



## BIOCHEMISTRY NUMERICALS AND THEIR CLINICAL APPLICATIONS IN MEDICINE: A QUANTITATIVE APPROACH FOR MBBS STUDENTS

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### ABSTRACT

Biochemistry is at the heart of understanding health and disease. For MBBS students, numerical biochemistry offers a practical link between biochemical concepts and clinical interpretation. Concentrations, enzyme activities, metabolic rates, acid–base variables and energy relationships are not simply numbers in a textbook; they are reflected in laboratory reports and physiological measurements. Modern medical biochemistry also places increasing emphasis on competency-based learning and the application of basic science to clinical practice. This article presents common numerical approaches involving molarity, dilution, pH, buffers, the Henderson–Hasselbalch equation, enzyme kinetics, energy metabolism, renal function, glucose and lipid calculations, bilirubin and laboratory quality parameters. The emphasis is on understanding the calculation and then explaining what the result means clinically, rather than memorising formulas alone.

### KEYWORDS :

#### 1. INTRODUCTION

Biochemistry and medicine are closely connected because biochemical processes form the molecular basis of normal physiology as well as disease. As described in Harper's Illustrated Biochemistry, understanding these processes helps students connect biochemical changes with disease, diagnosis and treatment.

In clinical practice, laboratory investigations are used for screening, diagnosis, monitoring disease and assessing response to treatment. MBBS students therefore encounter quantitative information regularly, including blood glucose, serum creatinine, urea, bilirubin, cholesterol, triglycerides, electrolytes, enzyme activities and arterial blood-gas values. Learning to solve numerical problems gives students a useful foundation for interpreting these results. The important point is not only to calculate the answer, but also to understand its clinical significance.

#### 2. Concentration, Molarity and Dilution

Molarity describes the amount of a substance present in a given volume of solution:

$M = \text{moles of solute} / \text{volume in litres}$

A commonly used dilution relationship is:

$$C_1 V_1 = C_2 V_2$$

For example, suppose we need to prepare 100 mL of a 0.2 M solution from a 1 M stock solution. Using the dilution equation:

$$V_1 = (0.2 \times 100) / 1 = 20 \text{ mL}$$

Therefore, 20 mL of the stock solution should be diluted to a final volume of 100 mL.

This is a simple calculation, but it has an important practical role in the laboratory. Reagents, standards and calibrators are routinely prepared by dilution, and an error in concentration can affect the accuracy of the final laboratory result.

#### 3. pH, Buffers and Acid–Base Biochemistry

pH is used to express the hydrogen-ion concentration of a solution:

$$\text{pH} = -\log[\text{H}^+]$$

For example, if  $[\text{H}^+] = 1 \times 10^{-7} \text{ M}$ , the pH is 7.

The Henderson–Hasselbalch equation is:

$$\text{pH} = \text{pK}_a + \log([\text{A}^-]/[\text{HA}])$$

For the bicarbonate buffer system, this can be written as:

$$\text{pH} = \text{pK}_a + \log([\text{HCO}_3^-]/[\text{H}_2\text{CO}_3])$$

This equation provides a useful way of understanding how changes in the bicarbonate buffer system are related to acid–base disturbances. For medical students, however, a

calculated value should not be considered in isolation. Biochemical calculations support clinical assessment and arterial blood-gas interpretation; they do not replace them.

#### 4. Enzyme Kinetics and Clinical Enzymology

The Michaelis–Menten equation describes the relationship between substrate concentration and reaction velocity:

$$v = V_{\text{max}}[\text{S}] / (K_m + [\text{S}])$$

Consider a reaction in which  $V_{\text{max}} = 100 \text{ units}$ ,  $K_m = 2 \text{ mM}$  and  $[\text{S}] = 2 \text{ mM}$ :

$$v = 100(2)/(2 + 2) = 50 \text{ units}$$

Thus, under these conditions, the reaction velocity is 50% of  $V_{\text{max}}$ .

Enzyme measurements are widely used in clinical medicine. Raised circulating enzymes or isoenzymes may provide evidence of tissue injury. ALT and AST are commonly considered in hepatocellular injury, alkaline phosphatase in hepatobiliary and bone disorders, creatine kinase in muscle injury, and amylase and lipase in pancreatic disease. A laboratory value, however, should always be interpreted together with the patient's clinical findings and the reference interval provided by the laboratory.

#### 5. Bioenergetics and ATP

ATP is the principal immediate energy currency of the cell. The relationship between free energy and reaction conditions can be expressed as:

$$\Delta G = \Delta G^\circ + RT \ln Q$$

When  $\Delta G$  is negative, the process is thermodynamically favourable under the specified conditions.

Oxidative phosphorylation connects electron transport with ATP production. Numerical questions in this area may involve ATP yield, energy expenditure, respiratory quotient, substrate oxidation or metabolic efficiency. Rather than treating these as isolated calculations, students can relate them to familiar physiological situations such as exercise, fasting and starvation. This makes the numbers easier to understand and gives the calculations a clearer clinical context.

#### 6. Blood Glucose and Diabetes Mellitus

Blood glucose is one of the biochemical measurements most frequently encountered in medical practice. Students therefore need to be comfortable converting between commonly used units.

$$\text{Glucose (mmol/L)} \approx \text{Glucose (mg/dL)} / 18$$

For example, 180 mg/dL is approximately 10 mmol/L.

Although the calculation is straightforward, unit conversion is an important skill because laboratory reports and clinical resources may use different units. Numerical interpretation is particularly useful when studying diabetes mellitus, glucose tolerance testing and the monitoring of glycaemic control.

## 7. Renal Function and Creatinine Clearance

Creatinine clearance can be estimated using:

$$Ccr = (Ucr \times V) / Pcr$$

Here, Ucr is the urine creatinine concentration, V is the urine flow rate and Pcr is the plasma creatinine concentration.

For example, if urine creatinine is 100 mg/dL, plasma creatinine is 1 mg/dL and urine flow is 1 mL/min:

$$Ccr = (100 \times 1) / 1 = 100 \text{ mL/min}$$

This example illustrates the calculation clearly. In actual clinical practice, estimated GFR equations and standardised methods are generally preferred when assessing kidney function. Students should therefore understand the numerical principle while also recognising its limitations in clinical use.

## 8. Lipid Profile and Cardiovascular Risk

A commonly taught method for estimating LDL cholesterol is the Friedewald equation:

$$LDL-C = TC - HDL-C - TG/5$$

This form is used when concentrations are expressed in mg/dL and the assumptions of the equation are satisfied.

For example, if TC = 200 mg/dL, HDL-C = 50 mg/dL and TG = 150 mg/dL:

$$LDL-C = 200 - 50 - 150/5 = 120 \text{ mg/dL}$$

The calculation is useful for teaching students how lipid values are related. At the same time, calculated LDL has limitations, particularly when triglyceride concentrations are high, and direct laboratory methods or newer equations may be preferred in particular situations.

## 9. Bilirubin and Liver Biochemistry

A simple way to represent total bilirubin is:

Total bilirubin  $\approx$  Conjugated bilirubin + Unconjugated bilirubin

For example, if total bilirubin is 6 mg/dL and direct bilirubin is 2 mg/dL:

$$\text{Indirect bilirubin} = 6 - 2 = 4 \text{ mg/dL}$$

Knowing these fractions helps students begin to recognise different patterns of jaundice. Bilirubin metabolism is a good example of how a numerical laboratory result can be connected to the underlying biochemical pathway and, ultimately, to pathology.

## 10. Laboratory Quality: Accuracy, Precision and Diagnostic Interpretation

Laboratory medicine depends not only on obtaining a value, but also on knowing how reliable that value is. Two basic concepts are:

$$\text{Bias} = \text{Measured value} - \text{True value}$$

$$CV (\%) = (\text{Standard deviation} / \text{Mean}) \times 100$$

A low coefficient of variation generally suggests good analytical precision. However, precision and accuracy are not the same: a method may give closely grouped results without necessarily being close to the true value.

Students should also become familiar with sensitivity, specificity and predictive values. These concepts are important when moving from the numerical laboratory result to the interpretation of a diagnostic test.

Clinical biochemistry has expanded considerably beyond traditional metabolic testing. Modern laboratories use techniques such as optical methods, electrochemistry, biosensors, electrophoresis, chromatography, mass spectrometry, immunochemical methods, automation, point-of-care testing and molecular diagnostics.

These technologies all depend, to some extent, on quantitative measurement. Spectrophotometry, for example, uses absorbance measurements; immunoassays quantify hormones and biomarkers; mass spectrometry measures molecular ions; biosensors translate biochemical reactions into measurable electrical signals; and molecular diagnostic methods can quantify nucleic acids and genetic variants.

For this reason, numerical biochemistry is not simply an examination topic. It is closely connected with the way modern diagnostic medicine actually works.

## 12. Recommended Method for Solving MBBS Biochemistry Numericals

A consistent method can make numerical problems easier to approach. Students can follow these seven steps:

1. Identify the biochemical or clinical problem.
2. Write down the given values and their units.
3. Convert the units before beginning the calculation.
4. Select the equation that is appropriate for the problem.
5. Substitute the values carefully.
6. Check the mathematical result and the units.
7. Interpret the result in its clinical context.

The final step is essential. An isolated laboratory number can be misleading if it is considered without the laboratory reference interval, analytical method, clinical history and other relevant investigations. The calculation is therefore only the beginning; interpretation gives it meaning.

## CONCLUSION

Numerical biochemistry is an important part of MBBS education because clinical medicine increasingly relies on quantitative laboratory information. Calculations involving concentration, dilution, pH, buffers, enzyme kinetics, ATP metabolism, glucose, renal function, lipids, bilirubin and laboratory quality help students connect biochemical principles with real clinical situations.

The main aim should not be to memorise a collection of equations. Students should learn to recognise the biochemical problem, choose a suitable quantitative approach, perform the calculation accurately and then interpret the result in the context of the patient. Developing this habit can strengthen learning in preclinical subjects and provide a useful foundation for pathology, pharmacology, medicine, paediatrics, endocrinology, nephrology and other clinical disciplines.

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