RC 170

Integrated Basic Sciences

Chapter 1 -Mathematics
Scientific Notation and Exponents

- Exponents

- Used to express numbers in scientific notation

- $50800000000 = 5.08 \times 10^{10}$
- $0.000000000508 = 5.08 \times 10^{-10}$

Scientific Notation and Exponents

Standard Notation	Scientific Notation
1,000	1×10^{3}
100	1×10^{2}
10	1×10^{1}
1	1×10^{0}
0.1	1×10^{-1}
0.01	1×10^{-2}
0.001	1×10^{-3}

Multiplication & Division

- $(5.80 \times 10^{6}) \times (4.30 \times 10^{7})$
- $(5.80 \times 4.30)\ 10^{6+7}$
- $(5.80 \times 4.30)\ 10^{13}$

- $(5.80 \times 10^{6}) / (4.30 \times 10^{7})$
- $(5.80/4.30)\ 10^{6-7}$
- $(5.80/4.30)\ 10^{-1}$

Addition

- Rule: exponents must be the same or they need to be changed.
- $(4.30 \times 10^{6}) + (5.80 \times 10^{6})$
- $(4.30 + 5.80) \times 10^{6}$

- $(4.30 \times 10^{6}) + (5.80 \times 10^{7})$
- $(4.30 + 58.00) \times 10^{6}$

Subtraction

- Same rules apply as in addition.
- The exponents must be the same.

Significant Digits

- What is Precision?
- What is Accuracy?
- Example: Spirometry measurements
- Remember that the accuracy of a measurement is limited by the precision of the measuring instrument.

Rules of Zeros

- Determine how many significant digits are in the value 9.002015?
- Answer: 7
- Remember that nonzero digits are always significant.
- All zeros after a decimal point are significant.
- Zeros between nonzeros are also significant.

Rules of Zeros

- Determine how many significant digits are in the value 0.0000000412
- Answer: 3
- Remember that nonzero digits are always significant.
- All final zeros following the decimal point are significant, as well as zeros in between significant digits.
- Zeros used exclusively for placing a decimal point are not significant.

Calculations

- Rules:
- When adding significant digits make sure the decimal points line up.
- When multiplying make sure to add the number of places behind the decimal and that your answer reflects the correct placement of the decimal point.

Ratios

- Air:Oxygen Ratio
- If an air entrainment mask was assembled to deliver 24% oxygen at 4 lpm, the air:oxygen ratio would be 25:1.
- What is the liter flow of air?
- Air/oxygen=ratio
- $x/4 = 25/1$
- $x=100$

Inspiratory:Expiratory Ratio

- I:E = TI/TI: TE/TI
- TI= 1.25 seconds
- TE= 2.50 seconds
- 1.25 seconds/1.25 seconds :
- 2.50 seconds/1.25 seconds
- = 1:2

Rules to remember

- Numerator: the value on the top
- Denominator: the value on the bottom

- If the denominator increases in greater proportion to the numerator, the overall ratio decreases.
- If the numerator increases in greater proportion to the denominator, the overall ratio increases.

Dead Space Volume:Tidal Volume Ratio

- $V_D/V_T = \underline{PaCO_2 - P_ECO2}$
- $PaCO_2$

- $PaCO_2 = 40$ $V_D = 150cc$ $V_T = 500cc$
- Solve for P_ECO2: $150cc/500cc = 40 - P_ECO2/40$
- $0.3 = 40 - P_ECO2/40$ $12 = 40 - P_ECO2$
- $-28 = -P_ECO2$
- $P_ECO2 = 28$

Proportions

- What is a mean?
- What is an extreme?
- Extremes=Means
- Means   Extremes

- a:b=x:y
- ay:bx
- a:b::x:y

Charles' Law

- Describes the relationship between volume (V) and absolute temperature (T). Mass and pressure are held constant.
- Direct proportion
- $V/T=k$
- As the temperature increases, the volume occupied by the gas also increases, with pressure remaining constant.

Boyle's Law

- States that the pressure (P) and volume (V) of a gas are inversely related, when the temperature (T) and mass are held constant.
- $P \times V = k$
- If the pressure increases, the gas volume will decrease proportionately to maintain the constant k.

Percents

- Find the percent of a number. What is 75% of 400?
- n = the number
- n = 75% of 400
- n = 75/100 (400)
- n=?

Percents

- Determine what percent one number is another.
- What percent is 5 of 3?
- % = the number
- 3= % (5)
- % = 3/5 (100)
- %=?

Percents

- Calculate the number when a percent of it is known.
- What number is 25% of 2.5?
- y=the number
- 2.5=y (25/100)
- y=2.5/0.25
- y=?

Relative Humidity

- Content x 100 = relative humidity
- Capacity

- Content=the actual weight of water present in a given volume of air.
- Capacity=the maximum amount of water that the air can hold at a given temperature.

Relative Humidity

- Content=18g/m^3 at 37C, The capacity of water at this temperature is 43.8g/m^3.

- Solve: 18g/m^3 / 43.8g/m^3 x 100
- =41%

Graphs

- Cartesian coordinate system
- Define abscissa, ordinate, origin and quadrants.
- Define dependent and independent variables.
- Define straight line, hyperbola and parabola.
- Define when graphs are used in Respiratory Care.

Algebra- Chapter 2

- Define variable
- A symbol used to represent one or more numbers
- Define a variable expression.
- The algebraic expression that contains the variable(s) is called a variable expression.
- How can the solution of an algebraic expression be found?
- Can be solved by giving a numerical value to substitute for the variable.

Recognizing different algebraic expressions

- Algebraic expression 10 + y
- Numerical expression 10 + 5
- Solution 15
- Discuss more examples.

Rules for Real Numbers

- Addition:
- Rule #1: Two real numbers with the same sign
- -6 + (-2) + -8

- Rule #2: Two real numbers with different signs
- -20 +10 + -10

Rules for real numbers

- Subtraction:
- 6 + (-10) + -4
- 20 - (-20) = 40

- Multiplication:
- (-10) x 3 = -30
- (-10) x (-4) = 40

Rules for real numbers

- Division:
- dividend/divisor = quotient
- 80/10 = 8
- -80/10 = -8
- 80/-10 = -8

Simplifying Numerical Expressions

- Rules:
- Perform operations within parentheses, ( ).
- Perform operations within brackets [ ].
- Perform operations within braces { }.
- Multiply and divide from left to right.
- Add and subtract from left to right.

Reciprocals

- What is a reciprocal?
- Can be used in practical application, including compliance, elastance, resistance and conductance.
- Two numbers whose product is unity, or 1 are called reciprocals.
- What is a multiplicative inverse?

Chapter 3 Chemistry

- Graham's Law of Diffusion
- What are the two forms?
  - The first deals with the diffusion of a gas within a gas.
  - The seconds deals with the diffusion of a gas through a liquid.
- The law governing the diffusion of a gas within a gas states that lighter molecules will diffuse and equilibrate faster than heavier molecules when both intermingle with one another in a container.

Graham's Law of Diffusion

- Oxygen and carbon dioxide can be used to demonstrate the state of this law.
- By using the density of molecular oxygen and carbon dioxide and substituting their molecular weights, it can be said that oxygen diffuses 1.17 times faster than carbon dioxide.
- Kinetic theory of matter states that increasing gas temperature increases gas velocity and accelerates the rate of diffusion.

Graham's Law of Diffusion

- The diffusion rate of gases through a liquid can be determined by examining factors peculiar to the situation under consideration.
  - the nature of the solvent
  - the temperature
  - and the pressure

Graham's Law of Diffusion

- Oxygen diffuses 1.17 times faster than carbon dioxide within a gas mixture. (Alveoli)
- Carbon Dioxide diffuses 19 times faster than oxygen across the alveolar-capillary membrane.

Henderson-Hasselbalch Equation

- Based on the law of mass action.
- It was applied to the carbonic acid/sodium bicarbonate buffer system.

- Variations of this equation can compute:
  - pH
  - PCO2
  - HCO3

Temperature Conversions

- Boiling point of water
  - 100C 373K 212F
- Freezing point of water
  - 0C 273K 32F
- Absolute zero
  - -273C 0K -459F

Temperature Conversions

- Conversion from Celsius to Kelvin
  - K = C + 273
  - C = K- 273

Chapter 4 Physics

- Kinetic Energy
  - is one type of mechanical energy.
  - the energy of an object of mass moving at a velocity.

- Acceleration = the rate of change of velocity.
- The units for kinetic energy are the same as those for work, ie. Joules, ergs, or foot-pounds.

Potential Energy

- This is another form of mechanical energy.

- It is the energy of an object resulting from its position or configuration.
- The potential energy acquired by an object and equals the work performed on that object against gravity or against elastic forces.

Kinetic Theory of Matter

- It states that any given sample of matter is composed of many small particles (molecules, atoms or ions) that are in constant motion.
- This theory applies to all three states of matter
  - solids
  - liquids and
  - gases

Gas Laws

- The physical behavior of matter in the gaseous state can be explained on the basis of the variables
  - temperature
  - pressure
  - volume
  - and mass (amount of gas)

Boyle's Law

- It states that for a given mass of gas the volume and pressure are inversely proportional when the temperature is constant.

- $P \times V = K$

Boyle's Law

- When an ideal gas changes from its original pressure (P1) and volume (V1) to a new pressure (P2) and (V2), the expression becomes: $P1V1 = P2V2$

- or

- $$\frac{P1}{P2} = \frac{V2}{V1}$$

Boyle's Law

- A constant mass of gas inside a cylinder at 30 degrees Celsius is at two different pressures and volume conditions. Piston A pressure (P1) is 700torr and the compressed volume (V1) is 350 ml. Piston B pressure (P2) has increased to 950torr.
- Solve for the compressed volume (V2).

Charles' Law

- States that for a given mass of gas the volume varies directly with the absolute temperature when the pressure is constant.
- V/T = K

Charles' Law

- V1/T1 = V2/T2
- For every degree increased in temperature, there is and equal increase in volume.
- Remember to convert temperature from C to K
- (K = C + 273)

Charles' Law

- :A volume of 1.5 liters of CO_2 gas at 30C is heated to 180C. Assume that this heating occurs under constant pressure conditions. Calculate the new volume.
- T_1=30C + 273 =303K
- T_2=180C + 273 = 453K
- $V_1/T_1 = V_2/T_2$ 1.5L/303K =V_2/453K
- V_2 = 2.24L

Gay-Lussac's Law

- States that for a given mass of gas the pressure varies directly with the absolute temperature when the gas volume remains constant.

- P/T = K
- or
- P1V1/T1 = P2V2/T2

Gay-Lussac's Law

- This combined gas law provides the quantitative relationship and is the basis for the calculation of gas volume conversions associated with pulmonary function testing.
- When calculating remember to correct the final pressure (P2) for the presence of water vapor pressure.
- $P2-PH2O$ = corrected PB
- Ex: 755 mmHg - 47 mmHg = 708 mmHg

Gay-Lussac's Law

- The original pressure is 760 mmHg and the original temperature is 0C or 273K; the final pressure is 755mmHg and the final temperature is 37C or 310K.
- The water vapor pressure at 37 C is 47 mmHg.
- P1=760mmHg   P2=755mmHg   T1 = 273K
- T2 =310K   PH2O = 0 mmHg   (V1)
- PH2O = 47 mmHg (V2)

Gay-Lussac's Law

- P1V1/T1 = P2V2/T2
- (760mmHg)(V1)/273K = (708mmHg)(V2)/303K
- V2=760(V1)(310)/708(273K)
- V2 = 1.219 (V1)
- This is the factor that is needed to convert gas volume from STPD to BTPS. Therefore, the volume (V2) at BTPS will be 1.219 times greater than (V1) at STPD.

Gay-Lussac's Law

- The original volume (V1) was 4.50 liters and the final volume (V2) would be calculated as follows:

- V2=1.219 (V1)
- V2=1.219 (4.50 liters)
- V2=5.49 liters

Dalton's Law

- States that the total pressure exerted by a mixture of gases is equal to the sum of the partial pressures of the constituent gases.
- $P_{total} = P_1 + P_2 + P_3 + P_n$
- Physiologic example: as the gas moves from the trachea to the alveoli, it experiences further alterations.

Dalton's Law

- The changes that occur result from the oxygen uptake and the carbon dioxide removal at the blood gas interface (the alveolar-capillary membrane).
- Oxygen is continuously removed while carbon dioxide is added to, the alveoli by the pulmonary capillary blood because of the respective pressure gradients for these two gases.
- No addition water vapor is added because inspired gas is fully saturated.

Dalton's Law

- The alveolar air equation is derived from Dalton's Law.
- PAO2=FIO2(PB-PH2O)-PACO2 (FIO2+1-FIO2/R)

Bernoulli Principle

- Describes the relationship between lateral wall pressure and velocity for an incompressible fluid flowing through a tube in laminar fashion.
- Because gas moves through a tube at a constant flow rate V1=V3) and with a constant driving pressure,(point 1) the gas velocity must increase as the gas moves through the tube's convergence (point 2) and must decrease as its traverses the divergence (point 3).

Bernoulli Principle

- At point 2 some of the pressure energy or lateral wall pressure is converted to kinetic energy, as manifested by the velocity increase. V2>V1
- Because V2 is greater than V1, the kinetic energy is greater at point 2.
- The reverse of this situation occurs as the conducting system at point 3 diverges.

Bernoulli Principle

- A portion of the kinetic energy is reconverted to pressure energy as the lateral wall pressure there increases (P3>P2) and gas velocity decreases.

- As the cross sectional area decreases, the velocity of the flowing fluid increases and vice versa.

Bernoulli Principle

- There are therapeutic ramifications is be aware of.
- If the flow rates at a constant driving pressure are applied to partially obstructed airways, the gas velocity will increase through these narrowed airways, and the lateral wall pressure will decrease.
- Increasing the flow rate will magnify the problem by widening the pre and post obstruction velocity gradient and will decrease lateral wall pressure further.

Bernoulli Principle and the Venturi Principle

- As lateral wall pressure decreases across a partial obstruction, less pressure becomes available for alveolar inflation distal to the narrowing.
- The Venturi Principle incorporates Bernoulli's Principle in that the decrease in lateral wall pressure across a convergence is taken advantage of to entrain another fluid into the source flow.

Types of flow patterns

- There are two types of flow patterns:
- Laminar flow
- Turbulent flow

- Physiologically a third type of flow pattern is thought to exist : Tracheobronchial flow

Resistance to Ventilation

- There are three components:
- Inertial resistance
- Airway resistance
- and nonelastic resistance

- The elastic components include the elastic properties of the lung and the chest wall.

Resistance to Ventilation

- The elastic properties of the ventilatory system are studied under static conditions (no airflow) as compliance (change in volume/change in pressure) or as its reciprocal, elastance (change in pressure/change in volume).
- The mathematical relationship between these two physical entities indicates that as lung compliance increases elastance decreases.

Resistance to Ventilation

- On the compliance curve
  - Pulmonary emphysema is shifted to the left of normal,
  - As lung tissue is destroyed such in pulmonary fibrosis the curve shifts to the right. The lung becomes flaccid and become stiffer and more difficult to inflate.

Chapter 5 Statistics

- Determine what is an acceptable data base.
- What are standard deviations.
- Where are they most commonly used in Respiratory?
  - Blood gas labs to determine quality control values and accuracy.

- How does a bell curve work?

Chapter 6 Physiologic Chemistry

- Basic principles of organic chemistry
- What are bonding capabilities
  - hydrogen, oxygen, nitrogen and carbon
- Pulmonary surfactant
  - components of…
- How is the relationship between alveolar surface tension and the alveolar concentration of pulmonary surfactant.
- Surfactant replacement in premature infants.

Oxygen toxicity

- What are the biochemical aspects of oxygen toxicity?
- Can be classified as systemic or pulmonary toxicity.
- Systemic
  - refers to the effects of oxygen administration on organ systems separate from the lunge (eyes-RLF and the central nervous system with respect to convulsions, paresthesia and reduced mucociliary activity).

Oxygen toxicity

- Pulmonary toxicity
  - manifests itself at the alveolar-capillary membrane.

- Causes destruction of the capillary endothelium, perivascular and interstitial edema and hemorrhage.

Biochemical mechanisms of Bronchospasm

- Maintenance of bronchial smooth muscle tone
- The production of bronchspasm
- And the alleviation of bronchial smooth muscle constriction.

Pharmacological agents

- What is the rational for administration of pharmacological agents used to prevent or reserve bronchspasm.
- What are some the the pharmacological agents that can be used and how do they work?

Chapter 7 Microbiology

- What types of bacteria exist that commonly cause Respiratory disease?
- Bacilli
  - Gram negative
  - Gram positive
  - Acid fast
- Cocci
  - gram positive
  - gram negative

Bacterial growth requirements

- Chemical constituents of artificial growth media
- Environmental requirements for bacterial growth
- Practical application of artificial growth media

Control of microorganism growth

- Sterilization
- Disinfection and Sanitization
- Chemotherapeutic Agents
- Commonly used techniques in Respiratory Departments.

Infection Control

- Define: Universal Precautions

- When should they be used?
- What does it protect you against?
- Apply barrier protection for what type of fluids?
- Judgement required for what type of fluids?