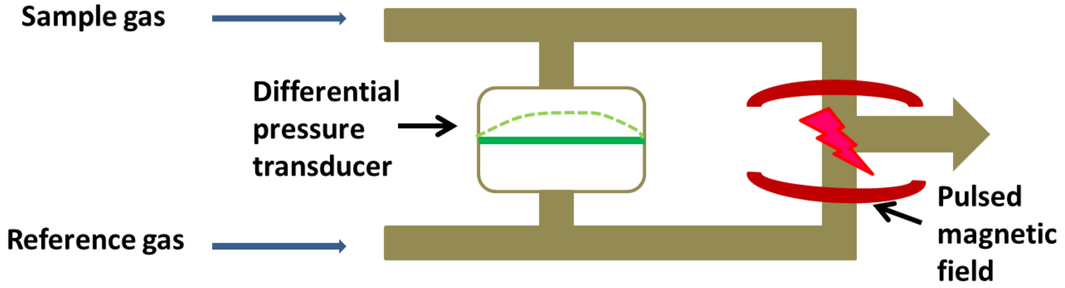
Previous Question

Next Question

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

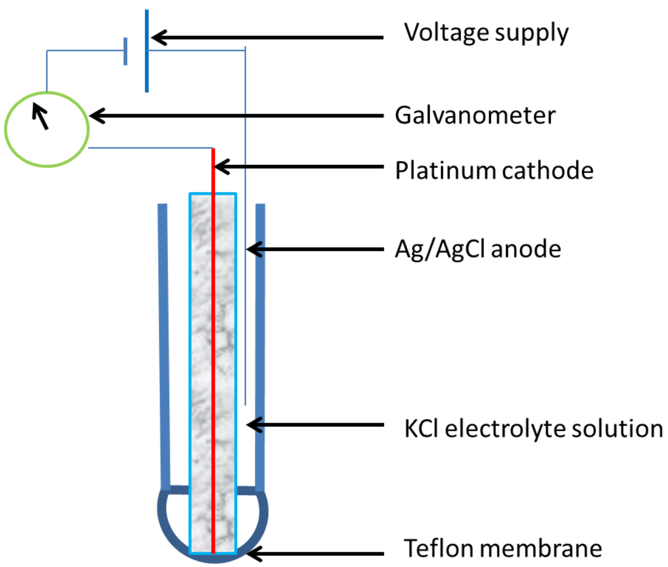
TRY AGAIN

- 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: $O_2 + 2H_20 + 4e^- = 4OH^-$
- 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

Previous Question Next Question

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)

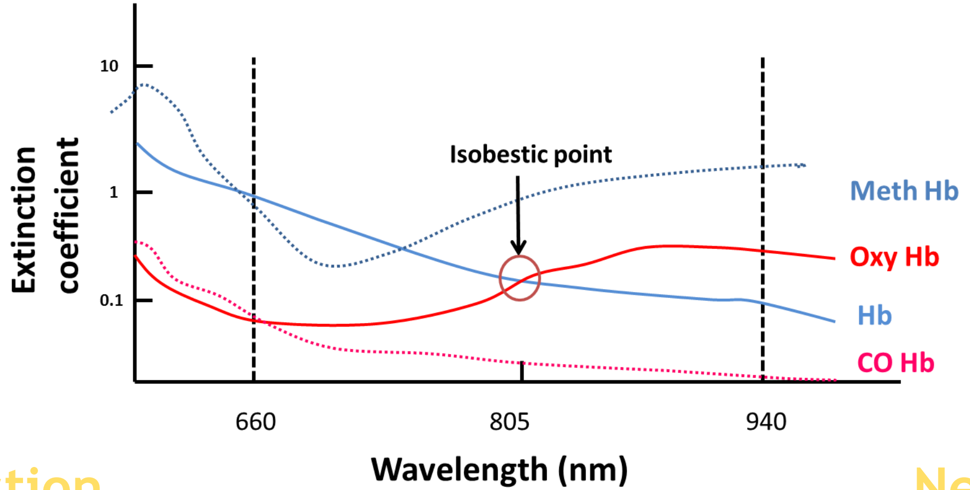
Next Question

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

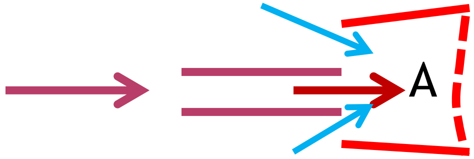
Next Question

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

Oxygen flow



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°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

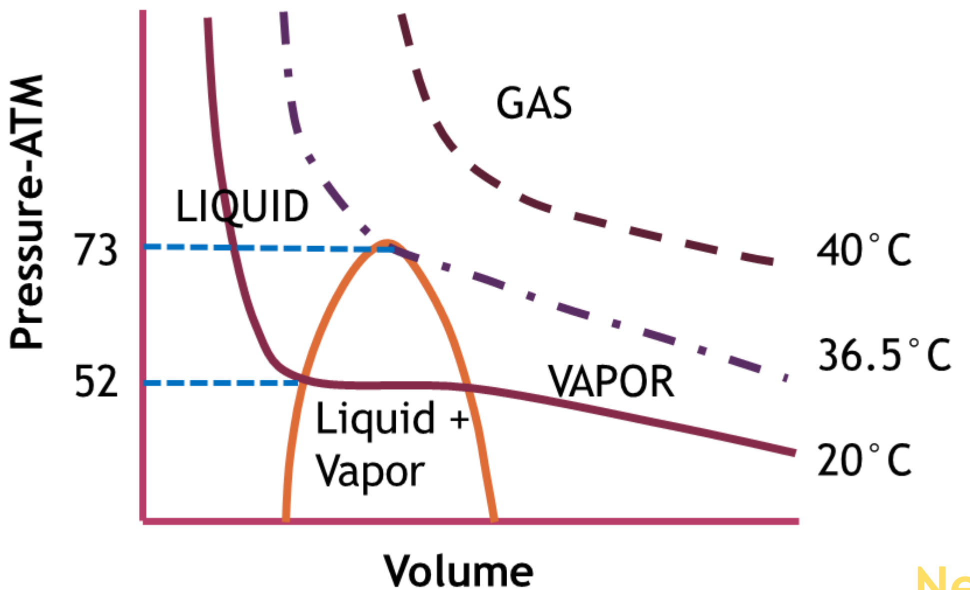
Previous Question
Next Question

4.A. THE CRITICAL TEMPERATURE OF N_2O IS 36.5°C

TRY AGAIN

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

Isotherms of N_2O



Next Question

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

TRY AGAIN

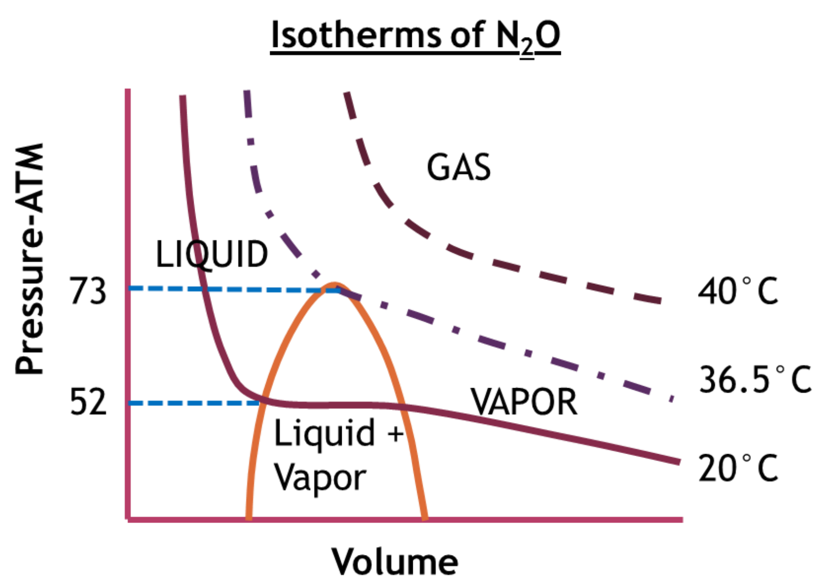
- N_2O cylinder contains both liquid and vapor and the gauge shows the saturated vapor pressure of N2O at 20°C – 50 atm
- As long as there is liquid N_2O in the cylinder the pressure would be same, provided the temperature is 20°C, which it is with normal usage

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°C is about 50 ATM
- The critical pressure (pressure needed to liquefy the gas at its critical temperature) of N_2O is about <u>73 ATM</u>



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°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)

Previous Question

References

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 (137x101kPA)
- 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°C/760mmHg

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