(c) The mixture could be converted to a single phase solution by adding more solvent, or by warming. Either process would dissolve the solid present.

2. Solids generally become more soluble as temperature increases, while gases generally become less soluble as temperature increases.

Applying Inquiry Skills

3. **Prediction**

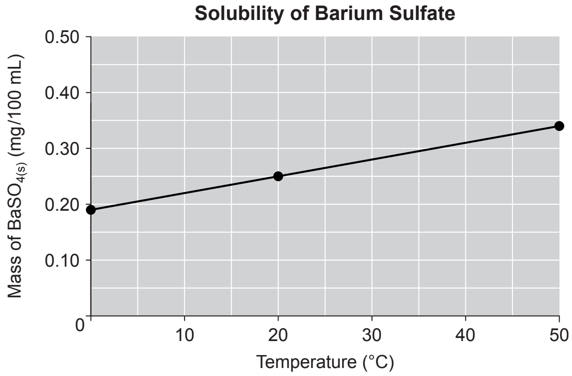
(a) Barium sulfate should become more soluble as temperature increases, according to the generalization about the solubility of ionic solids.

Experimental Design

(b) The independent variable is the solution temperature. The dependent variable is the mass of barium sulfate. The most important controlled variable is the volume of saturated solution taken each time.

Analysis

(c)



(d) According to the evidence from this investigation, barium sulfate does become more soluble as temperature increases.

Evaluation

(e) The experiment could be improved by just making and using a single saturated solution, and taking samples from it at different temperatures.

(f) The prediction was verified, according to the evidence gathered.

(g) The solubility generalization is supported by the results of this experiment. One test of one compound is certainly not enough evidence to justify stating such a generalization. Many repeated tests of many compounds would be required for scientific acceptance and confidence.

Making Connections

4. If a non-aqueous solvent is used, it is probably because the dirt and grease on clothing dissolves better in such solvents. Also, some clothing fabrics are damaged by water, but are not affected by non-aqueous solvents.

5. (a) Cold, fast-flowing streams will have a higher concentration of dissolved oxygen, because more air will be mixed with turbulent water, and because gases dissolve better in colder water.

(b) Trout probably require more oxygen than carp.

(c) Thermal pollution would probably affect trout seriously, because warming their water will reduce its oxygen concentration.

7.2 HARD WATER TREATMENT

PRACTICE

(Page 329)

Understanding Concepts

1. (a) Scale in kettles and soap scum are both evidence of hard water.

(b) Ground water is hard in areas where soluble calcium and magnesium minerals exist in the ground.

2. (a) $Na_2CO_{3(s)}$ and $Ca(OH)_{2(s)}$
   (b) The added carbonate ions cause calcium and magnesium ions in the hard water to precipitate, because $CaCO_3$ and $MgCO_3$ have very low solubility.
3. (a) $C_{CaCO_3} = 7.1 \times 10^{-5}$ mol/L

   $M_{CaCO_3} = 100.09$ g/mol

   $$c_{CaCO_3} = \frac{0.000071 \cancel{\text{mol}}}{\text{L}} \times \frac{100.09 \text{ g}}{\cancel{\text{mol}}}$$

   $$c_{CaCO_3} = 0.0071 \text{ g/L} = 7.1 \text{ mg/L}$$

   The concentration of calcium carbonate in the treated water will be equal to the solubility; 7.1 mg/L.

   (b) 7.1 mg/L is equal to 7.1 ppm.
   (c) The treated water is classified as soft, according to Table 1.
4. A home water softener unit has to be regenerated because the resin in it has a finite capacity to attract hard water ions, to replace sodium ions. The sodium ions go into the bath and washing machine, but no precipitate (bathtub ring) forms. When no more $Ca^{2+}_{(aq)}$ and $Mg^{2+}_{(aq)}$ ions can attach to the resin, the regeneration cycle replaces the hard water ions with fresh sodium ions. The hard water ions are flushed down the drain.

Making Connections

5. On a large scale, the amount of resin required for softening would be extremely expensive, and the volume of concentrated brine needed for regeneration would be enormous, and thus a problem to make and store. The quantity of sodium and chloride ions in the water might pose a health problem for some people.
6. Detergents clean well in harder water, producing no "soap scum," which was a huge benefit. However, they increased some pollution problems. Early detergents were not very biodegradable, and phosphates from detergents created (and sometimes still do create) eutrophication problems in lakes and rivers.
7. Home-softened water (from ion-exchange softeners) is often not routed to toilets (for economy), and sometimes not to a kitchen tap that provides drinking water (for possible health reasons). The incidence of heart disease is statistically slightly lower in areas with hard water than in areas with naturally soft water. People with heart concerns, particularly those on low-sodium diets, may not wish to drink home-softened water (which is often high in sodium).

   GO TO www.science.nelson.com, Chemistry 11, Teacher Centre.

SECTION 7.2 QUESTIONS

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Understanding Concepts

1. Water is naturally hard in areas where ground water comes in contact with minerals (such as limestone) that contain slightly soluble calcium and/or magnesium compounds.
2. $Ca^{2+}_{(aq)}$ and $Mg^{2+}_{(aq)}$ are the ions mostly responsible for water hardness.
3. (a) Laundry "scum" and kettle scale are the noticeable effects of hard water.
   (b) One serious effect of hard water that is not readily noticeable is the formation of scale in pipes. If it is allowed to build up unchecked, the scale can significantly reduce the flow of water through the pipe, and come close to blocking it completely.
4. $Na_2CO_{3(aq)} + Ca(HCO_3)_{2(aq)} \rightarrow 2\ NaHCO_{3(aq)} + CaCO_{3(s)}$
5. (a) Calcium ions are more readily attracted than sodium ions to negatively charged sulfonate sites on a resin molecule. This is mostly because a calcium ion has a charge of 2+, twice as much as the charge of a sodium ion.
   (b) During regeneration, there are very many more sodium ions present (at maximum concentration) than calcium ions, so the chance that sodium ions will collide with and attach to the sulfonate sites becomes very much greater, overcoming the fact that calcium ions are attracted more strongly than sodium ions.

Applying Inquiry Skills

6. **Question**
   (a) Is water softened by passing through a pipe to which a magnet is attached?

Experimental Design

Hard water is run through a pipe to a tap, and samples are tested for hardness, with and without a magnet being attached to the pipe.

(b) **Evaluation**

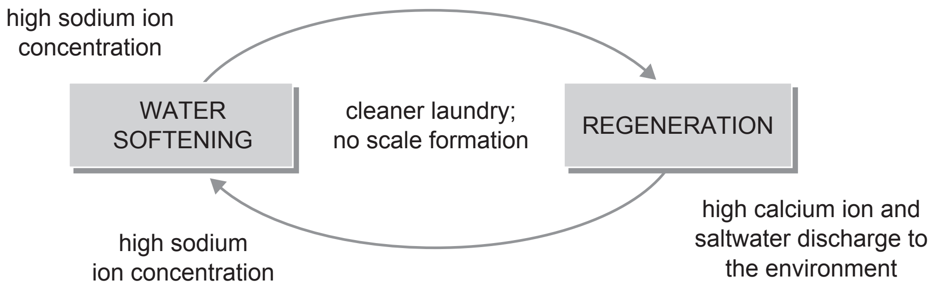
The original design is obviously useless in light of the new understanding of the claim made for the magnet; it is not testing the claimed result.

New Experimental Design

Hard water is run through identical piping that has and has not magnets attached. After several months, the piping is cut and the ease of removing the scaling from the inside of the pipe is determined.

Making Connections

7.



7.3 REACTIONS IN SOLUTION

PRACTICE

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Understanding Concepts

1. (a) silver sulfide: low solubility
   (b) magnesium nitrate: high solubility
   (c) zinc carbonate: low solubility
2. (a) Precipitate forms: $SrSO_{4(s)}$
   (b) No precipitate forms
   (c) Precipitate forms: $CuSO_{3(s)}$

PRACTICE

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Understanding Concepts

3. $Sr(NO_3)_{2(aq)} + Na_2CO_{3(aq)} \rightarrow SrCO_{3(s)} + 2\ NaNO_{3(aq)}$

   $Sr^{2+}_{(aq)} + 2\ NO^-_{3(aq)} + 2\ Na^+_{(aq)} + CO^{2-}_{3(aq)} \rightarrow SrCO_{3(s)} + 2\ Na^+_{(aq)} + 2\ NO^-_{3(aq)}$

   $Sr^{2+}_{(aq)} + CO^{2-}_{3(aq)} \rightarrow SrCO_{3(s)}$

4. (a) Compounds could be any four of:
   copper(II) nitrate, copper(II) sulfate, copper(II) acetate, copper(II) chloride, copper(II) bromide, or copper(II) iodide.

   Choose copper(II) nitrate as the example:

   (b) $2\ Al_{(s)} + 3\ Cu(NO_3)_{2(aq)} \rightarrow 3\ Cu_{(s)} + 2\ Al(NO_3)_{3(aq)}$

   (c) $2\ Al_{(s)} + 3\ Cu^{2+}_{(aq)} + 6\ NO^-_{3(aq)} \rightarrow 3\ Cu_{(s)} + 2\ Al^{3+}_{(aq)} + 6\ NO^-_{3(aq)}$

   (d) $2\ Al_{(s)} + 3\ Cu^{2+}_{(aq)} \rightarrow 3\ Cu_{(s)} + 2\ Al^{3+}_{(aq)}$

5. $Cl_{2(g)} + 2\ Br^-_{(aq)} \rightarrow Br_{2(l)} + 2\ Cl^-_{(aq)}$