Introduction to Solutions: Practice Questions

Read pages 264, 266-267 of Nelson Chemistry 11 and refer to your class notes (including the notes from the first unit) to answer the following questions:

1. Define the following terms:
a) matter, pure substance, mixture, element, compound, solution, mechanical mixture
b) aqueous solution, alloy
c) solvent, solute, homogeneous, heterogeneous, phase
d) electrolyte, non-electrolyte

2. Why is water known as the "universal solvent"? (page 264)

   Water is known as the universal solvent because most substances dissolve, at least a little bit, in water.

3. List six unwanted substances that are commonly dissolved in water supplies. (page 264)

   - **paints**
   - **cleaners**
   - **industrial waste**
   - **insecticides**
   - **fertilizers**
   - **road salt**

4. Explain why homogenized milk is not considered to be a solution. (page 266).

   Homogenized milk has been treated to break the fat up into tiny droplets so that it will stay evenly mixed in the milk. If you look at milk under a microscope, you can see that the fat droplets are separate from the watery part of the milk, they are not dissolved in the milk. Because milk has these two phases, it is not a solution. Also, if milk were a solution, it would be transparent because it is aqueous.

5. Are all solutions transparent? Give an example to defend your answer.

   No, not all solutions are transparent. Alloys such as sterling silver and brass are solid in solid solutions and they are opaque, not transparent. However, all aqueous solutions are transparent.

6. Are all aqueous solutions transparent? **Yes**.

7. Are all aqueous solutions colourless?

   No. Many aqueous solutions have lovely colours, for example, nickel (II) nitrate is green, copper (II) sulfate is blue and iron (III) nitrate is yellow.

8. What type of compounds are electrolytes? What type of compounds are non-electrolytes?

   Ionic compounds are electrolytes because they dissociate in water to form ions. Covalent compounds (molecular substances) are non-electrolytes.

9. Identify the solute(s) and solvent in each of the following solutions.

Solution	Solvent	Solute(s)
a) sterling silver (often stamped with the number 925) is an alloy of 92.5% silver and 7.5% copper	silver	copper
b) tincture of iodine is 3% solid iodine dissolved in 97% ethanol (alcohol)	ethanol	iodine
c) brass is 85% copper and 15% zinc	copper	zinc
d) "regular" gasoline is a mixture of 87% octane with other hydrocarbons	octane	other hydrocarbons
e) bronze can be made by melting together 80% copper and 20% tin	copper	tin
f) stainless steel is a homogeneous mixture of approximately 78% iron, 15% chromium and 7% nickel	iron	chromium nickel
g) air is 78% nitrogen, 20.9% oxygen and 1% trace gases (Ar, Ne, CH_4, CO_2, He etc)	nitrogen gas	oxygen, Ar, Ne, CH_4, CO_2, He etc
h) carbonated water is made by dissolving about 1.8 g of carbon dioxide in 1.0 L of water	water	carbon dioxide

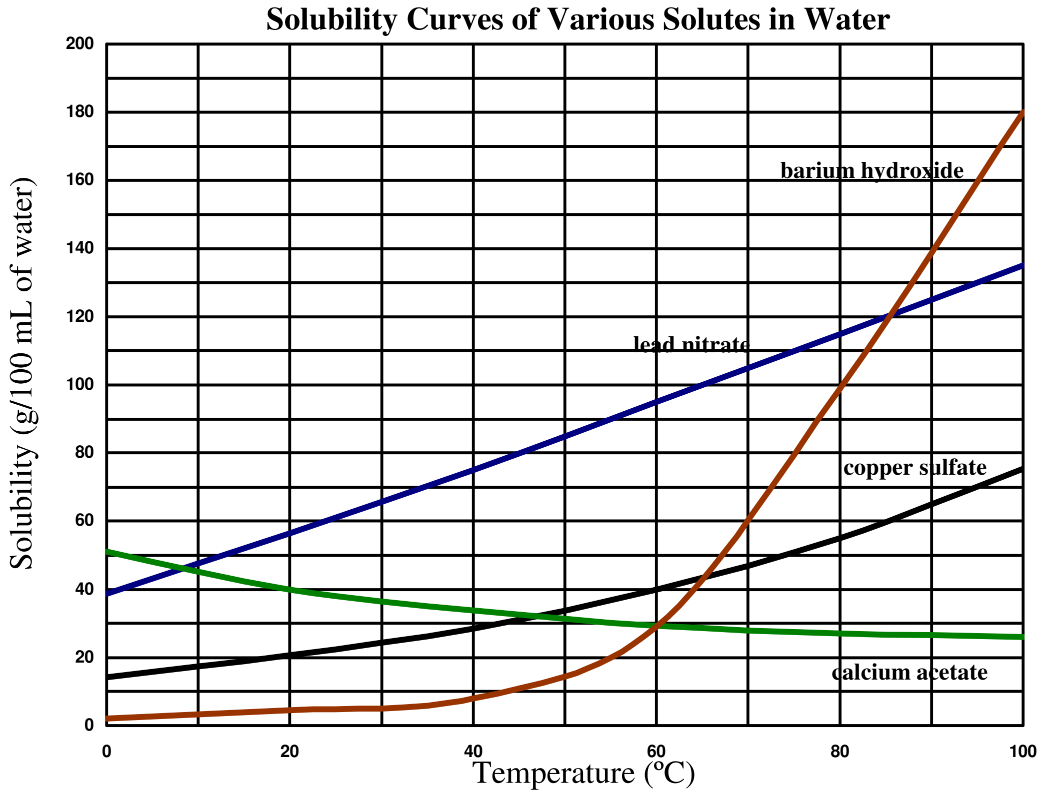
10. Answer questions 1, 2, 4, 5 and 6 on page 269. (Note: the text uses the term "molecular" to indicate a covalent compound)

Q1a) fresh squeezed orange juice- heterogeneous because of the pulp
b) white vinegar- homogeneous because it is transparent
c) red wine- heterogeneous because there is sediment in wine that settles out, and it is not transparent
d) antique bronze dagger- heterogeneous because you can see where the bronze has pitted and discoloured (different colours mean that there are different materials present)
e) a stainless steel knife- if the knife is all made of stainless steel, then it should be homogeneous because the whole knife should look the same
f) an old lead water pipe- heterogeneous because the pipe will be corroded and filled with deposits on the inside of the pipe
g) humid air- if the air is so humid that it looks foggy, then it is heterogeneous because the water is present as little droplets in the air. If the air is humid but still transparent, then it is homogeneous.
h) a cloud- heterogeneous because it is not transparent. Clouds contain water droplets, ice crystals and small bits of dirt, pollen and even salt crystals from the ocean.
i) a dirty puddle- heterogeneous because the dirt will settle out from the water with time.

Q2a) milk is not a solution because it is not transparent
b) apple juice is a solution if it is transparent. Fresh squeezed apple juice from a farm (fresh cider) is not a solution because it is not transparent
c) the gas in a helium balloon is homogeneous (it is air with helium, evenly mixed)
d) pop is homogeneous as long as it is sealed and there are no bubbles present. If you open the pop and the bubbles come out of solution, then it is no homogeneous
e) pure water is homogeneous
f) smoke filled air is heterogeneous because the particles of soot are not evenly mixed the colour of the smoke varies
g) silt-filled water is heterogeneous because the silt (fine particles of dirt and mud) will settle out of the water over time
h) rainwater is heterogeneous because it has tiny little bits of dirt and pollen in it (you can separate them from the water by filtering it)
i) 14K gold is homogeneous, it is an alloy so it is evenly mixed

Practice Questions: Solubility Curves

1. Define: concentration, dilute solution, concentrated solution, saturated solution, unsaturated solution, super-saturated solution, solubility.



2. From the solubility curves above, how many grams of copper (II) sulfate can dissolve in:

a) 100 mL of water at 40ºC: **29 g**

b) 50 mL of water at 80ºC: **27 or 28 g**

c) 10 mL of water at 100ºC: **7.5 g**

d) 250 mL of water at 60ºC: **100 g**

3. From the solubility curves above, how many grams of barium hydroxide can dissolve in:

a) 100 mL of water at 20ºC: **4 or 5 g**

b) 50 mL of water at 90ºC: **70 g**

c) 10 mL of water at 80ºC: **10 g**

d) 250 mL of water at 60ºC: **75 g**

4. From the solubility curves above, what is the minimum temperature required to dissolve:

a) 60 g of $Pb(NO_3)_2$ in 100 mL of water: **23 or 24 ºC**

b) 20 g of calcium acetate in 50 mL of water: **20 ºC**

c) 80 g of $CuSO_4$ in 200 mL water: **60ºC**

d) 35 g of $Ba(OH)_2$ in 25 mL water: **90 or 91ºC**

5. At what temperatures are the solubilities of the following substances equal?

a) copper (II) sulfate and barium hydroxide: **65 or 66ºC**

b) lead (II) nitrate and barium hydroxide: **86 ot 87ºC**

c) calcium acetate and lead (II) nitrate: **8 or 9 ºC**

d) calcium acetate and copper (II) sulfate: **47 ºC**

6. Are the following solutions saturated (S), unsaturated (U) or super-saturated (SS) at the temperatures below?

a) 100 g of lead nitrate in 100 mL water at 30ºC: **SS**

b) 20 g copper sulfate in 50 mL water at 80ºC: **U**

c) 15 g of $Ba(OH)_2$ in 25 mL water at 70ºC: **S**

d) 1 g of $Ca(CH_3COO)_2$ in 10 mL water at 90º: **U**

7. What is unusual about the solubility curve for calcium acetate? **Solubility of calcium acetate decreases at temperature increases. For most solids in solution, solubility increases with temperature**.

8. A hot solution of barium hydroxide contains 200 g of solute per 100 mL of water. The solution is cooled to 20^0C. What mass of solid will form as the solution is cooled?

There are 200 g of barium hydroxide in the solution, but at 20^0C the solution is saturated with 5 grams of barium hydroxide. So, if a seed crystal is added, (200 g – 5 g) = 195 g of solid will precipitate out.

Properties of Acids and Bases

Property	Acids	Bases
Arrhenius Definition	a substance which dissolves in water to produce H+ ions	a substance which dissolves in water to produce OH– ions
Examples	**HCl HI HF $HClO_3$ H_2SO_4 H_3PO_4**	**NaOH KOH NH_3 $NaHCO_3$ $Ca(OH)_2$ $Al(OH)_3$**
Produced by which type of element or oxide dissolving in water (metals or non-metals)	**non-metals**	**metals**
Which ion is responsible for their properties?	**H+**	**OH–**
Does the aqueous solution conduct electricity?	**Yes (acids are electrolytes)**	**Yes (bases are electrolytes)**
Taste	**sour**	**bitter**
Skin feel	**watery**	**slippery**
Colour with red or blue litmus paper	**red**	**blue**
Colour with phenolphthalein	**colourless**	**pink**
Colour with bromothymol blue	**yellow**	**blue**
Reaction with metals	**produce H_2 gas and a salt**	**no reaction**
Reaction with carbonates	**produce CO_2 gas, liquid water and a salt**	**no reaction**
pH	**less than 7.0**	**greater than 7.0**

Label the pH scale:

strong acids　　weak acids　　neutral　　weak bases　　strong bases

0　1　2　3　4　5　6　7　8　9　10　11　12　13　14

Reactions of Acids and Bases

Write **balanced** chemical equations for the reactions between the following substances. Include the states of all substances. Be sure that you can name all of the compounds from these equations.

1. $2\ HCl\ (aq) + 2\ Li\ (s) \rightarrow H_2\ (g) + 2\ LiCl\ (aq)$

2. $2\ HNO_3\ (aq) + Mg\ (s) \rightarrow H_2\ (g) + Mg(NO_3)_2\ (aq)$

3. $2\ HC_2H_3O_2\ (aq) + K_2CO_3\ (aq) \rightarrow H_2O\ (l) + CO_2\ (g) + 2\ KC_2H_3O_2\ (aq)$

4. $H_2SO_4\ (aq) + CaCO_3\ (s) \rightarrow H_2O\ (l) + CO_2\ (g) + CaSO_4\ (s)$

5. $KOH\ (aq) + HCl\ (aq) \rightarrow H_2O\ (l) + KCl\ (aq)$

6. $Ca(OH)_2\ (s) + H_2SO_4\ (aq) \rightarrow 2\ H_2O\ (l) + CaSO_4\ (s)$

7. nitrous acid + zinc metal

   $2\ HNO_2\ (aq) + Zn\ (s) \rightarrow H_2\ (g) + Zn(NO_2)_2\ (aq)$

8. acetic acid + ammonium hydroxide

   $HC_2H_3O_2\ (aq) + NH_4OH\ (aq) \rightarrow H_2O\ (l) + NH_4C_2H_3O_2\ (aq)$

9. hypobromous acid + aluminum metal

   $6\ HBrO\ (aq) + 2\ Al\ (s) \rightarrow 3\ H_2\ (g) + 2\ Al(BrO)_3\ (aq)$

10. ammonium hydroxide (aq) + hypophosphorous acid

    $3\ NH_4OH\ (aq) + H_3PO_3\ (aq) \rightarrow 3\ H_2O\ (l) + (NH_4)_3PO_3\ (aq)$

11. $2\ HBr\ (aq) + 2\ Na\ (s) \rightarrow H_2\ (g) + 2\ NaBr\ (aq)$

12. $HClO_4\ (aq) + LiOH\ (aq) \rightarrow H_2O\ (l) + LiClO_4\ (aq)$

13. $3\ HNO_3\ (aq) + Al(OH)_3\ (s) \rightarrow 3\ H_2O\ (l) + Al(NO_3)_3\ (aq)$

14. $H_2SO_3\ (aq) + MgCO_3\ (s) \rightarrow H_2O\ (l) + CO_2\ (g) + MgSO_3\ (s)$

Strength, Concentration and pH of Acids and Bases

1. Name the following acids, and then classify them as strong or weak and concentrated or dilute:

Concentration & Chemical Formula	Name of Acid	Strong or Weak?	Concentrated or Dilute?
3.0 M H_2CO_3	carbonic acid	weak	dilute
7.0 M HI	hydroiodic acid	strong	concentrated
12.0 M H_2SO_3	sulfurous acid	weak	concentrated
1.0 M $HBrO_3$	bromic acid	weak	dilute
15.0 M HCH_3COO	acetic acid	weak	concentrated
0.50M HI	hydroiodic acid	strong	dilute
6.0M HF	hydrofluoric acid	weak	concentrated
0.001M HNO_2	nitrous acid	weak	dilute

2. Name the following bases, and then classify them as strong or weak and concentrated or dilute:

Concentration & Chemical Formula	Name of Base	Strong or Weak?	Concentrated or Dilute?
2.0 M $Sr(OH)_2$	strontium hydroxide	strong	dilute
6.0M NH_4OH	ammonium hydroxide	weak	concentrated
9.0 M CaO	calcium oxide	strong	concentrated
0.10 M AgOH	silver hydroxide	weak	dilute
3.0 M LiOH	lithium hydroxide	strong	dilute
0.01 M $Sn(OH)_4$	tin (IV) hydroxide	weak	dilute
8.0 M Na_2O	sodium oxide	strong	concentrated
1.5 M $Ba(OH)_2$	barium hydroxide	strong	dilute

3. Circle the acid in each group which is the stronger electrolyte: (**stronger acid**)

a) H_2CO_3 or H_2SO_4
c) HCl or HClO
e) HBr or $HBrO_2$
b) HNO_3 or HNO_2
d) H_2SO_4 or H_2SO_3
f) HF or HI

4. Circle the base in each group which will have the higher pH: (**stronger base**)

a) NH_4OH or NaOH
c) SrO or SnO
e) Cr_2O_3 or Cs_2O
b) $Ca(OH)_2$ or $Cd(OH)_2$
d) AgOH or LiOH
f) H_2O or K_2O

5. Are the following bases soluble (aq) or insoluble (s) in water?

a) $Ca(OH)_2$: soluble (aq)
c) LiOH: soluble (aq)
e) $Al(OH)_3$: insoluble (s)
b) $Ni(OH)_3$: insoluble (s)
d) $Mn(OH)_2$: insoluble (s)
f) NH_4OH: soluble (aq)

6. Answer the following questions using the pH values for common substances in the chart:

a) The strongest base is: **oven cleaner**
b) The acid which will be the best conductor of electricity in solution is: **stomach acid**
c) Two (approximately) neutral substances: **milk** and **blood**
d) One substance that has ionized: **any of the acids**
e) One substance that will be blue with blue litmus paper : **any of the bases**
f) One substance that will be colourless with phenolphthalein: **any of the acids**
g) One weak acid: **tomato juice, dill pickles or lemon juice**

Window Cleaner	pH = 11
Lemon juice	pH = 2
Stomach acid (HCl)	pH = 1.5
Tomato juice	pH = 4.7
Oven cleaner (NaOH)	pH = 14
Dill pickles	pH = 3.3
Milk	pH = 6.6
Trisodium phosphate (TSP)	pH = 13
Sea water	pH = 8.4
Blood	pH = 7.4

Practice Questions: Concentrations of Acids and Bases

1. Calculate the volume of 15.0 M HNO_3 stock solution that is required to make 2.5 L of 1.25 M solution.
2. Calculate the mass of solid barium hydroxide that is needed to make 300.0 mL of 0.200 M solution.
3. 75.0 mL of 18.0 M sulfuric acid stock solution is diluted to make 1.00 L. What is the final concentration of this solution?
4. Calculate the final concentration of a solution that is made by dissolving 14.8 g of solid sodium hydroxide in 600.0 mL of solution.
5. 25.0 mL of 3.66 M ammonium hydroxide solution is diluted to make a final solution with a concentration of 1.50 M. What is the volume of the finished solution?
6. A biochemist needs a 0.0250 M solution of citric acid ($H_3C_6H_5O_7$) for an experiment. Citric acid is solid at SATP.

a) Is citric acid a strong or weak acid?

b) To what extent will citric acid ionize in water?

c) What mass of pure citric acid is required to make 680 mL of 0.0250 M solution?

7. Describe the steps that you would follow if you were making 500.0 mL of a 0.200 M solution of calcium hydroxide. Be complete.

Answers:

1. 210 mL of HNO_3 stock solution is needed (rounded from 208 mL, to 2 sig digs)
2. 10.3 g of $Ba(OH)_2$ required
3. 1.35 M is the final concentration
4. 0.617 M
5. 61.0 mL or 0.0610 L is the final volume

6a) weak

6b) it will only slightly ionize (it will be a weak electrolyte)

6c) 3.3 g of citric acid is needed (rounded from 3.266 g, to 2 sig digs)

7. Steps in making 500.0 mL of a 0.200 M $Ca(OH)_2$ solution:

- weigh out 7.41 g of solid $Ca(OH)_2$
- get a clean 500.0 mL volumetric flask, fill it about 2/3s with distilled water
- add the solid $Ca(OH)_2$ to the flask and swirl until it dissolves
- let the solution cool
- add distilled water until the bottom of the meniscus is just touching the etched line of the flask. Cover and mix.