Skills, knowledge and understanding for the course assessment

The following provides details of skills, knowledge and understanding sampled in the course assessment:

1 Chemical changes and structure

(a) Rates of reaction

1 To follow the progress of chemical reactions, changes in mass, volume and other quantities can be measured. Graphs can then be drawn and be interpreted in terms of:

- end-point of a reaction
- quantity of product
- quantity of reactant used
- effect of changing conditions

2 Rates of reaction can be increased:

a) ♦ by increasing the temperature
b) ♦ by increasing the concentration of a reactant
c) ♦ by increasing surface area/decreasing particle size
d) ♦ through the use of a catalyst

3 Catalysts are substances that speed up chemical reactions but can be recovered chemically unchanged at the end of the reaction.

4 The average rate of a chemical reaction can be calculated, with appropriate units, using the equation:

$$rate = \frac{\Delta quantity}{\Delta t}$$

5 The rate of a reaction can be shown to decrease over time by calculating the average rate at different stages of the reaction.

(b) Atomic structure and bonding related to properties of materials

(i) Periodic table and atoms

6 Elements in the periodic table are arranged in order of increasing atomic number.

7 The periodic table can be used to determine whether an element is a metal or non-metal.

8 Groups are columns in the periodic table containing elements with the same number of outer electrons, indicated by the group number.

9 Elements within a group share the same valency and have similar chemical properties because they have the same number of electrons in their outer energy levels.

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10	The electron arrangement of the first 20 elements can be written.
11	An atom has a nucleus, containing protons and neutrons, and electrons that orbit the nucleus.
12	Protons have a charge of one-positive, neutrons are neutral and electrons have a charge of one-negative. Protons and neutrons have an approximate mass of one atomic mass unit and electrons, in comparison, have virtually no mass.
13	The number of protons in an atom is given by the atomic number.
14	In a neutral atom the number of electrons is equal to the number of protons.
15	The mass number of an atom is equal to the number of protons added to the number of neutrons.
16	Isotopes are defined as atoms with the same atomic number but different mass numbers, or as atoms with the same number of protons but different numbers of neutrons.
17	Nuclide notation is used to show the atomic number, mass number (and charge) of atoms (ions) from which the number of protons, electrons and neutrons can be determined.
18	Most elements have two or more isotopes. The average atomic mass has been calculated for each element using the mass and proportion of each isotope present. These values are known as relative atomic masses.
	(ii) Covalent bonding
19	Covalent bonds form between non-metal atoms.
20	A covalent bond forms when two positive nuclei are held together by their common attraction for a shared pair of electrons.
21	Diagrams can be drawn to show how outer electrons are shared to form the covalent bond(s) in a molecule.
22	7 elements exist as diatomic molecules through the formation of covalent bonds: H_2, N_2, O_2, F_2, Cl_2, Br_2, I_2.
23	The shape of simple covalent molecules depends on the number of bonds and the orientation of these bonds around the central atom. These molecules can be described as linear, angular, trigonal pyramidal or tetrahedral.
24	More than one bond can be formed between atoms leading to double and triple covalent bonds.
25	Covalent substances can form either discrete molecular or giant network structures.

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26 Covalent molecular substances:

- have strong covalent bonds within the molecules and only weak attractions between the molecules
- have low melting and boiling points as only weak forces of attraction between the molecules are broken when a substance changes state
- do not conduct electricity because they do not have charged particles which are free to move

27 Covalent molecular substances which are insoluble in water may dissolve in other solvents.

28 Covalent network structures:

- have a network of strong covalent bonds within one giant structure
- have very high melting and boiling points because the network of strong covalent bonds is not easily broken
- do not dissolve

29 In general, covalent network substances do not conduct electricity. This is because they do not have charged particles which are free to move.

(iii) Ionic compounds

30 Ions are formed when atoms lose or gain electrons to obtain the stable electron arrangement of a noble gas.

31 In general, metal atoms lose electrons forming positive ions and non-metal atoms gain electrons forming negative ions.

32 Ion-electron equations can be written to show the formation of ions through loss or gain of electrons.

33 Ionic bonds are the electrostatic attraction between positive and negative ions.

34 Ionic compounds form lattice structures of oppositely charged ions with each positive ion surrounded by negative ions and each negative ion surrounded by positive ions.

35 Ionic compounds have high melting and boiling points because strong ionic bonds must be broken in order to break up the lattice.

36 Many ionic compounds are soluble in water. As they dissolve the lattice structure breaks up allowing water molecules to surround the separated ions.

37 Ionic compounds conduct electricity only when molten or in solution as the lattice structure breaks up allowing the ions to be free to move.

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38 Conduction in ionic compounds can be explained by the movement of ions towards oppositely charged electrodes.

(c) Formulae and reacting quantities

(i) Chemical formulae

39 Compound names are derived from the names of the elements from which they are formed. Most compounds with a name ending in '-ide' contain the two elements indicated. The ending '-ite' or '-ate' indicates that oxygen is also present.

40 Chemical formulae can be written for two element compounds using valency rules and a periodic table.

41 Roman numerals can be used, in the name of a compound, to indicate the valency of an element.

42 The chemical formula can also be determined from names with prefixes.

43 The chemical formula of a covalent molecular substance gives the number of each type of atom present in a molecule.

44 The formula of a covalent network gives the simplest ratio of each type of atom in the substance.

45 Ions containing more than one type of atom are often referred to as group ions.

46 Chemical formulae can be written for compounds containing group ions using valency rules and the data booklet.

47 Ionic formulae give the simplest ratio of each type of ion in the substance and can show the charges on each ion, if required.

48 In formulae, charges must be superscript and numbers of atoms/ions must be subscript.

(ii) Calculations involving the mole and balanced equations

49 Chemical equations, using formulae and state symbols, can be written and balanced.

50 The mass of a mole of any substance, in grams (g), is equal to the gram formula mass and can be calculated using relative atomic masses.

51 Calculations can be performed using the relationship between the mass and the number of moles of a substance.

52 A solution is formed when a solute is dissolved in a solvent.

53 For solutions, the mass of solute (grams or g), the number of moles of solute (moles or mol), the volume of solution (litres or l) or the concentration of the solution (moles per litre or mol l^{-1}) can be calculated from data provided.

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54 Given a balanced equation, the mass or number of moles of a substance can be calculated given the mass or number of moles of another substance in the reaction.

(iii) Percentage composition

55 The percentage composition of an element in any compound can be calculated from the formula of the compound.

(d) Acids and bases

(i) pH

56 The pH scale is an indication of the hydrogen ion concentration and runs from below 0 to above 14.

57 A neutral solution has equal concentrations of $H^+(aq)$ and $OH^-(aq)$ ions.

58 Water is neutral as it dissociates according to the equation

$H_2O(\ell) \rightleftharpoons H^+(aq) + OH^-(aq)$

producing equal concentrations of hydrogen and hydroxide ions. At any time, only a few water molecules are dissociated into free ions.

59 The $\rightleftharpoons$ symbol indicates that a reaction is reversible and occurs in both directions.

60 Acidic solutions have a higher concentration of $H^+(aq)$ ions than $OH^-(aq)$ and have a pH below 7.

61 Alkaline solutions have a higher concentration of $OH^-(aq)$ ions than $H^+(aq)$ ions and have a pH above 7.

62 Dilution of an acidic solution with water will decrease the concentration of $H^+(aq)$ and the pH will increase towards 7.

63 Dilution of an alkaline solution with water will decrease the concentration of $OH^-(aq)$ and the pH will decrease towards 7.

64 Soluble non-metal oxides dissolve in water forming acidic solutions.

65 Soluble metal oxides dissolve in water to form alkaline solutions:

metal oxide + water → metal hydroxide

66 Metal oxides, metal hydroxides, metal carbonates and ammonia neutralise acids and are called bases. Those bases that dissolve in water form alkaline solutions.

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(ii) Neutralisation reactions

67 A neutralisation reaction is one in which a base reacts with an acid to form water. A salt is also formed in this reaction.

68 Equations can be written for the following neutralisation reactions:

a) a metal oxide + an acid → a salt + water
b) a metal hydroxide + an acid → a salt + water
c) a metal carbonate + an acid → a salt + water + carbon dioxide

69 The name of the salt produced depends on the acid and base used. Hydrochloric acid produces chlorides, sulfuric acid produces sulfates and nitric acid produces nitrates.

70 Spectator ions are ions that remain unchanged by the reaction.

71 Reaction equations can be used to identify spectator ions.

72 For neutralisation reactions, equations can be written omitting spectator ions:

$2H^+(aq) + O^{2-}(s)$	→	$H_2O(\ell)$	for metal oxides
$H^+(aq) + OH^-(aq)$	→	$H_2O(\ell)$	for metal hydroxides
$2H^+(aq) + CO_3^{2-}(aq)$	→	$H_2O(\ell) + CO_2(g)$	for aqueous metal carbonates
$2H^+(aq) + CO_3^{2-}(s)$	→	$H_2O(\ell) + CO_2(g)$	for insoluble metal carbonates

73 In an acid-base titration, the concentration of the acid or base is determined by accurately measuring the volumes used in the neutralisation reaction. An indicator can be added to show the end-point of the reaction.

74 Given a balanced equation for the reaction occurring in any titration:

- the concentration of one reactant can be calculated given the concentration of the other reactant and the volumes of both solutions
- the volume of one reactant can be calculated given the volume of the other reactant and the concentrations of both solutions

(iii) Neutralisation reactions can be used to prepare soluble salts

75 Titration can be used to produce a soluble salt. Once the volumes of acid and alkali have been noted, the reaction can be repeated without the indicator to produce an uncontaminated salt solution. The solution can then be evaporated to dryness.

76 Insoluble metal carbonates and insoluble metal oxides can be used to produce soluble salts. Excess base is added to the appropriate acid, the mixture is filtered and the filtrate evaporated to dryness.