STUDENT BOOK ANSWERS

Chapter 1: The periodic table and trends

1.1 SECTION REVIEW

REMEMBERING

1 A substance made from one type of atom only

2 Mendeleev originally listed the elements in order of atomic mass and grouped them into rows and columns according to their properties. In the contemporary periodic table, the elements are now listed in order of atomic number.

3 A group is a vertical column of elements and a period is a horizontal row.

4 Group 1: alkali metals. Group 2: alkaline earth metals. Group 17: halogens. Group 18: noble gases.

UNDERSTANDING

5 The symbols for some elements are derived from their original name, which was not in English. The original Latin name for mercury was hydrargyrum, hence 'Hg'. The original name for tungsten was 'wolfram', derived from Swedish word for the metal, hence 'W'.

APPLYING

6 Na: sodium, Cl: chlorine and O: oxygen

7 Any group of three elements in a vertical column; for example, O, S and Se or B, Al and Ga

ANALYSING

8 Magnesium would react with chlorine to form magnesium chloride. This is because beryllium is in group 2, like magnesium, and chlorine in group 17, like fluorine. Therefore, the reactions would be very similar. Magnesium is below beryllium in group 2, therefore it is more reactive. Chlorine is lower than fluorine group 17, so it is less reactive. Therefore, it is not initially clear whether the overall reaction would be more or less vigorous.

9 Helium, neon, krypton, xenon and radon

10 Germanium

1.2 SECTION REVIEW

REMEMBERING

1 **a** Two

b Seven

c Five

d One

e Eight

2 The energy required to remove an electron from a gaseous atom

UNDERSTANDING

3 **a** 1

b 4

c 1

4 Lithium, because atomic radius decreases across the period

APPLYING

5 **a** Oxygen

b Beryllium

c Fluorine

d Carbon

ANALYSING

6 There is a greater number of protons in nucleus, so attraction between nucleus and electrons is greater. Thus, as you move from left to right across the period, the atomic radius decreases.

7 Although chlorine has more protons in the nucleus and is further to the right on the periodic table than oxygen, oxygen has one fewer electron shell than chlorine so its attraction for the external electrons is stronger, thus its electronegativity is greater.

1.3 SECTION REVIEW

REMEMBERING

1 An element that has some of the properties of both a metal and a non-metal

2 Metallic character decreases from left to right across the periodic table.

3 They react with water to form an alkaline solution.

UNDERSTANDING

4 It does not conduct electricity, it does not conduct heat, and it is not shiny.

5 Less vigorous: the reactivity of group 1 elements increases down the group, as the ionisation energy decreases and electrons can be more easily removed

APPLYING

6 They all have one electron in their valence shell and so lose that electron to form a positive ion

ANALYSING

7 Fluorine is to the right of the periodic table, which means it has a large number of protons in the nucleus and has only two electron shells. Therefore, there is a very strong attraction to external electrons.

8 Ionisation energy decreases down the periodic table. Group 1 elements react by losing their single valence electron and, so this is done more easily, there are a greater number of electron shells in the atoms. Thus, group 1 reactivity increases down the table.

However, group 17 reactivity decreases down the table, the reverse trend to ionisation energy. This is because the halogens react by gaining an additional electron rather than losing one.

ANALYSING

9 Magnesium is less reactive than sodium. It is further to the right in the periodic table, thus is more electronegative, with a higher ionisation energy. Therefore, it requires more energy to lose an electron, which means it reacts more slowly than sodium.

10 Tennessine will have a melting point and boiling point greater than iodine and astatine – a boiling point of possibly 300°C. It will therefore be a solid at room temperature and is unlikely to vaporise. It is likely to be toxic. It may well be coloured and may possibly be a metalloid, with some slightly conductive properties, as the metallic character increases down Group 17.

1.4 SECTION REVIEW

REMEMBERING

1 An oxide that reacts with both acid and alkaline solutions

2 As we move from left to right, the oxides become less acidic and more alkaline

UNDERSTANDING

3 Because it reacts with acid solutions and not with alkaline solutions and also dissolves sparingly in water to produce an alkaline solution

APPLYING

4 **a** Ionic

b Covalent

c Covalent

5 **a** Alkaline

b Acidic

c Acidic

ANALYSING

6 There is a greater proportion of alkaline oxides in period 4 than in period 3, because there are more metals – the transition metals are included in period 4. Therefore, the assumption is that they would form alkaline oxides.

CHAPTER REVIEW QUESTIONS

DETAIL QUESTIONS

1 **a** A sour-tasting substance that dissolves in water to produce a solution of low pH (dissociates in water, releasing hydrogen ions)

b An element in group 1 of the periodic table

c A substance that dissolves in water to produces a solution of high pH, which reacts with an acid solution

d A substance that reacts with both acids and bases

e The distance from the centre of the nucleus of an atom to the outermost electron shell

f The tendency for an atom to attract electrons from within a covalent bond

g A substance that is made from one type of atom only

h The amount of energy required to remove an electron from a gaseous atom

i A vertical column of elements in the periodic table

j An element in group 17 of the periodic table

k A substance that is shiny, malleable and conducts electricity when solid

l A substance that shows some of the properties of a metal, such as very low electrical conductivity when solid

m An element in group 18 of the periodic table

n A row of elements in the periodic table

o The section of the periodic table from groups 3–12, which consists of metals

p The number of other atoms that an atom tends to bond with

CATEGORY QUESTIONS

2 Elements are arranged in order of increasing atomic number. Elements with the same number of valence electrons are arrange in vertical columns.

3 **a** Increases, because the number of electron shells increases

b Decreases, because the nucleus gets further away from outermost electron shells

c Decreases, because attraction of nucleus to valence electrons becomes less as the atomic radius increases

4 **a** Decreases as nuclear charge increases and outer electrons are attracted more strongly to the nucleus

b Increases as nuclear charge increases and external electrons are attracted more strongly

c Increases as nuclear charge increases and electrons are more tightly bound to the atom

5 Sodium, magnesium and aluminium oxides are ionic substances with high melting points. Silicon dioxide is a covalent network with a very high melting point. Phosphorus, sulfur and chlorine oxides are small molecular substances with low melting points.

6 Sodium, magnesium and aluminium oxides are alkaline oxides. Silicon dioxide is amphoteric. Phosphorus, sulfur and chlorine oxides are acidic oxides.

ELABORATION QUESTIONS

7 Answers will vary. Elements 113, 115, 117 and 118 were named in 2016, so these may be good topics for research.

8 Electronegativity increases up and from left to right across the periodic table, so the relative position of two elements can be used to determine relative electronegativity.

EVIDENCE QUESTIONS

9 Electron shielding is the effect of inner electron shells experiencing the attraction of the nucleus to a greater extent than outer electron shells. Therefore, as the number of electron shells increases down a group of the periodic table, the atomic radius increases as the atom expands, and the first ionisation energy decreases, as the outer electrons are less tightly bound to the nucleus.

As we move across the periodic table, the atomic radius decreases, as there is no additional shielding of the outer electrons, so the increased nuclear charge causes the valence shell to be more strongly attracted to the nucleus. Therefore, the atom contracts. The first ionisation energy increases, again, as the valence electrons are more tightly bound to the atom, so require more energy to be removed.

10 The elements that he predicted the discovery of, and which were not known during his time, have indeed been discovered, largely with the properties he predicted.

Also, the grouping of elements in order of atomic number, rather than atomic mass, justifies Mendeleev's decision to swap the order of some elements, so that grouping them by properties took precedence over the atomic mass order.

11 Moseley looked at the interaction of X-rays with atoms. From the scattering patterns he observed, he could assign atomic numbers to elements, rather than atomic mass. As such, he could confirm that there were no additional elements with an atomic number less than 92 still to be discovered.

END-OF-CHAPTER EXAM

1 A **2** D

3 B **4** D

5 C

6 Greater attraction of the nucleus as number of protons increases, and no additional shielding of new electron shells, therefore outer electrons are harder to remove

7 Li, O, K, Ba

8

Radius of the K atom	>	Radius of the K^+ ion
Number of valence electrons in a Ca atom	=	Number of valence electrons in a Ba atom
Radius of an oxygen atom	<	Radius of a sulfur atom

9 a The ability of an atom to attract electrons (1) from within a covalent bond(1)

b Fluorine, element number 9

c
- Relatively high nuclear charge given the small size of the atom, as it is to the right of the period
- Only two shells of electrons with little shielding, as it is at the top of the table
- Strong attractiveness to external electrons

d Data selected from three atoms in the same group, such as He, Ne, Ar, or Li, Na, K. Increased number of electron shells down the group. Decreased attraction of nucleus to external electrons due to greater shielding from the inner shells.

e The atoms with lowest electronegativity are group 18 elements (noble gases). The next noble gas will be Kr. Difference in atomic number between the noble gases increases due to the greater size of the third shell.

10a–b Up to four of the following points, (or similar) should be made:

- Mendeleev listed the elements in order of atomic number.
- He noticed that elements with the same properties reoccurred at regular intervals, although there were some apparent exceptions to this rule.
- Mendeleev was prepared to leave gaps if necessary, so that the elements lined up in columns where the elements in each column had very similar properties. He surmised that this meant that there were yet undiscovered elements.
- Mendeleev was also prepared to swap the order of some elements, according to the properties, even if this contradicted the order of increasing atomic mass.
- Mendeleev identified the patterns and trends in the existing elements and could extrapolate and interpolate as necessary to predict the properties of elements yet to be discovered according to their position on the periodic table.
- The table shows that Mendeleev's predictions were accurate and that the elements that were discovered after his death did have the properties he had predicted.