

## 14.10: Exercises

### 14.2: Solution Terminology

1. One brand of ethyl alcohol (Everclear) is 95% ethyl alcohol, with the remaining 5% being water. What is the solvent and what is the solute of this solution?

#### Answer

The solvent is ethyl alcohol and the solute is water.

2. Give an example of each type of solution from your own experience.
  - a. A solution composed of a gas solute in a liquid solvent.
  - b. A solution composed of a solid solute in a liquid solvent.
  - c. A solution composed of a liquid solute in a liquid solvent.
  - d. A solution composed of a solid solute in a solid solvent. (Hint: usually such solutions are made as liquids and then solidified.)

#### Answer

Answers will vary. Possible answers include:

- a. carbonated beverages
- b. sugar water
- c. alcoholic beverages
- d. stainless steel

3. Differentiate between the terms *unsaturated* and *dilute*.

#### Answer

Unsaturated means that less than the maximum amount of solute is present in solution. Dilute means a small amount of solute is present. A solution can be unsaturated and still have a large amount of solute present.

4. Differentiate between the terms *saturated* and *concentrated*.

#### Answer

Saturated means that the maximum amount of solute is present in solution. Concentrated means that a large amount of solute is present. A solute can be concentrated and still have less than the maximum amount of solute possible. There are also weakly soluble compounds which can be saturated and have only a small amount of solute present in solution.

### 14.3: Aqueous Solutions of Solids

5. Which of the following compound(s) will dissolve in water to yield ions?
  - a. KOH
  - b.  $\text{FeCl}_3$
  - c.  $\text{CH}_3\text{COCH}_3$  (acetone)

#### Answer

KOH and  $\text{FeCl}_3$

6. Which of the following compound(s) are electrolytes?

- a.  $\text{CH}_3\text{OH}$
- b.  $\text{Li}_2\text{SO}_4$
- c.  $\text{C}_6\text{H}_{12}\text{O}_6$  (glucose)

**Answer**

$\text{Li}_2\text{SO}_4$

7. Using [Figure 14.3.4](#), how many grams of the indicated solute would dissolve in 100 g  $\text{H}_2\text{O}$  at the given temperature?

- a.  $\text{NH}_3$  at  $85^\circ\text{C}$
- b.  $\text{KClO}_3$  at  $45^\circ\text{C}$
- c.  $\text{HCl}$  at  $60^\circ\text{C}$
- d.  $\text{KI}$  at  $10^\circ\text{C}$

**Answer**

- a. 13 g
- b. 20 g
- c. 55 g
- d. 136 g

8. Using [Figure 14.3.4](#), indicate whether each of the following solutions is saturated, unsaturated, or supersaturated.

- a. 80 g  $\text{NH}_4\text{Cl}$  in 100 g  $\text{H}_2\text{O}$  at  $90^\circ\text{C}$
- b. 120 g  $\text{KNO}_3$  in 200 g  $\text{H}_2\text{O}$  at  $50^\circ\text{C}$
- c. 95 g  $\text{NaNO}_3$  in 100 g  $\text{H}_2\text{O}$  at  $40^\circ\text{C}$
- d. 30 g  $\text{KCl}$  in 50 g  $\text{H}_2\text{O}$  at  $60^\circ\text{C}$

**Answer**

- a. supersaturated
- b. unsaturated
- c. saturated
- d. supersaturated

9. Based on the information in [Figure 14.3.4](#), what temperature would be needed to dissolve 10 g  $\text{SO}_2$  in 100 g  $\text{H}_2\text{O}$ ?

**Answer**

$20^\circ\text{C}$  or colder

#### 14.5: Solution Concentration Measurements

10. The World Health Organization recommends that the maximum fluoride ion concentration in drinking water is 1.0 ppm.

Assuming water has the maximum concentration, if an average person drinks 1,920 mL of water per day, how many milligrams of fluoride ion are being ingested? Assume the density of drinking water is 1.00 g/mL.

**Answer**

1.9 mg  $\text{F}^-$

11. For sanitary reasons, water in pools should be chlorinated to a maximum level of 3.0 ppm. In a typical 5,000 gal pool that contains 21,200 kg of water, what mass of chlorine must be added to obtain this concentration?

**Answer**

64 g

12. Given its notoriety, you might think that uranium is very rare, but it is present at about 2–4 ppm of the earth's crust, which is more abundant than silver or mercury. If the earth's crust is estimated to have a mass of  $8.50 \times 10^{20}$  kg, what range of mass is thought to be uranium in the crust?

**Answer**

$1.7 \times 10^{15}$  -  $3.4 \times 10^{15}$  kg

13. Chromium is thought to be an ultratrace element, with about 8.9 ng present in a human body. If the average body mass is 75.0 kg, what is the concentration of chromium in the body in pptr (parts per trillion)?

**Answer**

$1.2 \times 10^{-4}$  pptr

14. What mass of nitric acid is needed to prepare 400.0 g of a 10.0% solution of  $\text{HNO}_3$  by mass?

**Answer**

40.0 g  $\text{HNO}_3$

15. What mass of a 4.00% NaOH solution by mass contains 15.0 g of NaOH?

**Answer**

375 g solution

16. What mass of solid NaOH is required to prepare 1.00 L of a 10.0% solution of NaOH by mass? The density of the 10.0% solution is 1.109 g/mL. (Hint: First find the total mass of the solution.)

**Answer**

111 g NaOH

17. What mass of HCl is contained in 45.0 mL of an aqueous HCl solution that has a density of 1.19 g/mL and contains 37.21% HCl by mass?

**Answer**

19.9 g HCl

18. Copper(I) iodide ( $\text{CuI}$ ) is often added to table salt as a dietary source of iodine. How many moles of  $\text{CuI}$  are contained in 1.00 lb (454 g) of table salt containing 0.0100%  $\text{CuI}$  by mass?

**Answer**

$$2.38 \times 10^{-4} \text{ mol CuI}$$

19. A cough syrup contains 5.0% ethyl alcohol,  $\text{C}_2\text{H}_5\text{OH}$ , by mass. If the density of the solution is 0.9928 g/mL, how many grams of alcohol are in 20.0 mL of the cough syrup, the typical adult dose?

**Answer**

0.99 g alcohol

20. D5W is a solution used as an intravenous fluid. It is a 5.0% by mass solution of dextrose  $\text{C}_6\text{H}_{12}\text{O}_6$  in water. If the density of D5W is 1.029 g/mL, how many grams of dextrose are needed to make 500.0 mL of solution?

**Answer**

26 g dextrose

#### 14.6: Molarity

21. What information do we need to calculate the molarity of a sulfuric acid solution?

**Answer**

We need to know the number of moles of sulfuric acid dissolved in the solution and the volume of the solution.

22. What does it mean when we say that a 200 mL sample and a 400 mL sample of a solution of salt have the same molarity? In what ways are the two samples identical? In what ways are these two samples different?

**Answer**

The two solutions have the same ratio of moles of solute to volume of solution. They have the same concentration. They are different because they have different volumes which results in the 400 mL solution have twice as much solute as the 200 mL solution.

23. Determine the molarity for each of the following solutions:
- 0.444 mol of  $\text{CoCl}_2$  in 0.654 L of solution
  - 98.0 g of phosphoric acid,  $\text{H}_3\text{PO}_4$ , in 1.00 L of solution
  - 0.2074 g of calcium hydroxide,  $\text{Ca}(\text{OH})_2$ , in 40.00 mL of solution
  - $7.0 \times 10^{-3}$  mol of  $\text{I}_2$  in 100.0 mL of solution
  - $1.8 \times 10^4$  mg of HCl in 0.075 L of solution

**Answer**

- 0.679 M
- 1.00 M
- 0.06998 M
- 0.070 M
- 6.6 M

24. Determine the molarity of each of the following solutions:
- 1.457 mol KCl in 1.500 L of solution
  - 0.515 g of  $\text{H}_2\text{SO}_4$  in 1.00 L of solution

- c. 20.54 g of  $\text{Al}(\text{NO}_3)_3$  in 1575 mL of solution
- d. 0.005653 mol of  $\text{Br}_2$  in 10.00 mL of solution
- e. 0.000889 g of glycine,  $\text{C}_2\text{H}_5\text{NO}_2$ , in 1.05 mL of solution

**Answer**

- a. 0.9713 M
- b.  $5.25 \times 10^{-3}$  M
- c. 0.06122 M
- d. 0.5653 M
- e. 0.0113 M

25. What mass of  $\text{FeCl}_2$  is present in 445 mL of 0.0812 M  $\text{FeCl}_2$  solution?

**Answer**

4.58 g

26. What mass of  $\text{SO}_2$  is present in 26.8 L of 1.22 M  $\text{SO}_2$  solution?

**Answer**

$2.09 \times 10^3$  g

27. What volume of 0.225 M  $\text{Ca}(\text{OH})_2$  solution is needed to deliver 100.0 g of  $\text{Ca}(\text{OH})_2$ ?

**Answer**

6.00 L

28. What volume of 12.0 M  $\text{HCl}$  solution is needed to obtain exactly 1.000 kg of  $\text{HCl}$ ?

**Answer**

2.29 L

29. What is the mass of the solute in 0.500 L of 0.30 M glucose,  $\text{C}_6\text{H}_{12}\text{O}_6$ , used for intravenous injection?

**Answer**

27 g

30. What is the mass of solute in 200.0 L of a 1.556 M solution of  $\text{KBr}$ ?

**Answer**

$3.703 \times 10^4$  g

31. Calculate the number of moles and the mass of the solute in each of the following solutions:

- a. 2.00 L of 18.5 M  $\text{H}_2\text{SO}_4$ , concentrated sulfuric acid
- b. 100.0 mL of  $3.8 \times 10^{-5}$  M  $\text{NaCN}$ , the minimum lethal concentration of sodium cyanide in blood serum

- c. 5.50 L of 13.3 M  $\text{H}_2\text{CO}$ , the formaldehyde used to “fix” tissue samples
- d. 325 mL of  $1.8 \times 10^{-6}$  M  $\text{FeSO}_4$ , the minimum concentration of iron sulfate detectable by taste in drinking water

**Answer**

- a. 37.0 mol;  $3.63 \times 10^3$  g
- b.  $3.8 \times 10^{-6}$  mol;  $1.9 \times 10^{-4}$  g
- c. 73.2 mol;  $2.20 \times 10^3$  g
- d.  $5.9 \times 10^{-7}$  mol;  $9.0 \times 10^{-5}$  g

32. Calculate the number of moles and the mass of the solute in each of the following solutions:

- a. 0.2500 L of 0.1135 M  $\text{K}_2\text{CrO}_4$ , an analytical reagent used in iron assays
- b. 10.5 L of 3.716 M  $(\text{NH}_4)_2\text{SO}_4$ , a liquid fertilizer
- c. 325 mL of  $8.23 \times 10^{-5}$  M KI, a source of iodine in the diet
- d. 75.0 mL of  $2.2 \times 10^{-5}$  M  $\text{H}_2\text{SO}_4$ , a sample of acid rain

**Answer**

- a. 0.02838 mol; 5.511 g
- b. 39.0 mol;  $5.15 \times 10^3$  g
- c.  $2.67 \times 10^{-5}$  mol;  $4.43 \times 10^{-3}$  g
- d.  $1.7 \times 10^{-6}$  mol;  $2.0 \times 10^{-4}$  g

33. What is the molarity of  $\text{KMnO}_4$  in a solution of 0.0908 g of  $\text{KMnO}_4$  in 0.500 L of solution?

**Answer**

$1.15 \times 10^{-3}$  M

34. What is the molarity of HCl if 35.23 mL of a solution of HCl contain 0.3366 g of HCl?

**Answer**

0.2621 M

35. Calculate the molarity of each of the following solutions:

- a. 0.195 g of cholesterol,  $\text{C}_{27}\text{H}_{46}\text{O}$ , in 0.100 L of serum, the average concentration of cholesterol in human serum
- b. 4.25 g of  $\text{NH}_3$  in 0.500 L of solution, the concentration of  $\text{NH}_3$  in household ammonia
- c. 1.49 kg of isopropyl alcohol,  $\text{C}_3\text{H}_7\text{OH}$ , in 2.50 L of solution, the concentration of isopropyl alcohol in rubbing alcohol
- d. 0.029 g of  $\text{I}_2$  in 0.100 L of solution, the solubility of  $\text{I}_2$  in water at 20 °C

**Answer**

- a.  $5.04 \times 10^{-3}$  M
- b. 0.499 M
- c. 9.92 M
- d.  $1.1 \times 10^{-3}$  M

36. Calculate the molarity of each of the following solutions:

- a. 293 g HCl in 666 mL of solution, a concentrated HCl solution
- b. 2.026 g  $\text{FeCl}_3$  in 0.1250 L of a solution used as an unknown in general chemistry laboratories
- c. 0.001 mg  $\text{Cd}^{2+}$  in 0.100 L, the maximum permissible concentration of cadmium in drinking water

d. 0.0079 g  $\text{C}_7\text{H}_5\text{SNO}_3$  in one ounce (29.6 mL), the concentration of saccharin in a diet soft drink

**Answer**

12.1 M

0.09993 M

$9 \times 10^{-8}$  M

$1.5 \times 10^{-3}$  M

37. There is about 1.0 g of calcium, as  $\text{Ca}^{2+}$ , in 1.0 L of milk. What is the molarity of  $\text{Ca}^{2+}$  in milk?

**Answer**

0.025 M

38. A 2.00-L bottle of a solution of concentrated HCl was purchased for the general chemistry laboratory. The solution contained 868.8 g of HCl. What is the molarity of the solution?

**Answer**

11.9 M

39. What volume of a 0.20 M  $\text{K}_2\text{SO}_4$  solution contains 57 g of  $\text{K}_2\text{SO}_4$ ?

**Answer**

1.6 L

#### 14.7: Solution Dilution

40. Explain what changes and what stays the same when 1.00 L of a solution of NaCl is diluted to 1.80 L.

**Answer**

The number of moles of NaCl remains the same. The volume of the solution increases.

41. What volume of a 1.00 M  $\text{Fe}(\text{NO}_3)_3$  solution can be diluted to prepare 1.00 L of a solution with a concentration of 0.250 M?

**Answer**

0.250 L

42. If 0.1718 L of a 0.3556 M  $\text{C}_3\text{H}_7\text{OH}$  solution is diluted to a concentration of 0.1222 M, what is the volume of the resulting solution?

**Answer**

0.4999 L

43. If 4.12 L of a 0.850 M  $\text{H}_3\text{PO}_4$  solution is be diluted to a volume of 10.00 L, what is the concentration the resulting solution?

**Answer**

0.350 M

44. What volume of a 0.33 M  $C_{12}H_{22}O_{11}$  solution can be diluted to prepare 25 mL of a solution with a concentration of 0.025 M?

**Answer**

1.9 mL

45. What is the concentration of the NaCl solution that results when 0.150 L of a 0.556 M solution is allowed to evaporate until the volume is reduced to 0.105 L?

**Answer**

0.794 M

46. What is the molarity of the diluted solution when each of the following solutions is diluted to the given final volume?

- a. 1.00 L of a 0.250 M solution of  $Fe(NO_3)_3$  is diluted to a final volume of 2.00 L
- b. 0.5000 L of a 0.1222 M solution of  $C_3H_7OH$  is diluted to a final volume of 1.250 L
- c. 2.35 L of a 0.350 M solution of  $H_3PO_4$  is diluted to a final volume of 4.00 L
- d. 22.50 mL of a 0.025 M solution of  $C_{12}H_{22}O_{11}$  is diluted to 100.0 mL

**Answer**

- a. 0.125 M
- b. 0.04888 M
- c. 0.206 M
- d.  $5.6 \times 10^{-3}$  M

47. What is the final concentration of the solution produced when 225.5 mL of a 0.09988 M solution of  $Na_2CO_3$  is allowed to evaporate until the solution volume is reduced to 45.00 mL?

**Answer**

0.5005 M

48. An experiment in a general chemistry laboratory calls for a 2.00 M solution of HCl. How many mL of 11.9 M HCl would be required to make 250 mL of 2.00 M HCl?

**Answer**

42.0 mL

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