**Problem Session 4: Chapters 15, 16, and 17**

# Directions: Answer each of the following questions. Be sure to use complete sentences where appropriate. For full credit be sure to show all of your work. Where appropriate answers should be boxed for clarity, written to the correct number of significant figures, and, include the proper units.

1. A typical air sample in the lungs contains oxygen at 100 mm Hg, nitrogen at 573 mm Hg, carbon dioxide at 40 mm Hg, and water vapor at 47 mm Hg. What is the total pressure of air in the lungs?

Poxygen = 100 mm Hg

Pnitrogen = 573 mm Hg

Pcarbon dioxide = 40 mm Hg

Pwater vapor = 47 mm Hg

Ptotal = P1 + P2 + …

Ptotal = Poxygen + Pnitrogen + Pcarbon dioxide + Pwater vapor

Ptotal = 100 mm Hg + 573 mm Hg + 40 mm Hg + 47 mm Hg = 760 mm Hg

1. A 35.20 g sample of metal is heated to 100.0 °C and is then placed in a calorimeter containing 42.5 g of water at 19.2 °C. If the final temperature of the metal and the water is 29.5 °C, what is the specific heat of the solid? Assume no heat loss; the specific heat of water is 4.184 J/g °C.

mmetal = 35.20 g mwater = 42.5 g

Ti metal = 100.0 °C Ti water = 19.2 °C

Tf metal = 29.5 °C Tf water = 29.5 °C

cmetal = ? cwater = 4.184 J/g °C

qin = - qout q = mc∆T

(mmetal)(cmetal)(∆Tmetal) = (mwater)(cwater)(∆Twater)

(35.20 g)(cmetal)(29.5 °C – 100.0 °C) = - (42.5 g)(4.184 J/g °C)(29.5 °C – 19.2 °C)

(35.20 g)(cmetal)(-70.5 ° C) = - (42.5 g)(4.184 J/g °C)(10.3 °C)

(-2481.6 g °C)(cmetal) = - 1831.546 J

cmetal = 0.738 J/g °C

1. Calculate the amount of heat in calories required to vaporize 2.00 g of acetone, C3H6O, at 25 °C. The heat of vaporization is 31.0 kJ/mol; the heat of fusion is 5.69 kJ/mol.

m = 2.00 g

T = 25 °C

∆Hvap = 31.0 kJ/mol

∆Hfus = 5.69 kJ/mol

q = m ∆H

$q=\left(2.00 g C\_{3}H\_{6}O\right)\left(31.0\frac{kJ}{mol C\_{3}H\_{6}O}\right)×\frac{1 mol C\_{3}H\_{6}O}{58.09 g C\_{3}H\_{6}O}×\frac{1000 J}{1 kJ}×\frac{1 cal}{4.184 J}=255 cal$

1. Identify each as an ionic, molecular, network or metallic solid.
	1. silicon dioxide, SiO2 network solid
	2. titanium tetrachloride, TiCl4 molecular solid
	3. cesium chloride ionic solid
2. Name the types of intermolecular forces for each molecule:
	1. ethanol, CH3CH2CH2OH London-dispersion forces, dipole forces, hydrogen bonding
	2. silicon dioxide, SiO2 London-dispersion forces
	3. carbon monoxide, CO London-dispersion forces, dipole forces
3. In hexane, C6H14, the intermolecular attraction is less than that in isopropyl alcohol, C3H7OH. Predict which liquid has the higher value for each of the following:
	1. vapor pressure hexane
	2. viscosity isopropyl alcohol
	3. boiling point isopropyl alcohol
	4. surface tension isopropyl alcohol
4. A tincture of iodine is prepared with 0.10 g I2 and 10.0 mL ethyl alcohol, density of ethyl alcohol solution is 1.064 g/mL. What is the solute, and what is the solvent?

 Solute: I2 Solvent: ethyl alcohol

1. Potassium nitrate has a solubility of 34 g KNO­3 in 100 g H2O at 20 °C. State if each of the following forms an unsaturated, saturated, or supersaturated solution.

34 g KNO3 and 200 g H2O unsaturated

$$\frac{34 g KNO\_{3}}{200 g H\_{2}O}= \frac{17 g KNO\_{3}}{100 g H\_{2}O}< \frac{34 g KNO\_{3}}{100 g H\_{2}O}$$

1.01 x 1023 molecules KNO3 and 50 g H2O saturated

$$\frac{1.01 × 10^{23}molecules KNO\_{3}}{50 g H\_{2}O}×\frac{1 mol KNO\_{3} }{6.02 ×10^{23} molecules KNO\_{3}}×\frac{101.11 g KNO\_{3}}{1 mol KNO\_{3}}=\frac{33.9 g KNO\_{3}}{100 g H\_{2}O}$$

$\frac{1.01 × 10^{23}molecules KNO\_{3}}{50 g H\_{2}O}×\frac{1 mol KNO\_{3} }{6.02 ×10^{23} molecules KNO\_{3}}×\frac{101.11 g KNO\_{3}}{1 mol KNO\_{3}}=\frac{33.9 g KNO\_{3}}{100 g KNO\_{3}}$

$$\frac{33.9 g KNO\_{3}}{100 g KNO\_{3}}≈ \frac{34 g KNO\_{3}}{100 g H\_{2}O}$$

1. Would the following pairs of liquids be miscible or immiscible?
	1. carbon tetrafluoride, CF4 and chloroform CHCl3 miscible
	2. carbon tetrafluoride, CF4, and water immiscible
2. What mass of solution containing 6.50% sodium sulfate, by mass contains 1.50g of sodium sulfate?

m/m% = 6.50 % Na2SO4

msolute = 1.50 g Na2SO4

msolution = ?

$$\frac{m}{m}\%=\frac{m\_{solute}}{m\_{solution}}×100\%⟹ m\_{solution}= \frac{m\_{solute}}{\frac{m}{m}\%}×100\%$$

$$m\_{solution}=\frac{1.50 g}{6.50\% }×100\%=23.1 g solution$$

1. A solution that contains 324.0 mg of acetic acid and 25.00 mL of solution.
	1. What is the molarity?

$$Molarity=M= \frac{moles solute}{Liters solution}$$

$$\frac{324.0 mg HC\_{2}H\_{3}O\_{2}}{25.00 mL solution}×\frac{1 mmol HC\_{2}H\_{3}O\_{2}}{60.06 mg HC\_{2}H\_{3}O\_{2}}=0.2158 M HC\_{2}H\_{3}O\_{2}$$

* 1. If 10.00 mL of the solution is diluted to 50.00 mL, what is the new molarity?

V1 = 10.0 mL

M1 = 0.2158 M HC2H3O2

V2 = 50.00 mL

M2 = ?

$$M\_{1}V\_{1}=M\_{2}V\_{2}⟹M\_{2}=M\_{1}\frac{V\_{1}}{V\_{2}}=\left(0.2158 M\right)\left(\frac{10.00 mL}{50.00 mL}\right)=0.04316 M HC\_{2}H\_{3}O\_{2}$$

1. What mass in gram of potassium sulfite is needed to prepare 150.00 mL of a solution that has a molarity of 0.250 M potassium ions?

$150.0 mL×\frac{1 L}{1000 mL}×\frac{0.250 mol K^{+}}{1 L soln}×\frac{1 mol K\_{2}SO\_{3}}{2 mol K^{+}}×\frac{158.26 g K\_{2}SO\_{3}}{1 mol K\_{2}SO\_{3}}=2.97 g K\_{2}SO\_{3}$

1. A solution is prepared with 70.0 g nitric acid and 130.0 g water. It has a density 1.21 g/mL.
	1. What is the mass percent of nitric acid solution?

$$\frac{m}{m}\%=\frac{m\_{solute}}{m\_{solution}}×100\%=\frac{m\_{solute}}{m\_{solute}+ m\_{solvent}}×100\%$$

$\frac{m}{m}\%=\frac{70.0 g HNO\_{3}}{70.0 g HNO\_{3}+130.0 g H\_{2}O}×100\%=\frac{70.0 g HNO\_{3}}{200.0 g soln}×100\%=35.0 \% HNO\_{3}$

* 1. What is its molarity?

$$\frac{35.0 g HNO\_{3}}{100 g soln}×\frac{1.21 g soln}{1 mL soln}×\frac{1000 mL}{1 L}×\frac{1 mol HNO\_{3} }{63.02 g HNO\_{3}}=6.72 M HNO\_{3}$$

1. A flask contains 47.5 mL of 0.150 M calcium hydroxide solution. How many liters of a 0.450 M sodium carbonate solution are required to completely react?

Ca(OH)2 (aq) + Na2CO3 (aq) → 2 NaOH (aq) + CaCO3 (s)

$$47.5 mL Ca(OH)\_{2} soln×\frac{0.150 mol Ca(OH)\_{2} }{1 L Ca(OH)\_{2} soln}×\frac{1 mol Na\_{2}CO\_{3}}{1 mol Ca(OH)\_{2}}×\frac{1 L Na\_{2}CO\_{3} soln }{0.450 mol Na\_{2}CO\_{3}}=15.8 mL Na\_{2}CO\_{3} soln$$

1. A 20.00 mL aliquot of a 0.1500 M nickel(II) chloride solution reacts with 25.00 mL aliquot of a 0.2000 M sodium hydroxide solution to produce solid nickel(II) hydroxide and aqueous sodium chloride.

NiCl2 (aq) + 2 NaOH (aq) → Ni(OH)2 (s) + 2 NaCl (aq)

Ni2+ (aq) + 2 Cl-(aq) + 2 Na+ (aq) + 2 OH- (aq) → Ni(OH)2 (s) + 2 Na+ (aq) + 2 Cl-(aq)

Ni2+ (aq) + 2 OH- (aq) → Ni(OH)2 (s)

I 0.003000 mol 0.005000 mol 0.00000 mol

C -x -2x +x

E 0.003000 mol – x = 0.00000 mol x = 0.002500 mol

 0.003000 mol – 0.002500 mol =

 0.000500 mol

$20.00 mL NiCl\_{2} soln×\frac{1 L}{1000 mL}×\frac{0.1500 mol NiCl\_{2} }{1 L NiCl\_{2} soln}×\frac{1 mol Ni^{2+}}{1 mol NiCl\_{2}}=0.003000 mol Ni^{2+} $

$$25.00 mL NaOH soln×\frac{1 L}{1000 mL}×\frac{0.2000 mol NaOH }{1 L NaOH soln}×\frac{1 mol OH^{-}}{1 mol NaOH}=0.005000 mol OH^{-}$$

$25.00 mL NaOH soln×\frac{1 L}{1000 mL}×\frac{0.2000 mol NaOH }{1 L NaOH soln}×\frac{2 mol OH^{-}}{1 mol NaOH}=0.005000 mol OH^{-}$Compare ratios

$$actual ratio= \frac{0.005000 mol OH^{-} }{0.003000 mol Ni^{2+}}=\frac{1.6667 mol OH^{-}}{1 mol Ni^{2+}}$$

$$theoretical ratio= \frac{2 mol OH^{-} }{1 mol Ni^{2+}}$$

$$So, \frac{1.66667 mol OH^{-}}{1 mol Ni^{2+}}<\frac{2 mol OH^{-} }{1 mol Ni^{2+}}, therefore OH^{-} is limiting$$

0.005000 mol – 2x = 0.00000 mol

0.005000 mol = 2x

0.002500 mol = x

1. How many grams of nickel(II) hydroxide are produced?

$$0.002500 mol Ni(OH)\_{2}×\frac{92.72 g Ni(OH)\_{2}}{1 mol Ni(OH)\_{2}}= 0.2318 g Ni(OH)\_{2}$$

1. What is the molarity of all ions that remain in the solution at the end of the reaction? Assume a 100% yield for nickel(II) hydroxide.

$20.00 mL NiCl\_{2} soln×\frac{0.1500 mmol NiCl\_{2} }{1 mL NiCl\_{2} soln}×\frac{2 mmol Cl^{-}}{1 mmol NiCl\_{2}}=\frac{6.000 mmol Cl^{-}}{20.00 mL+25.00 mL}=0.1333 M Cl^{-} $

$25.00 mL NaOH soln×\frac{0.2000 mmol NaOH }{1 mL NaOH soln}×\frac{1 mmol Na^{+}}{1 mmol NaOH}=\frac{5.000 mmol Na^{+}}{20.00 mL+25.00 mL}=0.1111 M Na^{+}$

$$\frac{0.000500 mol Ni^{2+}}{20.00 mL+25.00 mL}×\frac{1000 mL}{1 L}=0.0111 M Ni^{2+} $$

0.000 M OH-

1. If 23.45 mL of a 0.2345 M sodium phosphate solution is added to 56.00 mL of a 0.5643 M potassium sulfide solution.
	1. Write the balanced conventions, total and net ionic equations.

2 Na3PO4­ (aq) + 3 K2S (aq) → 2 K3PO4 (aq) + 3 Na2S (aq)

6 Na+ (aq) + 2 PO43- (aq) + 6 K+ (aq) + 3 S2- (aq) → 6 K+ (aq) + 2 PO43- (aq) + 6 Na+ (aq) + 3 S2- (aq)

No net ionic reaction, all ions are spectator ions.

* 1. What is the molarity of all of the ions that remain in the solution at the end of the reaction?

Vtotal = 23.45 mL + 56.00 mL = 79.45 mL

$23.45 mL Na\_{3}PO\_{4} soln×\frac{0.2345 mmol Na\_{3}PO\_{4} }{1 mL Na\_{3}PO\_{4} soln}×\frac{3 mmol Na^{+}}{1 mmol Na\_{3}PO\_{4}}=\frac{16.50 mmol Cl^{-}}{79.45 mL}=0.2076 M Na^{+} $

$23.45 mL Na\_{3}PO\_{4} soln×\frac{0.2345 mmol Na\_{3}PO\_{4} }{1 mL Na\_{3}PO\_{4} soln}×\frac{1 mmol PO\_{4}^{3-}}{1 mmol Na\_{3}PO\_{4}}=\frac{5.4990 mmol PO\_{4}^{3-}}{79.45 mL}=0.06921 M PO\_{4}^{3-} $ $56.00 mL K\_{2}S soln×\frac{0.5643 mmol K\_{2}S }{1 mL K\_{2}S soln}×\frac{2 mmol K^{+}}{1 mmol K\_{2}S}=\frac{63.20 mmol K^{+}}{79.45 mL}=0.7955 M K^{+}$

$$56.00 mL K\_{2}S soln×\frac{0.5643 mmol K\_{2}S }{1 mL K\_{2}S soln}×\frac{1 mmol S^{2-}}{1 mmol K\_{2}S}=\frac{31.60 mmol S^{2-}}{79.45 mL}=0.3978 M S^{2-}$$

1. A 355 mL sample of hydrochloric acid solution reacts with excess magnesium to produce 4.20 L hydrogen gas measured at 745 mm Hg and 35 °C. What is the molarity of the hydrochloric acid solution?

2 HCl (aq) + Mg (s) → H2 (g) + MgCl2 (aq)

VHCl = 355 mL

Vhydrogen gas = 4.20 L

Phydrogen gas = 745 mm Hg

T = 35 °C + 273 = 308 K

nhydrogen gas = ?

$$PV=nRT ⟹n=\frac{PV}{RT}=\frac{\left(745 mm Hg\right)(4.20 L)}{\left(0.0821 \frac{L atm}{mol K}\right)(308 K)}×\frac{1 atm}{760 mm Hg}=0.163 mol H\_{2}$$

$$0.163 mol H\_{2}×\frac{2 mol HCl}{1 mol H\_{2}}=\frac{0.326 mol HCl}{355 mL}×\frac{1000 mL}{1 L}=0.917 M HCl$$

1. Consider the reaction of potassium hydroxide and nitrous acid. Calculate the mL of 0.122 M potassium hydroxide required to neutralize 36.0 mL of 0.250 M nitrous acid.

KOH (aq) + HNO2 (aq) → KNO2 (aq) +H2O (l)

$36.0 mL HNO\_{2} soln×\frac{0.250 mmol HNO\_{2} }{1 mL HNO\_{2} soln}×\frac{1 mmol KOH}{1 mmol HNO\_{2}}×\frac{1 mL KOH soln}{0.122 mol KOH}=73.8 mL KOH soln$

1. For each reaction identify the acid, base, conjugate acid, and conjugate base.
	1. H2CO3 (aq) + H2O (l) $⇌$ H3O+(aq) + HCO3-

 acid base c.a. c.b.

* 1. HCN (aq) + NO2-(aq) $⇌$ CN-(aq) + HNO2 (aq)

 acid base c.b. c.a.

1. Name each acid. Then identify each acid as monoprotic, diprotic, or triprotic.
	1. H2S (aq) hyrosulfuric acid diprotic acid
	2. H2SO3 (aq) sulfurous acid diprotic acid
	3. H3PO4 (aq) phosphoric acid triprotic acid
2. Write the balanced chemical, total ionic, and net ionic equations for the following reactions:
	1. lead metal + perchloric acid →

Pb (s) + 2 HClO4 (aq) → H2 (g) + Pb(ClO4)2 (s)

Pb (s) + 2 H+ (aq) + 2 ClO4- (aq) → H2 (g) + Pb(ClO4)2 (s)

Pb (s) + 2 H+ (aq) + 2 ClO4- (aq) → H2 (g) + Pb(ClO4)2 (s)

* 1. nitric acid + lithium hydroxide →

HNO3 (aq) + LiOH (aq) → LiNO3 (aq) + H2O (l)

H+ (aq) + NO3- (aq) + Li+ (aq) + OH-­ (aq) → Li+ (aq) + NO3- (aq) + H2O (l)

H+ (aq) + OH- (aq) → H2O (l)

* 1. aqueous ammonia + hydrobromic acid →

NH3 (aq) + HBr (aq) →NH4Br (aq)

NH3 (aq) + H+ (aq) + Br- (aq) → NH4+ (aq) + Br- (aq)

NH3 (aq) + H+ (aq) →NH4+ (aq)

1. If 38.2 mL of 0.163 M potassium hydroxide react with 25.0 mL of 0.134 M sulfuric acid solution, how many grams of potassium sulfate can be formed?

2 KOH (aq) + H2SO4 (aq) → K2SO4 (aq) + 2 H2O (l)

2 K+ (aq) + 2 OH- (aq) + H+ (aq) + HSO4- (aq) → 2 K+ (aq) + SO42- (aq) + 2 H2O (l)

2 OH- (aq) + H+ (aq) + HSO4- (aq) → SO42- (aq) + 2 H2O (l)

I 6.23 mmol 3.35 mmol 3.35 mmol 0.00 mmol 0.00 mmol

C -2x -x -x +x +x

E 0.00 mmol 3.35 mmol – x = 3.35 mmol – x = x = 3.12 mmol x = 3.12 mmol

 3.35 mmol – 3.12 mmol = 3.35 mmol – 3.12 mmol =

 0.23 mmol 0.23 mmol

$$38.2 mL KOH soln×\frac{0.163 mmol KOH }{1 mL KOH soln}×\frac{1 mmol OH^{-}}{1 mmol KOH}=6.23 mmol OH^{-} $$

$$25.0 mL H\_{2}SO\_{4} soln×\frac{0.134 mmol H\_{2}SO\_{4} }{1 mL H\_{2}SO\_{4}H soln}×\frac{1 mmol H^{\mp }}{1 mmol H\_{2}SO\_{4}}=3.35 mmol H^{+}$$

$$25.0 mL H\_{2}SO\_{4} soln×\frac{0.134 mmol H\_{2}SO\_{4} }{1 mL H\_{2}SO\_{4}H soln}×\frac{1 mmol HSO\_{4}^{-}}{1 mmol H\_{2}SO\_{4}}=3.35 mmol HSO\_{4}^{-}$$

Compare ratios

$$actual ratio= \frac{6.23 mmol OH^{-} }{3.35 mmol H^{+}/HSO\_{4}^{-}}=\frac{1.86 mmol OH^{-}}{1 mmol H^{+}/HSO\_{4}^{-}}$$

$$theoretical ratio= \frac{2 mmol OH^{-} }{1 mol H^{+}/HSO\_{4}^{-}}$$

$$So, \frac{1.86 mol OH^{-}}{1 mol H^{+}/HSO\_{4}^{-}}<\frac{2 mol OH^{-} }{1 mol H^{+}/HSO\_{4}^{-}}, therefore OH^{-} is limiting$$

6.23 mmol OH – 2x = 0.00 mmol

6.23 mmol = 2x

3.12 mmol = x

$$3.12 mmol SO\_{4}^{2-}×\frac{1 mmol K\_{2}SO\_{4}}{1 mmol SO\_{4}^{2-}}×\frac{1 mol }{1000 mmol}×\frac{174.26 g K\_{2}SO\_{4}}{1 mol K\_{2}SO\_{4} }=0.544 g K\_{2}SO\_{4}$$

1. A vinegar solution has a [H3O+] of 2.0 x 10-3 M at 25 °C. What is the [OH-] of the vinegar solution? Is the solution acidic, basic, or neutral?

[H3O+] = 2.0 x 10-3 M

[OH-] = ?

$$K\_{w}=\left[H\_{3}O^{+}\right]\left[OH^{-}\right]⟹\left[OH^{-}\right]= \frac{K\_{w}}{[H\_{3}O^{+}]}=\frac{1.0×10^{-14}}{2.0×10^{-3}}=5.0×10^{-12} M$$

[H3O+] > [OH-], therefore the solution is acidic.

1. What is the pH and pOH of a solution prepared by dissolving 2.5 g hydrochloric acid, HCl, in water to make 425 mL of solution?

$$\frac{2.5 g HCl}{425 mL soln}×\frac{1000 mL}{1 L}×\frac{1 mol HCl}{36.46 g HCl}×\frac{1 mol H^{+}}{1 mol HCl}=0.16 M H^{+}$$

pH = - log[H+] = - log(0.16) = 0.792

pH + pOH = 14.000 → pOH = 14.000 – pH = 14.000 – 0.792 = 13.208