SECTION – A

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

1. (a) Explain how:

(i) An endergonic reaction can be carried out by coupling it with an exergonic reaction.

(ii) Thermodynamic equilibrium constant remains always constant unless temperature is changed.

(b) Establish a relation between the standard free energy change and the equilibrium constant of a reaction.

(c) At 2000 K, the standard free energy change for the reaction $N_2 + O_2 \leftrightarrow 2NO$ is given by $\Delta G^\circ = 92048 - 10.46 \times T$ J. Calculate $K_p$ for the reaction at 2000 K.

2. (a) Justify: P

(i) In a reversible process the net entropy change for the system and its surrounding is zero.

(ii) The entropy of a gaseous system increases due to mixing of the individual gasses.

(b) Derive an expression for the entropy change of an ideal gas when the pressure changes from $P_1$ to $P_2$ and the temperature changes from $T_1$ to $T_2$.

(c) Calculate the change in entropy of 5 moles of an ideal gas when the gas is expanded reversibly and isothermally from 2 atm to 1 atm at 25°C.

3. (a) Rationalize:

(i) The decrease in free energy of a system is a measure of maximum useful work obtainable from the process.

(ii) Ice melts spontaneously above 0°C even though the process is endothermic.
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Contd ... Q. No. 3

(b) Derive Gibbs-Helmholtz equation and discuss its importance.

(c) The $\Delta G$ value (in caloric) for a chemical reaction can be given by the equation:

$$\Delta G = -9190 + 7.12 T \ln T - 3.18 \times 10^{-1} T^2 + 1.32 \times 10^{-7} T^3 - 21.61 T.$$ 

Calculate the $\Delta H$ and $\Delta S$ values for the reaction.

4. (a) Define:

(i) Heat of reaction, (ii) Differential heat of solution, and (iii) Integral heat of solution.

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

(c) Calculate the heat of formation of $H_2O(l)$ at 60°C if the heat of formation at 25°C is $-68.370$ cal. The reaction is $H_2(g) + \frac{1}{2} O_2(g) = H_2O(l)$

The values of heat capacities are:

- $C_p(H_2) = 6.90$ cal mol$^{-1}$deg$^{-1}$
- $C_p(O_2) = 7.05$ cal mol$^{-1}$deg$^{-1}$
- $C_p(H_2O) = 18.0$ cal mol$^{-1}$deg$^{-1}$

SECTION - B

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

5. (a) Gold used in the ornaments is a solid solution – Justify the statement.

(b) Outline the quantitative relation between the solubility of gas in liquid with pressure. Using the concept of solubility of gas in liquid explain the term ‘Thermal pollution’. Relate it with the ecological imbalance.

(c) Give a molecular interpretation of solution process when a solid electrolyte is mixed with a polar solvent.

(d) A nurse needs 525 g of 2.00% sterile saline solution (NaCl). He has two sterile stock solutions of NaCl: 5.000% and 0.5000% by mass, but no sterile water. How can he make the required solution?
6. (a) State the Nernst distribution law. Specify the use of the law in the determination of equilibrium constant. For the following equilibrium, design an experimental setup.

\[ I_2 + I^- \leftrightarrow I_3^- \]  

(b) The deviation from Raoult’s law determines the non-ideality in solution. How can you account for the non-ideal behavior of miscible liquid pair? Show the nature of non-ideality.

(c) Raoult’s law fails to describe the nature of azeotropic mixture. Define an azeotrope and propose the techniques which can be applied for the separation of components from azeotropic solution.

(d) In the distribution of succinic acid between ether and water at 15°C, 20 mL of the ethereal layer contains 0.092 g of the acid. Find out the weight of the acid present in 50 mL of the aqueous solution in equilibrium with it if the distribution coefficient for succinic acid between water and ether is 5.2.

7. (a) Draw a suitable phase diagram showing the freezing point of solvent and solution. Applying Clausius-Clapeyron equation show that the depression of freezing point due to the addition of a non-volatile and non-electrolyte dependent on the concentration of the solute in molality.

(b) Determine the total vapor pressure over a solution of 0.600 moles of toluene and 0.400 moles of benzene of 60°C assuming ideal behavior. The vapor pressers of pure toluene and benzene are, respectively 139 mm Hg and 392 mm Hg at 60°C.

(c) What is the significance of Van’t Hoff factor in case of colligative properties of electrolytes? How the factor is related with the degree of dissociation in case of weak electrolytes?

(d) The freezing point of an aqueous 0.050 \textit{m} CaCl\textsubscript{2} solution is \(-0.27\)°C. What is the Van’t Hoff factor \(i\) for CaCl\textsubscript{2} at this concentration? How does it compare to the expected value of \(i\)?

8. (a) How can you account for the formation of charge in colloid by the selective adsorption of ions? Illustrate with suitable example.

(b) Specify the use of ultrasound in formation of colloid.
(c) Dynamic light scattering (DLS) also known as photon Correlation Spectroscopy is one of the most popular light scattering techniques for particle sizing. How does the principle of DLS apply in the measurement of particle size distribution? (10)

(d) Draw the schematic diagram showing the formation of electrical double layer. Write down the significance of the slipping plane in such diagram. (4+3=7)

(e) Relate the term 'protective colloid' and 'Gold number'. (5)
1. (a) The label of a gas cylinder was missing in your laboratory. You know only that one single gas is contained in the cylinder, but you do not know whether it is hydrogen, oxygen, or nitrogen. To find out, you evacuate a 5-liter flask, seal it and weigh it, then let gas from the cylinder flow into it until the gauge pressure equals 1.00 atm. The flask is reweighed, and the mass of the added gas is found to be 11.2 g. Room temperature is 27°C, and barometric pressure is 1.00 atm. What is the gas?

(b) Superheated steam at 40 bar absolute and 500°C flows at a rate of 250 kg/min to an adiabatic turbine, where it expands to 5 bar. The turbine develops 1500 kW. From the turbine the steam flows to a heater, where it is reheated isobarically to its initial temperature. Neglect kinetic energy changes.

(i) Write an energy balance on the turbine and use it to determine the outlet stream temperature.

(ii) Write an energy balance on the heater and use it to determine the required input (kW) to the steam.

(iii) Verify that an overall energy balance on the two-unit process is satisfied.

2. (a) A turbine discharges 200 kg/h of saturated steam at 10.0 bar absolute. It is desired to generate steam at 250°C and 10.0 bar by mixing the turbine discharge with a second stream of superheated steam of 300 °C and 10.0 bar.

(i) If 300 kg/h of the product steam is to be generated, how much heat must be added to the mixer?

(ii) If the mixing is carried out adiabatically, at what rate is the product steam generated?
(b) Trichloroethylene, a widely used degreasing solvent for machine parts, is produced in a two step reaction sequence. Ethylene is first chlorinated to yield tetrachloroethane, which is dehydrochlorinated to form trichloroethylene.

\[
\begin{align*}
C_2H_4(g) + 2Cl_2(g) & \rightarrow C_2H_2Cl_4(l) + H_2(g): \Delta H_f = -385.76 \text{ kJ/mol} \\
C_2H_2Cl_4(l) & \rightarrow C_2HCl_3(l) + HCl(g)
\end{align*}
\]

The standard heat of formation of liquid trichloroethylene is 276.2 kJ/mol. Use the given data and tabulated standard heats of formation of ethylene and hydrogen chloride to calculate the standard heat of formation of tetrachloroethane and the standard heat of the second reaction.

3. (a) A gas turbine power plant receives a shipment of hydrocarbon fuel whose composition is uncertain but may be represented by the expression C\textsubscript{x}H\textsubscript{y}. The fuel is burned with excess air. An analysis of the product gas gives the following results on a moisture-free basis: 10.5\% (v/v) CO\textsubscript{2}, 5.3\% O\textsubscript{2}, and 84.2\% N\textsubscript{2}.

(i) Determine the molar ratio of hydrogen to carbon in the fuel \(r\), where, \( r = \frac{y}{x} \) and the percentage excess air used in the combustion.

(ii) What is the air-to-fuel ratio \( m_{\text{air}} \) (m\textsuperscript{3} air/kg of fuel) if the air is fed to the power plant at 30°C and 98 kPa?

(b) Consider an automobile with a mass of 5500 lb braking to a stop from a speed of 55 miles/h.

(i) How much energy (Btu) is dissipated as heat by the friction of the braking process?

(ii) Suppose that throughout Bangladesh, 300,000,000 such braking processes occur in the course of a given day. Calculate the average rate (megawatts) at which energy is being dissipated by the resulting friction.

4. (a) Define the terms (i) Heat of reaction (ii) Standard heat of reaction, and (iii) Standard heat of formation.

(b) n-Butane is converted to isobutene in a continuous isomerization reactor that operates isothermally at 149°C. The feed to the reactor contains 93 mole% n-butane, 5% isobutene, and 2% HCl at 149°C, and a 40% conversion of n-butane is achieved.
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Contd … Q. No. 4(b)

Taking a basis of 1 mol of feed gas, calculate the moles of each component of the feed and product mixtures and the extent of reaction, $\xi$ (mol). Calculate the standard heat of the isomerization reaction (kJ/mol) from handbook data.

(i) Then, taking the feed and product species at 25°C as references, prepare an inlet-outlet enthalpy table and calculate and fill in the component amounts (mol) and specific enthalpies (kJ/mol).

(ii) Calculate the required rate of heat transfer (kJ) to or from the reactor (state which it is). Then determine the required heat transfer rate (kW) for a reactor feed of 325 mol/h.

SECTION – B

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

5. (a) Often Chemical Engineers use dimensionless numbers. The following is an equation used for heat transfer calculation:

$$\left( \frac{h}{C_p G} \frac{C_p \mu^2}{k} \right)^{2/3} = \frac{0.23}{(DG / \mu)}$$

where, $C_p$ is in Btu/(lbm °F), $\mu$ is in lbm/(h ft), $k$ is in Btu/(h ft°F), $D$ is in ft, $G$ is in lbm/(h ft). Find the unit of $h$ so that the above equation is dimensionally consistent.

(b) The feed to a plug flow reactor contains equimolar amounts of $CH_4$ and $O_2$. The following reactions take place.

$$CH_4 + O_2 \rightarrow HCHO + H_2O$$
$$CH_4 + 2O_2 \rightarrow CO_2 + H_2O$$

The fractional conversion of $CH_4$ is 0.9 and the fractional yield of formaldehyde is 0.85. Taking a basis of 100 mol feed/s, calculate the molar composition of the reactor output stream.

6. (a) A 100 kg/h fresh feed containing 20 wt% KNO$_3$ and the balance water is combined with a recycle stream and is fed to an evaporator. The concentrated liquid solution exited from the evaporator contains 50 wt% KNO$_3$ is fed to a crystallizer. The crystals obtained from the crystallizer are 96% KNO$_3$ and 4% water. The liquid from the crystallizer constitutes the recycle stream and contains 0.6 kg KNO$_3$ per 1 kg of water. Calculate all stream flow rates and their compositions.
b) To make strawberry jam, strawberries containing 15 wt% solids and 85% water are crushed and mixed with sugar in a ratio of 4:5. The mixture is heated to evaporate water. The residue contains 30% water by mass. Calculate the amount of strawberries needed to make 1 kg of jam.

7. (a) The level of Toluene (a flammable hydrocarbon) in a storage tank may fluctuate between 10 cm and 400 cm from the top of the tank (See Fig Q. 7a). Since it is impossible to see inside the tank, an open-end manometer with water or mercury as the manometer fluid is to be used to determine the Toluene level. One leg of the manometer is attached to the tank at 500 cm from the top. A Nitrogen blanket at atmospheric pressure is maintained over the tank contents.

\[ R = \frac{H_{\text{top}} - H_{\text{bottom}}}{\gamma_{\text{manometer}}} \]

What manometer reading, \( R \) (cm), would be obtained for a toluene level of 100 cm from the top of the tank if water is used as a manometer fluid? What would be this reading for mercury as a manometer fluid? What manometer fluid would you use and why?

(b) A mixture of Propane and Butane is burned with pure oxygen. The combustion product contains 47.4 mole% water. Upon removal of all water from the combustion product, the residual product contains 69.4% CO\(_2\) and the balance O\(_2\). What is the mole% of Propane in the fuel?

8. (a) Carbon dioxide and Hydrogen react to form Methanol and Water. The fresh feed to the process contains hydrogen, carbon dioxide and 0.50 mole% inerts (I). The reactor effluent passes to a condenser that removes essentially all of the methanol and water formed and none of the reactants or inerts. The latter substances are recycled to the reactor. To avoid buildup of the inerts in the system, a purge stream is withdrawn from recycle. The feed to the reactor contains 23.0 mole% CO\(_2\), 75 mole% H\(_2\) and 2% inert.
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Contd... Q. No. 8(a)

The single pass conversion of H₂ is 60%. Calculate the molar flow rates and molar compositions of the fresh feed, the total feed to the reactor, the recycle stream, and the purge stream for a methanol production rate of 200 kmol methanol/hr.

(b) The oxidation of ethylene to produce ethylene oxide proceeds as:

\[ 2C_2H_4 + O_2 \rightarrow 2C_2H_4O \]

The feed to the reactor contains 100 Kmol C₂H₄ and 200 Kmol O₂. What is the limiting reactant? What is the percentage excess of the other reactant?
SECTION - A

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

1. (a) What is an electric dipole and dipole moment? (8)

(b) An electric dipole is placed in a uniform external electric field \( \vec{E} \). Show that the torque on the dipole is given by \( \tau = \vec{p} \times \vec{E} \), where \( \vec{p} \) is the dipole moment of the dipole. (10)

(c) Show that the potential energy \( U \) stored in the system is given by \( U = -\vec{p} \cdot \vec{E} \). (10)

(d) A neutral water molecule in its vapor state has an electric dipole moment of \( 6.2 \times 10^{-30} \text{Coul-m} \). It is placed in an electric field of \( 1.5 \times 10^4 \text{N/C} \). How much work has to do to turn this molecule end for end in this field, starting from its aligned position for \( \theta = 0^\circ \). (7)

2. (a) Explain the terms self-inductance and mutual-inductance. What is back e.m.f? (8)

(b) Show that the energy required to build up a current \( I \) in a circuit having self inductance, \( L \) is \( \frac{1}{2} LI^2 \). (7)

(c) If a straight metal wire of length \( \ell \) carrying a current \( i \) is placed at right angles to a uniform magnetic field \( \vec{B} \), show that the deflecting force on it is given by \( \vec{F} = i \ell \times \vec{B} \). (12)

(d) In a hydrogen atom, an electron revolves around the nucleus in a circular orbit of radius \( 5.11 \times 10^{-11} \text{m} \) at a frequency of \( 6.8 \times 10^{15} \text{Hz} \). What is the magnetic field set up at the center of the orbit? (8)

3. (a) State and explain Curie’s law in magnetism. (5)

(b) Define the following terms: (i) Paramagnetic materials, (ii) Ferromagnetic materials, (iii) Antiferromagnetic and diamagnetic materials. (10)

(c) What is a magnetic hysteresis loop? Describe a method for obtaining hysteresis loop. (12)

(d) Explain the terms (i) Remanence and (ii) coercivity. How will you characterise the soft and hard magnetic materials? (8)

Contd ………… P/2
4. (a) Define the terms:
   (i) Crystalline solids  (ii) Point lattice  (iii) Unit cell
   (b) Explain the term Miller indices. Derive a relation between interplanar spacing ‘d’ and cube edge ‘a’.
   (c) Write a short note on
   (i) Sodium chloride unit cell (Nacl), (ii) Bragg’s law for X-ray diffraction.

**SECTION – B**

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

5. (a) What is packing fraction?
   (b) Find out the packing fraction of a simple cubic (s.c.), a body centered cubic (b.c.c) and a face centered cubic (f.c.c) crystal structure.
   (c) Sodium is a b.c.c. crystal. Its density is $9.6 \times 10^2$ kg/m$^3$ and atomic weight is 23. Calculate the lattice constant for a sodium crystal.

6. (a) Distinguish between ionic and covalent bonds.
   (b) Obtain an expression for binding energy for an ionic crystal and find the expression for the Madelung constant. Evaluate the Madelung constant for a linear ionic crystal.
   (c) Write a short note on: Point defects.

7. (a) What do you mean by simultaneity? With a suitable example show that simultaneity is a relative concept.
   (b) Derive Lorentz transformation equations. Show that Galilean transformation is a special case of Lorentz transformation.
   (c) Show that the momentum of a particle of rest mass $m_0$ and kinetic energy $K_E$ is given by the expression $p = \sqrt{\frac{k_E^2}{c^2} + 2m_0k_E}$

8. (a) Describe the nature of nuclear force.
   (b) Derive an expression for the change in wavelength of an incident X-ray photon on an electron at rest. What is Compton wavelength?
   (c) The radius of $^{107}_{47}$Ag is 5.7 Fermi. Deduce the radius of $^{238}_{92}$U.
There are FOUR questions in this Section. Answer Q. No. 1 and any TWO from the rest.

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

(i) "You have lost reason and taken wrong path. You have taken lies for truth, and hideousness for beauty."

(ii) "My dear child, it's no use asking me. I'm determined to leave everything to you children this year. Forget I am your mother."

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

(i) Make an evaluation of the role played by Laura Sheridan in the short story 'The Garden Party'.

(ii) How did the lawyer spend his fifteen years' term in jail?

(c) Answer any three of the following: (12)

(i) How are the Sheridans and their poor neighbours contrasted in the short story "The Garden Party"?

(ii) Under what circumstances did the banker decide to kill lawyer?

(iii) How do you see Mr. Loisel as a husband?

(iv) Why did Mrs. Forestier fail to recognize Mr. Loisel?

2. Recast and correct any ten of the following sentences: (20)

(i) This tanker is able to be restored.

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

(iii) Walt Whitman occupies a most unique place in literature.
(iv) It is I who is to make the call.
(v) Both of the mouse are underfed.
(vi) The militia is discussing the battle among itself.
(vii) Its a long way home.
(viii) Who did you want to help you?
(ix) If I were him I should not accept the post.
(x) He is something better today.
(xi) Last week our clergyman reminded us that living the upright life was a discipline.
(xii) This table is more square than that one.

3. (a) Give meanings of any ten of the following words:
   Albino, brandish, cider, cryptic, equivocal, feeble, garrulous, lanky, mumble, phlegmatic, rebut, scornful.

   (b) Make sentences with any ten of the following words:
   Acrid, blithe, congenital, deviate, eradicate, forbearance, impromptu, laud, loathe, munch pauper, reiterate.

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

   The great advantage of early rising is the good start it gives us in our day’s work. The early riser has done a large amount of hard work before other men have got out of bed. In the early morning the mind is fresh, and there are few sounds or other distractions, so that work done at that time is generally well-done. In many cases the early riser also finds time to take some exercise in the fresh morning air, and this exercise supplies him with a fund of energy that will last until the evening. By beginning so early, he knows that he has plenty of time to do thoroughly all the work he can be expected to do, and is not tempted to hurry over any part of it. All his work being finished in good time, he has a long interval of rest in the evening before the timely hour when he goes to bed. He gets to sleep several hours before midnight, at the time when sleep is most refreshing and after a sound nights’ rest, rises early next morning in good health and spirits for the labours of a new day. It is very plain that such a life as this is far more conducive to health than that of the man who shortens his waking hours by rising late, and so can afford in the course in the day little leisure for necessary rest. Any one who lies in bed late, must, if he wishes to do a full day’s work, go on working to a correspondingly late hour, and deny himself the hour of evening exercise that he ought to take for the benefit of his health. But in spite of all his efforts, he will produce not as good results as the early riser, because he misses the best working hours of the day.
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SECTION – B

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

5. Read the following passage carefully and answer the questions given below:

'Recycling refers to the process of treating used objects or materials so that they can be used again.' It is often very interesting to note that how the Western countries make a fuss over such recycling processes with a certain possessiveness as if they were the first to invent it and now is suffering from the dire burden to enlighten the rest of the world about it. They also view it as a trendy, conscientious, responsible thing to do! And if we probe we will learn that by recycling they mean – recycling paper to make paper, recycling glass to make glass, cans to cans and end up tongue twisters like-"Can you can a can, as a canner can can a can?" And within all these signs, all these brandings, all these publicity stunts we always feel how much they lack innovation. As our mom's old sarees were preserved, then sent to village homes for 'kanthas' to be stitched, men's old shirts or dresses became dusters or wipe clothe; our old school note books became packets for 'jhal muries', piles of old newspapers were sold to buy 'silly things; broken utensils earned as 'kotkoties' ... and it is still through that we do not recycle. So we should start posing questions to the West, 'Aren’t you simply recycling ideas those we have recycled all along?'

We are not the West of Waste; we have just become the waste of West.

Questions:

(a) What is the passage about? Can you relate to your own experiences?

(b) What do you think is the Western fuss about? Do you smell some fallacy?

(c) How do you think the writer feel about the recycling done in Bangladesh and what do you feel?

(d) Do you find any sense of nostalgia in the passage? Elaborate.

(e) What do you understand by the phrases “the West of Waste” and “the Waste of West?”

(f) Write down the meanings of the following words as used in the passage:

Fuss, dire, enlighten, trendy, conscientious.

6. (a) Write a claim letter as a Manager of a company to replace 10 (ten) computers which are found to be malfunctioning after purchase.
(b) Give phonetic transcriptions of the following words: (Any five): 

About, donor, cottage, enrich, captain, exam.

7. (a) Write a dialogue between two friends sharing their experiences of working as volunteers at Departmental alumni programme. 

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

(i) Virtualization of Friendship

(ii) Beautification of Dhaka City

(iii) My Favourite subject of Study.

8. (a) Transform the following sentences as directed: (Any Five):

(i) the news is too good to be true (Make it complex)

(ii) A man who is idle is sure to suffer in life. (Make it Simple)

(iii) Eat better and live better (Make it Simple)

(iv) Hasan was educated at Dhaka University and he joined the Defense service. (Make it Complex)

(v) The man came here in a black shirt. (Make it Compound)

(vi) We sow so that we reap. (Make it Compound)

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

(i) Components of a report

(ii) Diphthongs

(iii) Barriers to Communication.
1. Carry out the following integrals:

(a) \[ \int \frac{\sin x}{\sqrt{1 + \sin x}} \, dx \]
(b) \[ \int \log\left( x + \sqrt{x^2 + a^2} \right) \, dx \]
(c) \[ \int (x - 3) \sqrt{\frac{2x^3 - 3x + 1}{x - 1}} \, dx \]

2. (a) Find a reduction formula for \[ I_n = \int (\cos^{-1} x)^n \, dx \] and hence find \[ \int (\cos^{-1} x)^3 \, dx \].

(b) Evaluate: \[ \lim_{n \to \infty} \left[ n^{1/2} + \frac{n^{1/2}}{(n + 4)^{1/2}} + \frac{n^{1/2}}{(n + 8)^{1/2}} + \ldots + \frac{n^{1/2}}{(n + 4(n - 1))^{1/2}} \right] \]

(c) Find the value of: \[ \int_{0}^{\pi} \frac{x^3 \cos x \sin^2 x}{\pi^2 - 3\pi x + 3x^2} \, dx \] (Using properties)

3. (a) Show that \[ \int_{0}^{\infty} \frac{\sqrt{x}}{(1 + x)^2} \, dx = \frac{1}{2} + \frac{\pi}{4} \]

(b) Define gamma function and beta function. Establish a relation between gamma function and beta function.

(c) (i) If \( a + b > 0 \), then show that \[ \int_{0}^{\infty} \frac{dx}{(x + a)\sqrt{x - b}} = \frac{\pi}{\sqrt{a + b}} \]

(ii) Prove that \[ \int_{0}^{\infty} x^{3/2} e^{-4x} \, dx = \frac{3\sqrt{\pi}}{128} \]

4. (a) Find the area of the loop of the following curve \( y^2(a - x) = x^2(a + x) \).

(b) Find the volume of the solid generated by the revolution of the curve \( y(a^2 + x^2) = a^3 \) about its asymptote.

(c) Find the area of the surface formed by the revolution of the parabola \( y^2 = 4ax \) about the \( x \)-axis by the arc from the vertex to one end of the latus rectum.
There are **FOUR** questions in this section. Answer any **THREE**.

5. (a) Find the differential equation by eliminating arbitrary constants a and b from the equation \( y = ae^{3x} + be^{-2x} \).

(b) Solve the following differential equations:

(i) \((3y - 7x + 7)dx - (3x - 7y - 3)dy = 0\)  
\[\text{(i)}\]

(ii) \((2\sqrt{xy} - y)dx - xdy = 0\)  
\[\text{(ii)}\]

6. (a) Solve: \((1 + x) \frac{dy}{dx} + 3y = \frac{1 + x + x^2}{(1 + x)^3}\)

(b) Find the integrating factor of the following differential equation
\[
(3x^2 y^4 + 2xy)dx + (2x^3 y^3 - x^2)dy = 0
\]
and hence solve it.

(c) Solve: \(\frac{dy}{dx} + \frac{xy}{1-x^2} = x\sqrt{y}\)

7. Solve the following higher order differential equations:

(a) \(\frac{d^2 y}{dx^2} - 6\frac{dy}{dx} + 13y = e^{3x}sin2x\)

(b) \(\frac{d^3 y}{dx^3} + 2\frac{d^2 y}{dx^2} - 3\frac{dy}{dx} = x^3\)

(c) \(x^2 \frac{d^2 y}{dx^2} + 2x \frac{dy}{dx} - 20y = (x+1)^2\)

8. (a) Solve the following differential equation by the method of factorization of operator

\[\frac{x^2 \frac{d^2 y}{dx^2} + (x-2) \frac{dy}{dx} - 2y = x^3}{\text{(a)}}\]

(b) Solve: \((1 + 2x)^2 \frac{d^2 y}{dx^2} - 6(1 + 2x) \frac{dy}{dx} + 16y = 8(i + 2x)^2\)

(c) Solve: \(\frac{y \frac{d^2 y}{dx^2} + \left(\frac{dy}{dx}\right)^2}{\frac{dy}{dx}} = \frac{dy}{dx}\)

\[\text{(c)}\]