

INTRODUCTION TO CHEMISTRY

Lecture 1



Dr Ewa Kazimierska

e.kazimierska@uwtsd.ac.uk

AIM OF THE CHEMISTRY ACDA 4011 MODULE

To develop an understanding of the basic chemistry and chemical mechanisms involved in the broad range of energetic and related materials used in OME



LEARNING OUTCOMES

Upon the successful completion of this module the student should be able to:

- Evaluate and communicate an understanding of reaction chemistry, the concept of fuels and oxidisers, oxygen balance, energy, heat flow and energy release
- Utilise data and information to formulate a plan that delivers the desired effect from an OME device



INDICATIVE CONTENT

- Atomic and molecular structures
 - Solid, liquids and gaseous state
 - Phase transformation
 - Bonding
- Chemical reactions
- Fuels, oxidising agents and related materials used in OME
- Physical and chemical mechanism and kinetics involved in OME
- Introduction to Materials Science
- Introduction to materials selection for OME devices
- OME effects
 - Flame, heat, light, sound and pressure effects



ASSESSMENT

There will be 6 graded quizzes

One lowest grade will be dropped

Each quiz contributing to the grade will be worth 10%

Written exam (2h) – 50%



(TENTATIVE) TIMETABLE

		Date	Session 1	Session 2
BLOCK 1	Week 1	9.02	Lecture 1: Introduction + energy	Lecture 2: Periodic table
		10.02	Lecture 3: Atomic structure	Problems on AS and PT
		11.02	Lecture 5: Molecular structure and bonding	Problems on MS and bonding
	Week 2	16.02	Review of last week material	Lecture 7: Stoichiometry 1: Moles
		17.02	TEST: Atomic structure, electronic configuration Lecture 8: Stoichiometry 2: Balancing Equations	Problems on moles and balancing equations
		18.02	TEST: Molecular structure, bonding Lecture 10: Solids and Liquids	Problems on Solids and Liquids
BLOCK 2	Week 3	23.03	REVIEW of Block 1 material	Lecture 12: Reactions
		24.03	TEST: Moles, balancing equations, concentration Lecture 13: Reactions, cnt	Problems on reactions
		25.03	TEST: States of Matter Lecture 15: Thermochemistry	Problems on thermochemistry/LABS
	Week 4	30.03	Review of last week material	Lecture 16: Thermochemistry, cnt
		31.03	TEST: Reactions, Lecture 17: Kinetics	Kinetics, cnt
		1.04	TEST: Thermochemistry Lecture 18: Equilibrium	Problems on Equilibrium

Electronic course notes will be provided in Moodle

Practice problems will be available



READING LIST

Module Code	ACDA4011	
Module Title	Chemistry (OME)	
Classification	Reading List entry	Electronic*
Essential	Akhavan, J. <i>The Chemistry of Explosives</i> (Royal Society of Chemistry, 2011).	☒
Further	Atkins, P. <i>Reactions – The private life of atoms</i> (Royal Society of Chemistry, 2013).	☒
Further	Hall, C. <i>Materials – A very short introduction</i> (Royal Society of Chemistry, 2014).	☐
Further	Wayne, R.P. <i>Chemical Instrumentation</i> (Oxford Chemistry Primers, RSC 1994).	☐
Further	Metcalfe, I.S. <i>Chemical Reaction Engineering – A first course</i> (Oxford Chemistry Primers, RSC 1997).	☐
Further	Lawrence, N. Wadhawan, J., Compton, R. <i>Foundations of Physical Chemistry: Worked Examples</i> (Oxford Chemistry Primers, RSC 1999)	☐
Further	Ritchie, G., Sivia, D.S. <i>Foundations of Physics for Chemists</i> (Oxford Chemistry Primers, RSC 2000).	☐
Further	Sivia, D.S., Rawlings, S.G. <i>Foundations of Science Mathematics</i> (Oxford Chemistry Primers, RSC 1999).	☐
Further	Winterton, R.H.S. <i>Heat Transfer</i> (Oxford Chemistry Primers, RSC 1997).	☐
Further	Brouard M. <i>Reaction Dynamics</i> (Oxford Chemistry Primers, RSC 1998)	☐



WHAT IS CHEMISTRY?

- **Dictionary.com**

- the science that deals with the composition and properties of substances and various elementary forms of matter.

Chemical properties, reactions, phenomena, etc.: *the chemistry of carbon.*

- the interaction of one personality with another: *The chemistry between him and his boss was all wrong.*
- sympathetic understanding; rapport: *the astonishing chemistry between the actors.*
- any or all of the elements that make up something: *the chemistry of love.*

- **Oxford English Dictionary**

- the branch of science concerned with the substances of which matter is composed, the investigation of their properties and reactions, and the use of such reactions to form new substances.



BRANCHES OF CHEMISTRY

- **Organic Chemistry**

- Studies the structure, properties and reactions of organic compounds, which contain carbon in covalent bonding
- Study of the structure determines their chemical composition and formula
- Study of properties includes physical and chemical properties and evaluation of chemical reactivity to understand their behaviour
- The study of organic reactions include the chemical synthesis of natural products, drugs, and polymers and study of individual organic molecules in the laboratory and via theoretical study

- **Inorganic chemistry**

- Study of materials from non-biological origins. Typically, this refers to materials not containing carbon-hydrogen bonds, including metals, salts minerals

- **Physical chemistry**

- Concerned with the application of the techniques and theories of physics to the study of chemical systems
- Thermodynamics, quantum theory, gas laws, etc



WHY DO POTENTIAL OME ENGINEERS NEED A KNOWLEDGE OF CHEMISTRY?

- How can we select the best material for a particular application?
- What makes materials perform in the way they do?

Metals and alloys: Aluminium, brass (bullet cases)

Iron (structural applications – why does it corrode?)

Why not use lighter metals (e.g. caesium)

- Non-metals: sulphur, oxygen, nitrogen, carbon, phosphorus
- Compounds: a collection of elements (cement, glass, minerals)
- Polymers – most based on carbon, why not Si or S?

All materials are made up of chemical elements in different proportions



Chemical properties control their behaviour



THIS MODULE

- Atomic and molecular structure
- Chemical reactions
- Fuels, oxidising agents and related materials used in OME
- Physical and chemical mechanisms and kinetics involved in OME
- Introduction to materials science
- Introduction to materials selection for OME devices

OME effects...Obtaining energy to do work !



CHEMICAL ENERGY

What is it?

How much of it can we get?

How easily can we get it?

How quickly will it all happen?



CHEMICAL ENERGY

Chemical energy is defined as the energy which is stored in the bonds of chemical compounds (molecules and atoms).

It is released in the chemical reaction and mostly produces heat as a by-product.

Typically, the material is converted into an entirely new substance once chemical energy has been released from a substance.

Energy is the property of objects which can be transferred to other objects or converted into different forms but cannot be created or destroyed.



**high energy material
(HEM)**



*compound that stores chemical energy
and which upon stimulation undergoes
rapid decomposition with release of energy and gas*



explosives



propellants



pyrotechnics



CHEMICAL ENERGY: KINETIC ENERGY

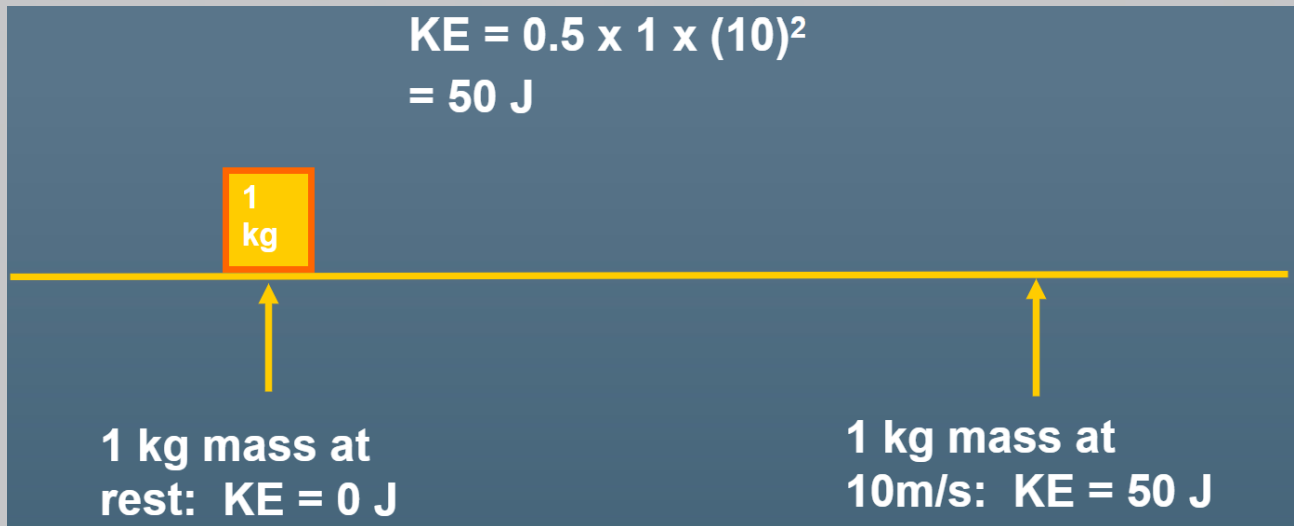
Kinetic energy is **a form of energy that an object or a particle has by reason of its motion.**

If work, which transfers energy, is done on an object by applying a net force, the object speeds up and thereby gains kinetic energy.

When electrons move from a higher energy level to a low energy state, they release kinetic energy.

$$E_K = \frac{1}{2}mv^2 \quad [J]$$

m – mass of the object (kg)
v – speed (m/s)



CHEMICAL ENERGY: POTENTIAL ENERGY

Potential energy is a stored energy that depends upon the relative position of various parts of a system.

The bonds that hold the atoms of molecules together have potential energy.

When electrons are excited they move to a higher energy level farther away from the centre and their potential energy increases

$$E_p = mgh \quad [\text{J}]$$

m – mass of the object (kg)

g – gravitational acceleration (m/s²)

h – height (m)



CHEMICAL ENERGY: ELECTRICAL ENERGY

Electrical energy is **the power an atom's charged particles have to cause an action or move an object**. The movement of electrons from one atom to another is what results in electrical energy.

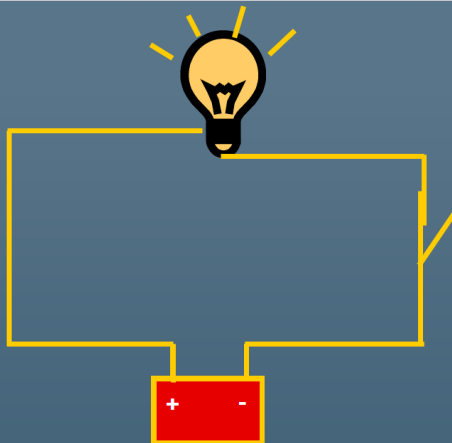
Using electrolysis, the chemical energy in a battery may also provide electrical fuel.

$$E = IVt \quad [\text{J}]$$

I – current (A)

V – potential difference (V)

t – time (s)



Electrical Energy over 10 s

$$= I \times T \times V$$

$$= 1 \times 10 \times 12$$

$$= 120 \text{ J}$$



CHEMICAL ENERGY: NUCLEAR ENERGY

Nuclear energy comes **from the binding energy that is stored in the centre of an atom and holds it together**. To release the energy, the atom has to be split into smaller atoms. This process is called fission.

Nuclear energy refers to the combined potential energy that binds nucleons (protons or neutrons) to form the atomic nucleus.

$$E = mc^2 \quad [\text{J}]$$

m – mass of the object (kg)

c – speed of light (3×10^8 m/s)

