Assignment - 2

Numericals

æ Mole concept and Stoichiometry

MOLE CONCEPT AND STOICHIOMETRY
Assignment Sheet

1. If a crop of wheat removes 20 kg of nitrogen per hectare of soil, what mass of the fertilizer calcium nitrate $Ca(NO_3)_2$ would be required to replace nitrogen in 10 hectare field?
   [N = 14, O = 16, Ca = 40]. Answer to nearest kg. **[1999]**

2. (a) Concentrated nitric acid oxidises phosphorus to phosphoric acid according to the following equation :
   $P + 5HNO_3 \longrightarrow H_3PO_4 + H_2O + 5NO_2$
   (i) What mass of phosphoric acid can be prepared from 6.2g of phosphorus?
   (ii) What mass of nitric acid will be consumed at the same time?
   (b) Ammonia may be oxidised to nitrogen monoxide in the presence of a catalyst according to the following equation :
   $4NH_3 + 5O_2 \longrightarrow 4NO + 6H_2O$
   If 27 litres of reactants are consumed, what volume of nitrogen monoxide is produced at the same temperature and pressure? **[1999]**

3. What is the volume (measured in dm^3 or litres) occupied by one mole of a gas at STP? **[1999]**

4. Determine the empirical formula of the compound whose composition by mass is 42% nitrogen, 48% oxygen and 9% hydrogen.
   [H = 1, N = 14, O = 16] **[2000]**

5. (a) Washing soda has the formula $Na_2CO_3.10H_2O$. What mass of anhydrous sodium carbonate is left when all the water of crystallization is expelled by heating 57.2g of washing soda?
   (b) When excess lead nitrate solution was added to a solution of sodium sulphate, 15.15g of lead sulphate were precipitated. What mass of sodium sulphate was present in the original solution?
   $Na_2SO_4 + Pb(NO_3)_2 \longrightarrow PbSO_4 + 2NaNO_3$
   [Na = 23, S = 32, O = 16, Pb = 207, N = 14] **[2000]**

6. Calculate the percentage of phosphorus in the fertilizer, superphosphate $Ca(H_2PO_4)_2$. (Correct to 1 decimal point).
   [H = 1, O = 16, P = 31, C = 40] **[2001]**

7. (a) A metal M forms a volatile chloride containing 65.5% chlorine. If the density of the chloride relative to hydrogen is 162.5, find the molecular formula of the chloride. [M = 56, Cl = 35.5]

   (b) The reaction
   $4N_2O + CH_4 \longrightarrow CO_2 + 2H_2O + 4N_2$
   takes place in the gaseous state. If all volumes are measured at the same temperature and pressure, calculate the volume of dinitrogen oxide (N_2O) required to give $150cm^3$ of steam.
   [N = 14, O = 16, C = 12, H = 1]

(c) From the equation :
$(NH_4)_2Cr_2O_7 \longrightarrow Cr_2O_3 + 2H_2O + N_2$
Calculate :
(i) The volume of nitrogen at STP, evolved when 63g of ammonium dichromate are heated.
(ii) The mass of chromium (III) oxide (Cr_2O_3) formed at the same time.
[N = 14, H = 1, Cr = 52, O = 16] **[2001]**

8. (a) When gases react together, their reaction volume bears a simple ratio to each other under the same conditions of temperature and pressure. Who proposed this gas law?

(b) What volume of oxygen would be required for the complete combustion of 100 litres of ethane according to the following equation?
$2C_2H_6 + 7O_2 \longrightarrow 4CO_2 + 6H_2O$

(c) The gases chlorine, nitrogen, ammonia and sulphur dioxide are collected under the same conditions of temperature and pressure. Copy the following table which gives the volumes of gases collected and the number of molecules in 20 litres of nitrogen. You have to complete the table giving the number of molecules in the other gases in terms of X. **[2001]**

Gas	Volume (litres)	Number of molecules
Chlorine	10	
Nitrogen	20	X
Ammonia	20	
Sulphur dioxide	5	

9. (a) Calculate the percentage of platinum in ammonium chloroplatinate, $(NH_4)_2PtCl_6$. [N = 14, H = 1, Pt = 195, Cl = 35.5]
(Give your answer correct to the nearest whole number.)

(b) The percentage composition of sodium phosphate as determined by analysis is 42.1% sodium, 18.9% phosphorus and 39% oxygen. Find the empirical formula of the compound (work to up to two decimal places.)
[Na = 23, P = 31, O = 16] **[2002]**

10. The gases hydrogen, oxygen, carbon dioxide, sulphur dioxide and chlorine are arranged in order of their increasing relative molecular masses. Given 8g of each at STP, which gas will contain the least number of molecules and which will the most? **[2003]**

11. 10g of a mixture of barium chloride and anhydrous sodium sulphate is dissolved in water. An excess of barium chloride solution is added and 6.99g of barium sulphate is precipitated according to the equation given below :
$Na_2SO_4 + BaCl_2 \longrightarrow BaSO_4 + 2NaCl$
[O = 16, Na = 23, S = 32, Ba = 137]
Calculate the percentage of sodium sulphate in the original mixture.
[2003]

12. An experiment showed that in a lead chloride solution, 6.21g of lead combined with 4.26g of chlorine. What is the empirical formula of this chloride? [Pb = 207, Cl = 35.5] **[2004]**

13. (a) A flask contains 3.2g of sulphur dioxide. Calculate the followings :
    (i) The moles of sulphur dioxide present in the flask.
    (ii) The number of molecules of sulphur dioxide at STP.
    (iii) The volume occupied by 3.2g of sulphur dioxide at STP.
    (S = 32, O = 16)

    (b) The reaction of potassium permanganate (VII) with acidified iron (II) sulphate is given below :

    $2KMnO_4 + 10FeSO_4 + 8H_2SO_4 \longrightarrow K_2SO_4 + 2MnSO_4 + 2Fe_2(SO_4)_3 + 8H_2O$

    If 15.8 g of potassium permanganate (VII) was used in the reaction, calculate the mass of iron (II) sulphate used in the above reaction.
    (K = 39, Mn = 55, Fe = 56, S = 32, O = 16] **[2004]**

14. When heated, potassium permanganate decomposes according to the following equation :

    $2KMnO_4 \longrightarrow K_2MnO_4 + MnO_2 + O_2$

    (a) Some potassium permanganate was heated in a test tube. After collecting one litre of oxygen at room temperature, it was found that the test tube had undergone a loss in mass of 1.32g. If one litre of hydrogen under the same conditions of temperature and pressure has a mass of 0.0825g, calculate the relative molecular mass of oxygen.

    (b) Given that the molecular mass of potassium permanganate is 158, what volume of oxygen (measured at room temperature) would be obtained by the complete decomposition of 15.8g of potassium permanganate?
    (Molar volume at room temperature is 24 litres.) **[2004]**

15. Calculate the percentage of nitrogen in aluminium nitride.
[Al = 27, N = 14] **[2005]**

16. The volume of gases A, B, C and D are in the ratio 1 : 2 : 2 : 4 under the same conditions of temperature and pressure.
    (a) Which sample of gas contains the maximum number of molecules?
    (b) If the temperature and the pressure of gas A are kept constant, then what will happen to the volume of A when the number of molecules is doubled?
    (c) If the ratio of gas volumes refers to the reactants and products of a reaction, which gas law is being observed?
    (d) If the volume of A is actually 5.6dm^3 at STP, Calculate the number of molecules in the actual volume of D at STP (Avogadro's number is 6×10^{23})
    (e) Using your answer from (d), state the mass of D if the gas is dinitrogen oxide (N_2O). **[2005]**

17. The equations given below relate to the manufacture of sodium carbonate (molecular weight of Na_2CO_3 = 106.)

1. $NaCl + NH_3 + CO_2 + H_2O \longrightarrow NaHCO_3 + NH_4Cl$
2. $2NaHCO_3 \longrightarrow Na_2CO_3 + H_2O + CO_2$

Questions (a) and (b) are based on the production of 21.2g of sodium carbonate.

(a) What mass of sodium hydrogen carbonate must be heated to give 21.2g of sodium carbonate (Molecular weight of $NaHCO_3$ = 84)?

(b) To produce the mass of sodium hydrogen carbonate calculated in (a), what volume of carbon dioxide, measured at STP, would be required?

[2005]

18. (a) Calculate the percentage of sodium in sodium aluminium fluoride (Na_3AlF_6) correct to the nearest whole number.
(F = 19, Na = 23, Al = 27).

(b) 560 ml of carbon monoxide is mixed with 500ml of oxygen and ignited. The chemical equation for the reaction is as follows :
$2CO + O_2 \longrightarrow 2CO_2$
Calculate the volume of oxygen used and carbon dioxide formed in the above reaction. **[2006]**

19. (a) Determine the empirical formula of a compound containing 47.9% potassium, 5.5% beryllium and 46.6% fluorine by mass.
(Atomic weight of K = 39, Be = 9, F = 19).
Work to one decimal place.

(b) Given that the relative molecular mass of copper oxide is 80, what volume of ammonia (measured at STP) is required to completely reduce 120g of copper oxide?
The equation for the reaction is :
$3\,CuO + 2NH_4 \longrightarrow 3Cu + 3H_2O + N_2$
(Volume occupied by 1 mole of gas at STP is 22.4 litres). **[2006]**

20. (a) Calculate the number of moles and the number of molecules present in 1.4g of ethylene gas. What is the volume occupied by the same amount of ethylene?

(b) What is vapour density of ethylene?
(Avogadro's number = 6×10^{23}; Atomic weight of C = 12, H = 1; Molar volume = 22.4 litres at STP) **[2006]**

21. A sample of ammonium nitrate when heated yields 8.96 litres of steam (measured at STP.)
$NH_4NO_3 \longrightarrow N_2O + 2H_2O$

(a) What volume of dinitrogen oxide is produced at the same time as 8.96 litres of steam?

(b) What mass of ammonium nitrate should be heated to produce 8.96 litres of steam?

(c) Determine the percentage of oxygen in ammonium nitrate. (O = 16)

[2007]

22. A compound X consists of 4.8% carbon and 95.2% bromine by mass.

(a) Determine the empirical formula of this compound working correct to one decimal place. [C = 12; Br = 80]

(b) If the vapour density of the compound is 252, what is the molecular formula of the compound? **[2007]**

23. (a) (i) A compound has the following percentage composition by mass : Carbon 14.4%, hydrogen 1.2% and chlorine 84.5%. Determine the empirical formula of this compound. Work correct to 1 decimal place. [H = 1; C = 12; Cl = 35.5]
(ii) The relative molecular mass of this compound is 168, so what is its molecular formula?
(iii) By what type of reaction could this compound by obtained from ethyne? **[2008]**

(b) From the equation :

$C + 2H_2SO_4 \longrightarrow CO_2 + 2H_2O + 2SO_2$

Calculate :
(i) The mass of carbon oxidized by 49g of sulphuric acid (C = 12; relative molecular mass of sulphuric acid = 98.)
(ii) The volume of sulphur dioxide measured at STP, liberated at the same time. (Volume occupied by 1 mole of a gas at STP is 22.4dm^3.)

24. The equation for the burning of octane is :

$2C_8H_{18} + 25O_2 \longrightarrow 16CO_2 + 18H_2O$

(a) How many moles of carbon dioxide are produced when one mole of octane burns ?
(b) What volume, at STP, is occupied by the number of moles determined in (a)?
(c) If the relative molecular mass of carbon dioxide is 44, what is the mass of carbon dioxide produced by burning two moles of octane?
(d) What is the empirical formula of octane? **[2008]**

25. (a) A gas cylinder contains 24×10^{24} molecules of nitrogen gas. If Avogadro's number is 6×10^{23} and the relative atomic mass of nitrogen is 14, calculate :
(i) mass of nitrogen as in the cylinder.
(ii) volume of nitrogen at STP in dm^3.

(b) Commercial sodium hydroxide weighing 30g has some sodium chloride in it. The mixture on dissolving in water and subsequent treatment with excess silver nitrate solution formed a precipitate weighing 14.3g. What is the percentage of sodium chloride in the commercial sample of sodium hydroxide? The equation for the reaction is

$NaCl + AgNO_3 \longrightarrow AgCl + NaNO_3$

[Relative molecular mass of NaCl = 58; AgCl = 143]

(c) A certain gas 'X' occupies a volume of 100cm^3 at STP and weight 0.5g. Find its relative molecular mass. **[2009]**

26. (a) Calcium carbide is used for the artificial ripening of fruits. Actually the fruit ripens because of the heat evolved while calcium carbide reacts with moisture. During the reaction calcium hydroxide and acetylene gas is formed. If 200cm^3 of acetylene is formed from a certain mass of calcium carbide, find the volume of oxygen required and carbon dioxide formed during the complete combustion. The

combustion reaction can be represented as below :

$2C_2H_2(g) + 5O_2(g) \longrightarrow 4CO_2(g) + 2H_2O(g)$

(b) A gaseous compound of nitrogen and hydrogen contains 12.5% hydrogen by mass. Find the molecular formula of the compound if its relative molecular mass is 37. [N = 14, H =1]. **[2009]**

27. 4.5 moles of calcium carbonate are reacted with dilute hydrochloric acid.
(i) Write the equation for the reaction.
(ii) What is the mass of 4.5 moles of calcium carbonate ? (Relative molecular mass of calcium carbonate is 100).
(iii) What is the volume of carbon dioxide liberated at STP ?
(iv) What mass of calcium chloride is formed ? (Relative molecular mass of calcium chloride is 111)
(v) How many moles of HCl are used in this reaction ? **[2010]**

28. Calculate the mass of
(i) 10^{22} atoms of sulphur,
(ii) 0.1 mole of carbon dioxide.
(Atomic mass: S = 32, C = 12, O = 16 and Avogadro's Number = 6×10^{23}) **[2011]**

29. An organic compound with vapour density = 94 contains C = 12.67%, and Br = 85.11%. Find the molecular formula.
(Atomic mass: C = 12, H = 1, Br = 80) **[2011]**

30. 67.2 liters of H_2 combines with 44.8 litres of N_2 to form NH_3 : $N_{2(g)} + 3H_{2(g)} \rightarrow 2NH_{3(g)}$. Calculate the vol. of NH_3 produced. What is the substance, if any, that remains in the resultant mixture.[44.8*l*, N_2(22.4*l*)] **[2012]**

31. The mass of 5.6dm^3 of a gas at stp to 12.0g. Calculate the relative molecular mass of the gas.[48g.] **[2012]**

32. The vapour density of carbon dioxide [C = 12, O = 16] is : A : 32, B : 16, C: 44, D : 22 [D:22] **[2012]**

33. Find the total percentage of magnesium in magnesium nitrate crystals. $Mg(NO_3)_2.6H_2O$. [Mg = 24, N = 14, O=16 and H=1][9.38%] **[2012]**

34. $P + 5HNO_3$[conc.] $\rightarrow H_3PO_4 + H_2O + 5NO_2$. If 9.3g of phosphorus was used in the reaction. Calculate :
(i) Number of moles of phosphorus taken.
(ii) The mass of phosphoric acid formed.
(iii) The volume of NO_2 produced at STP. [H=1, N=14, P=31, O=16] **[2012]**

35. Solve the following :
(i) What volume of oxygen is required to burn completely 90dm^3 of butane under similar conditions of temperature and pressure ?

$2C_4O_{10} + 13O_2 \longrightarrow 8CO_2 + 10H_2O$

(ii) The vapour density of a gas is 8. What would be the volume occupied by 24.0g of the gas at STP ?
(iii) A vessel contains X number of molecules of hydrogen gas at a certain temperature and pressure. How many molecules of nitrogen gas would be present in the same vessel under the same conditions of temperature and pressure ? **[2013]**

36. O_2 is evolved by heating $KClO_3$ using MnO_2 as a catalyst

$2KClO_3 \xrightarrow{MnO_2} 2KCl + 3O_2$

(i) Calculate the mass of $KClO_3$ required to produce 6.72 litre of O_2 at STP. [atomic masses of K = 39, Cl = 35.5, O = 16]

(ii) Calculate the number of moles of oxygen present in the above volume and also the number of molecules.

(iii) Calculate the volume occupied by 0.01 mole of CO_2 at STP.

37. Give one word or phrase for the following :
The ratio of the mass of a certain volume of gas to the mass of an equal volume of hydrogen under the same conditions of temperature and pressure. **[2014]**

38. Oxygen oxidises ethyne to carbon dioxide and water as shown by the equation :

$2C_2H_2 + 5O_2 \longrightarrow 4CO_2 + 2H_2O$

What volume of ethyne gas at STP is required to produce 8.4dm^3 of carbon dioxide at STP? [H=1, C=12, 0=16] **[2014]**

39. (i) State Avogadro's Law.

(ii) A cylinder contains 68g of ammonia gas at STP.

(1) What is the volume occupied by this gas?

(2) How many moles of ammonia are present in the cylinder?

(3) How many molecules of ammonia are present in the cylinder? [N-14, H-1] **[2014]**

40. Choose the most appropriate answer for each of the following:
Which of the following would weigh the least?

(A) 2 gram atoms of Nitrogen.

(B) 1mole of Silver

(C) 22.4 litres of oxygen gas at 1 atmospheric pressure and 273K

(D) 6.02 × 1023 atoms of carbon.

[Atomic masses: Ag = 108, N = 14, O = 16, C = 12] **[2015]**

41. Complete the following calculations. Show working for complete credit:

(i) Calculate the mass of Calcium that will contain the same number of atom as are present in 3.2gm of Sulphur.
[Atomic masses: S=32, Ca=40]

(ii) If 6 litres of hydrogen and 4 litres of chlorine are mixed and exploded and if water is added to the gases formed, find the volume of the residual gas.

(iii) If the empirical formula of a compound is CH and it has a vapour density of 13, find the molecular formula of the compound. **[2015]**

42. Consider the following reaction and based on the reaction answer the questions that follow:

$(NH_4)_2Cr_2O_7 \xrightarrow{heat} N_2(g) + 4H_2O(g) + Cr_2O_3$

Calculate:

(i) the quantity in moles of $(NH_4)_2Cr_2O_7$ if 63gm of$(NH_4)_2Cr_2O_7$ is heated.

(ii) the quantity in moles of nitrogen formed.

(iii) the volume in litres or dm^3 of N_2 evolved at S.T.P.
(iv) the mass in grams of Cr_2O_3 formed at the same time.
[Atomic masses: H=1, Cr= 52, N=14] **[2015]**

43. (i) A gas of mass 32gms has a volume of 20 litres at S.T.P. Calculate the gram molecular weight of the gas.
(ii) How much Calcium oxide is formed when 82g of calcium nitrate is heated? Also find the volume of nitrogendioxide evolved.

$2Ca(NO_3)_2 \longrightarrow 2CaO + 4NO_2 + O_2$
(Ca = 40, N = 14, O = 16) **[2016]**

44. A gas cylinder contains 12×10^{24} molecules of oxygen gas.
If Avogadro's number is 6×10^{23}; Calculate:
(i) the mass of oxygen present in the cylinder
(ii) the volume of oxygen at S.T.P. present in the cylinder. [O=16] **[2016]**

45. A gaseous hydrocarbon contains 82.76% of carbon. Given that its vapor density is 29, find its molecular formula. [C=12, H =1] **[2016]**

46. The equation $4NH_3 + 5O_2 \longrightarrow 4NO + 6H_2O_2$, represents the catalytic oxidation of ammonia. If $100cm^3$ of ammonia is used calculate the volume of oxygen required to oxidise the ammonia completely. **[2016]**

47. (i) Propane burns in air according to the following equation :

$C_3H_8 + 5O_2 \longrightarrow 3CO_2 + 4H_2O$.
What volume of propane is consumed on using 1000 cm^3 of air, considering only 20% of air contains oxygen?
(ii) The mass of 11.2 litres of a certain gas at s.t.p. is 24g. Find the gram molecular mass of the gas. **[2017]**

48. A gas cylinder can hold 1 kg of hydrogen at room temperature and pressure :
(i) Find the number of moles of hydrogen present.
(ii) What weight of CO_2 can the cylinder hold under similar conditions of temperature and pressure? (H =1, C =12, O = 16)
(iii) If the number of molecules of hydrogen in the cylinder is X, calculate the number of CO_2 molecules in the cylinder under the same conditions of temperature and pressure.
(iv) State the law that helped you to arrive at the above result. **[2017]**

49. (i) Calculate the number of gram atoms in 4.6 grams of sodium (Na = 23).
(ii) Calculate the percentage of water of crystallization in $CuSO_4.5H_2O$
(H = 1, O = 16, S = 32, Cu = 64)
(iii) A compound of X and Y has the empirical formula XY_2. Its vapour density is equal to its empirical formula weight. Determine its molecular formula. **[2017]**

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