Module 1: The Chemical Earth

Further exercises

For pages 8–9

A1. Some samples of air are homogeneous while others are heterogeneous. Explain how this is possible.

A2. **(a)** Can a mixture be homogeneous? If so give an example. Explain fully.
(b) Can a pure substance be heterogeneous? If so give an example. Explain fully.

A3. When some silvery aluminium turnings were mixed with powdered yellow sulfur and the mixture heated, a white homogeneous solid formed. On cooling it remained as a white solid. When heated again, it underwent no apparent change. When the experiment was repeated several times using different masses of aluminium turnings and sulfur, the white solid always contained 36% aluminium. Is the white solid a mixture or a compound? Explain why.

For pages s 15 and 18–19

Some of the exercises in this set require techniques described in the Supplementary Material section above.

B1. Brandy (about 40% ethanol) is made by distilling wine (12 to 14% ethanol). In such a distillation is the brandy the distillate or is it the liquid left in the distillation flask? Explain. If you distilled some brandy, would the distillate contain a higher or lower percentage of ethanol than the original brandy? Explain.

B2.2. A student accidentally poured an aqueous solution of silver nitrate into a bottle of kerosene. How would you recover the aqueous solution?

B3. When air (after removal of moisture and carbon dioxide and impurities) is cooled to –210^{o}C, a homogeneous liquid mixture (solution) of nitrogen and oxygen forms. If this mixture is slowly warmed until it starts to boil, what would you expect the vapour formed to be – pure oxygen, pure nitrogen, or a mixture? If a mixture how would its composition compare with that of the liquid? How could you obtain a sample of one pure substance from the original liquid and what substance would it be? Again use Table1.8 on page 23 to answer this question. Note that there should be minus signs in front of the boiling points of oxygen, nitrogen and hydrogen, that is –183, –196 and –253^{o}C.

B4. In a school laboratory a new supply of small lead pellets was accidentally put into a jar containing iron filings. How would you separate the lead from the iron? More than one way may be possible.

B5. How would you separate a mixture of **(a)** sand and iodine (neither has a significant solubility in water) **(b)** sodium chloride and ammonium chloride (both are soluble in water).

B6. When a solution of ammonia was added to a solution of copper sulfate, the resulting mixture had an intense dark blue colour. When a solution of sodium hydroxide was added to a solution of copper sulfate, the resulting mixture had a pale blue milky appearance. Both mixtures remained unchanged for many minutes. Then both mixtures were centrifuged. The deep blue mixture remained unaltered, but the pale blue one separated into a clear solution and a pale blue solid at the bottom of the centrifuge tube. Which, if either, of the original mixtures was heterogeneous and which, if either, was a solution? Explain why.

B7. How would you separate a mixture of carbon, iodine and ammonium chloride. Ammonium chloride is readily soluble in water but insoluble in hexane; iodine is readily soluble in hexane but only slightly soluble in water while carbon is insoluble in both solvents.

For page 22

C1. **(a)** At room temperature (20^{o}C), which of the substances in Table 1.7 on page 21 are **(i)** solid **(ii)** liquid **(iii)** gas?

(b) Which if any of these substances would undergo a change of state if the temperature was **(i)** lowered to –2^{o}C **(ii)** raised to 100^{o}C?

For page 23

D1. To determine the density of lead a pair of students took some lead shot (pellets), determined their mass then poured them into a burette containing some water. They noted the reading on the burette before and after adding the lead pellets. Use their results below to determine the density of lead.

Mass of lead pellets taken = 142.6 g

Initial reading of the burette = 34.7 mL

Burette reading after adding the lead shot = 22.2 mL

D2. Explain how you would determine the density of a fine gold chain (necklace). How could you use your answer to decide whether the chain was solid gold or just gold plated copper. You may use data in Table 4.4 on page 104.

For page 25

E1. Each tablet of the Alka Seltzer shown in the photo on page 24 contains
324 mg aspirin, 1.9 g sodium bicarbonate and 1.05 g citric acid. Calculate the per cent composition of this mixture.

E2. To determine the composition of bagged dry concrete mix (crushed rock, sand, cement), a pair of students used a set of shop scales to weigh out a sample of the mixture (3.23 kg). They then used a coarse sieve to separate out the crushed rock (aggregate) then weighed the separated rock (1.85 kg). They then used a fine sieve to separate the sand from the cement. Using laboratory scales they found that the sand has a mass of 910 g and the cement 420 g. Determine the percentage composition of the dry concrete mix.

E3. In Exercise E2 above why do you think the sum of the masses of the separated components was less than the starting mass? Suggest another source of error in this experiment. How would it affect the results? How could the experiment be modified to give more accurate results?

E4. Chalcocite is a mineral of copper (not a common one in Australia). It is a compound containing copper and sulfur. When carefully heated in air black chalcocite decomposes to reddish brown copper (with the sulfur vaporising as sulfur dioxide). A 2.36 g sample of chalcocite formed 1.89 g copper. Calculate the percentage copper in chalcocite.

E5. Brass is an alloy (solid solution) of copper and zinc. To determine the composition of a sample of brass filings a chemist mixed 1.72 g of the filings with warm hydrochloric acid; this dissolved the zinc but left the copper unaffected. After complete reaction (no further evolution of gas) the remaining solid was filtered off and weighed: it had a mass of 0.92 g. Calculate the percentage copper in that particular brass.

E6. The experiment in Exercise E5 was repeated on three other samples of brass. Use the results below to show that brass is a mixture and not a compound.

Mass of sample used (g)	1.38	2.04	1.87
Mass of copper left (g)	0.81	1.00	1.05

There are no F *exercises*

For page 39

G1. Molecular formulae for some everyday substances are given below.
- **(a)** How many atoms of each type are present in a molecule of each of these substances?
- **(b)** What is the total number of atoms in each of these molecules?
  - **(i)** boracic acid or boric acid (disinfectant), $B(OH)_3$
  - **(ii)** acetic (ethanoic acid) (in vinegar), CH_3COOH
  - **(iii)** urea (common nitrogenous fertiliser), $CO(NH_2)_2$
  - **(iv)** ascorbic acid (Vitamin C), $C_6H_4O_2(OH)_4$

G2. Write molecular formulae for the compounds below. The number of each type of atom present in the molecule is given:
- **(a)** Refrigerant 134a (currently used in air conditioners); 2 carbon, 2 hydrogen and 4 fluorine atoms
- **(b)** Cysteine, on of the essential amino acids; 3 carbon, 7 hydrogen, 2 oxygen 1 sulfur and 1 nitrogen atoms
- **(c)** peroxyacetyl nitrate, a constituent of photochemical smog; 2 carbon, 3 hydrogen, 1 nitrogen and 4 oxygen atoms

For pages 42–3 and 45

H1. What are the atomic and mass numbers of the element in which the atoms contain
- **(a)** 14 protons and 15 neutrons
- **(b)** 42 neutrons and 33 electrons
- **(c)** 22 neutrons and 18 protons
- **(d)** 12 electrons and 12 neutrons

Name, and give the symbol for, each of these four elements.

H2. Two atoms each have 12 protons in the nucleus: one has 12 neutrons while the other has 13. How many electrons do each of these atoms contain? Do these two atoms belong to the same or different elements? Explain.

H3. Using Figure 2.9(b) on page 53 as a guide, give the electron configuration of the following elements (atomic number in brackets): Sr (38), Zr (40), Tc (43), Sb (51), Xe (54).

H4. Give the electron configuration of O, S, Se and Te for which the atomic numbers are 8, 16, 34 and 52. What common feature is there about these four configurations?

For page 49

J1. Write down the electron configurations of elements having atomic numbers 9, 3, 12, 18, 15, 4, 20, 30, 13, 36, 6, 16. State which group of the Periodic Table each belongs to.

J2. Use the Periodic Table to predict how many electrons there are in the outermost energy level (shell) of the following atoms:
barium, bromine, gallium, arsenic, caesium, selenium

J3. We often talk about the electron configuration of monatomic ions. To obtain the electron configuration of an ion, we start with the configuration of the atom and add or subtract the necessary number of electrons to form the ion. We add electrons to the next available positions in the energy levels and we remove them from the highest energy level (last in, first out!). Hence give the electron configuration of the following, taking atomic numbers from the Periodic Table if necessary

(a) potassium atom, potassium ion
(b) fluorine atom, fluoride ion
(c) aluminium atom, aluminium ion
(d) sulfur atom, sulfide ion

J4. **(a)** Write down the electron configuration of the members of each of the following sets of atoms and ions:
(i) O^{2-}, F^{-}, Ne, Na^{+}, Mg^{2+}
(ii) S^{2-}, Cl^{-}, Ar, K^{+}, Ca^{2+}
(b) What do all five species in each set have in common? Why is this so?

For pages 52 and 56

K1. Draw diagrams similar to those in Examples 1 and 2 on pages 50–1 to show the formation of ionic bonds involving
(a) lithium and bromine
(b) magnesium and sulfur
(c) sodium and oxygen

K2. Using a Periodic Table, deduce the electron configuration of, and the charge on, the ions you would expect to be formed by:
(a) strontium
(b) iodine
(c) rubidium
(d) selenium

K3. Draw electron dot diagrams and give the molecular formulae for covalent molecules formed between
(a) chlorine and iodine
(b) hydrogen and sulfur
(c) phosphorus and fluorine

K4. Hydrogen and nitrogen are able to form the negative hydride and nitride ions respectively. Draw electron dot structures for these two ions, showing clearly the charge on each. Sodium can form both a hydride and a nitride; what formulae do you expect for these compounds?

K5. Which of the following compounds would you expect to be ionic? Explain why, and draw electron dot diagrams of the ions present, and give the formulae of the compounds:
(a) magnesium chloride
(b) sulfur dichloride
(f) boron trifluoride
(g) calcium chloride

(c) barium oxide
(d) nitrogen triiodide
(e) sodium sulfide
(h) potassium iodide
(i) oxygen fluoride
(j) iodine chloride

K6. Which of the compounds in Exercise K5 would you expect to be covalent? Draw electron-dot diagrams for them and give their molecular formulae.

For pages 59 and 63

L1. Arsenic tribromide and magnesium bromide are white solids at room temperature. The solids melt at 31°C and 711°C respectively. As liquids, magnesium bromide conducts electricity while arsenic tribromide does not. Explain the difference in melting points and conductivities in terms of the bonding in the two substances.

L2. Tungsten carbide (carborundum) is an extremely hard substance (comparable to diamond) with a very high melting point, 2870°C. it does not conduct electricity and is insoluble in all common solvents. What do you conclude about its structure?

L3. Tin forms two distinct compounds with chlorine, $SnCl_2$ and $SnCl_4$. $SnCl_2$ is a solid at room temperature while $SnCl_4$ is a liquid. The melting point of $SnCl_2$ is 247°C and the boiling point of $SnCl_4$ is 113°C. Liquid $SnCl_2$ conducts electricity while liquid $SnCl_4$ does not.

(a) What do you conclude about the bonding in $SnCl_2$ and $SnCl_4$? Give your reasoning.

(b) For any ionic compound(s) state what ions you expect to be present. For any covalent compound(s) draw an electron-dot diagram. Again give reasons for your conclusions.

L4. Use the Periodic Table to answer the following:

(a) Sodium chloride, oxide, fluoride and sulfide have the formulae, NaCl, Na_2O, NaF, Na_2S. What do you expect to be the formulae of:
(i) rubidium chloride and oxide,
(ii) caesium fluoride and sulfide?

(b) Sodium reacts with water to form hydrogen gas. Name three other elements you would expect to react with water to form hydrogen.

(c) Magnesium and calcium form chlorides, $MgCl_2$ and $CaCl_2$. What compounds do you expect fluorine, bromine and iodine to form with magnesium and calcium?

(d) Fluorine forms with carbon the compound carbon tetrafluoride, CF_4. What compounds do you expect chlorine and bromine to form with carbon?

(e) Oxygen and nitrogen with hydrogen form the compounds, water, H_2O and NH_3 respectively. Give the formulae you would expect for the compounds formed between sulfur and hydrogen and between phosphorus and hydrogen.

L5. Some properties of six substances that are solids at room temperature are listed below. Which (if any) of these would you consider to be a **(a)** metals **(b)** ionic lattices **(c)** covalent molecular substances **(d)** covalent lattices? Give your reasons for each.

	Melting point (°C)	Does it conduct electricity?		Other properties
		as a solid	as a liquid	
L	63	yes	yes	soft and malleable
M	44	no	no	soft and crumbly
N	2990	no	no	extremely hard

P	2045	no	yes	very hard
Q	725	yes	yes	hard but can be rolled into sheets
R	373	no	yes	moderately hard but can be ground into a powder

For pages 70 and 75

M1. 1.00 g of a pale blue solid was heated strongly in a crucible open to the atmosphere; it changed to a black solid which weighed 0.64 g. After being allowed cool down and stand on the bench for several hours, there was no further change in the appearance or mass of the black solid. Explain why there has been a decrease in mass. Is this a chemical or physical change? Why? Was the original pale blue solid an element or a compound? Explain why.

M2. **(a)** Classify the italicised substances mentioned in the passage below as mixtures, elements or compounds. In many cases the information in the passage will help you with the classification.

(b) Identify three chemical and three physical changes in the passage and give your reasons for so identifying them.

Aluninium is a substance in widespread use today in building materials, aircraft construction and household utensils. Aluminium is obtained from *bauxite* a red brown granular material composed of variable amounts of *aluminium oxide*, *iron oxide* and silicaceous material (dirt). The bauxite is ground up very finely then treated with hot concentrated *sodium hydroxide solution*. This reacts with the aluminium oxide to form a *solution of sodium aluminate*. The insoluble iron oxide and dirt are filtered off and disposed of as *red mud*. Aluminium oxide is recovered by cooling the sodium aluminate solution to precipitate out *aluminium hydroxide* which is filtered off and heated to form *aluminium oxide*.
The pure white aluminium oxide known as alumina is then sent to an aluminium smelter where an electric current is passed through a molten mixture of alumina and *cryolite* a substance containing sodium, aluminium and fluorine in fixed proportions. This process, called electrolysis, breaks the aluminium oxide into aluminium and oxygen. However rather than forming oxygen gas the electrolysis causes the oxygen to combine with the *graphite* of the electrode to form *carbon dioxide*.
The sodium aluminate mentioned above is also formed onaluminium utensils cleaned in automatic dishwashers. *Dishwashing powder* contains variable amounts of detergent, bleaches and *sodium hydroxide*. The latter substance attacks aluminium to form the aluminate which discolours the utensils.

For pages 79 and 82

N1. Name the following compounds:

(a) SO_3 **(b)** MgH_2 **(c)** Li_2S **(d)** As_2O_3
(e) CF_4 **(f)** Al_2O_3 **(g)** CuS **(h)** NO_2
(i) S_2Cl_2 **(j)** $FeCl_3$ **(k)** Cl_2O_7 **(l)** $Zn(OH)_2$

N2. Write the formulae of the following compounds:

(a) **(i)** potassium oxide
(ii) dichlorine trioxide
(iii) antimony pentafluoride
(iv) aluminium hydroxide
(v) silver oxide
(vii) diphosphorus trisulfide
(viii) iron(III) sulfide
(ix) silicon tetrabromide
(x) iron(II) chloride
(xi) magnesium hydride

(vi) iodine trichloride

(xii) sulfur hexafluoride

(b) **(i)** magnesium nitrate

(ii) silver carbonate

(iii) ammonium sulfate

(iv) iron(III) sulfate

(v) aluminium phosphate

(vi) lead(IV) chloride