

BANGLADESH UNIVERSITY OF ENGINEERING AND TECHNOLOGY, DHAKA

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

Sub : **MATH 191** (Differential and Integral Calculus)

Full Marks: 280

Time : 3 Hours

USE SEPARATE SCRIPTS FOR EACH SECTION

The figures in the margin indicate full marks.

SECTION – AThere are **FOUR** questions in this section. Answer any **THREE**.

Symbols used have their usual meaning.

1. (a) A function $f(x)$ is defined as follows: (20 $\frac{2}{3}$)
- $$f(x) = \begin{cases} x^2 & \text{when } x < 1 \\ 2.5 & \text{when } x = 1 \\ x^2 + 1 & \text{when } x > 1 \end{cases}$$
- Discuss the continuity and the differentiability of $f(x)$ at $x = 1$. Also sketch the graph of $f(x)$.
- (b) Evaluate: $\lim_{x \rightarrow 0} (\cos x)^{\cot^2 x}$ (12)
- (c) Find the n-th derivative of the function $y = \frac{1}{x^2 + 16}$. Hence find $y_n(0)$. (14)
2. (a) State Leibnitz theorem. If $y = \cos(a \sin^{-1} x)$ show that $(1 - x^2)y_{n+2} - (2n + 1)xy_{n+1} - (n^2 - a^2)y_n = 0$. Also find the value of y_n when $x = 0$. (18 $\frac{2}{3}$)
- (b) If $f = \tan^{-1}\left(\frac{x^2 + y^2}{x - y}\right)$ the find the value of $x^2 \frac{\partial^2 f}{\partial x^2} + 2xy \frac{\partial^2 f}{\partial x \partial y} + y^2 \frac{\partial^2 f}{\partial y^2}$. (16)
- (c) Find the first three terms in the expansion in powers x of $\log_e(1 + \tan x)$. (12)
3. (a) State Lagrange's Mean value theorem. If $f(a + h) = f(a) + hf'(a + \theta h)$, $0 < \theta < 1$, find θ , when $a = 5$, $h = 5$ and $f(x) = (x - 1)^{1/2}$. (14)
- (b) Find the volume of the greatest right circular which can be inscribed in a cone of height 30cm. and semi-vertical angle 30° . (18 $\frac{2}{3}$)
- (c) If $lx + my = 1$ is the normal to the parabola $y^2 = 4ax$, then show that $al^3 + 2alm^2 = m^2$. (14)
4. (a) Find the pedal equation of the circle $x^2 + y^2 = 2ax$. (14)
- (b) Find the radius of curvature of the cardioid $r = a(1 + \cos \theta)$ at the point (r, θ) . (14)
- (c) Find all the asymptotes of the curve $4x^3 - x^2y - 4xy^2 + y^3 + 3x^2 + 2xy - y^2 - 7x + 5 = 0$. (18 $\frac{2}{3}$)

MATH 191/IPE

SECTION-B

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

5. Work out the following:

$$(a) \int \frac{dx}{x^3(a+bx)^2}. \quad (15)$$

$$(b) \int \frac{dx}{(2x+1)\sqrt{4x+3}}. \quad (15)$$

$$(c) \int \frac{5 \cos x + 5}{2 \cos x + \sin x + 3} dx. \quad (16\frac{2}{3})$$

6. Evaluate the following:

$$(a) \int_0^1 \frac{dx}{(x+1)\sqrt{1+2x-x^2}}. \quad (15)$$

$$(b) \int_0^{\frac{\pi}{4}} \ln(1 + \tan x) dx. \quad (16\frac{2}{3})$$

$$(c) \int_0^1 \frac{1-x^2}{1+x^2} \frac{dx}{\sqrt{1+x^2+x^4}}. \quad (15)$$

7. (a) Obtain a reduction formula for $I_{m,n} = \int \cos^m x \cos nx dx$ and using it find $\int \cos^3 x \cos 4x dx$. (18)

(b) Show that $\beta(m,n) = \frac{\Gamma(m)\Gamma(n)}{\Gamma(m+n)}$. (14\frac{2}{3})

(c) Evaluate: $\int_0^{\infty} \frac{\sin bx}{x} dx$. (14)

8. (a) Find the length of the cardioid $r = (1 + \cos \theta)$. (14\frac{2}{3})

(b) Find the area of the segment cut off from parabolas $y^2 = 2x$ and $y = 4x^2$. (14)

(c) Find the volume of the solid formed by the revolution of the curve $x^{\frac{2}{3}} + y^{\frac{2}{3}} = a^{\frac{2}{3}}$ about an axis. (18)

BANGLADESH UNIVERSITY OF ENGINEERING AND TECHNOLOGY, DHAKA

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

Sub : **IPE 105** (Principles of Cost and Management Accounting)

Full Marks: 210

Time : 3 Hours

USE SEPARATE SCRIPTS FOR EACH SECTION

The figures in the margin indicate full marks.

SECTION – AThere are **FOUR** questions in this section. Answer any **THREE**.

Assume reasonable values for missing data (if any)

1. (a) Write a linear cost function equation for each of the following conditions. Use Y for estimated costs and X for activity of the cost driver. (10)

- (i) Direct manufacturing labor is \$10 per hour.
- (ii) Direct materials cost \$9.20 per cubic yard.
- (iii) Utilities have a minimum charge of \$1,000, plus a charge of \$0.05 per kilowatt-hour.
- (iv) Machine operating costs include of \$200,000 of machine depreciation per year, plus \$75 of utility costs for each day the machinery is in operation.

- (b) Being a prudent investor, Sally Parkins always investigates a company thoroughly before purchasing shares of its stocks for investment. Ms. Parkins is interested in the common stock of Plunge Enterprise. The following data are available for the company: (25)

	Year 3	Year 2	Year 1
Current ratio	2.8	2.5	2.0
Acid-test ratio	0.7	0.9	1.2
Accounts receivable turnover	8.6	9.5	10.4
Inventory turnover	5.0	5.7	6.8
Sales trend	130.0	118.0	100.0
Dividends paid per share	\$2.50	\$2.50	\$2.50
Dividend yield ratio	5%	4%	3%
Dividend payout ratio	40%	50%	60%
Return on total assets	13.0%	11.8%	10.4%
Return on common stockholders' equity	16.2%	14.5%	9.0%

There were no changes in common stock outstanding over the three-year period.

Ms. Perkins would like answers to a number of questions about the trend of events over the last three years in Plunge Enterprises. Her questions are as follows:

- a. Is the market price of the company's stock going up or down?
- b. Is the earnings per share increasing or decreasing?
- c. Is the price-earnings ratio going up or down?
- d. Is the company employing financial leverage to the advantage of the common stockholders?
- e. Is it becoming easier for the company to pay its bills as they come due?
- f. Are customers paying their bills at least as fast now as they did in Year 1?
- g. Is the total of the accounts receivable increasing, decreasing, or remaining constant?
- h. Is the level of inventory increasing, decreasing, or remaining constant?

Required: Answer each of Ms. Perkins's questions and explain how you arrived at your answer.

IPE 105

2. (a) Marvel Parts, Inc., manufactures auto accessories. One of the company's products is a set of seat covers that can be adjusted to fit nearly any small car. The company has a standard cost system in use for all of its products. According to the standards that have been set for the seat covers, the factory should work 2,850 hours each month to produce 1,900 sets of covers. The standard cost associated with this level of production are:

	Total	Per Set of Covers
Direct materials	\$42,560	\$22.40
Direct labor	\$17,100	9.00
Variable manufacturing overhead (based on direct labor-hours)	\$6,840	3.60
		<u>\$35.00</u>

(20)

During August, the factory worked only 2,800 direct labor-hours and produced 2,000 sets of covers. The following actual costs were recorded during the month:

	Total	Per Set of Covers
Direct materials (12,000 yards)	\$45,600	\$22.80
Direct labor	\$18,200	9.10
Variable manufacturing overhead	\$7,000	3.50
		<u>\$35.40</u>

At standard, each set of covers should require 5.6 yards of material. All of the materials purchased during the month were used in production.

Required: Compute the following variances for August:

- (i) The materials price and quantity variances.
 - (ii) The variable overhead rate and efficiency variances.
- (b) What is a master budget? Explain important with a suitable diagram.

(15)

3. (a) Dexter Corporation produces and sells a single product, a wooden hand loom for weaving small items such as scarves. Selected cost and operating data relating to the product for two years are given below:

(20)

Selling price per unit	\$50
Manufacturing costs:	
Variable per unit produced:	
Direct materials	\$11
Direct labor	\$6
Variable manufacturing overhead	\$3
Fixed manufacturing overhead per year	\$120,000
Selling and administrative expenses:	
Variable per unit sold	\$4
Fixed per year	\$70,000

	Year 1	Year 2
Units in beginning inventory	0	2,000
Units produced during the year	10,000	6,000
Units sold during the year	8,000	8,000
Units in ending inventory	2,000	0

Required:

- (i) Compute the unit product cost and prepare an income statement for each year if the company uses absorption costing.
- (ii) Compute the unit product cost and prepare an income statement for each year if the company uses variable costing.

IPE 105

Contd... Q. No. 3

(b) The Regal Cycle Company manufactures three types of bicycles — a dirt bike, a mountain bike, and a racing bike. Data on sales and expenses for the past quarter follow:

(15)

	Total	Dirt Bikes	Mountain Bikes	Racing Bikes
Sales	\$300,000	\$90,000	\$150,000	\$60,000
Variable manufacturing and selling expenses	120,000	27,000	60,000	33,000
Contribution margin	180,000	63,000	90,000	27,000
Fixed expenses:				
Advertising, traceable	30,000	10,000	14,000	6,000
Depreciation of special equipment	23,000	6,000	9,000	8,000
Salaries of product-line managers	35,000	12,000	13,000	10,000
Allocated common fixed expenses	60,000	18,000	30,000	12,000
Total fixed expenses	148,000	46,000	66,000	36,000
Net operating income (loss)	\$32,000	\$17,000	\$24,000	\$(9,000)

* Allocated on the basis of sales dollars.

Management is concerned about the continued losses shown by the racing bikes and wants a recommendation as to whether or not the line should be discontinued. The special equipment used to produce racing bikes has no resale value and does not wear out.

Required: Should production and sale of the racing bikes be discontinued? Explain. Show computations to support your answer.

4. (a) Come-Clean Corporation produces a variety of cleaning compounds and solutions for both industrial and household use. While most of its products are processed independently, a few are related, such as the company's Grit 337 and its Sparkle silver polish.

(20)

Grit 337 is a coarse cleaning powder with many industrial uses. It costs \$1.60 a pound to make, and it has a selling price of \$2.00 a pound. A small portion of the annual production of Grit 337 is retained in the factory for further processing. It is combined with several other ingredients to form a paste that is marketed as Sparkle silver polish. The silver polish sells for \$4.00 per jar.

This further processing requires one-fourth pound of Grit 337 per jar of silver polish. The additional direct costs involved in the processing of a jar of silver polish are:

Other ingredients	\$0.65
Direct labor	1.48
Total direct cost	\$2.13

Overhead costs associated with processing the silver polish are:

Variable manufacturing overhead cost	25% of direct labor cost
Fixed manufacturing overhead cost (per month)	
Production supervisor	\$3,000
Depreciation of mixing equipment	\$1,400

IPE 105

Contd... Q. No. 4(a)

The production supervisor has no duties other than to oversee production of the silver polish. The mixing equipment is special-purpose equipment acquired specifically to production the silver polish. Its resale value is negligible and it does not wear out though use.

Direct labor is a variable cost at Come-Clean Corporation.

Advertising costs for the silver polish total \$4,000 per month. Variable selling costs associated with the silver polish are 7.5% of sales.

Due to a recent decline in the demand for silver polish, the company is wondering whether its continued production is advisable. The sales manager feels that it would be more profitable to sell all of the Grit 337 as a cleaning powder.

Required:

(i) What is the incremental contribution margin per jar from further processing of Grit 337 into silver polish?

(ii) What is the minimum number of jars of silver polish that must be sold each month to justify the continued processing of Grit 337 into silver polish? Explain.

Show all computations.

(b) Ferris Corporation makes a single product — a fire-resistant commercial filing cabinet — that it sells to office furniture distributors. The company has a simple ABC system that it uses for internal decision making. The company has two overhead departments whose costs are listed below:

Manufacturing overhead	\$500,000
Selling and administrative overhead	300,000
Total overhead costs	\$800,000

(15)

The company's ABC system has the following activity cost pools and activity measures:

Activity Cost Pool	Activity Measure
Assembling units	Number of units
Processing orders	Number of orders
Supporting customers	Number of customers
Other	Not applicable

Costs assigned to the "Other" activity cost pool have no activity measure; they consist of the costs of unused capacity and organization-sustaining costs — neither of which are assigned to orders, customers, or the product.

Ferris Corporation distributes the costs of manufacturing overhead and selling and administrative overhead to the activity cost pools based on employee interviews, the results of which are reported below:

	Assembling Units	Processing Orders	Supporting Customers	Other	Total
Manufacturing overhead	60%	35%	5%	10%	100%
Selling and administrative overhead	10%	45%	25%	20%	100%
Total activity	1,000 units	250 orders	100 customers		

Required:

(i) Perform the first-stage allocation of overhead costs to the activity cost pools.

(ii) OfficeMart is one of Ferris Corporation's customers. Last year, OfficeMart ordered filing cabinets four different times. OfficeMart ordered a total of 80 filing cabinets during the year. Compute the overhead costs attributable to OfficeMart.

IPE 105

SECTION-B

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

5. (a) The Polaris Company uses a job-order costing system. The following data relate to October, the first month of the company's fiscal year. (18)
- (a) Raw materials purchased on account, \$210,000.
 - (b) Raw materials issued to production, \$190,000 (\$178,000 direct materials and \$12,000 indirect materials).
 - (c) Direct labor cost incurred, \$90,000; indirect labour cost incurred, \$110,000.
 - (d) Depreciation recorded on factory equipment, \$40,000.
 - (e) Other manufacturing overhead costs incurred during October, \$70,000 (credit Accounts Payable).
 - (f) The company applies manufacturing overhead cost to production on the basis of \$8 per machine-hour. There were 30,000 machine-hours recorded for October.
 - (g) Production orders costing \$520,000 according to their job cost sheets were completed during October and transferred to Finished Goods.
 - (h) Production orders that had cost \$480,000 to complete according to their job cost sheets were shipped to customers during the month. These goods were sold on account at 25% above cost.

Required:

1. Prepare journal entries to record the information given above.
2. Prepare T-accounts for Manufacturing Overhead and Work in Process. Post the relevant information above to each account. Compute the ending balance in each account, assuming that Work in Process has a beginning balance of \$42,000.

(b) Kingsport Containers, Ltd, of the Bahamas experiences wide variation in demand for the 200- litre steel drums it fabricates. The leakproof, rustproof steel drums have a variety of uses from storing liquids and bulk materials to serving as makeshift musical instruments. The drums are made to order and painted according to the customer's specifications — often in bright patterns and designs. The company is well known for the artwork that appears on its drums. Unit product costs are computed on a quarterly basis by dividing each quarter's manufacturing costs (materials, labour, and overhead) by the quarter's production in units. The company's estimated costs, by quarter, for the coming year follow: (17)

	Quarter			
	First	Second	Third	Fourth
Direct materials	\$240,000	\$120,000	\$60,000	\$180,000
Direct labour	128,000	64,000	32,000	96,000
Manufacturing overhead	<u>300,000</u>	<u>220,000</u>	<u>180,000</u>	<u>260,000</u>
Total manufacturing costs	<u>\$668,000</u>	<u>\$404,000</u>	<u>\$272,000</u>	<u>\$536,000</u>
Number of units to be produced	80,000	40,000	20,000	60,000
Estimated unit product cost	\$8.35	\$10.10	\$13.60	\$8.93

ContdP/6

IPE 105

Contd... Q. No. 5(b)

Management finds the variation in unit costs to be confusing and difficult to work with. It has been suggested that the problem lies with manufacturing overhead, since it is the largest element of cost. Accordingly, you have been asked to find a more appropriate way of assigning manufacturing overhead cost to units of production. After some analysis, you have determined that the company's overhead costs are mostly fixed and therefore show little sensitivity to changes in the level of production.

Required:

1. The company uses a job-order costing system. How would you recommend that manufacturing overhead cost be assigned to production? Be specific, and show computations.
 2. Re-compute the company's unit product costs in accordance with your recommendations in (1) above.
6. (a) The following cost and inventory data are taken from the accounting records of Mason Company for the year just completed:

(15)

Costs incurred:		
Direct labor cost		\$70,000
Purchases of raw materials		\$118,000
Indirect labor		\$30,000
Maintenance, factory equipment		\$6,000
Advertising expense		\$90,000
Insurance, factory equipment		\$800
Sales salaries		\$50,000
Rent, factory facilities		\$20,000
Supplies		\$4,200
Depreciation, office equipment		\$3,000
Depreciation, factory equipment		\$19,000
	Beginning of	End of
	the Year	the Year
Inventories:		
Raw materials	\$7,000	\$15,000
Work in process	\$10,000	\$5,000
Finished goods	\$20,000	\$35,000

Required:

1. Prepare a schedule of cost of goods manufactured in good form.
2. Prepare the cost of goods sold section of Mason Company's income statement for the year.

(b) Mark Hansen is employed by Eastern Products, Inc., and works on the company's assembly line. Mark's basic wage rate is \$20 per hour. The company's union contract states that employees are to be paid time and a half (i.e., \$30 per hour) for any work in excess of 40 hours per week.

(20)

IPE 105

Contd... Q. No. 7

- (a) Compute the new CM ratio and the new break-even point in both units and dollars.
- (b) Assume that the company expects to sell 26,000 units next month. Prepare two contribution format income statements, one assuming that operations are not automated and one assuming that they are. (Show data on a per unit and percentage basis, as well as in total, for each alternative.)
- (c) Would you recommend that the company automate its operations? Explain.

8. (a) Builder products Inc. manufactures a caulking compound that goes through three processing stages prior to completion. Information for the month of May in the first department is given below:

Production Data:	
Units in process May 1:	
100% complete as to material	10000
80% complete as to labor and overhead	100000
Units started into production during May	95000
Units completed and transferred out	
Units in process May 31:	
60% complete as to material	
20% complete as to labor and overhead	
Cost Data:	
Work in process inventory May 1:	
Material cost	\$ 1500
Labor cost	1800
Overhead cost	5400
Cost added during May	
Material cost	154500
Labor cost	22700
Overhead cost	68100

(18)

Required:

- 1. Compute equivalent unit and cost per equivalent unit for May using weighted average method.
- 2. Prepare cost reconciliation for the mentioned data.

(b) Martin company manufactures a single product. The company uses weighted average method in the process costing. Activity for June just been completed. An incomplete production report for the processing department:

Production Data:	
Units in process June 1:	
100% complete as to material	8000
75% complete as to labor and overhead	45000
Units started into production during May	48000
Units completed and transferred out	
Units in process June 30:	
100% complete as to material	
40% complete as to labor and overhead	
Cost Data:	
Work in process inventory June 1:	
Material cost	\$ 5150
Labor cost	660
Overhead cost	1320
Cost added during May	
Material cost	29300
Labor cost	9840
Overhead cost	19680

(17)

Required:

- 1. Compute equivalent unit and cost per equivalent unit for June.
- 2. Prepare cost reconciliation for the mentioned data.

IPE 105

Contd... Q. No. 6(b)

Required:

1. Suppose that in a given week Mark works 46 hours. Compute Mark's total wages for the week. How much of this amount would be allocated to direct labor cost? To manufacturing overhead cost?
 2. Suppose in another week that Mark works 48 hours but is idle for 3 hours during the week due to machine breakdowns. Compute Mark's total wages for the week. How much of this amount would be allocated to direct labor cost? To manufacturing overhead cost?
 3. Eastern Products, Inc., has an attractive package of fringe benefits that costs the company \$6 for each hour of employee time (either regular time or overtime). During a particular week, Mark works 50 hours but is idle for 2 hours due to material shortages. Compute Mark's total wages and fringe benefits for the week. If the company treats all fringe benefits as part of manufacturing overhead cost, how much of Mark's wages and fringe benefits for the week would be allocated to direct labor cost? To manufacturing overhead cost?
 4. Refer to the data in (3) above. If the company treats that fringe benefits relating to direct labor as added direct labor cost, how much of Mark's wages and fringe benefits for the week will be allocated to direct labor cost? To manufacturing overhead cost?
7. Due to erratic sales of its sole product — a high-capacity battery for laptop computers — PEM, Inc., has been experiencing difficulty for some time. The company's contribution format income statement for the most recent month is given below:

(35)

Sales (19,500 units × \$30 per unit)	\$585,000
Less variable expenses	<u>409,500</u>
Contribution margin	175,500
Less fixed expenses	<u>180,000</u>
Net operating loss	<u>\$ (4,500)</u>

Required:

1. Compute the company's CM ratio and its break-even point in both units and dollars.
2. The president believes that a \$16,000 increase in the monthly advertising budget, combined with an intensified effort by the sales staff, will result in an \$80,000 increase in monthly sales. If the president is right, what will be the effect on the company's monthly net operating income or loss? (Use the incremental approach in preparing your answer.)
3. Refer to the original data. The sales manager is convinced that a 10% reduction in the selling price, combined with an increase of \$60,000 in the monthly advertising budget, will cause unit sales to double. What will the new contribution format income statement look like if these changes are adopted?
4. Refer to the original data. The Marketing Department thinks that a fancy new package for the laptop computer battery would help sales. The new package would increase packaging costs by 75 cents per unit. Assuming no other changes, how many units would have to be sold each month to earn a profit of \$9,750?
5. Refer to the original data. By automating certain operations, the company could reduce variable costs by \$3 per unit. However, fixed costs would increase by \$72,000 each month.

SECTION – A

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

1. (a) What is meant by crystalline solids? What is a unit cell? Explain the unit cell of sodium chloride (NaCl) structure. (12)
 (b) Draw face centered cubic (FCC) lattice. What do you mean by packing fraction? Show that the packing fraction for FCC lattice is about 0.74. (15)
 (c) Sodium is a body centered cubic (BCC) crystal. Its density is $9.6 \times 10^2 \text{ kg/m}^3$ and atomic weight is 23. Calculate the lattice constant for a sodium (Na) crystal. (8)

2. (a) Explain the term – Miller indices (hkl). Obtain an expression for the Bragg's law of X-ray diffraction. (15)
 (b) What is an intrinsic semiconductor? Derive an expression for conductivity of an intrinsic semiconductor. (12)
 (c) Lead is FCC lattice with an atomic radius of $r = 1.746\text{\AA}$. Find the spacing of (i) (220) planes and (ii) (111) planes. (8)

3. (a) What is Madelung energy? (5)
 (b) Describe the formation of a stable bond using the potential energy versus interatomic distance curve. Derive an expression for binding energy for an ionic crystal. Evaluate the Madelung constant for a linear ionic crystal. (20)
 (c) What is meant by crystal defects? Write a short note on: Point defects. (10)

4. (a) Write down the postulates of special theory of relativity. Derive the transformation equations which hold both of these two postulates in relativistic mechanics. Also derive the velocity transformation equations corresponding to these transformation equations. (22)
 (b) What are the consequences of special relativity? Graphically represent the consequences of length contraction and time dilation. (7)
 (c) Suppose you started your journey from your home to the BUET campus at 7:25 am and it is 8.00 am when you arrived in the campus. What will be your travel time as observed by a person from a spacecraft moving at a speed of $2.8 \times 10^8 \text{ m/sec}$? (6)

PHY 117/IPE

SECTION – B

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

5. (a) How does Planck's radiation formula solve the problem of ultraviolet catastrophe in explaining the spectrum of black body radiation? (8)
- (b) Drawing suitable diagrams and using quantum theory explain photoelectric effect (PEE) and the results of this effect which cannot be explained by classical theory. Also graphically show the relative probability of occurring PEE, Compton effects and pair production with energy of incident radiation on a material. (20)
- (c) 1.5 mW of 350 nm light is directed at a photoelectric cell. If 0.20 percent of the incident photons produce photoelectrons, find the current in the cell. (7)
6. (a) State radioactive decay law and briefly explain the modes of radioactivity with example of each. (8)
- (b) Define half-life and mean-life of a radioactive substance and find an expression for mean-life. A wooden block is found having ^{14}C with activity of 3.9 disintegration per second per gram. Assuming the activity and half-life of fresh ^{14}C 15.6 disintegration per second per gram and 5568 years, respectively find the age of the block. (21)
- (c) Mention different radioactive decay series with their basic characteristics. (6)
7. (a) What is inductance? Derive expressions for inductance of a long solenoid and a toroid having circular cross-section. (20)
- (b) Show that the energy stored in an inductor is $U = \frac{1}{2} Li^2$, where the symbols have their usual meanings. Calculate the stored energy in an ideal solenoid. (15)
8. (a) What is electric potential? Derive an expression for electric potential due to dipole. (13)
- (b) What is volume charge density? A solid nonconducting sphere of radius R has a total charge Q. Find the electric potential (i) inside and (ii) outside the charged sphere. (22)
-

SECTION – A

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

1. (a) What is meant by quantization of energy? (4)
- (b) In your own words, explain photoelectric effect. How does photon concept explain this effect? (4+3)
- (c) Why does the Bohr model of Hydrogen atom violate the uncertainty principle? How is the concept of electron density used to describe the position of an electron in the quantum mechanical model of an atom? (6+4)
- (d) Consider Ca^{19+} ion with its electron in 5th excited state (i) calculate the longest wavelength of light that could be emitted when the electron jumps to a lower energy state. [Rydberg's constant is $2.18 \times 10^{-18}\text{J}$], (ii) Suppose the same transition as in part (i) took place in hydrogen atom, would the wavelength of emission be longer than, shorter than or the same as your answer to part(i). (6+2)
- (e) Explain what it means for the peak in the radial probability distribution plot for the $n = 1$ level of an H atom to be at 0.529 \AA . (6)

2. (a) For a given value of the principle quantum number, n , how do the energies of the s , p , and d sub levels vary for (i) Hydrogen (ii) Phosphorus? (6)
- (b) Consider both the filled and unfilled orbitals of element **X**, determine the number of (i) total nodes in 3d orbital (ii) angular nodes in the $4p_y$ orbital (iii) degenerate 2p orbitals. (2×3=6)
- (c) Define iso-electronic species. Explain why the anions are larger than the cation. Arrange the following species as iso-electronic pairs with electron configurations: O^+ , Ar, S^{2-} , Ne, Zn, Cs^+ , N^{3-} , As^{3+} , N, Xe, etc. (2+2+7)
- (d) Define effective nuclear charge Z_{eff} . Sketch the outline of the periodic table and show the periodic trends for atomic size, ionization energy, electron affinity, acidity of oxides and metallic character. (2+6)
- (e) Comment on the following observations: (i) First ionization energy of 'N' is more than that of 'O' (ii) Electron affinities of noble gases are positive but 'Be' has almost zero electron affinity. (2+2)

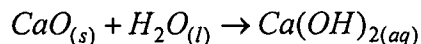
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3. (a) What is lattice energy and what role does it play in the stability of ionic compounds? (3)
- (b) Explain how the lattice energy of an ionic compound such as KCl can be determined using Born-Haber cycles. (7)
- (c) What is a polar covalent bond? Sketch the bond moments and resultant dipole moments for the following molecules: H₂O, PCl₅, NH₃, CF₄. (1+4)
- (d) Why is the study of molecule geometry important? Find out the hybridization, geometry and shape of the following ions/ molecules: ICl₂⁻, IF₂⁺, OF₂, SO₂, and CO₃²⁻. (12)
- (e) Sketch the shapes of molecular orbitals formed by linear combination of any two *p* atomic orbitals. (4)
- (f) Show the formation of SP³ hybrid orbitals. (4)
4. (a) Determine the bond orders of the following dinitrogen species: N₂, N₂²⁺, N₂⁻, and N₂²⁻. List the species in order of decreasing bond energy and in order of decreasing bond length. (10)
- (b) What effect of *2s-2p* mixing is observed in relative energy level of molecular orbitals (MOs) in homonuclear diatomic molecules of period 2 elements? (5)
- (c) “*cis*-1, 2- Dichloroethylene (C₂H₂Cl₂) boils 13°C higher than *trans*-1, 2 dichloroethylene” – explain. (3)
- (d) Liquid ammonia autoionizes like water: (6+2)
- $$2\text{NH}_3(l) \rightarrow \text{NH}_4^+(am) + \text{NH}_2^-(am)$$
- where (*am*) represents solvation by NH₃. (i) Write the ion-product constant expression, *K*_{am} (ii) What are the strongest acid and base that can exist in NH₃(*l*)?
- (e) What will be the ratio of H₂CO₃ and HCO₃⁻ needed to maintain the blood pH 7.4 (*pK*_a = 6.37). What is acidosis? (5+4)

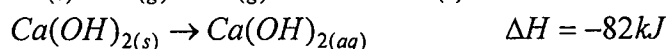
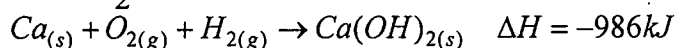
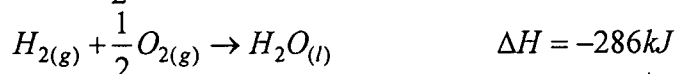
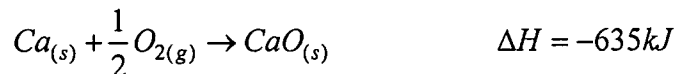
SECTION-B

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

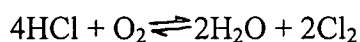
5. (a) How is internal energy of a chemical system changed during a chemical reaction? Explain why internal energy and Gibbs free energy are considered as state functions? (8)
- (b) How does the temperature affect the reaction enthalpies? Derive the kirchhoff's equation for the temperature dependence of reaction enthalpies. (13)
- (c) State and explain the third law of thermodynamics. How is entropy related to the reaction spontaneity? (8)
- (d) Self-heating cans may be used to warm drinks such as coffee. When the button on the can is pushed, a seal is broken, allowing water and calcium oxide to mix and react. The reaction produces solid calcium hydroxide and release heat. If more water is used calcium hydroxide is produced as a solution instead of as solid. The equation for the reaction is: (6)

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using the following data, calculate the enthalpy change in kJ for this reaction.



6. (a) Enumerate the different methods employed in the determination of the "order of a reaction". Give one method in detail. (8)
- (b) Derive the integrated rate law equation of a first order reaction. How is half-life related to the second order reaction kinetics? (15)
- (c) Distinguish between equilibrium constant and velocity constant. (6)
- (d) The half-life of a first order reaction is found to be 28.25 min. (6)
- (i) What is the rate constant for this reaction?
- (ii) Using the integrated rate law for a first-order reaction, how long would it take for 95% of the original amount of reactant to disappear?
7. (a) What are the colligative properties? Why are they so called? (8)
- (b) Explain each of the following terms: (6)
- (i) Ideal solution (ii) Azeotropic mixture
- (c) How is the boiling point elevation connected with the molecular concentration of a solution? Deduce the relationship with the help of Raoult's law for dilute solution. How is the elevation of boiling point method could be utilized to determine the molecular mass of an unknown solute? (16)
- (d) An isotonic solution will produce an osmotic pressure of 7.84 atm measured against pure water at human body temperature (37.0°C). How many grams of sodium chloride must be dissolved in a liter of water to produce an isotonic solution? (5)
8. (a) Explain each of the following terms used in heterogeneous equilibria: (9)
- (i) Triple point (ii) Invariant system (iii) Critical point
- (b) What is meant by a phase diagram? Draw and discuss the phase diagram for a two-component system with the application of phase rule. (14)
- (c) The gas-phase reaction below has a negative enthalpy of reaction for the forward reaction. (12)



Predict the result of each of the following changes to this reaction at equilibrium:

- (i) Temperature increase (ii) Volume decrease
- (iii) Addition of krypton (iv) Addition of a catalyst
- (v) Pressure decrease (vi) Removal of water with a desiccant.
