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

1. (a) What is meant by reaction rate? What is the difference between average rate and instantaneous rate? Name three factors that can effect the rate of a chemical reaction.

(b) For a generic second order reaction $A \rightarrow B$, what quantity, when graphed versus time, will yield straight line? What will be the slope of the straight line? How do the half-lives of first-order and second-order reactions differ?

(c) What factors determine, whether a collision between two molecules will lead to a chemical reaction? Does the rate constant of a chemical reaction will increase or decrease with increase in temperature? How does the kinetic molecular theory help us to understand the temperature dependence of chemical reactions?

(d) The reaction $2\text{ClO}_2(aq) + 2\text{OH}^- (aq) \rightarrow \text{ClO}_3^-(aq) + \text{ClO}_2^-(aq) + \text{H}_2\text{O}(l)$ was studied with the following results:

<table>
<thead>
<tr>
<th>Experiment</th>
<th>$[\text{ClO}_2]$ (M)</th>
<th>$[\text{OH}^-]$(M)</th>
<th>Initial Rate (M/s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>0.060</td>
<td>0.030</td>
<td>0.0248</td>
</tr>
<tr>
<td>2</td>
<td>0.020</td>
<td>0.030</td>
<td>0.00276</td>
</tr>
<tr>
<td>3</td>
<td>0.020</td>
<td>0.090</td>
<td>0.00828</td>
</tr>
</tbody>
</table>

Determine the rate law for the reaction. Calculate the rate constant for the reaction. Calculate the rate when $[\text{ClO}_2] = 0.100$ M and $[\text{OH}^-] = 0.050$ M.

2. (a) Considering the energetics of solute-solute, solvent-solvent, and solute-solvent interactions, explain why NaCl dissolves in water but not in benzene. What factors cause a cation to be a strongly hydrated?

(b) How does the increase in concentration of a nonvolatile solute in water affect the properties; vapor pressure and osmotic pressure?

(c) What is the freezing point of an aqueous solution that boils at 105.0°C? Here consider, $K_b = 0.51$ and $K_f = 1.86$
CHE 127/BME
Contd ... Q. No. 2

(d) Describe Henry’s Law and explain the effect of pressure on the solubility of different gases in liquid. 
(5)

(e) Most fish need at least 4 ppm dissolved $O_2$ for survival. What is this concentration in mol/L? What partial pressure of $O_2$ above the water is needed to obtain this concentration at 10°C? (The Henry’s law constant for $O_2$ at this temperature is $1.7 \times 10^{-3}$ mol/L-atm.) 
(7)

3. (a) Describe the kinetic molecular theory of gases. How it describes the effect of temperature on the pressure of gas? 
(8)

(b) What is an ideal gas? Show how Boyle’s law, Charles’s law, and Avogadro’s law can be combined to give the ideal gas equation. 
(7)

(c) Explain the factors that are responsible for deviation of real gases to follow ideal gas equation? Write down the van der Waals equation of real gases. Briefly explain the significance of the constants $a$ and $b$ in the van der Waals equation. 
(15)

(d) Explain the difference between diffusion and effusion. 
(5)

4. (a) Explain the effect of changes in entropy on the formation of solution. 
(7)

(b) How the molecular weight of a protein can be determined by measuring osmotic pressure? 
(5)

(c) What is anemia? Explain the cause of anemia in terms of chemical structure changes in protein? 
(8)

(d) Derive the integrated rate equation of zero-order, first order and second order reactions. 
(15)

SECTION – B
There are FOUR questions in this section. Answer any THREE.
Assume reasonable values for any missing data.
Symbols used here bear usual meaning.

5. (a) Explain why: 
(12)

(i) The specific conductance increases but the equivalent conductance decreases with increasing the concentration of an electrolyte in solution.

(ii) The ionic mobility of alkali metal ions follows the trend: $K^+ > Na^+ > Li^+$ although their size follows the same trend.

Contd .......... P/3
(b) State and explain the Ostwald dilution law. Explain how you can determine $\alpha$ and $\gamma_0$ of a weak electrolyte with the help of the law. (14)

(c) The resistance of 0.01 N NaCl solution at 298 K is 200 ohm. If the cell constant is unity, calculate the equivalent conductance of the solution. (9)

6. (a) Rationalize: (12)

(i) Platinum is used in hydrogen electrode.

(ii) The electrical work produced in a reversible cell is equal to the decrease in free energy accompanying the cell reaction.

(b) Define hydrolysis. Derive expression for hydrolysis constant and pH of a solution of a weak acid and a strong base. (14)

(c) What would be the pH of a 0.1 M sodium acetate solution when the dissociation constant for acetic acid is $1.8 \times 10^{-5}$? (9)

7. (a) Justify: (12)

(i) All spontaneous processes are accompanied by an increase in entropy.

(ii) Hydrogen and helium show heating effect in Joule-Thomson experiments.

(b) Obtain an expression for entropy change of an ideal gas when the temperature changes from $T_1$ to $T_2$ and volume from $V_1$ to $V_2$. (14)

(c) Calculate the entropy change involved in the isothermal reversible expansion of 5 moles of an ideal gas from a volume of 10L to a volume of 100L at 300K. (9)

8. (a) Define the following terms: (12)

(i) Phase. (ii) Components (iii) Degree of freedom

(b) Draw and explain the phase diagram of a two-component system where a compound is formed by the components showing two eutectics and a congruent melting point. (14)

(c) What is a condensed system? Why is the reduced phase rule used for such a system? (9)
SECTION – A

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

1. (a) Which one is known as the "control center" of cells? With a schematic show the different morphological components of that "control center". (11)
   (b) Why cholesterol is important for cells? (6)
   (c) Describe the fluid-mosaic model. What is the most important concept of this model? (12)
   (d) Describe the functions of microtubules. (6)

2. (a) Write down the cellular, matrix, organic and inorganic composition of bones. (10)
   (b) What are the important functions of bone and cartilage? What are the factors affecting bone growth? (8+5)
   (c) Which one is the most movable joint in the body? Why the knowledge of synovial joint is important for a biomedical engineer? (12)

3. (a) Write down the functions of the cardiac muscle. (8)
   (b) When a muscle is attached eccentrically and contracts, the force exerted along the line of its tendon can be resolvable into three components. With schematic explain these three components. (9)
   (c) In general, why are intramuscular injections absorbed faster than subcutaneous injections? Why are intramuscular injections given into deltoid muscle? (8)
   (d) Mention the differences between the right and left lung. (10)

4. (a) What are pleura? With a schematic, label the parts of the pleura. (10)
   (b) With a schematic, describe the pulmonary circulation. (10)
   (c) Name the main components of cardiac conducting system? Which is known as the pace maker of the heart, and why? (10)
   (d) Mention the differences between children and adult trachea. (5)

Contd .......... P/2
BME 103

SECTION – B

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

5. (a) Name the lymphatic organs. Mention the functions of lymphatic system. (3+5=8)
(b) Write about the characteristic features of large intestine. State the functions of
(i) Liver (ii) Gall bladder. (4+6=10)
(c) Draw and label the different parts of (i) Pancreas (ii) Stomach. (4+4=8)
(d) Write briefly on-
   (i) constrictions of oesophagus
   (ii) constrictions of ureter

6. (a) Mention two examples of each of the following joints (i) Ball and socket joint
(ii) Pivot (iii) Hinge (iv) Secondary cartilaginous joint. (4×2=8)
(b) What is line of gravity? Write about the transmission of weight through the body of
a man weighing 76 kg carrying 24 kg weight in his right hand. (5+10=15)
(c) Name the bones contributing to the formation of arch of the foot. Mention the
functions of arch of the foot. (6+6=12)

7. (a) What are the parts of male urethra? Draw and label the functional unit of kidney. (4+4=8)
(b) Differentiate between exocrine and endocrine gland. Explain why pituitary gland is
connected with hypotalamus.
   Name the hormones of anterior pituitary gland. (4+4+4=12)
(c) Name the lobes of cerebrum. Mention the functions of any two of them. (2+6=8)
(d) Explain why auditory tube opens into the pharynx. (2+2+3)
   Name the skin appendages
   Mention the functions of skin.

8. (a) What are the glial cells? Mention their functions. (3+5=8)
(b) What are the contents of middle ear cavity?
   What are the parts of different coats of eyeball? (5+6=11)
(c) How subarachnoid space is formed? Give its contents. (3+3=6)
(d) Write the contents of (i) superior mediastinum (ii) female pelvic cavity. (5×2=10)
SECTION A

1. (a) Assume that a current $i(t) = I_m \cos \omega t$ flows through a series RC branch. Derive the expressions for applied voltage, impedance, instantaneous power, real power and reactive power. Also draw the wave shape of power. (15)

(b) Find $Z_{eq}$ in the circuit shown in Fig. for Q. No. 1(b) (20)

2. (a) Draw the phasor diagram of $V_C$, $V_R$, $V_L$, $I$, $I_1$ and $I_2$ assuming $V_{AB}$ as reference for the circuit shown in Fig. for Q. No. 2(a). (20)

(b) Assume that a voltage $v(t) = 10 \sin(2000\pi t + 30^\circ)V$ is applied in the circuit shown in Fig. for Q. No. 2(b). Find the expressions of $i(t)$, $i_1(t)$ and $v_1(t)$. (15)

3. (a) Find the Thevenin equivalent circuit at terminals a-b in the circuit shown in Fig. for Q. No. 3(a). (17)

(b) Find $I_0$ of the circuit shown in Fig. for Q. No. 3(b). Also, find (i) expression of instantaneous power in 0.1 F capacitance, (ii) total real power dissipated in the circuit, and (ii) power factor of the load seen by the current source. (18)

4. (a) Find the mesh currents $I_1$ and $I_2$ in the circuit shown in Fig. for Q. No. 4(a) (12)

(b) Find $I_a$ and $I_{AB}$ in the circuit shown in Fig. for Q. No. 4(b) (10)

(c) Design a circuit using op-amp with inputs $v_1$, $v_2$, and $v_3$ to compute $v_0 = 4v_1 + 6v_2 + 3v_3$. (13)

Contd ........... P/2
EE 171/BME

SECTION – B

There are FOUR questions in this Section. Answer any THREE.

Symbols have their usual meanings.

5. (a) Find the equivalent resistance between terminals ‘a’ and ‘b’ in the circuit shown in Fig. for Q. No. 5(a).

(b) For the circuit shown in Fig. for Q. No. 5(b), calculate the power supplied by each independent source. Is the total power supplied and absorbed by the different elements of the circuit equal? Justify your answer.

6. (a) Find $v_1$, $v_2$, and $v_3$ using nodal analysis for the circuit shown in Fig. for Q. No. 6(a).

(b) Using mesh analysis, find the value of $v_0$ in the circuit shown in Fig. for Q. No. 6(b).

7. (a) The variable resistor ($R_L$) in the circuit shown in Fig. for Q. No. 7(a) is adjusted until the power dissipated in the resistor ($R_L$) is 250 W. Find the values of $R_L$ that satisfy this condition.

(b) Find $V_0$ using superposition theorem for the circuit shown in Fig. for Q. No. 7(b).

8. (a) Determine what type of filter is shown in Fig. for Q. No. 8(a). Calculate the cutoff frequency. Take $R = 2 \, \text{k} \Omega$, $L = 2 \, \text{H}$, and $C = 2 \, \mu\text{F}$.

(b) Design an active high pass filter with a high frequency gain of 5 and a cutoff frequency of 2 kHz. Use a 0.1 \mu\text{F} capacitor in your design.
L-1/T-2/BME  
Date: 28/02/2018

BANGLADESH UNIVERSITY OF ENGINEERING AND TECHNOLOGY, DHAKA


Sub: MATH 115 (Complex Variable and Vector Calculus)

Full Marks: 210  Time: 3 Hours

The figures in the margin indicate full marks.

Symbols have their usual meaning.

USE SEPARATE SCRIPTS FOR EACH SECTION

SECTION-A

There are FOUR questions in this Section. Answer any THREE.

1. (a) Find the loci of the points \( z \) satisfying the following conditions:

\[
\begin{align*}
(i) & \quad \left| \frac{z-i}{z+i} \right| \geq 2 \\
(ii) & \quad |z^2 - 1| < 1
\end{align*}
\]

(b) Show that \( f(z) = |z| \) is nowhere differentiable.

(c) Show that \( u = e^{-x}(x \sin y - y \cos y) \) harmonic. Find \( v \) such that \( f(z) = u + iv \) is analytic.

2. (a) Find all solutions of the equation \( \cosh z = 2 \).

(b) For any nonzero complex numbers \( z_1 \) and \( z_2 \) prove that \( |z_1 + z_2| \leq |z_1| + |z_2| \).

(c) Find the values of \( \oint_C \frac{e^z}{z^2 + 1} dz \), where \( C \) is the circle \( |z| = 3 \) and \( t > 0 \).

3. (a) Expand \( f(z) = \ln\left(\frac{1+z}{1-z}\right) \) in a Taylor series about \( z = 0 \) and state the region where the expansion is valid.

(b) Expand the function \( f(z) = \frac{1}{(z+1)(z+3)} \) in a Laurent series valid in the regions

\[
\begin{align*}
(i) & \quad 1 < z < 3 \\
(ii) & \quad 0 < |z + 1| < 2
\end{align*}
\]

(c) Evaluate the value of \( \oint_C \frac{e^{3z}}{z - \pi i} dz \), where \( C \) is a curve \( |z - 2| + |z + 2| = 6 \).

4. (a) Find the singular points of the following functions and determine their nature:

\[
\begin{align*}
(i) & \quad f(z) = \frac{z^2}{(z+1)^2} \sin\left(\frac{1}{z-1}\right) \\
(ii) & \quad f(z) = \frac{\sin\left(\frac{1}{z}\right)}{(z^2 - 1)^2} \\
(iii) & \quad f(z) = \frac{1}{z(e^z - 1)}
\end{align*}
\]

(b) Evaluate \( \oint_C \frac{e^{2z}}{z^2 (z^2 + 2z + 2)} dz \), where \( C \) is the circle with equation \( |z| = 3 \).

Contd ........... P/2
MATH 115/BME

SECTION – B

There are FOUR questions in this Section. Answer any THREE.

5. (a) A particle moves along the curve \( x = e^{-t}, \ y = 2\cos 3t, \ z = 2\sin 3t \). Find the components of its velocity and acceleration at time \( t = 0 \) in the direction \( i - 3j + 2k \).

(b) Find the directional derivative of \( \phi(x, y, z) = 4xz^3 - 3x^2y^2z \) at the point \( (2, -1, 2) \) in the direction of \( 2i - 3j + 6k \).

(c) Find the equation of the tangent line and normal plane to the curve of intersection \( x^2 + y^2 + z^2 = 1 \), and \( x + y + z = 1 \) at the point \( (1, 0, 0) \).

6. (a) A fluid motion is given by \( \vec{v} = (y \sin z - \sin x)i + (x \sin z + 2yz)j + (xy \cos z + y^2)k \). Is the motion irrotational? If so, find the velocity potential.

(b) If \( \vec{a} \) is a constant vector and \( \vec{r} = xi + yj + zk \),

\( \text{(i) find } \nabla \cdot (\vec{a} \times \vec{r}) \ \text{and } \nabla \times (\vec{a} \times \vec{r}) \ \text{as } r^n \)

\( \text{(ii) show that } \nabla \times (\vec{a} \times \vec{r}) = -\frac{\vec{a}}{r^3} + \frac{3r}{r^3}(\vec{a} \cdot \vec{r}) \)

7. (a) Evaluate \( \iint_{S} \vec{F} \cdot \hat{n} \, dS \), where \( \vec{F} = 2xyi - yzj + x^2k \) over the surface \( S \) of the cube bounded by the co-ordinate planes and the planes \( x = a, \ y = a \) and \( z = a \).

(b) Evaluate \( \iiint_{V} y^2z \, dV \), where \( V \) is the region bounded by the planes \( x + 4y + 2z = 4, \ x = 0, \ y = 0 \) and \( z = 0 \).

8. (a) Use Green’s theorem to evaluate the integral \( \oint_{C} (xy + y^2) \, dx + x^2 \, dy \), where \( C \) is the closed curve of the region bounded by \( y = x \) and \( y = x^2 \).

(b) State Gauss divergence theorem and verify this theorem for the vector function \( \vec{F} = 4xi - 2y^2j + z^2k \) taken over the region bounded by \( x^2 + y^2 = 4, \ z = 0 \) and \( z = 3 \).
L-1/T-2/BME Date: 06/03/2018

BANGLADESH UNIVERSITY OF ENGINEERING AND TECHNOLOGY, DHAKA


Sub: PHY 167 (Electricity and Magnetism, Modern Physics and Mechanics)

Full Marks: 210 Time: 3 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.

1. (a) State Gauss’s law. Explain why it is important in electrostatics. (7)
   (b) Obtain an expression for the electric field at a point (i) inside, (ii) outside, and (iii) surface of a uniformly charged spherical shell. (18)
   (c) The plates of a capacitor carry charge +q and –q. Each plate has area of 40 cm² separated by a distance of 10 mm. Between the plate the field is constant at E = 100 kV/m and the field is zero outside the plates. Find q. (10)

2. (a) Define electric potential, electric potential energy and equipotential surface. (9)
   (b) Show that the potential at a point in an electric field at a distance r
      (i) due to a point charge is \( V = \frac{1}{4 \pi \varepsilon_0} \frac{q}{r} \) and (ii) due to an electric quadrupole is
      \( V = -\frac{1}{4 \pi \varepsilon_0} \frac{Q}{r^3} \), where the symbols have their usual meanings. (18)
   (c) The protons in a nucleus of U²³⁸ are 6.0 \( \times 10^{-15} \) meter apart. What is their mutual electric potential energy? (8)

3. (a) State and explain Faraday’s law of electromagnetic induction. Calculate the coefficient of self-induction of a long solenoid which is wound on an iron core of relative permeability \( \mu_r \). (13)
   (b) A circuit contains an inductor having inductance, L, and a resistance, R, placed in series with a battery of emf, \( \varepsilon \). Obtain an expression for the growth of current in the circuit. What is the time constant of the circuit? (14)
   (c) Find the values of current in the above mentioned LR circuit at time \( t = 0 \) and at \( t = \frac{1}{2} \frac{L}{2R} \). (8)

Contd .......... P/2
PHY 167/BME

4. (a) Explain inertial frame of reference and non-inertial frame of reference. 
   (b) Describe the Michelson-Morley experiment. Explain the physical significance of the result of this experiment.
   (c) The rest mass and kinetic energy of a particle are \( m_0 \) and \( K \), respectively. Show that the momentum of that particle is
   \[
   P = \sqrt{\frac{k^2}{c^2} + 2m_0K}
   \]
   Where ‘c’ is the velocity of light.

SECTION - B

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

5. (a) Briefly describe a photomultiplier tube with schematic diagram.
   (b) What is de Broglie’s hypothesis? Derive an expression for the matter wavelength using de Broglie’s hypothesis.
   (c) A photon of 1 MeV collides with a free but stationary electron and scatters off at an angle 90°. What are the energies of the scattered photon and the kinetic energy of the recoil electron?

6. (a) Write a short note on magic number of nucleons.
   (b) Describe the different parts of a nuclear reactor with a schematic diagram.
   (c) A nuclear reactor uses \( ^{238}_{92}U \) to create a power level of 300 MW. Calculate the rate of consumption of \( ^{238}_{92}U \) per year. Given that the energy released per fission of \( ^{238}_{92}U \) is 200 MeV and mass of each nucleon is equal to 1 a.m.u. = \( 1.66 \times 10^{-27} \) kg.

7. (a) Define torque. State the principle of the conservation of angular momentum. Show that the relation \( L = I_0 \omega \) where the symbols have their usual meaning.
   (b) Derive Bernoulli’s equation for a fluid in streamline motion.
   (c) Calculate the speed at which the velocity head of a stream of water is equal to 0.50 m of Hg.

Contd ………… P/3
8. (a) What is meant by the coefficient of viscosity of a liquid? Write down its unit and dimensions.

(b) Write down the time-independent Schrödinger equation for a particle moving in a potential $V$. Consider a particle moving freely in a one-dimensional box of length $D$. The potential energy of the particle may be expressed as

$$V(x) = \begin{cases} 0, & 0 \leq x \leq D \\ \infty, & x < 0, x > D \end{cases}$$

Determine its energy eigenvalue and normalized wave function.

(c) Find the probability current density carried by a plane wave $\psi(x) = Ae^{ikx}$ in one dimension.