**UNIT 1**

**Chapter 1**

**1.** Label each as either a physical or a chemical property.

**(a)** The boiling point of water is 100°C.

**(b)** Chlorine gas reacts violently with sodium metal.

**(c)** Bromine has a brown colour.

**(d)** Sulfuric acid causes burns when it comes in contact with skin.

**2.** How many significant digits are in the following quantities?

**(a)** 624 students

**(b)** 22.40 mL of water

**(c)** 0.00786 g of platinum

**3.** Round off the following measured quantities to the number of significant digits specified.

**(a)** 9.276 103 m (2 significant digits)

**(b)** 87.45 g (3 significant digits)

**(c)** 93.951 kg (3 significant digits)

**4.** The masses of several samples of titanium were measured to be:

193.67g;

28.9 g;

78 g;

4.946 x10-1 kg.

These samples were all put into an overflow can together. The water displaced had a volume of

176.1 mL. What is the average density of the titanium pieces?

**5.** Characterize each of the following occurrences as a physical or as a chemical change.

**(a)** sugar is heated over a flame and caramelises (turns black)

**(b)** blood clots

**(c)** a rubber band is stretched until it snaps

**(d)** a match burns

**(e)** a grape is crushed

**(f)** salt is put on the roads in the winter, melting the ice.

**Chapter 2**

**6.** Draw Lewis structures to represent each of the following atoms.

**(a)** Mg

**(b)** K

**(c)** Ne

**(d)** B

**(e)** C

**(f)** Al

**7.** Draw Lewis structures to represent each of the following ions.

**(a)** H

**(b)** K

**(c)** F-

**(d)** S2

**(e)** Al3

**(f)** Br

**8.** Using only a periodic table (not the values for atomic radius), rank the following sets of atoms in order of increasing size.

**(a)** W, Cr, Mo

**(b)** As, Ca, K

**(c)** I, Cl, F, Br

**(d)** Cl, P, Mg

**(e)** Zn, Cd, Hg

**9.** Using only a periodic table (not the values for ionization energy), rank the following sets of atoms in order of increasing ionization energy.

**(a)** Ar, Xe, Ne

**(b)** P, Al, Cl

**(c)** Rb, Li, K

**(d)** Mg, Be, Ca

**Chapter 3**

**10.** Predict whether each of the following bonds has a primarily ionic or covalent character.

**(a)** BF

**(b)** CH

**(c)** NaCl

**(d)** SiO

**11.** Draw Lewis structures representing the following ionic compounds.

**(a)** KBr

**(b)** CaO

**(c)** MgCl2

**(d)** Mg3N2

**12.** Draw Lewis structures to represent the following covalent compounds.

**(a)** F2

**(b)** CH4

**(c)** CO2

**(d)** CO

**(e)** NO

**(f)** N2

**13.** For the previous problem, indicate any polar covalent bonds with a partial negative or positive charge on the appropriate atom.

**14.** Name each of the following ionic compounds.

**(a)** MgCl2

**(b)** Na2O

**(c)** FeCl3

**(d)** CuO

**(e)** AlBr3

**15.** Write the chemical formula for each of the following

compounds.

**(a)** aluminum bromide

**(b)** magnesium oxide

**(c)** sodium sulfide

**(d)** iron(II) oxide

**(e)** copper(II) chloride

**16.** Write the formula for each of the following.

**(a)** sodium hydrogen carbonate

**(b)** potassium dichromate

**(c)** sodium hypochlorite

**(d)** lithium hydroxide

**(e)** potassium permanganate

**17.** Name each of the following compounds.

**(a)** K2CrO4

**(b)** NH4NO3

**(c)** Na2SO4

**(d)** KH2PO4

**(e)** Sr3(PO4)2

**18.** Name each of the following covalent compounds.

**(a)** Cl2O7

**(b)** H2O

**(c)** BF3

**(d)** N2O4

**(e)** N2O

**19.** Write the formula for each of the following compounds.

**(a)** tetraphosphorus decoxide

**(b)** nitrogen trichloride

**(c)** sulfur tetrafluoride

**(d)** xenon hexafluoride

**Chapter 4**

**20.** Balance each of the following skeleton equations. Classify each chemical reaction.

**(a)** Fe Cl2 → FeCl2

**(b)** FeCl2 Cl2 → FeCl3

**(c)** C4H10O O2 → CO2 H2O

**(d)** Al H2SO4 → Al2(SO4)3 H2

**(e)** N2O5 H2O → HNO3

**(f)** (NH4)2CO3 → NH3 CO2 H2O

**21.** Write the product(s) of each of the following chemical reactions. Also, identify the reaction type. In the case of no reaction, state NR.

**(a)** MgCO3(s) →

(The magnesium carbonate is heated.)

**(b)** Ca(s) Cl2(g) →

**(c)** NH4CO3(aq) KOH(aq) →

(Group I ions, hydrogen ions, and ammonium ions always form soluble ionic compounds.)

**(d)** I2(aq) KBr(aq) →

**(e)** Na2CO3(aq) MgCl2(aq) →

(Carbonate compounds form precipitates except when they contain ions from Group I, hydrogen,

or ammonium. Group I ions form soluble ionic compounds.)

**(f)** K(s) O2(g) →

**22.** Balance the following chemical equation.

BiCl3 NH3 H2O → Bi(OH)3 NH4Cl

**23.** Balance the equation.

NiSO4 NH3 H2O → Ni(NH3)6(OH)2 (NH4)2SO4

**24.** Complete and balance if necessary, each of the following nuclear equations.

**(a)** 237U92 → 0e-1 

**(b)** 231Th90 → 231Pa91 

**(c)** 215Po84 → 4He2 

**25.** Write a balanced nuclear equation for each of the following.

**(a)** Radon-233 decays with the emission of an alpha particle.

**(b)** Actinium-228 decays with the emission of a beta particle.

**26.** Complete and balance each of the following nuclear equations.

**(a)** 23Na11  → 23Mg12 1n0

**(b)** 96Mo42 4He2 → 100Tc43 

**(c)** 1H1 → 29Si14 0λ0

**(d)** 209Bi83  → 210Po84 1n0

**UNIT 2**

**Chapter 5**

**27.** Gallium exists as two isotopes, Ga-69 and Ga-71.

**(a)** How many protons and neutrons are in each isotope?

**(b)** If Ga-69 exists in 60.0relative abundance, estimate the average atomic mass of gallium using the mass numbers of the isotopes.

**28.** Rubidium exists as two isotopes: Rb-85 has a mass of 84.9117 u and Rb-87 has a mass of 86.9085 u. If the average atomic mass of rubidium is 85.4678, determine the relative abundance of each isotope.

**29.** Calculate the molar mass of each of the following compounds.

**(a)** Al2(CrO4)3

**(b)** C4H9SiCl3 (n-butyltrichlorosilane, an intermediate in the synthesis of silicones)

**(c)** Cd(ClO3)2 ・ 2H2O (cadmium chlorate dihydrate, an oxidizing agent)

**30.** How many atoms are contained in 3.49 moles of manganese?

**31.** How many atoms are there in 8.56 g of sodium?

**32.** What is the mass of 5.67 x1023 molecules of pentane, C5H12?

**33.** Consider a 23.9 g sample of ammonium carbonate, (NH4)2CO3.

**(a)** How many moles are in this sample?

**(b)** How many formula units are in this sample?

**(c)** How many atoms are in this sample?

**Chapter 6**

**34.** Pyridine, C5H5N, is a slightly yellow liquid with a nauseating odour. It is flammable and toxic by ingestion and inhalation. Pyridine is used in the synthesis of vitamins and drugs, and has many other uses in industrial chemistry. Determine the percentage composition of pyridine.

**35.** Bromine azide is an explosive compound that is composed of bromine and nitrogen. A sample of bromine azide was found to contain 2.35 g Br and 1.24 g N.

**(a)** Calculate the percentage by mass of Br and N in bromine azide.

**(b)** Calculate the empirical formula of bromine azide.

**(c)** The molar mass of bromine azide is 122 g/mol. Determine its molecular formula.

**36.** Progesterone is a female hormone. It is 80.2% C, 9.62H and 10.2O by mass.

**(a)** Determine the empirical formula of progesterone.

**(b)** From the given data, is it possible to determine the molecular formula of progesterone? Explain your answer.

**37.** Potassium tartrate is a colourless, crystalline solid. It is 34.6K, 21.1C, 1.78H, 42.4O by mass.

**(a)** Calculate the empirical formula of potassium tartrate.

**(b)** If the molar mass of potassium tartrate is 226 g/mol, what is the molecular formula of

potassium tartrate?

**38.** Menthol is a compound that contains C, H and O. It is derived from peppermint oil and is used in cough drops and chest rubs. When 0.2393 g of menthol is subjected to carbon-hydrogen combustion analysis, 0.6735 g of CO2 and 0.2760 g of H2O are obtained.

**(a)** Determine the empirical formula of menthol.

**(b)** If each menthol molecule contains one oxygen atom, what is the molecular formula of menthol?

**39.** Glycerol, C3H8O3, also known as glycerin, is used in products that claim to protect and soften skin. Glycerol can be purchased at the drug store. If 0.784 g of glycerol is placed in a carbon-hydrogen combustion analyzer, what mass of CO2 and H2O will be expected?

**40.** Calculate the percentage by mass of water in potassium sulfite dihydrate, K2SO3 ・(2H2O).

**41.** What mass of water is present in 24.7 g of cobaltous nitrate hexahydrate, Co(NO3)2・6H2O?

**42.** A chemist requires 1.28 g of sodium hypochlorite, NaOCl, to carry out an experiment, but only has sodium hypochlorite pentahydrate, NaOCl・(5H2O) in the lab. How many grams of the hydrate should the chemist use?

**Chapter 7**

**43.** Consider the equation corresponding to the decomposition of mercuric oxide.

2HgO(s) → 2Hg(l) O2(g)

What mass of liquid mercury is produced when 5.79 g of mercuric oxide decomposes?

**44.** Examine the following equation.

C3H8(g) 5 O2(g) → 3 CO2(g) 4 H2O(g)

**(a)** What mass of propane, C3H8, reacting with excess oxygen, is required to produce 26.7 g of carbon dioxide gas?

**(b)** How many oxygen molecules are required to react with 26.7 g of propane?

**45.** Metal hydrides, such as strontium hydride, SrH2, react with water to form hydrogen gas and the corresponding metal hydroxide. SrH2(s) 2H2O(l) → Sr(OH)2(s) 2H2(g)

**(a)** When 2.50 g of SrH2 is reacted with 8.03 x1022 molecules of water, what is the limiting reagent?

**(b)** What mass of strontium hydroxide will be produced?

**46.** Consider the following successive reactions.

reaction (1): A → B

reaction (2): B → C

If reaction (1) proceeds with a 45yield and reaction (2) has a 70yield, what is the overall

yield for the reactions that convert A to C?

**47.** Disposable cigarette lighters contain liquid butane, C4H10. Butane undergoes complete combustion to carbon dioxide gas and water vapour according to the skeleton equation below:

C4H10(l) O2(g) → CO2(g) H2O(l)

A particular lighter contains 5.00 mL of butane, which has a density of 0.579 g/mL.

**(a)** How many grams of O2 are required to combust all of the butane?

**(b)** How many molecules of water will be produced?

**(c)** Air contains 21.0O2 by volume. What mass of air is required to combust 5.00 mL of butane?

**48.** If the following reaction proceeds with a 75yield, how much diborane, B2H6, will be produced when 23.5 g of sodium borohydride, NaBH4 reacts with 50.0 g of boron trifluoride, BF3?

NaBH4(s) BF3(g) → B2H6(g) NaBH4(s)

**UNIT 3**

**Chapter 8**

**49.** What is the molar concentration of the solution made by dissolving 1.00 g of solid sodium nitrate, NaNO3, in enough water to make 315 mL of solution?

**50.** What volume of 4.00x102 mol/L calcium nitrate solution, Ca(NO3)2(aq) will contain 5.0 x 10-2 mol of nitrate ions?

**51.** By the addition of water, 80.0 mL of 4.00 mol/L sulfuric acid, H2SO4, is diluted to 400.0 mL. What is the molar concentration of the sulfuric acid after dilution?

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

**53.** If a burette delivers 20 drops of solution per 1.0 mL, how many moles of HCl(aq) are in one drop of a 0.20 mol/L HCl solution?

**54.** Human blood serum contains about 3.4 g/L of sodium ions. What is the molar concentration of Nain blood serum?

**Chapter 9**

**55.** Write the net ionic equation for the reaction between aqueous solutions of barium chloride and sodium sulfate. Be sure to include the state of each reactant and product.

**57.** Write the net ionic equation for the reaction between aqueous sodium hydroxide and aqueous nitric acid. Be sure to include the state of each reactant and product.

**58.** What are the spectator ions when solutions of Na2SO4 and Pb(NO3)2 are mixed?

**59.** Iron(II) sulfate reacts with potassium hydroxide in aqueous solution to form a precipitate.

**(a)** What is the net ionic equation for this reaction?

**(b)** Which ions are spectator ions?

**60.** Write the balanced molecular and net-ionic equations for the following reactions:

**(a)** Na3PO4(aq) Ca(OH)2(aq) → NaOH(aq) Ca3(PO4)2(s)

**(b)** Zn(s) Fe2(SO4)3(aq) → ZnSO4(aq) Fe(s)

**Chapter 10**

**61.** Name each of the following acids. Indicate whether each one is a strong or weak acid.

**(a)** H2SO4(aq)

**(b)** HNO3(aq)

**(c)** HBr(aq)

**(d)** HCl(aq)

**(e)** HF(aq)

**62.** 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?

**63.** How many millilitres 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?

**64.** What are the concentrations of hydrogen ions and hydroxide ions in a solution that has a pH of 5?

**65.** What is the pH of a 1.0 x10-5 mol/L Ca(OH)2 (calcium hydroxide) solution?

**66.** How many moles of calcium hydroxide will be neutralized by one mole of hydrochloric acid, according to the following equation?

Ca(OH)2(s) 2HCl(aq) → CaCl2(aq) 2H2O(l)

**67.** In an experiment, 50.0 mL of 0.0800 mol/L NaOH is titrated by the addition of 0.0500 mol/L HNO3. What is the hydroxide ion concentration after 30.0 mL of HNO3 solution has been added?

**68.** A100 mL volume of 0.200 mol/L HCl was placed in a flask. What volume of 0.400 mol/L NaOH solution must be added to bring the solution to a pH of 7.0?

**69.** What is the pH of a solution in which 2.0 x104 mol of HCl is dissolved in enough distilled water to make 300 mL of solution?

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

**71.** For each of the following reactions, identify the acid, the base, the conjugate base, and the conjugate acid:

**(a)** HF(aq) NH3(aq) → NH4(aq) F-(aq)

**(b)** Fe(H2O)6 3(aq) H2O(l) → Fe(H2O)5(OH)2 (aq) H3O(aq)

**(c)** NH4 (aq) CN-(aq) → HCN(aq) NH3(aq)

**(d)** (CH3)3N(aq) H2O(l) → (CH3)3NH(aq) OH-(aq)

**72.** A solution was prepared by mixing 70.0 mL of 4.00 mo/L HCl(aq) and 30.0 mL of 8.00 mol/L HNO3(aq). Water was then added until the final volume was 500 mL. Calculate [H] and find the pH of the solution.

**UNIT 4**

**Chapter 11**

**73.** The gas in a large balloon occupies 30.0 L at a pressure of 300 kPa. If the temperature is kept constant at 300 K, what volume will the balloon be at a pressure of 1200 kPa?

**74.** A gas occupies a 2.0 L container at 25°C and 300 kPa pressure. If the gas is transferred to a 3.0 L container at the same temperature, what will be the new pressure?

**75.** If the volume of a given amount of gas is tripled while the temperature remains constant, what will be the new pressure of the gas, relative to the initial pressure?

**76.** To what temperature must an ideal gas at 27°C be cooled to reduce its volume by one third? In other words, the new volume will be 23 the original volume.

**77.** If 2.0 L of gas in a piston at 400 K is expanded to 3.0 L while keeping the pressure constant, what is the final temperature of the gas in kelvins?

**78.** If a certain mass of gas occupies 55 cm3 at 303 K and 780 mm Hg, what is its volume in L at SATP?

**79.** If 1.00 L of helium gas at 20°C and 100 kPa is forced into a 250 mL container and subjected to a pressure of 400.0 kPa, what will be the new temperature of the gas?

**80.** A mixture of gases contains equal masses of H2, O2 and CH4. If the partial pressure of CH4 is 80 kPa, what is the partial pressure of H2?

**81.** The gases inside a balloon exerted a total pressure of 150.0 kPa on the walls of the balloon. Seventy-five percent of the gas was nitrogen and twelve percent was oxygen. There was also some water vapour, which exerted a pressure of 2.4 kPa and some carbon dioxide. Calculate the pressure exerted by the CO2 gas.

**Chapter 12**

**82.** A container holds one mole of gaseous neon at a certain temperature and pressure. A second, identical container holds gaseous nitrogen at three times the pressure and twice the temperature (in kelvins). How many moles of neon are in the second container?

**83.** If the mass of a gas is tripled and the pressure is quadrupled while the temperature is constant, by what factor will the volume of the gas change?

**84.** A cylinder with a volume of 25.0 L contains carbon dioxide at a pressure of 120 kPa and a temperature of 25°C. How much carbon dioxide is in the cylinder?

**85.** One litre of a certain gas has a mass of 2.05 g at SATP. What is the molar mass of this gas?

**86.** What amount of gas is contained in a 10.0 L flask at a pressure of 180 kPa and a temperature of 300 K?

**87.** When a spark ignites a mixture of hydrogen gas and oxygen gas, water vapour is formed. What mass of oxygen gas would be required to react completely with 1.00 g of hydrogen?

**88.** A student collected 375 mL of oxygen gas from the decomposition of hydrogen peroxide. The gas was collected over water at 19°C and 100.2 kPa. What mass of oxygen was collected? The vapour pressure of water at 19°C is 2.2 kPa.

**89.** Examine the reaction below and answer the following questions.

C7H16(g) 11O2(g) → 7CO2(g) 8H2O(g)

**(a)** if 10.0 L of C7H16(g) are burned, what volume of oxygen gas, measured at the same temperature and pressure, is required?

**(b)** if 200 g of CO2 are formed, what mass of C7H16(g) was burned?

**(c)** if 200 L of CO2 are formed, measured at STP, what mass of oxygen was consumed?