Name: ______________________________ Date: ______________________________

**BCI SCIENCE**
**SCH 3U**

**Solutions and Solubility:**
**Unit Review**

**Definitions:**

Solution
Solvent
Solutes
Aqueous
Miscible
Immiscible
Alloys
Solubility
Saturated solution
Unsaturated solution
Rate of dissolving
Concentration
Hydronium ion
Conjugate acid-base pair
Conjugate base
Conjugate acid
Weak acid
Strong base
Weak base
Binary acid
Oxy acid
pH
Neutralization reaction
Acid-base indicator
Titration

1. What factors affect the rate of dissolving of a solid in a liquid?

2. Compare and contrast the Arrhenius and Bronsted-Lowry theories of acids and bases.

3. What is the molar concentration of the solution made by dissolving 1.00g of solid sodium nitrate, $NaNO_3$, in enough water to make 315mL of solution?

4. What volume of $4.00 \times 10^{-2}$ mol/L calcium nitrate solution, $Ca(NO_3)_{2(aq)}$ will contain $5.0 \times 10^{-2}$ mol of nitrate ions?

5. By the addition of water, 80.0 mL of 4.00 mol/L sulfuric acid, $H_2SO_4$, is diluted to 400.0 mL. What is the molar concentration of the sulfuric acid after dilution?

6. How many moles of NaOH are in 100.0 mL of 0.00100 mol/L NaOH solution?

7. What is the mass percent concentration of nicotine in the body of a 70kg person smokes a pack of cigarettes (20 cigarettes) in one day? Assume that there is 1.0 mg of nicotine per cigarette, and that all the nicotine is absorbed into the person's body.

8. Human blood serum contains about 3.4 g/L of sodium ions. What is the molar concentration of $Na^+$ in blood serum?

9. Name each of the following acids. Indicate whether each one is a strong or weak acid.
a) $H_2SO_{4(aq)}$ b) $HNO_{3(aq)}$ c)$HBr_{(aq)}$ d) $HCl_{(aq)}$ e) $HF_{(aq)}$

10. A sample of lemon juice was found to have a pH of 2.50. What is the concentration of hydronium ions in the lemon juice?

10. How many milliliters of sodium hydroxide solution are required to neutralize 20 mL of 1.0 mol/L acetic acid if 32 mL of the same sodium hydroxide solution neutralized 20 mL of 1.0 mol/L hydrochloric acid?

11. What is the pH of a $1.0 \times 10^{-5}$ mol/L $Ca(OH)_2$ (calcium hydroxide) solution?

12. What is the pH of a solution containing 2.5 g of NaOH dissolved in 100 mL of water?

13. For each of the following reactions, identify the acid, the base, the conjugate base, and the conjugate acid:
a) $HF_{(aq)} + NH_{3(aq)}$ . $NH_4^{+}{}_{(aq)} + F^{-}{}_{(aq)}$
b) $Fe(H_2O)_6^{3+}{}_{(aq)} + H_2O_{(l)}$ . $Fe(H_2O)_5(OH)_2^{+}{}_{(aq)} + H_3O^{+}$
c) $NH_4^{+}{}_{(aq)} + CN^{-}{}_{(aq)}$ . $HCN_{(aq)} + NH_{3(aq)}$
d) $(CH_3)_3N_{(aq)} + H_2O_{(l)}$ . $(CH_3)_3NH^{+}{}_{(aq)} + OH^{-}{}_{(aq)}$

14. A solution was prepared by mixing 70.0 mL of 4.00 mol/L $HCl_{(aq)}$ and 30.0 mL of 8.00 mol/L $HNO_{3(aq)}$. Water was then added until the final volume was 500 mL. Calculate $[H^+]$ and find the pH of the solution.

**Solutions & Solubility Sample Questions**

1. Calcium chloride, $CaCl_2$, can be used instead of road salt to melt the ice on roads during the winter. To determine how much calcium chloride had been used on a nearby road, a student took a sample of slush to analyze. The sample had a mass of 23.47g. When the solution was evaporated, the residue had a mass of 4.58g. What was the mass/mass percent of $CaCl_2$ in the slush (19.5%)

2. A fungus that grows on peanuts produces a deadly toxin. When ingested in large amounts, this toxin destroys the liver and can cause cancer. Any shipment of peanuts that contains more than 25 ppb of this dangerous fungus is rejected. A company receives 20 000 kg of peanuts to make peanut butter. What is the maximum mass (in g) of fungus that is allowed? (0.5g)

3. A saline solution contains 0.90g of NaCl dissolved in 100 ml of solution. What is the molar concentration of the solution? (0.15M)

4. For a class experiment, Mr. Arthur must make 2.0 L of 0.10 M sulfuric acid. This acid is usually sold as an 18 M concentrated solution. How much of the concentrated solution and how much water should be used to make a new solution with correct concentration? (0.011L, 1.89L)

5. A chemical reaction occurs when the following aqueous solutions are mixed: sodium sulfide and iron(II)sulfate. Identify the spectator ions. Then write the balanced net ionic equation.

6. Explain how, by using a single test, to identify a solution of an unknown concentration as being saturated, unsaturated, or supersaturated. In your answer make sure to fully explain the expected results of each possibility.

7. Mercury salts have a number of important uses in industry and in chemical analysis. Because mercury compounds are poisonous, however, the mercury ions must be removed from the wastewater. Suppose that 25.00 ml of 0.085 M aqueous sodium sulfide is added to 56.5 ml of 0.10 M mercury(II)nitrate. What mass of mercury(II)sulfide, $HgS_{(s)}$ precipitates? (0.493g)

8. Hydrogen cyanide is a poisonous gas at room temperature. When this gas dissolved in water, the following reaction occurs:

$$HCN_{(aq)} + H_2O_{(l)} \Rightarrow H_3O^+_{(aq)} + CN^-_{(aq)}$$

   Identify the conjugate acid-base pairs.

9. Calculate the pH of a solution with $[H_3O^+] = 3.8 \times 10^{-3}$ (2.42)

10. 13.84 ml of hydrochloric acid just neutralizes 25.00 ml of a 0.100 M solution of sodium hydroxide. What is the concentration of the hydrochloric acid? (0.1806M)

Other Things to Know:

- solubility terms
- solubility charts
- acids & bases chart
- saturated vs. unsaturated solutions
- how to make solutions
- steps of titration

# Solutions & Solubility Unit Review

3. $n_{NaNO_3} = \frac{m}{M}$

$= \frac{(1.00 g)}{(85.0 g/mol)}$

$\doteq 0.011765 \text{ mol } NaNO_3$

$C = \frac{n}{V}$

$= \frac{(0.011765 \text{ mol})}{(0.315 L)}$

$\doteq 0.037 M$

∴ the $[NaNO_3]$ is 0.037 M

4. $Ca(NO_3)_{2(aq)} \rightarrow Ca^{2+}{}_{(aq)} + 2NO_3^-{}_{(aq)}$

$n = 5.0 \times 10^{-2} \text{ mol}$

$\frac{2 \text{ mol } NO_3^-}{5.0 \times 10^{-2} \text{ mol}} = \frac{1 \text{ mol } Ca(NO_3)_2}{x}$

$x = 0.025 \text{ mol } Ca(NO_3)_2$

$V = \frac{n}{c}$

$= \frac{(0.025 \text{ mol})}{(4.00 \times 10^{-2} \text{ mol/L})}$

$= 0.625 L$

∴ 0.625 L of $Ca(NO_3)_2$ contains $5.0 \times 10^{-2}$ mol of $NO_3^-$

5. $C_1V_1 = C_2V_2$

$C_2 = \frac{C_1V_1}{V_2}$

$= \frac{(4.00 M)(0.080 L)}{(0.400 L)}$

$= 0.8 M$

∴ the $[H_2SO_4]$ is 0.8 M

6. $n = cV$

$= (0.00100 M)(0.100 L)$

$= 1.0 \times 10^{-4} \text{ mol } NaOH$

∴ there are $1.0 \times 10^{-4}$ mol of NaOH

7. $m/m\% = \dfrac{\text{mass of solute (g)}}{\text{mass of solution (g)}} \times 100$

$= \dfrac{(0.02\,g)}{(70000\,g)} \times 100$

$\doteq 2.86 \times 10^{-5}\ \%$

nic/day = nic./cig × cig/day
$= (0.001g) \times 20$
$= 0.02g$ nic

8. $n_{Na^+} = \dfrac{m}{M}$

$= \dfrac{(3.4\,g)}{(22.99\,g/mol)}$

$\doteq 0.1479$ mol $Na^+$

$C = \dfrac{n}{V}$

$= \dfrac{(0.1479\,mol)}{(1\,L)}$

$= 0.1479\,M$

∴ $[Na^+]$ is $0.1479\,M$

9. a) $H_2SO_4\,(aq)$ sulphuric acid

b) $HNO_3\,(aq)$ nitric acid

c) $HBr\,(aq)$ hydrobromic acid

d) $HCl\,(aq)$ hydrochloric acid

e) $HF\,(aq)$ hydrofluoric acid

10. a) $[H_3O^+] = 10^{-pH}$
$= 10^{-2.5}$
$\doteq 3.16 \times 10^{-3}\ M$
∴ the $[H_3O^+]$ is $3.16 \times 10^{-3}\,M$

10. b) $NaOH\,(aq) + HCl\,(aq) \longrightarrow H_2O\,(l) + NaCl\,(aq)$
$V = 0.032L$ | $V = 0.020L$, $C = 1.0M$

$n_{HCl} = CV$
$= (1.0M)(0.020L)$
$= 0.020$ mol HCl

$\dfrac{1\text{ mol HCl}}{0.020\text{ mol}} = \dfrac{1\text{ mol NaOH}}{x}$

$x = 0.020$ mol NaOH

$C = \dfrac{n}{V}$
$= \dfrac{(0.020\,mol)}{(0.032L)}$
$= 0.625M$

$V = \dfrac{n}{c}$
$= \dfrac{(0.020\text{[illegible]})}{(0.625\text{[illegible]})}$
$= 0.032L$

∴ 0.032L is required

11. $Ca(OH)_{2(aq)} \leftrightarrow Ca^{2+}{}_{(aq)} + 2OH^-{}_{(aq)}$

$C = 1.0 \times 10^{-5} M$ $\qquad$ $C = 2.0 \times 10^{-5} M$

$pOH = -\log[OH^-]$

$= -\log[2.0 \times 10^{-5}]$

$\doteq 4.70$

$pH = 14 - pOH$

$= 14 - 4.70$

$= 9.3$

$\therefore$ the pH of $Ca(OH)_2$ is 9.3

12. $n_{NaOH} = \frac{m}{M}$

$= \frac{(2.5g)}{(40.0 g/mol)}$

$= 0.0625 \text{ mol NaOH}$

$C = \frac{n}{V}$

$= \frac{(0.0625 mol)}{(0.100 L)}$

$= 0.625 M$

$pOH = -\log[OH^-]$

$= -\log[0.625]$

$\doteq 0.204$

$pH = 14 -$

$= 12.8$

$\therefore$ the pH is 12.8

13. a) $HF_{(aq)} + NH_{3(aq)} \rightarrow NH_4^+{}_{(aq)} + F^-{}_{(aq)}$

acid $\quad$ base $\quad$ conj acid $\quad$ conj base

b) $Fe(H_2O)_6^{3+}{}_{(aq)} + H_2O_{(l)} \rightarrow Fe(H_2O)_5(OH)_2^+{}_{(aq)} + H_3O^+{}_{(aq)}$

acid $\quad$ base $\quad$ conj base $\quad$ conj acid

c) $NH_4^+{}_{(aq)} + CN^-{}_{(aq)} \rightarrow HCN_{(aq)} + NH_3$

acid $\quad$ base $\quad$ conj acid $\quad$ conj base

13.d) $(CH_3)_3N_{(aq)} + H_2O_{(l)} \rightarrow (CH_3)_3NH^+_{(aq)} + OH^-_{(aq)}$
base acid conj acid conj base

14.
$HCl + H_2O \rightarrow H_3O^+ + Cl^-$

$n_{HCl} = CV$
$= (4.00M)(0.07L)$
$= 0.28$ mol HCl

$HNO_3 + H_2O \rightarrow H_3O^+ + NO_3^-$

$n_{HNO_3} = CV$
$= (8.00M)(0.030L)$
$= 0.24$ mol $HNO_3$

$\frac{1 \text{ mol } HCl}{0.28 \text{ mol}} \rightarrow \frac{1 \text{ mol } H_3O^+}{x}$
$x = 0.28$ mol $H_3O^+$

$\frac{1 \text{ mol } HNO_3}{0.24 \text{ mol}} = \frac{1 \text{ mol } H_3O^+}{x}$
$x = 0.24$ mol $H_3O^+$

$n_{H_3O^+ \text{ total}} = 0.28 + 0.24$
$= 0.52$ mol $H_3O^+$

$V_{total} = 0.070 + 0.030$
$= 0.100L$

$[H_3O^+] = \frac{n}{V}$
$= \frac{0.52 \text{ mol}}{0.100L}$
$= 5.2M$

$C_2 = \frac{C_1V_1}{V_2}$
$= \frac{(5.2M)(0.100L)}{(0.500)}$
$= 1.04M$

$pH = -\log[H_3O^+]$
$= -\log[1.04]$
$\doteq -0.017$
$\approx 0$

$\therefore$ the pH of the solution is 0.

# Solutions & Solubility Sample Questions



1. $$m/m\% = \frac{m_{solute}(g)}{m_{solution}(g)} \times 100$$

$$= \frac{(4.58g)}{(23.47g)} \times 100$$

$$\doteq 19.5\%$$

∴ the m/m% of $CaCl_2$ is 19.5%.

2. $$ppb = \frac{m_{solute}(g)}{m_{solution}(g)} \times 10^9$$

$$m_{solute} = \frac{ppb \times m_{solution}}{10^9}$$

$$= \frac{(25)(20000000)}{10^9}$$

$$= 0.5g$$

∴ 0.5g is the maximum mass allowed.

3. $$n_{NaCl} = \frac{m}{M}$$

$$= \frac{(0.90g)}{(58.44g/mol)}$$

$$\doteq 0.0154 \text{ mol NaCl}$$

$$c = \frac{n}{V}$$

$$= \frac{(0.0154mol)}{(0.100L)}$$

$$\doteq 0.15M$$

∴ the [NaCl] is 0.15M

4. $$V_1 = \frac{C_2 V_2}{C_1}$$

$$= \frac{(0.10M)(2.0L)}{(18M)}$$

$$= 0.0111L$$

$$V_{H_2O} = V_{total} - V_1$$

$$= 2.0 - 0.0111$$

$$= 1.989L \; H_2O$$

∴ Mr. Arthur needs 0.0111L of 18M $H_2SO_4$ & 1.989L of $H_2O$.

5. $Na_2S_{(aq)} + FeSO_{4(aq)} \rightarrow Na_2SO_{4(aq)} + FeS_{(s)}$

$\cancel{2Na^+_{(aq)}} + S^{2-}_{(aq)} + Fe^{2+}_{(aq)} + \cancel{SO_4^{2-}}_{(aq)} \rightarrow \cancel{2Na^+_{(aq)}} + \cancel{SO_4^{2-}}_{(aq)} + FeS_{(s)}$

spectator ions: $Na^+_{(aq)}$ & $SO_4^{2-}{}_{(aq)}$

$Fe^{2+}_{(aq)} + S^{2-}_{(aq)} \rightarrow FeS_{(s)}$

6. Add one crystal if it
- ↳ dissolves = unsaturated
- ↳ does not dissolve = saturated
- ↳ recrystallizes = supersaturated

7. $Na_2S_{(aq)} + Hg(NO_3)_{2(aq)} \rightarrow HgS_{(s)} + 2NaNO_{3(aq)}$

$Na_2S$: $V = 0.025L$, $C = 0.085M$
$Hg(NO_3)_2$: $V = 0.0565L$, $C = 0.10M$
$HgS$: $m = ?$

$n_{Na_2S} = CV$
$= (0.085)(0.025)$
$= 2.125\times10^{-3}$ mol

$n_{Hg(NO_3)_2} = CV$
$= (0.10)(0.0565)$
$= 5.65\times10^{-3}$ mol

$\frac{1 \text{ mol } Na_2S}{2.125\times10^{-3}} = \frac{1 \text{ mol } HgS}{x}$
L.R. $x = 2.125\times10^{-3}$ mol HgS

$\frac{1 \text{ mol } Hg(NO_3)_2}{5.65\times10^{-3}} = \frac{1 \text{ mol } HgS}{x}$
$x = 5.65\times10^{-3}$ mol HgS

$m_{HgS} = nM$
$= (2.125\times10^{-3})(232.65)$
$\doteq 0.493$ g

∴ 0.493 g of HgS is expected to precipitate

8. $HCN_{(aq)} + H_2O_{(l)} \leftrightarrow H_3O^+_{(aq)} + CN^-_{(aq)}$
acid — base — conj acid — conj base

9. $pH = -\log[H_3O^+]$
$= -\log[3.8\times10^{-3}]$
$= 2.42$ ∴ the pH of the solution is 2.42.

10. $HCl_{(aq)} + NaOH_{(aq)} \rightarrow NaCl_{(aq)} + H_2O_{(l)}$

$V = 0.01384L$ $\quad V = 0.025L$

$C = ?$ $\quad C = 0.100M$

$n_{NaOH} = CV$

$= (0.100M)(0.025L)$

$= 2.5 \times 10^{-3} mol\ NaOH$

$\frac{1\ mol\ NaOH}{2.5 \times 10^{-3} mol} = \frac{1\ mol\ HCl}{x}$

$x = 2.5 \times 10^{-3} mol\ HCl$

$C_{HCl} = \frac{n}{V}$

$= \frac{(2.5 \times 10^{-3})}{(0.01384L)}$

$\doteq 0.1806M$

$\therefore$ the [HCl] is 0.1806M.