L-1/T-1/CE **Date: 28/04/2024**

BANGLADESH UNIVERSITY OF ENGINEERING AND TECHNOLOGY, DHAKA

L-1/T-1 B.Sc. Engineering Examinations 2022-2023

Sub: **PHY 101** (Physical Optics, Waves and Oscillations and Heat & Thermodynamics)

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** questions.

1. (a) What is degrees of freedom? State the law of equipartition of energy. **(8)**

   (b) Two reversible engines, A and B, are operating between the same two temperature limits, T_1 (higher) and T_2 (lower). Prove that their efficiencies are equal. **(17)**

   (c) A Carnot engine has an initial efficiency of $\frac{1}{2}$. When the temperature of the sink reservoir is increased by 100K, the efficiency drops to $\frac{1}{3}$. Determine the temperatures of both the source reservoir and the sink reservoir in the original state. **(10)**

2. (a) State the third laws of thermodynamics. **(5)**

   (b) Discuss and obtain the expression of Clausius-Clapeyron's latent heat equation. **(20)**

   (c) Calculate the latent heat of ice given that change of pressure of 1 atmosphere changes the melting point of ice by 0.0074°C and when 1 gm of ice melts volume changes by 0.0907 cc. **(10)**

3. (a) Enlist thermodynamic functions with their mathematical expressions. **(5)**

   (b) Formulate the Maxwell's thermodynamic relations by using the thermodynamic functions. **(20)**

   (c) The critical temperature and pressure of Argon are -122°C and 48 atm, respectively. Given R = 8.31 J/mole-K, $N_A = 6.02 \times 10^{23}$ mol^{-1} and 1 atm = 1.013×10^5 N/m^2. Find the radius of an Argon atom. **(10)**

4. (a) What do you understand by the missing order in case of diffraction grating? Discuss the difference between dispersive power and resolving power of a grating. Write down Rayleigh's criterion. **(10)**

   (b) Obtain the expressions of dispersive power and resolving power of a grating. **(18)**

   (c) Calculate the minimum number of lines in grating which will just resolve the sodium lines in the first order spectrum. The wavelengths of sodium lines are 589 nm and 589.6 nm. **(7)**

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SECTION – B

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

5. (a) How can a coherent light be produced? Distinguish between constructive and destructive interference of light. **(8)**

(b) (i) Discuss Lloyd experiment and conclude its results, and (ii) State and prove Stock's theorem about phase changes of light. **(20)**

(c) In a Newton's rings experiment, if a drop of water, whose refractive index is 1.33, is placed in between the plano-convex lens and the glass plate, the diameter of the 10^{th} ring is found to be 0.6 cm. Calculate radius of curvature of the plano-convex lens. The wavelength of light used is 600 nm. **(7)**

6. (a) Why natural light is unpolarized? What is polarization of light? Write down the name of the processes by which unpolarized light can be polarized. **(8)**

(b) (i) A beam of circularly polarized light falls on a polarizing sheet. Show that the intensity of the transmitted light is half the intensity of the circularly polarized light.

(ii) A plane polarized light wave of amplitude E_o falls on a calcite quarter-wave plate with its plane of vibration at 45° to the optic axis of the plate, which is taken as y-axis. The emerging light will be circularly polarized. In what direction will the electric vector appear to rotate? Assume that the direction of propagation is out of the page. **(8+12)**

(c) Two polarizing sheets have their polarizing directions parallel so that the intensity I_m of the transmitted light is a maximum. Through what angle must either sheet be turned if the intensity is to drop by one-half? **(7)**

7. (a) Define forced vibrations. Describe what happens when the frequency of the applied force is equal to the natural frequency of the oscillating body. **(7)**

(b) A U-tube, open at both ends, is filled with an incompressible fluid of density ρ. The cross-sectional area A of the tube is uniform, and the total length of the fluid in the tube is $L(=2l)$, see Figure 7(b). A piston is used to depress the height of the liquid column on one side by a distance x (raising the other side by the same distance) and then is quickly removed; Find an expression for the total energy of the oscillation and hence derive the differential equation of motion. Neglect any resistive forces at the walls of the U-tube. **(16)**

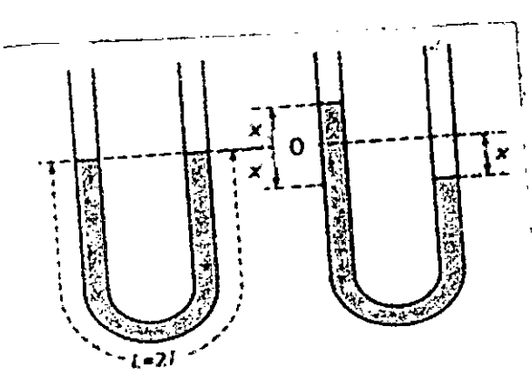

Figure for question no. 7(b)

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PHY 101 (CE)

(Continuation Q. No.7)

(c) A building consist of two floors. The first floor is attached rigidly to the ground, and the second floor is of mass m=10,000 kg. The elastic framed of the building behaves as a spring that resist horizontal displacements of the second floor; it requires a horizontal force of 50,000 N to displace the second floor a distance of 0.5 m. Assume that in an earth-quake, the ground oscillates horizontally with amplitude A_o and angular frequency ω", resulting in an external horizontal force $F(t) = mA_o(\omega'')^2 \sin(\omega''t)$ on the second floor. (i) What is the natural frequency (in hertz) of oscillations of the second floor? (ii) If the ground undergoes one oscillation every 2.25 s with an amplitude of 0.075 m, what is the amplitude of the resulting forced oscillations of the second floor? Ignore the air resistance. **(12)**

8. (a) What are reverberation and reverberation time? Describe the acoustic requirements of a good auditorium. **(8)**

(b) A plane progressive wave is propagating through a fluid medium of density ρ. Deduce the expressions for energy density and intensity of the plane progressive wave. **(17)**

(c) A progressive wave is represented by th4e equation $y = 0.25 \sin\frac{\pi}{65}(6800t - 2x)\,cm$.

If the wave is travelling through a medium of density $0.00129\ g/cm^3$, find the flow of energy across cm^2/sec. **(10)**

L-1/T-1/CE Date: ~~04/05/2024~~ 25/5/2024

BANGLADESH UNIVERSITY OF ENGINEERING AND TECHNOLOGY, DHAKA

L-1/T-1 B. Sc. Engineering Examinations 2022-2023

Sub: **CHEM 103** (Chemistry-I)

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 to **Question no. 1 is Compulsory**.
Answer any **TWO** questions from Questions 2-4.

1. (a) Define internal energy and enthalpy of a system. Relate internal energy, enthalpy and P-V work of a system. **(10)** (CO1)

   (b) Discuss the construction of two calorimeters to measure enthalpy and internal energy change of a reation. **(10)** (CO2)

   (c) Apply Hess's law to determine the enthalpy of formation of a compound. **(10)** (CO3)

   (d) A 0.5865g sample of lactic acid ($HC_3H_5O_3$) is burned in a calorimeter whose heat capacity is 4.812 kJ/°C. The temperature increases from 23.10 °C to 24.95 °C. Calculate the heat of combustion of lactic acid per mole. **(5)** (CO4)

2. (a) Identify the effects of change in concentrations, electrode area, and temperature on the emf of the cell. **(10)**

   (b) Discuss the processes of rusting on iron and proof that rusting of iron constructs a voltaic cell. **(10)**

   (c) Apply the principle of concentration cell to measure the pH of a solution using a pH electrode. **(10)**

   (d) Show the steps for balancing the following reaction in basic medium **(5)**

   $NO_2^-(aq) + Al(s) \rightarrow NH_4^+(aq) + AlO_2^-(aq)$

3. (a) Define conjugate acids and conjugate bases. Outline the concept of conjugate acid and conjugate base to describe strong acid, strong base, weak acid and weak base. **(10)**

   (b) Relate the nature of cation and anion to determine the relative acidity and basicity of the aqueous salt solutions. **(10)**

   (c) Sketch the titration plots of strong acid with strong base and weak acid with strong base. Demonstrate their differences. **(10)**

   (d) Calculate the pH in the solution formed by adding 10 mL of 0.05 M NaOH to 40 mL of 0.0250 M benzoic acid ($K_a = 6.3\times10^{-5}$). **(5)**

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CHEM 103/CE

4. (a) Identify and outline the factors that affect solubility of solute in aqueous solution. **(10)**

   (b) Explain that elevation of boiling point and osmotic pressure are colligative properties. **(10)**

   (c) Apply Henry's law for the identification of gases. **(10)**

   (d) Glycerin ($C_3H_8O_3$) is a nonvolatile nonelectrolyte with a density of 1.26 g/mL at 25°C. Calculate the vapor pressure at 25°C of a solution made by adding 50 mL of glycerin to 500.0 mL of water. The vapor pressure of pure water at 25°C is 23.8 torr, and its density is 1 g/mL. **(5)**

SECTION – B

There are **FOUR** questions in this section. Answer to **Question no. 5 is Compulsory**.
Answer any **TWO** questions from Questions 6-8.

5. (a) State the principles of valence bond theory (VBT) for formation of covalent bonding. **(10)** (CO1)

   (b) Discuss the polarity of BF_3 and NH_3 by drawing their structures according to VSEPR theory. **(10)** (CO2)

   (c) Compare the bond length, stability and magnetic properties of N_2^- and N_2^+ by drawing the molecular orbital diagrams. **(10)** (CO3)

   (d) Identify the most preferable Lewis structure of N_2O by drawing all the possible Lewis structures with formal charges. **(5)** (CO4)

6. (a) The last electron of potassium atom is placed at *4s* orbital rather than at *3d* – rationalize this based on Aufbau principle and effective nuclear charge. **(15)**

   (b) Arrange Mg, Al, Ga according to increasing IE_3 (3^{rd} ionization energy) values and justify your answer. **(10)**

   (c) What do you understand by isoelectronic species? Arrange F^-, Ne and Na^+ according to increasing radii and justify your answer. **(10)**

7. (a) What do you understand by quantization of angular momentum? Heisenberg's uncertainty principle contradicts Bohr's atomic model-explain. **(15)**

   (b) Draw the radial probability distribution curve for *3s* orbital and discuss its radial nodes and angular nodes. **(10)**

   (c) Spectral lines of Lyman and Balmer series do not overlap – verify this statement by calculating the longest wavelength associated with the Lyman series and the shortest wavelength associated with the Balmer series (in nm) ($R_H = 10973731\ m^{-1}$). **(10)**

8. (a) What do you understand by emulsification? The concept of colloid formation is used in the cleansing action of soap and detergent – explain. **(15)**

   (b) Discuss the concepts of peptization and coagulation with suitable examples. **(10)**

   (c) The concept of colloids can be applied to remove dust from the industrial smoke-illustrate this by drawing a tentative diagram. **(10)**

CO-Question Mapping for Accreditation Purposes

Course No: Chem 103

CO1	Identify fundamental concepts of atomic structure, chemical bonding, periodic table, colloids, thermochemistry, electrochemistry, solutions and acids and bases	C1
CO2	Illustrate the basic principles associated with atomic structure, chemical bonding, periodic table, colloids, thermochemistry, electrochemistry, solutions and acids and bases	C2
CO3	Solve problems associated with atomic structure, chemical bonding, periodic table, colloids, thermochemistry, electrochemistry, solutions and acids and bases	C3
CO4	Analyze the behavior of materials and examine environmental challenges with the concept of chemistry.	C4

L-1/T-1/CE Date: ~~18/04/2024~~ 19/05/2024

BANGLADESH UNIVERSITY OF ENGINEERING AND TECHNOLOGY, DHAKA

L-1/T-1 B. Sc. Engineering Examinations 2022-2023

Sub: **MATH 137** (Differential and Integral Calculus, Matrices)

Full Marks: 210 Time: 3 Hours

The figures in the margin indicate full marks.

Symbols used have their usual meaning.

USE SEPARATE SCRIPTS FOR EACH SECTION

SECTION – A

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

1. (a) Use numerical evidence to make a conjecture about the value of $\lim_{x\to 0}\frac{e^x-1}{x}$. Confirm your conclusion about the limit by graphing the function over an appropriate interval. **(15)**

(b) Discuss the continuity and differentiability of $f(x)=\begin{cases} x^2\sin\frac{1}{x}, & x\neq 0 \\ 0, & x=0 \end{cases}$. Sketch the graph of f near $x=0$. **(20)**

2. (a) If $x=\sin(\ln y)$, then find $(y_n)_0$. **(10)**

(b) Find an equation for the tangent line to the Folium of Descartes $x^3+y^3=3xy$ at the point $\left(\frac{3}{2},\frac{3}{2}\right)$. At what point(s) in the first quadrant is the tangent line to the Folium of Descartes horizontal? **(15)**

(c) Compute the length of the polar subtangent, subnormal of the curve $r^2=4\cos\theta$ at $\theta=\frac{\pi}{6}$. **(10)**

3. (a) Find the pedal equation of $r^m\cos m\theta=1$. **(10)**

(b) If $u(x,y,z)=x^3+y^3+z^3$ then prove that $x\frac{\partial u}{\partial x}+y\frac{\partial u}{\partial y}+z\frac{\partial u}{\partial z}=3u$. How can you justify it with the Euler's Theorem. **(10)**

(c) A concrete barrier whose cross section is an isosceles triangle runs parallel to a wall. The height of the barrier is 3 feet, the width of the base of a cross section is 8 feet, and the barrier is positioned on level ground with its base 1 feet from the wall. A straight, stiff metal rod of negligible diameter has one end on the ground, the other end against the wall, and touches the top of the barrier. What is the minimum length the rod can have? **(15)**

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MATH 137/CE

4. (a) Evaluate the integral **(15)**

$$\int \frac{2}{(2-x)^2}\sqrt[3]{\frac{2-x}{2+x}}\,dx$$

(b) Derive the reduction formula for $\int \frac{dx}{\sin^m x \cos^n x}$ and hence evaluate $\int \frac{dx}{\sin^3 x \cos^3 x}$. **(20)**

SECTION – B

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

5. (a) Derive the reduction formula for $\int x^m (\ln x)^n dx$ and hence evaluate $\int x^3 (\ln x)^2 dx$. **(15)**

(b) Evaluate $\lim_{n\to\infty}\left[\frac{1}{n^2}\sec^2\left(\frac{1}{n^2}\right)+\frac{2}{n^2}\sec^2\left(\frac{4}{n^2}\right)+\frac{3}{n^2}\sec^2\left(\frac{9}{n^2}\right)+\cdots\cdots+\frac{1}{n}\sec^2(1)\right]$. **(10)**

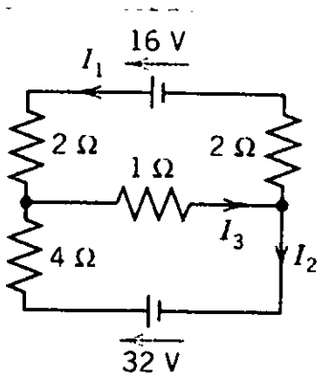
(c) Calculate the value of the integral using Gamma-Beta function: $\int_0^{\pi/2}\sqrt{\tan\theta}\,d\theta$. **(10)**

6. (a) Identify and measure the area interior to the curves $y = 4x - x^2$ and $y = x^2$. **(11)**

(b) Evaluate $\iint_R 7xy\,dA$, where R is bounded by $2x+3y=1, 2x+3y=3, x-2y=2$, and $x-2y=-2$. **(12)**

(c) Find the volume of the solid bounded by the surface $z = x^2 + y^2$, the cylinders $y = 2\sqrt{x}$, $x = 2\sqrt{y}$ and the xy-plane using triple integral. **(12)**

7. (a) Apply Kirchhoff's laws to derive the system of linear equations and evaluate the currents using matrix from the following diagram: **(18)**



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(b) Suppose that in 2020, land in Dhaka city of built-up area is C: Commercially used 26%, I: Industrially used 23%, R: Residentially used 51%. Find the states in 2025, 2030, and 2035, assuming that the transition probabilities for 5-year intervals are given by the matrix A and remain practically the same over the time considered. **(17)**

$$A = \begin{array}{c} \begin{matrix} \text{From C} & \text{From I} & \text{From R} \end{matrix} \\ \begin{bmatrix} 0.7 & 0.1 & 0 \\ 0.2 & 0.9 & 0.2 \\ 0.1 & 0 & 0.8 \end{bmatrix} \end{array} \begin{array}{l} \text{To C} \\ \text{To I} \\ \text{To R} \end{array}$$

8. (a) An elastic membrane in the x_1x_2-plane with boundary circle $x_1^2 + x_2^2 = 1$ is stretched so that a point P: (x_1, x_2) goes over into the point Q: (y_1, y_2) given by $\mathbf{y} = B\mathbf{x}$, where $B = \begin{bmatrix} 7 & 4 \\ 4 & 7 \end{bmatrix}$. Find the principal directions. What shape does the boundary circle take under this deformation? **(18)**

(b) Reduce $A = \begin{bmatrix} 1 & 2 & 3 & 4 \\ 2 & 7 & 3 & 5 \\ 3 & 8 & 1 & -2 \\ 2 & 4 & 6 & 8 \end{bmatrix}$ to the normal form N and obtain the non-singular matrices S and W such that N = SAW. Hence find rank. **(17)**
