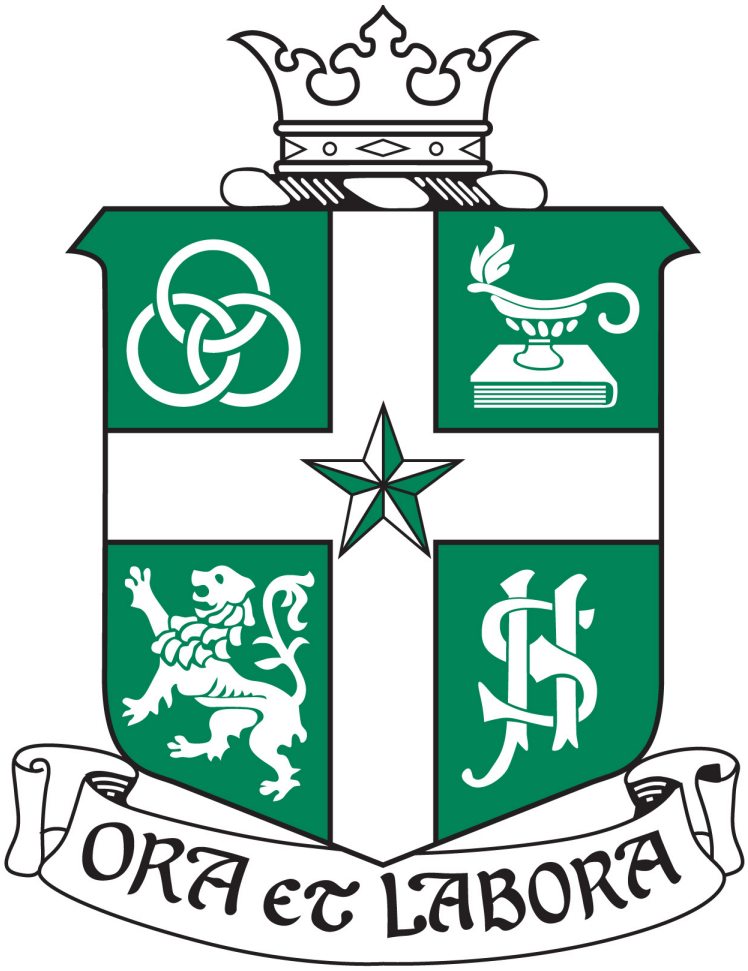
ST. JOSEPH'S INSTITUTION INTERNATIONAL MALAYSIA



CHEMISTRY HANDBOOK

Why Study CHEMISTRY?

Chemistry is an experimental science that combines academic study with the acquisition of practical and investigational skills. Chemical principles underpin both the physical environment in which we live and all biological systems. Chemistry is often a prerequisite for many other courses in higher education, such as medicine, biological science and environmental science.

All students undertake both theory and practical work as they complement one another naturally, both in school and in the wider scientific community. The DP Chemistry course allows students to develop a wide range of practical skills and to increase facility in the use of Mathematics. It also allows students to develop interpersonal and information technology skills, which are essential to life in the 21st Century.

By studying Chemistry students will become aware of how scientists work and communicate with each other. While the scientific method may take on a wide variety of forms, it is the emphasis on a practical approach through experimental work that characterises the subject. Teachers provide students with opportunities to develop manipulative skills, design investigations, collect data, analyse results and evaluate and communicate their findings.

At SJII Malaysia, Chemistry is offered at both higher level (HL) and standard level (SL).

A background in Chemistry at IB level aids a successful pursuit of a variety of studies, including medicine, dentistry, pharmacy, biological sciences, agriculture, food technology and dietetics, environmental studies, material sciences and physics. To enter certain courses, it may be required that Chemistry be studied in the IBDP, (i.e. Biology).

Approaches to Teaching and Learning in Chemistry

The Chemistry course is “concept based”. That means that it is based on a number of “Essential Ideas”. Some examples include:

- Organic chemistry focuses on the chemistry of compounds containing carbon
- The arrangement of elements in the periodic table helps to predict their electron configuration
- Lewis (electron dot) structures show the electron domains in the valence shell and are used to predict molecular shape

Learning to learn in the context of the Essential Ideas, rather than thinking every lesson is separate, is a very empowering way of appreciating learning in general.

In addition, the Chemistry course considers the very Nature of Science and asks students to think about these deeply. For example:

- Obtain evidence for scientific theories by making and testing predictions based on them.
- Use theories to explain natural phenomena.
- Use scientific models to represent the real world.

Thus, the teacher will not expect you to simply learn information then repeat it in an examination. The teacher will expect you to take responsibility for your own learning. This is the same in all IB DP subjects, not just Chemistry.

This means that we expect you to develop a **broad set of skills**. How these skills can relate to Chemistry is outlined below.

Research Skills	How to look up information and find things out for yourself in constructive ways, how to tell if information you have found is trustworthy and how to use information honestly. For example, you may want to research the effect of carbon chain length on the enthalpy of combustion.

Communication Skills	This means expressing your judgements and views distinctly, writing responses to questions succinctly, and writing your individual assessment report well. Many students do not realise that even answering questions clearly in class is a communication skill!

Social Skills	In Chemistry, students often work in groups, for example during practical work. You are expected to participate fully, but also listen to and encourage the participation of others.

Thinking Skills	These skills are required in Chemistry in every lesson! You must be prepared to learn how to analyse, explain, evaluate, discuss, make links and see the "big picture".

Self-Management Skills	These are crucial to success in the IB Diploma, because you will be studying a lot of subjects and participating in a lot of activities. You must be able to work independently, effectively and in an organised manner.

This means that your teacher will also use a **broad set of approaches**, including:

Inquiry	Whilst teachers know that they have to give students information, they know that students finding things out and coming to conclusions by themselves rather than always being told is very good. You will be expected to find things out AND ask questions throughout your Chemistry course.

Emphasising Concepts	Teachers will try to encourage you to see the big pictures, like some of the ideas above, rather than expect you to see each lesson as an individual entity that can be pushed to one side as soon as it is over.

Differentiation	Teachers will use a variety of teaching strategies and approaches so that everyone's different needs and preferred ways of learning can be addressed.

Development of Independence	Your teacher will set challenging tasks to do on your own, and have high expectations of you, so they will help you to develop their self-management skills

Assessment	Your teacher will use a variety of assessment methods and give feedback in different ways; he or she will also expect you to be able to assess your own and your classmates' work in a useful way. The aim is that you will not simply be looking to see what marks you have got – but what you need to do next in order to improve.

Chemistry and the IB Learner Profile

While you progress through your diploma programme studies and activities, you will develop a number of attributes. The IB calls this the IB "learner profile". This table shows you what the learner profile attributes are and some examples of how Chemistry can help you develop these, qualities...

We hope you will become …	Examples in Chemistry
Inquirers	Students will **find out** how manufacturing has changed over the last century to take into account efficiencies, energy consumption and atom economies.
Knowledgeable	Students will **build up knowledge** based on factual content related to the detection of substances through spectrometry, trends of the periodic table, physical properties of materials and the particulate nature of matter.
Thinkers	Students will need to **understand** concepts such as atomic structure and acid-base theories, as well as **develop meaningful action** whilst learning.
Communicators	Students will **verbally communicate** ideas, research findings, opinions and judgements. They will **write** reports of investigations e.g. to establish whether there is a relationship between two experimental variables and **keep written records** of investigations e.g. how to calculate the percentage of ammonia in a window cleaner. They will also **respond to problems** including a written data analysis exercise specifically requiring students to respond in full to questions.
Principled	Students will form and keep to their **own views** on issues such as recycling, reduction of waste, conservation of resources, atom economy, etc.
Open-Minded	In connection with the above, students will learn to **respect others' views** even though they feel others may not be right and/or they do not agree with them.
Caring	Students will learn how to respect and **care for the environment**.
Risk-Takers	Students will need to uphold the principles they have developed **even though this may generate disagreement** with their peers.
Balanced	The topic contributes to the students' **whole IB education**.
Reflective	In particular, students will be able to **evaluate** their experimental procedures and theories such as, Kekulé deducing the structure of Benzene through a dream.

Topics Studied

Core (SL)

- Stoichiometric relationships
- Atomic structure
- Periodicity
- Chemical bonding and structure
- Energetics/thermochemistry
- Chemical kinetics
- Equilibrium
- Acids and bases
- Redox processes
- Organic chemistry
- Measurement and data processing

Additional higher level (AHL)

- Atomic structure
- The periodic table - the transition metals
- Chemical bonding and structure
- Energetics/thermochemistry
- Chemical kinetics
- Equilibrium
- Acids and bases
- Redox processes
- Organic chemistry
- Measurement and analysis

Option (Choice of one out of four)

- Materials
- Biochemistry
- Energy
- Medicinal chemistry

Chemistry in the timetable at SJIIM

The IB requires 240 hours of teaching for Higher Level (HL) and 150 hours of teaching for Standard Level (SL). At SJIIM, HL Chemistry is allocated three double lessons per week and SL Chemistry is allocated two double lessons per week.

It sometimes happens that HL and SL Chemistry are taught in the same class. In this case, the teacher will let the SL students know when they do not need to come to lessons. Sometimes students will find they need to go to all three lessons in a week; sometimes they will only attend one or two of the lessons in a week and sometimes there will be periods of time when they will not be required to attend at all.

The IB Chemistry Course

Chemistry, like all IB DP subjects, consists of two “components”.

The first of these is the theory and practical work taught during lessons, and which may be examined in the examination papers at the end of the course. Completed examination papers are sent to IB and marked by IB examiners.

The second of these is the ‘coursework’. In Chemistry, this in an individual investigation occupying about 10 hours of work, that each student must complete. The student, with the teacher’s advice, chooses his or her own topic. The investigation is marked by the teacher according to a set of criteria, then uploaded to the IB servers to be checked by the IB moderators.

Assessment Criteria for the Chemistry Individual Investigation

So, that you have some idea of what will be expected of you in advance, these are the criteria that teachers use to mark the individual investigation.

CRITERION	EVIDENCE
Personal Engagement	Have I chosen a novel investigation? Have I shown that I have incorporated my own ideas and hypothesis? Have I designed or modified apparatus to use?
Exploration	Have I planned my investigation well, in accordance with scientific method?
Analysis	Have I looked at my results thoroughly, and have I processed them well into graphs etc., that make it easy to see what the results show?
Evaluation	Have I considered errors and weaknesses in my method and how it could be improved for next time??
Communication	Is my report clear and readable? Have I used the correct terminology? Have I referred to and cited sources of information correctly?

Final Assessment in Chemistry

An overview of how you will be assessed on the final set of skills and knowledge that you have acquired is as follows.

LEVEL	ASSESSMENT	WEIGHTING (%)
Higher	3 exam papers	80
Standard	3 exam papers	80
All	Individual Investigation	20

Chemistry Course Outline

This table reflects the topics covered but not necessarily the order in which they will be taught.

Year 1	Topic 2 / 12	Atomic Structure	8 lessons
	Topic 11	Measurement and Data Processing Pt.1	5 lessons
	Topic 3	Periodicity Pt.1	7 lessons
	Topic 1	Stoichiometric Relationships	18 lessons
	Topic 4 / 14	Chemical Bonding and Structure	20 lessons
	Topics 13	Periodicity Pt.2	8 lessons
	Topic 5 / 15	Energetics and Thermochemistry	13 lessons
	Topic 6 / 16	Chemical Kinetics	13 lessons
	Topic 7 / 17	Equilibrium	8 lessons
Year 2	Topic 8 / 18	Acids and Bases	23 lessons
	Topic 9 / 19	Redox Processes	15 lessons
	Topic 10 / 20	Organic Chemistry	28 lessons
	Topic 21	Measurement and Data Processing	8 lessons
	Option	TBC	TBC
	Examination Revision		

Chemistry Resources

Textbooks

The textbook we use is the Chemistry for the IB Diploma from Hodder. It is written by Christopher Talbot, Richard Harwood and Christopher Coates. (ISBN: 9781471829055).

This is a list of **other Chemistry textbooks** available for reference or loan in the school library:

Chemistry for the IB Diploma: Exam Preparation, by Steve Owen and Chris Martin
IB Science Skills: Chemistry, by Chris Conoley

This list is growing all the time so do keep a look out.

Books of Chemical Interest

There are **other books** of chemical interest too, such as “Extreme Science” by Phil Clarke; “The Science Delusion” by Curtis White; “A Short History of Nearly Everything” by Bill Bryson, “Bad Science” by Ben Goldacre and many more, which will broaden your appreciation of Chemistry and Science.

Chemistry Flash Cards

There is a boxed set of Chemistry flash cards available for reference in the library and Chemistry lab.

Websites and Apps

There are many websites and apps - not all of them reputable, so beware. Reputable and useful ones include:

Khan Academy (APP)
Doc Brown’s Chemistry http://www.docbrown.info/page19/IBchemistry.htm
IB Chemistry Web http://ibchem.com/
MSJ Chem http://www.msjchem.com/
InThinking: IB Chemistry http://www.thinkib.net/chemistry

YouTube Channels

Rich Thornley https://www.youtube.com/user/richthornley
Crash Course: Chemistry https://www.youtube.com/user/crashcourse
Fuse School https://www.youtube.com/user/virtualschooluk
TED Ed https://www.youtube.com/user/TEDEducation

Teaching Order Year 12

SL Material | HL Material | Fundamental Experiment | Experiment

2. Atomic Structure (6/2)

	Lesson
1	Atoms and Isotopes
2	Relative Masses
3	Emission Spectra
4	Flame Test and Emission Spectrum
5	Orbitals
6	Electron Configuration
7	1st Ionisation Energy
8	Successive Ionisation Energies

11. Measurement and Data Processing (10/2)

	Lesson
9	Precision and Accuracy
10	Systematic and Random Error
11	Uncertainty in Calculation
12	Determining the Enthalpy of Combustion of Primary Alcohols
13	Graphical Techniques

3. Periodicity (6)

	Lesson
14	The Periodic Table
15	Periodic Overview
16	Atomic Radii, ionic Radii and Ionisation energy
17	Electron Affinity, Electronegativity and Metallic Character
18	The Reactivity of Group 1
19	The Reactivity of Group 17
20	The Acid-Base Character of Period 3 Oxides

1. Stoichiometric Relationships (13.5)

	Lesson
21	The Particulate Nature of Matter
22	Elements, Compounds and Mixtures
23	Writing Chemical Equations
24	The Mole and Avogadro's Constant
25	Avogadro's Number
26	Relative Masses
27	Empirical and Molecular Formula
28	Determining the Empirical Formula of Copper Oxide
29	Empirical Formula of a Hydrate
30	Percentage Yields
31	Decomposition of Potassium Perchlorate, ($KClO_3$)
32	Avogadro's Law and the Molar Volume of a Gas
33	Molar Volume of a Gas
34	The Ideal Gas Equation
35	Determining the Molar Mass of an Unknown Ideal Gas
36	Solutions
37	Determining the Concentration of Ammonia in Window Cleaner
38	Limiting Reagents

4. Chemical Bonding and Structure (13.5/7)

	Lesson
39	Ionic Bonding and Structure
40	Properties of Sodium Chloride, (NaCl)
41	Covalent Bonding
42	Modelling Covalent Compounds
43	Properties of Covalent Bonds
44	Lewis Structures
45	VSEPR (Up to 4 e^- Domains)
46	Delocalisation and Resonance
47	Molecular Polarity
48	Allotropes of Carbon
49	Silicon and Silicon Dioxide
50	Coordinate Bonding
51	Intermolecular Forces
52	Intermolecular Forces and Boiling Point
53	Metallic Bonding
54	Formal Charge
55	VSEPR (Up to 6 e^- Domains)
56	Bonding Orbitals
57	Ozone and Catalysis
58	Hybridisation

3. Periodicity (4)

	Lesson
59	Transition Elements
60	Ligands and Coordination
61	Preparing Transition Metal Complexes
62	Catalytic and Magnetic Properties
63	Coloured Complexes
64	Transition Metal Complexes

5. Energetics and Thermochemistry (9/7)

	Lesson
65	Energetics and Thermochemistry
66	Exothermic and Endothermic Reactions
67	Measuring Energy Changes
68	Calibrating a Calorimeter
69	Standard Enthalpy Changes
70	The Direct Determination of an Enthalpy of Reaction
71	Hess' Law
73	The Indirect Determination of an Enthalpy of Reaction
74	Bond Enthalpies
75	Lattice Enthalpies
76	Born-Haber Cycles
77	Entropy
78	Free Energy and Spontaneity

6. Chemical Kinetics (7/6)

	Lesson
79	Collision Theory and Rate of Reaction
80	Measuring the Rate of a Reaction
81	Investigating the Factors that Affect the Rate of a Reaction
82	Factors Affecting Rate
83	Investigating the Effect of Concentration on the Rate of a Reaction
84	Maxwell-Boltzmann Distribution
85	The Order of Reaction
86	Determination of the Order of Reaction
87	Rate Equations
88	Determining the Rate Equation for the Iodination of Propane
89	Reaction Mechanisms
90	The Arrhenius Equation
91	Determining the Activation Energy of a Chemical Reaction

7. Equilibrium (4.5/4)

	Lesson
92	Equilibrium Reactions
93	Concentration Equilibrium
94	The Equilibrium Expression
95	Le Châtelier's Principle
96	Equilibrium Constant
97	Reaction Quotients
98	Temperature Equilibrium
99	Gibbs Free Energy and Equilibrium

Teaching Order Year 13

SL Material | HL Material | Fundamental Experiment | Experiment

8. Acids and Bases (6.5/10)

	Lesson
100	Brønsted-Lowry Acid and Base Theory
101	Reactions of Acids
102	Reactions of Acids
103	Investigating the Colour Change of Indicators
104	The Power of Hydrogen, pH
105	Acids, Bases and Amphiprotic Substances
106	The Ionic Product of Water
107	pH and K_w Calculations
108	Strong and Weak Acids and Bases 1
109	Conductivity of Solutions
110	Determining the Ethanoic Acid Content of Vinegar
111	Acid Deposition
112	Lewis Acid and Base Theory
113	Determining the Nitrogen Content in a Fertiliser
114	Acid and Base Dissociation Constants
115	Determination of the K_a of a Weak Acid
116	Titration Calculations
117	Determining the Mass of $CaCO_3$ in Egg Shells (Back Titration)
118	Back-Titration Calculations
119	pH Curves
120	Indicators
121	Buffer Solutions
122	Salt Hydrolysis

9. Redox Processes (8/6)

	Lesson
123	Oxidation and Reduction
124	Enthalpy of Redox
125	The Activity Series
126	Redox Reactions
127	Biological Oxygen Demand, (BOD) - The Winkler Method
128	Voltaic Cells
129	Investigating the Factors that Affect Voltaic Cells
130	Electrolytic Cells
131	Electrolysis
132	Electrolysis of a Molten Salt
133	Standard Hydrogen Electrode
134	Electrolysis of Aqueous Solutions
135	Factors Affecting Electrolysis
136	Electro-refining and Electroplating
137	Investigating Replacement Reactions

10. Organic Chemistry (11/12)

	Lesson
138	The Homologous Series
139	Properties of Alkanes
140	Alcohols, Aldehydes and Ketones
141	Carboxylic Acids and Halides
142	Modelling Organic Compounds
143	The Reactivity and Combustion of Alkanes
144	Free Radical Reactions
145	Testing for Alkenes
146	Alkanes and Alkenes
147	Electrophilic Addition
148	Alcohols and Carboxylic Acids
149	Addition Polymerisation
150	Oxidation of Alcohols
151	Nucleophilic Substitution of Halogenoalkanes
152	Esters
153	S_N1 Mechanisms
154	S_N2 Mechanisms
155	The Rate Determining Step
156	Markovnikov's Rule
157	Electrophilic Addition Mechanisms
158	Electrophilic Substitution Mechanisms
159	Reduction Reactions
160	Organic Synthetic routes
161	Retro-Synthesis of Organic Compounds
162	Stereoisomerism
163	Modelling Organic Compounds
164	Optical Isomers
165	Racemic Mixtures

11. Measurement and Data Processing (10/2)

	Lesson
166	The Index of Hydrogen Deficiency
167	Mass Spectrometry
168	Mass Spectrometry of Air
169	The Electromagnetic Spectrum
170	Infra-Red Spectroscopy
171	^{1}H NMR Spectroscopy
172	^{1}H NMR Spectroscopy
173	X-Ray Crystallography

Option B - Biochemistry (15/10) - TBC

174	
	Identifying Sugars
	Vitamin C in Juice
	Colourimetric Analysis of Iron
	Sucrose