

**IFP**

INORGANIC FEED PHOSPHATES

Inorganic feed phosphate test methods

Solubility in 2% Citric Acid

Ambient temperature
(Regulation 2003/2003/EC, method 3.1.3)

1. Sample

Weigh out 1 gram (± 0.001 g) of the feed phosphate sample, ground to a granular size of less than 0.5mm. Place in a 250ml flask with sufficient space to allow for good agitation (ie Stohmann).

2. Reagent

Prepare 200ml 2% (w/w) citric acid solution by dissolving pure citric acid ($C_6H_8O_7 \cdot H_2O$) in distilled water.

3. Procedure

Add part of the reagent to the flask at ambient temperature (20°C) shaking vigorously to avoid the formation of lumps and to prevent any of the sample sticking to the walls of the flask. Add the remainder of the solution and stop up the flask.

Agitate for two hours in a rotary shaker at 35-40 revolutions per minute. Filter the resulting solution immediately through a paper filter free of phosphates into a dry volumetric flask, discarding the first 20ml of the filtrate.

Taking an appropriate aliquot part of the clear filtrate, use the gravimetric quinoline phosphomolybdate method to determine its phosphorus (P) content.

Solubility in Alkaline Ammonium Citrate

Petermann method: 65°C (Regulation 2003/2003/EC, method 3.1.5)

1. Sample

Weigh out 1 gram (± 0.001 g) of the feed phosphate sample, ground to a granular size of less than 0.5mm. Place in a 500ml flask (ie Stohmann).



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2. Reagent

Prepare 200ml of alkaline ammonium citrate from bi-ammonium citrate or from citric acid and ammonia. The reagent should have a pH between 9.4 and 9.7, a density of 1.082 or 1.083 and an ammoniacal N content of 42g/litre.

3. Procedure

Add the reagent to the flask, shaking vigorously. Stop up the flask and place in a warm water bath at 65°C, ensuring that the level of water in the bath is above that of the solution. Shake the flask well every five minutes for 30 minutes, releasing the pressure after each agitation. Leave the flask for a further 60 minutes, shaking at ten minute intervals.

Cool down the solution to ambient temperature (20°C) and make it up to 500ml with distilled water. Mix well and filter through a paper filter free of phosphates, discarding the first 20ml of the filtrate.

Determine the P content of an appropriate aliquot part of the filtrate using the gravimetric quinoline phosphomolybdate method.

Determination of content

Total phosphorus

1. Scope and field of application

This method of analysis specifies a quinoline phospho-molybdate gravimetric method for the determination of the total phosphorus content of feed phosphates (based on *Regulation 2003/2003/EC* method 3.2).

2. Principle

Solubilisation and hydrolysis of a test portion by boiling with mineral acid. Precipitation of phosphoric acid in the form of quinoline phosphomolybdate, in the presence of acetone. Filtration, washing, drying and weighing of the precipitate.

3. Apparatus

Usual laboratory equipment and in particular:

- 3.1** Filter crucible of sintered glass, porosity P10 or P16 (pore size index from 4 to 16µm).
- 3.2** Oven, capable of being controlled at 250°C ± 10°C.
- 3.3** Flameless heating apparatus.

4. Reagents

During the analysis, use only reagents of recognised analytical reagent grade and only distilled water of equivalent quality.

4.1 Hydrochloric acid (HCl)

$\rho = 1.13\text{g/ml}$, about 26% (m/m)

4.2 Nitric acid (HNO₃)

$\rho = 1.20\text{g/ml}$, about 32% (m/m)

4.3 Citromolybdate or quimociac reagent:

1. Dissolve 70g of sodium molybdate dihydrate (Na₂MoO₄·2H₂O) in 150ml of water.
2. Dissolve 60g of citric acid monohydrate (C₆H₈O₇·H₂O) in 150ml of water and add 85ml of nitric acid (HNO₃) solution, approximately 1.38g/ml, about 63% (m/m)
3. Pour, while stirring, solution 1 into solution 2
4. Add 25ml of nitric acid (HNO₃) solution, approximately 1.38g/ml, about 63% (m/m), then 5ml of recently distilled quinoline (C₆H₄NC₃H₃) to 100ml of water.
5. Pour solution 4 into solution 3 and mix. Allow to stand for 12 hours and filter through the filter crucible (3.1). Store this solution in a well stoppered flask for example, polyethylene.
6. Add 280ml of acetone ((CH₃)₂CO) to solution 5 and dilute to 1000ml with water. Store under the same conditions as solution 5.

4.4 Monopotassium dihydrogen orthophosphate (KH₂PO₄) to dried constant mass at 100°C.

5. Procedure

5.1 Test portion and preparation of test solution: <

1. Grind at least 100g of the material until it passes a 500 μm sieve (size ISO 565). Materials in which the absence of water insolubles and polyphosphates has not been verified: Weigh to the nearest 0.0002g, 2.5g of the test portion in such a way that there is no gain or loss of moisture. Transfer the test portion to a flask of about 250ml capacity, add 150ml of water, 10ml of hydrochloric acid (4.1) and 40ml of nitric acid (4.2), then boil for 30 minutes. Cool, transfer the solution quantitatively to a 500ml one mark volumetric flask, dilute to the mark and filter.
2. Materials in which the absence of water insolubles has been verified, but which contain polyphosphates: Place the test portion in the flask, add 15ml of hydrochloric acid (4.1) and boil for about 20 minutes. Cool and add about 100ml of water. Fit a reflux condenser and boil for one hour. Cool and prepare the solution as described above.

5.2 Determination

Depending on the expected phosphorus content, transfer to a 400ml beaker the aliquot part of the test solution (5.1) containing 6.5-11mg P with a maximum of 15mg P and shown in the following table:

Expected P content % (m/m)	Aliquot part of test solution 5.1 to be taken (ml)
6.5 - 11.0	20
11.0 - 22.00	10
> 22.0	5

Dilute to about 100ml and add 50ml of the citromolybdate reagent (4.3). Cover the beaker with a clock glass and warm its contents on a hot-plate at $75^{\circ}\text{C} \pm 5^{\circ}\text{C}$ for about 30 seconds (*do not use a flame and do not mix during the addition of the reagent or while heating, in order to prevent the formation of clots*). Allow to cool to ambient temperature, stirring three or four times with a glass rod.

Place the filter crucible in the oven at $250^{\circ}\text{C} \pm 10^{\circ}\text{C}$ and leave for 15 minutes counted from the moment when this temperature has been re-established. Allow to cool in a dessicator and weigh to the nearest 0.0001g.

Decant the liquid through the filter crucible and wash the precipitate six times by decantation, using about 30ml of water each time. Transfer the rest of the precipitate to the filter crucible by means of a jet of water from a washbottle. Then wash the precipitate four times, removing each portion of wash water by means of a vacuum pump.

Place the filter crucible in the oven at $250^{\circ}\text{C} \pm 10^{\circ}\text{C}$ and heat to constant mass. Normally 15 minutes, counted from the moment when this temperature is re-established, is sufficient. Allow to cool to ambient temperature in a dessicator and weigh to the nearest 0.0001g.

5.3 Blank test

Carry out a blank test, in parallel with the determination and following the same procedure, using the same quantities of all the reagents as those used for the determination.

5.4 Check-test

Carry out the determination on an aliquot portion, containing 6.54mg of P, of monopotassium dihydrogen orthophosphate solution: Weigh 2.8742g of the monopotassium dihydrogen orthophosphate into a 1000ml one mark volumetric flask. Dissolve in water and dilute to the mark. Use as the test-portion 10ml of this solution, equivalent to 6.54mg of P, and use the same conditions, reagents and blank-test.

6. Expression of results

The total phosphorus (P) content, in % (m/m), is given by the formulae :

$$P = \frac{(m1 - m2) \times f \times 100}{\frac{2,500 \times D}{500}} = \frac{(m1 - m2) 0.2800}{D}$$

where :

m1 is the mass, in grams, of the precipitate obtained with the aliquot part of the test solution (5.2),

m2 is the mass, in grams, of the precipitate obtained with the corresponding aliquot part of the blank test solution (5.3)

D is the volume of test solution 5.1 in ml

f is 0.013998 for conversion of quinoline phosphomolybdate to phosphorus (P).

Calcium

1. Scope and field of application

Method for the determination of calcium content of calcium phosphates, fertilisers, calcium oxide and carbonate containing more than 10% CaO.

2. Principle

Dissolution of the test portion:

- a) in water (water soluble fertilisers only)
- b) by boiling in mineral acid.

Precipitation of phosphates, fluorides, iron and aluminium (if present) by addition of zirconyl chloride, potassium sulphate and sodium hydroxide at pH 3.8.

Iron and aluminium are precipitated as phosphates, the excess phosphate as zirconium phosphate, and fluoride as the insoluble zirconium fluoride. Excess zirconium is precipitated as potassium zirconium sulphate.

Filtration and titration of the filtrate (still containing 100% of the present calcium ions) at pH 12 with a Na₂-EDTA solution.

3. Standard solution

Na₂-EDTA solution, 0.05M, commercially available or determined by titration with a calcium standard volumetric solution.

4. Procedure

4.1 Procedure A (including pre-treatment):

For dissolution of the samples: water soluble extraction (ISO 5316) or boiling in mineral acid with hydrochloric/nitric acid attack (ISO 7497).

Pipette an amount of the sample solution, containing max. 100mg P₂O₅ and preferably 100-175mg CaO, or less at high P₂O₅ levels, into a 250ml beaker. Add successively water until approx. 125ml, 10ml of a 0.3M zirconyl chloride solution and, after mixing, 10ml of a 105g/l potassium sulphate solution.

Add 2M NaOH solution to pH 3.8 (just purple on bromophenol blue). Transfer in a 250ml volumetric flask, bring to volume with water, mix and filtrate. Proceed as described in procedure B.

4.2 Procedure B:

Pipette 100ml of the filtrate described above or, if pretreatment is not necessary, direct from the sample solution an amount of 40-70mg CaO (max. 100ml of sample solution) into a 250ml beaker. Add water until 100ml and prepare for titration.

Add 10ml of a 2M NaOH solution (free of carbonates) and 1ml of indicator (4g/l calconcarbonic acid in methanol) and titrate directly with the standard EDTA solution. Avoid, as much as possible, CO₂ absorption from the air, as precipitation of CaCO₃ at these high pH values can suppress the result.

Prepare blank-solutions in the same way.

Calculate the calcium-content of the sample:

$$\% \text{ CaO} = \frac{v \times c}{g} \times \frac{M}{10} \times f$$

where:

v is the net titrant consumption up to the equivalence point (ml)

c is the concentration of the titrant (mmol/ml)

M is the molar mass of calcium oxide = 56.08mg/mmol

g is the weight of the sample (g)

f is the dilution factor.

Determination of impurities

Fluorine

1. Scope and field of application

This method is designed to determine the fluoride content of feed phosphates by means of an ion-selective electrode. When fluorophosphates are present, the pH may be raised up to more than 9 in order to hydrolyse the fluorophosphates completely. At this pH, EDTA has to be added to prevent precipitation of calcium hydroxide and care must be taken to have a F-concentration of 10⁻³ or higher to avoid interference of the hydroxide ion.

The method is applicable to products having fluorine contents, expressed as F, greater than 0.02mg/kg (limit of quantitation).

2. Principle

The sample is dissolved in hot diluted HCl. An aliquot of the solution is mixed with a buffer solution in order to bring the pH within 6.5 to 8 which is the best working range of the fluorine electrode.

A citrate buffer has the advantage of breaking up the complexes of Fe and Al with fluoride because of the greater stability of the metal citrate complexes.

3. Apparatus

3.1 Specific ion meter

3.2 Fluoride specific electrode

3.3 Reference electrode: calomel electrode or silver/silver chloride electrode.

4. Reagents

4.1 Trisodium citrate buffer solution: 40%
Dissolve 400g of trisodium citrate dihydrate in water and dilute to 1000ml with water. Adjust with HCl 6M to the correct pH 6.5.

4.2 Fluoride stock solution: 120mg F/l
Dissolve 0.2652g of NaF, previously dried for 2 hours at 105°C and cooled in a dessicator, in water and dilute to 1,000ml.

4.3 Fluoride standard solutions:

1. Pipette 5 and 50ml of the stock solution (4.2) into two 500ml volumetric flasks.
2. To each flask add 20ml of HCl 6M, dilute to the mark with water and mix well. This gives standard solutions of 1.2mg and 12mg F/l and corresponds with 0.03% and 0.3%F in the sample.

4.4 Hydrochloric acid 6M.

5. Calibration

Pipette 20ml of the standard solution (4.3.2) into 50ml beakers. Add 20ml of the buffer solution (4.1). Place on a magnetic stirrer, immerse the electrodes and wait until a stable reading of the instrument.

Notice the mV readings and make a calibration graph or, in the case of a direct concentration reading, calibrate the instrument on 0.03% and 0.3%.

6. Determination

Weigh 1.000g of the sample in a 250ml volumetric flask. Add about 90ml water and 10ml HCl (4.4). Place a funnel in the neck of the flask. Bring to about 70°C on a hotplate and then place on a magnetic stirrer for 10 minutes to cool while stirring.

Cool to ambient temperature, fill up to the marker with water and mix well. Pipette 20ml of this solution and 20ml buffer solution (4.1) into a 50ml beaker. Place on a magnetic stirrer, immerse the electrodes and wait until a stable reading of the instrument.

Read the fluorine content:

1. by using the calibration graph
2. by direct concentration read-out on the instrument.

Care must be taken to do the calibration and the sample determination at the same temperature to avoid the influence of temperature on the electrode potential (*the relative temperature coefficient is about 2% of the potential per degree Centigrade*).

Arsenic

1. Scope and field of application

Method for determination of the arsenic content of feed phosphates by means of atomic absorption spectrophotometry.

2. Principle

The sample is dissolved in HCl and HNO₃ and the determination is done with the atomic absorption spectrophotometer.

3. Apparatus

- 3.1 Atomic absorption spectrophotometer
- 3.2 Hydride generator
- 3.3 Hollow cathode lamp for Arsenic
- 3.4 Normal laboratory equipment.

4. Reagents

- 4.1 Hydrochloric acid conc. p.a.
- 4.2 Nitric acid conc. p.a.
- 4.3 10M hydrochloric acid
- 4.4 0.6% NaBH₄ solution containing 0.5% NaOH
- 4.5 10% KI - in 0.6% NaBH₄ solution (4.4)
- 4.6 Distilled water

4.7 As standards containing 5-10-20-40-60µg/l As:

1. Standard 1,000mg As/l Merck 1.19774.0500 (as As₂O₅ in 0.5mol HNO₃/l)
2. Dilute 10ml of (1) and 5ml HNO₃ conc. to 500ml with distilled water = 20mg As/l
3. Dilute 5ml of (2) with distilled water to 500ml = 200µg As/l
4. Dilute 60ml HCl conc. and the following volumes of (3) to 100ml with distilled water:

2.5ml -> 5µg As/l

5ml -> 10µg As/l

10ml -> 20µg As/l

20ml -> 40µg As/l

30ml -> 60µg As/l

5. Operating conditions

Wavelength: 193.7nm

Lamp current : 10mA

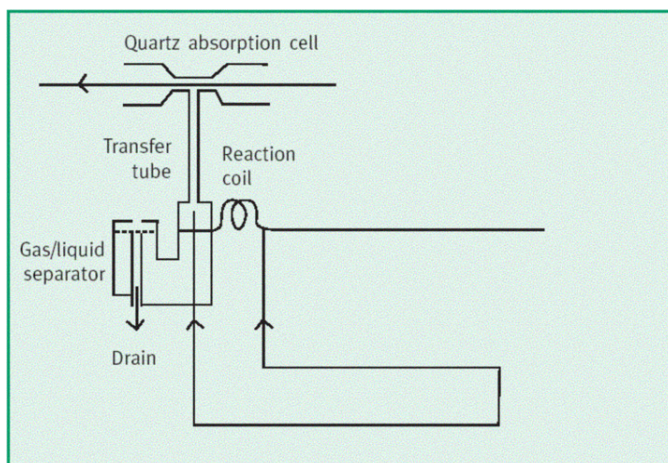
Slit width : 0.5nm

Fuel : acetylene

Support : air

D2-lamp : on (background correction).

6. Schematic of vapour generation



7. Procedure

Dissolve 5.000g of the sample in 10ml HCl (4.1), 3.5ml HNO₃ (4.2) and 20ml H₂O. Boil gently for 30 minutes. Cool and transfer in 100ml volumetric flask and make up to volume with distilled water. Filter the solution through a folded filter paper MN 616 1/4.

Take 1ml of the filtered solution into a 20ml volumetric flask. Add 12ml HCl (4.1) and make up to 20ml with distilled water. Make the calibration curve with the as standards (4.7). Read the concentration of the dilute sample conditions.

8. Results

Example: reading 12.5 μ g/l 5000 μ g/kg 5ppm
Express the results to 1 decimal point, for instance 6.4 ppm.

Cadmium and Lead

1. Scope and field of application

Method for determination of the cadmium and lead content of feed phosphates by means of I.C.P.

2. Principle

The sample is dissolved in HCl and HNO₃ (aqua regia) and the determination is done by I.C.P.

3. Apparatus

I.C.P. instrument.

4. Reagents

4.1 Hydrochloric acid conc. p.a.

4.2 Nitric acid conc. p.a.

4.3 Standard solution of 1mg/l Cd and 1mg/l Pb containing 39.2g/l CaCl₂·2H₂O p.a. and 5ml HCl conc. p.a. in water

4.4 Primary standard solution of 1000mg Cd/l (for instance Merck, Riedel de Haen or others)

4.5 Primary standard solution of 1000mg Pb/l (for instance Merck, Riedel de Haen or others).

5. Instrument parameters

		Cd	Pb
Wavelength	nm	228.802	220.353
Window search	nm	0.027	0.027
Window scan	nm	0.040	0.040
Voltage	V	650	650
Power	kW	1.2	1.2
Plasma	l/min	15.0	15.0

Auxiliary	l/min	1.5	1.5
Pump speed	rpm	15	15
Standard	mg/l	1	1

6. Procedure

Weigh 5.0000g of the sample into a beaker. Add 10ml HCl p.a. and 3.5ml HNO₃ p.a. Cover with a watch glass and boil gently for 30 minutes.

Add 50ml H₂O and transfer into a volumetric flask of 100ml. Cool and bring up to volume - mix well and filter. Use the filtrate for the determination of Cd and Pb with the I.C.P. instrument.

7. Detection limit

Cd 0.4 ppm

Pb 4 ppm

Mercury

1. Scope and field of application

Flameless atomic absorption method: this method of analysis specifies an atomic absorption method for the determination of mercury in feed phosphates. The method is applicable to products having a mercury content greater than 0.004mg Hg per kg of sample (limit of quantitation).

2. Principle

The sample is digested at oxidising conditions to transfer all mercury compounds to mercury (II) salts. By adding tin (II) chloride in a gas wash bottle these mercury (II) salts are reduced to metallic mercury. The metallic mercury is stripped off by a stream of air, which is fed to a flow-through gas cuvette.

The absorbance is measured at 253.7nm in an atomic absorption spectrophotometer or a special mercury meter.

3. Equipment

Usual laboratory equipment and in particular:

3.1 Gas wash bottle with fritted disc, pore size 100-160µm. Volume 100ml.

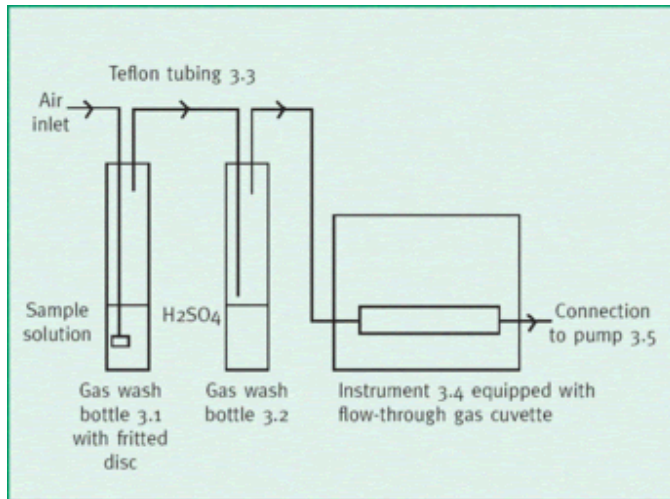
3.2 Gas wash bottle according to Dreschel. Volume 100ml. For drying the gas from

3.1 the tube is shortened to end just above the surface of the sulphuric acid as drying agent. Fill conc. sulphuric acid to a 50ml mark in the gas wash bottle. Change the acid after each 40 hours operation.

3.3 Teflon tubing with inner diameter 2mm to connect 3.1 with 3.2, and 3.2 with 3.4.

3.4 Atomic absorption spectrophotometer equipped with a mercury hollow cathode lamp and flow-through gas cuvette with quartz windows; alternatively, a special mercury meter. The gas cuvette must be cleaned at regular intervals to avoid changes of the shape of the calibration curve. Note: Common atomic absorption spectrophotometers have space only for a 100mm cuvette, while mercury meters are equipped with a cuvette up to 200mm length. The longer the cuvette, the smaller is the scattering.

3.5 Gas pump capable of giving a reproducible and constant flow rate: flow rate about 150l/h. The exhaust from the pump is connected to a fume hood or to a ventilation duct or the mercury vapour must be absorbed on active carbon with iodide. A suitable set up is shown in the figure.



Principle set up for mercury determination

4. Reagents

During the analysis use only reagents of recognised analytical reagent grade with low Hg content and only distilled water or water of equivalent quality. Note: Different brands of regular analytical grade of acids may differ considerably in mercury content. Brands must be chosen to give a blank less than 0.005g (alternatively less than 50% of the mercury content in the aliquot).

4.1 Nitric acid (HNO₃) p = 1.40 about 65% (m/m) **4.2** Hydrochloric acid (HCl) p = 1.19 about 37% (m/m)

4.3 Tin (II) chloride solution: dissolve 20g SnCl₂·2H₂O in 200ml hydrochloric acid (37% HCl). Strip off any traces of mercury with a stream of air through the solution for 1 hour.

4.4 Preservation solution: dissolve 4g potassium chromate K₂Cr₂O₇ in 1000ml nitric acid (HNO₃ 1:1). Its use makes solutions 4.5, 4.6 and 4.7 stable for several months.

4.5 Stock mercury solution, 100µgHg/ml: dissolve 0.1354g HgCl₂ in 75ml water in a 1000ml one mark volumetric flask, add 25ml preservation solution 4.4, add 100ml nitric

acid (65% HNO₃) and dilute to the mark with water.

4.6 Intermediate mercury solution, 1µg Hg/ml: pipette 10ml stock solution into a 1000ml one mark volumetric flask with 500ml water, add 3ml nitric acid (65% HNO₃), add 25ml preservation solution 4.4 and dilute to the mark with water.

4.7 Standard mercury solution, 1µgHg/ml: pipette 20ml stock solution into a 200ml one mark volumetric flask with 50ml water, add 5ml nitric acid (65% HNO₃), add 5ml preservation solution 4.4 and dilute to the mark with water.

4.8 Sulphuric acid (H₂SO₄) $\rho = 1.84$ about 96% (m/m).

4.9 Potassium permanganate (KMnO₄) 5% solution in water.

4.10 Potassium peroxy disulphate (K₂S₂O₈) 5% solution in water.

4.11 Hydroxylamine hydrochloride (NH₂OH.HCl) 1.5% solution

4.12 Anti-foam solution: dissolve 0.3g Dow Corning anti-foam-M, or equivalent, in 1000ml water.

5. Calibration

Before starting up, all glass ware must be cleaned with nitric acid 1:1 and rinsed with water.

To clean the whole system add water at ambient temperature to a 50ml mark on the gas wash bottle 3.1. Add 2ml of the tin (II) chloride solution 4.3 and strip off any traces of mercury. Empty the gas wash bottle 3.1.

In a series of measurements pipette 0.1, 0.3, 0.5, 0.7 and 1.0ml respectively of the standard mercury solution 4.6 into the gas wash bottle 3.1.

In each case proceed as follows:

1. Add 50ml water at ambient temperature.
2. Add 2ml tin (II) chloride solution 4.3 and strip off the mercury.
3. Record the peak absorbance.
4. Empty the gas wash bottle 3.1.
5. Plot a calibration curve.

6. Preparation of the sample and the blank

All glass ware must be cleaned with nitric acid 1:1 and rinsed with water. Before starting up a set of analyses, clean the whole system as described in 5:

Calibration.

Weigh out 4.00g of the sample into 250ml Erlenmeyer flask with ground joint. Add 20ml water, 15ml nitric acid (65% HNO₃) and 5ml hydrochloric acid (37% HCl). Connect a 500mm Hempel column and boil gently for 15 minutes. Cool to ambient temperature and transfer the solution to a 100ml one mark volumetric flask and dilute to the mark. Prepare a blank solution as above, omitting the sample.

Alternatively, digest as follows:

to the weighed sample in a 250ml Erlenmeyer flask add 5ml nitric acid (65% HNO₃) and 10ml sulphuric acid (96% H₂SO₄) and place in an ice-bath. Then heat in a water-bath to 50-60°C for 3 hours and cool again in the ice bath. Add 5ml 5% potassium permanganate (KMnO₄) water solution (4.9) and wait for 15 minutes. The colour should then persist. Add 2ml 5% potassium peroxy disulfate water solution K₂S₂O₈ (4.10) and wait again for 4 hours.

Transfer to a 100ml one mark volumetric flask, dilute partly with water, add 5ml 1.5% hydroxyl-amine hydrochloride (NH₂OH.HCl) water solution (4.11) or more until colourless. Then dilute to the mark.

7. Procedure

Pipette an aliquot of the sample/blank solution into the gas wash bottle 3.1. The size of the aliquot is adapted to the expected content of mercury, usually 5-10ml, but not larger than 25ml. The foaming may limit the size of the aliquot and at large aliquots there may be a matrix effect.

Dilute with water to the 50ml mark on the gas wash bottle 3.1., add 2ml tin (II) chloride solution 4.3 and strip off the mercury. Record the peak absorbance. The aliquot of sample solution and blank solution should coincide.

Notes: If the solution too much during stripping, add 1ml antifoam-M-solution. If used, it must be added to both the sample solution and the standard mercury solution. The temperature difference of 5°C changes the absorbance by about 10 %.

8. Expression of the results

Express the result of the analysis as Hg contained per kg of the sample, as it has been received for analysis.

Calculate the content of Hg with the formula:

$$A = 25 \frac{(B-C)}{D}$$

Where:

A is the mercury content in the sample, mg Hg/kg

B is the reading from the calibration curve for the sample solution, µg Hg

C is the reading from the calibration curve for the blank solution, µg Hg

D is the size of the aliquot, ml