Chemistry

Cambridge University Examinations

General Certificate of Education Ordinary Level
O – LEVEL 5070. Notes, P1, P2 and P4

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Chapter

The Mole Concepts

Work Sheet
Paper *1*

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1 Iron(III) oxide can be reduced by carbon monoxide.

$$Fe_2O_3 + 3CO \rightarrow 2Fe + 3CO_2$$

(i) Calculate the maximum mass of iron that can be formed when 14.4 g of iron(III) oxide is reduced by excess carbon monoxide.

Give your answer to three significant figures.

mass of iron = ... g [3]

(ii) Calculate the maximum volume of carbon dioxide, in dm^3, produced by this reaction, at room temperature and pressure.

volume of carbon dioxide = ... dm^3 [2]

2 An impure sample of iron(II) sulphate was analysed by titration.

The sample was dissolved in 25.0 cm^3 of dilute sulphuric acid and then titrated against 0.0400 mol/dm^3 potassium dichromate(VI) solution.

19.0 cm^3 of potassium dichromate(VI) solution was required to reach the end-point.

(i) Calculate the number of moles of potassium dichromate(VI) used in the titration.

..... moles [1]

(ii) One mole of potassium dichromate(VI) reacts with six moles of iron(II) ions. Calculate the mass, in grams, of iron(II) ions in the sample analysed.

mass of iron(II) ions..... g [2]

3 Iron(II) sulphate, $FeSO_4$, is easily oxidised to iron(III) sulphate.

(a) Calculate the percentage by mass of iron in iron(II) sulphate.

..... %

4 Methylamine is made by reacting methanol with excess ammonia under pressure in the presence of a catalyst.

$$CH_3OH + NH_3 \rightarrow CH_3NH_2 + H_2O$$

(i) Define the term *catalyst*.

.....[1]

(ii) Calculate the theoretical yield of methylamine that can be obtained from 240 kg of methanol.

[2]

Methylamine is a gas. Calculate the volume occupied by 6.2 g of methylamine at room temperature and pressure.

[2]

5 A compound, **P**, contains 40.0% carbon, 6.7% hydrogen and 53.3% oxygen.

What is its empirical formula?

6 Solid zinc chloride absorbs ammonia to form tetrammine zinc chloride, $Zn(NH_3)_4Cl_2$.

$$ZnCl_2 + 4NH_3 \rightarrow Zn(NH_3)_4Cl_2$$

Calculate the maximum yield, in grams, of tetrammine zinc chloride formed when 3.4 g of zinc chloride reacts with excess ammonia.

[2]

7 Using the information that one mole contains 6.02×10^{23} particles, calculate the number of electrons in one mole of NO molecules.

.....

..... [1]

8 Phosphine, PH_3, is a gas which has a smell of garlic. It is formed when white phosphorus is warmed with aqueous sodium hydroxide.

$$4P + 3NaOH + 3H_2O \rightarrow PH_3 + 3NaH_2PO_2$$

(i) Calculate the maximum mass of phosphine formed when 1.86 g of phosphorus reacts with excess aqueous sodium hydroxide.

[2]

(ii) Calculate the volume of phosphine formed from 1.86 g of phosphorus at r.t.p.

[1]

9 **(c)** Carboxylic acid **X** contains 55.8% carbon, 7.0% hydrogen and 37.2% oxygen.

(i) Calculate the empirical formula of **X**.

[2]

10 A student makes hydrogen chloride by reacting sodium chloride with excess concentrated sulfuric acid at room temperature and pressure.

$$NaCl + H_2SO_4 \rightarrow NaHSO_4 + HCl$$

(i) Calculate the maximum volume of hydrogen chloride that can be made from 0.2 moles of sodium chloride at room temperature and pressure.

11 A student reacts 3.0 g of magnesium with 2.5 mol/dm^3 sulfuric acid.
Calculate the minimum volume of sulfuric acid that reacts with all the magnesium.

[2]

12 The student uses 25.0 cm^3 of 1.60 mol/dm^3 sodium hydroxide to prepare the crystals.

$$2NaOH(aq) + H_2SO_4(aq) + 8H_2O(l) \rightarrow Na_2SO_4.10H_2O(s)$$

Calculate the maximum mass of hydrated sodium sulfate crystals that can be formed.

[4]

13 $N_2(g) + O_2(g) \rightarrow 2NO(g) \quad \Delta H = +66\,kJ\,mol^{-1}$

Calculate the mass of nitric oxide formed when 100 g of nitrogen reacts completely with oxygen.

mass of nitric oxide = ... g [3]

14 Farmers that grow vegetable oil crops often use large quantities of ammonium nitrate fertiliser, NH_4NO_3.
Calculate the percentage by mass of nitrogen in ammonium nitrate.

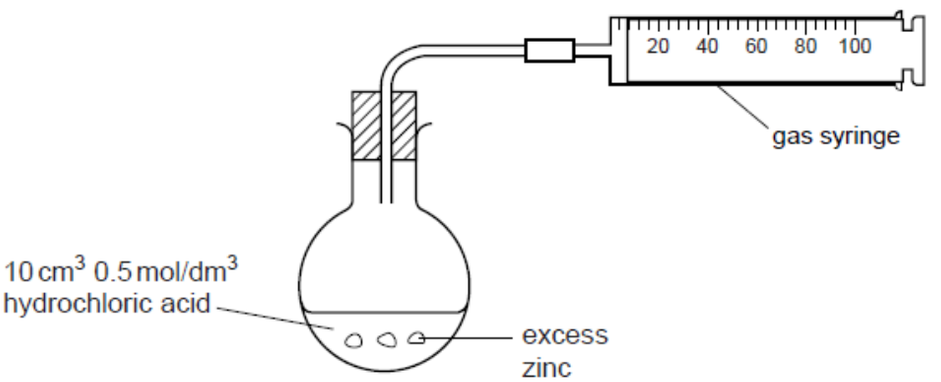
percentage = ... % [2]

15 A 0.105 g sample of sulfamic acid is dissolved in 25.0 cm^3 of water. The sulfamic acid solution requires 10.8 cm^3 of 0.100 mol dm^{-3} potassium hydroxide for complete neutralisation.

Calculate the number of moles of sulfamic acid that react with one mole of potassium hydroxide.

number of moles of sulfamic acid = ... [3]

16 An **excess** of zinc was added to 10 cm^3 of 0.5 mol/dm^3 hydrochloric acid, using the apparatus below.



$$Zn(s) + 2HCl(aq) \rightarrow ZnCl_2(aq) + H_2(g)$$

(a) Calculate the maximum volume of hydrogen which could be produced in the reaction at r.t.p. [3]

17 An aqueous solution of calcium hydroxide was titrated with 0.0150 mol/dm^3 hydrochloric acid.

$$Ca(OH)_2 + 2HCl \rightarrow CaCl_2 + 2H_2O$$

It required 6.00 cm^3 of this aqueous hydrochloric acid to neutralise 20.0 cm^3 of the calcium hydroxide solution.
Calculate the concentration, in mol/dm^3, of the calcium hydroxide solution.

18 A solution of fumaric acid was titrated against aqueous sodium hydroxide.

$$HO_2CCH{=}CHCO_2H + 2NaOH \rightarrow NaO_2CCH{=}CHCO_2Na + 2H_2O$$

18.0 cm^3 of 0.200 mol/dm^3 sodium hydroxide were required to neutralise 60.0 cm^3 of fumaric acid solution.
Calculate the concentration, in mol/dm^3, of the fumaric acid solution.

.....

.....

.....

.....

.....

19 Dilute phosphoric acid, $H_3PO_4(aq)$, reacts with aqueous potassium hydroxide to make potassium phosphate.

$$H_3PO_4(aq) + 3KOH(aq) \rightarrow K_3PO_4(aq) + 3H_2O(l)$$

A student titrates 25.0 cm^3 of $H_3PO_4(aq)$ with 0.200 mol/dm^3 KOH(aq).

12.5 cm^3 of KOH(aq) is required to react exactly with the $H_3PO_4(aq)$.

Calculate the concentration of the $H_3PO_4(aq)$.

20 Potassium sulfate can be prepared by reacting aqueous potassium hydroxide with dilute sulfuric acid.

$$2KOH + H_2SO_4 \rightarrow K_2SO_4 + 2H_2O$$

In an experiment, $20.0\,cm^3$ of $0.650\,mol/dm^3$ sulfuric acid is just neutralised by aqueous potassium hydroxide.

(i) Calculate the maximum mass of potassium sulfate, K_2SO_4, that could be prepared.

[The relative formula mass of K_2SO_4 is 174.]

maximum mass of potassium sulfate = ... g [2]

(ii) After crystallisation, 1.72 g of dry potassium sulfate was obtained. Calculate the percentage yield of potassium sulfate.

percentage yield of potassium sulfate = ... % [1]

21 The equation for the reaction is

$$CaCO_3 + 2HCl \longrightarrow CaCl_2 + H_2O + CO_2$$

(c) 50 cm^3 of 0.20 mol/dm^3 hydrochloric acid is added to an excess of calcium carbonate.

(i) Calculate the number of moles in 50 cm^3 of 0.20 mol/dm^3 hydrochloric acid.

..... moles [1]

(ii) Calculate the relative formula mass of calcium carbonate.
[A_r: C,12; O,16; Ca, 40.]

.....[1]

(iii) Using your answers to **(c)(i)** and **(c)(ii)** and the equation for the reaction, calculate the mass of calcium carbonate required to completely react with 50 cm^3 of 0.20 mol/dm^3 hydrochloric acid.

..... cm^3 [1]

(iv) Calculate the maximum volume of carbon dioxide that is produced when 50 cm^3 of 0.20 mol/dm^3 of hydrochloric acid reacts completely with the excess calcium carbonate.
[1 mole of a gas occupies a volume of 24 dm^3 at room temperature and pressure.]

..... cm^3 [1]

22 Dilute ethanoic acid and dilute hydrochloric acid both react with magnesium ribbon to form hydrogen.

(a) Give the formula of one ion found in both of these dilute acids. [1]

(b) Magnesium ribbon reacts with hydrochloric acid as shown in the equation.

$$Mg + 2HCl \longrightarrow MgCl_2 + H_2$$

A 0.24 g sample of magnesium ribbon is added to 5.0 cm^3 of 2.0 mol/dm^3 hydrochloric acid.

(i) Which reactant, magnesium or hydrochloric acid, is in excess? Use calculations to explain your answer. [2]

(ii) Calculate the maximum mass of magnesium chloride that can be formed in this reaction. [2]

(iii) A 0.24 g sample of magnesium ribbon is added to 5.0 cm^3 of 2.0 mol/dm^3 ethanoic acid.
Explain why this reaction forms the same volume of hydrogen but takes place much more slowly than the reaction of the same mass of magnesium with 5.0 cm^3 of 2.0 mol/dm^3 hydrochloric acid. [3]

23 Analysis of a compound **Z** obtained from the planet Mars showed **Z** has the following composition.

element	percentage by mass
potassium	39.4
iron	28.3
oxygen	32.3

(a) Show that the empirical formula of **Z** is K_2FeO_4.

.....

.....

.....

.....

..... [2]

(b) K_2FeO_4 can be prepared in the laboratory by the reaction between iron(III) oxide, Fe_2O_3, chlorine, Cl_2, and potassium hydroxide, KOH.

$$Fe_2O_3 + 3Cl_2 + 10\,KOH \longrightarrow 2K_2FeO_4 + 6KCl + 5H_2O$$

A 2.00 g sample of Fe_2O_3 is added to 20.0 cm^3 of 4.00 mol dm^{-3} KOH.

(i) Calculate the amount, in moles, of Fe_2O_3 used.

.....

..... [2]

(ii) Calculate the amount, in moles, of KOH used.

.....

..... [1]

(iii) Which reagent, Fe_2O_3 or KOH, is in excess in this reaction?

.....

Explain your answer.

.....

..... [1]

24

$$4NH_3(g) + 5O_2(g) \rightleftharpoons 4NO(g) + 6H_2O(g) \qquad \Delta H = -909\,kJ\,mol^{-1}$$

A factory uses 100 tonnes of ammonia each day to produce 160 tonnes of nitrogen monoxide, NO.
Calculate the percentage yield of nitrogen monoxide.

percentage yield = ... % [3]

25 $CH_3OH + CO \rightleftharpoons CH_3COOH \quad \Delta H = -137\,kJ\,mol^{-1}$

In an investigation 10.0 moles of methanol are mixed with 20.0 moles of carbon monoxide.
At the end of the reaction 9.8 moles of ethanoic acid are formed.
Calculate the percentage yield of ethanoic acid.

percentage yield = ... % [2]