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A Level

Chemistry

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CHEMISTRY 196

ADVANCED LEVEL

PAPER I

(Two hours and a half)

Answer **five** *questions.*

Answers to questions in Sections A *and* B *are to be given up separately.*

Begin each answer on a fresh sheet of paper and write on one side of the paper only.

Mathematical tables are provided.

SECTION A

1. How does the presence of a dissolved solid affect (*a*) the freezing-point, (*b*) the boiling-point, of a pure solvent? Explain how the effect in (*a*) is used to indicate the presence of impurities in organic compounds, and how the effect in (*b*) is used to determine the molecular weight of a solute.

When 0·71 gm. of a substance *A*, whose formula-weight is 74·5, was dissolved in 49·6 gm. of water, the freezing-point of the water was depressed by 0·672° C. What conclusions can you draw about the state of *A* in aqueous solution, assuming that the molecule of *A* contains only two atoms?

[Molecular depression constant for water = 18·6° C. per 100 gm.]

2. What method would you use in the laboratory to prepare a specimen of nitrogen? [No experimental details are required.]

Give an example of (*a*) a metal, (*b*) a non-metal, (*c*) a compound, which combines directly with nitrogen, stating the conditions and products in each case. Describe the action of water on the products obtained in (*a*), (*b*) and (*c*).

3. How may hydrogen iodide be prepared?

How, and under what conditions, does it react with (*a*) sulphuric acid, (*b*) ethyl alcohol, (*c*) chlorine? Explain the theoretical basis of **two** methods by which the concentration of an aqueous solution of hydrogen iodide could be determined.

4. State Dulong and Petit's law. Discuss its use in the determination of *exact* atomic weights, pointing out what other information is required.

A metal *M*, whose specific heat is 0·056, forms two chlorides containing 37·40 and 54·43 per cent. of chlorine respectively. The former dissolves in water but deposits a white precipitate on standing; the latter is a colourless, fuming liquid. Suggest formulae for the two chlorides, calculate the atomic weight of *M* and suggest, with reasons, a suitable position for it in the periodic table. [Cl = 35·46.]

Section B

5. Describe the differences in properties of yellow phosphorus and red phosphorus, and explain how the yellow form may be converted into the red form. Explain what happens when phosphorus is heated (*a*) in dry air, (*b*) with nitric acid. How may the product of reaction (*a*) be changed into the product of reaction (*b*)?

6. Give, in outline, **two** methods by which sulphuric acid is manufactured.

How, and under what conditions, does sulphuric acid react with (*a*) copper, (*b*) zinc, and (*c*) benzene?

7. Describe fully the laboratory preparation of an aqueous solution of acetaldehyde.

How do acetaldehyde and acetone react with (*a*) sulphuric acid, (*b*) phenylhydrazine, and (*c*) an ammoniacal solution of silver nitrate?

8. Describe the action of heat on (*a*) a mixture of calcium acetate and calcium formate, (*b*) sodium formate, (*c*) ammonium acetate, (*d*) a mixture of sodium acetate and soda lime, and (*e*) a mixture of sodium benzene sulphonate and sodium hydroxide.

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Paper II

(*Two hours and a half*)

Answer **five** *questions.*

Answers to questions in Sections A *and* B *are to be given up separately.*

Begin each answer on a fresh sheet of paper and write on one side of the paper only.

Mathematical tables are provided.

Section A

1. State Faraday's laws of electrolysis.

A direct current of 5 amp. is passed through an aqueous solution of sodium chloride, under conditions in which the anode product and cathode product remain separated, until one litre of hydrogen, measured over water at 15° C. and 750 mm. pressure, is liberated. Calculate (*a*) the time required for this volume of hydrogen to be obtained, (*b*) the weight of sodium hydroxide formed in this time.

Describe and explain how you would modify the above arrangement in order to produce a solution of sodium hypochlorite.

[H = 1, O = 16, Na = 23; 1 gram equivalent of an electrolyte is decomposed by 96,500 coulombs; the saturated vapour pressure of water at 15° C. = 13 mm.; 1 gram-molecule of a gas occupies 22·4 litres at N.T.P.]

2. Give the electronic structures of the atoms of carbon, chlorine, argon and potassium.

Show how these structures account for the following:

(*a*) both potassium and chlorine have valency 1;

(*b*) the formation of a compound between potassium and chlorine which is an electrolyte;

(*c*) the formation of a compound between carbon and chlorine which is a non-electrolyte.

3. Write equations for the reactions between:

(*a*) oxalic acid, potassium permanganate and dilute sulphuric acid;

(*b*) sodium thiosulphate and iodine;

(*c*) potassium chromate and silver nitrate;

(*d*) barium chloride and sodium carbonate.

Write brief notes on the uses of reactions (*a*), (*b*) and (*c*) in volumetric analysis.

How would you collect and estimate the purity of the barium compound formed in (*d*)?

4. Describe the manufacture of pig-iron from haematite, and outline briefly **two** methods for converting pig-iron into steel.

How, starting from iron filings, would you prepare specimens of (*a*) ferric oxide, (*b*) ferrous ammonium sulphate?

SECTION B

5. Explain, giving examples, the meaning of **five** of the following terms: (*a*) thermal dissociation, (*b*) *p*H, (*c*) salt hydrolysis, (*d*) exothermic compound, (*e*) polymerization, (*f*) deliquescence.

6. Describe briefly (no diagrams required) the methods used to produce three fuel gases of industrial importance. How may hydrogen be obtained from one of these fuels?

How, and under what conditions, does hydrogen react with (*a*) chlorine, (*b*) compounds of arsenic, (*c*) ethylene?

7. *X* is an ester of a monocarboxylic acid and a monohydric alcohol. When one gram of *X* is boiled with 25 ml. *N* potassium hydroxide solution until saponification is complete, it is found that 13·65 ml. *N* hydrochloric acid are required to neutralize the excess alkali. Calculate the molecular weight of the ester. Name and give the structural formulae of all such esters which have this molecular weight. Describe the preparation of **one** of them in the laboratory. [H = 1, C = 12, O = 16.]

8. Describe tests which would enable you to detect the presence of (*a*) sulphur, (*b*) chlorine, in an organic compound.

What products may be obtained by the action of concentrated sulphuric acid on ethyl alcohol? Give the equation for each reaction, and state the conditions necessary.

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PRACTICAL TEST

(*Three hours*)

Mathematical tables are provided. Candidates wishing to use qualitative analysis tables must first show them to the Supervisor and obtain his permission for their use.

50 *per cent of the marks for this paper are assigned to each question. In Question* 1 *an* **outline** *only of the method should be given. Details of all titrations and calculations should be recorded* **clearly**. *In your calculations use the following atomic weights* H = 1; B = 11; C = 12; O = 16; Na = 23.

In Question 2 *record your work in tabular form showing the tests, the observations, and the inferences.*

1. You are provided with three solutions:

F 1. A solution containing 20·0 gm. per litre of borax, $Na_2B_4O_7.10H_2O$.

F 2. A solution containing hydrochloric acid.

F 3. A solution containing 5·00 gm. per litre of anhydrous sodium carbonate.

(*a*) Titrate 20 ml. (or 25 ml.) portions of solution **F 1**, with the given hydrochloric acid **F 2**, using the indicator provided. Calculate the normality of the acid **F 2**.

(*b*) Titrate 20 ml. (or 25 ml.) portions of solution **F 3** with the given hydrochloric acid **F 2**, using the indicator provided. From your results, calculate the number of molecules of hydrochloric acid which react with one molecule of sodium carbonate under these conditions.

2. Analyse qualitatively substance **F 4** which contains two cations and two anions.

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SCHOLARSHIP PAPER

PAPER III

(*Two hours and a half*)

Answer **five** *questions, of which not more than* **three** *may be selected from one section.*

The answers to questions in Sections A *and* B *are to be given up separately.*

Begin each answer on a fresh sheet of paper and write on **one** *side of the paper only.*

Mathematical tables and squared paper are provided.

SECTION A

1. Explain what is meant by the equivalent conductivity of a solution, and describe briefly how this quantity varies with concentration for different types of electrolyte.

How may measurements of conductivities be used to determine the solubility of barium sulphate?

2. What is meant by the *electrochemical series*? Show how the methods used for the isolation of (*a*) sodium, (*b*) aluminium, (*c*) zinc, (*d*) mercury, are related to the positions of these metals in the series.

3. Suggest **one** method for the determination of each of the following:

(*a*) the heat of the reaction

$$CuSO_4 . 5H_2O_{(solid)} = CuSO_{4(solid)} + 5H_2O_{(liquid)},$$

(*b*) the sign of the charge on a colloidal suspension of ferric hydroxide,

(*c*) the solubility of bromine in water at 25° C.

4. Describe how (*a*) sodium cyanide, (*b*) potassium ferrocyanide, and (*c*) potassium dichromate may be prepared, and give an account of their properties and reactions. What would you expect to happen when, by using platinum electrodes, an aqueous solution of potassium ferrocyanide is electrolysed?

SECTION B

5. 20 ml. of a 0·2 *N* acid were titrated with sodium hydroxide solution and during the course of the titration the following measurements were made:

ml. NaOH added	pH	ml. NaOH added	pH
0	2·4	24	4·7
4	3·1	28	5·1
8	3·6	30	5·7
12	3·9	31	6·3
16	4·1	31·5	7·5
20	4·4	31·7	9·0

Plot, on the squared paper provided, a titration curve, and deduce the dissociation constant of the acid. What is the normality of the alkali, and what indicator would be suitable for such a titration?

6. Describe how the accurate equivalent weights of (*a*) carbon, and (*b*) chlorine, may be determined. What further experimental evidence is required to fix the atomic weights of these elements?

7. An organic compound *A*, $C_3H_7O_2N$, was boiled with dilute alkali under a reflux condenser; ammonia was evolved. Some of the remaining liquid was distilled and the distillate, with caustic soda and iodine, gave a yellow crystalline precipitate. The residue from the distillation evolved carbon dioxide with dilute acid. With ammonia, *A* gave a compound *B*, CON_2H_4, which, on boiling with alkali, gave ammonia; the residue, with dilute acid, gave carbon dioxide.

Deduce what you can about the structures of *A* and *B*, and trace the reactions described above.

8. Describe precisely how each of the following structural formulae can represent two compounds, (*a*) $CH_3.CH(OH).COOH$, (*b*) HOOC.CH:CH.COOH. Write down possible compounds having the empirical formulae C_3H_8O. Comment on the number of possible compounds of empirical formula CH_2.

F

PRACTICAL CHEMISTRY INSTRUCTIONS

PAPER 198 (ADVANCED LEVEL)

JUNE 1957

Each candidate will be allowed the use of a book on qualitative analysis. Those parts of any book that deal with quantitative work must be securely sealed and inspected by the Supervisor before the papers are given out.

In addition to the fittings and reagents ordinarily contained in a chemical laboratory, the following apparatus and solutions will be required:

For each candidate—one burette, one pipette (either 25 ml. or 20 ml., but all candidates in one centre are to use pipettes of the same volume), and titration flasks.

Candidates will also require:

(*a*) Solution of borax containing exactly 20·0 gm. per litre of borax, $Na_2B_4O_7.10H_2O$, and labelled "**F 1**, containing 20·0 gm. per litre of borax, $Na_2B_4O_7.10H_2O$." Allow each candidate 150 ml.

(*b*) Solution of hydrochloric acid containing between 3·5 gm. and 4·0 gm. per litre of HCl and labelled "**F 2**, containing hydrochloric acid." Allow each candidate 300 ml.

(*c*) Solution of sodium carbonate containing exactly 5·00 gm. per litre of anhydrous sodium carbonate Na_2CO_3 and labelled "**F 3**, containing 5·00 gm. per litre of anhydrous sodium carbonate." Allow each candidate 150 ml.

(*d*) *A supply of methyl orange (or screened methyl orange), to be labelled "Methyl orange" (or "Screened methyl orange").

(*e*) Substance **F 4**, which will be sent from Cambridge.

ACCURACY OF SOLUTIONS

All the solutions are to be labelled as shown.

Those supplied by Messrs Boots Ltd. will not necessarily be of exactly this concentration, but the Examiners will be informed of the concentrations of the different batches.

If the concentrations of the solutions prepared by the school differ slightly from those shown on the label, the Examiners will make the necessary allowance. They should be informed of the exact concentration.

INFORMATION REQUIRED BY THE EXAMINER

1. The Supervisor is asked to carry out the titrations required of the candidates and to enter the results on the Report Form. *They should be correct to one part in two hundred, and the figures should be carefully verified.*

* Any other suitable indicator may be used in place of methyl orange, provided that the colour change takes place within a similar pH range. If an alternative indicator is used the Examiner must be notified on the report form.

2. The Supervisor is invited to add a note of any particular difficulties experienced by a candidate, especially if the Examiner would be unable to discover them from the written answers.

Provision of Chemicals

A sufficient amount of the solutions F 1 and F 3 will be sent to the schools direct by Messrs Boots Ltd., and should be kept stoppered until required. Specifications are given merely in case of accidents. The outer cases, which contained the solutions, must be returned to Messrs Boots as soon as possible. An addressed card for the return of the empty packing cases is enclosed in this envelope. Please write your Centre Number in the bottom right-hand corner of this addressed card before returning the case. On the day of their despatch the cards enclosed with these instructions should be posted. Unless this is done, the school will be charged with the cost of the packing cases.

Substance **F 4** will be sent from Cambridge. *The parcel should be opened and the contents checked as soon as it is received, the card enclosed in it being posted at once.*