L-4/T-II/BME Date: 19/01/2021

BANGLADESH UNIVERSITY OF ENGINEERING AND TECHNOLOGY, DHAKA

L-4/T-II B.Sc. Engineering Examination 2018-19 (January 2020 Term)

Sub: **BME 405** (Healthcare System Management)

Full Marks: 180 Time 2 Hours

The Figures in the margin indicate full marks.

All the symbols have their usual meanings.

Assume reasonable values for missing data.

USE SEPARATE SCRIPTS FOR EACH SECTION

SECTION – A

There are **FOUR** questions in this section. Answer any **THREE.**

1. (a) What does it mean by 'Hybrid Leadership' in healthcare? Explain the significance of hybrid roles in healthcare sector. **(15)**

   (b) Discuss in brief the sources of healthcare financing in Bangladesh. **(15)**

2. (a) Classify and discuss healthcare organizations based on their ownership, and focus of work. **(20)**

   (b) What does it mean by critical, semi-critical and noncritical medical devices? **(10)**

3. (a) Draw the hierarchy of healthcare delivery organizations in Bangladesh. **(12)**

   (b) Draw a diagram showing the various phases in the life span of a medical device. What safety concerns are related to the packaging and labeling of a medical device? **(18)**

4. (a) Write down the requirements of 'Safe Medical Device Act' (SMDA)? **(14)**

   (b) Why is it important to report medical device problems? What should healthcare professionals do if they experience an incident that falls under the SMDA? **(16)**

SECTION – B

There are **FOUR** questions in this section. Answer any **THREE.**

5. (a) Describe the building blocks of WHO health systems framework. **(18)**

   (b) Draw a diagram showing the interactions between the building blocks of the health systems framework. **(12)**

6. (a) Briefly discuss the role of Bangladesh 'Directorate General of Drug Administration (DGDA)' in medical device regulation. Classify medical devices as per the DGDA guidelines. **(15)**

   (b) Write down the steps of premarket approval and post-market surveillance of medical devices in Bangladesh. What safeguard clauses does DGDA have for medical devices? **(15)**

7. (a) What are the methods used for decontamination of medical devices? Which method is used when and why? **(16)**

   (b) Name the factors affecting the efficacy of the various decontamination methods. **(14)**

8. (a) What are the functions of a clinical engineering department in a hospital? **(10)**

   (b) Discuss in brief the fundamental resources required to develop a clinical engineering department in a hospital. **(20)**

L-4/T-II/BME Date: 09/01/2021

BANGLADESH UNIVERSITY OF ENGINEERING AND TECHNOLOGY, DHAKA

L-4/T-II B.Sc. Engineering Examination 2018-19 (January 2020 Term)

Sub: **BME 407** (Quantitative Physiology)

Full Marks: 180 Time 2 Hours

The Figures in the margin indicate full marks.

All the symbols have their usual meanings.

Assume reasonable values for missing data.

USE SEPARATE SCRIPTS FOR EACH SECTION

SECTION – A

There are **FOUR** questions in this section. Answer any **THREE.**

1. (a) In a patient receiving peritoneal dialysis treatment, the volume of each dialysate exchange is 2 L. The patient has a total blood volume of 6 L, a hematocrit of 50%, and an initial plasma urea concentration of 80 mg/dL (normal value of 15 mg/dL). There is no urea present in the starting dialysate solution and you can assume for the purpose of this calculation that the rate of urea production by metabolism is negligible during the dialysis period. Note that urea is a penetrating solute. Also, assume that the osmolality of the dialysis solution matches that of blood so that there is no net movement of water between the blood and the peritoneal cavity. What will be the final plasma urea concentration after one dialysate exchange, if dialysis reaches equilibrium? How will the plasma urea concentration change if the osmolality of the dialysis solution is increased, resulting in a net movement of 1 L of water into the peritoneal cavity? (15)

   (b) With proper illustration and based on your knowledge on Darrow-Yannet diagram, how would the diagram change and what would be the renal response to hemorrhage? (15)

2. (a) A man's leg was crushed between a car bumper and a wall. His physicians believed that their patient suffered kidney damage from myoglobin blocking glomerular pores. Tests showed the following results: (20)

Plasma creatinine: 30 mg/100 mL plasma

24 hour urine specimen volume: 1 L

Urine creatinine: 30 mg/mL urine

Based on the above data, comment whether the patient has sustained kidney damage or not.

(b) What is renin? Where does it originate and what does it do? (10)

3. (a) If the afferent arteriole of a nephron constricts, what happens to renal blood flow (RBF), glomerular filtration rate (GFR) and filtration fraction (FF) in that nephron and why? If the efferent arteriole of a nephron relaxes, what happens to RBF, GFR, and FF in that nephron and why? Assume that no autoregulation takes place. (15)

(b) The kinetics of ligand binding to receptors can be graphically represented in a variety of ways. Briefly explain those plots and mention when they are used. (15)

4. (a) Your friend has discovered a new species of cetacean (marine mammal) and has asked you to analyze its renal physiology. You measure the following parameters: (15)

Inulin clearance: 250 mL/min

Glucose transport maximum: 50 mg/min

What is the renal threshold for glucose in these species? What is the glucose clearance when plasma glucose concentration is 15 mg/mL?

(b) When the rate of hormone loss is proportional to how much hormone is present, the reaction rate constant is equal to the fractional turnover rate. Derive the mathematical expression representing the above statement. (15)

SECTION – B

There are **FOUR** questions in this section. Answer any **THREE.**

5. (a) A premature baby born is unable to produce adequate surfactant. In order to inhale an adequate amount of air, what do you think the intrapleural pressure has to be compared to a full-term baby? (10)

   (b) The rate of formation of red blood cells depends in part on the recycling of iron from destroyed red blood cells, but can be increased by erythropoietin and mobilization of Fe from ferritin stores in the liver. Suppose that the life-span of the red blood cells is a constant 120 days. Suppose further that the rate of incorporation of Fe into Hb in this person is a constant 21mg per day. How long does it take to recover one-half of the lost Hb when your friend accidently lost his leg and lost 1.5 L of blood before you stopped the bleeding? (20)

6. (a) Show that for an idealized capillary, the fraction of arteriolar solute that would be transferred across the capillary wall if there is no solute in the interstitial fluid can be calculated from the ratio of total diffusional transfer against blood flow and solute concentration difference between the entrance of the capillary and interstitial fluid? (18)

   (b) Draw the operating points of the cardiovascular system and compare with the normal condition for the following cases: (12)

   (i) Hemorrhage

   (ii) Strenuous exercise

   (iii) Transfusion

   (iv) Use of positive inotropic agent

7. (a) Normal values of net rate of CO_2 production or elimination by the body (Q_{CO_2}) = 200 mL min^{-1} (STPD); tidal volume (V_T) = 510 mL (BTPS); anatomic dead space (V_D)= 150 mL (BTPS) and respiration rate (v_R) = 12 min^{-1}. During exercise, Q_{CO_2} increased to 1000 mL min^{-1}(STPD) and v_R increased to 20 min^{-1}. (15)

   (i) What would the V_T be if P_{ACO_2} did not change?

   (ii) If R 0.8, calculate P_{AO_2} (assuming that P_{ACO_2} = 40 mmHg).

(b) What are the effects of the following cases on O_2 dissociation curve compared to the normal condition: (15)

(i) Addition of acid

(ii) Effect of CO_2

(iii) Effect of temperature

Explain the reason for the effect.

8. (a) With appropriate assumption, derive the Henderson-Hasselbalch equation for the HCO_3^- buffer system in terms of partial pressure of CO_2. (18)

(b) Identify the status of different points in the following pH-HCO_3^- diagram. Point A refers to a normal situation where P_{CO_2} is normal, pH is normal and $[HCO_3^-]$ is normal. (12)

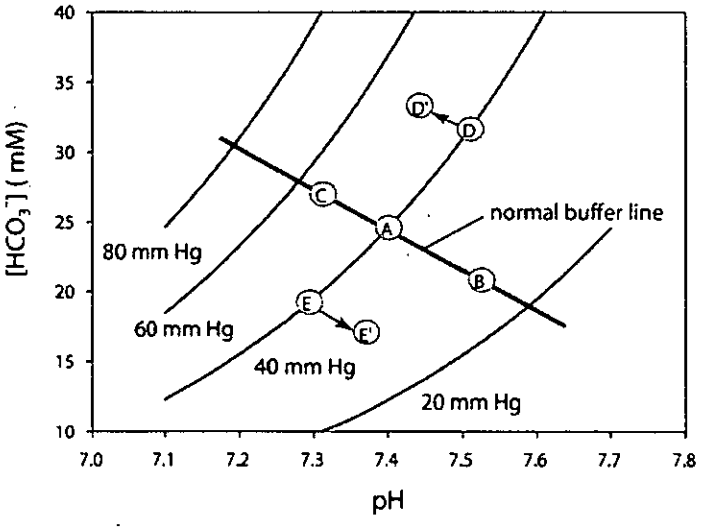

Fig. for Q. 8(b)

L-4/T-II/BME Date: 23/01/2021

BANGLADESH UNIVERSITY OF ENGINEERING AND TECHNOLOGY, DHAKA

L-4/T-II B.Sc. Engineering Examination 2018-19 (January 2020 Term)

Sub: **BME 415** (Bionanomaterials)

Full Marks: 180 Time 2 Hours

The Figures in the margin indicate full marks.

All the symbols have their usual meanings.

Assume reasonable values for missing data.

USE SEPARATE SCRIPTS FOR EACH SECTION

SECTION – A

There are **FOUR** questions in this section. Answer any **THREE.**

1. (a) Biomaterials can be classified as metallic, ceramic, polymeric, and composites. Briefly describe their advantages, disadvantages, and applications along with the examples. **(15)**

   (b) Why do the crystallinity, mechanical properties, thermal properties, aqueous solution properties, and degradation are important for biomedical application? **(15)**

2. (a) Surface modification is a process that considerably changes the surface composition, structure, and morphology of the biomaterials. Describe various surface modification techniques used for biomaterials. **(15)**

   (b) What are the properties required for tissue grafts to work? **(15)**

3. (a) Briefly describe the properties of noble gold nanoparticles that are related to biomedical application. **(15)**

   (b) Bionanocomposites offer versatility in designing specific properties due to a better control of interactions between nanoparticles and polymers. Briefly describe these specific properties of bionanocomposotes. **(15)**

4. (a) Describe different synthesis processes of gold nanoparticles. **(15)**

   (b) How biomaterials can be used for gene and drug delivery? **(15)**

SECTION – B

There are **FOUR** questions in this section. Answer any **THREE.**

5. (a) Explain optical, magnetic and electrical properties of gold nanoparticles, iron nanoparticles and carbon nanotubes, respectively. **(15)**

   (b) The concentration of freshly synthesized silver nanoparticles is measured as 0.25 µg/L using ICP. Assuming that the shape of the particles is cubic and no surface coating are present determine total number of nanoparticle and total surface area of nanoparticle in solution. Assume that the nanosuspension is monodisperse and the average size of the nanoparticles is 100 nm. Silver density is 10.5 g/cm^3. What will be the number and total surface area of nanoparticles if size is reduced to 20 nm? **(15)**

6. (a) With the help of a schematic diagram, explain the conventional methods of nanoparticle synthesis. **(15)**

   (b) Explain how synthesis parameters affect the size and shape of nanoparticles? You may consider gold nanoparticle synthesis protocol of different size and shape. **(15)**

7. (a) Explain the basic principles of nanotools associated with the characterization (i.e., morphology, surface charge, and size) of nanomaterials. **(15)**

   (b) Describe how carbonaceous nanoparticles (i.e., carbon nanotube and graphene) and metallic nanoparticles (i.e., silver nanoparticle) are actively used as antimicrobial agents. **(15)**

8. (a) Distinguish among primary molecular imaging modalities, i.e., ultrasound, optical imaging, magnetic resonance imaging, and nuclear imaging techniques with respect to basic principle of operation, resolution, time and cost. **(15)**

   (b) Explain how a contrast medium alters the MR signal and thus enhances contrast on the resultant image. **(15)**

L-4/T-II/BME Date: 12/01/2021

BANGLADESH UNIVERSITY OF ENGINEERING AND TECHNOLOGY, DHAKA

L-4/T-II B.Sc. Engineering Examination 2018-19 (January 2020 Term)

Sub: **BME 431** (Telemedicine Systems)

Full Marks: 180 Time 2 Hours

The Figures in the margin indicate full marks.

All the symbols have their usual meanings.

Assume reasonable values for missing data.

USE SEPARATE SCRIPTS FOR EACH SECTION

SECTION – A

There are **FOUR** questions in this section. Answer any **THREE.**

1. (a) What is telemedicine? What are the benefits and limitations of telemedicine? (15)

   (b) Briefly describe LAN and WAN and their application in telemedicine. (15)

2. (a) What are the functions of an EMR? Briefly discuss the relationship among EMR, EHR and PHR, and highlight their differences. (20)

   (b) What is the importance of standards in medical data exchange? Name a few commonly used medical data standards and mention their applications. (10)

3. (a) How does electromagnetic interference (EMF) affect a wireless telemedicine system? Discuss its potential sources and possible solutions. (10)

   (b) You are designing a wireless monitoring system for a tele-ICU. The frequency content of physiological signals to be transmitted are provided below: (20)

   (i) Phonocardiogram (PCG) 20 – 500 Hz

   (ii) Electrocardiogram (ECG) 0.5 – 150 Hz

   (iii) Electromyogram (EMG) 0 – 500 Hz

   The wireless transmission channel signal-to-noise-ratio (SNR) is 10dB. Where SNR is defined as: $\text{SNR}\,(dB) = 20\,log_{10}\left(\frac{S}{N}\right)$

   where, S = Maximum peak signal power level.

   N = Channel noise power level.

What is the required bandwidth if all of the physiological signals are needed to be transmitted faithfully for this tele-ICU system? What is the maximum bit-rate that can be achieved in the given scenario?

4 (a) What is medical grade broadband? How is multiprotocol label switching (MPLS) used to achieve a higher quality of service? Compare between traditional IP switching and MPLS. (20)

(b) What are the typical information sources in a telemedicine system? (10)

SECTION – B

There are **FOUR** questions in this section. Answer any **THREE.**

5. (a) What is a Picture Achieving and Communication System (PACS)? Describe the components of a PACS using an appropriate diagram. (20)

(b) What are the benefits of an effective health information system (HIS)? (10)

6. (a) What is mHealth? Discuss its applications and benefits. (20)

(b) Describe the function of an mHealth gateway. Show a basic block diagram. (10)

7. (a) Briefly describe the factors of success in a telemedicine venture. (25)

(b) Google Health has recently developed artificial intelligence (AI) algorithms for breast cancer screening that was published in Nature. The authors claim that the algorithm performs better than radiologists even on unseen test data. However, top academics demanded that Google must open-source their models and data (in a secured way) so that the research results are reproducible. What are the potential security issues in releasing the models and data? (5)

8. (a) What is WBAN? Discuss its function and advantages. (20)

(b) Using a diagram to describe intra-BAN and extra-BAN. (10)

L-4/T-II/BME Date: 16/01/2021

BANGLADESH UNIVERSITY OF ENGINEERING AND TECHNOLOGY, DHAKA

L-4/T-II B.Sc. Engineering Examination 2018-19 (January 2020 Term)

Sub: **BME 443** (Magnetic Resonance Imaging)

Full Marks: 180 Time 2 Hours

The Figures in the margin indicate full marks.

USE SEPARATE SCRIPTS FOR EACH SECTION

SECTION – A

There are **FOUR** questions in this section. Answer any **THREE.**

All the symbols have their usual meanings. Figures in the margin indicate full marks.

Assume reasonable values for missing data.

1. (a) What are the safety hazards in MRI? Discuss any three kinds of such hazard. (20)

   (b) How is an MRI room divided into zones? What kind of personnel has access to the different zones and why? (10)

2. (a) Draw a diagram showing the different components of an MRI equipment. (5)

   (b) Briefly describe the different components of the instrumentation of MRI. (25)

3. (a) Why is magnetic shielding important in MRI instrumentation? Discuss how passive and active shielding are done. (20)

   (b) Briefly discuss the major issues regarding the choice of materials for radiofrequency shielding in an MRI suite. (10)

4. (a) Write short notes on (i) Quench, (ii) RF waveguides and filters, and (iii) LED lighting in MRI suites. (25)

   (b) Discuss the importance of decoupling of transmit and receive coils of the MRI. (5)

SECTION – B

There are **FOUR** questions in this section. Answer any **THREE**

All the symbols have their usual meanings. Figures in the margin indicate full marks.

Assume reasonable values for missing data.

5. (a) Show that (15)

$$\Delta N = \frac{\hbar \gamma B_0}{kT} \frac{1}{2} N_T$$

What is the physical significance of the above expression in MRI?

(b) Find the solution to the Bloch equation given by (15)

$$\frac{d\overline{M}}{dt} = \overline{M} \times \gamma \overline{B}$$

Comment on your solution.

6. (a) Explain why is T_1 relaxation time longer than the T_2 relaxation time? Why is T_2 relaxation called spin-spin relaxation? (15)

(b) Briefly discuss how the contrast of an MRI image of body tissues is affected by the selection of T_1, T_2 and T_E times. (15)

7. (a) Develop the analytical relation between signal intensity in the X-Y plane with the corresponding flip angle after RF excitation. What is the optimal value of the flip angle? (15)

(b) Show that the samples of the received signal in the receiver coil are actually the samples of the Fourier transform of the object under scanning in an MRI system. (15)

8. (a) What is phase encoding? Explain with a suitable example. (15)

(b) Write short notes on the following for an MRI system: (i) image artefacts, (ii) field of view and aliasing, and (iii) effect of RF and *Larmor* frequencies on slice selection. (15)