Welcome to First Year Chemistry

- Questions or problems with the course?
  Director of First Year Studies
  Adam Bridgeman (Room 222)
  A.Bridgeman@chem.usyd.edu.au

- Questions or problems with the labs?
  Lab Director
  Emily Shuter (Room 224)
  E.Shuter@chem.usyd.edu.au

Need extra help with course work?
Duty tutors are available. Free of charge.
Tues – Fri, 12-2pm from week 2
dutytutor@chem.usyd.edu.au

Not sure about something – ask Sophie!
First Year Enquiry Office (10 am - 3.15 pm)
firstyear@chem.usyd.edu.au

Information and Resources
- First Year Chemistry web site: firstyear.chem.usyd.edu.au
- CHEM1101 website: www.firstyear.chem.usyd.edu.au/chem1101
  - access answers to tutorial problems, lecture notes, exam papers etc
- WebCT: learn-on-line.usyd.edu.au
  - access pre-lab quizzes and resources from off-site
- ChemCAL: chemcal.chem.usyd.edu.au
  - self-help tutorials and quizzes
First Year Chemistry

Tutorials
Start in week 2.
Check answers on the web before tutorial
Go over problems and exam questions in tutorial

Laboratory Work
Start in week 2. Buy your lab book in week 1. $15 at the front of lab C

Assessment
10% laboratory assessment (pre-lab quiz, lab work and lab assessment)
15% tutorial quizzes (4 per semester; the best three marks used)
75% 3 hour exam at the end of semester

Staff-Student Liaison Committee

First Year Chemistry

Lecturers
We are very approachable— if you have questions, talk to us!

Weeks 1-7:
- Dr Angus Gray-Weale (Room 315)
  gusgw@chem.usyd.edu.au
  www.chem.usyd.edu.au/~gusgw

Weeks 7-13:
- Dr Adam Bridgeman (Room 222)
  A.Bridgeman@chem.usyd.edu.au

Chemistry 1101 - Semester 1, 2006

Lecture 1
- Administration and Course Organisation
- Overview of the Course
- Review of the Development of Modern Chemistry and Atomic Theory

Lecture 2.4
- Nuclear and Radiation Chemistry.
Overview of this Course

There is much more to be learned or appreciated than I can examine you on. On slides rimmed with pink hash you need not take notes—just listen.

- Course Administration
- Demonstrations
- Cool stuff

Overview of this Course

But there is much that I can examine you on—such information is on green rimmed slides.

- Examinable material
- What you need to cram
- Not necessarily all you should know as a chemist— but all that will appear in the exam

Overview of this Course

There is much that is interesting and that I will tell you but is not examinable—such information is on yellow slides.

- Historical information
- Anecdotes
- Contexts of examinable content in everyday life
Overview of this Course

- Science is a discipline in which we seek an understanding of the observable world
- We perform experiments - that is, make observations under controlled conditions to test hypotheses
- If our theories predict yet unobserved phenomena – these may be tested by experiments which may suggest a new theory
- The interplay between theory and experiment is how our understanding of the universe advances

Overview of this Course

- Chemistry is a separate subject to physics since, by and large, we use approximate and descriptive theories to predict chemical phenomena (the mathematics is intractable)
- Rigorous theoretical treatments of chemical problems is often called chemical physics, or physical chemistry
- Descriptive chemistry of mostly carbon based chemical phenomena is called organic chemistry – that pertaining to the rest of the periodic table is historically called inorganic chemistry
- Names are not important – modern chemistry is a mix of traditional disciplines and often overlaps external disciplines...

Experimental Atomic Resolution Picture of a GaAs Surface

Modern chemistry includes microscopic experimental investigations of individual atoms and molecules.

E.g. Ion channel conduction effects through biological membranes
Shapes and structures of individual DNA strands
Surface atoms imaged by Scanning Tunnelling Microscopy

1 Å = 10^{-10} m
Overview of this Course

The lectures begin with the smallest scale and work up from there

(Lectures 1-4)
Sub-atomic/nuclear structure

(Lectures 5-19)
Atomic, electronic and molecular structure
(quantum theory)

Lectures 20-38 focus on macroscopic chemical processes and forces between molecules. (Dr Adam Bridgeman)

We will make frequent reference to the experimental basis for our understanding throughout. That is, we will relate the molecular-scale theories to macroscopically observable properties.

Some important specific examples will be discussed in detail and examined alongside general principles.

Assumed Knowledge

We assume HSC Chemistry Core.
Some aspects of HSC Options will be covered in this Unit.

To get a clear idea of what you are expected to be familiar with, see Assignment 1.

For revision, see Web Resources on the First Year Chemistry Web site, and read over the introductory topics in any General Chemistry text

E.g. Silberberg Chapters 1-4
Housecroft & Constable Chapter 1

Topics - Atomic and molecular structure, states of matter, elements & compounds, moles, stoichiometry (balancing reactions), classes of chemical reactions, periodic table.

The Origins of Modern Chemistry

Some key events in the history of "chemistry"

~1200 BC Copper, lead, tin & iron all produced from their ores
~450 BC Empedocles adopts the idea of four elements: earth, air, fire, water.
1660 Boyle argues that these four are not elemental.
1667 Becher & Stahl propose an invisible "elemental earth" - phlogiston theory

(http://www.jimloy.com/physics/phlogstn.htm)
Lavoisier’s definition of an element was empirical — something that cannot be further decomposed by chemical action.

1783 - Published “On the Nature of Water and on Experiments that Appear to Prove that this Substance is not Properly Speaking an Element, but can be Decomposed and Recombined”

This paper showed that water is not elemental, but also did so without mentioning phlogiston theory, which had gained some currency.

The Origins of Modern Chemistry

Chemical understanding took off in the late 18th century

What did Lavoisier do?
1. Decomposed water into its elements by heating in a gun barrel.
2. Then recombined the elements to re-form water.

$H_2O \rightarrow H_2 + O_2$

Lavoisier’s 1789 list of “elements” obtained by chemical decomposition.

"Caloric" the element then believed to make up heat!

Gases were referred to as “airs”, having all been designated as forms of the same (ancient) element. Oxygen had been known as "air - dephlogisticated" and a combination of carbon dioxide and nitrogen as “phlogisticated gas.”
Elements

1803 - ~29 elements known

Calculated/Published atomic weights of

- H 1 (used as a reference)
- C 4.3
- N 4.2
- O 5.5
- P 7.2
- S 14.4

1808 - Dalton publishes atomic theory

1810 - 32 atomic weights & 38 known elements

Dalton's Big Idea

Lavoisier's definition of an element was empirical, and based on macroscopic observations something that cannot be further decomposed by chemical action.

Dalton's Atomic Theory

- All matter consists of indivisible particles known as atoms.
- Atoms of one element cannot be converted into atoms of another element.
- Atoms of an element are identical, but are different from atoms of any other element.
- Compounds result from chemical combination of a specific ratio of atoms of different elements.

A Timeline of Atomic Structure Development

1803 J Dalton provided evidence for fundamental indivisible particles - atoms.
1897 JJ Thomson discovered electrons - "cathode rays."
1909 RA Millikan measured the charge of an electron.
1909 E Rutherford proposed an atom be composed of a small positive nucleus (1912) surrounded by a lot of space occupied by electrons.
1913 HGJ Moseley determined the charge on the nucleus.
Rutherford & others regard the atomic weight as being the number of protons and the nuclear charge as being the number of protons minus the number of electrons in the nucleus.
1913 N Bohr applied quantum theory to electrons in atoms.
1920 J Aston finds isotopes by mass spectrometry.
1932 J Chadwick discovered the neutron.
This gives a fairly complete picture of the nucleus as composed of charged protons and uncharged neutrons.
Dalton’s Big Idea

**Dalton’s Atomic Theory (1808)**
- All matter consists of indivisible particles known as atoms.
- Atoms of one element cannot be converted into atoms of another element.
- Atoms of an element are identical, but are different from atoms of any other element.
- Compounds result from chemical combination of a specific ratio of atoms of different elements.

**Current Atomic Theory (2005)**
- Atoms are made of subatomic particles - protons, neutrons, electrons.
- Atoms can be interconverted by nuclear reactions.
- Atoms of an element have identical atomic number, but may have different atomic masses (isotopes).
- Generally true, but some exceptions.

How do we identify atoms? How do we know about different isotopes?

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**Spectroscopy and Spectrometry**

Atoms and molecules are identified by a set of techniques known collectively as spectroscopy.

- Many spectroscopic techniques examine the electrons in atoms and molecules. See lectures 8-9, following from quantum mechanics.
- Others examine atomic and molecular motions. See lecture 19.
- **Atomic and molecular masses are measured by Mass Spectrometry.**

**Mass Spectrometry** was developed by F.W. Aston (Nobel Prize 1922), who was an assistant of J.J. Thomson and worked with him on discharge tubes.

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**How Mass Spectrometry Works**

In a mass spectrometer, the atoms or molecules to be studied are vaporized and then ionized, usually by an electrical discharge.

In the conventional design of a mass spectrometer, ions follow a curved path and their deflection depends on the mass-to-charge ratio, m/z (sometimes denoted m/e). This deflection was originally recorded as impact on a strip of photographic film, but now use digital current or luminescence detectors.
Mass Spectrometry

Aston’s results established the existence of isotopes. (They were already known for radioactive elements, but never shown for stable elements.)

1920 - Aston measured two isotopes of Na (20 and 22), three of S (32, 33, 34), three of Si (28, 29, 30), six of Kr (78, 80, 82, 83, 84, 86), and many others.

Development of Mass Spectrometry

1919 - Aston separates isotopes in a mass spectograph.
1946 - Pulsed gas injection and time-of-flight detectors
1956 - Mass spectrometry to identify complex organic molecules.
1977 - Accelerator Mass spectrometry developed for trace analysis.
2002 - Nobel Prize in Chemistry to Koichi Tanaka and John Fenn for developments to Mass Spec. allowing the study of large (bio)molecules.
See: http://www.nobel.se/chemistry/laureates/2002/
for more details see:
http://masspec.scripps.edu/information/history/abstracts/index.html
**Summary**

You should now

- Understand the structure and assessment procedure of this course.
- Be able to summarise the postulates of Dalton’s Atomic theory, and put them into a modern context.
- Be able to recognise the components of a Mass Spectrometer, and know what it is used for.

- Do Assignment 1.

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**Next Lecture**

Nuclear and Radiation Chemistry

- Nucleons, nuclides and isotopes
- Nuclear fusion and stellar nucleogenesis
- Natural Radioactivity