Student Exam No.________________

GANPAT UNIVERSITY

B. Tech. Semester: VIII (Biomedical & Instrumentation) Engineering

CBCS Regular Examination April - June 2015

2BM803 Transportation Phenomena in Living Systems

Time: 3 Hours | Total Marks: 70

Instruction:
1 Write each section in separate answer book.
2 Answer should be brief and to the point.
3 Figure to the right indicates marks.
4 Assume suitable data, if necessary.

Section - I

Que. – 1 12

a) How the thermal equilibrium establishes between blood and tissue. Draw and explain the schematic diagram of vascular system and blood perfused tissue.

b) What is the need of dialysis? Draw the schematic arrangement and explain in detail.

OR

Que. – 1 12

a) Explain the respiratory gas transport process in the human body. Mention the components of inspired and expired air for the single breath analysis.

b) Which bio heat model represents the concept of countercurrent blood flow? Draw the schematic arrangement of it and enlist its assumptions.

Que. – 2 11

a) What are the features of transport system? Enlist the types of transport system and explain.

b) Describe the concept of mass transfer of ions and water from the tubules of the nephron.

OR

Que. – 2 11

a) What are the shortcomings Pennes bioheat models? Write the standard thermal diffusion equation for pennes model.

b) How the radiation heat transfer is takes place in human body? Write the mathematical equation for it and determine the heat transfer rate for the area of human body about 2 m^2.

Que. – 3 12

a) Draw & explain the neat diagram for mass transfer across systemic capillaries. Show the relationship between inlet and outlet flow of liquids across the capillaries for constant osmotic pressure and decreasing hydrostatic pressure.

b) Why is the heat of vaporization more at body temperature? Also give a mathematical proof.

Section – II

12

Que. – 4

a) What is sickle cell anemia? What is polycythemia?

b) What is drift velocity? What is tortuosity?

c) Explain the formation of interstitial fluid with the two types of pressures in Starling's equation.

d) Describe marginal zone theory.

e) What is the difference between laminar flow and turbulent flow? What is the significance of Reynold's number? What do the high and low values of Reynold's number indicate?

f) The osmotic pressure of a solution containing a protein is equivalent to the pressure exerted by 8 cm of water. Consider that 33.91 feet (ft) H_2O has the pressure of 1 atm. The mass concentration of protein in the solution is 15 g / L. Find out the molecular weight or molecular mass of this protein in g / mol.
Temperature is 298 K. , Gas constant R is 8.314 Pa m^3 / mol K, 1 atm = 101,325 Pa
1 in = 2.54 cm, 1 ft = 12 in.

OR 12

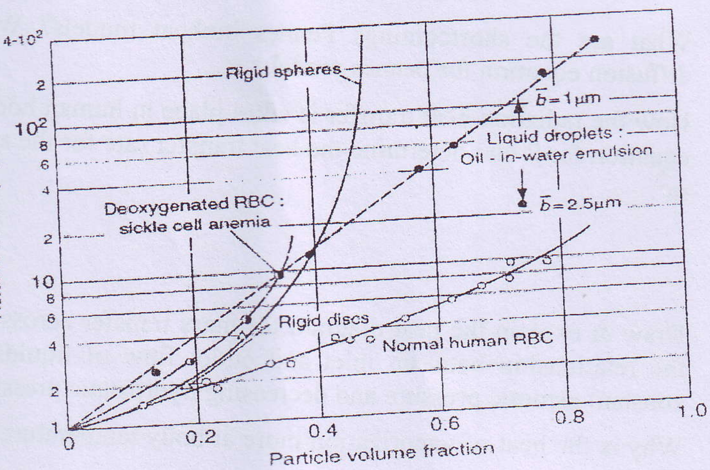
Que. – 4

a) Which cells show the process of extravasation? Explain extravasation and what does it depend on?

b) What is Rouleaux formation? Explain Fahraeus-Lindqvist effect.

c) Calculate the normal rate of net filtration for the human body in cm^3/min. Assume that the capillaries have a total surface area of 500 m^2 and that the slit pore surface area is $1/1000^{th}$ part of the total capillary surface area. Consider the mean net filtration pressure or pressure drop as 0.3 mmHg in humans.
diameter of capillary pore = 10 nm, viscosity of blood plasma filtrate = 1.2 cP (centiPoise), thickness of the membrane = 0.5 micrometer, tortuosity = 2, 1 P = 100 cP, P = g / cm sec, 760 mmHg = 1 atm., 1 atm. = 101,325 Pa, Pa = N / m^2 ,N = kg m / sec^2

d) Study the graph given below and answer the following questions:
   i) Comment on the viscosity of sickle cell anaemia RBC and normal human RBC.
   ii) The viscosity of normal blood is less than the viscosity of other particulate mixtures shown in the figure, like rigid discs, rigid spheres and oil in water emulsion. Why is it so?



Que. – 5 11

a) Define:

1. shear stress 2. diathermal wall 3. diffusivity

4. osmosis 5. system 6. mean free path

7. Gibb's free energy 8. internal energy 9. thermodynamics

b) Find out the no. of osmoles obtained from the dissociation of 5 moles of magnesium acetate. Do show the equation.

OR

Que. – 5 11

a) Explain the Steric Exclusion & Hydrodynamic drag while discussing the hindrances a solute experiences passing through the capillary pore.

b) Name all the kinds of pressures which create Net Filtration Pressure in the glomerulus of a nephron of kidney.

c) The only life that is present on the planet Biophilus is a small, slimy flat worm that is about 200 mm in length and about 20 mm in width. The slimy gel-like material that covers the flesh of the worm has a thickness of 200 µm. The worm survives through metabolic processes that are limited by the transport of methane present in the planet's atmosphere. Based on the slimy coverings found on earth-based worms, it is estimated that the diffusivity of methane through the worm's slimy covering is 75% of the diffusivity of methane in water at 37 degree Celsius. Consider the diffusivity of methane in water as $2.83 \times 10^{-5}\ cm^2 / sec$. The effective diffusivity of methane in the flesh of the worm is estimated to be about $1.4 \times 10^{-5} cm^2 / sec$. The concentration of methane in the planet's atmosphere was found to be 0.20 mol / L and the molar solubility ratio of methane in the slimy covering of this worm relative to atmospheric methane is 0.10 and is given by:

Solubility ratio = (conc. of methane in slime / conc. of methane in atmosphere) = 0.1

If the fleshy part of the worm is 2 mm thick, estimate the metabolic rate of methane consumption for the worm based on the total volume of the worm (means bulk)

i.e. $T'_{metabolic} = T_{metabolic}(1-\varepsilon)$ in µM / sec.

$$C_{methane}(x) = C_{methane}\big|_{slime\ surface} - \left[\frac{\Gamma_{metabolic}(1-\varepsilon)\delta}{P_m}\right] + \left[\frac{\Gamma_{metabolic}(1-\varepsilon)\delta^2}{2D_e}\right]\left[\left(\frac{x}{\delta}\right)^2 - 2\left(\frac{x}{\delta}\right)\right].$$

Que. – 6 **Answer any three:** 12

a) Derive the Hill's equation and state its significance.

b) Describe the applications of biorheology discussing its usage in any two diseases in detail.

c) What is diffusion? Explain any two equations to understand the physical chemistry of diffusion.

d) Discuss the following in terms of biorheology of blood or shape of RBCs:

I. What would happen if RBCs in blood are exposed to high shear rate?

II. What would happen if RBCs in blood are exposed to low shear rate?

III. What would happen to the viscosity of blood, if Hematocrit value increases?

END OF PAPER