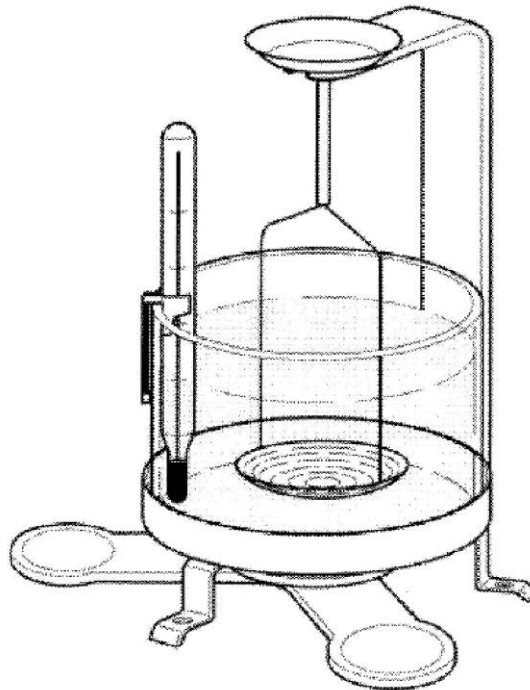




# Density Determination Kit Instruction Manual



This Kit is compatible with OHAUS<sup>®</sup> Adventurer<sup>™</sup>, Adventurer<sup>™</sup> Pro (except AV53x), Adventurer<sup>™</sup> SL (except AS153x), Pioneer, Explorer<sup>®</sup> Pro, Voyager<sup>®</sup> and Voyager<sup>®</sup> Pro models with capacities up to 610g and readability of 0.1mg and 1mg, Explorer<sup>®</sup> models with capacities up to 1100g and readability of 0.1mg and 1mg. Before using this accessory, carefully read these instructions.



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## 1 Introduction

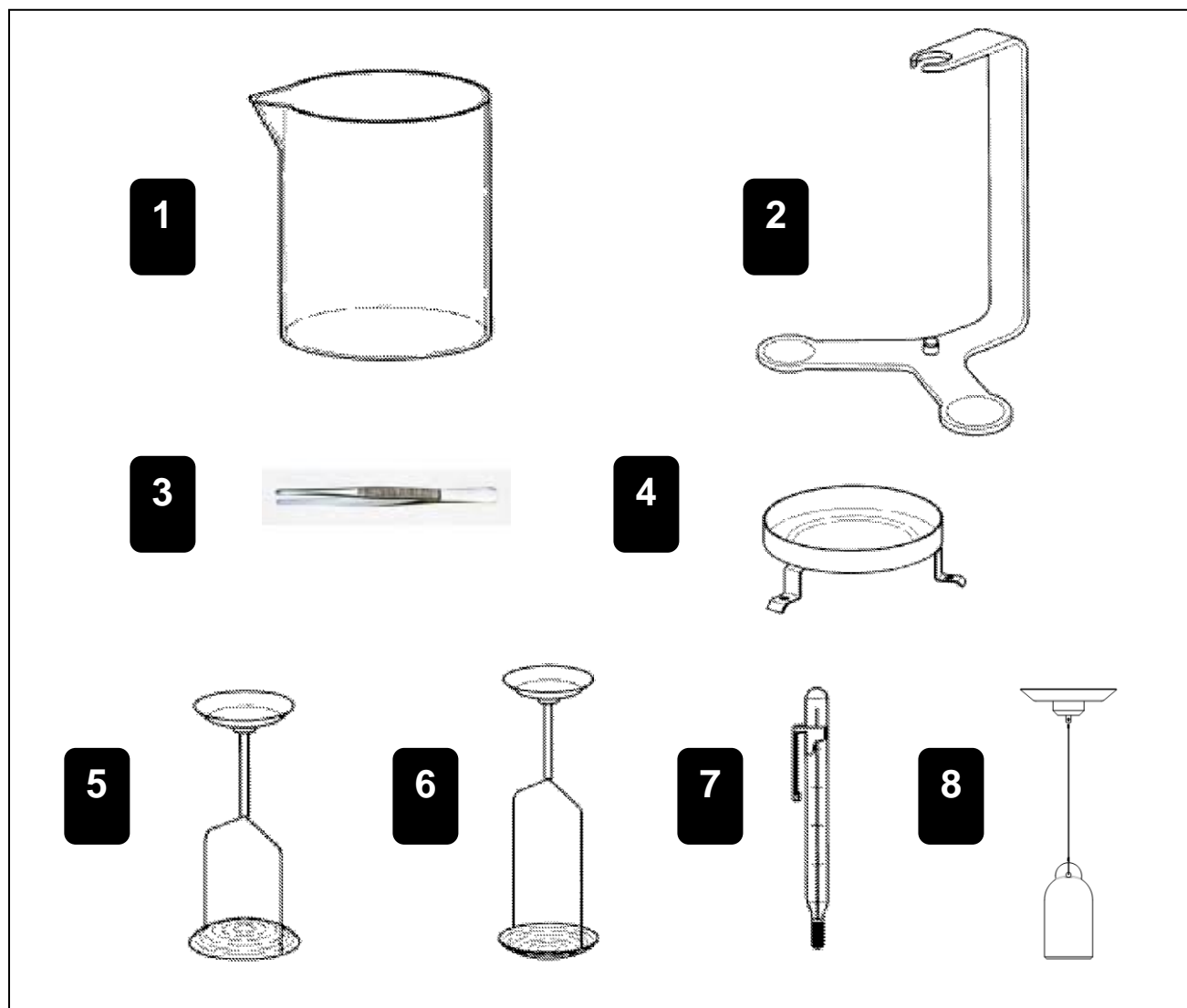
### 1.1 Before we begin

Thanks for purchasing the density determination kit for your OHAUS balances. With the aid of this kit you can use your balance for the determination of the density of solids and liquids.

### 1.2 Standard equipment

The kit contains the individual parts shown in the illustration below.

For the density determination of liquids, you need the kit and also the optional 10ml sinker.



**1** Glass beaker

**3** Forceps

**5** Holder for floating solids

**7** Precision thermometer with holder

**2** Bracket

**4** Platforms

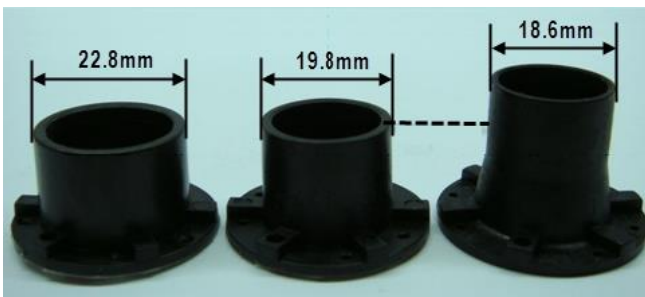
**6** Holder for non floating solids

**8** Sinker 10ml (optional equipment)



**9** Pan support (Height = 38.1mm)  
For AR 0.1mg/EP/VP

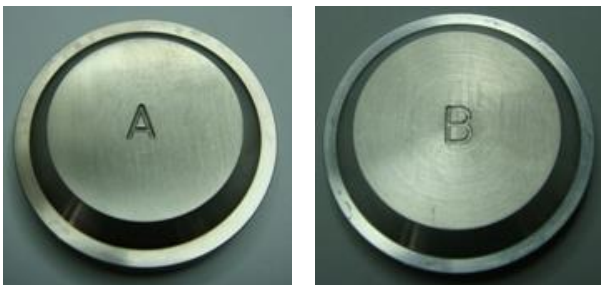
**10** Pan support (Height = 23.5mm)  
For PA 0.1mg/CP 0.1mg



**11** Pan support (Diameter = 22.8mm)  
For PA1mg/CP1mg/AR1mg/EX 1mg

**12** Pan support (Diameter = 19.8mm)  
For AV/CAV

**13** Pan support (Diameter = 18.6mm)  
For EX 0.1mg



**14** Off setting weights A

**15** Off setting weights B

Balances	Weights NO.	Quantity
EX 1mg	A	1
AV 1mg	A	1
EP/VP 1mg	A	3
PA/CP 1mg	B	1



**16** Pan support DV



**17** Pan support EX5(0.01mg)

**18** Pan support AX (1mg)

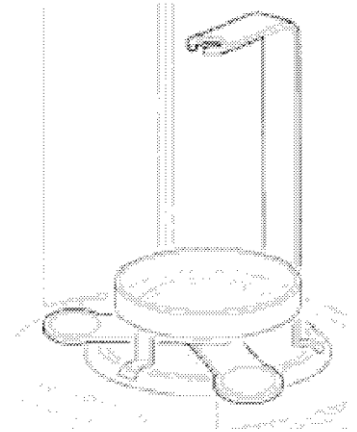
## 2 Preparing the balance for density determinations

This section describes how you can convert your balance to determine densities. Please follow the steps as below.

Select the pan support according to your balance as described in Section 1.2. Remove the cover of tape on the pan support, and adhere centrally to the bottom of the bracket (2).

1. Open the draft shield door and remove the weighing pan.
2. Place the bracket with the pan support on the weighing cone.
3. Place the platform (4) above the bracket. The three support feet should be between the weighing arms of bracket and stand stably on the bottom plate of draft shield.

**Note: The bracket must not touch the platform under any circumstances!**



## 3 Principle of the density determination

The density  $\rho$  is the quotient of the mass  $m$  and the volume  $V$ .

$$\rho = \frac{m}{V}$$

The international system of units specifies  $\text{Kg/m}^3$  as the unit of density. However, the unit  $\text{g/cm}^3$  is better suited to lab purposes.

Density determinations are frequently performed by **Archimedes' principle**, which is also used with the density determination kit for the balances. This principle states that every solid body immersed in a fluid apparently loses weight by an amount equal to that of the fluid it displaces.

The procedure for the density determination by Archimedes' principle depends on whether the **density of solids or liquids** has to be determined.

## 4 Density determination of solids

### 4.1 Fundamentals

The density of a solid is determined with the aid of a liquid whose density  $\rho_0$  is known (water or ethanol are usually used as auxiliary liquids). The solid is weighed in air (A) and then in the auxiliary liquid (B). The density  $\rho$  can be calculated from the two weighings as follows:

$$\text{Density: } \rho = \frac{A}{A-B} (\rho_0 - \rho_L) + \rho_L$$

$\rho$  = Density of sample

A = Weight of sample in air

B = Weight of sample in the auxiliary liquid

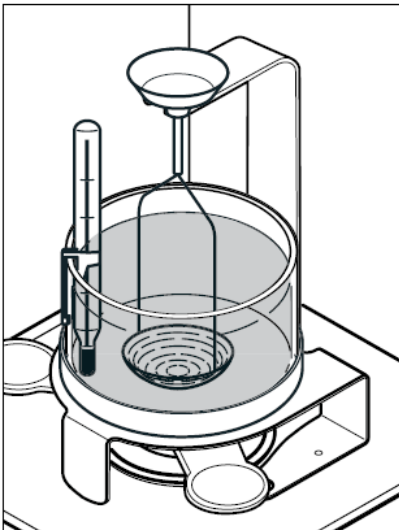
$\rho_0$  = Density of the auxiliary liquid

$\rho_L$  = Air density (0.0012 g/cm<sup>3</sup>)

$\alpha$  = Balance correction factor (0.99985), takes air buoyancy of the adjustment weight into account.

$$\text{Volume: } V = \alpha \frac{A-B}{\rho_0 - \rho_L}$$

### 4.2 Performing the density determination of solids



**Note:** These instructions explain how to work with the density determination kit. They describe the procedure for performing a density determination manually.

If you need information about operating your balance, please refer to the instruction manual provided with the balance.

For the density determination of solids, use the glass beaker (2) and one of the two holders for solids which float (5) or sink (6). For certain OHAUS 1mg balances, use off setting weights according to your balance as described in Section 1.2.

Prepare the balance for the density determination (install platform and bracket) as described in Section 2.

Suspend the supplied thermometer (7) from the edge of the beaker (1). Place the beaker on the platform and fill it with auxiliary liquid (liquid of known density  $\rho_0$ , usually distilled water or ethanol). Add enough liquid to ensure the solid is covered by at least 1 cm liquid after immersion.

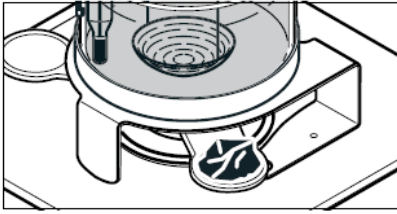
Suspend the suitable holder (5) or (6) for solids which float or sink from the bracket (the adjacent illustration shows the holder for solid which sink).

Ensure that no air bubbles adhere to the immersed part of the holder (Remove any air bubbles by moving the holder or by means of a fine brush).

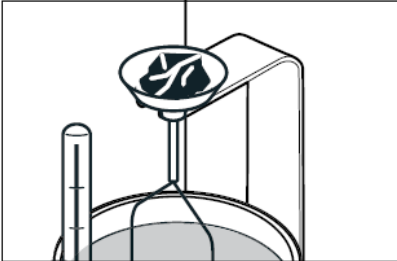
For certain OHAUS 1mg balances, place off setting weights on the holder (the adjacent illustration shows the weights for EP/VP 1mg balances).

Close the draft shield doors and tare the balance.





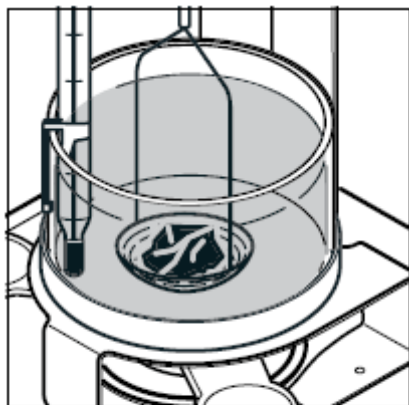
Place the solid in one of the two weighing pans of the bracket (2). Wait until the weight display of the balance is stable and note the displayed weight A (weight of sample in air).



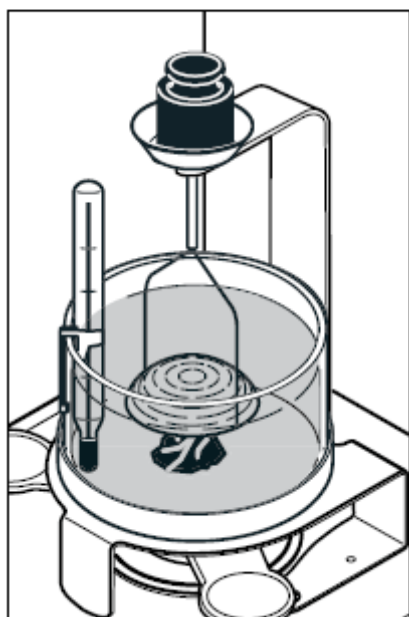
**Note for 0.1mg models**

When **solids with a weight greater than 20g** are weighed in air, place in the pan at the top of the holder (above 20g corner load errors may appear on one arm in the weighing).

Remove the solid from the pan, close the draft shield doors and tare the balance.



Place the solid after in the holder (6). Ensure that no air bubbles adhere to the solid (remove any air bubbles with a fine brush).



**Note**

With **solids with a density less than  $1\text{g/cm}^3$**  the holder for floating solids (5) must be used as it holds the solid body below the surface of the auxiliary liquid. If the buoyancy of the solid is greater than the weight of the holder, the holder must be weighted by placing an additional weight on the top weighing pan of the bracket. **After loading the additional weight, tare the balance and restart the density determination procedure by first weighing the solid in air (A) and then in the auxiliary liquid (B).**

Wait until the balance has reached stability and note the displayed weight B (weight of sample in the auxiliary liquid).

Now determine the density  $\rho$  of the solid according to the preceding formula (Section 4.1).



### 4.3 Improving the accuracy of the result

The following tips should help you improve the accuracy of the results in the **density determination of solids**.

#### Temperature

Solids are generally so insensitive to temperature fluctuations that the corresponding density changes are of no consequence. However, as work is performed with an auxiliary liquid in the density determination of solids following Archimedes' principle, their temperature must be taken into account as the temperature has a great effect with liquids and causes density changes of order of magnitude 0.1 to 1% per °C. This effect is already apparent in the third decimal place of the result.

**To obtain accurate results, we recommend that you always take the temperature of the auxiliary liquid into account in all density determinations.** You can take the appropriate values from a book of tables. You will find tables for distilled water and ethanol in Section 6.

#### Surface tension of the auxiliary liquid

Adhesion of the auxiliary liquid to the suspension wires of the holder causes an apparent weight increase of up to 3mg.

As the holder is immersed in the auxiliary liquid in both weighings of the solid (in air and in the auxiliary liquid) and the balance is tared before every measurement, the influence of the apparent weight increase can be neglected.

If the greatest possible accuracy is required, use a few drops of the wetting agent.

## 5 Density determination of liquids

### 5.1 Fundamentals

The density of a liquid is determined using a sinker of known volume. The sinker is weighed in air and then in the liquid whose density is to be determined. The density  $\rho$  can be determined from the two weighings as follows:

$$\text{Density: } \rho = \alpha \frac{A-B}{V} + \rho_L$$

With an electronic balance it is possible to determine the weight of the displaced liquid  $P$  ( $P=A-B$ ), and thus the buoyancy, allowing the preceding formula to be simplified to:

$$\rho = \alpha \frac{P}{V} + \rho_L$$

$\rho$  = Density of liquid

$A$  = Weight of sinker in air

$B$  = Weight of sinker in the liquid

$V$  = Volume of sinker

$\rho_L$  = Air density (0.0012 g/cm<sup>3</sup>)

$\alpha$  = Balance correction factor (0.99985), takes air buoyancy of the adjustment weight into account

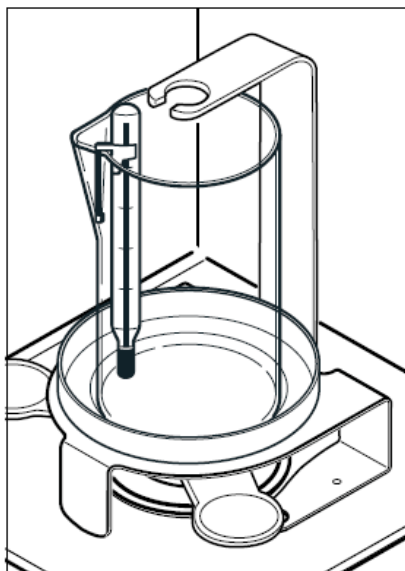
$P$  = Weight of displaced liquid ( $P = A - B$ )

## 5.2 Performing the density determination of liquids

**Note:** These instructions explain how to work with the density determination kit. They describe the procedure for performing a density determination manually.

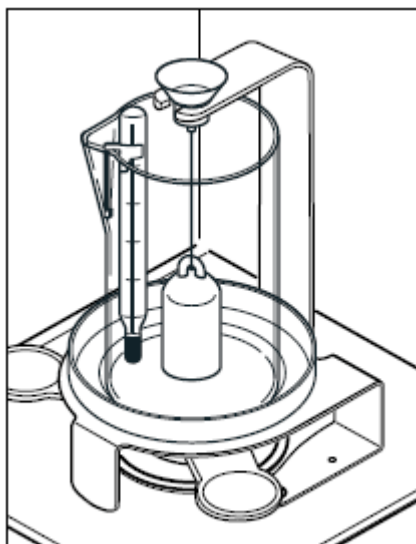
If you need information about operating your balance, please refer to the instruction manual which you received with the balance.

For the density determination of liquids, use the glass beaker (1) and the optional sinker (8).



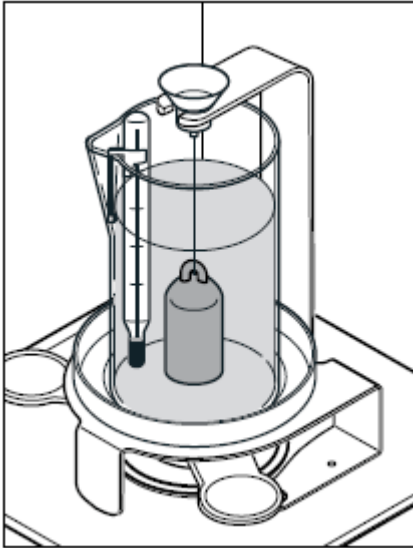
Prepare the balance for the density determination (install the platform and bracket) as described in Section 2.

Place the empty beaker (1) on the platform and suspend the thermometer supplied (7) from the edge of the beaker.



Suspend the sinker (8) from the bracket and ensure that it does not touch either the beaker or the thermometer.

Tare the balance.



Add the liquid whose density you wish to determine to the beaker (up to approx. 1 cm above the suspension eye of the sinker). Ensure that no air bubbles adhere to the sinker (remove any air bubbles with a fine brush).

Wait until the weight display of the balance is stable and note the displayed value  $P$  (weight of displaced liquid)

Now determine the density  $\rho$  of the liquid (at the temperature read off on the thermometer), according to the preceding formula (Section 5.1).

### 5.3 Improving the accuracy of the result

The following tips will help you improve the accuracy of the results in the **density determination of liquids**.

#### Volume tolerance of the sinker

The optional sinker recommended for the density determination of liquids corresponds to the requirements of the German Weights and Measures Regulation (EO 13-4, paragraph 9.21). The volume of the sinker including the upper half of the suspension wire is so adjusted that the maximum error in the density determination of water at a temperature of 20°C is  $\pm 0.0005 \text{ g/cm}^3$

## 6 Supplementary information

This section offers information on the influencing factors which can have an adverse effect on the accuracy of the experimental results. In addition, you will find density tables for distilled water and ethanol in this section.

### 6.1 Influencing factors

In addition to temperature, air buoyancy and surface tension of the liquid, the following factors can affect the experimental results:

- Immersion depth of the holder or the sinker
- Air bubbles
- Porosity of the solid body

#### Immersion depth of the holder or sinker

The sinker for the **density determination of liquids** is suspended from a platinum wire of **0.2 mm diameter**. In water the wire experiences a **buoyancy of approximately 0.3 mg per 10mm immersion depth**.

**Example:** If the liquid is 10mm above the suspension eye of the sinker, approx. 40mm wire is immersed. This results in a buoyancy of 1.2mg at densities around 1. Owing to division of the buoyancy by  $10\text{cm}^3$  (=volume of the sinker), the error in the result is negligibly small and need not be corrected.

The immiscible part of the holders for the **density determination of solids** comprises 2 wires **each of diameter 0.7mm**. With a liquid density of 1, this results in a **buoyancy of approx. 0.4mg millimeter immersion depth**.

In the weighing of the solid in air, the immersion depth of the holder remains the same. The buoyancy force on the holder is thus constant and can therefore be neglected. However, it is important to ensure that the **liquid level is not changed** between weighings (the change in the liquid level by immersion of the solid is usually insignificant).

#### Air bubbles

With poorly wetting liquids (e.g. water without wetting agent), it is possible that air bubbles remain adhered to the immersed parts (solid, sinker, and holder) and influence the result owing to their buoyancy. A bubble with a diameter of 1 mm causes a buoyancy of 0.5 mg, whereas one of diameter 2 mm results in buoyancy as high as

4 mg. To avoid air bubbles, we advise the following **precautionary measures:**

- Degrease solvent-resistant solids
- Clean holders and sinker at regular intervals, never touched parts which are immersed with your hand
- Gently shake holders and sinker on first-time immersion to dislodge any air bubbles.
- Remove tenaciously adhering air bubbles with a fine brush.
- Use enclosed or commercial wetting agent or organic liquids (the density change experienced by distilled water on the addition of wetting agent can be neglected).

**Porosity of the solid**

When solid bodies are immersed in a liquid, usually not all the air in the pores is displaced. This leads to buoyancy errors and thus the density of porous bodies can only be determined approximately.

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## 6.2 Density table for distilled water

T/°C	0.0	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9
10.	0.99973	0.99972	0.99971	0.99970	0.99969	0.99968	0.99967	0.99966	0.99965	0.99964
11.	0.99963	0.99962	0.99961	0.99960	0.99959	0.99958	0.99957	0.99956	0.99955	0.99954
12.	0.99953	0.99951	0.99950	0.99949	0.99948	0.99947	0.99946	0.99944	0.99943	0.99942
13.	0.99941	0.99939	0.99938	0.99937	0.99935	0.99934	0.99933	0.99931	0.99930	0.99929
14.	0.99927	0.99926	0.99924	0.99923	0.99922	0.99920	0.99919	0.99917	0.99916	0.99914
15.	0.99913	0.99911	0.99910	0.99908	0.99907	0.99905	0.99904	0.99902	0.99900	0.99899
16.	0.99897	0.99896	0.99894	0.99892	0.99891	0.99889	0.99887	0.99885	0.99884	0.99882
17.	0.99880	0.99879	0.99877	0.99875	0.99873	0.99871	0.99870	0.99868	0.99866	0.99864
18.	0.99862	0.99860	0.99859	0.99857	0.99855	0.99853	0.99851	0.99849	0.99847	0.99845
19.	0.99843	0.99841	0.99839	0.99837	0.99835	0.99833	0.99831	0.99829	0.99827	0.99825
20.	0.99823	0.99821	0.99819	0.99817	0.99815	0.99813	0.99811	0.99808	0.99806	0.99804
21.	0.99802	0.99800	0.99798	0.99795	0.99793	0.99791	0.99789	0.99786	0.99784	0.99782
22.	0.99780	0.99777	0.99775	0.99773	0.99771	0.99768	0.99766	0.99764	0.99761	0.99759
23.	0.99756	0.99754	0.99752	0.99749	0.99747	0.99744	0.99742	0.99740	0.99737	0.99735
24.	0.99732	0.99730	0.99727	0.99725	0.99722	0.99720	0.99717	0.99715	0.99712	0.99710
25.	0.99707	0.99704	0.99702	0.99699	0.99697	0.99694	0.99691	0.99689	0.99686	0.99684
26.	0.99681	0.99678	0.99676	0.99673	0.99670	0.99668	0.99665	0.99662	0.99659	0.99657
27.	0.99654	0.99651	0.99648	0.99646	0.99643	0.99640	0.99637	0.99634	0.99632	0.99629
28.	0.99626	0.99623	0.99620	0.99617	0.99614	0.99612	0.99609	0.99606	0.99603	0.99600
29.	0.99597	0.99594	0.99591	0.99588	0.99585	0.99582	0.99579	0.99576	0.99573	0.99570
30.	0.99567	0.99564	0.99561	0.99558	0.99555	0.99552	0.99549	0.99546	0.99543	0.99540

### 6.3 Density table for ethanol

T/°C	0.0	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9
10.	0.79784	0.79775	0.79767	0.79758	0.79750	0.79741	0.79733	0.79725	0.79716	0.79708
11.	0.79699	0.79691	0.79682	0.79674	0.79665	0.79657	0.79648	0.79640	0.79631	0.79623
12.	0.79614	0.79606	0.79598	0.79589	0.79581	0.79572	0.79564	0.79555	0.79547	0.79538
13.	0.79530	0.79521	0.79513	0.79504	0.79496	0.79487	0.79479	0.79470	0.79462	0.79453
14.	0.79445	0.79436	0.79428	0.79419	0.79411	0.79402	0.79394	0.79385	0.79377	0.79368
15.	0.79360	0.79352	0.79343	0.79335	0.79326	0.79318	0.79309	0.79301	0.79292	0.79284
16.	0.79275	0.79267	0.79258	0.79250	0.79241	0.79232	0.79224	0.79215	0.79207	0.79198
17.	0.79190	0.79181	0.79173	0.79164	0.79156	0.79147	0.79139	0.79130	0.79122	0.79113
18.	0.79105	0.79096	0.79088	0.79079	0.79071	0.79062	0.79054	0.79045	0.79037	0.79028
19.	0.79020	0.79011	0.79002	0.78994	0.78985	0.78977	0.78968	0.78960	0.78951	0.78943
20.	0.78934	0.78926	0.78917	0.78909	0.78900	0.78892	0.78883	0.78874	0.78866	0.78857
21.	0.78849	0.78840	0.78832	0.78823	0.78815	0.78806	0.78797	0.78789	0.78780	0.78772
22.	0.78763	0.78755	0.78746	0.78738	0.78729	0.78720	0.78712	0.78703	0.78695	0.78686
23.	0.78678	0.78669	0.78660	0.78652	0.78643	0.78635	0.78626	0.78618	0.78609	0.78600
24.	0.78592	0.78583	0.78575	0.78566	0.78558	0.78549	0.78540	0.78532	0.78523	0.78515
25.	0.78506	0.78497	0.78489	0.78480	0.78472	0.78463	0.78454	0.78446	0.78437	0.78429
26.	0.78420	0.78411	0.78403	0.78394	0.78386	0.78377	0.78368	0.78360	0.78351	0.78343
27.	0.78334	0.78325	0.78317	0.78308	0.78299	0.78291	0.78282	0.78274	0.78265	0.78256
28.	0.78248	0.78239	0.78230	0.78222	0.78213	0.78205	0.78196	0.78187	0.78179	0.78170
29.	0.78161	0.78153	0.78144	0.78136	0.78127	0.78118	0.78110	0.78101	0.78092	0.78084
30.	0.78075	0.78066	0.78058	0.78049	0.78040	0.78032	0.78023	0.78014	0.78006	0.77997

Density values of C<sub>2</sub>H<sub>5</sub>OH taken from "American Institute of Physics Handbook".



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