

TOPIC 1 PROBLEM SET – QUANTITATIVE CHEMISTRY

Many of these questions involve concepts you should be familiar with from MYP chemistry. They progress from simple to more challenging. After completing 1 – 58, a selection of prior exam questions follows. It is important that you develop a feel for what prior exam questions are like, as being familiar with exam questions will be quite helpful when you take your IB chemistry exam.

1. Practice your fluency in inorganic nomenclature with these charts.

formula	# and type of atoms and A_r of each atom	Formula mass (M_r)
$Ba_3(PO_4)_2$		
$Fe(NO_3)_3$		
$(NH_4)_2SO_4$		

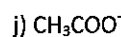
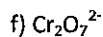
Ionic Compounds:

cations	anions	formula	name	Formula mass (M_r)
Al^{3+}	S^{2-}			
			Potassium oxide	
Ca^{2+}	NO_3^-			
			Zinc (II) carbonate	
		CuF_2		

Molecular (Covalent) Compounds:

Name	Formula	Formula mass (M_r)
	SO_3	
	P_2O_5	
Carbon tetrachloride		
Trinitrogen hexasulfide		
	NO_2	

2. Give the name for the following ions:



3.

3. How many moles are there in 4.2 g aluminum chloride?
4. How many moles are there in 42.5 g copper (II) fluoride?
5. What is the mass of 2.25 moles zinc (II) phosphate?
6. How many moles are there in 27.5 g aluminum nitrate?
7. How many molecules of sulfur dioxide are there in 1.25 g of sulfur dioxide?
8. What is the mass of 3.29×10^{25} molecules of water?
9. How many moles of hydrogen are there in 64.9 g water?
10. What mass of zinc is in 14.4 g zinc (II) fluoride?
11. How many atoms of bromine are there in 0.155 g magnesium bromide?
12. How many atoms are there in 12 g of K_2O ?
13. Ionic compounds form solid crystals that are held together by the attractive force between positive cations and negative anions. A hydrated ionic compound contains small amounts of water distributed throughout the crystal. A hydrated ionic compound has a unique formula, in which the number of moles of water is denoted after the formula of the compound. For example, in calcium chloride dihydrate, there are two moles of water to every one mole of calcium chloride, and the formula is written: $CaCl_2 \cdot 2H_2O$.

A hydrated copper (II) sulfate crystal is dehydrated by heating above a flame. Hydrated copper (II) sulfate has a characteristic light blue color, while dehydrated copper (II) sulfate is gray/white.

Consider the data

Object	Mass (± 0.1 g)
evaporating dish	47.4 g
evaporating dish and $CuSO_4 \cdot X H_2O$	52.6 g 52.5g
mass of dish and $CuSO_4$ remaining after heating	50.9 g

Calculate the formula of the hydrate.

For each of the following (14 – 22):

- a) classify the reaction
- b) write chemical equation (include state symbols: s, l, g, aq)
- c) balance the equation

14. liquid ethyl alcohol ($\text{CH}_3\text{CH}_2\text{OH}$) burns in the presence of oxygen

15. sodium reacts with aqueous aluminum carbonate

16. zinc reacts with oxygen

17. aqueous sodium sulfide reacts with aqueous barium nitrate

18. copper (II) carbonate reacts to form copper (II) oxide and a gas

19. potassium reacts with iodine

20. ethane (C_2H_6) burns in air

21. barium reacts with aqueous zinc (II) chloride

22. aqueous sodium carbonate reacts with aqueous zinc (II) fluoride

23. lead (II) oxide decomposes

For each of the following (24 – 27), determine the empirical formula from the percentage composition or mass data given. An empirical formula displays the **lowest whole number mole ratio of elements in a compound**. A molecular formula shows this same ratio, only it isn't always in the most simplified form (for example, glucose has a molecular formula of $\text{C}_6\text{H}_{12}\text{O}_6$, but when simplified, its empirical formula is CH_2O).

24) A ^y4.00 gram sample of an unknown compound that contains 1.71 g carbon and 2.29 g oxygen

25. A 7.95 gram sample of an unknown compound that contains 2.03 g magnesium and 5.92 g chlorine

26. An unknown sample that contains 31.9 % potassium, 29.0 % chlorine, and 39.1 % oxygen, by mass.

27. Deduce the empirical formula of a compound that contains 25.9 % nitrogen and 74.1% oxygen, by mass.

28. A compound is 80% carbon and 20% hydrogen, by mass.

a) What is the empirical formula?

b) If the molar mass is about 30, what is the molecular formula?

29. Determine the empirical and molecular formulas of a compound with a molecular weight of 42 that contains 85.9% C and 14.1% H.

30. A compound is analyzed and found to contain: 4.80g carbon, 0.80g hydrogen, 3.20g oxygen and 2.80g nitrogen. What is the empirical formula? If the molar mass is about 174, what is the molecular formula?

31. A sample of a hydrocarbon burns completely in oxygen to form 13.2g carbon dioxide and 5.4g water. What is the empirical formula?

For 32 - 37:

- ◇ Write correct formulas for products and reactants.
- ◇ Write the equation
- ◇ Balance the equation
- ◇ Perform the conversion, using the following T-chart template as a guide if you like:

mass given	mol given	unknown from equation	formula mass unknown
	Formula mass given	given from equation	mol unknown

32. How many grams of oxygen react with excess hydrogen to form 13.5 g water?

33. How many grams of silver are formed as 125 g zinc reacts with excess aqueous silver nitrate?

34. What mass of aqueous lithium carbonate reacts with excess calcium nitrate to form 87 g of aqueous calcium carbonate?

35. How many grams of oxygen form as 50.0 g of Hg_2O decomposes?

36. How many grams of potassium oxide form as 15.0g potassium burns in the presence of oxygen?

37. Calculate the amount (in grams) of potassium and the amount (in grams) of silver (I) oxide required to produce 4.6 grams of silver.

38. 45.0 g of potassium carbonate react with 45.0 g silver nitrate. The products of the reaction are silver carbonate and potassium nitrate.

a) What is the theoretical yield of silver (I) carbonate (i.e. what is the maximum mass of silver (I) carbonate that can be produced)?

b) What is the limiting reactant?

c) What is the reactant present in excess?

d) Determine the percentage yield if only 30.0 grams of silver (I) carbonate are produced experimentally.

39. 15.0 g of potassium reacts with 5.0 g sulfur.

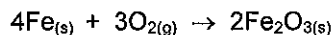
a) What is the theoretical yield of potassium sulfide (i.e. what is the maximum mass of potassium sulfide that can be produced)?

b) What is the limiting reactant?

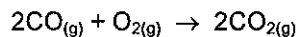
c) What is the reactant present in excess?

d) Determine the percentage yield if only 10.9 grams of potassium sulfide are produced experimentally.

40. What is the maximum mass of iron (III) oxide produced when 10.0 grams of iron are allowed to completely oxidize?



41. What volume of carbon dioxide is released when 10 dm³ of carbon monoxide are combined with 10 dm³ of oxygen?



42. 1.00 moles of NaCl are dissolved in 500 ml of solution. What is the concentration in mol dm⁻³?

43. 3.5 moles of KF are dissolved in 2.0 L of solution. What is the concentration in mol dm⁻³?

44. 133.0 g of NaCl are dissolved in 1.00 L of solution. What is the concentration in mol dm⁻³?

45. How many moles of sodium carbonate are dissolved in 500 ml of 0.055 mol dm⁻³ solution?

46. What is the concentration in mol dm⁻³ of 38 g lead (II) iodide dissolved in 500 ml of solution?

47. How many grams of NaCl are there in 500 ml of a 1.3 mol dm⁻³ solution NaCl?

48. What mass of copper (II) chloride will react with 500 mL of 2 mol dm⁻³ magnesium chloride?

49. Methanol, CH₃OH, can be prepared according the equation: $\text{CO} + 2\text{H}_2 \rightarrow \text{CH}_3\text{OH}$

When 175 g of carbon monoxide is mixed with 36.5 g hydrogen gas and allowed to react, 112 g of product forms. Determine a) theoretical yield b) percent yield c) limiting reactant

50. 150 mL of 1.5 mol dm^{-3} BaCl_2 and 30.0g Na_2SO_4 are placed in a beaker to react.

- How many grams of BaSO_4 form?
- Which reactant is the limiting reactant?
- Which reactant is present in excess?

d) If 20 g of BaSO_4 is isolated, what is the percent yield?

51. 12 mL of 3.5 mol dm^{-3} calcium nitrate and 27.5 ml of 1.2 mol dm^{-3} aluminum sulfate are placed in a beaker to react.

- What is the theoretical yield of CaSO_4 ?
- Which reactant is the limiting reactant?
- Which reactant is present in excess? How much will remain unreacted?

52. A mixture of MgSO_4 and $\text{MgSO}_4 \cdot 7 \text{H}_2\text{O}$ with a mass of 11.08 g is heated until the water is removed. The total mass of the anhydrous MgSO_4 after heating is 7.25g. Determine the percentage of the hydrate in the original mixture.

53. If 12.56 g of a solid dibasic acid reacts completely with 24.4 cm^3 of 1.8 mol dm^{-3} NaOH , what is the molar mass of the acid, in g/mol?

54. Menthol is a compound that contains only carbon, hydrogen and oxygen. When a 0.0956g sample of menthol burns in air, 0.269 g CO_2 and 0.110 g H_2O are formed. What is the empirical formula of menthol?

55. 7.321 mg of an organic compound containing carbon, hydrogen, and oxygen was analyzed by combustion. The amount of carbon dioxide produced was 17.873 mg and the amount of water produced was 7.316 mg. Determine the empirical formula of the compound.
56. 0.1101 gram of an organic compound containing carbon, hydrogen, and oxygen was analyzed by combustion. The amount of carbon dioxide produced was 0.2503 gram and the amount of water produced was 0.1025 gram. A determination of the molar mass of the compound indicated a value of approximately 115 grams/mol. Determine the empirical formula and the molecular formula of the compound.