L-1/T-1/ME **Date : 04/09/2018**

BANGLADESH UNIVERSITY OF ENGINEERING AND TECHNOLOGY, DHAKA

L-1/T-1 B.Sc. Engineering Examinations 2017-2018

Sub : **MATH 161** (Differential Calculus, Solid Geometry and Vectors)

Full Marks: 280 Time : 3 Hours

USE SEPARATE SCRIPTS FOR EACH SECTION

The figures in the margin indicate full marks.

SECTION – A

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

Symbols used have their usual meaning.

1. (a) Find the n-th derivative of $y = \sin^{-1}\frac{2x}{1+x^2}$. **(10)**

(b) If $x = \sin(\frac{1}{m}lny)$ then prove that **(16)**

$$(1-x^2)y_{n+2} - (2n+1)xy_{n+1} - (n^2+m^2)y_n = 0.$$

(c) Evaluate: (i) $lim_{x\to 0}\left(\frac{\sin x - \tan^{-1} x}{x^2 \ln(1+x)}\right)$. **(10⅔)**

(ii) $lim_{x\to 1}(1-x^2)^{\frac{1}{\ln(1-x)}}$. **(10)**

2. (a) If $u = \ln r$, then show that $\frac{\partial^2 u}{\partial x^2} + \frac{\partial^2 u}{\partial y^2} + \frac{\partial^2 u}{\partial z^2} = \frac{1}{r^2}$ **(20)**

where $r^2 = (x-a)^2 + (y-b)^2 + (z-c)^2$.

(b) State Rolle's theorem. Discuss the applicability of Rolle's theorem for the function defined by $f(x) = \begin{cases} x^2+1, & 0 \le x \le 1 \\ 3-x, & 1 < x \le 2 \end{cases}$ on the interval $[0,2]$. **(15)**

(c) Expand $\frac{1}{1-x}$ in power of x with Lagrange form of remainder after n terms and find the value of θ in R_n. **(11⅔)**

3. (a) Find the absolute maximum and minimum value of the function $f(x) = x - 2\sin x$ on the interval $\left[-\frac{\pi}{4}, \frac{\pi}{4}\right]$ and determine where the absolute extremum values occur. **(16)**

(b) Find the radius of curvature and centre of curvature of the parabola $x^2 = 4ay$ at $(2a, a)$. **(15⅔)**

(c) Find the equation of tangent and normal to the curve $y(x-2)(x-3) - x + 7 = 0$ at x-intercepts. **(15)**

4. (a) Prove that the asymptotes of the curve $(x^2-y^2)^2 = 2(x^2+y^2)$ form a square. **(16)**

(b) Find the angle between the tangent to the curve $r^n = a^n \cos n\theta$ and the radius vector. **(15)**

(c) Find the envelopes of the family of parabola $\sqrt{\frac{x}{a}} + \sqrt{\frac{y}{b}} = 1$, where $ab = k^2$; a, b being variable parameters. **(15⅔)**

Contd P/2

MATH 161/ME

SECTION-B

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

5. (a) Show that AB and BC are perpendicular to each other, where A(-11, 8, 4), B(-1, -7, -1) and C(9, -2, 4). **(8)**

(b) Find equation of a plane which passes through the intersection of the planes $7x-4y+7z+16=0$ and $4x+3y-2z+3=0$ and is parallel to the plane $3x-7y+9z+5=0$. **(18)**

(c) Find the equation of the line perpendicular to both the lines **(20⅔)**

$\frac{x-1}{1}=\frac{y-1}{2}=\frac{z+2}{3}$, $\frac{x+2}{2}=\frac{y-5}{-1}=\frac{z+3}{2}$ and passing through their intersection. Also find the equation of the plane containing the given lines.

6. (a) Show that the lines $\frac{x+3}{2}=\frac{y+15}{3}=\frac{z-7}{-3}$, $\frac{x+1}{4}=\frac{y+1}{5}=\frac{z+1}{-1}$ are coplanar. Also, find the equation of the plane containing them. **(20)**

(b) Find the length and equation of the line of shortest distance between the lines $\frac{x-1}{2}=\frac{y-2}{3}=\frac{z-3}{4}$, $\frac{x-2}{3}=\frac{y-3}{4}=\frac{z-4}{5}$, and state whether they are coplanar or not. **(26⅔)**

7. (a) If **a, b, c** are non- coplanar vectors, then show that the four points **–a+4b-3c, 3a+2b-5c, -3a+8b-5c and -3a+2b+c** are coplanar. **(15)**

(b) Show that the vectors **a = 3i- 2j +k, b = i – 3j +5k, c = 2i + j – 4k** form a right angled triangle. Also, find the remaining angles of the triangle. **(16⅔)**

(c) Find a vector that is orthogonal to both of the vectors **a = 4i + 3j – k** and **b = 2i -6j – 3k**. Also, find a unit vector perpendicular to the plane of **a** and **b**. **(15)**

8. (a) By vector method show that the perpendiculars from the vertices to the opposite side of a triangle are concurrent. **(16⅔)**

(b) Find a set of vectors reciprocal to the set of vectors **2i + 3j – k, i – j – 2k** and **–i + 2j + 2k.** **(15)**

(c) Solve the vector equation for **r:** $k\,\mathbf{r} + (\mathbf{r} \times \mathbf{a}) = \mathbf{b}$, where, k is a non-zero scalar and **a, b** are two vectors. **(15)**

L-1/T-1/ME **Date : 15/09/2018**

BANGLADESH UNIVERSITY OF ENGINEERING AND TECHNOLOGY, DHAKA

L-1/T-1 B.Sc. Engineering Examinations 2017-2018

Sub : **ME 101** (Introduction to Mechanical Engineering)

Full Marks: 210 Time : 3 Hours

USE SEPARATE SCRIPTS FOR EACH SECTION

The figures in the margin indicate full marks. Symbols have their usual meaning.

SECTION – A

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

1. (a) Define boiler horsepower and boiler efficiency. **(5)**

   (b) How are the limitations of a simple vertical boiler overcome in a Cochran boiler? **(5)**

   (c) Write down the functions of super-heater, economizer and air pre-heater in a boiler. What are the advantages of using superheated steam? **(10)**

   (d) With a suitable diagram, explain the working principle of a water tube boiler. **(15)**

2. (a) "A reaction turbine is moved primarily by reactive forces, but also to some extent by direct impulse"- explain. **(8)**

   (b) What are the functions of blade, rotor, diaphragm and gland in a steam turbine? **(10)**

   (c) What is the purpose of compounding in a steam turbine? With suitable diagram(s), explain the velocity compounding in an impulse turbine. **(17)**

3. (a) What benefits make MEMS a great choice in numerous applications in the modern days? **(10)**

   (b) Write down the differences between- **(10)**

   (i) Bulk and surface micromachining

   (ii) Substrate and additive films

   (c) What is mechatronics? Explain the mechatronics system model taking a typical washing machine as an example. **(15)**

4. (a) What is a gear? What are the power transmission and motion control capabilities of gear? **(8)**

   (b) Classify materials. Write down the important properties of metal as a material. **(10)**

   (c) Draw the T-s diagram of the ideal vapor compression refrigeration cycle and identify each process. **(5)**

   (d) Define and classify refrigerants. What are the required properties of a good refrigerant? **(12)**

Contd P/2

ME 101

SECTION-B

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

5. (a) Briefly describe the scope of Mechanical Engineering and point out 5 key activities associated with practicing Mechanical Engineers. Mention some technical subject areas that form the main basis for their work. **(10)**

(b) What are the fossil fuels? Classify them with examples. Distinguish between higher and lower heating value of a fuel. Arrange 4 types of coal according to their heating value. **(10)**

(c) What are the 5 basic types of environmental pollution? With examples describe the sources of these pollutants and their effect in the environment. **(15)**

6. (a) Distinguish between Renewable and Non-Renewable energies. Define wind energy. What is the power co-efficient and tip speed ratio of a wind turbine? What is Betz limit? **(10)**

(b) What is solar energy? What are the 3 processes by which it can be converted into other forms of energy? Give example in each case. Distinguish between P-type and n-type semiconductor. Draw the I-V characteristic curve for a typical silicon photovoltaic cell showing I_{SC}, V_{OC}, and P_{max} (symbols have their usual meaning). **(15)**

(c) How nuclear energy becomes available from Uranium U_{235}? With schematic diagram, show how electricity is produced from a nuclear reactor. **(10)**

7. (a) Draw and label the following 4 pressure-volume diagrams. (i) Actual 4 stroke cycle SI engine, (ii) Actual 4 stroke cycle CI engine, (iii) Actual 2 stroke cycle SI engine, (iv) Actual 2 stroke cycle CI engine. **(16)**

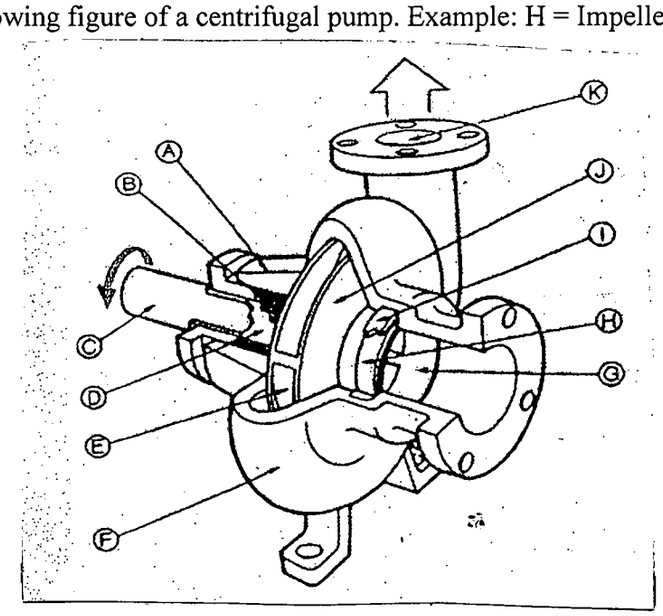
(b) Total volume of a motorbike is 142.54 cc with its compression ratio 8.13 and bore 56.4 mm. Calculate its stroke and engine capacity. **(9)**

(c) What are the functions of IC engine lubricating system? Why piston rings are used in IC engines? **(10)**

8. (a) Draw the schematic diagram of components of a closed cycle gas turbine that works on Brayton cycle with an intercooler and a reheater. Draw also the corresponding P-V and T-s plots. **(15)**

(b) Define specific ratio related to turbomachinery. Distinguish between fans, blowers and compressors in terms of specific ratio. **(10)**

(c) Mention only the names of the components as labeled from "A" to "K" of the following figure of a centrifugal pump. Example: H = Impeller. **(10)**



L-1/T-1/ME **Date : 19/09/2018**

BANGLADESH UNIVERSITY OF ENGINEERING AND TECHNOLOGY, DHAKA

L-1/T-1 B.Sc. Engineering Examinations 2017-2018

Sub : **PHY 105** (Structure of Matter, Electricity and Magnetism and Modern Physics)

Full Marks: 210 Time : 3 Hours

USE SEPARATE SCRIPTS FOR EACH SECTION

The figures in the margin indicate full marks.

SECTION – A

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

1. (a) Discuss charge and matter in electrostatics. Describe the three examples namely, the radioactive decay, annihilation, and pair production to prove that 'charge' is conserved'. **(10)**

(b) Define an electric dipole and an electric quadrupole. Figure 1(b) shows a positive and a negative charge of equal magnitude q placed a distance 2a apart. **(15)**

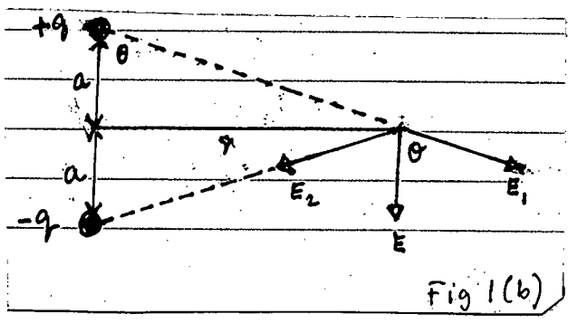


Fig 1(b)

Derive an expression for $\vec{E}$ due to these charges at point P a distance r along the perpendicular bisector of the line joining the charges (assume r >> a).

(c) Fig. 1(c) shows an assembly of two charges +q and –q separated by a distance 2a. **(10)**

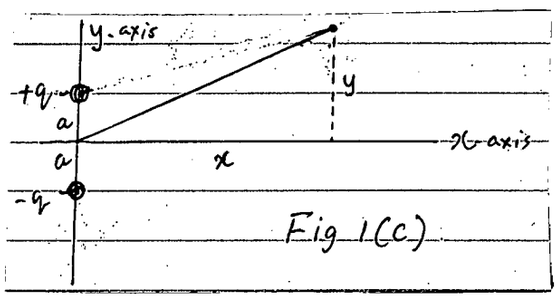


Fig 1(c)

Show that the components of the electric field $\vec{E}$ due to the dipole are given at distant points by

$$E_x = \frac{1}{4\pi \in_0}\frac{3pxy}{\left(x^2+y^2\right)^{5/2}} \quad \text{and} \quad E_y = \frac{1}{4\pi \in_0}\frac{p\left(2y^2-x^2\right)}{\left(x^2+y^2\right)^{5/2}}$$

where the symbols have their usual meanings.

2. (a) Define electric potential V. Compare electric potential difference and field strength. Write down the expression of V for a group of point charges. **(10)**

Contd P/2

PHY 105/ME

Contd... Q. No. 2

(b) Calculate the electric field E from electric potential V. Show that if V is known for all points of space V(x, y ,z), one can find the components of E as $E_x = -\frac{\partial V}{\partial x}$, $E_y = -\frac{\partial V}{\partial y}$ and $E_z = -\frac{\partial V}{\partial z}$. **(15)**

Derive equipotential surfaces for (i) a point charge (ii) a uniform electric field, and (iii) an electric dipole.

(c) A charge q is distributed uniformly throughout a nonconducting spherical volume of radius R. **(10)**

(i) Show that the potential a distance 'a' from the center where a<R is given by

$$V = \frac{q\left(3R^2 - a^2\right)}{8\pi \in_0 R^3}.$$

(ii) Is it reasonable that according to this expression, V is not zero at the center of the sphere? (all symbols have their usual meaning)

3. (a) Discuss magnitude field $\vec{B}$. How would you determine the direction of a magnetic field? Define Lorentz force and Hall field. Briefly discuss the practical use of Hall experiment. **(10)**

(b) Write down Ampere's law. Write down the expression of B for a solenoid.

A flat strip of copper of width 'a' and negligible thickness carrying a current i (as shown in the Fig. 3b). Find the magnetic field at a distance R from the center of the strip, at right angles to the strip. (point P shown in Fig.) Also show that at a distant points the strip behaves like a cylindrical wire. **(15)**

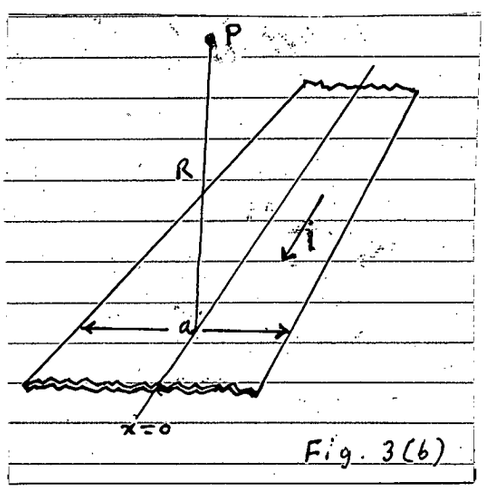


Fig. 3(b)

(c) A long straight wire carries a current of 50 amp. An electron travelling at 10^7 meters/sec. is 5.0 cm from the wire. What force acts on the electron if the electron velocity is directed (i) toward the wire (ii) parallel to the wire, and (iii) at right angles to the direction defined by (i) and (ii)? **(10)**

4. (a) What do you mean by crystal defects? Why crystal defects are important in modern solid state physics? **(10)**

(b) Explain various types of bonds in solids. **(17)**

(c) The Maddelung constant of sodium chloride structure is 1.748 and the ions of opposite signs are separated by a distance 0.281 nm in the structure. If the ionization energy of Na is 5.14 eV and n = 9, calculate the cohesive energy of NaCl crystal. **(8)**

SECTION – B

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

5. (a) Draw a unit cell for NaCl crystal. Describe its crystal structure. **(12)**

(b) Define packing fraction for crystal structure. Calculate packing fraction for bcc and fcc crystal structure. **(15)**

(c) An element is cubic with lattice constant 3.92 Å and width two of its atoms in the unit cibe at (0, 0, 0) and $\left(\frac{1}{2},\frac{1}{2},\frac{1}{2}\right)$. How many nearest neighbours does each atom have in this element, and how far away are they? **(8)**

6. (a) Explain Bragg's law of X-ray diffraction. Write down the characteristic features of Bragg's law. **(15)**

(b) Show that in a crystal of cubic structure, the distance between two adjacent planes with Miller indices h, k, l is equal to $\frac{a}{\sqrt{h^2+k^2+l^2}}$ where a is the lattice parameter. **(12)**

(c) Calculate the glancing angle on the plane (110) of a cube rock salt (a = 2.81 Å) corresponding to second order diffraction maximum for the X-rays of wavelength 0.71Å. **(8)**

7. (a) State the potentials of special theory of relativity. **(7)**

(b) Derive Lorentz transformation equations of special theory of relativity. **(20)**

(c) Spacecraft M is moving at 0.90 c with respect to the earth. If spacecraft N is to pass M at a relative speed of 0.70 C in the same direction, what speed must N have with respect to the earth? **(8)**

Contd P/4

8. (a) Explain the phenomenon of photoelectric effect. **(7)**

(b) Discuss the experimental observations of photoelectric effect which could not be explained by classical theory. Establish Einstein's equation of photoelectric effect. **(20)**

(c) Light of wavelength 430 nm is incident on (i) a nickel surface of work function 5.0 eV, and (ii) a potassium surface of work function 2.3 eV. Calculate, if electrons are ejected, and if so, the maximum velocity of the ejected electrons in each case. (Given eV = 1.6×10^{-19}J, h = 6.63×10^{-34}J-s, and c = 3×10^{8}m/s). **(8)**

L-1/T-1/ME **Date : 25/09/2018**

BANGLADESH UNIVERSITY OF ENGINEERING AND TECHNOLOGY, DHAKA

L-1/T-1 B.Sc. Engineering Examinations 2017-2018

Sub : **CHEM 109** (Chemistry - I)

Full Marks: 210 Time : 3 Hours

USE SEPARATE SCRIPTS FOR EACH SECTION

The figures in the margin indicate full marks.

SECTION – A

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

1. (a) Justify the following statements: **(4×7=28)**

   (i) Bohr model can successfully explain the line spectra of hydrogen atoms.

   (ii) Plank's quantization of energy leads Albert Einstein to explain the photoelectric effect.

   (iii) The solution of Schrödinger equation introduces the concept of atomic orbital.

   (iv) The effective nuclear charge increases as you move from left to right in a periodic table.

   (b) Spectral lines of the Lyman and Balmer series do not overlap. Verify this statement by calculating the longest wavelength associated with the Layman series and the shortest wavelength associated with the Balmer series (in nm). [$R_H = 2.18 \times 10^{-18}$J]. **(7)**

2. (a) How is the concept of bond polarization introduced the covalent character in the ionic boding? Which one of the following pairs is more covalent in nature: (i) $MgCl_2$ and MgI_2, (ii) $BaCl_2$ and $BeCl_2$, (iii) $SnCl_2$ and $SnCl_4$, and (iv) KCl and $TiCl_4$. **(6+4=10)**

   (b) State the main assumptions in VSEPR theory in predicting the geometry of molecules or ions. Draw the geometry and predict angles of the followings (i) BrF_3 (ii) IF_4^+. **(5+4=11)**

   (c) Show the process of hybridization of acetylene and draw the hybrid orbitals. **(8)**

   (d) Apply the concept of MOT and show that N_2 is diamagnetic but O_2 is paramagnetic. **(6)**

3. (a) Chemical kinetics is a branch of chemistry that deals with the study of reaction rates, factors influence the reaction rates and the molecular events occur during the overall reaction. Answer the followings: **(6+3+3=12)**

   (i) Compare average rate and instantaneous rate.

   (ii) How does the physical state of reactions influence the rate?

   (iii) What do you understand by the term 'molecular events?

   (b) Describe your understanding on zero order reaction. *Unlike other type of reaction the rate of a zero order reaction in independent of the progress of reaction with time-* justify the statement. **(8)**

Contd P/2

CHEM 109/ME

Contd... Q. No. 3

(c) For the following consecutive reaction, where k_1 and k_2 are the rate constants, respectively. Draw the typical reaction profiles when (i) $k_1 >> k_2$, (ii) $k_2 >> k_1$. **(8)**

$$A \rightarrow B \rightarrow C$$

(d) The thermal decomposition of N_2O_5 obeys first order kinetics. At 45°C, a plot of $\ln[N_2O_5]$ versus time (t) gives a slope of -6.18×10^{-4} min^{-1}. Calculate the half-life of the reaction. **(7)**

4. (a) In the following equilibrium identify the number of phase, the number of component and the number of degrees of freedom. Show the existence of the equilibrium in a diagram. **(3+5=8)**

$$Ice(s) \rightleftharpoons Water\ (l) \rightleftharpoons Vapor\ (g)$$

(b) Relate the term 'True equilibrium' and 'Metastable equilibrium'. Draw the phase diagram of sulfur system and show the formation of metastable equilibrium. **(6+8=14)**

(c) Draw a typical two component condensed system phase diagram having an eutectic mixture at 40% A and 60% B. **(5+8=13)**

(i) Identify the characteristic properties of eutectic composition.

(ii) Consider the point X above the freezing point of component A having the composition of 20% A and 8% B. Draw a vertical line from point X to the composition axis. Draw a cooling curve showing the temperature as a function of time along the line with proper argument.

SECTION-B

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

5. (a) For thermochemical reactions **(10)**

(i) Define enthalpy and internal energy. Explain that change in internal energy is a state function.

(ii) Prove that the change in enthalpy is equal to the heat gained or lost at constant pressure.

(b) Calorimeter is used for the measurement of heat transfer in chemical transformation. **(10)**

(i) Draw a schematic diagram of bomb-calorimeter. How is it possible to measure enthalpy change for a reaction from bomb-calorimetric measurements?

(ii) A 0.5865 g sample of lactic acid is burnt in a bomb 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.

Contd P/3

CHEM 109/ME

Contd... Q. No. 5

(c) The fuel value of any food or fuel can be measured by calorimetry. **(10)**

(i) What is meant by the term fuel value? Why fats are well suited for energy storage in human body?

(ii) Why metabolism of proteins produces less energy than combustion in a calorimeter?

(iii) A serving of a particular ready-to-serve chicken noodle soup contains 2.5 g fat, 14 g carbohydrate, and 7 g protein. Estimate the number of calories in a serving. The fuel values of carbohydrate, fat and protein are 17 kJ/g, 38 kJ/g and 17 kJ/g, respectively.

(d) What are the difference between renewable energy sources and nonrenewable energy sources? Give two examples of each type. **(5)**

6. (a) For electrochemical voltaic cells **(10)**

(i) How anode and cathode can be defined?

(ii) What is the equation for calculation of electromotive force (emf) of a cell in standard condition?

(iii) What is the equation for calculation of the emf of a cell in nonstandard condition?

(iv) What is the effect of change in concentrations of reactant and product in emf of cell?

(v) How does surface area of electrodes affect the cell emf?

(b) The solubility product of iron(II) iron fluoride is 2.4×10^{-6} and standard reduction potential of Fe^{2+} (aq) is -0.440 V. **(10)**

(i) Write the half-reaction that gives the likely products of the two-electron reduction of FeF_2(s) in water.

(ii) Use the solubility product value and standard reduction potential of Fe^{2+} (aq) to calculate the standard reduction potential for the half reaction in part (i).

(iii) Rationalize the difference between the required potential in part (i) and the required potential for Fe^{2+}.

(c) Write down the steps for balancing the following redox reaction that takes place in basic solution and identify oxidizing agent and reducing agent. **(10)**

(d) Write the anode and cathode reactions that cause the corrosion of iron metal to aqueous iron (II). Write the balanced half-reactions involved in the air oxidation of Fe^{2+} (aq) to $Fe_2O_3.3H_2O$. **(5)**

7. (a) For acids and bases **(10)**

(i) Define strong acids and weak acids in terms of conjugate acid-base concept.

(ii) What are the factors, which defines the relative acidity and basicity of different substances?

(iii) Explain that HX can act as strong acid or weak acid, when dissolved in water, if X is different.

(iv) Calculate the ion-product constant for water at 25°C.

Contd P/4

CHEM 109/ME

Contd... Q. No. 7

(b) A 0.1 M solution of bromoacetic acid ($BrCH_2COOH$) is 13.2% ionized. Calculate $[H^+]$, $[BrCH_2COO^-]$, $[BrCH_2COOH]$ and K_a of bromoacetic acid. **(10)**

(c) Consider two titrations. One is the titration of a strong, monoprotic acid with a strong base. Another, titration of a weak, monoprotic acid with a strong base. How do these two titrations differ with respect to the following and explain your answer. **(10)**

(i) Quantity of base required to reach the equivalence point,

(ii) pH at the beginning of titration,

(iii) pH at the equivalence point,

(iv) pH after the addition of a slight excess of base

(v) Choice of indicator for determining the equivalence point?

(d) Give the chemical formula for hydrosulfuric acid, chloric acid, perchloric acid, hypochlorous acid and chlorous acid. **(5)**

8. (a) When ammonium chloride dissolves in water, the solution becomes colder. **(10)**

(i) Draw energy level diagram for the solution process.

(ii) Why does the solution form? Explain in terms of the enthalpy and entropy changes.

(b) Some physical properties of solutions differ in important ways from those of pure solvent. **(10)**

(i) What are colligative properties of dilute solutions?

(ii) Explain that elevation of boiling point is a colligative property.

(iii) Describe one of the applications of the measurement of colligative properties.

(c) Ascorbic acid (vitamin C, $C_6H_8O_6$) is a water-soluble vitamin. A solution containing 80.5 g of ascorbic acid dissolved in 210 g of water has density of 1.22 g/mL at 55°C. Calculate the mass percentage, the mole fraction, the molality, the molarity and parts per million expressions of ascorbic acid in solution. **(10)**

(d) Why vitamin 'C' should be included in the daily diet? **(5)**
