PACIFIC SENIOR SECONDARY CERTIFICATE

Contents

CHEMISTRY

PRESCRIPTION

This pre scription takes effect from January, 1999

RATIONALE

Chemistry continues to have an important place in the senior secondary curriculum of Pacific countries. This prescription document provides considerably greater detail than its predecessor in two important areas.

Firstly, the content of the course is expanded to describe the expectations in terms of student outcome objectives. This aims to improve the understanding of the combined depth and scope of the specified content, and at the same time focuses more clearly on skills which should be demonstrated by successful students of the course.

Secondly, the school-based assessment element of the course is more tightly controlled through the inclusion of a Common Assessment task, which is centrally designed.

The course is intended to provide a sound base for students wishing to continue with studies in chemistry at a higher level.

PREREQUISITES

Students will be expected to have a sound grasp of the chemical principles covered at school certificate level.

The prescription for PSSC Chemistry is built on the assumption that the student has received instruction in the following elementary chemistry:

Metals and their Compounds

A study of some common metals, and some of their compounds to illustrate similarity of physical and chemistry properties and gradation of properties in terms of the activity series.

a) Symbols of common elements - those of the first twenty elements in the periodic table, plus Cr, Mn, Fe, Co, Ni, Cu, Zn, Br, Ag, Ti, Sn, I, Ba, Pb. A simple model of the atom in terms of electrons and the nucleus containing protons and neutrons.

b) Ions - a knowledge of ion formation, and charges on the following simple ions:

K^+, Na^+, NH_4^+, Cl^-, OH^-, NO_3^-, Mg^{2+}, Ca^{2+}, Fe^{2+},

Fe^{3+}, Pb^{2+}, Cu^{2+}, Al^{3+}, O^{2-}, S^{2-}, SO_4^{2-}, CO_3^{2-}, PO_4^{3-}.

c) General chemical and physical properties - reactions of the following metals: Ca, Mg, Al, Zn, Fe, Pb, Cu; with oxygen, water and dilute acids. The activity series to be developed. The rusting of iron and its prevention.

d) Selected metal compounds - common compounds of K, Na, Mg, Al, Zn, Fe, Pb, Cu. The existence of hydroxides, carbonates, sulfates, chlorides and nitrates. Trends in their solubilities. The effect of heat on calcium and copper carbonates.

e) Oxidation - reduction in simple terms of gain or loss of oxygen. Examples of reduction limited to the extraction of metals from their oxide ores.

Non-metals

a) Sulfur - allotropes and effect of heat on sulfur. The reaction of sulfur with oxygen and with a metal such as iron or copper. The acidic nature of sulfur dioxide and sulfur trioxide as sulfurous and sulfuric acids. Chemical aspects of the manufacture of sulfuric acid (technical details not expected). Effect of sulfur oxides in the atmosphere.

b) Nitrogen - occurrence in the atmosphere and as amino acids in living matter. Lack of chemical reactivity. Reactions with oxygen to form nitrogen oxides which can act as atmospheric pollutants.

Ammonia - preparation, solubility in water, alkalinity and formation of ammonium salts. The nitrogen cycle and the use of ammonia, ammonium salts, urea and nitrates in agriculture. Particular stress made on the importance of nitrogen in nature and agriculture.

c) Carbon - forms of carbon, charcoal - its formation, combustion and uses. The formation of carbon dioxide and its uses. Carbon monoxide as a product of incomplete combustion; its nature and its use as a fuel. The nature and common uses of calcium carbonate, sodium carbonate and sodium hydrogen carbonate. Stress made on the importance of carbon as a fuel and as a reducing agent.

Carbon Compounds

To highlight the special nature and importance of carbon chemistry in everyday life.

a) The ability of carbon to form linear and branched chains. Simple description of bonding e.g. carbon forms four bonds and hydrogen one.

b) The alkanes as a family showing gradual changes in physical properties such as melting point and boiling point with increasing molecular size (chain length). Combustion of alkanes to form carbon dioxide and water, and the pollution effects of incomplete combustion.

c) The use of molecular models.

Acids and Bases

a) pH scale

b) Examples of strong and weak acids, and strong and weak bases.

GENERAL AIMS

1. To foster an awareness of the importance of chemistry in the lives of students and to stimulate a continuing interest in chemistry.

2. To provide students with a knowledge of appropriate chemical facts in order to understand important concepts and principles in chemistry.

3. To guide students to apply scientific methods in their study of chemistry (by developing skills in the laboratory) and in the environment in which they live.

4. To develop an awareness of how knowledge of chemical facts and principles can be applied.

5. To develop an ability to communicate chemical ideas and results of investigations/practicals after appropriate experimentation and analysis.

COURSE OBJECTIVES

On completing the course of study based on this prescription statement, students should be able to:

1. demonstrate a knowledge of facts related to:
   - atomic structure
   - quantitative chemistry
   - inorganic chemistry
   - principles of physical chemistry
   - oxidation and reduction
   - organic chemistry

2. demonstrate an understanding of important chemical facts and principles by applying them to new situations.

3. show competence in the following scientific skills:
   - **numeracy**: calculate, estimate, understand, analyse and present information in tables and graphs.
   - **information**: gather, process and interpret information; organise, analyse, evaluate and report information.
   - **problem solving**: identify and describe a problem; inquire and research ideas; test hypotheses and make decisions on the evidence then evaluate the outcome.
   - **physical**: develop manipulative skills and the safe and effective use of equipment and chemicals in cooperation with others.
   - **measurement**: accurate use of the following measuring instruments: balance, measuring cylinder, burette, volumetric flask, pipette, stopwatch, thermometer.
   - **communication**: present chemical ideas and experimental findings clearly, logically and precisely, both written and orally; use formulae, equations and models and show the makeup of substances and the changes they undergo during reactions.
   - **social**: work independently as well as cooperatively in groups and where possible with chemists and researchers from the wider community.

4. demonstrate positive attitudes such as curiosity, honesty, flexibility, initiative and open-mindedness

on which scientific investigation depends.

I. ATOMIC STRUCTURE AND BONDING

1. Periodic Table

Students should be able to:

a) describe the structure of an atom in terms of protons, neutrons and electrons.

b) describe isotopes as atoms of an element with differing number of neutrons and mass numbers.

c) write the electron configurations for the first 20 elements and their respective ions in terms of principal energy levels.

d) know that atoms are arranged in Periods (rows) according to the principal energy levels and Groups (columns) according to their valence ele ctrons.

e) relate the charge on monatomic ions to their positions on the periodic table.

f) describe the meaning of the following terms:
   1) first ionization energy
   2) atomic radii
   3) ionic radii
   4) electronegativity

g) know the trends of 1 - 4 above, across Periods 2 and 3 and within Groups.

h) use the trends in the periodic table to explain the properties of atoms and ions.

i) use the trends in electronegativity to determine probable types of bond.

2. Bonding

a) Ionic Bonding

Students should be ab le to:

(i) describe ionic bonding as a process of electron transfer.
(ii) describe the properties of ionic substances (electrical conductivity, solubility, boiling/melting points, brittleness) and relate the physical properties of ionic substances to the ir structures and bonding.

b) Covalent Bonding

Students should be able to:

(i) describe a covalent bond as a shared pair of electrons.
(ii) distinguish between polar and non-polar covalent bonds.

(iii) recognise the continuum in the distribution of electrons moving from non-polar through polar to ionic bonding.
(iv) describe the polarity of the water molecule and the process of hydration of ionic substances.
(v) describe the properties of discrete molecular substances and infinitely extended covalent networks and relate these physical properties to their structures and bonding (electrical conductivity, melting point/boiling point, solubility, hardness).
(vi) compare the strength of inter-molecular and intra-molecular forces and the role played by the hydrogen bond.

(c) Metallic bonding

Students should be able to

(i) describe the metallic bond as a lattice of positive ions and de-localised electrons.
(ii) describe the physical properties of metallic substances and relate these properties to their structures and bonding (electrical conductivity, melting point, boiling point, malleability, ductility, lustre).

3. Shapes of Molecules

Students should be able to:

a) state the octet rule and use it to draw Lewis structures for simple covalent molecules which have only four valence shell electron pairs.
b) deduce the shape of simple covalent molecules using electron pair repulsion theory.
c) name and draw molecules with the following shapes:
   (i) linear e.g. HCl
   (ii) bent (v-shaped) e.g. H_2O
   (iii) trigonal (triangular) pyramid e.g. NH_3
   (iv) tetrahedral e.g. CH_4
d) use the molecular shape and electron distribution to determine whether the molecules are polar.

II. QUANTITATIVE CHEMISTRY

1. Mole and Molar Mass

Students should be able to:

a) define moles (n), Avogadro=s Number, relative atomic mass (A_r), molar mass (M), relative molecular mass (M_r).

b) carry out simple calculations involving mass (grams), molar mass (g/mol), amount (moles), Avogadro=s Number and chemical formulae.

2. Empirical and Molecular Formulae

Students should be able to:

a) distinguish between an empirical formula and a molecular formula.

b) calculate
   (i) percentage composition
   e.g. X water of crystallisation
   X elements in a compound.

   (ii) empirical formula from mass percentage (and vice versa).

   (iii) molecular formula from empirical formula and molar mass (and vice versa).

3. Stoichiometry in Chemical Reactions

Students should be able to:

a) balance equations given the reactants and products.

b) recognise the symbols used to describe states of molecules in chemical equations
   [(g) gas (l) liquid (s) solid (aq) aqueous solution]

c) carry out stoichiometric calculations based on mass, number of moles, concentration and volume.

$$c = \frac{n}{V} \qquad n = \frac{m}{M}$$

4. Acid Base Titration

Students should be able to:

a) define stoichiometric equations, standard solution, titre, aliquot, equivalency point, end point.

b) express concentration in terms of g L^{-1} and mol L^{-1}

c) calculate
   (i) concentration to specified dilutions.
   (ii) mass required to make a standard solution given the size of volumetric flask and molar mass.
   (iii) unknown concentration based on titration data.

d) describe all the equipment and methodology for preparing a standard solution and carrying out a titration and a dilution.

e) describe the colour changes of the common indicators, methyl orange and phenolphthalein, when the end point is reached.

III. INORGANIC CHEMISTRY

1. Properties of Selected Period 2 Compounds

a) Oxides (illustrated by Na_2O, MgO, Al_2O_3, SiO_2, SO_3)

Students should be able to:

(i) explain the ratio of the atoms in the oxides as it relates to the position of the element in the periodic table.
(ii) relate the ionic and covalent oxides to their position in the periodic table.
(iii) describe the trend from basic oxides to acidic oxides.
(iv) write balanced equations which demonstrate the acidic, amphoteric or basic property of an oxide.

b) Chlorides (as illustrated by NaCl, $MgCl_2$, $AlCl_3$, PCl_3, HCl)

Students should be able to:

(i) explain the ratio of the atoms in the chlorides in relation to the position of the element in the period from Na - P.
(ii) relate the melting points and the electrical conductivities of chlorides to their structure and bonding.
(iii) write balanced equations which demonstrate the reaction of chlorides with water.

2. Testing for Unknown Ionic Species

Students should be able to:

a) recall the solubilities of nitrates, sulfates, chlorides, carbonates, hydroxides, salts of Group I metals and ammonium salts.
b) recognise the formulae and the appearance of the following complex ions: $[Cu(NH_3)_4]^{2+}$, $[Ag(NH_3)_2]^{+}$, $[Fe\ CNS]^{2+}$, $[Al(OH)_4]^{-}$.
c) apply their knowledge of solubilities and complex ions to carry out tests for the presence of Mg^{2+}, Ag^{+}, Fe^{2+}, Fe^{3+}, Cu^{2+}, Al^{3+}, CO_3^{2-}, Cl^{-}, SO_4^{2-} and state observations made when tests are positive.
d) write balanced equations to represent the reactions which occur during the test in c) above. (Equations involving the formation of complex ions will not be examined.)

3. Chemistry of Water

a) Properties of water

Students should be able to:

(i) describe the following properties of water: boiling point and melting point, heat capacity, electrical conductivity, density of ice compared with water, solvent properties.

(ii) use anhydrous copper sulfate and cobalt chloride paper to test for water and state the colour changes which occur.

b) Some reactions of water

Students should be able to:

(i) write balanced ionic equations (including state), to show the dissociation of ionic substances in water.

(ii) describe the reaction of water with basic and acidic oxides and some of the implications of these reactions. (e.g. acid rain, engine pollution, formation of alkaline solution).

c) Purification of water

Students should be able to:

(i) explain the processes of filtration, flocculation and chlorination.

(ii) use a flow diagram to describe a modern water purification system.

(iii) construct a flow diagram which shows a local water treatment system.

(iv) relate water treatment to community health.

IV. PRINCIPLES OF PHYSICAL CHEMISTRY

1. Energy Changes

Students should be able to:

a) explain that chemical reactions are accompanied by heat changes (or enthalpy change, ♠H).

b) define exothermic and endothermic reactions and recognise them in terms of the qualitative treatment of energy changes in a chemical reaction.

♠H reaction = 3 ♠H products - 3 ♠H reactants.

c) interpret energy profile diagrams in terms of:
- activation energy.
- energy change in a reaction (♠H).
- catalysed pathways.

d) state Hess= Law and apply it to calculate the energy change for a chemical reaction by rearranging and combining two related equations.

2. Rate of Reaction

Students should be able to:

a) explain what is meant by rate of reaction.

b) list the factors affecting rate of reaction (temperature, concentration, catalyst, and particle size) and explain the effects of these factors in terms of simple collision theory.

c) describe the role of a catalyst in a chemical reaction.

3. Equilibrium

Students should be able to:

a) define dynamic equilibrium using equations of the type: $A + B \equiv C + D$.

b) (i) recognise a closed and an open system.
(ii) infer that equilibrium can only occur in a closed system.

c) use Le Chatelier=s principle to explain the qualitative effects of changing
(i) temperature
(ii) total pressure (reduction in volume results in an increase in pressure.)
(iii) concentration.

d) describe the effect of catalysts on equilibrium systems.

e) describe the Haber process (ammonia production) and Contact process (sulfur trioxide) as commercial examples of equilibrium reactions.

4. Acids and Bases

Students should be able to:

a) define acids as proton donors and bases as proton acceptors.

b) (i) recall strong and weak acids and bases.
(ii) apply equilibrium to differentiate the degree of dissociation of strong and weak acids and bases, including writing relevant equations.

c) obtain the strength of an acid or base using universal indicator.
(use HCl, HNO_3, H_2SO_4, CH_3COOH, NaOH, Na_2CO_3, NH_3 as examples.)

d) describe the basic properties of hydroxides and write equations to indicate such properties.

e) demonstrate that water can behave as an acid and as a base (amphiprotic).

f) describe the equilibrium reaction for water and its ionic product (K_w) represented by

$$[H_3O^+]\,[OH^-] = K_w = 10^{-14}$$

g) know that Ap≅ notation in pOH or pH is (-log) and use it to deduce
pH + pOH = 14.

h) calculate pH and pOH given the hydrogen ion and hydroxide ion concentrations (and vice versa).

i) use the pH scale to differentiate acidic, neutral and basic pH ranges.

V. OXIDATION AND REDUCTION

1. Oxidation State

Students should be able to:

a) determine the oxidation state (number) of each atom in a given element, molecule or ion.
b) recognise and explain oxidation and reduction reactions in terms of:
   (i) changes in oxidation states (numbers).
   (ii) transfer of electrons.
   (iii) transfer of atoms.

2. Oxidising and Reducing Agents

Students should be able to:

a) define oxidising agents (oxidant) and reducing agents (reductant) and recognise them in a chemical reaction.
b) (i) identify the common oxidising agents (oxygen, chlorine, metals with dilute acids, hydrogen peroxide, permanganate, dichromate).
   (ii) identify the common reducing agents: metals e.g. zinc, magnesium and iron; carbon, sulfur dioxide, carbon monoxide.
c) (i) formulate and balance half equations for a given reaction using the ion-electron method.
   [Redox reaction in aqueous solution will be restricted to those in acid solution.]
   (ii) combine half equations and write fully balanced equations for the redox reactions.

3. Applications

Students should be able to:

a) apply oxidation and reduction processes to the electrolysis of some common ionic solutions e.g. NaCl (aq) and molten ionic compounds e.g. NaCl (l).
b) predict and describe observations made at the electrodes (anode and cathode) during electrolysis.
c) recognise and interpret instances of oxidation and reduction in settings commonly found in society and the environment e.g. batteries of vehicles; corrosion of metals in vehicles, buildings and bridges; oxidation of foods; galvanic protection with sacrificial electrodes; fuels; breathalyser test.

VI. ORGANIC CHEMISTRY

1. Alkanes, Alkenes and Alkynes

Students should be able to:

a) (i) use the general formula to determine the molecular formulae and structural formulae of alkanes C_{1-8}, alkenes C_{2-5}, and alkynes C_{2-5}.
   (ii) apply the concept of >structural isomerism= to alkanes and alkenes.
   (iii) use the IUPAC rules to name simple organic compounds.
b) identify the functional groups of alkanes, alkenes and alkynes.
c) distinguish the meaning of saturation and unsaturation.
d) recognise and write equations for:
   (i) substitution reactions in terms of alkanes reacting with halogens
   (ii) addition reactions in terms of alkenes and alkynes reacting with halogens, water (H_2O) and hydrogen (H_2)

   Note: The mechanism of electron transfer will not be examined.
e) describe and use the bromine and $KMnO_4$ tests for unsaturated compounds.
f) describe the laboratory preparation of ethene (by steam cracking and by dehydration), and ethyne (from calcium carbide), and write equations for each.

2. Polymerisation

Students should be able to:

a) explain using structural formulae, the production of polythene and PVC from ethene.
b) give examples of the use of PVC and polythene.
c) describe the environmental problems caused by PVC and polythene products.

3. Alkyl Halides

Students should be able to name simple primary alkyl halides and their formation from a reaction between hydrogen halides and alkenes.

4. Alcohols, Ketones and Aldehydes

Students should be able to:

a) (i) use the general formulae to determine the molecular formula of $C_1 - C_5$ alcohols.
   (ii) identify the functional groups for alcohols, ketones and aldehydes.
   (iii) use the IUPAC rules to name $C_1 - C_5$ alcohols, ketones and aldehydes and give examples of each.

b) (i) identify and name the three types of alcohol (primary, secondary, tertiary) and give examples of each.
   (ii) demonstrate an understanding of the oxidation of the three types of alcohol.
   (iii) test for ketones and aldehydes.

5. Carboxylic Acids

Students should be able to:

a) recognise the functional group.
b) use the general formula to determine the molecular formula and structural formula of C_1 - C_5 carboxylic acids and use the IUPAC rules to name them.
c) demonstrate an understanding of the acidic behaviour of ethanoic acid and be able to write equations to show its reaction with aqueous sodium hydroxide.
d) carry out a laboratory preparation of an ester and write the equation for its formation.
e) give the common physical properties of esters.

6. Fats and Oils

Students should be able to:

a) (i) recognise the general structure of fats and oils as esters.
Note: structure of glycerol is required.
(ii) draw the structures of tri-glycerides given the formulae of the constituent fatty (carboxylic) acids.
b) relate the trend of rising melting points with increasing saturation of fats/oils.
c) describe the extraction of fats/oils from their respective sources.
d) describe how fats and oils are refined using alkali to remove free fatty acids and steam distillation to remove the undesirable volatile products.
e) describe the effects of hydrogenation on fats and oils.
f) compare butter with margarine in terms of chain length, degree of unsaturation of fatty acids, melting points and rancidity.
g) (i) describe and write the structural formula for a soap.
(ii) describe the process of soap manufacture.
(iii) describe how the chemical nature of soap promotes its role as a cleaning agent.
(iv) compare the behaviour of soap in hard and soft water.
(v) describe the chemical processes involved in softening hard water.
h) compare the structure of common synthetic detergents with that of soap and relate this to the behaviour of each in hard water.

7. Carbohydrates

Students should be able to:

a) draw the open and cyclic structures of glucose and be aware of their inter-conversion.
b) use Fehlings or Benedicts reagent to test for the presence of the aldehyde group in an open glucose structure.
c) draw the structure of a disaccharide (maltose) and a polysaccharide (starch)
d) know the differences in structure and property of two types of starch (linear and branched).

ASSESSMENT

Assessment will be by an external examination (60%) and by internal assessment (40%).

1. The assessment of this prescription will test the following skills:

   Recognising and communicating chemical principles and concepts.
   Applying chemical knowledge to new situations.
   Using experimental techniques.
   Recall of knowledge.
   Drawing chemical diagrams, including flow diagrams.

   These skills are not regarded as being of equal weighting.

2. **THE EXAMINATION**

   a) The six (6) sections of the prescription will be examined by a written paper in approximately the following weighting:

Atomic Structure	13%
Quantitative Chemistry	17%
Inorganic Chemistry	16%
Principles of Physical Chemistry	16%
Oxidation and Reduction	10%
Organic Chemistry	28%

   b) There will be one three-hour paper set.

   c) The examination will comprise approximately:

      30% multiple-choice type questions.
      70% structured items.

A copy of the Periodic Table, (in which the main Groups are labelled I [H, Li, ...] through VIII [He, Ne, ...], the Periods labelled 1, 2, ..., and which gives the element symbols and their atomic numbers only) will be provided.

The use of silent, hand-held electronic calculators will be permitted.

3. INTERNAL ASSESSMENT

1. The major purpose of a PSSC internal assessment programme is to measure subject-related skills and abilities that cannot easily be measured by pencil-and-paper tests, i.e. practical skills, long-term research and investigative skills.

   This should be kept in mind when designing such a programme for submission to the SPBEA.

2. The PSSC Internal Assessment will be weighted as 40% of the total assessment.

3. At least **ten (10)** practical activities directly related to course objectives and content, as described in this prescription, **must** be carried out by each student. Students must also write a report on each of these activities. **At least one of these must be based on each of the prescribed topics**.

4. There are four (4) areas on which the internal assessment will be based.

Common Assessment Task (CAT) Manipulative skills test	8%
Extended investigation project	16%
Practical Reports (Minimum of 5)	12%
Other Tasks (Can include assignments, tests etc.)	4%

   Practical reports will be based on a minimum of five (5) - the same five for each student in the school.

5. Although certain student attitudes and behaviours may be desirable (e.g. co-operativeness, perseverance, politeness, etc.) they should not be included as skills to be assessed when recorded through the marking schemes in the PSSC Internal Assessment programme submitted by any school. Attempts to quantify and report such qualities should be done as a separate school activity.

6. Schools that intend to enrol students in PSSC Chemistry must submit a completed A**PSSC Internal Assessment Summary Form**≅ by March 1st in the year of enrolment. These forms will be provided by the SPBEA. Several forms may be necessary to document a school=s Internal Assessment programme. Further information must also be attached to these forms. This information should include details of procedures, the marking of separate teacher-designed tasks, and descriptions of intra-school moderation of internal assessments if a school has more than one class taking PSSC Chemistry.

7. Schools must supply a single mark out of 40 for every enrolled student - this mark being directly based on teacher-designed tasks (practical reports and other tasks) in the school=s SPBEA-approved Internal Assessment programme.

8. Clear records and documentation regarding the school=s approved PSSC Internal Assessment programme must be kept. Furthermore, all students= work that has been assessed under this programme (tests, essays, practical reports, projects, etc.) must be available for verification by SPBEA officers during any one school year.

9. Students who will be enrolled in PSSC Chemistry must be given a copy of the school=s PSSC Internal Assessment programme for the subject. Each student must also be informed of when assessment tasks are to be given, and be notified of his or her assessment result for each task as soon as it is marked.

10. Chemistry teachers and school principals will be required to sign the APSSC School Agreement≅ form to confirm that the above PSSC Internal Assessment programme procedures will be followed.

PSSC Internal Assessment Summary Form

CHEMISTRY

Country _____ *School* _____ *Class* _____

Included Tasks	Start Date	Completion Date	Brief Description	Task Weight %	
Practical Report 1					A
Practical Report 2					
Practical Report 3					30
Practical Report 4					
Practical Report 5					
Extended Investigation Project				20	
CAT				40	A
Other Task 1					
Other Task 2					10
Other Task 3					
			TOTAL	100%	

Teacher .....

Note: Task outlines and detailed marking schemes for all practical reports and A Other Tasks≅ must be submitted together with this completed IA Summary Form.

CAT for PSSC Chemistry 20%

Guidelines for CAT

The CAT should

1. be designed by the board or their appointee annually. (T.C)
2. assess manipulative skills listed below.
3. have a station type format.
4. have a limited number of stations which require a teacher check.
5. each station to have a time limit.
6. have checklist type marking scheme.
7. use common chemicals and equipment for stations.
8. have a list of equipment required and instructions for setting up.
9. be scheduled for late in the year.

Manipulative skills to be assessed

1. Measuring skills using the following equipment:
   - balances
   - measuring cylinder
   - burette
   * - volumetric flask
   - pipette
   - stop watches
   - thermometer

2. Following instructions
   - simple instructions
   - multi step instructions
   - limited instructions (students to be able to develop working procedures or sequencing)

3. Experimental skills
   - safe handling of chemicals
   - safe disposal of chemicals
   - cleaning procedures
   - equipment setup
   - using correct procedures for the following equipment
     - burette
     - pipette
     - filter funnel
     - volumetric flask
     - conical flask
     - distilled water bottle
     - watch glass/ weighing bottle

     as in titrations, standard solutions and dilutions.

4. General efficiency
   - how quickly and confidently the tasks are carried out.
   - successful completion of the task or part task within a time limit.
   - good use of available working space (bench space + placing of equipment + chemicals).

Manipulative skills to be assessed to be included in Advisory Section.

Recommendation for SPBEA (on CAF for PSSC Chemistry)

Propose to

X use the attached assessment schedule sheet as the common criteria for CAF on extended investigative project (must be practical in nature).

X use the attached sample Yr 12 Chemistry Assignment sheet as a guideline for the CAF.

X have an extended time period for the project with a minimum of 2 months and we recommend that there should be definitely 2 weeks of class time (to help students on starting the project).

X use the TIMELINE (pg. 26) as guideline/ or basis on which to form/produce one for the CAF. (separate booklet provided)

X mark for CAF 16/40 (40%).

PSSC CHEMISTRY

Extended Investigative Assessment Schedule

Data obtained from Student Log, Report, Display and Talk

Name: ..... Class: .....

Achieved high standard	3
Achieved good standard	2
Attempted	1
Not attempted	0

Four Aspects -

- ! Focusing and Planning
- ! Information Gathering
- ! Processing and Interpreting
- ! Reporting

will be assessed. Each aspect has 5 achievement criteria which are judged on the 4 point scale shown above.

FOCUSING AND PLANNING

Achievement Criteria

! Episodes of work recorded on a log	
! Details on finding/ choosing topic, and refining of the research question given	
! Details on experimental design development given including problems, solutions and follow-up on any advice given.	
! Method developed with clear specifications, replications and control of variables if required	
! Details of resources, references etc. given	
Total:	------ 15

INFORMATI ON GATHERING

Achievement Criteria

! Appropriate equipment used for collecting data of required accuracy	
! Correct use of equipment	
! Appropriate overall method/ procedures used	
! Appropriate method of recording results used: i.e. tables, graphs, charts etc.	
! Variety of relevant background information used to support investigation.	
Total:	----- 15

PROCESSING AND INTERPRETING

Achievement Criteria

! Trends, relationships or patterns in results (if present) identified	
! Limitations of results recognised: i.e. sources of errors, problems etc.	
! Evidence of continuing review of procedures	
! Possible future lines of investigation identified	
! Findings compared with established theory	
Total:	----- 15

REPORTING

Achievement Criteria

! Valid conclusions drawn based on discussion of the results	
! Oral presentation of project produced	
! Student produced visual display	
! Report produced which is based on project outline and makes scientific sense	
! Tidy presentation using appropriate forms of communication in report and presentation; i.e. scientific terms, units, charts, tables, etc.	
Total:	----- 15
Overall Total:	------ 60

COMMENT:

ADVISORY SECTION

A. Common Assessment Task (CAT)

1. Each year, SPBEA will design a Common Assessment Task (CAT) which will form part of the overall assessment for PSSC Chemistry. The CAT will be designed to specifically assess the student skill in:
   - X measurement
   - X following instructions
   - X handling materials and equipment.

2. Activities involving measurement will draw from the following list of equipment:

balance, measuring cylinder, burette, pipette, volumetric flask, stopwatch and thermometer

3. Activities involving handling materials and equipment will draw from the following list:

chemicals, burette, pipette, filter funnel, volumetric flask, conical flask, watch glass, weighing bottle and distilled water bottle

4. The task will be in the format of Astation activity≅, with a maximum of four stations each having a specified time limit for students.

5. The teacher will be required to assess each student. This will be done by matching performance with a supplied checklist.

6. The CAT will be scheduled for late in the year (August-September), and will be comprehensive in its guidelines for preparation, control and marking.

7. The format of the CAT will specify:
   - X a title
   - X a statement of course objectives assessed by the task
   - X a listing of material requirements for completion of the task
   - X guidelines for the teacher on advance preparation requirements
   - X guidelines for the teacher on task completion and task control
   - X notes on preparation by the student (if applicable)
   - X task outline for the student
   - X task detail for the student
   - X marking scheme for the task
   - X mark capture for the task.

8. Schools will be informed on the list of materials, chemicals and equipment required by the CAT at least three months before the CAT is due for completion, but teachers should ensure that the school has the items mentioned in 2 and 3 above.

B. Extended Investigation Project

I. Introduction

As part of the requirements of the PSSC Chemistry course you are required to do a piece of individual research of your own choice. This project is an extended investigation and is worth 16% of your overall grade.

In the next week or two you need to decide upon a *topic* in Chemistry that you would like to know more about. Once you decide upon an area of Chemistry that interests you; e.g. vitamins, forensic science, soft drinks, gardening, acid rain or the ozone layer, then you need to *explore* the area by reading and collecting resource material, writing to or interviewing experts and having discussions with teachers, parents and your peers. At some stage you need to decide what you want to find out. You need to decide upon an *investigatable question*. That means you need to have a clear, specific question which allows you to design an investigation that will give you answers. Here are examples of investigatable questions:

- Do vitamin C levels in fruit change as they ripen?
- Which citrus fruit contains the most acid?
- What % of carbonate is in an antacid tablet?
- How effective is the iodine method of obtaining fingerprints from different surfaces compared with the silver nitrate method?
- Does glucose content vary in different brands of lemonade?
- What are pH, phosphorus and nitrogen levels in garden soil and what effect does adding fertiliser(s) to the soil have on these levels?
- What effect does perming have on the texture of different types of hair?

Alternatively, you may have a problem you want to solve. You may want to design or prepare a new product with specific properties; e.g. a cleaner for removing stains from concrete or a waterproof hand cream; or design fair tests for comparing commercial products. These are all valid investigations providing you carry out a *practical investigation* and learn some chemistry new to you. Practical investigations need not be complex and can have everyday applications.

II. Project Guidelines for Students

1. PROJECT LOG

As part of your project you will be expected to complete a log (or diary) showing your work. At the end of the project you will write a report which will use the information in the log. The log will show how your project developed and must be presented for assessment with your report and display. Use a similar form to the one below. Fill in the log whenever you do any work on your project. This log will be taken in by your teacher at regular intervals so it is essential to keep it up to date.

Date:
Intentions: - *what you want to do*
Actions: - *what you did*
Problems: - *what problems were found*?
Possible solutions: - *ideas, people etc.*
Results: - *what actually happened?*
Time Taken: - *how long did you work*?

Deadlines for development and completion of your project is shown on page 25. It is important to keep on schedule. If you get behind make sure you talk it over with your teacher - don=t leave it! Your log is a record of your progress and will be taken in by your teacher at each of the milestones.

2. PROJECT REPORT

A project report is used to summarise your findings and should be approximately 4 - 5 pages long. It should be easily read by anyone even if he/she was not involved in your project. You should organise your ideas in various sections - this will help you write the report. A suggested outline is included here. You can see how the log information can be used.

(i) Writing your draft report

a) Introduction

- Write an introduction for your report which should be a page or less.
- Use the two headings opposite to structure your notes.

INTRODUCTION
! Background research
! Aim(s)

b) Methods and Materials

- Write a detailed description of what you did which would allow another chemist to duplicate your experiment if required.
- Use the headings opposite and include diagrams and sketches if appropriate.

METHODS AND MATERIALS
! Chemicals
! Experimental Design
! Equipment
! Materials

c) Results

- Write a detailed description of what you discovered in your investigation.
- Use the aspects in the box opposite to outline your results, if appropriate.

RESULTS
! Written Notes
! Tables
! Graphs
! Charts
! Diagrams and Drawings

d) Discussion

- Your discussion should be less than a page and in it you should try to interpret your results in relation to your aim(s).
- Make sure that you cover the aspects in the box opposite.

DISCUSSION
! trends (with supporting evidence)
! problems arising
! suggestions for further modification

e) Conclusion

- Write a short paragraph to summarise your results in relation to the aim.

CONCLUSION
AThe results show that ....@

f) Acknowledgement

- Write a note thanking those who gave evidence and assistance.

ACKNOWLEDGEMENT
AI wish to thank the Beauty Hair Salon ...@

g) References

- List the books and articles used in your research alphabetically.
- Use the format shown opposite.

REFERENCES
Alphabetical listing using the format - Author, date, title, publisher

h) Abstract

- Finally write a brief overview of the essence of your report in 200 words or less. Try to cover the aspects in the box opposite.

ABSTRACT
! purpose
! chemicals
! procedure
! results

(ii) Editing Your Draft Copy

! Use the checklist opposite to edit your rough copy.

EDITING CHECKLIST

1. Spelling and grammar correct.	9	
2. Impersonal passive style used.	9	
3. Written in the past tense throughout.		9
4. Style is clear and simple to understand.		9
5. Illustrations, graphs, etc. clearly titled.		9

(iii) Writing Your Final Copy

! As you write out your final copy for handing in, keep the points on the checklist in mind.
! Remember the Abstract goes at the **front** of the report.

FINAL EDITING CHECKLIST

1. Title page with your name and school on it.		9
2. Correct headings used for each section.		9
3. Sections in conventional order.	9	
4. Neat, legible writing used throughout.		9
5. Attractively presented illustrations and graphs.	9	
6. Pages in order, numbered and stapled together.		9
7. Final check on spelling and grammar.		9

Hand in your completed **original** log with your log. It does not matter if it is spattered with chemicals.

3. PROJECT DISPLAY (OPTIONAL)

Part of your report is to be taken and presented as a display suitable for a public viewing; ie a *3-part chart which will fit in a space no more than 120 cm long by 75 cm deep*. There is only enough room to show the essentials of your project. You need to show briefly:

- what you investigated
- how you investigated it (*drawings/ photos/ display, equipment used*)
- a summary of your results (*best as a graph or table*)
- your conclusions.

Keep it simple. Do not show much information - leave this for your report. As a general rule have no more than 200-300 words on your display.

NOTE: If you have problems with producing a display you *must* discuss them with your Chemistry Teacher.

Completion Date

You must hand in your display, project and report by July 31st. You should be prepared to give a short talk to the class about your project.

This should be an exciting, interesting and rewarding activity for you. If you feel apprehensive and unsure, talk to your teacher, class mates, parents, experts and friends about possible research problems; eg. *if you are interested in cosmetics, write to a cosmetic firm and ask if you can speak to a chemist involved with their manufacture*. Ideas for research are sure to crop up as you learn more about the industry. You should be working in an area that is new ground for you and is stimulating.

It should be your own work but you should feel free to ask others for help with ideas, techniques etc.

Guidelines for development and completion of project	
What	**When**
Project Introduction	By 3rd week of March
First Log Check	By 1st week of April
Research Question Established	By 1st week of May
Second Log Check	By 1st week of May
Practical Work Intentions	By 1st week of June
Third Log Check	By 1st week of June
Practical Work Completion	By 3rd week of July
Fourth Log Check	By 3rd week of July
Project Submission	By July 31st

Nomenclature Conventions

General Chemistry

Symbols for the physical quantities, ***M, V, H, s, K***, are written in italics (sloping letters). Any following subscripts will be in upright type.

Symbol/ Expression	Units in common use
X ***M***, molar mass, is the mass of one mole of a defined substance and will be used for elements and compounds. M_r relative molecular mass and A_r relative atomic mass, will not be used.	g mol[1]
X ***V***, volume A looped *R* is not used in these abbreviations.	L and mL
X ***n***, amount of substance, expressed in moles. It is incorrect to use the term Anumber of moles≅. See the footnote at the bottom of this page.	mol
X ***c***, *amount concentration*, is expressed as moles per litre, also denoted by the format [ ]. Concentrations may also be written as *mass concentration*, expressed as grams per litre. *Composition of a mixture*, commonly expressed as % w/V, %w/w and % V/V, will be used only after giving a clear definition of their meaning (e.g. grams per 100 mL, grams per 100 grams, mL per 100 mL respectively).	mol L^{-1} g L^{-1}
X ***s*** (*italic s*), solubility, units as for concentration.	mol L^{-1}

Amount of Substance

This is a physical quantity, symbol *n* (*italic n*), measured in a unit called the mole, which has the abbreviation mol.

The term Anumber of moles@ is to be avoided in favour of the Aamount of substance@. In the same manner, the size of an object can be described in terms of its Alength@, rather than its Anumber of metres@.

Enthalpy Changes, $^{a}\boldsymbol{H}$. *Units commonly used, kJ mol*$^{-1}$

X $\spadesuit_r\boldsymbol{H}^o$, standard enthalpy of reaction. For example:

$2H_2(g) + O_2(g) \equiv 2H_2O(l)$ $\quad\spadesuit_r\boldsymbol{H}^o(H_2O, 298\ K) = -570\ kJ\ mol^{-1}$

The term mol^{-1} means one mole of reaction, which is defined by the chemical equation; i.e. 2 mol of H_2 reacting with 1 mol of O_2 to give 2 mol of H_2O.

X $\spadesuit_f\boldsymbol{H}^o$, standard enthalpy of formation, per mole of product. For example the standard enthalpy of formation of liquid water:

$H_2(g) + 2\,O_2(g) \equiv H_2O(l)$ $\quad\spadesuit_f\boldsymbol{H}^o(H_2O, l, 298\ K) = -285\ kJ\ mol^{-1}$

X $\spadesuit_c\boldsymbol{H}^o$, standard enthalpy of combustion, per mole of substance burnt. For example the standard enthalpy of combustion of hydrogen gas to give liquid water:

$H_2(g) + 2\,O_2(g) \equiv 2H_2O(l)$ $\quad\spadesuit_c\boldsymbol{H}^o(H_2, g, 298\ K) = -285\ kJ\ mol^{-1}$

Note (i) The superscript E denotes a defined standard state.
(ii) The alternative superscript $^{\theta}$ (plimsol) may be accepted.
(iii) A space is always left between any value and its unit, as well as between units for composite units.

X $\spadesuit_{fus}\boldsymbol{H}$, enthalpy of fusion (melting).

X $\spadesuit_{vap}\boldsymbol{H}$, enthalpy of vaporisation.

Chemical Formulae

These denote entities composed of more than one atom (molecules, simple and complex ions, groups of atoms etc.)

e.g.	**Formula**	**Information conveyed**
	H_2O	one water molecule or one mole of water
#	$2O_2$	half a mole of oxygen molecules
	$Zn_3(PO_4)_2$	one mole of zinc phosphate comprising zinc and phosphate ions in a 3:2 ratio
	$2MgSO_4$	two moles of magnesium sulfate
#	$\frac{1}{5}KMnO_4$	one-fifth of a mole of potassium manganate VII (permanganate)

# Indicates examples that are artificial and are used as a convenient way of calculating amounts of substance (moles).

Equations for Chemical Reactions

$H_2(g) + Br_2(g) \rangle\ 2HBr(g)$	forward reaction
$H_2(g) + Br_2(g) \equiv 2HBr(g)$	equilibrium
$H_2(g) + Br_2(g) = 2HBr(g)$	stoichiometric relation

States of Aggregation

These are written in parentheses printed in upright type, immediately after the formula or substance and on the same line as chemical formula symbols.

E.g. **s** solid, **l** liquid (preferably serif font *l*, not looped *R*), **g** gas or vapour
aq aqueous solution (dissolved in water)
HCl(g) hydrogen chloride in the gaseous state

Temperature

Celsius temperature	EC
Thermodynamic (Kelvin) temperature	K

Pressure

Symbol p. Units are Pascals (Pa), or more commonly kPa.
Standard pressure, $\mathbf{p^o}$, = 10^5Pa = 1 bar

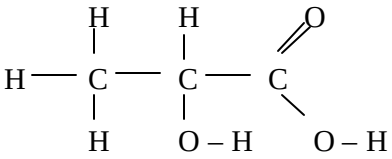
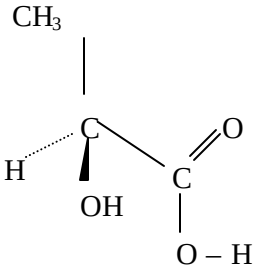
IUPAC Approved Spelling

Spelling of the element with atomic number 16 is the original English spelling of **sulfur**.
Derived ions have consistent spelling
e.g. sulfide sulfate sulfite thiosulfate

Graph Axes and Table Headings

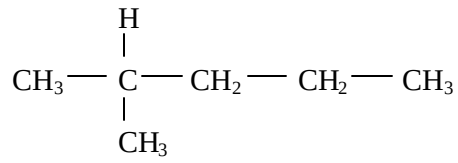
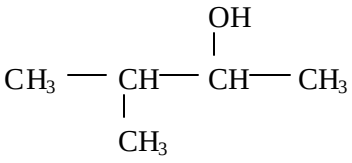
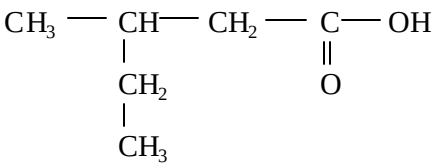
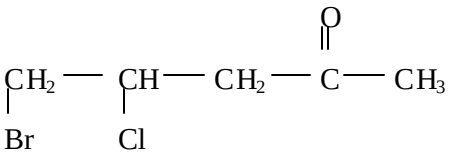
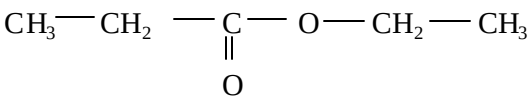
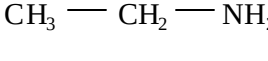
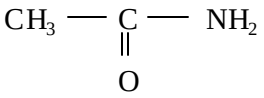
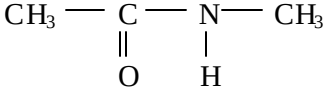
Labeled as quantity/unit e.g. c / mol L^{-1} and not c (mol L^{-1}). Only values will then be written on the axes or in a table.

Organic Chemical Formulae

Formula	**Information conveyed**	**Example for lactic acid**
empirical	Stoichiometric proportions of atoms only. Simplest ratio formula	CH_2O
molecular	Formula of the actual molecule	$C_3H_6O_3$
constitutional	Structure relationships of atoms shown	$CH_3CHOHCOOH$
structural	Atoms and bonds shown	
structural formula showing stereochemistry	Arrangement of atoms in space shown	

Organic chemical nomenclature

IUPAC conventions will be followed. Some examples are:

Structure	**IUPAC name**
	2-methylpentane
	3-methyl-2-butanol
	3-methylpentanoic acid
	5-bromo-4-chloro-2-pentanone
	ethyl propanoate
	ethylamine
	ethanamide
	N-methylethanamide

References:

Mills I., Cvitas T., Homann K., Kallay N. and Kutchitsu K. *Quantities, Units and Symbols in Physical Chemistry*. Blackwell Scientific Publications, Melbourne, 1988.

Packer, J.E. *The Basic Vocabulary and Language of Chemistry.* Copies from the author at the Chemistry Department, University of Auckland, Private Bag 92019, Auckland 1996.

Note A: Physical Quantities, Units and Symbols

Quantitative aspects of chemistry are to be based on the following physical quantities in terms of their SI definition.

Physical quantity (symbol)	**Name of Unit**	**Symbol of Unit**
mass (m)	kilogram (gram)	kg (g)
length (l)	metre	m
temperature (T)	kelvin	K
time (t)	second	s
amount of substance (n)	mole	mol
volume (V)	litre	L

Note B: Significant Figures

1. During calculations rounding off should occur in the final answer.

2. Answers should be to the lowest number of significant figures present in the data.

e.g. Use the information given below to find the mass of water removed by heating.

Show your working clearly and neatly.

Data:

Mass of $Na_2CO_3.XH_2O$ before heating = 3.48g

Mass of anhydrous Na_2CO_3 remaining after heating = 1.59g

$M(Na_2CO_3)$ = 106 g/mol

$M(H_2O)$ = 18 g/mol

In this problem, the lowest significant figure given 2 in the mass of water.
Hence the answer should be given to 2 significant figures.

Mass of water = 3.48g - 1.59g = 1.89 ∃ 1.9g