1. (a) What is de Broglie relationship? Why is this relationship meaningful only for submicroscopic particles, such as electrons and atoms, and not for macroscopic objects? (8)

(b) Consider the hypothetical atom X that has one electron like the hydrogen atom but has different energy levels. The energies of an electron in an X atom are described by the equation.

$$E_X = \frac{R_H}{n^3}$$

where $R_H$ is the same as for H ($2.179 \times 10^{-18}$ J)

(i) How would the ground-state energy levels of X and H compare? (3+4+5)

(ii) How do the spacings of the energy levels of X and H compare?

(iii) Which would involve the emission of a higher frequency of light, the transition of an electron in an H atom from the $n = 4$ to the $n = 2$ level or a similar transition in an X atom?

(c) The $n$ quantum number of an atomic orbital is 5. What are the possible values of $l$? What are the possible values of $m_l$ if the $l$ quantum number is 5? (6)

(d) Sketch the radial probability plots for the 1S, 2S and 2p orbitals. Indicate the nodes (if any) on the plots and comment on the meanings of their presence. (9)

2. (a) Explain the meaning of diamagnetic and paramagnetic. Give examples. What does it mean when we say that electrons are paired? (9)

(b) How does a hybrid orbital differ from a pure atomic orbital? Can two 2p orbitals of an atom hybridize to give two hybridized orbitals? Why? (7)

(c) Predict the geometries of the following species using the VSEPR method:

(i) $\text{H}_3\text{O}^+$  (ii) $\text{ICl}_4^-$  (iii) $\text{SF}_4$

(d) Use molecular orbital theory (MOT) to explain why the bond order of $\text{N}_2$ is greater than that of $\text{N}_2^+$ but the bond order of $\text{O}_2$ is less than that of $\text{O}_2^+$. (10)
CHEM 117

3. (a) What is ion-dipole force? Explain how this force is important in determining the solubility of ionic solid in water. Use the dissolution of NaCl in water as an example.

(b) Consider two pure substances, NaCl(s) and glucose(s). When equal molar amounts of these substances are placed in separate 500-mL samples of water, they undergo the following reactions:

\[
\text{NaCl (s)} \rightarrow \text{Na}^+ (\text{aq}) + \text{Cl}^- (\text{aq}) \\
\text{Glucose (s)} \rightarrow \text{Glucose (aq)}
\]

(i) Which solution would you expect to have the lower boiling point? Why?

(ii) Which one would have higher vapor pressure?

(iii) The container of glucose (aq) is left out on the bench top for several days. Which allows some of the water to evaporate from the solution. How would the freezing point of this solution compare to the freezing point of the original solution?

(c) Using the following table calculate the boiling point of a solution of 0.150 g of ethanol, C₂H₅OH, in 20.0 g of water. What is the freezing point?

<table>
<thead>
<tr>
<th>Solvent</th>
<th>Boiling point (°C)</th>
<th>Freezing point (°C)</th>
<th>K_b (°C/m)</th>
<th>K_f (°C/m)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Water</td>
<td>100</td>
<td>0</td>
<td>0.512</td>
<td>1.858</td>
</tr>
<tr>
<td>Ethanol</td>
<td>78.3</td>
<td>-114.6</td>
<td>1.07</td>
<td>1.99</td>
</tr>
</tbody>
</table>

(d) Solutions A and B containing the same solute have osmotic pressure of 2.4 atm and 4.6 atm, respectively, at a certain temperature. What is the osmotic pressure of a solution prepared by mixing equal volumes of A and B at the same temperature?

4. (a) Why the group VIII A elements are called the noble gases? What are the sources and uses of He and Ar gases?

(b) Xenon tetrafluoride, XeF₄, is a colorless solid. How can it be synthesized? Give the Lewis formula for the XeF₄ molecule. What is the hybridization of the Xe atom in this compound? What geometry is predicted by the VSEPR model? Draw the geometry.

(c) Define complex ion, ligand, and coordination number. Give examples of a monodentate ligand, bidentate ligand, and polydentate ligand.

(d) What is the use of EDTA? How does it complex with metal ion like Ca²⁺? Draw the structure of the complex.

SECTION – B

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

5. (a) Define (i) rate of reaction and (iii) order of reaction.

(b) Explain how you can determine the order of reaction by half life method.
(c) Derive an expression for the rate constant of a first order reaction. Explain the characteristic features of such reactions. (11)

(d) A first order reaction is 40% complete in 50 minutes. Calculate the value of the rate constant. In what time will the reaction be 80% complete? (8)

6. (a) Thermodynamic equilibrium constant of a reaction is actually a true equilibrium constant—justify. (8)

(b) Derive the relation between free energy change and equilibrium constant of a reaction. Under what condition the standard free energy change of a reaction is related to the equilibrium constant at a definite temperature? (17)

(c) At 2155°C and 1 atm pressure H2O(g) is 1.18% decomposed into H2(g) and O2(g) in accordance with the equation 2H2O(g) = 2H2(g) + O2(g). Calculate Kp for the process. (10)

7. (a) Define reversible and irreversible cells. (7)

(b) What do you mean be heat capacity and heat of reaction? (7)

(c) Derive an expression for the variation of heat of reaction with temperature. (14)

(d) Calculate the heat of formation of H2O(l) at 60°C if the heat of formation of H2O(l) at 25°C is 68,370 cal. The reaction is: H2(g) + \( \frac{1}{2} \)O2(g) = H2O(l)

Given that

\[ C_p(H_2) = 6.90 \text{ cal mol}^{-1}\text{deg}^{-1} \]
\[ C_p(O_2) = 7.05 \text{ cal mol}^{-1}\text{deg}^{-1} \]
\[ C_p(H_2O) = 18.0 \text{ cal mol}^{-1}\text{deg}^{-1} \]

8. (a) Explain the following terms: (i) Phase (ii) Components (iii) Degree of freedom. (9)

(b) Deduce the phase rule equation, F = C - P + 2. What is a condensed system? Show the reduced phase rule equation for such systems. (11)

(c) Give the labelled phase diagram of water system and explain its various lines, points and areas. Explain why fusion curve of ice has a negative slope. (15)
SECTION - A

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

1. (a) Sketch roughly the graph of the function \( f(x) = \begin{cases} x^2 + 1 & ; \ x < 0 \\ x & ; \ 0 \leq x \leq 1 \\ \frac{1}{x} & ; \ x > 1 \end{cases} \) (15)

Test the continuity of \( f(x) \) at \( x = 0 \) and differentiability of \( f(x) \) at \( x = 1 \).

(b) Evaluate \( \lim_{x \to 1} \frac{\log(x-1) - \tan^{-1} x}{\cot \pi x} \). (10)

(c) If \( y = a \cos(log x) + b \sin(log x) \), show that \( x^2 y_{n+2} + (2n+1)y_{n+1} + (n^2 + 1)y_n = 0 \). (10)

2. (a) In the mean value theorem, \( f(a+h) = f(a) + hf'(a + \theta h) \); \( 0 < \theta < 1 \) if \( f(x) = \frac{1}{3}x^3 - \frac{3}{2}x^2 \), find the value of \( \theta \) in the interval \( (0, 3) \). (10)

(b) Prove that in the curve \( x = \frac{y^2 - a^2}{4a} - \frac{a}{2} \log \frac{y}{a} \) the difference between the lengths of the tangent and subtangent is constant. (15)

(c) Expand the function \( y = \cos^2 x \) in powers of \( x \) in an infinite series up to the term \( x^6 \). (10)

3. (a) If \( z = \frac{x^2 y^2}{x + y} \), then show that \( x \frac{\partial^2 z}{\partial x^2} + y \frac{\partial^2 z}{\partial x \partial y} = 2 \frac{\partial z}{\partial x} \). (12)

(b) If \( (\alpha, \beta) \) be the co-ordinates of the centre of curvature of the parabola \( \sqrt{x} + \sqrt{y} = \sqrt{a} \) at \( (x, y) \), then prove that \( \alpha + \beta = 3(x + y) \). (12)

(c) Find the pedal equation of the astroid \( x^{3/2} + y^{3/2} = a^{3/2} \). (11)

4. (a) Find all the asymptotes of the curve \( 4(x^4 + y^4) - 17x^2y^2 - 4x(4y^2 - x^2) + 2(x^2 - 2) = 0 \). (18)

(b) A closed rectangular container with a square base is to have a volume of 2000 cm\(^3\). It costs twice as much per square centimeter for the top and bottom as it does for the sides. Find the dimensions of the container of least cost. (17)

Contd ......... P/2
MATH 181

SECTION – B

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

5. Carryout the following:
   (i) \( \int \frac{\cos x + 2 \sin x + 3}{4 \cos x + 5 \sin x + 6} \, dx \) (12)
   (ii) \( \int \frac{x^2 - 1}{x^4 + x^2 + 1} \, dx \) (12)
   (iii) \( \int \frac{x^2}{(x \sin x + \cos x)^2} \, dx \) (11)

6. (a) Obtain a reduction formula for \( I_n = \int \frac{x^n \, dx}{\sqrt{ax^2 + bx + c}} \) and hence compute
      \[ \int \frac{1 - 7x^2 + 14x^4 - 8x^6}{\sqrt{2x^2 - 1}} \, dx . \] (11+12)
      (b) Evaluate \( \int_0^{\cos^{-1}(1-x^2)} \, dx \). (12)

7. (a) Evaluate: \( \int_0^{\infty} \frac{\ln x}{1 + x^2} \, dx \). (11)
      (b) Show that \( \beta(m,n) = \frac{\Gamma(m)\Gamma(n)}{\Gamma(m+n)} \). (12)
      (c) Find the area of the loop of the curve \( y^2 = x^2(4-x^2) \). (12)

8. (a) Determine the perimeter of the curve \( r = 2a \cos \theta \). (15)
      (b) Find the volume and surface area of the solid formed by the revolution of the cardiode \( r = a (1 + \cos \theta) \) about the initial line. (20)
SECTION – A

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

1. (a) What are electric field and electric field lines of force? Obtain an expression for the electric field \( E \) at a distance \( Y \) from an infinite line of positive charges whose linear charge density is \( \lambda \) (C/m).

(b) An electric dipole of length 5 cm, when placed with its axis making an angle 70° with a uniform electric field experiences a torque of \( 5\sqrt{3} \) Nm. Calculate the (i) magnitude of the electric field and (ii) potential energy of the dipole. If the dipole has charges of +10 nC and −10 nC.

2. (a) Define magnetic field induction, \( B \) and hence discuss characteristics of the deflecting force in a magnetic field.

(b) Derive an expression for the torque on a current loop of \( N \) turns carrying a current \( i \) placed in a magnetic field, \( B \).

(c) Find the frequency of a circulating charge in a plane perpendicular to the direction of the magnetic field, \( B \).

3. (a) State and explain laws of electromagnetic induction.

(b) Define the coefficient of self-induction. Obtain an expression for the self inductance of a long straight solenoid of length, \( L \), cross-sectional area, \( A \), and wound uniformly with ‘\( n \)’ turn of wire per unit length, which is carrying an instantaneous current, \( i \).

(c) A solenoid 12 cm long has 150 turns. The cross-sectional area of the solenoid is 10 cm². Find the coefficient of self induction of the solenoid. Assume air inside the solenoid. \( \mu_0 = 4\pi \times 10^{-7} \) wb/A–m).

4. (a) Derive velocity transformation equations from the Lorentz transformation equations and using these explain the postulate of constancy of speed of light.

(b) Discuss time dilation and length contraction in special relativity.

(c) An observer detects two explosions, one that occurs near her at a certain time and another that occurs 2 ms later 100 km away. Another observer finds that two explosions occur at the same place. What time interval separates the explosions to the second observer?
**PHY 113**

**SECTION – B**

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

5. (a) How does Planck's radiation formula remove the ultraviolet catastrophe in explaining the black body radiation? (13)

(b) Show that classical wave theory fails to explain the results of photoelectric effect but quantum theory can explain the theory. (14)

(c) Ultraviolet light of wavelength 350 nm and intensity 1.0 W/m°² is directed at a potassium surface of work function 2.2 eV. If 0.25% of the incident photons produce photoelectrons, how many photoelectrons are emitted per second from potassium surface of area 2.0 cm°²? (8)

6. (a) Discuss why an electron cannot stay inside a nucleus? (6)

(b) Explain that radioactivity is a special and time dependent property of a nucleus. Define mean life (Tavg) of a radioactive specimen and show that Tavg = \( \frac{1}{\lambda} \), where \( \lambda \) is the decay constant. (18)

(c) What are the radioactive decay series in radioactivity? Among the nuclear fission and fusion reactors, which one is more safer and viable, and why? (11)

7. (a) Establish the relation between interplanar spacing ‘d’ and indices of crystal plane (hkl) for an orthorhombic crystal system. Which are the other crystal systems for which this relation is also valid? Modify this relation for those crystal systems. (15)

(b) Show that the ratio of interplanar spacing for low index planes \( d_{100} : d_{110} : d_{111} \) of a body centred cubic crystal does not match with that of simple cubic crystal. (6)

(c) What does point defect mean? Discuss different classes of point defects of a crystal. (14)

8. (a) Illustrate the splitting of energy levels with the decrease of interatomic distance during the formation of bands in a solid. (10)

(b) If germanium is doped with boron, what type of extrinsic semiconductor it will be? Justify your answer with necessary diagrams. (10)

(c) Compare the properties of ionic, covalent and metallic bonds. (15)
L-1/T-1/NAME Date: 03/08/2016

BANGLADESH UNIVERSITY OF ENGINEERING AND TECHNOLOGY, DHAKA


Sub: HUM 111 (English)

Full Marks : 140  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 including Question No. 1 as compulsory.

1. Read the passage carefully and answer all the questions given below:

Some old people are oppressed by the fear of death. In the young there is a justification for this feeling. Young men who have reason to fear that they will be killed in battle may justifiably feel bitter in the thought that they have been cheated of the best things that life has to offer. But in an old man who has known human joys and sorrows, and has achieved whatever work it was in him to do, the fear of death is somewhat abject and ignoble. The best way to overcome it – so at least it seems to me is to make your interests gradually wider and more impersonal, until bit by bit the walls of the ego recede, and your life becomes increasingly merged in the universal life. An individual human existence should be like a river – small at first, narrowly contained within its banks, and rushing passionately past boulders and over waterfalls. Gradually the river grows wider, the banks recede, the waters flow more quietly, and in the end, without any visible break, they become merged in the sea, and painlessly lose their individual being. The man who in old age, can see life in this way, will not suffer from the fear of death, since the things he cares for will continue. And if, with the decay of vitality, weariness increases, the thought of rest will be not unwelcome. I should wish to die while still at work, knowing that others will carry on what I can no longer do, and content in the thought that what was possible has been done.

Questions:

(i) Why, according to the author, is it justifiable for a young man to fear death?
(ii) How does the author regard the fear of death in old people?
(iii) What, in the opinion of the author, is the best way for an old person to overcome the fear of death?
(iv) How can someone make his/her interests 'wider' and 'impersonal'?
(v) How successfully has the author used the analogy of river?
(vi) Write the meaning of the following words as used in the passage:

Abject, ego, recede, merge, vitality.

2. (a) Suppose you are the chief engineer of a firm. You have purchased some equipment for your organization. After receiving the delivery of the equipment you find some of them sub-standard. Now write a letter of complaint to the supplier of these products.

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

About, paper, catch, month, son, there.

Contd ............... P/2
HUM 111

3. (a) Write a dialogue between two students of your department about the recent ship wreckage in the Bay of Bengal. (You may base your talk on an imaginary situation). (10)

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

(i) Depression: A Global Crisis
(ii) Teacher – Student Relationship
(iii) Online Education

4. (a) Transform the following sentences as directed. (Any five).

(i) He studied medicine to be a doctor. (Complex)

(ii) Hemel gave up smoking because of his doctor’s advice. (Complex)

(iii) Monika repeated the question slowly so that Maisha would understand. (Simple)

(iv) I am glad that you have passed the exam. (Simple)

(v) On account of his negligence the company suffered a heavy loss. (Compound)

(vi) I offended him by doing this. (Compound)

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

(i) The Diphthongs
(ii) Components of a formal report
(iii) Terminator in a paragraph

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:

(i) “The geniuses of all ages and of all lands speak different languages, but the same flame burns in them all.”

(ii) “Oh! my poor Matilda! Mine were false. They were not worth over five hundred francs!”

(b) Answer any one the following:

(i) ‘The Bet’ is a story about a man’s journey to spiritual perfection. – Discuss the statement according to the story you have read.

(ii) Make an evaluation of the character of Mrs. Matilda Loisel.

(c) Answer any three of the following:

(i) What was the topic of discussion among the guests at the evening party given by the banker?

Contd ……… P/3
(ii) Describe the terms and conditions of the bet agreed upon by the banker and the lawyer.

(iii) What did the Loisel couple do to return the lost necklace?

(iv) Based on your study of ‘The Garden Party’, what impression do you get about Laura Sheridan?

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

(i) We had a large amount of students on hand for the rally.

(ii) It is the Robinsons whom, I feel certain, are to come.

(iii) If I were him, I should not accept the post.

(iv) Both the mouse is underfed.

(v) The militia is discussing the battle among itself.

(vi) He is something better today.

(vii) This box is more square than that one.

(viii) Last week the priest said that living the upright life was a discipline.

(ix) He decided to work slow and easy.

(x) He could not come to the class due to illness.

(xi) I didn’t speak but once.

(xii) We must guard and cast aside any infringement on our rights.

7. Give the meanings of any ten of the following words:

(a) Abhor, blizzard, cataclysm, detest, flounder, germinate, jeopardy, menace, Pauper, roam, smolder, wayward.

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

Audacious, brandish, concoct, deprecate, grouchy, moron, oblivion, posterity, rebut, sinuous, tyro, vestige.

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

What happens when one person sends a message and another receives it? First consider the nature of language – the words in which most messages are expressed. All words are symbols. A symbol is a standardized sign, seen or heard, which stands for an object, event, or idea as agreed upon by senders and recipients of messages. It need not resemble what it stands for. Thus it differs from a pictorial presentation or imitation, such as portrait, a street plan, or an organization chart. A set of symbols agreed upon by two or more people is called code. By far the most important codes are those which form language. In any civilized language there is a primary code of spoken words, formed from speech sounds.
There is also a secondary code of letters (the alphabet) which can be combined to stand for the speech sounds of the primary code, as the letters – t, r, e, e – for the sound of ‘tree’. Neither letters nor sounds have any resemblance to what they denote – a tree. Whenever language is used, a sender must encode his message, and a recipient must decode it. For language communication to be effective, senders and receivers must agree on all the details of the language code. If you go to France in ignorance of the French code and meet people ignorant of the English code, you have to resort to gestures and attempts at direct representation of what you want to say. How inadequate this can be is shown by the story, of an English tourist, who suffering from hunger in a French street, moved his hands and jaw to convey his wish to find a restaurant, he was obligingly conducted to a dentist’s waiting room.