15. Students are to research the composition and design of safety matches and produce a poster.

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UNIT 1 REVIEW

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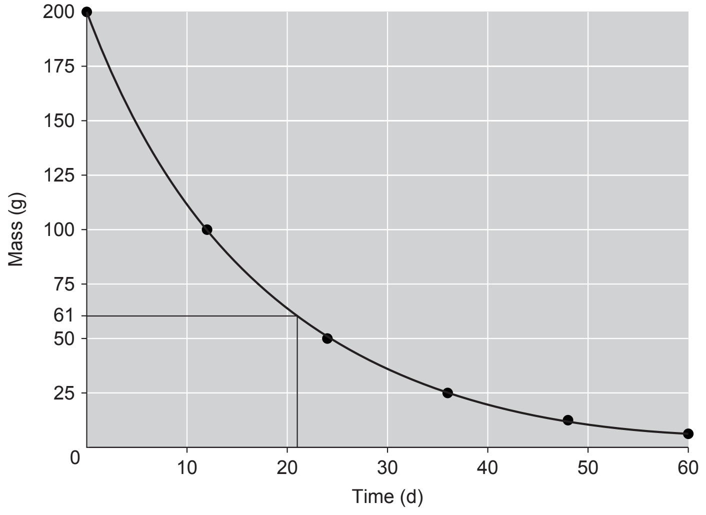
Understanding Concepts

1. (a) iodine-127: p = 53; e = 53; n = 74 (127 − 53)
   (b) phosphorus-32: p = 15; e = 15; n = 17 (32 − 15)
   (c) Cu-64 (copper-64): p = 29; e = 29; n = 35 (64 − 29)
   (d) Hg-203 (mercury-203): p = 80; e = 80; n = 123 (203 − 80)
2. Comparison of Radiation

	mass	speed	charge
alpha particles	4u	relatively low	2+
beta particles	very small	high	1-
gamma rays	none (for now)	speed of light	0

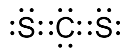
3.

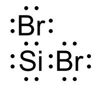


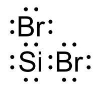
4. (a) Bromine and fluorine each have seven electrons in their outer shell.
   (b) After the removal of the first electron, the nuclear charge has not been reduced, but the number of electrons has been. The pull of the nucleus on the remaining valence electron should be stronger. As a result it will take more energy to remove the second electron.
   (c) In order to achieve a full octet (full outer shell of electrons), oxygen must gain two electrons, producing the O^{2-} ion.
   (d) Argon has a full outer shell of electrons, which is a very stable arrangement.
   (e) Fluorine requires one electron to reach a stable octet and it has few electrons shielding the charge of the nucleus. As a result it has a high electron affinity.
5. The phenomenon of radioactivity indicated that atoms could change, i.e., that Dalton's model of an indivisible, ball-like atom was flawed. That radiation often consisted of charged particles (alpha and beta) indicated that the atom had positive and negative components.
6. (a) mercury; transition metal
   (b) halogen
   (c) alkali metal
   (d) alkaline earth metal
   (e) halogen
   (f) noble gas

7. (a) Metals are shiny, tend to be malleable, and conduct electricity well; nonmetals tend to be dull, brittle, and not conduct electricity.
   (b) With pH paper or litmus paper.
   (c) Elements will not decompose under heating; compounds will. Compounds may be highly soluble in water, elements are not.
   (d) Ionic compounds are often highly soluble in water, and when dissolved conduct electricity. Among molecular compounds, only acids have these properties; however, an acid will also turn blue litmus paper red in solution. Ionic compounds, when heated to melting, form a liquid that conducts electricity; molecular compounds do not.
8. (a) The rubidium ion (Rb^{+}) will have the greater radius (ion radius chart, p. 52 of text).
   (b) The sulfur ion (S^{2-}) will have the greater radius.
   (c) The calcium atom will have the greater radius.
   (d) The magnesium atom will have the greater radius.
9. (a) magnesium (Rb = 0.8; Mg = 1.2)
   (b) fluorine (B = 2.0; F = 4.0)
10. 8(a) rubidium vs. sodium: same family; more shells of electrons and more shielding should result in a larger ion.
    8(b) sulfur vs. sodium: the sulfur ion, by acquiring two more electrons, fills a shell. Because of repulsion between the electrons, the ion is larger than the atom. The sodium ion has lost an electron that was in a higher shell; its electrons are all now in the lower shell and drawn more strongly by the nucleus, resulting in an ion that is smaller than the atom.
    8(c) calcium vs. magnesium atoms: the two elements are in the same family, but calcium has one more electron shell.
    8(d) magnesium vs. phosphorus atoms: the elements are in the same period, and there is a trend to smaller atoms from left to right as electrons are added. Valence electrons are in the same shell, but exposed to increased nuclear charge.
    9(a) magnesium vs. rubidium: there is a trend to decreased electronegativity from the top of groups 1 and 2 toward the bottom. This is a result of shielding by added shells of electrons. There is also a trend to decreased electronegativity from right to left, as the larger atoms have a lower electron affinity (the outer valence electron is farther from the nucleus; a new electron would be equally far, and so electronegativity is lower). As magnesium is both above rubidium and to its right in the periodic table, the atom should have a greater electronegativity.
11. (a) In metals, the lower the first ionization energy (and so the easier to remove an electron), the more reactive the metal should be, as metals become positive ions to form ionic compounds.

    In nonmetals, the higher the first ionization energy (and so the easier to add an electron), the more reactive the nonmetal should be, as nonmetals become negative ions to form ionic compounds.
    (b) Atoms with low first ionization energies can be stripped of the first electron easily, making it easier for the atom to form a cation and therefore to react with an atom of high first ionization energy to form an ionic compound. Atoms with high first ionization energies will not give up an electron easily, and so will tend to form anions and ionic compounds with atoms of low first ionization energy. Atoms with more equal first ionization energies will not be able to "take" electrons from each other, and so must share, in a covalent bond.
12. Lithium oxide is an ionic compound; the bonding in nitrogen dioxide is covalent. The ions in lithium oxide will form a crystal lattice that is stable at room temperature, as each of the negative ions is attracted to surrounding positive ions, and vice versa. The molecules of nitrogen dioxide are attracted to each other only by van der Waals forces (London). Lithium oxide would be expected to be an electrolyte and highly soluble in water, whereas the solubility of nitrogen dioxide would be expected to be low.
13. (a) carbon sulfide, molecular
    (b) silicon bromide, molecular
    (c) magnesium chloride, ionic
    (d) sulfur trioxide, molecular
    (e) lithium oxide, ionic

14. 





15. Although there is a difference in charge within the molecule (the chlorine atoms being slightly more negative), the chlorine atoms are evenly distributed, so there is no positive or negative “end” of the molecule, so it is nonpolar.

16. (a) iron(II) oxide
    (b) mercury(II) iodide
    (c) tin(II) sulfide
    (d) antimony(V) chloride
    (e) iron(III) sulfate
    (f) calcium carbonate
    (g) copper(II) sulfate pentahydrate
    (h) potassium permanganate
    (i) dinitrogen oxide
    (j) boron fluoride

17. (a) $Cu(NO_3)_{2(s)}$
    (b) $MgCO_{3(s)}$
    (c) $BO_{3(g)}$
    (d) $ZnCl_{2(s)}$
    (e) $NaOH_{(s)}$
    (f) $Zn(ClO)_{2(s)}$
    (g) $NH_4Cl_{(s)}$
    (h) $H_2S_{(g)}$
    (i) $HBr_{(aq)}$
    (j) $SO_{2(g)}$

18. (a) $2\ ZnCO_{3(s)} \rightarrow 2\ Zn_{(s)} + 2\ CO_{2(g)} + O_{2(g)}$
    (b) $Li_{(s)} + H_2O_{(l)} \rightarrow H_{2(g)} + LiOH_{(aq)}$
    (c) $2\ Ca_{(s)} + O_{2(g)} \rightarrow 2\ CaO_{(s)}$
    (d) $Pb(NO_3)_{2(aq)} + 2\ NaCl_{(aq)} \rightarrow 2\ NaNO_{3(aq)} + PbCl_{2(s)}$
    (e) $Sn_{(s)} + 2\ Cl_{2(g)} \rightarrow SnCl_{4(s)}$
    (f) $Zn_{(s)} + 2\ HCl_{(aq)} \rightarrow H_{2(g)} + ZnCl_{2(aq)}$
    (g) $2\ NaOH_{(aq)} + H_2SO_{4(aq)} \rightarrow Na_2SO_{4(aq)} + 2\ H_2O_{(l)}$
    (h) $BaCl_{2(aq)} + K_2SO_{4(aq)} \rightarrow BaSO_{4(s)} + 2\ KCl_{(aq)}$
    (i) $CH_{4(g)} + 2\ O_{2(g)} \rightarrow CO_{2(g)} + 2\ H_2O_{(l)}$
    (j) $C_6H_{12}O_{6(l)} + 6\ O_{2(g)} \rightarrow 6\ CO_{2(g)} + 6\ H_2O_{(l)}$

19. (a) $2\ Al_{(s)} + 6\ H_2O_{(aq)} \rightarrow 3\ H_{2(g)} + 2\ Al(OH)_{3(s)}$
    (b) $Ni_{(s)} + 2\ HCl_{(aq)} \rightarrow H_{2(g)} + NiCl_{2(s)}$
    (c) $(NH_4)_2CO_{3(s)} + CaCl_{2(aq)} \rightarrow 2\ NH_4Cl_{(aq)} + CaCO_{3(s)}$
    (d) $Ca(NO_3)_{2(aq)} + Na_2SO_{4(aq)} \rightarrow 2\ NaNO_{3(aq)} + CaSO_{4(s)}$
    (e) $I_{2(s)} + HCl_{(aq)} \rightarrow NR$
    (f) $Sn_{(s)} + 4\ H_2O_{(l)} \rightarrow 2\ H_{2(g)} + Sn(OH)_{4(aq)}$
    (g) $2\ Fe_{(s)} + 6\ H_2O_{(l)} \rightarrow 3\ H_{2(g)} + 2\ Fe(OH)_{3(aq)}$
    (h) $Ba(OH)_{2(aq)} + NaNO_{3(aq)} \rightarrow NR$
    (i) $CuSO_{4(aq)} + NaNO_{3(aq)} \rightarrow NR$

20. 18(a): decomposition
    18(b): single displacement
    18(c): synthesis (combustion)
    18(d): double displacement

18(e): synthesis
18(f): single displacement
18(g): neutralization (double displacement)
18(h): double displacement
18(i): combustion
18(j): combustion
19(a): single displacement
19(b): single displacement
19(c): double displacement
19(d): double displacement
19(e): single displacement
19(f): single displacement

21. 18(d), lead(II) chloride
18(h), barium sulfate
19(d), calcium sulfate

Applying Inquiry Skills

22. If the two elements are in the same group (Group 1), they will have similar properties and react with various chemicals in a similar way.

Procedure

1. Observe the physical properties of the elements by:
   (a) Cutting off a small sample and observing the cut face. (Expecting the cut to be easy because the metal is soft, and the cut area to be at first shiny and then rapidly form an oxide layer.)
   (b) Measuring electrical conductance of a sample. (Expecting to measure conductance.)
   (c) Slowly heating samples of each element in an airless container until they melt. (Expecting a low melting point.)
1. Place a small quantity of X and an equal quantity of Y in a test tube containing a small amount of water. If any gas is released, test it with a glowing splint. (Hydrogen expected from both.)
2. When the reaction (if any) is complete, test the solution with blue litmus paper. (Expecting it to turn pink.)
3. When the reaction (if any) is complete, test the solution for conductance of electricity. (Expecting to find that the solution conducts.)
4. Place a small quantity of X and an equal quantity of Y in a test tube containing a small amount of dilute hydrochloric acid. If any gas is released, test it with a glowing splint. (Hydrogen expected from both.)

23. (a) Epsom salts → solid + water
(b) It is probably an ionic hydrate. When heated, hydrates decompose to release water.

24. (a) The formation of bubbles, which appear to be oxygen gas based on the test, are evidence of a chemical change. The changing of the cobalt paper in filtrate is not evidence, as the same test was not conducted before adding the manganese dioxide.
(b) Hydrogen peroxide:

$$2\ H_2O_{2(l)} \rightarrow O_{2(g)} + 2\ H_2O_{(l)}$$

(c) It has acted as a catalyst: it has returned unchanged.

25. (a) Is the sample calcium carbonate?

Analysis

(b) It acted as expected if it is calcium carbonate, which has low solubility in water. This test eliminates a large number of ionic compounds.
(c) The substance may contain calcium, but could also contain lithium or strontium.
(d) The substance decomposes when heated to form carbon dioxide and probably an ionic compound (steps 5, 6), which indicates that it is a carbonate, perhaps:
$CaCO_{3(s)} \rightarrow CO_{2(g)} + CaO_{(s)}$
and reacts slowly with dilute hydrochloric acid to produce carbonic acid, which decomposes to form carbon dioxide (step 3).
$CaCO_{3(s)} + 2\ HCl_{(aq)} \rightarrow H_2CO_{3(aq)} + CaCl_{2(aq)}$
$H_2CO_{3(aq)} \rightarrow CO_{2(g)} + H_2O_{(l)}$
(e) The evidence indicates that the substance is calcium carbonate.

Making Connections

26. $CaCO_{3(s)} \rightarrow CO_{2(g)} + CaO_{(s)}$
The process releases carbon dioxide, which is presumably vented into the atmosphere. This should contribute to the greenhouse effect. Given that much of the shell mass (and therefore, the carbon) would normally be buried in sediment and so eventually sequestered in rock (limestone), students might argue that this is actually a double blow for the environment.

27. Students are to provide the results of a "Senate inquiry" into the health of Emperor Nero.

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28. Students are to research fireworks and report on five compounds used, including their reactions.

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29. Students are to research and report on the development of metallurgical technology, including that of steel.

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30. Students are to research and report, in a form useful in hardware stores, on the alloys used in specialty steel-making, including the properties the alloying elements give to the steel.

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31. (a) $Sb_2S_{3(s)} + 2\ Fe_{(s)} \rightarrow 2\ Sb_{(s)} + Fe_2S_{3(s)}$ (single replacement)

    (b) $Sb_2S_{3(s)} + 5\ O_{2(g)} \rightarrow 3\ SO_{2(g)} + Sb_2O_{4(s)}$

    (c) $Sb_2O_{4(s)} + 2\ C \rightarrow 2\ Sb_{(s)} + 2\ CO_{2(g)}$

    (d) The second method releases both sulfur dioxide and carbon dioxide, which, if released into the atmosphere, will produce acid rain (sulfur dioxide) and increase the greenhouse effect (carbon dioxide). However, responsible production, using scrubbers in the stack, would oxidize the sulfur dioxide (using a catalyst), and then convert it to sulfuric acid (a useful industrial chemical):
    $2\ SO_{2(g)} + O_{2(g)} \rightarrow 2\ SO_{3(g)}$
    $SO_{3(g)} + H_2O_{(g)} \rightarrow H_2SO_{4(aq)}$

    The first method appears more benign, but the iron had to come from somewhere. Depending on the source, refining the iron could also produce sulfur and certainly carbon oxides.

Exploring

32. The students are to produce a report on the banning of leaded gasoline in Canada, including steps that must be taken to pass such a law.

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33. Students are to produce a report of a kind that might appear in a popular science magazine on the uses of radioisotopes in medicine.

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34. Students are to report on the use of mass spectrometers in forensics.

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35. Students are to study the nomenclatures used in industry, comment on possible confusions, and produce a warning poster for use in schools.

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