UNIT 1 MATTER AND QUALITATIVE ANALYSIS

ARE YOU READY?

(Pages 2–3)

Knowledge and Understanding

1. (a) physical, quantitative
   (b) physical, quantitative
   (c) physical, qualitative
   (d) chemical
   (e) chemical
2. (a) Physical change: water molecules are changing state from liquid to gas. There is no change in the structure of the water molecule.
   (b) Chemical change: propane reacts with oxygen in the air to form carbon dioxide and water.
   (c) Chemical change: the iron is now rust (iron oxide)—a new substance has been formed.
   (d) Chemical change: the molecules found in the apple have reacted, producing different molecules. The change is irreversible: new substances have been formed.
   (e) Physical change: the sugar molecules have not undergone any chemical rearrangement in the tea. If the water from the tea is evaporated, the sugar molecules could be recovered along with the tea molecules.
   (f) Chemical change: the molecules in the egg have reacted, forming new molecules. The change is irreversible.
   (g) Physical change: the butter has changed state from solid to liquid, but the atoms within the butter molecules have not been rearranged.
   (h) Chemical change: the molecules in the wood react with oxygen in the air to form new substances, such as carbon dioxide, carbon monoxide, water, and ash. The change is irreversible.
   (i) Physical change: the copper molecules have not reacted to form a new substance.
   (j) Chemical change: the molecules that make up the candle have formed new substances. The change is irreversible.
   (k) Physical change: the water molecules found in snow have changed state from solid to liquid.
3. (a) malleability
   (b) conductivity
   (c) density
   (d) melting point
   (e) hardness
4. (a) Elements and compounds are pure substances. Elements are composed of only one type of atom (e.g., O_2, Cu, Pb) and cannot be broken down further into simple substances using chemical means. Compounds are composed of more than one type of atom in fixed ratios (e.g., H_2O, NaCl).
   (b) The solute and the solvent are the components of a solution. The solvent is the part of a solution that is in greater quantity, while the solute is the component in lesser quantity. The solute dissolves in the solvent. Air is an example of a solution. The solvent in air is nitrogen gas because it comprises 78% of the air solution. Oxygen, one of the solutes found in air, comprises approximately 21% of the air solution. Other solutes found in air include argon gas and carbon dioxide.
   (c) A mechanical mixture and a solution are types of mixtures with variable compositions. A mechanical mixture has more than one phase and is therefore heterogeneous. A pizza is an example of a mechanical mixture. A solution is a mixture that is homogeneous to the naked eye. Salt water is an example of a solution.
   (d) The term “homogeneous” describes a mixture in which the components are uniformly distributed. There is only one phase in a homogeneous mixture. Windshield washer fluid is an example of a homogeneous mixture. The term “heterogeneous” describes a mixture in which the components are not uniformly distributed. Italian salad dressing is an example of a heterogeneous mixture because you can distinguish between the oil, vinegar, oregano, and other herbs.
   (e) Protons and neutrons are both subatomic particles found in the nucleus of an atom. A proton carries a positive charge, whereas a neutron carries zero charge.

(f) In general, metals have the following physical properties: they are lustrous, ductile, malleable, and they conduct electricity. They are found on the left side of the periodic table. Copper is an example of a metal. Nonmetals, found on the right side of the periodic table, are brittle, that is, they break or shatter under mechanical stress. In addition, they are poor conductors of heat and electricity. Sulfur is an example of a nonmetal.

(g) An atom is the smallest particle of an element. A molecule is an entity composed of two or more atoms held together by covalent bonds. For example, an oxygen molecule is composed of two oxygen atoms (O_2), bonded together covalently.

(h) The atomic number is the number of protons in the nucleus of an atom. Each element has a different atomic number. The mass number is the number of protons and neutrons found in the nucleus of an atom. For example, helium has an atomic number of 2 and a mass number of 4. Therefore, helium contains two protons and two neutrons in its nucleus.

(i) A pure substance is composed of only one type of atom or molecule. For example, table salt, NaCl, is a pure substance because it is always composed of sodium ions and chloride ions in a 1:1 ratio. A mixture is composed of more than one type of pure substance in variable composition. Salt water is a mixture because different quantities of salt can be dissolved in water.

5. (a) element
   (b) compound
   (c) compound
   (d) mixture made up of two elements
   (e) mixture made up of two elements
   (f) mixture made up of two elements and one compound
   (g) mixture made up of one element and two compounds
   (h) mixture made up of one element and one compound

6.

Particle	Relative mass	Relative charge	Location within atom
proton	1	1+	nucleus
electron	0	1–	orbiting the nucleus
neutron	1	zero charge	nucleus

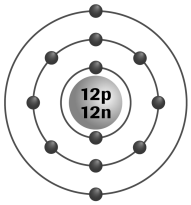
7. (a) fluorine, chlorine, bromine, iodine, astatine
   (b) lithium, sodium, potassium, rubidium, cesium, francium
   (c) helium, neon, argon, krypton, xenon, radon
   (d) beryllium, magnesium, calcium, strontium, barium, radium

8.

Chemical name	Chemical symbol	Atomic number	Number of protons	Number of neutrons	Mass number	Number of electrons
helium	He	2	2	2	4	2
sulfur	S	16	16	16	32	16
oxygen	O	8	8	8	16	8
neon	Ne	10	10	10	20	10
potassium	K	19	19	20	39	19

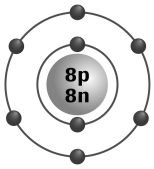
9. (a) calcium
   (b) oxygen
   (c) sodium
   (d) chlorine

10. (a)



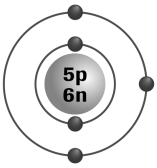
magnesium

(e)



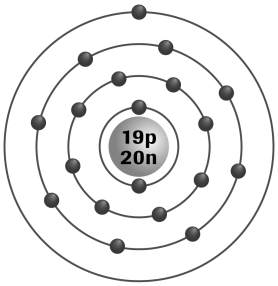
oxygen

(b)



boron

(d)



potassium

(c)

helium

11. (a) The elements in column A are metals.
    (b) The elements in column B are nonmetals.
    (c) calcium oxide, CaO; potassium fluoride, KF; aluminum nitride, AlN

Inquiry and Communication

12. Student answers will vary.
    (a) The individual components of this mixture can be separated from each other by using knowledge of their different physical properties. Sand and iron filings are solid, whereas rubbing alcohol and water are both liquids. This mixture can be passed through filter paper. The sand and iron filings will remain in the filter paper, and the alcohol–water mixture will pass through it. The water that remains mixed with the sand and iron filings will eventually evaporate. Since iron filings are magnetic, whereas sand is not, the iron filings can be separated from the sand using a magnet. For the remaining two components, rubbing alcohol has a lower boiling point than water. When the water–alcohol mixture is heated, the rubbing alcohol will evaporate first, leaving behind water.
    (b) mixture, magnet, paper towel, filter paper, large beaker, distillation apparatus, funnel, ring clamp, retort stand , Bunsen burner, 10-mL graduated cylinder, round-bottomed flask
    (c) **Procedure**

Part A: Removal of Sand and Iron Filings from Liquid

1. Pour the mixture through the filter paper. Collect the liquid flowing through the filter paper into a large beaker.
2. Remove the sand and iron filings from the filter paper onto a paper towel.
3. Pour the collected liquid through the filter paper a second time. Collect any additional sand and iron filings caught in the filter paper and add it to the pile on the paper towel. Allow the pile to dry.

Part B: Removal of Iron Filings

4. Use a magnet to collect the iron filings from the pile of sand and iron filings on the paper towel.
5. Using your fingers, sweep off the filings from the magnet onto another paper towel.
6. Repeat steps 4 and 5 until all the iron filings have been separated from the sand.

Part C: Separation of Alcohol and Water

7. Pour the liquid from the large beaker into a round-bottomed flask.
8. Turn on the water tap so that the condenser tube in the distillation apparatus has water running within its outer walls.
9. Light the Bunsen burner and place it under the round-bottomed flask.
10. When the temperature reaches approximately 78°C, the alcohol will start to boil. At this temperature, the distillate is alcohol.
11. Collect the distillate at the end of the condenser tube into a 10-mL graduated cylinder.
12. Stop collecting the distillate when the temperature has reached 82°C.

13. Distribute the gas into three test tubes. To determine whether the gas is hydrogen, invert the first test tube and place a burning splint just inside its mouth. If you hear a popping sound, the gas is hydrogen. To determine whether the gas is oxygen, invert the second test tube and place a glowing splint just inside its mouth. If the splint ignites, the gas is oxygen. To determine whether the gas is carbon dioxide, pour limewater into the third test tube. If a white precipitate forms, the gas is carbon dioxide.

Technical Skills and Safety

14. (a) This action is unsafe. The student may cut herself with the broken glass through the paper towel. The broken glass may be coated with toxic or corrosive chemicals. Also, the student may not be able to collect all the pieces of broken glass with a paper towel, leaving behind an unsafe work area for other students. The student should have obtained a brush and dustpan from the teacher to collect the broken glass. The broken glass should have been placed in the container designated "Broken Glass" in the classroom.
    (b) This action is unsafe. Rubbing one's eyes does not remove the chemical, but further distributes it and allows it to be further absorbed by the eye, resulting in more irritation and damage. The student should have proceeded immediately to the eye wash station and flushed the eye with water for 10 min.
    (c) This action is safe.
    (d) This action is unsafe. The substances ingested may be poisonous. No chemicals should ever be ingested in a chemistry laboratory.
15. (a) compressed gas
    (b) flammable and combustible materials
    (c) corrosive materials

GETTING STARTED

TRY THIS ACTIVITY: AN INTRODUCTION TO QUALITATIVE ANALYSIS

(Page 7)

(a) Depending on the type of ink used, the banding pattern will vary. One possible colour pattern of bands, moving up the chalk, is blue, brown, red/orange, and yellow. If the steps were repeated using the same black ink and a similar piece of chalk, the pattern of colour would be identical. It would only vary in terms of distance between bands, which depends on how long the chalk was allowed to sit in the water.
(b) As the black ink moved up the chalk, it separated into its component colours.
(c) The separation distances between the bands vary.
(d) The most soluble ink molecules are yellow in colour and the least soluble ink molecules are blue in colour. An experiment that could be conducted to test this hypothesis is to obtain one yellow marker, one blue marker, and two pieces of chalk. One piece of chalk could be used to separate the components of yellow ink, while the second piece of chalk could be used to separate the components of blue ink. The chalk would be identical and the test would be conducted at the same time. The distance travelled up the chalk by each colour of ink would be recorded. If chromatography is based only on size of molecules, the yellow ink should travel farther up the chalk than the blue ink in the same amount of time.
(e) The observations are very similar to the prediction made in (a). The prediction is therefore valid.
(f) An advantage of this separation method is that it is quick, easy to set up, and produces qualitative results. Some disadvantages are that the colour separation is not definitive, and that it is difficult to quantify the results.