Evaluation

(e) The evidence is questionable because the design did not take into account the fact that the same volume of two different liquids would contain different numbers of molecules. This is a flaw in the design that needs to be corrected. The materials were of suitable quality to provide reasonable evidence. The procedure appears to be adequate because the steps were sufficiently clear and included multiple trials to increase the reliability of the evidence. The difficulty experienced with pouring the viscous glycerol could be eliminated by measuring the mass used instead of the volume. This change would also make it easier to compare or control the number of molecules of the alcohol used.

(f) I am not very certain about the evidence because of the flaw identified in the design. Measurements of the temperature and volume also provide some experimental error but this is not expected to be a major factor.

(g) The evidence is sufficiently uncertain to make a judgment of the prediction quite unreliable. It is hard to tell if the disagreement of the evidence with the prediction is due to the flaw identified or other factors related to the mixing and bonds breaking and forming. The experiment needs to be redesigned and redone.

INVESTIGATION 4.6.1 CLASSIFYING MYSTERY SOLIDS

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Experimental Design

(a) The class of each solid is identified by observing the appearance, electrical conductivity, solubility in water, electrical conductivity in water, and effect of heating (relative melting point).

Materials

(b) tweezers
stirring rod
conductivity tester
4 small beakers
distilled water
hot plate
vials with mystery solids

Procedure

(c)

1. Observe the appearance of each solid.
2. Test a crystal of each solid for electrical conductivity.
3. Place a crystal of each solid on a hot plate at a low heat setting. Observe the solids as the heat is slowly increased.
4. Test the electrical conductivity of pure water in a clean, dry beaker.
5. Place a few crystals of each solid in separate beakers and add about 10 mL of water to each. Stir to dissolve as much as possible.
6. Test the electrical conductivity of each mixture.
7. Dispose of solids into the waste basket and liquids in the sink.

Evidence

Properties of the Mystery Solids				
Solids	**1**	**2**	**3**	**4**
Appearance	clear, colourless	clear, colourless, some white patches	silvery grey	clear, colourless
Conductivity of solid	none	none	good	none
Effect of heating	no change	no change	none	melts quickly and turns black
Solubility in water	did not dissolve	dissolved	did not dissolve	dissolved
Conductivity in water	none	good	none	none

Analysis

(d) According to the evidence collected, solid 1 is network covalent, 2 is ionic, 3 is metallic, and 4 is molecular.

Evaluation

(e) Most of the evidence was sufficient to classify the majority of the solids. The classification of the network covalent solid fits with the properties of network covalent solids but was done mainly by elimination once the others were classified. This classification is very uncertain and it is possible that solid 1 may be a low-solubility ionic solid. The classification of solids 2, 3, and 4 seems relatively certain.

Other properties such as hardness and melting points would help to make the classification more certain.

CHAPTER 4 SUMMARY

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Force or bond	Central particle	Surrounding particles
covalent	electron pair	nuclei
covalent network	electron pair	nuclei
dipole–dipole	charge site	opposite charge sites
hydrogen	proton	electron pairs
ionic	ion	oppositely charged ions
London	nuclei	nearby valence electrons
metallic	nuclei	mobile valence electrons (electron sea)

Substance	Hardness	Melting point	Electrical conductivity		
			Solid	Liquid	Solution
molecular	low	low	negligible	negligible	negligible
ionic	medium to high	high	negligible	high	high
covalent network	high	very high	negligible	negligible	n/a
metallic	medium	medium to high	high	high	n/a

CHAPTER 4 SELF-QUIZ

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1. False: The shape of molecules of the rocket fuel hydrazine, $N_2H_{4(l)}$, is predicted by VSEPR theory to be pyramidal around each nitrogen.
2. True
3. False: A central atom with two bonded atoms and two unshared electron pairs has a V-shaped arrangement of its electron pairs.
4. False: Ionic substances are ionic solids, with ionic bonding.
5. False: Hydrogen bonding is possible whenever the molecule contains hydrogen atoms bonded to N, O, or F atoms.
6. False: A molecule with a pyramidal shape and polar bonds will be polar.
7. True
8. True
9. False: The end of a soap molecule that attracts and dissolves oily dirt must be nonpolar.
10. True
11. (b)
12. (b)