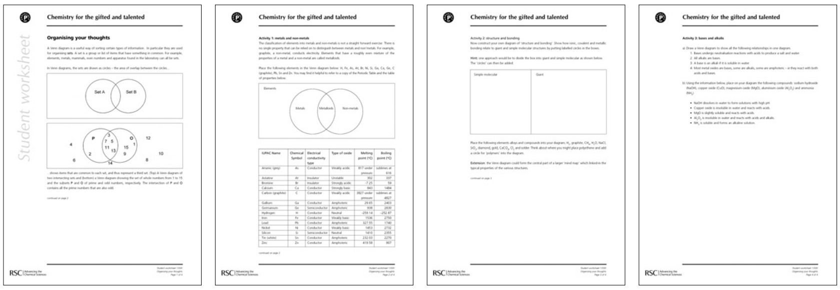
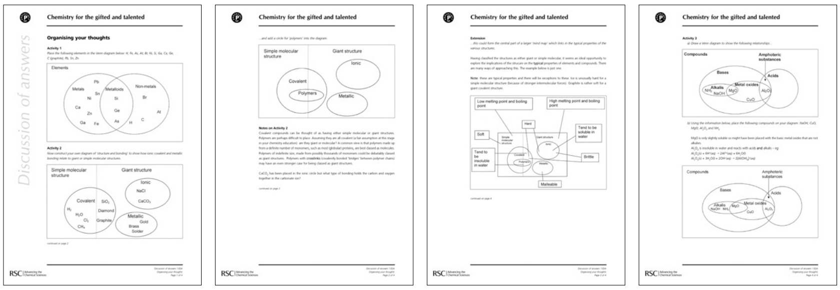
Organising your thoughts



Student worksheet: CDROM index 13SW



Discussion of answers: CDROM index 13DA

Topics

Activity 1: metals, metalloids and non-metals; Activity 2: structure and bonding; Activity 3: alkalis and bases.

Level

Able 14–16 year old students.

Prior knowledge

Activity 1: characteristics of metals; Activity 2: giant and molecular structures; Activity 3: pH.

Rationale

These activities are designed to help students clarify the relationship between various parts of their knowledge in these topics and develop the skill of using 'Venn'-like diagrams in organising their understanding. The Venn diagram is introduced with a simple mathematical example. Students then do three activities that progressively stretch their skills in the context of the chemical topics of: elements, structure and bonding and, finally, alkalis and bases.

Use

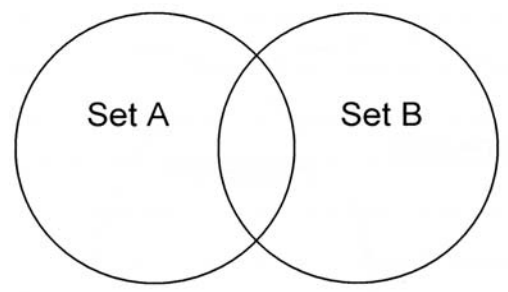
The worksheet was written for students to work through the introduction and all three activities in one go, but each of the three activities could be done separately (with the introduction if required) when those topics are most relevant in a student's course. Activity 2 suggests a concept map (or mind map/spider diagram) could be drawn flowing out from a central Venn diagram. This could be set as homework and the students given a sheet of A3 paper for adequate space to display their knowledge and understanding of the topic.

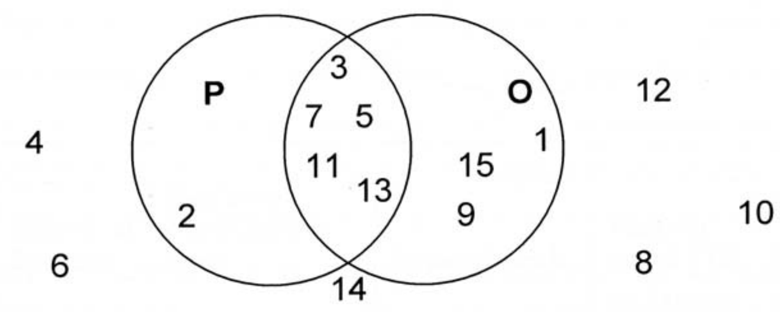
When the students have completed the worksheet they should be given the *Discussion of answers* sheet. They could check their own work or conduct a peer review of the work of another student or group.

Organising your thoughts

A Venn diagram is a useful way of sorting certain types of information. In particular they are used for organising **sets**. A set is a group or list of items that have something in common. For example, elements, metals, mammals, even numbers and apparatus found in the laboratory can all be sets.

In Venn diagrams, the sets are drawn as circles – the area of overlap between the circles...





...shows items that are common to each set, and thus represent a third set. (Top) A Venn diagram of two intersecting sets and (bottom) a Venn diagram showing the set of whole numbers from 1 to 15 and the subsets **P** and **O** of prime and odd numbers, respectively. The intersection of **P** and **O** contains all the prime numbers that are also odd.

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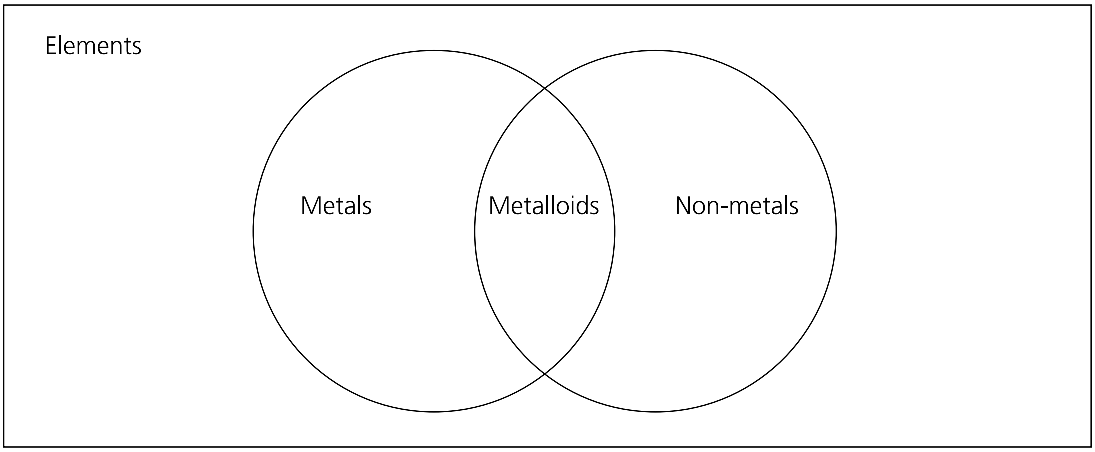
Activity 1: metals and non-metals

The classification of elements into metals and non-metals is not a straight forward exercise. There is no single property that can be relied on to distinguish between metals and non-metals. For example, graphite, a non-metal, conducts electricity. Elements that have a roughly even mixture of the properties of a metal and a non-metal are called metalloids.

Place the following elements in the Venn diagram below: H, Fe, As, At, Br, Ni, Si, Ga, Ca, Ge, C (graphite), Pb, Sn and Zn. You may find it helpful to refer to a copy of the Periodic Table and the table of properties below.



IUPAC Name	Chemical symbol	Electrical conductivity type	Type of oxide	Melting point (°C)	Boiling point (°C)
Arsenic (grey)	As	Conductor	Weakly acidic	817 under pressure	Sublimes at 616
Astatine	At	Insulator	Unstable	302	337
Bromine	Br	Insulator	Strongly acidic	-7.25	59
Calcium	Ca	Conductor	Strongly basic	843	1484
Carbon (graphite)	C	Conductor	Weakly acidic	3827 under pressure	Sublimes at 4827
Gallium	Ga	Conductor	Amphoteric	29.65	2403
Germanium	Ge	Semiconductor	Amphoteric	938	2830
Hydrogen	H	Conductor	Neutral	–259.14	–252.87
Iron	Fe	Conductor	Weakly basic	1536	2750
Lead	Pb	Conductor	Amphoteric	327.55	1740
Nickel	Ni	Conductor	Weakly basic	1453	2732
Silicon	Si	Semiconductor	Neutral	1410	2355
Tin (white)	Sn	Conductor	Amphoteric	232.03	2270
Zinc	Zn	Conductor	Amphoteric	419.58	907

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Activity 2: structure and bonding

Now construct your own diagram of 'structure and bonding'. Show how ionic, covalent and metallic bonding relate to giant and simple molecular structures by putting labelled circles in the boxes.

Hint: one approach would be to divide the box into giant and simple molecular as shown below. The 'circles' can then be added.

Simple molecular	Giant

Place the following elements, alloys and compounds into your diagram: H_2, graphite, CH_4, H_2O, NaCl, SiO_2, diamond, gold, $CaCO_3$, Cl_2 and solder. Think about where you might place polyethene and add a circle for 'polymers' into the diagram.

Extension: the Venn diagram could form the central part of a larger 'mind map' which linked in the typical properties of the various structures.

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Activity 3: bases and alkalis

a) Draw a Venn diagram to show all the following relationships in one diagram:

1. Bases and acids are compounds.
2. All alkalis are bases.
3. A base is an alkali if it is soluble in water.
4. Most metal oxides are bases, some are alkalis, some are amphoteric – *ie* they react with both acids and bases.

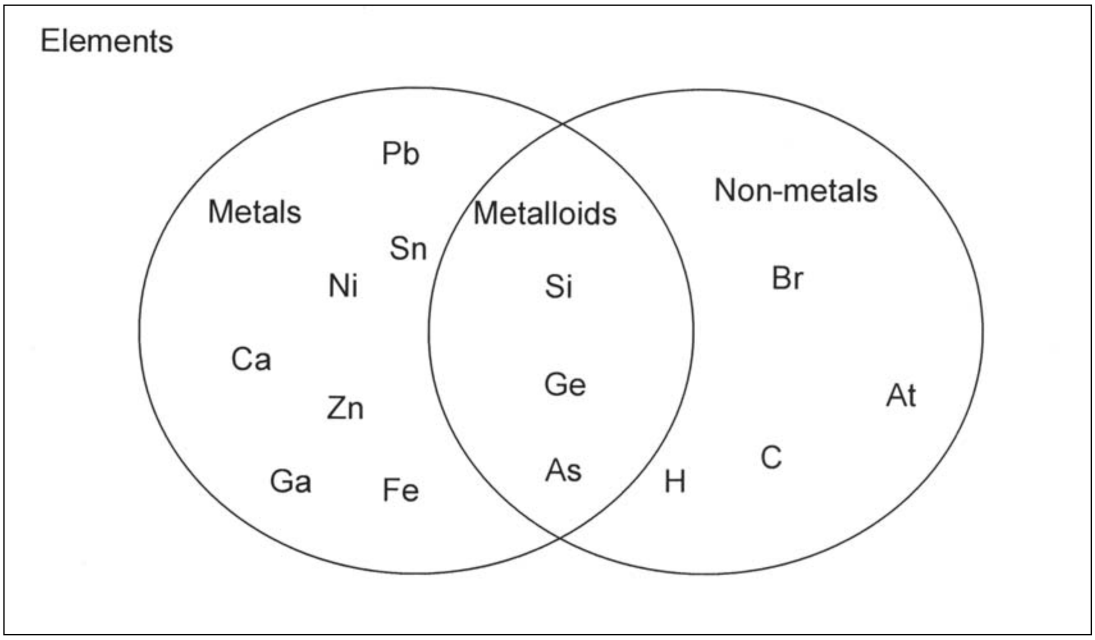
b) Using the information below, place on your diagram the following compounds: sodium hydroxide (NaOH), copper oxide (CuO), magnesium oxide (MgO), aluminium oxide (Al_2O_3) and ammonia (NH_3).

- NaOH dissolves in water to form solutions with high pH.
- CuO is insoluble in water and reacts with acids.
- MgO is slightly soluble and reacts with acids.
- Al_2O_3 is insoluble in water and reacts with acids and alkalis.
- NH_3 is soluble and forms an alkaline solution.

Organising your thoughts

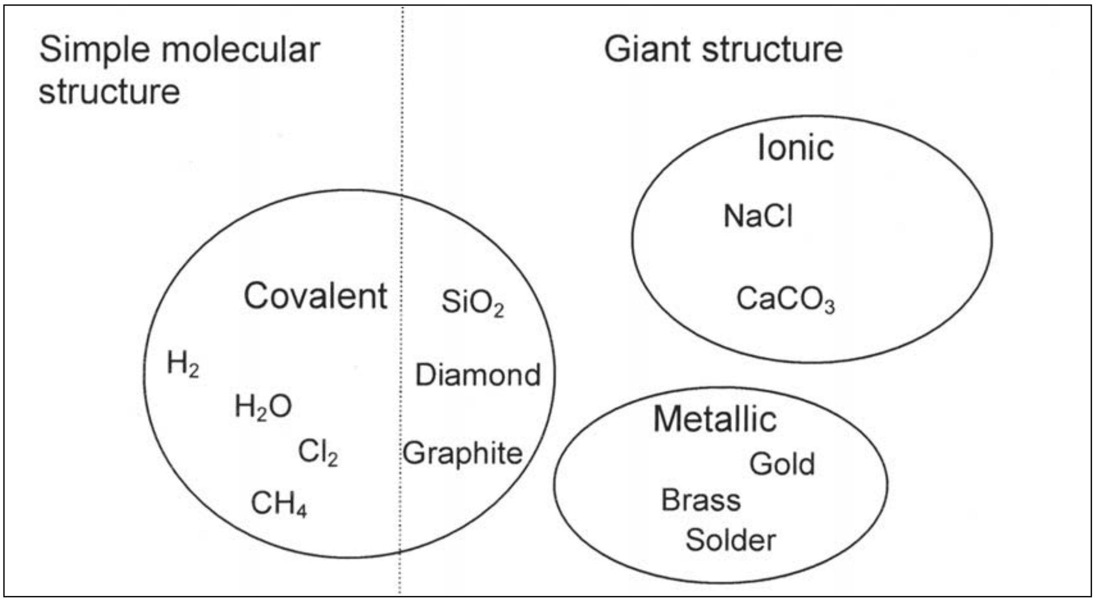
Activity 1

Place the following elements in the Venn diagram below: H, Fe, As, At, Br, Ni, Si, Ga, Ca, Ge, C (graphite), Pb, Sn, Zn.



Activity 2

Now construct your own diagram of 'structure and bonding' to show how ionic, covalent and metallic bonding relate to giant or simple molecular structures.



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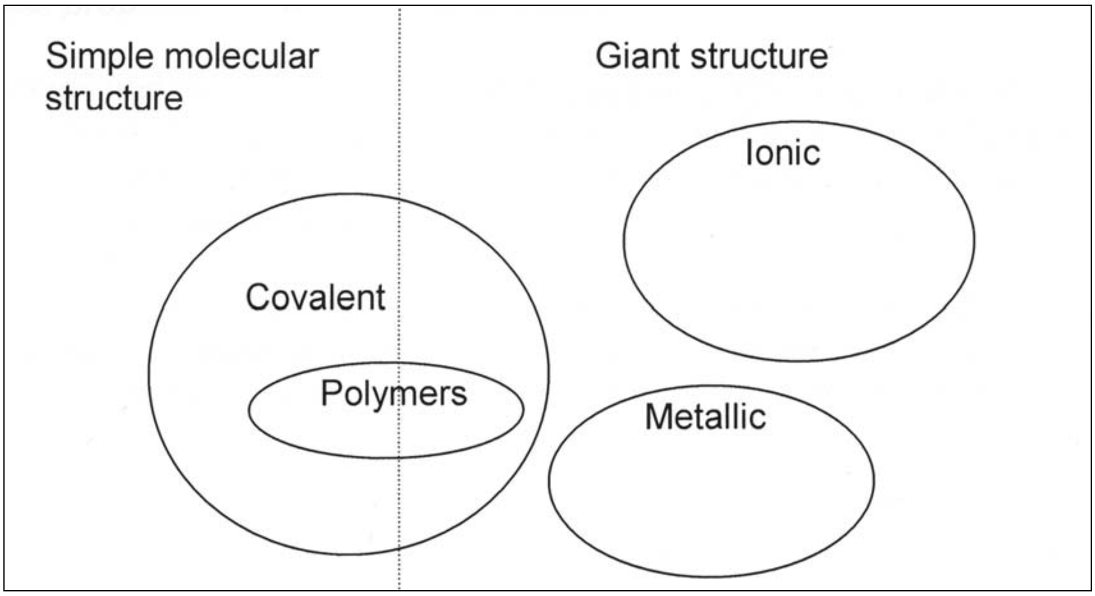
...and add a circle for 'polymers' into the diagram.



Notes on Activity 2

Covalent compounds can be thought of as having either simple molecular or giant structures. Polymers are perhaps difficult to place. Assuming they are all covalent (a fair assumption at this stage in your chemistry education), are they giant or molecular? A common view is that polymers made up from a definite number of monomers, such as most (globular) proteins, are best classed as molecules. Polymers of indefinite size, made from possibly thousands of monomers, could be debatably classed as giant structures. Polymers with **crosslinks** (covalently bonded 'bridges' between polymer chains) may have an even stronger case for being classed as giant structures.

$CaCO_3$ has been placed in the ionic circle but what type of bonding holds the carbon and oxygen together in the carbonate ion?

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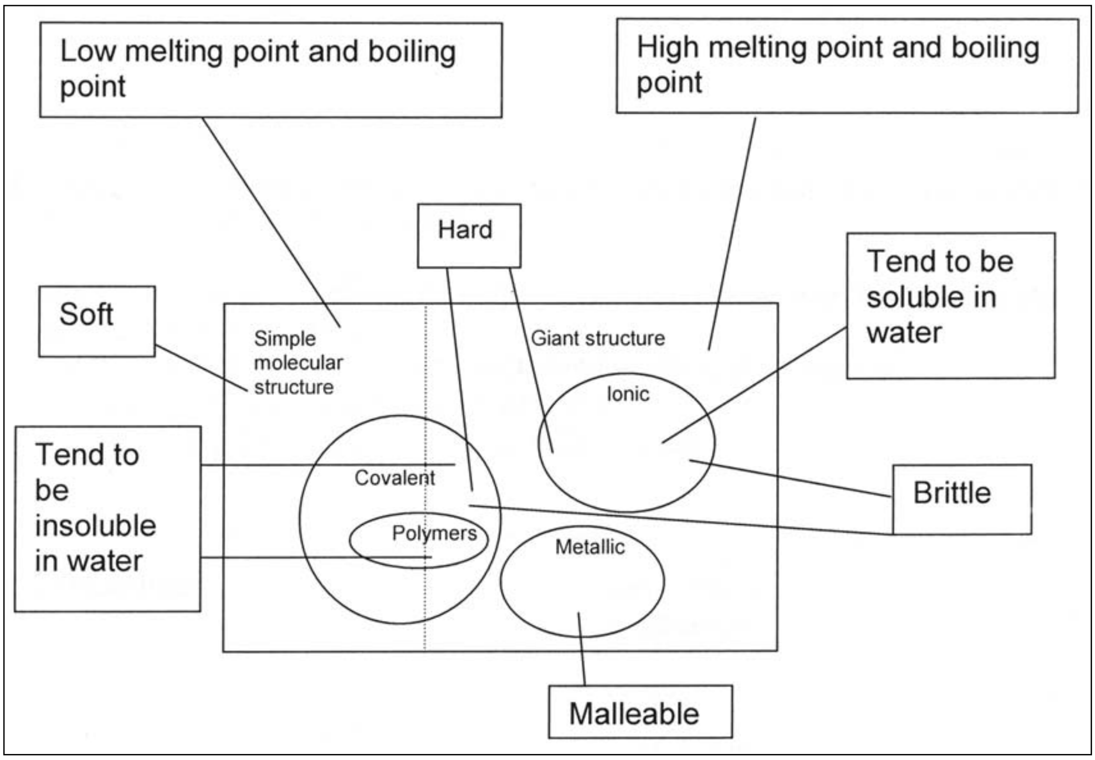
Extension

...this could form the central part of a larger 'mind map' which links in the typical properties of the various structures.

Having classified the structures as either giant or simple molecular, it seems an ideal opportunity to explore the implications of the strucure on the **typical** properties of elements and compounds. There are many ways of approaching this. The example below is just one.

Note: these are typical properties and there will be exceptions to these. Ice is unusually hard for a simple molecular structure (because of stronger intermolecular forces). Graphite is rather soft for a giant covalent structure.



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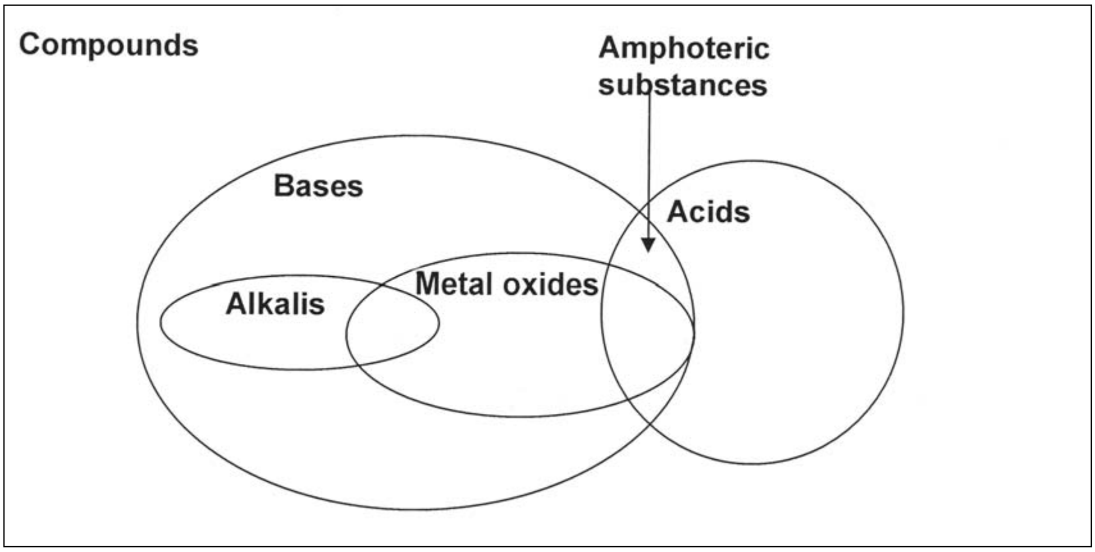
Activity 3

a) Draw a Venn diagram to show the following relationships...



b) Using the information below, place the following compounds on your diagram: NaOH, CuO, MgO, Al_2O_3 and NH_3.

MgO is only slightly soluble so might have been placed with the basic metal oxides that are not alkalis.

Al_2O_3 is insoluble in water and reacts with acids **and** alkalis – *eg*

$Al_2O_3(s) + 6H^+(aq) \rightarrow 2Al^{3+}(aq) + 3H_2O(l)$

$Al_2O_3(s) + 3H_2O(l) + 2OH^-(aq) \rightarrow 2[Al(OH)_4]^-(aq)$