Please see me by June 21, 2019 if you want a textbook for the summer.

2019 AP Chemistry Summer Problem Set

You are to complete the following problem set prior to the first day of class in September. I will collect your answers, which should be done on separate pages because there is not enough room in this question set unless you reprint them with much more space.

The difficulty of the problems varies, so don't be surprised if you are challenged by several of them. Do give them all a good try, though. I would estimate that this problem set should take you from 15 to 20 hours, so please do not leave it for the last day before school.

I have textbooks (Chemistry, The Central Science, 12th edition by Brown, et al.). Check a copy out from me or use other resources such as review books, your Regents reference tables, borrowed or purchased used college or high school text books, the internet, and other technical references. Please also feel free to contact me during the summer if you get stuck or have questions. My e-mail address is rsaar@briarcliffschools.org.

1. **Memorize** the names, formulas and charges for the common **anions**. Aside from the following table, you can make use of Regents Reference Table E.

Formula	Ion Name	Formula	Ion Name	Formula	Ion Name
		-1 Charge			
H^-	hydride	N_3^-	azide	ClO^-	hypochlorite
F^-	fluoride	CN^-	cyanide	ClO_2^-	chlorite
Cl^-	chloride	OH^-	hydroxide	ClO_3^-	chlorate
Br^-	bromide	$C_2H_3O_2^-$	acetate	ClO_4^-	perchlorate
I^-	iodide	$H_2PO_4^-$	dihydrogen phosphate	SCN^-	thiocyanate
NO_2^-	nitrite	HCO_3^-	hydrogen carbonate	HSO_4^-	hydrogen sulfate
NO_3^-	nitrate				
MnO_4^-	permanganate				
		-2 Charge			
O^{2-}	oxide	CO_3^{2-}	carbonate	SO_4^{2-}	sulfate
O_2^{2-}	peroxide	CrO_4^{2-}	chromate	$C_2O_4^{2-}$	oxalate
S^{2-}	sulfide	$Cr_2O_7^{2-}$	dichromate	HPO_4^{2-}	hydrogen phosphate
$S_2O_3^{2-}$	thiosulfate	SO_3^{2-}	sulfite		
		-3 Charge			
N^{3-}	nitride	P^{3-}	phosphide	PO_4^{3-}	phosphate

2. **Memorize** the names, formulas and charges for the common **cations**. Aside from the following table, you can make use of Regents Reference Table E.

Formula	Ion Name	Formula	Ion Name	Formula	Ion Name
+1 Charge					
H^+ Li^+ Na^+	hydrogen lithium sodium	K^+ Cs^+ Ag^+	potassium cesium silver	NH_4^+ H_3O^+ Cu^+	ammonium hydronium copper(I) or cuprous
+2 Charge					
Mg^{2+} Ca^{2+} Sr^{2+} Ba^{2+} Pb^{2+}	magnesium calcium strontium barium lead(II) or plumbous	Zn^{2+} Cd^{2+} Sn^{2+} Co^{2+} Ni^{2+}	zinc cadmium tin(II) or stannous cobalt(II) or cobaltous nickel	Cu^{2+} Fe^{2+} Hg_2^{2+} Hg^{2+} Mn^{2+}	copper(II) or cupric iron(II) or ferrous mercury(I) mercury(II) manganese
+3 Charge					
Al^{3+}	aluminum	Fe^{3+}	iron(III) or ferric		

3. **Memorize** the solubility rules for compounds that are **soluble**. Aside from the following table, you can make use of Regents Reference Table F.

Soluble Compounds Contain:	**Exceptions**
most common acids	-
Group 1 Metals (Li^+, Na^+, K^+, Rb^+, Cs^+)	none
ammonium (NH_4^+)	none
nitrate (NO_3^-)	none
acetate ($C_2H_3O_2^-$)	$AgC_2H_3O_2$ is only slightly soluble
chlorate (ClO_3^-)	none
perchlorate (ClO_4^-)	none
hydrogen carbonate (HCO_3^-)	none
halides (F^-, Cl^-, Br^-, I^-)	Ag^+, Pb^{2+}, Hg_2^{2+} and CaF_2
sulfates (SO_4^{2-})	Ag^+, Pb^{2+}, Hg_2^{2+}, Ca^{2+}, Ba^{2+}, Sr^{2+}

4. **Memorize** the solubility rules for compounds that are **insoluble**. Aside from the following table, you can make use of Regents Reference Table F.

Insoluble Compounds Contain:	Exceptions
carbonates (CO_3^{2-})	Group 1 metals, ammonium, dilute acids
oxides (O^{2-})	Group 1 metals, ammonium, dilute acids
phosphates (PO_4^{3-})	Group 1 metals, ammonium, dilute acids
sulfides (S^{2-})	Group 1 metals, ammonium
sulfites (SO_3^{2-})	Group 1 metals, ammonium, dilute acids
hydroxides (OH^-)	Group 1 metals, ammonium, dilute acids, Ca^{2+}, Ba^{2+}, Sr^{2+}
chromates (CrO_4^{2-})	Group 1 metals, ammonium, dilute acids, Ca^{2+}, Mg^{2+}

5. What is the difference between weight and mass? What are the SI units for each?

6. Perform the following volume conversions involving the liter: 1 L = ____ dm^3; 1 L = ____cm^3; 1 L = ____ m^3.

7. Calculate the ratio of the following properties for 1.0 kg of air versus 1.0 kg of iron at 25°C. (a) mass (b) volume (c) density

8. Write the number 1200 three ways: to 2, 3, and 4 significant figures.

9. A container has a volume of 1.05×10^3 cm^3. When filled with gas, the mass of the container + gas = 837.6 g. The mass of the container alone = 836.2 g. To the correct number of significant figures, what is the density of the gas?

10. Perform the following conversion: What was the cost of gasoline in U.S.$ per gallon for fuel in France that costs €1.67 per liter in May 2019? (€1.00 = U.S.$1.12)

11. Describe how you would separate and recover into four separate containers the following four components of a mixture: liquid water ($H_2O(\ell)$) + iron filings ($Fe(s)$) + sodium chloride dissolved in the water ($NaCl(aq)$) + beach sand grains ($SiO_2(s)$).

12. Classify each of the following as to pure substance or mixture. If an item is a mixture, specify whether it is heterogeneous or homogeneous. (a) concrete (b) seawater (c) magnesium (d) gasoline (e) air (f) tomato juice (g) iodine crystals (h) a nickel

13. How would you separate a mixture of granulated sugar and beach sand of comparable grain size and appearance?

14. Name the following elements: H, Mg, Pb, Si, F, Sn, Cu, Ca, Ba, Cf, Mo, Se, Tl, V, Au, Zr.

15. A solid white substance A is heated strongly in the absence of air. It decomposes to form a new white solid substance B and a gas C. The gas has exactly the same properties as the product obtained when carbon is burned in excess oxygen. What can you say about whether solids A and B and the gas C are elements or compounds?

16. In the process of attempting to characterize a substance, a chemist makes the following observations: The substance is a silvery white, lustrous metal. It melts at 649°C and boils at 1105°C. Its density at 20°C is 1.738 g/cm^3. The substance burns in air, producing an intense white light. It reacts with chlorine to give a brittle white solid. The substance can be pounded into thin sheets or drawn into wires. It is a good conductor of electricity. Which of these characteristics are <u>physical</u> properties are which are <u>chemical</u> properties?

17. Use appropriate metric prefixes to write the following measurements without use of exponents. (a) 6.5×10^{-9} cm (b) 3.35×10^{-4} mL (c) 2.5×10^{-3} mol (d) 4.23×10^{-12} m^3 (e) 12.5×10^{-8} s (f) 3.5×10^{3} L (g) 6.54×10^{9} fs

18. Convert (a) 2.52×10^{3} kg to g (b) 0.0023 mm to nm (c) 6.25×10^{-4} s to ms

19. Calculate the mass (in g or kg) of 1.00 ft^3 of pure iridium metal. How many times your body mass is this? Could you alone lift this 1.00 ft^3 of iridium?

20. Calculate the mass (in g or kg) of a 12.0 cm diameter sphere of pure lead metal.

21. A 200. mg piece of gold can be hammered into a sheet that is 2.4 ft x 1.0 ft. (a) What is the thickness of the sheet in m? (b) Quote the answer using an SI prefix so that no exponent is needed.

22. Convert the following temperatures. (a) 1000 K to °C (b) 273°C to K

23. Indicate which of the following are exact numbers. (a) mass of a paper clip (b) the surface area of a dime (c) the number of inches in a mile (d) the number of ounces in a pound (e) the number of microseconds in a week (f) the mass of a 15 ounce can of coffee (g) the number of students in your first period class last year (h) the temperature on the surface of the Sun (i) the mass of a postage stamp (j) the number of mL in a cubic meter of water (k) the average height of students in the school

24. What is the number of significant figures in each of the following measured quantities? (a) 1282 kg (b) 0.00296 s (c) 8.070 mm (d) 8,070 mm (e) 0.0105 L (f) 9.7750×10^{-4} cm (g) 1.689×10^{-3} km (h) 0.0234 m^2 (i) 7,194,300 cm (j) 435.983 K (k) 204.080 g

25. Round each of the following numbers to three significant figures and express the result in standard exponential notation. (a) 143700 (b) 0.09750 (c) 890,000 (d) 6.764×10^{4} (e) 33,987.22 (f) -6.5559

26. Carry out the following operations, and express the answers with the appropriate number of significant figures. (a) 1.24056 + 75.80 (b) 23.67 - 75 (c) 890.00 x 112.3 (d) 78,132/2.50

27. Perform the following calculation and report the result to the correct number of significant figures: $(1.01 \times 10^{2}) \times (1.0 \times 10^{-4} + 10.2 \times 10^{-5})$

28. A lake has an area of 15,500 mi^2. What is this area expressed in m^2?

29. If a person has 285 mg of cholesterol per 100. mL of blood, and a total blood volume of 5.3 L, how many grams of cholesterol does the person have in total in his blood?

30. An asthma drug dose is 6.0 mg/kg of body mass. What should the dose be for a 175 lb person?

31. If an electric car goes 225 km on a single charge, how many recharges are needed for the 2850 mile trip from New York to Los Angeles? Assume a full charge at the start of the trip in New York.

32. At 1.0 atm and 25°C, air has a density of 1.19 g/L. What is the mass, in kilograms, of the air in a class room that measures 26 ft x 41 ft x 8.0 ft?

33. A copper refinery produces a copper ingot weighing 150. lb. If the copper is drawn into wire whose diameter is 1.25 mm, how many meters of copper wire can be obtained from the ingot?

34. Surgeons removed 5.5 kg of fat from a patient by a procedure called liposuction. One fat cell has a mass of 0.80 μg. How many fat cells were removed?

35. The gas constant R (as in PV = nRT) = 8.314 $m^3 \cdot Pa/mol \cdot K$. Also, R = 8.314 $J/mol \cdot K$. Therefore 1 $m^3 \cdot Pa$ = 1 J. Using fundamental SI units (m, kg, and s), demonstrate that 1 $m^3 \cdot Pa$ does indeed equal 1 J.

36. Find the formula for sarin (a toxic nerve agent) and draw its Lewis electron dot diagram.

37. Two students determine the percentage of lead in solid metal samples as a laboratory exercise. The true value is 22.52%. Student #1 results were 22.52%, 22.48% and 22.54%. Student #2 results were 22.64%, 22.58% and 22.62%. (a) Calculate the average for each student and tell which data set is more accurate. (b) Calculate the absolute deviation for each value from the average value for each set. Which data set is more precise based on the average of the deviations?

38. The production of sodium hydroxide in the United States during 1998 was 30.8 billion pounds. (a) How many grams of NaOH were produced during 1998? (b) The density of NaOH is 2.130 g/cm^3. How many cubic meters of NaOH were produced?

39. Mercury is traded by the "flask," a unit that has a mass of 34.5 kg. What is the volume of a "flask" of mercury in liters?

40. A 26.27 g sample of a solid is placed in a flask. Toluene, in which the solid is insoluble, is added to the flask so that the total volume of solid and liquid together is 50.00 mL. The solid and toluene together have a mass of 52.65 g. The density of toluene at the experimental temperature is 0.864 g/mL. What is the density of the solid?

41. Suppose you define your own temperature scale (G) using the freezing point (-11.5°C) and the boiling point (197.6°C) of ethylene glycol (the main ingredient of automobile antifreeze). You set the freezing point of ethylene glycol as 0°G and the boiling point of ethylene glycol as 100°G. On the G temperature scale, what is the temperature for the freezing point of water?

42. The world record for the marathon running race is 2 hours 1 minute and 39 seconds (Eliud Kipchoge from Kenya, Berlin Marathon, September 16, 2018). The race length is 26 miles 385 yards. What was Kipchoge's average speed for the race in miles/hr? In km/hr?

43. The annual global increases in carbon dioxide, the major greenhouse gas, are 5.5 gigaton from fossil-fuel burning, 6.5 gigaton from industrial activity, and 1.6 gigaton from deforestation. What is the total annual increase in CO_2 in kg? (Note: The ton referred to in this problem is a metric ton, which equals exactly 1000 kg).

44. The U.S. quarter has a mass of 5.67 g and is approximately 1.55 mm thick. (a) How many quarters would have to be stacked to reach 575 ft, the height of the Washington Monument? (b) What would be the mass of this stack? (c) What would be the dollar value of the stack? (d) As of May 29, 2015, the national debt was $18.247 trillion. How many of these stacks would be needed to pay off this debt?

45. A 15.0-cm long cylindrical glass tube, sealed at one end, is filled with ethanol. The mass of ethanol needed to fill the tube is 9.64 g. The density of ethanol is 0.789 g/mL. Calculate the inner diameter of the tube in centimeters.

46. Gold is alloyed (mixed) with other metals to increase its hardness for jewelry making. Consider a piece of gold jewelry that has a mass of 9.85 g and a volume of 0.675 cm^3. The piece contains only gold and silver. Assuming that the total volume of the jewelry piece is the sum of the volumes of the gold and silver it contains, calculate the percentage of gold (by mass) in the piece.

47. The Pacific Ocean contains how many liters of water (volume = 139 million cubic miles)?

48. What are the six most abundant elements in the human body by mass?

49. A student finds that 15.20 g of nitrogen will react with 17.37g, 34.74 g, or 43.43 g of oxygen to form three different compounds. What are the empirical formulas for these three compounds. (Hint: convert masses to moles)

50. Account for the fact that alpha (α) particles and beta (β) particles are deflected in opposite directions by an electric field.

51. How many chromium atoms, if lined up, would be needed to span 1.0 cm?

52. How many protons, neutrons, and electrons are there in each of the following? (a) ^{40}Ar (b) ^{55}Mn (c) $^{65}Zn^{2+}$ (d) $^{79}Se^{2-}$ (e) ^{184}W (f) ^{235}U

53. The following nuclides are used in medicine. Indicate how many protons and neutrons there are in each. (a) phosphorus-32 (b) chromium-51 (c) cobalt-60 (d) technetium-99 (e) iodine-131 (f) thallium-201

54. Fill in the gaps in the following table assuming the atoms are neutral.

symbol	^{39}K				
protons		25			82
neutrons		30	64		
electrons			48	56	
mass #				137	207

55. Fill in the gaps in the following table.

symbol	$^{52}Cr^{3+}$	$^{130}I^{-}$			
protons			47		33
neutrons			60	69	42
electrons			46	48	
net charge				2+	3-

56. Write the symbol for each of the following elements and indicate whether it is a metal, metalloid, or nonmetal. (a) silver (b) helium (c) phosphorus (d) aluminum (e) cadmium (f) calcium (g) bromine (h) arsenic

57. How many hydrogen atoms are in each of the following? (a) C_2H_5OH (b) $Ca(CH_3COO)_2$ (c) $(NH_4)_2HPO_4$

58. Write the empirical formula corresponding to each of the following molecular formulas. (a) S_4N_4 (b) C_7H_{15} (c) $C_6H_{10}O_2$ (d) P_4O_6 (e) $C_6H_{10}F_8$ (f) Si_3O_9 (g) H_2O_2 (h) $C_6H_{12}O_6$

59. Each of the following elements can form an ion in a chemical reaction. By referring to the periodic table or other references, predict the charge of the most stable ion of each. (a) Al (b) Ca (c) S (d) I (e) Cs

60. Write the formula and the name of the compound formed by each of the following pairs of elements. (a) Ga and F (b) Li and H (c) Al and I (d) K and S.

61. The most common charge associated with silver in its compounds is +1. Indicate the formulas you would expect for compounds formed between Ag and (a) iodine (b) sulfur (c) fluorine.

62. Hydrogen can have oxidation states of +1, 0, -1. Write the formula and name for one chemical species for each of these three oxidation states.

63. Predict the formulas for compounds formed from the following ions: (a) Ca^{2+} and Br^- (b) NH_4^+ and Cl^- (c) Al^{3+} and $C_2H_3O_2^-$ (d) K^+ and SO_4^{2-} (e) Mg^{2+} and PO_4^{3-}

64. Predict whether each of the following compounds is molecular or ionic. (a) B_2H_6 (b) CH_3OH (c) $LiNO_3$ (d) Sc_2O_3 (e) CsBr (f) NOCl (g) NF_3 (h) Ag_2SO_4

65. Give the chemical formula for (a) chlorite ion (b) chloride ion (c) chlorate ions (d) perchlorate ion (e) hypochlorite ion

66. Selenium, an element required nutritionally in very small amounts, forms compounds and ions analogous to those for sulfur (note their proximity in the periodic table). Name the following ions. (a) SeO_4^{2-} (b) Se^{2-} (c) HSe^- (d) $HSeO_3^-$

67. Name the following ionic compounds. (a) AlF_3 (b) $Fe(OH)_2$ (c) $Cu(NO_3)_2$ (d) $Ba(ClO_4)_2$ (e) Li_3PO_4 (f) Hg_2S (g) $Ca(C_2H_3O_2)_2$ (h) $Cr_2(CO_3)_3$ (i) K_2CrO_4 (j) $(NH_4)_2SO_4$ (k) $SrSO_3$ (l) $ZnHPO_4$ (m) SnI_2

68. Write the chemical formulas for the following compounds. (a) copper(I) oxide (b) potassium peroxide (c) aluminum hydroxide (d) zinc nitrate (e) mercury(I) bromide (f) iron(III) carbonate (g) sodium hypobromite (h) magnesium nitride (i) potassium hypochlorite (j) iron(II) sulfite

69. Provide the name or chemical formula, as appropriate, for each of the following acids. (a) sulfurous acid (b) HBr (c) $HBrO_3$ (d) hypochlorous acid (e) iodic acid (f) H_2CO_3 (g) $HC_2H_3O_2$ (h) nitrous acid

70. Provide the name or chemical formula, as appropriate, for each of the following molecular substances. (a) NF_3 (b) dinitrogen tetroxide (c) hydrogen cyanide (d) SF_6 (e) IF_5 (f) XeO_3 (g) tetraphosphorus hexasulfide

71. The oxides of nitrogen are often present in urban air pollution. Name each of the following oxides of nitrogen. (a) N_2O (b) NO (c) NO_2 (d) N_2O_5 (e) N_2O_4

72. Write the formulas for each of the following substances. (a) Zinc carbonate can be heated to form zinc oxide and carbon dioxide. (b) On treatment with hydrofluoric acid, silicon dioxide forms silicon tetrafluoride and water. (c) Sulfur dioxide reacts with water to form sulfurous acid. (d) The substance hydrogen phosphide, also known as phosphine, is a toxic gas. (e) Perchloric acid reacts with cadmium to form cadmium perchlorate. (f) Vanadium(III) bromide is a colored solid.

73. The nucleus of a potassium atom has a diameter on the order of 1×10^{-5} nm. A potassium atom has a diameter of approximately 0.5 nm. In terms of volume, how many times larger is the potassium atom than the potassium nucleus?

74. The element oxygen has three naturally occurring isotopes: oxygen-16, oxygen-17, and oxygen-18. Discuss the similarities and differences between these three types of atoms.

75. Consider the elements Ar, H, Ga, Al, Ca, Br, Ge, K, and O. Pick the one that best fits each of the following descriptions. Use each element only once. (a) an alkali metal (b) an alkaline earth metal (c) a noble gas (d) a halogen (e) a metalloid (f) a nonmetal listed in Group 1 (g) a metal that forms a 3+ ion (h) a nonmetal that forms a 2- ion (i) an element that resembles aluminum

76. The compound Fe_3S_4 is magnetic. It is found in bacteria, which may use this magnetic property to help them be oriented in earth's magnetic field. If the sulfur charge is -2, the Fe charge is not an integer. How can you explain this? (Hint: think of this material as a mixture of two different iron/sulfur compounds.)

77. Give the chemical names for each of the following common compounds. (a) NaCl (table salt) (b) $NaHCO_3$ (baking soda) (c) NaOCl (bleach) (d) NaOH (lye) (e) $(NH_4)_2CO_3$ (smelling salts) (f) $CaSO_4$ (plaster of Paris) (g) $Mg(OH)_2$ (milk of magnesia) (h) CaO (lime—as in the white powder, not the green fruit) (i) HCl (muriatic acid)

78. Many ions and compounds have very similar names and there is a great potential for confusion. Write the correct chemical formulas to distinguish between each of the following pairs of chemicals. (a) calcium sulfide and calcium hydrogen sulfide (b) hydrobromic acid and bromic acid (c) aluminum nitride and aluminum nitrate (d) iron(II) oxide and iron(III) oxide (e) ammonia and ammonium ion (f) potassium sulfate and potassium thiosulfate (g) magnesium chloride and manganese(II) chloride

79. The periodic table is ordered by increasing atomic <u>number</u>. As such, it is possible for elements to be out of order based on atomic <u>mass</u>. In fact, there are at least six pairs of elements that are out of order based on atomic mass. Find and list six pairs.

80. Calculate the percent oxygen by mass and the percent hydrogen by mass in each of the following compounds or ions. (a) H_2O (b) H_2O_2 (c) OH^- (d) H_3O^+

81. For the reaction $2H_2(g) + O_2(g) \rightarrow 2H_2O$, give a complete list of the bonds that are broken and the bonds that are formed as the reactants are converted to product.

82. Balance the following equation:
$FeSO_4 + K_2Cr_2O_7 + H_2SO_4 \rightarrow K_2SO_4 + Cr_2(SO_4)_3 + H_2O + Fe_2(SO_4)_3$

83. The mass of a proton is 1.67×10^{-27} kg. If its diameter is 1.0×10^{-15} m, calculate the density of the proton in units of g/cm^3.

84. If the formula for yttrium chloride is YCl_3, and the formula for sodium stannate is Na_2SnO_3, what is the formula for yttrium stannate?

85. To 10.0 mL of 1.0 M aqueous hydrochloric acid enough pure, distilled water is added to make 1.0 L of solution. Does the pH rise or fall and by how many pH units?

86. If 100. g of $MgCO_3$ is fully decomposed by heating to form MgO, calculate the maximum mass of MgO produced.

87. The natural abundance of ^2H is 0.015% and that of ^{18}O is 0.20%. How many $^2H_2{}^{18}O$ molecules are there in 1.0 moles of water?

88. An organic compound is found in the lab to be 52.1% carbon, 13.1% hydrogen, and 34.8% oxygen by mass. What is its formula if its molar mass is 45 ± 2 g?

89. Using the formula from #88, draw <u>two</u> isomeric structures, one each with two different organic functional groups as per Regents Table R. Provide names for them.

90. A neutral atom has an electron configuration of $[Rn]7s^2 5f^{14} 6d^{10} 7p^4$. What Period 2 element is a member of the same group?

91. Atoms of element X have two valence electrons each. Atoms of element Y have six valence electrons each. What is the expected formula for the compound when elements X and Y chemically combine?