

Topic: Water & Solutions

Outline

1. Water has some unusual properties.

- ✓ The bonds between H and O inside a water molecule are “polar covalent.”
- ✓ Due to its structure, it is a polar molecule. This means it has an uneven distribution of electrons in it. The O end is (-) and the H ends are (+).
- ✓ ***Draw its Lewis dot structure here!*** _____
- ✓ Water is actually a VERY polar substance. As a result, it uses the very strong type of intermolecular (between molecule) forces of attraction called “HYDROGEN BONDS.”
- ✓ As a result of H-bonding, water has an unusually high melting point and boiling point compared with similar molecules like H₂S.
- ✓ Water has a very high specific heat, so it heats up and cools down much more slowly than most materials. This value is found on Table B.
- ✓ Water solutions that contain ions are capable of conducting electricity. The substances that form the ions in solution are called “electrolytes.”

2. Water is able to make solutions with many substances.

- ✓ Solutions are ALWAYS HOMOGENEOUS MIXTURES.
- ✓ Water will dissolve many ionic compounds.
- ✓ Water will dissolve molecular substances if they are also polar.
- ✓ This reminds us of the “like dissolves like” principle.
- ✓ Acids dissolve in water to form H⁺ ions. (This includes organic acids: R-COOH)
- ✓ Bases dissolve in water to form OH⁻ ions. (This does NOT include alcohols: R-OH)

3. Ionic compounds may be either soluble or insoluble in water.

- ✓ Use Table F to decide!

4. Solubility describes how much of a particular solute will dissolve in a set amount of water at a certain temperature.

- ✓ Use Table G. The amount of water used is 100 g.
- ✓ Saturated solutions hold all the solute possible at the temperature chosen for the water.
- ✓ An increase in temperature of the water usually makes it capable of dissolving more solute. The opposite is true for gas solutes like O₂ gas, or NH₃ or SO₂ or HCl.
- ✓ An increase in pressure over the solution increases the solubility of gas solutes. It does not affect solubility of solutes that are liquids or solids.

5. Solutions have a lower freezing point and a higher boiling point than pure water. This effect becomes larger with more concentrated solutions.

6. “Concentration” describes how much solute is dissolved in a certain amount of water.

- ✓ You should know how to calculate:
 - Molarity
 - % mass
 - Parts per million
 - Use Table T and “plug in given values”

Water & Solutions – questions from previous Regents exams

1. A 3.0 M HCl(aq) solution contains a total of
 - (1) 3.0 grams of HCl per liter of water
 - (2) 3.0 grams of HCl per mole of solution
 - (3) 3.0 moles of HCl per liter of solution
 - (4) 3.0 moles of HCl per mole of water
2. A dilute, aqueous potassium nitrate solution is best classified as a
 - (1) homogeneous compound
 - (2) homogeneous mixture
 - (3) heterogeneous compound
 - (4) heterogeneous mixture
3. According to one acid-base theory, a water molecule acts as an acid when the water molecule
 - (1) accepts an H^+
 - (2) accepts an OH^-
 - (3) donates an H^+
 - (4) donates an OH^-
4. An Arrhenius base yields which ion as the only negative ion in an aqueous solution?
 - (1) hydride ion
 - (2) hydrogen ion
 - (3) hydronium ion
 - (4) hydroxide ion
5. Which barium salt is *insoluble* in water?
 - (1) $BaCO_3$
 - (2) $BaCl_2$
 - (3) $Ba(ClO_4)_2$
 - (4) $Ba(NO_3)_2$
6. Which unit can be used to express solution concentration?
 - (1) J/mol
 - (2) L/mol
 - (3) mol/L
 - (4) mol/s
7. Under which conditions of temperature and pressure is a gas most soluble in water?
 - (1) high temperature and low pressure
 - (2) high temperature and high pressure
 - (3) low temperature and low pressure
 - (4) low temperature and high pressure
8. Given the equation representing a system at equilibrium:
$$H_2O(s) \rightleftharpoons H_2O(l)$$
At which temperature does this equilibrium exist at 101.3 kilopascals?
 - (1) 0 K
 - (2) 0°C
 - (3) 32 K
 - (4) 273°C
9. As water is added to a 0.10 M NaCl aqueous solution, the conductivity of the resulting solution
 - (1) decreases because the concentration of ions decreases
 - (2) decreases, but the concentration of ions remains the same
 - (3) increases because the concentration of ions decreases
 - (4) increases, but the concentration of ions remains the same
10. Which substance is an Arrhenius acid?
 - (1) $Ba(OH)_2$
 - (2) CH_3COOCH_3
 - (3) H_3PO_4
 - (4) NaCl
11. Which compound releases hydroxide ions in an aqueous solution?
 - (1) CH_3COOH
 - (2) CH_3OH
 - (3) HCl
 - (4) KOH
12. Which liquid has the highest vapor pressure at 75°C?
 - (1) ethanoic acid
 - (2) ethanol
 - (3) propanone
 - (4) water
13. Which sample of matter is a single substance?
 - (1) air
 - (2) ammonia gas
 - (3) hydrochloric acid
 - (4) salt water
14. At standard pressure, a certain compound has a low boiling point and is insoluble in water. At STP, this compound most likely exists as
 - (1) ionic crystals
 - (2) metallic crystals
 - (3) nonpolar molecules
 - (4) polar molecules
15. An unsaturated solution is formed when 80. grams of a salt is dissolved in 100. grams of water at 40.°C. This salt could be
 - (1) KCl
 - (2) KNO_3
 - (3) NaCl
 - (4) $NaNO_3$
16. Which substance, when dissolved in water, forms a solution that conducts an electric current?
 - (1) C_2H_5OH
 - (2) $C_6H_{12}O_6$
 - (3) $C_{12}H_{22}O_{11}$
 - (4) CH_3COOH

17. Compared to a 2.0 M aqueous solution of NaCl at 1 atmosphere, a 3.0 M aqueous solution of NaCl at 1 atmosphere has a
- (1) lower boiling point and a higher freezing point
 - (2) lower boiling point and a lower freezing point
 - (3) higher boiling point and a higher freezing point
 - (4) higher boiling point and a lower freezing point

18. A student prepares four aqueous solutions, each with a different solute. The mass of each dissolved solute is shown in the table below.

**Mass of Dissolved Solute
for Four Aqueous Solutions**

Solution Number	Solute	Mass of Dissolved Solute (per 100. g of H ₂ O at 20.°C)
1	KI	120. g
2	NaNO ₃	88 g
3	KCl	25 g
4	KClO ₃	5 g

Which solution is saturated?

- (1) 1
- (2) 2
- (3) 3
- (4) 4

Base your answers to question 19 on the information below.

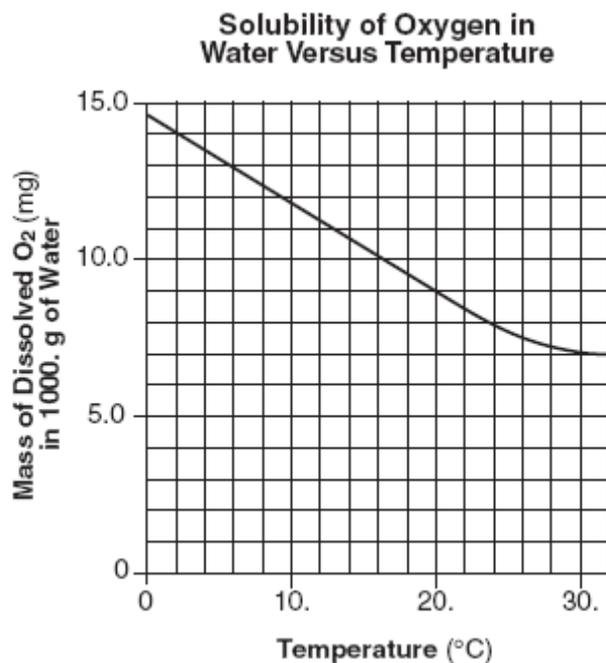
The equilibrium equation below is related to the manufacture of a bleaching solution. In this equation, Cl⁻(aq) means that chloride ions are surrounded by water molecules.



19. Draw *two* water molecules in the box, showing the correct orientation of each water molecule toward the chloride ion. [1]

Base your answers to questions 20 through 22 on the information below.

Scientists who study aquatic ecosystems are often interested in the concentration of dissolved oxygen in water. Oxygen, O_2 , has a very low solubility in water, and therefore its solubility is usually expressed in units of milligrams per 1000. grams of water at 1.0 atmosphere. The graph below shows a solubility curve of oxygen in water.



20. A student determines that 8.2 milligrams of oxygen is dissolved in a 1000.-gram sample of water at 15°C and 1.0 atmosphere. In terms of saturation, what type of solution is this sample? [1] _____

21. Explain, in terms of molecular polarity, why oxygen gas has low solubility in water. Your response must include *both* oxygen and water. [1]

22. An aqueous solution has 0.0070 gram of oxygen dissolved in 1000. grams of water. Calculate the dissolved oxygen concentration of this solution in parts per million. Your response must include *both* a correct numerical setup and the calculated result. [2]

Base your answers to questions 23 and 24 on the information below.

A solution is made by completely dissolving 90. grams of $\text{KNO}_3(\text{s})$ in 100. grams of water in a beaker. The temperature of this solution is 65°C .

23. Describe the effect on the solubility of $\text{KNO}_3(\text{s})$ in this solution when the pressure on the solution increases. [1]

24. Determine the total mass of $\text{KNO}_3(\text{s})$ that settles to the bottom of the beaker when the original solution is cooled to 15°C . [1]

Base your answers to questions 25 through 27 on the information below.

The compound 1,2-ethanediol can be mixed with water. This mixture is added to automobile radiators as an engine coolant. The cooling system of a small van contains 6690 grams of 1,2-ethanediol. Some properties of water and 1,2-ethanediol are given in the table below.

Properties of Water and 1,2-ethanediol

Property	Water (H_2O)	1,2-ethanediol ($\text{CH}_2\text{OHCH}_2\text{OH}$)
gram-formula mass (g/mol)	18.0	62.0
boiling point at standard pressure ($^\circ\text{C}$)	100.0	197.2

25. Identify the class of organic compounds to which 1,2-ethanediol belongs. [1]_____

26. State, in terms of molecular polarity, why 1,2-ethanediol is soluble in water. [1]

27. Calculate the total number of moles of 1, 2-ethanediol in the small van's cooling system. Your response must include *both* a correct numerical setup and the calculated result. [2]

28. An aqueous solution contains 300. parts per million of KOH. Determine the number of grams of KOH present in 1000. grams of this solution. [1]

29. A liquid boils when the vapor pressure of the liquid equals the atmospheric pressure on the surface of the liquid. Using Reference Table *H*, determine the boiling point of water when the atmospheric pressure is 90. kPa. [1]