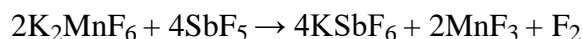
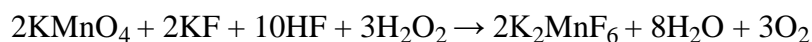


## CHEMICAL CALCULATIONS -TUTORIAL 5- 2025

1. Because the bond between fluorine atoms in  $F_2$  is relatively weak while the bonds between fluorine atoms and atoms of other elements are relatively strong, it is difficult to make diatomic fluorine,  $F_2$ . One way it can be made is to run an electric current through liquid hydrogen fluoride, HF. This reaction yields hydrogen gas,  $H_2$ , and fluorine gas,  $F_2$ .
  - a) Write a complete balanced equation, including states, for this reaction.
  - b) Write a stoichiometry that could be used to convert between moles of HF and moles of  $F_2$ .
  - c) How many moles of  $F_2$  form when one mole of HF reacts completely?
  - d) How many moles of HF react to yield 3.452 moles of  $H_2$ ? (2:1, 0.5 mol, 6.904 mol)
2. Fluorine gas is an important chemical because it is used to add fluorine atoms to many different compounds. It is difficult to make, but the following two-step process produces high yields of  $F_2$ .



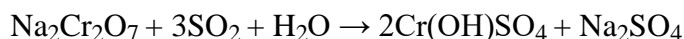
For the second of these two reactions:

- a) Write a stoichiometry that could be used to convert between moles of antimony pentafluoride,  $SbF_5$ , and moles of fluorine,  $F_2$ .
  - b) How many moles of  $F_2$  form when 8 moles of  $SbF_5$  react completely?
  - c) What is the maximum number of moles of  $F_2$  that could form in the combination of 2.00 moles of  $K_2MnF_6$  and 5.00 moles of  $SbF_5$ ?  
(4:1, 2 mol, 1 mol)
3. The thiocyanate polyatomic ion,  $SCN^-$ , is commonly called a pseudohalogen because it acts very much like halide ions. For example, we know that the pure halogens consist of diatomic molecules, such as  $Cl_2$ . Thiocyanate ions form similar molecules in the following reaction:
$$2NaSCN + 2H_2SO_4 + MnO_2 \rightarrow (SCN)_2 + 2H_2O + MnSO_4 + Na_2SO_4$$
    - a) Write a stoichiometry that could be used to convert between moles of  $NaSCN$  and moles of  $(SCN)_2$ .
    - b) How many moles of  $(SCN)_2$  form when 0.50 moles of  $NaSCN$  react completely?
    - c) What is the maximum number of moles of  $(SCN)_2$  that could form in the combination of 4 moles of  $NaSCN$  and 3 moles of  $MnO_2$  if there is excess  $H_2SO_4$ ?
    - d) Write a stoichiometry that could be used to convert between moles of sulfuric acid,  $H_2SO_4$ , and moles of manganese(II) sulfate,  $MnSO_4$ .

- e) What is the minimum number of moles of  $\text{H}_2\text{SO}_4$  that must react to form 1.75 moles of manganese(II) sulfate?

(2:1, 0.25 mol, 2 mol, 2:1, 3.50 mol)

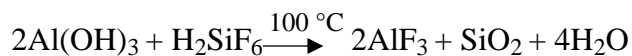
4. The tanning agent,  $\text{Cr}(\text{OH})\text{SO}_4$ , is formed in the reaction of sodium dichromate ( $\text{Na}_2\text{Cr}_2\text{O}_7$ ), sulfur dioxide, and water. Tanning protects animal hides from bacterial attack, reduces swelling, and prevents the fibers from sticking together when the hides dry. This leads to a softer, more flexible leather.



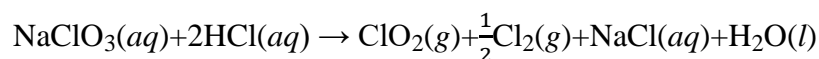
- a) How many kilograms of sodium dichromate,  $\text{Na}_2\text{Cr}_2\text{O}_7$ , are necessary to produce 2.50 kg of  $\text{Cr}(\text{OH})\text{SO}_4$ ?
- b) How many grams of sodium sulfate are formed with 250 g of  $\text{Cr}(\text{OH})\text{SO}_4$ ? (1.984 kg, 107.57 g)
5. The mineral hausmannite,  $\text{Mn}_3\text{O}_4$ , which contains both manganese(II) and manganese(III) ions, is formed from heating manganese(IV) oxide to 890 °C.



- a) What is the maximum mass, in kilograms, of  $\text{Mn}_3\text{O}_4$  that can be formed from the decomposition of 31.5 kg of manganese(IV) oxide,  $\text{MnO}_2$ ?
- b) If 24.5 kg of  $\text{Mn}_3\text{O}_4$  is isolated in the decomposition reaction of 31.5 kg of manganese(IV) oxide,  $\text{MnO}_2$ , what is the percent yield? (27.635 kg, 88.67 %)
6. The equation for one process for making aluminum fluoride follows. What is the maximum mass, in grams, of aluminum fluoride,  $\text{AlF}_3$ , that can be produced from the complete reaction of  $1.4 \times 10^3$  g of aluminum hydroxide,  $\text{Al}(\text{OH})_3$ , with  $1.0 \times 10^3$  g of  $\text{H}_2\text{SiF}_6$ ? (1165.9 g)



7. Most of the sodium chlorate,  $\text{NaClO}_3$ , produced in the Sri Lanka is converted into chlorine dioxide, which is then used for bleaching wood pulp.



- a) How many milliliters of  $12.1 \text{ mol dm}^{-3}$   $\text{HCl}$  are necessary to react completely with 35.09 g of sodium chlorate,  $\text{NaClO}_3$ ?
- b) What is the maximum mass, in grams, of  $\text{ClO}_2$  that can be formed from the complete reaction of 65 mL of  $12.1 \text{ mol dm}^{-3}$   $\text{HCl}$ ?

(54.38 mL, 26.325 g)

8. When a water solution of sodium sulfite,  $\text{Na}_2\text{SO}_3$ , is added to a water solution of iron(II) chloride,  $\text{FeCl}_2$ , iron(II) sulfite,  $\text{FeSO}_3$ , precipitates from the solution.
- Write a balanced equation for this reaction.
  - What is the maximum mass of iron(II) sulfite that will precipitate from a solution prepared by adding an excess of a  $\text{Na}_2\text{SO}_3$  solution to 25.00 mL of  $1.1 \text{ mol dm}^{-3}$   $\text{FeCl}_2$ ?

(3.74 g)

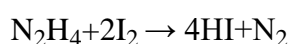
9. Consider the precipitation reaction that takes place when a water solution of aluminum nitrate,  $\text{Al}(\text{NO}_3)_3$ , is added to a water solution of potassium phosphate,  $\text{K}_3\text{PO}_4$ .
- Write a balanced equation for this reaction.
  - What is the maximum mass of aluminum phosphate that will precipitate from a solution prepared by adding an excess of an  $\text{Al}(\text{NO}_3)_3$  solution to 50.00 mL of  $1.525 \text{ mol dm}^{-3}$   $\text{K}_3\text{PO}_4$ ? (9.3 g)

10. Consider the neutralization reaction that takes place when nitric acid reacts with aqueous potassium hydroxide.
- Write a stoichiometry that relates moles of  $\text{HNO}_3$  to moles of  $\text{KOH}$  for this reaction.
  - What is the minimum volume of  $1.50 \text{ mol dm}^{-3}$   $\text{HNO}_3$  necessary to neutralize completely the hydroxide in 125.0 mL of  $0.5 \text{ mol dm}^{-3}$   $\text{KOH}$ ?

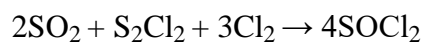
(41.67 mL)

11. Consider the neutralization reaction that takes place when phosphoric acid reacts with aqueous potassium hydroxide.
- What is the minimum volume of  $2.1 \text{ mol dm}^{-3}$   $\text{H}_3\text{PO}_4$  necessary to neutralize completely the hydroxide in 183 mL of  $0.550 \text{ mol dm}^{-3}$   $\text{KOH}$ ? (15.98 mL)

12. Hydriodic acid is produced industrially by the reaction of hydrazine,  $\text{N}_2\text{H}_4$ , with iodine,  $\text{I}_2$ .  $\text{HI}(\text{aq})$  is used to make iodine salts such as  $\text{AgI}$ , which are used to seed clouds to promote rain. What is the minimum mass of iodine,  $\text{I}_2$ , necessary to react completely with 87.0 g of hydrazine,  $\text{N}_2\text{H}_4$ ? (1381.8 g)



13. Thionyl chloride,  $\text{SOCl}_2$ , is a widely used source of chlorine in the formation of pesticides, pharmaceuticals, dyes, and pigments. It can be formed from disulfur dichloride in the following reaction.



If 1.15 kg of thionyl chloride is isolated from the reaction of 457.6 grams of disulfur dichloride,  $\text{S}_2\text{Cl}_2$ , with excess sulfur dioxide and chlorine gas, what is the percent yield? (71.29 %)

14. A precipitation reaction takes place when an aqueous solution of sodium carbonate,  $\text{Na}_2\text{CO}_3$ , is added to an aqueous solution of chromium(III) nitrate,  $\text{Cr}(\text{NO}_3)_3$ .

- Write a balanced equation for this reaction.
- What is the maximum mass of chromium(III) carbonate that will precipitate from a solution prepared by adding an excess of a  $\text{Na}_2\text{CO}_3$  solution to 10.00 mL of  $0.100 \text{ mol dm}^{-3} \text{ Cr}(\text{NO}_3)_3$ ?

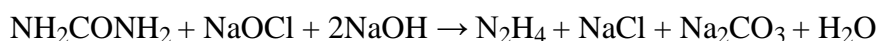
(0.142 g)

15. A solution is made by adding 22.6 g of a solid that is 96 % NaOH to a beaker of water. What volume of  $2.00 \text{ mol dm}^{-3} \text{ H}_2\text{SO}_4$  is necessary to neutralize the NaOH in this solution? (135 mL)

16. Sodium tripolyphosphate (or STPP),  $\text{Na}_5\text{P}_3\text{O}_{10}$ , is used in detergents. It is made by combining phosphoric acid with sodium carbonate at 300 to 500 °C. What is the minimum mass, in kilograms, of sodium carbonate that would be necessary to react with excess phosphoric acid to make enough STPP to produce  $1 \times 10^5 \text{ kg}$  of a detergent that is 32%  $\text{Na}_5\text{P}_3\text{O}_{10}$ ? ( $23.04 \times 10^3 \text{ kg}$ )



17. Hydrazine,  $\text{N}_2\text{H}_4$ , is a liquid with many industrial purposes, including the synthesis of herbicides and pharmaceuticals. It is made from urea in the following reaction at 100 °C.



If the percent yield for the reaction is 90%, how many kilograms of hydrazine,  $\text{N}_2\text{H}_4$ , are formed from the reaction of 243.6 kg of urea,  $\text{NH}_2\text{CONH}_2$ , with excess sodium hypochlorite and sodium hydroxide? (116.93 kg)

18. What is the molarity of a solution of sodium hydroxide, NaOH, if 36.9 mL of this solution is required to react with 35.2 mL of  $0.1 \text{ mol dm}^{-3}$  hydrochloric acid solution?

( $0.095 \text{ mol dm}^{-3}$ )

19. An impure sample of  $(\text{COOH})_2 \cdot 2\text{H}_2\text{O}$  that had a mass of 2.00 g was dissolved in water and reacted with standard NaOH solution. The complete reaction required 38.32 mL of  $0.198 \text{ mol dm}^{-3}$  NaOH solution. Calculate the percent  $(\text{COOH})_2 \cdot 2\text{H}_2\text{O}$  in the sample. Assume that the sample contains no acidic impurities.

(23.87 %)