KUMAUN UNIVERSITY, NAINITAL

SYLLABUS FOR FIRST AND SECOND SEMESTER B.Sc. (THREE YEAR)
Chemistry Course

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SYLLABUS FOR FIRST AND SECOND SEMESTER B.Sc. (Hons.) (THREE YEAR)
Chemistry Course

Effective from academic year 2019-020

Papers and distribution of marks for different Semesters

Semester	Paper I	Marks		Paper II	Marks		Practical	
		Ext	Int		Ext	Int	Ext	Int
I	Organic	60	20	Inorganic	60	20	30	10
II	Inorganic	60	20	Physical	60	20	30	10
III	Organic	60	20	Physical	60	20	30	10
IV	Inorganic	60	20	Organic	60	20	30	10
V	Physical	60	20	Inorganic	60	20	30	10
VI	Organic	60	20	Physical	60	20	30	10

Pattern of examination theory papers (for all semesters and each paper I and II)

A. Theory

Each theory paper shall consist three sections A and B.

***Section A**: (Short answers type with reasoning); 30 marks, eight questions of six marks each, any five have to be attempted).*

***Section B**: (Long answers type); 30 marks, two questions of fifteen marks with internal choice would be given, both have to be attempted.*

B. Internal assessment

For each theory paper an internal assessment (in the form of class test and or assignment) of 20 marks for each paper which shall be conducted during each semester. The evaluated answer sheets/assignments have to be retained by the Professor In-Chargeand a copy of the award list has to be submitted to Headof the Department.

C. Practical

The practical work of the students has to be evaluated periodically. The internal assessment (in the form of lab test, lab record, internal evaluation, assignment/home assignment and attendance) of total 10 marks for each semester shall be conducted during the semester. A minimum of 12 experiments covering all kinds of exercises have to be conducted during a semester. In each semester practical examination of 30 marks has to be conducted by two examiners (External and internal) having duration of 6 hours. The total number of students to be examined per batch should not be more than seventy. Marks of the practical have to be submitted to the Head of the department/ Principal.

D. Instructions for paper setter

Note to be mentioned in each theory paper*: This question paper consists of two sections Section A consists of eight short answer type questions with logical approach bearing six marks each. Attempt any five questions from this section. Section B consists of two long answer type question (with internal choice) carrying 15 marks each. Attempt both the questions from this section.Questions are to be attempted section wise sequentially as far as possible. If the student attempts more questions, the marks will be allotted sequentially. The question/questionsat the last of sequence is/are considered extra/treated cancelled during the evaluation*.

Semester I Paper I (Organic)

S. No.	Contents	Contact Hours/Lectures
1	Structure and Bonding	4 Lectures
2	Mechanism of Organic Reactions	7 Lectures
3	Stereochemistry of Organic Compounds	7 Lectures
4	Alkanes and Cycloalkanes	7 Lectures
5	Alkenes, Cycloalkenes, Dienes and Alkynes	7 Lectures
6	Arenes and Aromaticity	7 Lectures

Semester I Paper II (Inorganic)

S. No.	Contents	Contact Hours/Lectures
1	Atomic Structure	7 Lectures
2	Periodic Properties	5 Lectures
3	Chemical Bonding-I	8 Lectures
4	Ionic Solids	5 Lectures
5	s-Block Elements	6 Lectures
6	p-Block Elements	8 Lectures

Semester II Paper I (Inorganic)

S.No.	Contents	Contact Hours/Lectures
1	Chemical Bonding-II	8 Lectures
2	Redox Reactions	7 Lectures
3	Coordination Chemistry-I	9 Lectures
4	Chemistry of Transition Elements (First Transition Series)	6 Lectures
5	Chemistry of Transition Elements (Second and Third Series)	5 Lectures
6	Metallurgical Processes	4 Lectures

Semester II Paper II (Physical)

S. No.	Contents	Contact Hours/Lectures
1	Gaseous State	12 Lectures
2	Solid State	8 Lectures
3	Colloidal State	8 Lectures
4	Chemical Kinetics and Catalysis	12 Lectures

Semester III Paper I (Organic)

S.No.	Contents	Contact Hours/Lectures
1	Alkyl and Aryl Halides	7 Lectures
2	Alcohols	5 Lectures

3	Phenols	5 Lectures
4	Ethers and Epoxides	5 Lectures
5	Aldehydes and Ketones	7 Lectures
6	Carboxylic Acids; Carboxylic acid derivatives	10 Lectures

Semester III Paper II (Physical)

S. No.	Contents	Contact Hours/Lectures
1	Thermodynamics- I	12 Lectures
2	Chemical Equilibrium	8 Lectures
3	Thermochemistry	12 Lectures
4	Surface Chemistry	8 Lectures

Semester IV Paper I (Inorganic)

S.No.	Contents	Contact Hours/Lectures
1	Chemistry of Lanthanides	7 Lectures
2	Chemistry of Actinides	5 Lectures
3	Acids and Bases	6 Lectures
4	Hard and Soft Acid-Base Theory	7 Lectures
5	Non Aqueous Solvents	6 Lectures
6	Bioinorganic Chemistry	8 Lectures

Semester IV Paper II (Organic)

S.No.	Contents	Contact Hours/Lectures
1	Electromagnetic Spectrum: Absorption Spectroscopy	8 Lectures
2	Nitrogen Containing Organic Compounds	8 Lectures
3	Organic Synthesis via Enolates	5 Lectures
4	Organo-Metallic Compounds	5 Lectures
5	Synthetic Dyes	5 Lectures
6	Heterocyclic Compounds	8 Lectures

Semester V Paper I (Physical)

S. No.	Contents	Contact Hours/Lectures
1	Thermodynamics II	12 Lectures
2	Solutions and Colligative Properties	8 Lectures
3	Photochemistry	8 Lectures
4	Energy and Distribution Law	6 Lectures
5	Thermodynamics III	6 Lectures

Semester V Paper II (Inorganic)

S. No.	Contents	Contact Hours/Lectures
1	Thermodynamic and Kinetic Aspects of Coordination Compounds	5 Lectures
2	Coordination Chemistry-II	8 Lectures
3	Magnetic Properties of Transition Metal Complexes	7 Lectures
4	Electronic Spectra of Transition Metal Complexes	7 Lectures
5	Organometallic Chemistry	7 Lectures
6	Inorganic Polymers of Silicon and Phosphorus	5 Lectures

Semester VI Paper I (Organic)

S. No.	Contents	Contact Hours/Lectures
1	Spectroscopy	8 Lectures
2	Carbohydrates	7 Lectures
3	Amino Acids, Peptides, Proteins and Nucleic Acids	7 Lectures
4	Fats, Oils and Detergents	6 Lectures
5	Synthetic Polymers	6 Lectures
6	Natural Products	5 Lectures

Semester VI Paper II (Physical)

S. No.	Contents	Contact Hours/Lectures
1	Electrochemistry I	10 Lectures
2	Electrochemistry II	8 Lectures
3	Phase Equilibrium	8 Lectures
4	Elementary Quantum Mechanics 8	8 Lectures
5	Spectroscopy	6 Lectures

Semester I Paper I (Organic Chemistry)

1. Subject Code: Course Title: B.Sc. / B.Sc. (Hons.)
2. Subject Area : Organic Chemistry
3. Course Hours Lecture : L- 39 T: 0 P:20
4. Exam Time Theory: 3 hours Practical : 6 hours
5. Relative weightage Theory : 80marks
6. Credits :

Details of Course:

S.No.	Contents	Contact Hours/ Lectures
1	**Structure and Bonding :** Hybridization, bond lengths and bond angles, bond energy, localized and delocalized chemical bond, Van der Waals interactions, resonance, hyperconjugation, aromaticity, inductive and field effects, hydrogen bonding	4 Lectures
2	**Mechanism of Organic Reactions :** Curved arrow notation, drawing electron movements with arrows, half -headed and double-headed arrows, homolytic and heterolytic bond breaking. Types of reagents- electrophiles and nucleophiles. Types of organic reactions. Energy considerations. Reactive intermediates- carbocations, carbanions, free radicals, carbenes, (with examples).	7 Lectures
3	**Stereochemistry of Organic Compounds** Concepts of isomerism. Types of isomerism-optical isomerism-elements of symmetry, molecular chirality, enantiomers, stereogenic centers, optical activity, properties of enantiomers, chiral and achiral molecules with two stereogeniccentre, diastereomers, threo and erythrodiastereomers, meso compounds, resolution of enantiomers, inversion, retention and racemization. Relative and absolute configuration, sequence rules, D & L and R & S systems of nomenclature. Geometrical isomerism: determination of configuration of geometrical isomers, E & Z system of nomenclature, geometrical isomerism in oximes and alicyclic compounds. Conformational isomerism:conformational analysis of ethane and n- butane.	7 Lectures

4	**Alkanes and Cycloalkanes :** IUPAC nomenclature of branched and unbranched alkanes, the alkyl group, classification of carbon atoms in alkanes. Isomerism in alkanes, sources, methods of formation (with special reference to Wurtz reaction, Kolbe reaction, Corey-House reaction and decarboxylation of carboxylic acids), physical properties and chemical reactions of alkanes. Mechanism of free radical halogenation of alkanes: Mechanism of free radical, orientation, reactivity. Cycloalkanes- nomenclature, methods of formation, chemical reactions, Baeyer's strain theory and its limitations. Ring strain in small rings (cyclopropane and cyclobutane), theory of strainless rings. The case of cyclopropane ring-bent or banana bonds.	7 Lectures
5	**Alkenes, Cycloalkenes, Dienesand Alkynes :**Nomenclature of alkenes , methods of formation, mechanism of dehydration of alcohols and dehydrohalogenation of alkyl halides, regioselectivity in alcohol dehydration. The Saytzeff Rule, Hoffmann Elimination, physical properties and relative stabilities of alkenes. Chemical reactions of alkenes - mechanisms involved in hydrogenation, electrophilic and free radical additions, Markownikoff's Rule, hydroboration-oxidation, oxymercuration-reduction. Epoxidation, ozonolysis, hydration, hydroxylation and oxidation with $KMnO_4$, Polymerization of alkenes. Substitution at the allylic and vinylic positions of alkenes.Industrial applications of ethylene and propene. Nomenclature and classification of dienes; isolated, conjugated and cumulative dienes. Methods of formation, polymerization. Chemical reactions- 1,2 and 1,4 additions. Nomenclature, structure and bonding in alkynes. Methods of formation. Chemical reactions of alkynes, acidity of alkynes. Mechanism of electrophilic and nucleophilic addition reactions, hydroboration- oxidation, metal- ammonia reduction, oxidation and polymerization.	7 Lectures
6	**Arenes and Aromaticity: Nomenclature** of benzene derivatives. The aryl group. Aromatic nucleus and side chain. Structure of benzene: molecular formula and Kekule structure. Stability and MO picture. Aromaticity –the Hückel rule, aromatic ions. Aromatic electrophilic substitution –Mechanism of nitration, halogenation, sulphonation, mercuration and Friedel- Crafts reaction.Energy profile diagrams. Activating and deactivating substituents and orientation. Side chain reactions of benzene derivatives. Birch reduction.	7 Lectures

Books Recommended:

i. I.L. Finar, Organic Chemistry, Pearson.

ii. E. L. Eliel, Stereochemistry of Organic Compounds, Willey.
iii. Morrison and Boyd, Organic Chemistry, Prentice-Hall, New Delhi.
iv. George S. Zweife and Michael He Nantz, University of California, Davis, New York 2 Edt. 2006.
v. Francis A. Carey and Richard J. Sunderberg, University of Virginia Charlottesville, Virginia, Advanced Organic Chemistry 5Ed, 2007.
vi. Clayden J. Organic Chemistry (Oxford, 2000).
vii. Dr. R. Bruckner and Organic Mechanisms Reactions, Stereochemistry and Synthesis 1st Edt. 2010.
viii. S.M. Mukerji and Singh. Reaction mechanism in Organic Chemistry, Macmillan, Reprint.
ix. Jagdamba Singh. Undergraduate Organic Chemistry Vol.-I, PragatiPrakashan.
x. R.L. Madan, Chemistry for degree students, S. Chand & Company, New Delhi.
xi. G. Marc Loudon, Organic Chemistry, Oxford University Press (Replica press), Kundali, Haryana.

Semester I Paper II (Inorganic Chemistry)

1. Subject Code: Course Title: B.Sc. / B.Sc. (Hons.)
2. Subject Area : Inorganic Chemistry
3. Course Hours Lecture: L-39 T:-0 P:-20
4. Exam Time : Theory: 3 hours Practical: 6 hours
5. Relative weightage Theory: 80 Marks
6. Credits :

Details of Course:

S. No.	Contents	Contact Hours/ Lectures
1	**Atomic Structure:** Dual nature of matter; de Broglie concept. Heisenberg uncertainty principle and its significance. Atomic orbitals, Schrödinger wave equation (no derivation), significance of ψ and ψ^2. Quantum numbers, radial and angular wave functions and probability distribution curves, shapes of s, p and d orbitals. Aufbau energy diagram, Pauli's exclusion principle. Hund's rule of maximum multiplicity. Electronic configuration of elements (s block, p block and first series of d-block elements). Effective nuclear charge.	7 Lectures
2	**Periodic Properties** : Atomic and ionic radii, ionization potential, electron affinity and electronegativity- Definition, methods of determination/evaluation, trends of variation in periodic table and their application in prediction and explaining the chemical behaviour of elements and compounds thereof.	5 Lectures
3	**Chemical Bonding-I**: Ionic bond, covalent bond-Valence Bond Theory and its limitations; directional nature of covalent bond;	8 Lectures

	various types of hybridization and shapes of different inorganic molecules and ions. Valence Shell Electron Pair Repulsion Theory (VSEPR) and shapes of NH_3, H_2O, H_3O^+, SF_4, ClF_3, ICl_2^-, NH_4^+, and other simple molecules/ions. Chemistry of xenon; structure and bonding in xenon compounds with oxygen and fluorine.	
4	**Ionic Solids:** Ionic structures, radius-ratio effects and coordination number. Lattice defects, semiconductors, lattice energy and Borne-Haber cycle. Solvation energy and solubility of ionic solids. Polarizing power and polarizability; Fajan's rule.	5 Lectures
5	**s-Block Elements**: General discussion with respect to all periodic and chemical properties, diagonal relationship, salient features of hydrides, solvation and complexation tendencies, an introduction to their alkyls and aryls. Role of alkali and alkaline earth metal ions in bio-systems.	6 Lectures
6	**p-Block Elements** : General discussion and comparative study (all periodic and chemical properties) including diagonal relationship, of groups 13 to 17 elements; chemistry of elements-hydrides, oxides & oxy-acids, and halides (including inter-halogen compounds). Diborane-properties & structure, borohydrides, carbides, fluorocarbons, basic properties of iodine and polyhalides. Inert-pair effect: in heavier elements of 13, 14 & 15 group elements; its consequences in redox properties of their halides.	8 Lectures

Books Recommended:

i. J. D. Lee, Concise Inorganic Chemistry, ELVS.
ii. B. R. Puri, L. R. Sharma and K. C. Kaliya, Principles of Inorganic Chemistry, Milestone Publisher and Distributors.
iii. R. L. Madan, Chemistry for Degree Students, S. Chand & Company, New Delhi.
iv. W. U. Malik, G. D. Tuli and R. D. Madan, Selected Topics in Inorganic Chemistry, S. Chand & Company, New Delhi**.**
v. Sulekh Chandra, Comprehensive Inorganic Chemistry, New Age International Publications.
vi. R. D. Madan and SatyaPrakash, Modern Inorganic Chemistry, S. Chand & Company, New Delhi.
vii. B. E. Douglas and D. H. Mc Daniel, Concepts & Models of Inorganic Chemistry, Oxford.
viii. P.W. Atkins and J. Paula, Physical Chemistry, Oxford Press.
ix. M. C. Day and J. Selbin, Theoretical Inorganic Chemistry, ACS Publications.

Semester I
Chemistry Practical

Practical: **Max. Marks: 40**

1. Laboratory hazards and safety precautions
2. Mixture analysis: identification of Acid and Basic Radicals including anions in combination and interfering radicals. Home assignments: problems based on Law of mass action, Le Chatelier Principle; common ion effect, solubility product, pH and buffer

solutions, mole concept, molar solution, normal solution, molarity, molality and formality, Calculation for the preparation of standard solutions of acids and bases.

3. Volumetric exercise: acid-base titrations; preparation of a solution in normal/molar terms, its standardization using a primary standard solution, determination of the strength of unknown solution. For example: preparation of NaOH solution (secondary standard say N/10), preparation of $(COOH)_2$ solution (primary standard say N/10), standardization of NaOH solution titrating it against $(COOH)_2$ solution using phenolphthalein (indicator) and then determination of the strength of given HCl solution.
   One exercise each from inorganic mixture (qualitative 06 radicals), and volumetric exercise (quantitative) shall be given in the examination.

Distribution of marks shall be as given below:

A.	Inorganic mixture analysis (Acidic and Basic)	15
B.	Volumetric exercise	10
C.	Viva	05
D.	Home assignment/internal assessment, lab record and attendance	10

Note:

- ***The lab work of the student has to be evaluated and assessed carefully and periodically. A minimum of 12 experiments covering all the kind of exercises has to be performed during a semester. The semester record has to be maintained by the department/college as an official record.***
- ***Less than zero mark will not be awarded.***
- ***The total number of students to be examined per batch shall not be more than sixty.***
- ***Duration of the practical examination shall be of 06 (six) hours.***
- ***Marks have to be uploaded onto the University portal and print out of award list from the portal has to be submitted to the Controller Examination, KumaunUniversity, in a sealed envelope making a copy to the Principal/Head of the department*.**

Semester II Paper I (Inorganic Chemistry)

1. Subject Code: Course Title: B.Sc. / B.Sc. (Hons.)
2. Subject Area : Inorganic Chemistry
3. Course Hour Lecture : L :39 T: 0 P: 20
4. Exam Time Theory: 3 hours Practical: 6 hours
5. Relative weightage Theory: 80 Marks
6. Credits **:**

Details of Course :

S.No.	Contents	Contact Hours/ Lectures
1	**Chemical Bonding-II:** Molecular Orbital Theory (MOT) as applied to diatomic homonuclear/heteronuclear inorganic molecules. MO diagrams and bond order of H_2, He_2, Li_2, Be_2, B_2, C_2, N_2, O_2, F_2, Ne_2, CO and NO, difference between VB and MO theories. Multicentre bonding in electron deficient molecules. Polarization of covalent molecules; percentage ionic character	8 Lectures

	from dipole and electronegativity difference. Hydrogen bonding. Weak interactions. Metallic bond- electron pool and MO theories.	
2	**Redox Reactions:** Displacement and redox reactions, oxidation state. Balancing of redox reactions (ion-electron and oxidation state methods). Computation of equivalent weights. Standard electrode potential, Reference electrode, determination of electrode potential, electrochemical series, uses of electrode potential data, reaction feasibility and related numerical problems.	7 Lectures
3	**Coordination Chemistry-I:** Werner's theory for coordination compounds; its experimental verification, effective atomic number (EAN) concept, chelates. Nomenclature of coordination compounds (IUPAC system), stability of complexes and factors contributing to the stability. Valence Bond Theory (VBT) for coordination compounds, magnetic properties of complex compounds. Isomerism- structural and stereoisomerism.	9 Lectures
4	**Chemistry of Transition Elements (First Transition Series):** Characteristic properties of the elements- Electronic configuration, ionic radii, ionization energy, oxidation states, complex compound formation, catalytic properties, colour and magnetic properties. Their binary compounds, illustrating relative stability of their oxidation states, coordination number and geometry.	6 Lectures
5	**Chemistry of Transition Elements (Second and Third Series):** General characteristics, comparative treatment with their analogues in respect of ionic radii, oxidation state, magnetic behaviour and stereochemistry.	5 Lectures
6	**Metallurgical Processes:** Minerals & ores; general metallurgical processes- Concentration of ores, calcination, roasting, smelting, slag & flux. Extraction and refining of Lithium and Beryllium.	4 Lectures

Books Recommended:

i. J. D. Lee, Concise Inorganic Chemistry, ELVS.
ii. B. R. Puri, L. R. Sharma and K. C. Kaliya, Principles of Inorganic Chemistry, Milestone Publisher and Distributors.
iii. R. L. Madan, Chemistry for Degree Students, S. Chand & Company, New Delhi.
iv. W. U. Malik, G. D. Tuli and R. D. Madan, Selected Topics in Inorganic Chemistry, S. Chand & Company, New Delhi**.**
v. Sulekh Chandra, Comprehensive Inorganic Chemistry, New Age International Publications.
vi. R. D. Madan and SatyaPrakash, Modern Inorganic Chemistry, S. Chand & Company, New Delhi.
vii. B. E. Douglas and D. H. Mc Daniel, Concepts & Models of Inorganic Chemistry, Oxford.
viii. P.W. Atkins and J. Paula, Physical Chemistry, Oxford Press.
ix. M. C. Day and J. Selbin, Theoretical Inorganic Chemistry, ACS Publications.

Semester II Paper II (Physical Chemistry)

1. Subject Code: Course Title: B.Sc. / B.Sc. (Hons.)
2. Subject Area : Physical Chemistry
3. Course Hour Lecture : L :40 T: 0 P: 20
4. Exam Time Theory: 3 hours Practical: 6 hours
5. Relative weightage Theory: 80 Marks
6. Credits **:**

Details of Course:

S.No.	Contents	Contact Hours/ Lectures
1	**Gaseous State:** Postulates of kinetic theory of gases, Molecular velocities: Root mean square, average and most probable velocities, qualitative discussion of the Maxwell's distribution of molecular velocities, collision number, mean free path and collision diameter, Deviation from ideal behavior, van der Waal's equation of states, Critical phenomena – PV isotherms of real gases, relationship between critical constants and van der Waals constants, the law of corresponding states, reduced equation of state.	12 Lectures
2.	**Solid State:** Definition of space lattice, unit cell, crystal planes, Miller indices, Laws of crystallography – (i) law of constancy of interfacial angles (ii) law of rationality of indices (iii) law of symmetry. Symmetry elements in crystals, X-ray diffraction by crystals. Derivation of Bragg's equation.	8 Lectures
3	**Colloidal State:** Definition of colloids, classification of colloids. Properties of colloids – Brownian movement, optical and electrical; stability of colloids, protective action, Hardy-Schulze law, gold number. Sol, gel and emulsions: types and properties. Applications of colloids	8 Lectures
4.	**Chemical Kinetics and Catalysis: R**ate of a reaction, factors influencing the rate of a reaction: Concentration, temperature, pressure, solvent, and catalyst, classification of catalyst with suitable examples. Concept of molecularity and order of reaction, zero order, first order, second order, pseudo order reactions with examples, half life, concept of activation energy.	12 Lectures

Books Recommended:

i. Atkins P.W., Physical Chemistry, Oxford University Press.
ii. D.W. Bell, Physical Chemistry, Thomson Press.
iii. R.L. Madan, Chemistry for degree students, S. Chand & Company, New Delhi
iv. Puri and Sharma and Pathaniya, Principles of Physical Chemistry, Milestone Publisher and Distributors, New Delhi.
v. Bahl and Tuli, Essentials of Physical Chemistry, S. Chand & Company, New Delhi.

vi. Bariyar, Singh and Dwivedi, BSc Chemistry I (combined), Krishna Prakashan Media, Meerut.

SEMESTER II
B. Sc. Chemistry Practical

Lab Course : **Max Marks : 40**

1. Lab Hazards and Safety precautions
2. Determination of surface tension, viscosity, parachor and relative surface tension/viscosity of given liquids.
3. Organic compounds: basic difference between inorganic salts and organic compounds- solubility in water, unsaturation tests; difference between aromatic and aliphatic compounds, determination of MP/BP. Identification of aromatic/aliphatic hydrocarbons, their halogen derivatives, Fusion of organic compound with sodium, preparation of sodium extract- test for the presence of halogens in organic compounds.
4. Home assignments.

One exercise each from organic and physical chemistry experiment shall be given in the examination.

Distribution of marks shall be as given below:

A.	Determination of viscosity and surface tension measurements etc. of given liquids	10
B.	Organic chemistry exercise	15
D.	Viva	05
E.	Home assignment/internal assessment, lab record and attendance	10

Note:

- ***The lab work of the student has to be evaluated and assessed carefully and periodically. A minimum of 12 experiments covering all the kind of exercises has to be performed during a semester. The semester record has to be maintained by the department/college as an official record.***
- ***Less than zero mark will not be awarded.***
- ***The total number of students to be examined per batch shall not be more than sixty.***
- ***Duration of the practical examination shall be of 06 (six) hours.***
- ***Marks have to be uploaded onto the University portal and print out of award list from the portal has to be submitted to the Controller Examination, KumaunUniversity,Nainital in a sealed envelope making a copy to the Principal/Head of the department*.**