- colourless elements - oxygen

Classification rationale: Clear distinctions can be made among the elements in terms of colour.

(d) Third possible three–group classification:
- malleable solids - aluminum, silicon, magnesium, iron, copper, tin, lead
- non-malleable solids - carbon, sulfur
- gases - oxygen.

Classification rationale: Clear distinctions can be made among the solid elements in terms of malleability. Gases (and liquids) could be classed as "others".

(e) The description given in (a) of the various samples is fairly comprehensive. At this stage, students may add some of those attributes to their original descriptions.

(f) The process of classification puts a substance under careful examination and tends to reveal similarities to and differences from other substances. As more and more similarities and differences are identified, a more detailed description of the substance can be made.

(g) Other ways to classify the substances include: electrical conductivity, chemical reactivity, melting point, boiling point, freezing point, density, viscosity, etc. To assist in classification, for example, the substances could be connected to a source of electricity and then a multi-meter could be used to measure voltage and current; the substances could be reacted with other substances to determine chemical reactivity, etc.

1.1 ELEMENTS AND THE PERIODIC TABLE

PRACTICE

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Understanding Concepts

1. (a) iron; metal
   (b) aluminum; metal
   (c) gallium; metal
   (d) carbon; nonmetal
   (e) silver; metal
   (f) silicon; metalloid
2. (a) International Union of Pure and Applied Chemistry
   (b) IUPAC agrees to and specifies rules for chemical names and symbols. Although the names of elements are different in different languages, the same symbols are used in all languages. Scientific communication throughout the world depends on this language of symbols, which is international, precise, logical, and simple.
3. Three sources of names for elements are: Latin names; names based on the country or region in which the element was discovered; names that pay tribute to a notable scientist.

Making Connections

4. An example: furniture polish contains "isoparaffinic hydrocarbon." Isoparaffinic hydrocarbon is a compound that contains hydrogen (a nonmetal) and carbon (a nonmetal).
5. The student is to use the Internet to research the possible link between aluminum and Alzheimer's disease. The student is also to comment on whether aluminum is a significant environmental risk. Students may well find evidence to support either position. The focus of ongoing research is to clarify how aluminum affects the body and whether it is a factor in Alzheimer's disease. However, most researchers believe that not enough evidence exists to consider aluminum a risk factor for Alzheimer's disease. The strip mining of aluminum ore (bauxite) may be harmful to the environment. Processing aluminum from ore uses large amounts of electricity. Aluminum is also used in food, drinking water, cosmetics, and drugs.


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6. An example:

	Metal (gold)	Nonmetal (phosphorus)
How Discovered	Gold in small quantities was probably first found lying on the ground by prehistoric humans. It is soft, easy to work, and retains a shine. It was probably being used for ornamentation shortly after discovery.	A German scientist distilled the residue from boiled-down, well-putrefied urine; condensed the vapours underwater; and found something that glowed in the dark.
When Discovered	long before 4000 B.C.	1669
Where Discovered	unknown	Hamburg, Germany
Who Discovered	prehistoric peoples.	Hennig Brand
Common Industrial or Applications Technological	Gold's superior electrical conductivity, its malleability, and resistance to corrosion have made it vital to the manufacture of components of electronic products and equipment, including computers and telephones. Gold is extraordinarily reflective and does not tarnish, so is used to shield spacecraft and satellites from radiation and to focus light in industrial and medical lasers. Gold is biologically inactive, but is used in the direct treatment of rheumatism.	Matches, fireworks displays, phosphorous acid, phosphoric acid (used to give a tart taste to soft drinks, and to make fertilizer), phosphorous trichloride, etc.— used mainly for the further manufacture of other chemicals.


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Reflecting

7. It would be unwise for each country to choose its own names and symbols for elements because this would seriously impair scientific communication throughout the world, for example, causing confusion if two countries used the same name for different elements.
8. Example: "Special Education" as a useful classification:
   Intellectual differences, sensory handicaps, communication disorders, physical handicaps, behaviour disorders, and developmental disabilities have all been used to modify education for students who need something extra to help them work toward their potential.
   "Special Education" as a harmful classification:
   Negative connotations are attached to such forms of classification, and educational jurisdictions tend to interpret some of the "special education" categories in an arbitrary manner. For example, the classification "developmental disabilities" may be interpreted in a variety of different ways, even within a single province like Ontario.

PRACTICE

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Understanding Concepts

9. (a) Mendeleev's periodic law states that "elements arranged in order of increasing atomic mass show a periodic recurrence of properties at regular intervals."
   (b) Mendeleev was able to predict the properties of the as yet undiscovered elements, with some accuracy — but not with complete accuracy. In general, periodic law is inadequate to fully predict properties of elements.

10. According to the law of triads, the middle element of a triad should have an atomic mass about halfway between the atomic masses of the other two elements. The halfway value between fluorine, with an atomic mass 19.00, and bromine, with an atomic mass of 79.90, would be an atomic mass of 49.45. The value for the atomic mass of chlorine in today's periodic table is actually 35.45.
11. Johann Döbereiner (1780–1849): Döbereiner was among the first scientists to consider the idea of trends among the properties of the elements. By 1829, he had noted a similarity among the physical and chemical properties of several groups of three elements. Döbereiner's discovery is often referred to as the law of triads.

    John Alexander Newlands (1837–1898): In 1864, Newlands arranged all of the known elements in order of increasing atomic mass. He noticed that similar physical and chemical properties appeared for every eighth element. He also noticed that some elements shared similar properties with other elements even though they did not follow the "eighth element" pattern. He identified elements that share similar properties as being in the same family. Newlands called his discovery "the law of octaves." However, the law of octaves seemed to be true only for elements up to calcium.

    Julius Lothar Meyer (1830–1895): Meyer also arranged the elements in order of atomic mass. Meyer thought he saw a repeating pattern in the relative volumes of the individual atoms of known elements. He also observed a change in length of that repeating pattern. By 1868, Meyer had developed a table of the elements that closely resembles the modern periodic table.
12. Mendeleev placed sulfur and oxygen in the same family because of their similar chemical properties. For example, both oxygen and sulfur react with hydrogen according to the formula of H_2R.
13. The discovery of noble gases supported Mendeleev's periodic table in the sense that these new elements had similar physical properties (they are all gases) and similar chemical properties (they are all unreactive). This added another family of elements to Mendeleev's periodic table to illustrate the periodic recurrence of properties.
14. Students will find that science is not always objective. Fear of ridicule (as of Newland's musical analogy), fear of risking reputation by making a major blunder (as in Lothar Meyer's lack of the courage needed to propose new elements to fill in the gaps in the repeating pattern of atomic volumes), and fear of the power of authority (challenging an established theory supported by a well-established group of scientists could be hazardous to the career of the maverick) are all powerful factors that affect the progress of science. Social factors and personal attributes probably delayed the development and acceptance of the periodic table.

PRACTICE

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Understanding Concepts

15.

Element Name	Atomic Symbol	Atomic Number	Group Number	State at SATP
lithium	Li	3	1 or IA	solid
beryllium	Be	4	2 or IIA	solid
boron	B	5	13 or IIIA	solid
carbon	C	6	14 or IVA	solid
nitrogen	N	7	15 or VA	gas
oxygen	O	8	16 or VIA	gas
fluorine	F	9	17 or VIIA	gas
neon	Ne	10	18 or VIIIA	gas

16. Metals = 89; nonmetals = 19; metalloids = 7
17.

Representative Elements of Period 2 - Groups I to 18

Element Name	Atomic Symbol	Atomic Number	Atomic Mass	State at SATP	Melting Point ˚C	Boiling Point ˚C
lithium	Li	3	6.94	solid	181	1342
beryllium	Be	4	9.01	solid	1278	2970
boron	B	5	10.81	solid	2300	2550
carbon	C	6	12.01	solid	3550	4827
nitrogen	N	7	14.01	gas	-210	-196
oxygen	O	8	16.00	gas	-218	-183
fluorine	F	9	19.00	gas	-220	-188
neon	Ne	10	20.18	gas	-249	-246

18.

	Physical Property	Chemical Property
Alkali Metals	• soft • silver-coloured	• react violently with water, liberating hydrogen gas • react with halogens to form compounds similar to sodium chloride (NaCl)
Halogens	• may be solids, liquids, or gases at SATP • not lustrous and nonconductors of electricity	• extremely reactive • react readily with hydrogen and metals
Noble Gases	• gases at SATP • low melting and boiling points	• extremely unreactive • heavier gases may form compounds with fluorine

19. According to the position of phosphorus in the periodic table, the most likely formula for a compound of phosphorus and hydrogen is $PH_3(g)$ — commonly called phosphine, an extremely poisonous gas with a garlic odour. Its chief use is in the manufacture of plastics used to make compounds that make cotton cloth flame-resistant.

Making Connections

20. Some support for the Age of Silicon: Silicon is a metalloid solid, metallic in appearance, and has a high melting point (1410°C). However, its electrical conductivity is much less than that of a typical metal. It is this "semiconductor" property that makes this element extremely useful in the electronics and communication technology industries. Silicon is the material currently used to make most microchips — integrated circuits — a tiny piece of silicon that contains thousands of tiny, interconnected electrical circuits that work together to receive and send information. Microchips can process a great deal of information, and yet take up very little space. However, silicon's status as indispensable to computation is being challenged with new methods, including photonics, that will not require silicon. Perhaps, many years from now, this will be referred to as the Age of Silicon, but a case could be made for a more general description: the Age of Information.

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SECTION 1.1 QUESTIONS

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Understanding Concepts

1. Lithium, sodium, and potassium are elements in the same family that are arranged in order of increasing atomic number and show a periodic recurrence of properties — all are soft, silvery-coloured elements, all are solids at SATP, all exhibit metallic properties, and all react violently with water to form basic solutions and liberate hydrogen gas.
2. (a) Percentage approach: If we take each melting point as a percentage of the previous melting point and then average the percentages, the predicted melting point of Rb would be about 37.6˚C. The actual melting point of Rb is 38.9˚C.
   (b) Alkali metals and alkaline earth metals show a periodic recurrence of decreasing melting points as you move down a group, whereas nonmetals show a periodic recurrence of increasing melting points as you move down a group. Thus, based on the periodic recurrence of decreasing melting points Li, Na, K, and Rb would be classified as metals.
   (c) As alkali metals, Li, Na, K, and Rb would be expected to be soft, silvery-coloured elements; to be solids at SATP; to exhibit metallic properties; and to show decreasing boiling points as you move down the group.
3. (a) "Shiny, grey solid at SATP" are physical properties that are in line with elements from the alkaline earth metals group, or from the transition metals group.

   "When heated in the presence of oxygen, a white, powdery solid forms" is a chemical property also in line with elements from the alkaline earth metals group, or from the transition metals group - elements from either of these two groups, especially elements from the alkaline earth metals group, react with oxygen to form oxides.
   (b) Before 1800, scientists distinguished elements from compounds by heating the substances to find out if they decomposed. If the products they obtained after cooling had different properties from the starting materials, then the experimenters concluded that decomposition had occurred, so the original substance was a compound. In this case, the scientist would have concluded the original grey solid substance to be a compound, and the white powder (which will not decompose on heating) to be an element.

4.

Table 4: Elements and Mineral Resources

Mineral resource or use	Element name	Atomic number	Element symbol	Group number	Period number	SATP state
High-quality ores at Great Bear Lake, NT	radium	88	Ra	2	7	solid
Rich ore deposits at Bernic Lake, MB	cesium	55	Cs	1	6	solid
Potash deposits in Saskatchewan	potassium	19	K	1	4	solid
Large deposits in New Brunswick	antimony	51	Sb	15	5	solid
Extracted from Alberta sour natural gas	sulfur	16	S	16	3	solid
Radiation source for cancer treatment	cobalt	27	Co	9	4	solid
Large ore deposits in Nova Scotia	barium	56	Ba	2	6	solid
World-scale production in Sudbury, ON	nickel	28	Ni	10	4	solid
Fuel in CANDU nuclear reactors from Saskatchewan	uranium	92	U	_	7	solid
Fluorspar deposits in Newfoundland	fluorine	9	F	17	2	gas
Large smelter in Trail, BC	zinc	30	Zn	12	4	solid

Applying Inquiry Skills

5. The chemical property — "reacts violently with water to form basic solutions and liberate hydrogen gas" — is associated with the alkali metals. However, the alkaline earth metals can also react with water to liberate hydrogen. The element could be further investigated to see if the reaction with water produced a basic solution — which is a chemical property of the alkali metals.

Experimental Design

A small piece of the unknown element is placed in water and the reactivity observed. After the element has reacted with water, dip litmus paper into the solution. If the litmus paper turns blue, then the solution is basic — this would indicate that the element is an alkali metal. If the litmus paper does not turn blue, then the solution is either neutral or possibly acidic. This would indicate that the element is not an alkali metal — other tests could then be carried out to further narrow down which group the element is from.

6. (a) Radium was discovered by Pierre and Marie Curie in 1898 (France). Radium ore is mined — extracted from the ground. The element emits alpha particles and gamma rays to form radon, and is used chiefly in luminous materials and in the treatment of cancer. Uranium is a byproduct of the extraction process.
   (b) It is intensely radioactive and poses a serious threat to health — overexposure can cause cancer. Protective measures must be taken in its handling, storage, and disposal.
   (c) Advantages — treatment of cancer, use in luminous materials.
   Drawbacks — intensely radioactive and can cause cancer.
   The main advantage is the use of radium to treat cancer. Providing that adequate protective measures are taken in its handling, storage, and disposal, it can be argued that the advantages outweigh the drawbacks. Nevertheless, it would be desirable to discontinue its use in the future, and to replace it with other effective and less health-threatening methods of treating cancer.


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