BANGLADESH UNIVERSITY OF ENGINEERING AND TECHNOLOGY, DHAKA
Sub: CHEM 115 (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 any THREE questions.

1. (a) What is the standing wave concept of de-Broglie in atomic system? (8)
   (b) Deduce the equation by which the propagation of electron wave in space can be described. How the solution of the equation can be applied for the probability of finding the electron in space? (8+4=12)
   (c) Apply the concept of Bohr theory and explain “The energy of an electron in a hydrogen atom is quantized.” (9)
   (d) Rank the ions according to the size and explain your ranking.
   (i) K+, Sc^{3+}, Ca^{2+} (ii) P^{3-}, Cl^{-}, S^{2-} (6)

2. (a) What is shielding effect? How shielding effect is related with the effective nuclear charge? How the effective nuclear charge changes if you move in the first period from Li to Ne? Explain. (5+5+6=16)
   (b) Predict and draw the geometry of the followings:
   (i) CO_2^- (ii) O_3 (iii) IOF_5 (9)
   (c) According to VBT, what is the hybridized state of carbon in carbonyl group? Explain with diagram. (10)

3. (a) Define ‘solution’. Explain that the solution process is governed by energy and entropy. (4+6=10)
   (b) How the solubility of a solid in a liquid at different temperature can be applied for the determination of heat of solution. (8)
   (c) Give the quantitative relation between the solubility of gas in liquid with pressure. Explain the relation with suitable example. (10)
   (d) Hydrogen peroxide is a powerful oxidizing agent; it is used in concentrated solution in rocket fuel, but in dilute condition in hair bleach. An aqueous solution of H_2O_2 is 30% by mass and a density of 1.11 g/mL. Calculate (i) molality (ii) molarity. (7)

Contd ……… P/2
4. (a) Define ‘boiling point of solution’. Show that elevation of boiling point due to the addition of non-volatile and non-electrolyte is dependent on the concentration of the solution in molality but not on the nature of the solute.

(b) A solution was prepared by dissolving 18.00 g glucose in 150.0 g water. The resulting solution was found to have a boiling point of 100.34°C. Calculate the molar mass of glucose. Glucose is a molecular solid that is present as individual molecules in solution. 

\( K_b = 0.51 \text{°C/m} \)

(c) Explain with the help of MOT

(i) He\(_2^+\) exist but He\(_2\) not (ii) N\(_2^+\) paramagnetic but N\(_2\) is diamagnetic

### SECTION – B

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

5. (a) What are the factors to be considered for the successful preparation of colloid by association method? Describe the preparation of any sol formed by association method with necessary chemical reaction(s).

(b) How many particles of 5.5 nm in diameter can be obtained when 1500 mm\(^3\) of a colloid is placed between revolving discs of a colloidal mill (assume all the particles formed are spherical in shape and uniform in size). What will be the total surface area available for interaction with added electrolyte if the colloidal particles obtained in cube shape from mill with the edge of 10\(^{-6}\) cm.

(c) What is electrophoretic effect? How could you determine the sign of the charge on a colloidal particle by electrophoresis method? Explain with an example.

(d) Describe how bomb calorimeter can be used to determine the heat change of a combustion reaction.

6. (a) Derive an expression that shows the influence of temperature on equilibrium constant. From this expression graphically represent the change of equilibrium constant with the change of temperature for exothermic and endothermic reaction.

(b) What are the thermodynamic criteria of a chemical equilibrium? Show that the equilibrium constants \( K_c \) and \( K_x \) are related by; \( K_x = K_c e^{-\Delta H / R T} \) (where the symbols have their usual meaning.)

(c) Calculate the pressure required to obtain 50% dissociation of PCl\(_5\) at 250°C. The equilibrium constant, \( K_p \) for this reaction, \( \text{PCl}_5(g) \rightleftharpoons \text{PCl}_3(g) + \text{Cl}_2(g) \) is 1.8.

(d) What is buffer capacity? Graphically explain buffer action and buffer range for a system. Find at the condition at which the buffer solution exhibits maximum buffer capacity.
7. (a) What is fuel cell? Construct and explain the working principle of H₂-O₂ fuel cell. (10)  
(b) What is concentration cell? Give an example of concentration cell without transference. Find out the expression of this cell E.M.F from Nernst equation. (10)  
(c) Calculate the voltage of the following concentration cell at 25°C and make comment of the spontaneity of the reaction. (5)  
Pt/Cl₂, Cl⁻ (Concentration, C = 0.10 molL⁻¹)||Cl⁻(C = 0.0010 molL⁻¹), Cl₂/Pt  
(d) Give and explain the expression of heat of reaction at constant pressure and constant volume. Define the term; (i) Enthalpy of neutralization (ii) Heat of formation and (iii) Standard enthalpy of atomization. (10)

8. (a) Why does ice float on water? Explain the reason from the structural point of view of water and ice. (8)  
(b) What are the troubles caused by the hard water in a boiler? Describe zeolite process for softening hard water. (8)  
(c) What are the basic raw materials of cement clinker? Sketch flow diagram for manufacturing of Portland cement by wet process. Discuss about chemical reactions and thermal changes that occur at different sections of rotary kiln in a cement manufacturing plant. (15)  
(d) Write a note on the type of cement you should use to build a water reservoir in the south western region of Bangladesh. (4)
SECTION – A

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

1. (a) A body is subjected to the three forces as shown in the figure-1. Determine the direction of the force $F$ so that the resultant is in X-direction, when $F = 5000$ N. What will be the resultant?

(b) A 5000-lb sphere rests on a smooth plane inclined at an angle of $40^\circ$ with the horizontal and against a smooth vertical wall as shown in the figure-2. What are the reactions at the contact surfaces A and B?

(c) A 250 kg mass is suspended by flexible cables as shown in the figure-3. Determine the tension in the cables AC and BC.

2. (a) For the frame structure shown in the figure-4, find external support reactions at A and D and internal support reaction at B. Also determine the force in member CE.

(b) For the truss as shown in the figure-5, determine all the bar forces.

3. (a) What is a catenary curve? Derive the equation for the length of a catenary.

(b) At the point of support of a catenary cable, the tension is 25% greater than the tension at the low point. The cable weighs 1 lb. per ft and the sag is 20 ft. If the points of support are on the same level, find the span. What is the length of the cable?

(c) A body weighs 250 N, rests on a $30^\circ$ inclined plane as shown in the figure-6. The co-efficient of static friction is 0.3 between the body and the inclined plane, and that is 0.4 between the rope and the drums. What force “W” will cause motion of the body to impend up the plane?

4. (a) A wedge is shown in the figure-7. If the co-efficient of friction for all surfaces is 0.2, what value $F$ is required to move the 50 lb blocks? The forces is vertical and the floor is horizontal.

(b) A table whose top is triangular in shape as shown in the figure-8 has a load of $W = 100$ N. What is the force on each leg at A, B, and C?
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Contd ... Q. No. 4

(c) Three timbers, AB, BC, and BD, each 20 ft. long form a tripod as shown in the figure-9. The ends of the timbers on the ground form an equilateral triangle ACD, the sides of which are each 20 ft. long. If the safe compressive load for each timber is 20,000 lb., what safe loads \( W \) may be suspended from point B?

**SECTION – B**

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

5. (a) Determine the location of the centroid of the area enclosed by arcs of the parabolas 
\( y^2 = 9x \) and \( x^2 = 4y \), shown in Figure-10.

(b) Determine \( I_x \) and \( I_y \) for the shaded area shown in Figure-11. Also find polar moment of inertia and the radius of gyration of this area about an axis through point A.

(c) Derive the expression for the moment of inertia of a sphere about a diameter and also about a line tangent to the sphere. The density of the material is constant.

6. (a) Find the minimum radius of gyration of the Z-section shown in Figure-12.

(b) A ball is thrown vertically upward and observed to go level with the top of a 50 m tree. Find (i) the initial velocity, (ii) the distance traveled during the first second of flight, (iii) the time required for the ball to return to the starting point.

(c) Derive the expression for tangential and normal acceleration of a point moving in a curved path.

7. (a) In Figure 13, \( W_A = 120 \) lb and \( W_B = 80 \) lb. Consider the cord and pulleys weightless and neglect friction. Determine the acceleration of each body and tension in the cords \( P_1 \) and \( P_2 \).

(b) In Figure-14, the weightless cord wraps about a central groove 12 inch in diameter and passes over a smooth peg to a 30 lb body B. The central groove is in a 24 inch disk A, which weighs 96.6 lb and has a radius of gyration 9 inch. If the disk rolls without slipping, what is the speed of B after 6 sec, when the bodies start from rest? Also find the frictional force \( F \).

(c) A body P is projected vertically downward from a 500 ft cliff with an initial velocity of 10 fps. One second later, a body Q is projected vertically upward from the bottom of the cliff with an initial velocity of 70 fps. If time is to be measured from the beginning of the motion P, determine
WRE 101

Contd ... Q. No. 7(c)

(i) When do these bodies pass one another?
(ii) How far above the bottom of the cliff are the bodies when they pass?
(iii) What is the direction of motion and speed of Q when they pass?

8. (a) Locate by integration the centroid of a slender wire bent into a parabolic curve whose equation is \( y^2 = 4x \) and whose ends are defined by points (0, 0) and (4, 4).

(b) A jet of water, flowing at a rate of \( W = 5 \) lb per sec, issues from a nozzle with velocity \( V_H = 400 \) fps (Figure-15). It enters a fixed blade and is turned through 120° before it is discharged. Determine

(i) What are the horizontal and vertical components of the force exerted upon the fixed blade?
(ii) When the blade starts to move with a speed \( V_b = 200 \) fps toward the right, find the reactions \( Q_x \) and \( Q_y \).

(c) The body A in Figure 16, weighs 161 lb and 12 inch in diameter. It is being rolled up the incline by a constant force \( Q = 96.5 \) lb. If \( \theta = 30^\circ \), determine

(i) What is the speed of its center of gravity after a displacement of 15 ft from rest?
(ii) What is its angular acceleration?
(iii) What is the frictional force between the plane and the cylinder?
(iv) What coefficient of friction is necessary for rolling?
= 4 =

Figure-1 (Problem 1(a))

Figure-2 (Problem 1(b))

Figure-3 (Problem 1(c))

Figure-4 (Problem 2(a))
Figure 5 (Problem 2(a))

Figure 6 (Problem 3(c))

Figure 7 (Problem 4(a))

Figure 8 (Problem 4(b))

Figure 9 (Problem 4(c))
Figure 10 for Q.No. 5(a)

Figure 11 for Q.No. 5(b)

Figure 12 for Q.No. 6(a)

Figure 13 for Q.No. 7(a)

Figure 14 for Q.No. 7(b)

Figure 15 for Q.No. 8(b)

Figure 16 for Q.No. 8(c)
SECTION - A

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

1. (a) What do you mean by simple harmonic motion? Using an expression for the displacement of simple harmonic oscillation show that the total energy of an oscillator remain constant during oscillation.

   (b) Briefly discuss the term “superposition of oscillation”. By considering two simple harmonic vibrations having same frequency, show all the possible figures that can be obtained when they superpose perpendicularly. Please provide proper mathematical and physical reasoning behind your answer.

   (c) Two vibrations at right angles to one another are described by the equations:

   \[ x = 10 \cos (5\pi t); \quad y = 10 \cos (5\pi t + \frac{\pi}{4}) \]

   Construct the Lissajous figure of the combined motion.

2. Consider that a one-dimensional oscillator of mass m and spring constant k is subjected to a damping force.

   (a) Set up the differential equation of motion for the system.

   (b) Derive an expression for the displacement of the oscillator, and hence show how the amplitude decays with time.

   (c) If an object of mass 0.2 kg is hung from a spring whose constant is 0.8 N/m. The object is subjected to a resistive force by \(- bv\), where \(v\) is the velocity in meter per second. If the damped frequency is \(\sqrt{3} \) of the undamped frequency find out the quality factor \((Q)\) of the system.

3. (a) Explain the terms, “transient state”, and “stationary state” for a forced harmonic motion.

   (b) Derive an expression for the power absorbed by a driven oscillator in steady state and graphically show how it varies with the quality factor \((Q)\) of the system.

   (c) A forced damped oscillator of mass \(m\) has a displacement \(x = A \cos (\omega t - \phi)\) and its resistive force is \(F = - bv\), where \(v\) is its velocity.

   (i) Show that the instantaneous rate of doing work against the resistive force is \(- bv^2\).

   (ii) Using the expression for resistance show that the mean rate of doing work is \(\frac{b\omega A^2}{2}\).

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4. (a) What do you understand by degree of freedom and equipartition of energy of a system of molecules. Prove that the ratio of specific heats \( \gamma = 1 + \frac{2}{n} \), where \( n \) is the number of degrees of freedom. (10)

(b) Deduce and explain Vander Wall’s equation for a real gas. (15)

(c) Calculate the molecular KE of a unit mass of helium at N.T.P. What will be its KE at 100°C? Given that \( R = 8.31 \text{ mol}^{-1}\text{K}^{-1} \) and molecular weight of helium = 4. (10)

SECTION – B

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

5. (a) Describe Carnot cycle. Obtain expressions for the work done in each operation of the cycle and the net work done in the cycle. (20)

(b) State Carnot’s theorem. (5)

(c) An engine works in a Carnot cycle between the temperatures 100°C and 0°C. If the work done in the cycle is 1500 kg-m, find how much neat, measured in cal, is taken in at the higher temperature. (10)

6. (a) Derive Maxwell’s thermodynamic relations.

(b) Using Maxwell’s thermodynamic relations show that

(i) For a perfect gas \( C_p - C_v = R \) and

(ii) for a Vander Waals gas \( C_p - C_v = \frac{R}{v^3} \left( \frac{p + \frac{a}{v^2}}{p - \frac{a}{v^2} + \frac{2ab}{v^3}} \right) \)

The symbols have their usual meanings. (5+5)

(b) Define resolving power of a telescope and find an expression for it. (15)

(c) In a Newton’s ring experiment, if a drop of water having refractive index 1.33 is placed between the lens and the plate, the diameter of the 10th ring is found to be \( 6 \times 10^{-3} \) m. If the wavelength of light used is 600 nm, calculate the radius of curvature of the plane convex lens. (10)

7. (a) Show with a neat diagram how coherent sources are produced in Newton’s rings experiments. Why Newton’s rings are circular in shape? (5+5)

(b) Define resolving power of a telescope and find an expression for it. (15)

(c) In a Newton’s ring experiment, if a drop of water having refractive index 1.33 is placed between the lens and the plate, the diameter of the 10th ring is found to be \( 6 \times 10^{-3} \) m. If the wavelength of light used is 600 nm, calculate the radius of curvature of the plane convex lens. (10)

8. (a) What do you understand by a quarter wave plate? For what purpose one can use it? (8)

(b) Write short notes on the following:

(i) Principal section

(ii) Double refraction

(iii) Position crystal

(c) The polarizing angle to a piece of glass for green light is 56°. What is the angle of minimum deviation for a 60° prism made of the same glass? (9)
SECTION – A

There are FOUR questions in this Section. Answer any THREE questions including Question No. 1 as compulsory.

1. Read the following passage carefully and answer the questions that follow:

   If mastery of the material world were civilization, ours would be most civilized age in history. But, turning to the purely intellectual aspect of our civilization, we have at the moment a philosophy of little importance even for its own time, and in pure science, as in literature, we have a remarkable diffusion of good work. Still, we also have and have had some creative minds of the highest quality. In applied science no age can compare with ours, and in general we might say that the characteristic achievement of the modern world is the effective mobilization and organization of intellectual effort in every field. But in artistic and liberty quality our civilization will, I believe, certainly rank below that of fifth and fourth century Athens, and of fourteenth and fifteenth century Italy.

   That brings me to an important practical questions Can a democracy be civilized? Of course very few people can be creators in the field of art or of the intellect: our task, the task of the intelligent public, is to honour and appreciate what the few create; to know, or at least wish to know, what is really first rate in literature, art, architecture, music, in science, and the world of thought, in all activities that make civilization. But are the masses capable of such discrimination? And if not, shall we not have a nation where an elite is civilized but the rest of the people is not? Call the masses into power, and automatically you will find the national culture molded by their interest and tastes. They will expect, and plenty of people will be ready to supply, the kind of music and art, films and reading which is their taste. That is at present a reality for all of us in Bangladesh. Keep an watchful eyes on news papers, and film industry. You will have your bitter exposition.

   Questions:
   
   (i) What is the condition of civilization at present?
   (ii) What are the positive achievements of modern civilization?
   (iii) What is the task of the intelligent public?
   (iv) What are you bitter exposition regarding our newspapers and film industry?
   (v) What is your own vision of civilization?
   (vi) Write the meanings of the following words as used in the passage. Diffusion, mobilization, discrimination, elite, exposition.
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2. (a) As an assistant Engineer of a company you have recently bought some electrical appliances for your organization. But after the delivery the appliances are found to be defective. Now write a letter of complaint for the replacement of those products. (10)

(b) Write phonetic transcription of the following words: (Any five)

Basic, adjective, bone, child, pair, think. (10)

3. (a) Write a dialogue between two dwellers of Dhaka city about low quality water supply. (10)

(b) Write a short essay on any ONE of the following: (10)

(i) Expected Education system
(ii) Reading Books: A Habit on the Wane
(iii) Global Peace: A Need of the Time

4. (a) Transform the following sentence as directed: (Any five) (10)

(i) To his misfortune he last all his money. (Compound)
(ii) He follows the example which was set by his father. (Simple)
(iii) He will not go unless he is compelled. (Simple)
(iv) When he will arrive here is uncertain. (Compound)
(v) He is rich enough to help you. (Complex)
(vii) Be just and fear not. (Complex)

(b) Write short notes on any two of the following: (10)

(i) Principles of writing of Business letter
(ii) The diphthongs
(iii) Annual Confidential Report.

SECTION – B

There are FOUR questions in this Section. Answer Q. No. 5 and any other TWO from the rest.

5. (a) Explain with reference to the context any one of the following: (8)

(i) “Forgive my hat.” She said.
(ii) “All these things, which another woman of her station would not have noticed, tortured and angered her.”

(b) Answer any one of the following: (10)

(i) Would it be correct to say that one of the themes of ‘The Bet’ is material objects can blind you to what is truly important in life?
(ii) How does the writer try to make Matilda interesting for the reader in “The Diamond Necklace”?

Contd ......... P/3
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Contd... Q. No. 5

(c) Answer any three of the following:

(i) After the loss of the necklace, appearance and social status seem less important to Matilda. Why?
(ii) In “The Bet,” who won the bet? How?
(iii) What impression do you get about Mrs. Sheridan as mentioned in “The garden Party”?
(iv) What argument does the lawyer provide for preferring life imprisonment to death sentence?

6. (a) Recast and correct any ten of the following sentences:

(i) You should take the medicine every alternative day.
(ii) The orange tasted badly.
(iii) I have more mistakes on my paper than him.
(iv) The reason I am ill is because I ate too much.
(v) Mr. Hardy is a professional cashier.
(vi) We suspected that something was amiss.
(vii) Each individual person must handle the question.
(viii) The boat slipped out of the harbor, I suddenly realized I was on my way to Myanmar.
(ix) Let us look into the agenda of the last five meetings.
(x) This law is able to be evaded.
(xi) Father objected to Mary singing.
(xii) Due to the weather, there was a large crowd.

7. (a) Write down meaning of any ten of the following words:

Alluring, Bicker, Credulous, Facile, Gauche, Hilarious, Intrepid, Moron, Obsequious, Perforate, Quell, Wayward.

(b) Make sentences with any ten of the following words:

Anomalous, Brawl, Deride, Exasperate, Garrulous, Holocaust, Limpid, Mumble, Oration, Pilfering, Ramble, Tumult.

8. Write a précis of the following passage with a suitable title:

Even in 1971 there were among the Bengali intellectuals some, though negligible in number, who clung to Pakistani nationalism. And there is no denying that most intellectuals of the pre-1947 generation had been supportive of the demand for Pakistan.
This had happened owing partly to the non-inclusiveness of the Hindu-dominated Indian National Congress and partly to hope that a separate homeland would augur the Bengali Muslims well. The turning point in the intellectual life of East Pakistan was the State Language Movement of 1952. That movement sought to replace religion-based Pakistani nationalism by secular Bengali nationalism. The upsurge was political; it was against the very foundation of the newly-established state itself and its ultimate objective was to establish people’s control over state power. Whereas the Pakistan movement had aimed at, and was successful in, winning a homeland for the Muslims, the anti-state Language Movement wanted to transform that homeland into a habitat of a people released from fetters of a bureaucratic-capitalist state, engaged as it was in protecting a class-divided society. The movement was more than an undertaking of resistance against an imposition. Its expectation was to go much further. In really, the movement was driven by the unspoken agenda of establishing a system of socialist dispensation, capable of guaranteeing equality of rights and opportunity to all citizens, irrespective of religion and class. Pakistan was a semi-colonial state carved out of the colonial state to British India, and turned out to be no less exploitative than the one it replaced. The weak suffered in relation to the strong; the Bengalis were weak because state power was monopolistically wielded by the non-Bengali military bureaucracy with the assistance of an obliging civil bureaucracy. The martyred intellectuals of 1971 carried in them the secular democratic spirit of the State Language Movement, which spirit drew the people together. The spirit became stronger as it moved on and ultimately found itself released in the liberation war. These intellectuals were positively secular in outlook and secularism, one knows is essential for stepping into a democracy of rule by the people and not merely by the parliament.