

PROJECTS

Project 1

Title

Study the variation in the amount of oxalate ions in guava fruit at different stages of ripening.

Objective

The objective of this project is to investigate the variation in the amount of oxalate ions present in guava at different stages of its ripening (i.e. unripe, partially ripe and fully ripe).

Brief Procedure

Collect different samples of guava fruit (green, pale-green, yellowish-white and yellowish, i.e. from unripe to fully ripe variety). Take 100 grams of one of the sample of guava fruit, crush it into a mortar and transfer the paste in 100 mL of water. Boil the contents for 10-15 minutes and filter. Take the filtrate, add about 5 mL of dilute sulphuric acid and titrate it against 0.001 M KMnO_4 solution. Repeat the procedure with other samples of guava and draw conclusion.

Project 2

Title

A study to compare the quantity of casein present in different samples of milk.

Objective

To compare the quality of different samples of milk by finding out quantity of casein present in them.

Brief Procedure

Take 200 mL of each sample of milk in separate 500 mL beakers. Heat the milk samples upto 50 – 60°C. Add a few drops of dilute hydrochloric acid slowly with constant stirring for 5-10 minutes. Casein coagulates as an amorphous substance. Filter the substance and wash the precipitate several times with tap water. Remove the fat by using a suitable organic solvent. Weigh casein so obtained after drying.

Project 3**Title**

Preparation of soyabean milk and its comparison with natural milk.

Objective

To prepare soyabean milk and compare it with natural milk with respect to curd formation, effect of temperature, taste etc.

Brief Procedure

Prepare soyabean milk by first soaking soyabean seeds in warm water and keeping them overnight in water. Make a paste of seeds by crushing and finely grinding them. Mix the pasty mass with warm water to get soya milk. Filter the mixture and discard the undissolved portion. Compare soya milk with natural milk and conclude whether soya milk can be a substitute for natural milk. The comparison may be made with respect to the nutrients present, colour, smell, taste, effect of temperature, curd formation, etc.

Project 4**Title**

Study the effect of potassium metabisulphite as a food preservative under various conditions.

Objective

To study the effect of concentration of potassium metabisulphite (preservative), temperature and time on preservation of food.

Brief Procedure

Collect amla fruits and wash these with water. Cut these into small pieces and dry in the sunlight for a few hours. Mix the salt and the spices to the pieces. Pour 25g of amla pieces into each of the six boiling tubes numbered as 1, 2, 3...etc. Weigh 500 mg of potassium metabisulphite and dissolve it in 20 mL of distilled water. Keep the boiling tube No. 1 without mixing preservative and oil. In boiling tube No. 2 and 3 add 1 mL of the preservative solution and 2 mL of oil and mix the mixture with the glass rod. Keep the boiling tube No. 2 at the room temperature (25-35°C) and the boiling tube No. 3 at a temperature of 40°C. In boiling

tube No. 4, 5 and 6, add 2 mL, 4 mL and 8 mL of the preservative solution respectively and 2 mL of mustard oil. Keep these boiling tubes at the room temperature. Prepare again the fresh mixtures in boiling tubes No. 4, 5 and 6 and keep them at 40°C temperature.

Keep all these boiling tubes for 3 to 5 days. Note the growth of fungi, if any, in these tubes. Record your observations and draw conclusion.

Project 5

Title

A Study of enzymatic hydrolysis of starch

Objective

Study the hydrolysis of starch by salivary amylase and the effect of pH and temperature on it.

Brief Procedure

Take about 20-30 mL of warm distilled water (30°C– 40°C) in the mouth and mix it with the saliva by gargling in the mouth. Collect the saliva mixed water in a beaker.

Digestion of Starch by Saliva Solution

Take 10 mL of the starch solution in a boiling tube and add 2 mL of 1% sodium chloride solution in it. Keep the boiling tube in a water bath, maintained at 30° – 40°C, for at least 15 minutes. Pour 2 mL of the saliva solution in the boiling tube and start the stopwatch immediately. Take out 2-3 drops of the mixture after one minute and pour it in the test tube containing iodine solution. Shake the contents of the test tube and note the colour of the solution, if any. Similarly, take out 2-3 drops of the mixture from the boiling tube after every one-minute and add to iodine solution contained in the test tubes. Record the colour of the solution in each case. Stop taking readings when there is no change in colour. Record the readings in a tabular form.

In order to study the effect of temperature on the digestion of starch by saliva, perform the above experiment at 50°C.

The effect of pH of reaction medium can also be studied by using small quantities of dilute HCl and dilute NaOH in the separate experiments carried out in the same manner as above.

Project 6**Title**

A comparative study of the rate of fermentation of the following substances: (a) Wheat flour, (b) Gram flour, (c) Potato juice, (d) Carrot juice, (e) Orange juice, (f) Apple juice, and (g) Sugar-cane juice.

Objective

To determine the rate of fermentation of different substances and study the effect of concentration, time and temperature on the rate of fermentation of these substances.

Brief Procedure

Take a conical flask (100 mL) fitted with a delivery tube as shown in Fig. 12.1. Remove the delivery tube and add 10 g of wheat flour and about 80 mL of the distilled water into the flask. Stir the contents of the flask with a glass rod and add 2 g of yeast. Stir the contents again. Fit the delivery tube into the mouth of the flask. Tie a balloon with the help of a thread to the upper end of the delivery tube as shown in Fig. 12.1. As the fermentation proceeds, carbon dioxide gas is evolved and the balloon inflates. The extent to which the balloon inflates in the given time is the measure of the rate of reaction. Repeat the experiment with other materials such as potato juice, orange juice, apple juice and sugar-cane juice.



Fig. 12.1 : Determination of rate of fermentation

Effect of concentration of yeast

Study the effect of concentration of yeast on the rate of fermentation of any one of the above materials. For this, carry out the reaction using 2, 3 and 4 grams of yeast and note the extent of inflation of balloon in each case in a fixed time interval.

Effect of time

Carry out the reaction using the same ingredients for different intervals of time and observing the extent of inflation of balloon.

Effect of temperature

Carry out the reaction using the same ingredients for a fixed interval of time but at three different temperatures (25°C, 30°C, and 35°C). Note the extent of reaction by observing the inflation of balloon in these reactions.

Project 7

Title

Extraction of essential oils present in saunf (aniseeds), Ajwain (carum) and illaichi (cardamom)

Objective

To extract essential oils from aniseeds, carum, and cardamom by using petroleum ether as a solvent.

Brief Procedure

Take 100 g of crushed aniseed in a conical flask and add 100 mL of petroleum ether (of boiling range 60°-80°) in it. Close the mouth of the flask with a rubber cork and shake it for sometime. Keep the flask for a day. Filter the solution and collect in a distillation flask. Distill off the petroleum ether at 60°C - 80°C. Petroleum ether is a highly inflammable liquid. Do not bring any flame near it. Use heating mantle for heating the flask. Do not heat it directly on flame. Transfer the liquid (oil) which is left in the flask to a boiling tube and close the mouth of the boiling tube with a rubber cork. Note the colour, odour and volume of the essential oil so collected.

Similarly, extract essential oils of carum and cardamom.

Project 8

Title

Study of common food adulterants.

Objective

To identify the food adulterants in fat, oil, butter, sugar, turmeric powder, chilli powder and pepper.

Background information

Adulteration of food means substitution of the genuine food material wholly or in part with any cheaper or inferior substance or removal of any of its constituents, wholly or in part, which affects adversely the nature, substance or quality of the food. According to the Indian Preservation of Food Adulteration Act (PFA) 1954, any ingredient which when present in food, is injurious to health is an adulterant.

Some of the foods commonly adulterated in India and the adulterants found in them are as follows ; corresponding form of Khesari dal (grain/bean/flour) is mixed with pulses like masoor, bengal gram dal, red gram dal, black gram, and channa. Consumption of khesari dhal for a long time results in paralysis of the lower limbs.

Sometimes seeds, barks, leaves and other matter are dressed up to look like genuine foodstuffs and are used to adulterate pure ones. For example exhausted tea leaves or coloured sawdust are mixed into fresh tea. Powdered bran and sawdust may be present in ground spices. Easily obtainable seeds are substituted for cumin, cardamom, black pepper, mustered seeds etc.

Edible oils and fats are adulterated with cheap edible and non edible oils. Seeds of *Argemone maxicana* resemble mustered and are used to mix with mustard seeds and oil extracted from seeds is used to adulterate oils such as coconut, mustard, sesame and groundnut. *Argemone* oil is poisonous and its use results in dropsy in human beings. Oils and fats are also adulterated with petroleum products which cause gastrointestinal disorders.

Talc and chalk powder are used to adulterate wheat flour, Arrowroot powder and confectionary, starch is used as a filler in milk and milk products.

Coal tar dyes and mineral pigments like lead chromate and red or yellow earth are common food adulterants used for colouring milk products, confectionary, soft drinks, beverages, tea, spices, bakery products, fruits and vegetables to give better look.

Brief procedures for testing food adulterants in some of the food materials are given below :

Brief Procedure

Vanaspati ghee in butter

Take 0.5g of butter sample in a test tube and melt it by heating gently. To this liquid add a small amount of sugar and a few drops

of HCl and shake the mixture for 5 minutes. Appearance of pink colour indicates the presence of vanaspati ghee in the butter.

Dyes in fats and oils

Take 1 mL of fat/oil in a test tube and add 1 mL of the mixture of sulphuric acid and glacial acetic acid in the ratio 1:4. Heat the mixture. Appearance of pink colour indicates the presence of dyes in fats and oils.

Chalk in sugar

Take 1 g of sugar in a test tube and add 2 mL of dilute H_2SO_4 in it. Evolution of effervescence indicates the presence of chalk in sugar.

Artificial colour in red chillies

Take a glass tumbler filled with distilled water and pour a few grams of red chilli powder in it. Stir the mixture with the glass rod and allow it to stand for a few minutes. Appearance of brick red colour in water shows the presence of artificial colour in red chilli.

Coloured chalk powder in turmeric powder

Take about 0.5g of turmeric powder in a test tube and add 1 mL of dilute H_2SO_4 . Evolution of effervescence shows the presence of coloured chalk powder in turmeric.

Sawdust coloured with coaltar dye in turmeric powder

Take about 1.0 g turmeric powder in a test tube add a few drops of conc. HCl . Instant appearance of violet colour which persists on dilution with distilled water indicates the presence of sawdust coloured with metanil yellow, a coaltar dye.

Pappaya seeds in black pepper

Take a beaker filled with distilled water and add one spoon full of pepper. Papaya seeds float over water while pepper settles down.

APPENDICES

APPENDIX I

SOME USEFUL TABLES

Table 1 : Fundamental physical constants

Physical constant	Symbol	Value
Acceleration due to gravity	g	9.81 ms^{-2}
Atomic mass unit	amu	$1.66053 \times 10^{-27} \text{ Kg}$
Avogadro constant	N_A	$6.02217 \times 10^{23} \text{ mol}^{-1}$
Boltzmann constant	K	$1.38062 \times 10^{-23} \text{ J K}^{-1}$
Electronic charge	e	$1.602192 \times 10^{-19} \text{ C}$
Faraday cosntant	F	$9.64867 \times 10^4 \text{ C mol}^{-1}$
Gas constant	R	$8.314 \text{ J K}^{-1} \text{ mol}^{-1}$
'Ice-point' temperature	Tice	273.150 K
Molar volum of ideal gas at stp.	V_m	$2.24136 \times 10^{-2} \text{ m}^3 \text{ mol}^{-1}$
Permittivity of a vaccuum	E_0	$8.854185 \times 10^{-12} \text{ Kg}^{-1} \text{ m}^{-3} \text{ s}^4 \text{ A}^2$
Plank constant	h	$6.62620 \times 10^{-34} \text{ J s}$
Rydberg constant	R_w	$1.973731 \times 10^7 \text{ m}^{-1}$
Standard pressure (atmosphere)	p	101325 N m^{-2}
Triple point of water		273016 K
Velocity of light of vacuum	c	$2.997925 \times 10^8 \text{ m s}^{-1}$

Table 2 : General properties of some organic compounds

Compound	mp.°C	bp.°C	Density/ Kg m ⁻³ (298 K)	Refractive index (nD) (293 K)	10 ⁴ × Viscosity/ N s m ⁻² (298 K)	10 ³ × Surface Tension/ N m ⁻¹ (293 K)
Acetic acid	16.7	117.9	1044.0	1.3716	11.55	27.8
Acetanilide	114.0	-	-	-	-	-
Acetone	-94.7	56.1	785.0	1.3588	3.16	23.7
<i>p</i> -aminoazobenene (aniline yellow)	125.0	-	-	-	-	-
Aniline	-6.3	184.1	1022.0 (293)	1.5863	3.71	42.9
Benzoic acid	122.4	249.0	1266.0 (288)	1.504 (405)	-	-
Carbon tetra-chloride	-22.9	76.5	1584.0	1.4601	8.8	26.95
Chlorobenzene	-45.2	132.0	1106.0	1.5241	7.97	33.56
Chloroform	-63.5	61.7	1480.0	1.4459	5.42	27.14
Cyclohexane	6.6	80.7	774.0	1.42662	9.8	25.5
Dibenzal acetone	112.0	-	-	-	-	-
Di-ethyl ether	-116.2	34.51	714.0	1.3526	2.22	17.01
Ethyl acetate	-82.4	77.1	900.0 (293)	1.3723	4.41	23.9
Ethanol	-114.1	78.3	785.0	1.3611	10.6	22.75
Glycerol	18.07	290.0	1264.4	1.4746	942.0	63.4
Hexane	-95.3	68.7	655.0	1.37506	2.94	18.43
Methanol	-97.7	64.5	787.0	1.3288	5.47	22.61
Napthalene	80.3	218.0	1180.0	1.4003 (297)	-	-
<i>p</i> -Nitroacetanilide	214.0	-	-	-	-	-
Phenol	40.9	181.8	1132.0	1.5509	-	-
Phenyl-azo-β-naphthol (azo dye)	113.0	-	-	-	-	-
Toluene	-95.1	110.6	862.0	1.4961	5.50	28.5

Table 3 : Solubility of common inorganic compounds in water

Name of Anion	Symbol	These ions form soluble compounds (solubility greater than 0.1 M) with these cations	Form slightly soluble compounds (solubility less than 0.1 M)
nitrate	NO_3^-	Most cations	None
acetate	CH_3COO^-	Most cations	Ag^+
chloride	Cl^-	Most cations	Ag^+ , Pb^{2+} , Hg_2^{2+}
bromide	Br^-	Most cations	Ag^+ , Pb^{2+} , Hg_2^{2+}
iodide	I^-	Most cations	Ag^+ , Pb^{2+} , Hg_2^{2+}
sulphate	SO_4^{2-}	Most cations	Ba^{2+} , Sr^{2+} , Pb^{2+} , Ag^+
chromate	CrO_4^{2-}	Most cations	Ba^{2+} , Sr^{2+} , Pb^{2+} , Ag^+
sulphide	S^{2-}	NH_4^+ , alkali metal cations, and alkaline earth metal cations	Most other cations
hydroxide	OH^-	NH_4^+ , alkali metal and alkaline earth metal and Ba^{2+} and Sr^{2+}	Most other cations
carbonate	CO_3^{2-}	NH_4^+ and alkali metal cations	Most other cations
phosphate	PO_4^{3-}	except Li^+	

APPENDIX II

ELEMENTS, THEIR ATOMIC NUMBER AND MOLAR MASS

Element	Symbol	Atomic Number	Molar mass/ (g mol ⁻¹)	Element	Symbol	Atomic Number	Molar mass/ (g mol ⁻¹)
Actinium	Ac	89	227.03	Mercury	Hg	80	200.59
Aluminium	Al	13	26.98	Molybdenum	Mo	42	95.94
Americium	Am	95	(243)	Neodymium	Nd	60	144.24
Antimony	Sb	51	121.75	Neon	Ne	10	20.18
Argon	Ar	18	39.95	Neptunium	Np	93	(237.05)
Arsenic	As	33	74.92	Nickel	Ni	28	58.71
Astatine	At	85	210	Niobium	Nb	41	92.91
Barium	Ba	56	137.34	Nitrogen	N	7	14.0067
Berkelium	Bk	97	(247)	Nobelium	No	102	(259)
Beryllium	Be	4	9.01	Osmium	Os	76	190.2
Bismuth	Bi	83	208.98	Oxygen	O	8	16.00
Bohrium	Bh	107	(264)	Palladium	Pd	46	106.4
Boron	B	5	10.81	Phosphorus	P	15	30.97
Bromine	Br	35	79.91	Platinum	Pt	78	195.09
Cadmium	Cd	48	112.40	Plutonium	Pu	94	(244)
Caesium	Cs	55	132.91	Polonium	Po	84	210
Calcium	Ca	20	40.08	Potassium	K	19	39.10
Californium	Cf	98	251.08	Praseodymium	Pr	59	140.91
Carbon	C	6	12.01	Promethium	Pm	61	(145)
Cerium	Ce	58	140.12	Protactinium	Pa	91	231.04
Chlorine	Cl	17	35.45	Radium	Ra	88	(226)
Chromium	Cr	24	52.00	Radon	Rn	86	(222)
Cobalt	Co	27	58.93	Rhenium	Re	75	186.2
Copper	Cu	29	63.54	Rhodium	Rh	45	102.91
Curium	Cm	96	247.07	Rubidium	Rb	37	85.47
Dubnium	Db	105	(263)	Ruthenium	Ru	44	101.07
Dysprosium	Dy	66	162.50	Rutherfordium	Rf	104	(261)
Einsteinium	Es	99	(252)	Samarium	Sm	62	150.35
Erbium	Er	68	167.26	Scandium	Sc	21	44.96
Europium	Eu	63	151.96	Seaborgium	Sg	106	(266)
Fermium	Fm	100	(257.10)	Selenium	Se	34	78.96
Fluorine	F	9	19.00	Silicon	Si	14	28.08
Francium	Fr	87	(223)	Silver	Ag	47	107.87
Gadolinium	Gd	64	157.25	Sodium	Na	11	22.99
Gallium	Ga	31	69.72	Strontium	Sr	38	87.62
Germanium	Ge	32	72.61	Sulphur	S	16	32.06
Gold	Au	79	196.97	Tantalum	Ta	73	180.95
Hafnium	Hf	72	178.49	Technetium	Tc	43	(98.91)
Hassium	Hs	108	(269)	Tellurium	Te	52	127.60
Helium	He	2	4.00	Terbium	Tb	65	158.92
Holmium	Ho	67	164.93	Thallium	Tl	81	204.37
Hydrogen	H	1	1.0079	Thorium	Th	90	232.04
Indium	In	49	114.82	Thulium	Tm	69	168.93
Iodine	I	53	126.90	Tin	Sn	50	118.69
Iridium	Ir	77	192.2	Titanium	Ti	22	47.88
Iron	Fe	26	55.85	Tungsten	W	74	183.85
Krypton	Kr	36	83.80	Ununbium	Uub	112	(277)
Lanthanum	La	57	138.91	Ununnilium	Uun	110	(269)
Lawrencium	Lr	103	(262.1)	Ununonium	Uuu	111	(272)
Lead	Pb	82	207.19	Uranium	U	92	238.03
Lithium	Li	3	6.94	Vanadium	V	23	50.94
Lutetium	Lu	71	174.96	Xenon	Xe	54	131.30
Magnesium	Mg	12	24.31	Ytterbium	Yb	70	173.04
Manganese	Mn	25	54.94	Yttrium	Y	39	88.91
Meitneium	Mt	109	(268)	Zinc	Zn	30	65.37
Mendelevium	Md	101	258.10	Zirconium	Zr	40	91.22

The value given in parenthesis is the molar mass of the isotope of largest known half-life.

APPENDIX III

SOME USEFUL CONVERSION FACTORS

Common Unit of Mass and Weight

1 pound = 453.59 grams

1 pound = 453.59 grams = 0.45359 kilogram

1 kilogram = 1000 grams = 2.205 pounds

1 gram = 10 decigrams = 100 centigrams
= 1000 milligrams

1 gram = 6.022×10^{23} atomic mass units or u

1 atomic mass unit = 1.6606×10^{-24} gram

1 metric tonne = 1000 kilograms
= 2205 pounds

Common Unit of Volume

1 quart = 0.9463 litre

1 litre = 1.056 quarts

1 litre = 1 cubic decimetre = 1000 cubic

centimetres = 0.001 cubic metre

1 millilitre = 1 cubic centimetre = 0.001 litre
= 1.056×10^{-3} quart

1 cubic foot = 28.316 litres = 29.902 quarts
= 7.475 gallons

Common Units of Energy

1 joule = 1×10^7 ergs

1 thermochemical calorie** = 4.184 joules
= 4.184×10^7 ergs
= 4.129×10^{-2} litre-atmospheres
= 2.612×10^{19} electron volts

1 ergs = 1×10^{-7} joule = 2.3901×10^{-8} calorie

1 electron volt = 1.6022×10^{-19} joule
= 1.6022×10^{-12} erg
= 96.487 kJ/mol†

1 litre-atmosphere = 24.217 calories
= 101.32 joules
= 1.0132×10^9 ergs

1 British thermal unit = 1055.06 joules
= 1.05506×10^{10} ergs
= 252.2 calories

Common Units of Length

1 inch = 2.54 centimetres (exactly)

1 mile = 5280 feet = 1.609 kilometres

1 yard = 36 inches = 0.9144 metre

1 metre = 100 centimetres
= 39.37 inches
= 3.281 feet
= 1.094 yards

1 kilometre = 1000 metres
= 1094 yards
= 0.6215 mile

1 Angstrom = 1.0×10^{-8} centimetre
= 0.10 nanometre
= 1.0×10^{-10} metre
= 3.937×10^{-9} inch

Common Units of Force* and Pressure

1 atmosphere = 760 millimetres of mercury
= 1.013×10^5 pascals
= 14.70 pounds per square inch

1 bar = 10^5 pascals

1 torr = 1 millimetre of mercury

1 pascal = $1 \text{ kg/ms}^2 = 1 \text{ N/m}^2$

Temperature

SI Base Unit: Kelvin (K)

K = -273.15°C

K = $^\circ\text{C} + 273.15$

$^\circ\text{F} = 1.8(^\circ\text{C}) + 32$

$^\circ\text{C} = \frac{^\circ\text{F} - 32}{1.8}$

* Force: 1 newton (N) = 1 kg m/s^2 , i.e., the force that, when applied for 1 second, gives a 1-kilogram mass a velocity of 1 metre per second.

** The amount of heat required to raise the temperature of one gram of water from 14.5°C to 15.5°C .

† Note that the other units are per particle and must be multiplied by 6.022×10^{23} to be strictly comparable.

APPENDIX IV

STANDARD POTENTIALS AT 298 K IN ELECTROCHEMICAL

Reduction half-reaction	E° / V	Reduction half-reaction	E° / V
$\text{H}_4\text{XeO}_6 + 2\text{H}^+ + 2\text{e}^- \longrightarrow \text{XeO}_3 + 3\text{H}_2\text{O}$	+3.0	$\text{Pu}^{4+} + \text{e}^- \longrightarrow \text{Pu}^{3+}$	+0.97
$\text{F}_2 + 2\text{e}^- \longrightarrow 2\text{F}^-$	+2.87	$\text{NO}_3^- + 4\text{H}^+ + 3\text{e}^- \longrightarrow \text{NO} + 2\text{H}_2\text{O}$	+0.96
$\text{O}_3 + 2\text{H}^+ + 2\text{e}^- \longrightarrow \text{O}_2 + \text{H}_2\text{O}$	+2.07	$2\text{Hg}_2^{2+} + 2\text{e}^- \longrightarrow \text{Hg}_2^{2+}$	+0.92
$\text{S}_2\text{O}_8^{2-} + 2\text{e}^- \longrightarrow 2\text{SO}_4^{2-}$	+2.05	$\text{ClO}^- + \text{H}_2\text{O} + 2\text{e}^- \longrightarrow \text{Cl}^- + 2\text{OH}^-$	+0.89
$\text{Ag}^+ + \text{e}^- \longrightarrow \text{Ag}$	+1.98	$\text{Hg}_2^{2+} + 2\text{e}^- \longrightarrow \text{Hg}$	+0.86
$\text{Co}^{3+} + \text{e}^- \longrightarrow \text{Co}^{2+}$	+1.81	$\text{NO}_3^- + 2\text{H}^+ + \text{e}^- \longrightarrow \text{NO}_2 + \text{H}_2\text{O}$	+0.80
$\text{H}_2\text{O}_2 + 2\text{H}^+ + 2\text{e}^- \longrightarrow 2\text{H}_2\text{O}$	+1.78	$\text{Ag}^+ + \text{e}^- \longrightarrow \text{Ag}$	+0.80
$\text{Au}^+ + \text{e}^- \longrightarrow \text{Au}$	+1.69	$\text{Hg}_2^{2+} + 2\text{e}^- \longrightarrow 2\text{Hg}$	+0.79
$\text{Pb}^{4+} + 2\text{e}^- \longrightarrow \text{Pb}^{2+}$	+1.67	$\text{Fe}^{3+} + \text{e}^- \longrightarrow \text{Fe}^{2+}$	+0.77
$2\text{HClO} + 2\text{H}^+ + 2\text{e}^- \longrightarrow \text{Cl}_2 + 2\text{H}_2\text{O}$	+1.63	$\text{BrO}^- + \text{H}_2\text{O} + 2\text{e}^- \longrightarrow \text{Br}^- + 2\text{OH}^-$	+0.76
$\text{Ce}^{4+} + \text{e}^- \longrightarrow \text{Ce}^{3+}$	+1.61	$\text{Hg}_2\text{SO}_4 + 2\text{e}^- \longrightarrow 2\text{Hg} + \text{SO}_4^{2-}$	+0.62
$2\text{HBrO} + 2\text{H}^+ + 2\text{e}^- \longrightarrow \text{Br}_2 + 2\text{H}_2\text{O}$	+1.60	$\text{MnO}_4^{2-} + 2\text{H}_2\text{O} + 2\text{e}^- \longrightarrow \text{MnO}_2 + 4\text{OH}^-$	+0.60
$\text{MnO}_4^- + 8\text{H}^+ + 5\text{e}^- \longrightarrow \text{Mn}^{2+} + 4\text{H}_2\text{O}$	+1.51	$\text{MnO}_4^- + \text{e}^- \longrightarrow \text{MnO}_4^{2-}$	+0.56
$\text{Mn}^{3+} + \text{e}^- \longrightarrow \text{Mn}^{2+}$	+1.51	$\text{I}_2 + 2\text{e}^- \longrightarrow 2\text{I}^-$	+0.54
$\text{Au}^{3+} + 3\text{e}^- \longrightarrow \text{Au}$	+1.40	$\text{I}_3^- + 2\text{e}^- \longrightarrow 3\text{I}^-$	+0.53
$\text{Cl}_2 + 2\text{e}^- \longrightarrow 2\text{Cl}^-$	+1.36	$\text{Cu}^+ + \text{e}^- \longrightarrow \text{Cu}$	+0.52
$\text{Cr}_2\text{O}_7^{2-} + 14\text{H}^+ + 6\text{e}^- \longrightarrow 2\text{Cr}^{3+} + 7\text{H}_2\text{O}$	+1.33	$\text{NiOOH} + \text{H}_2\text{O} + \text{e}^- \longrightarrow \text{Ni(OH)}_2 + \text{OH}^-$	+0.49
$\text{O}_3 + \text{H}_2\text{O} + 2\text{e}^- \longrightarrow \text{O}_2 + 2\text{OH}^-$	+1.24	$\text{Ag}_2\text{CrO}_4 + 2\text{e}^- \longrightarrow 2\text{Ag} + \text{CrO}_4^{2-}$	+0.45
$\text{O}_2 + 4\text{H}^+ + 4\text{e}^- \longrightarrow 2\text{H}_2\text{O}$	+1.23	$\text{O}_2 + 2\text{H}_2\text{O} + 4\text{e}^- \longrightarrow 4\text{OH}^-$	+0.40
$\text{ClO}_4^- + 2\text{H}^+ + 2\text{e}^- \longrightarrow \text{ClO}_3^- + \text{H}_2\text{O}$	+1.23	$\text{ClO}_4^- + \text{H}_2\text{O} + 2\text{e}^- \longrightarrow \text{ClO}_3^- + 2\text{OH}^-$	+0.36
$\text{MnO}_2 + 4\text{H}^+ + 2\text{e}^- \longrightarrow \text{Mn}^{2+} + 2\text{H}_2\text{O}$	+1.23	$[\text{Fe(CN)}_6]^{3-} + \text{e}^- \longrightarrow [\text{Fe(CN)}_6]^{4-}$	+0.36
$\text{Pt}^{2+} + 2\text{e}^- \longrightarrow \text{Pt}$	+1.20	$\text{Cu}^{2+} + 2\text{e}^- \longrightarrow \text{Cu}$	+0.34
$\text{Br}_2 + 2\text{e}^- \longrightarrow 2\text{Br}^-$	+1.09	$\text{Hg}_2\text{Cl}_2 + 2\text{e}^- \longrightarrow 2\text{Hg} + 2\text{Cl}^-$	+0.27

$\text{AgCl} + \text{e}^- \longrightarrow \text{Ag} + \text{Cl}^-$	+0.27	$\text{S} + 2\text{e}^- \longrightarrow \text{S}^{2-}$	-0.48
$\text{Bi}^{3+} + 3\text{e}^- \longrightarrow \text{Bi}$	+0.20	$\text{In}^{3+} + \text{e}^- \longrightarrow \text{In}^{2+}$	-0.49
$\text{SO}_4^{2-} + 4\text{H}^+ + 2\text{e}^- \longrightarrow \text{H}_2\text{SO}_3 + \text{H}_2\text{O}$	+0.17	$\text{U}^{4+} + \text{e}^- \longrightarrow \text{U}^{3+}$	-0.61
$\text{Cu}^{2+} + \text{e}^- \longrightarrow \text{Cu}^+$	+0.16	$\text{Cr}^{3+} + 3\text{e}^- \longrightarrow \text{Cr}$	-0.74
$\text{Sn}^{4+} + 2\text{e}^- \longrightarrow \text{Sn}^{2+}$	+0.15	$\text{Zn}^{2+} + 2\text{e}^- \longrightarrow \text{Zn}$	-0.76
$\text{AgBr} + \text{e}^- \longrightarrow \text{Ag} + \text{Br}^-$	+0.07	$\text{Cd}(\text{OH})_2 + 2\text{e}^- \longrightarrow \text{Cd} + 2\text{OH}^-$	-0.81
$\text{Ti}^{4+} + \text{e}^- \longrightarrow \text{Ti}^{3+}$	0.00	$2\text{H}_2\text{O} + 2\text{e}^- \longrightarrow \text{H}_2 + 2\text{OH}^-$	-0.83
$2\text{H}^+ + 2\text{e}^- \longrightarrow \text{H}_2$ (by definition)	0.0	$\text{Cr}^{2+} + 2\text{e}^- \longrightarrow \text{Cr}$	-0.91
$\text{Fe}^{3+} + 3\text{e}^- \longrightarrow \text{Fe}$	-0.04	$\text{Mn}^{2+} + 2\text{e}^- \longrightarrow \text{Mn}$	-1.18
$\text{O}_2 + \text{H}_2\text{O} + 2\text{e}^- \longrightarrow \text{HO}_2^- + \text{OH}^-$	-0.08	$\text{V}^{2+} + 2\text{e}^- \longrightarrow \text{V}$	-1.19
$\text{Pb}^{2+} + 2\text{e}^- \longrightarrow \text{Pb}$	-0.13	$\text{Ti}^{2+} + 2\text{e}^- \longrightarrow \text{Ti}$	-1.63
$\text{In}^+ + \text{e}^- \longrightarrow \text{In}$	-0.14	$\text{Al}^{3+} + 3\text{e}^- \longrightarrow \text{Al}$	-1.66
$\text{Sn}^{2+} + 2\text{e}^- \longrightarrow \text{Sn}$	-0.14	$\text{U}^{3+} + 3\text{e}^- \longrightarrow \text{U}$	-1.79
$\text{AgI} + \text{e}^- \longrightarrow \text{Ag} + \text{I}^-$	-0.15	$\text{Sc}^{3+} + 3\text{e}^- \longrightarrow \text{Sc}$	-2.09
$\text{Ni}^{2+} + 2\text{e}^- \longrightarrow \text{Ni}$	-0.23	$\text{Mg}^{2+} + 2\text{e}^- \longrightarrow \text{Mg}$	-2.36
$\text{V}^{3+} + \text{e}^- \longrightarrow \text{V}^{2+}$	-0.26	$\text{Ce}^{3+} + 3\text{e}^- \longrightarrow \text{Ce}$	-2.48
$\text{Co}^{2+} + 2\text{e}^- \longrightarrow \text{Co}$	-0.28	$\text{La}^{3+} + 3\text{e}^- \longrightarrow \text{La}$	-2.52
$\text{In}^{3+} + 3\text{e}^- \longrightarrow \text{In}$	-0.34	$\text{Na}^+ + \text{e}^- \longrightarrow \text{Na}$	-2.71
$\text{Tl}^+ + \text{e}^- \longrightarrow \text{Tl}$	-0.34	$\text{Ca}^{2+} + 2\text{e}^- \longrightarrow \text{Ca}$	-2.87
$\text{PbSO}_4 + 2\text{e}^- \longrightarrow \text{Pb} + \text{SO}_4^{2-}$	-0.36	$\text{Sr}^{2+} + 2\text{e}^- \longrightarrow \text{Sr}$	-2.89
$\text{Ti}^{3+} + \text{e}^- \longrightarrow \text{Ti}^{2+}$	-0.37	$\text{Ba}^{2+} + 2\text{e}^- \longrightarrow \text{Ba}$	-2.91
$\text{Cd}^{2+} + 2\text{e}^- \longrightarrow \text{Cd}$	-0.40	$\text{Ra}^{2+} + 2\text{e}^- \longrightarrow \text{Ra}$	-2.92
$\text{In}^{2+} + \text{e}^- \longrightarrow \text{In}^+$	-0.40	$\text{Cs}^+ + \text{e}^- \longrightarrow \text{Cs}$	-2.92
$\text{Cr}^{3+} + \text{e}^- \longrightarrow \text{Cr}^{2+}$	-0.41	$\text{Rb}^+ + \text{e}^- \longrightarrow \text{Rb}$	-2.93
$\text{Fe}^{2+} + 2\text{e}^- \longrightarrow \text{Fe}$	-0.44	$\text{K}^+ + \text{e}^- \longrightarrow \text{K}$	-2.93
$\text{In}^{3+} + 2\text{e}^- \longrightarrow \text{In}^+$	-0.44	$\text{Li}^+ + \text{e}^- \longrightarrow \text{Li}$	-3.05

LOGARITHMS

Table 1

N	0	1	2	3	4	5	6	7	8	9	1	2	3	4	5	6	7	8	9
10	0000	0043	0086	0128	0170	0212	0253	0294	0334	0374	5	9	13	17	21	26	30	34	38
											4	8	12	16	20	24	28	32	36
11	0414	0453	0492	0531	0569	0607	0645	0682	0719	0755	4	8	12	16	20	23	27	31	35
											4	7	11	15	18	22	26	29	33
12	0792	0828	0864	0899	0934	0969	1004	1038	1072	1106	3	7	11	14	18	21	25	28	32
											3	7	10	14	17	20	24	27	31
13	1139	1173	1206	1239	1271	1303	1335	1367	1399	1430	3	6	10	13	16	19	23	26	29
											3	7	10	13	16	19	22	25	29
14	1461	1492	1523	1553	1584	1614	1644	1673	1703	1732	3	6	9	12	15	19	22	25	28
											3	6	9	12	14	17	20	23	26
15	1761	1790	1818	1847	1875	1903	1931	1959	1987	2014	3	6	9	11	14	17	20	23	26
											3	6	8	11	14	17	19	22	25
16	2041	2068	2095	2122	2148	2175	2201	2227	2253	2279	3	6	8	11	14	16	19	22	24
											3	5	8	10	13	16	18	21	23
17	2304	2330	2355	2380	2405	2430	2455	2480	2504	2529	3	5	8	10	13	15	18	20	23
											3	5	8	10	12	15	17	20	22
18	2553	2577	2601	2625	2648	2672	2695	2718	2742	2765	2	5	7	9	12	14	17	19	21
											2	4	7	9	11	14	16	18	21
19	2788	2810	2833	2856	2878	2900	2923	2945	2967	2989	2	4	7	9	11	13	16	18	20
											2	4	6	8	11	13	15	17	19
20	3010	3032	3054	3075	3096	3118	3139	3160	3181	3201	2	4	6	8	11	13	15	17	19
21	3222	3243	3263	3284	3304	3324	3345	3365	3385	3404	2	4	6	8	10	12	14	16	18
22	3424	3444	3464	3483	3502	3522	3541	3560	3579	3598	2	4	6	8	10	12	14	15	17
23	3617	3636	3655	3674	3692	3711	3729	3747	3766	3784	2	4	6	7	9	11	13	15	17
24	3802	3820	3838	3856	3874	3892	3909	3927	3945	3962	2	4	5	7	9	11	12	14	16
25	3979	3997	4014	4031	4048	4065	4082	4099	4116	4133	2	3	5	7	9	10	12	14	15
26	4150	4166	4183	4200	4216	4232	4249	4265	4281	4298	2	3	5	7	8	10	11	13	15
27	4314	4330	4346	4362	4378	4393	4409	4425	4440	4456	2	3	5	6	8	9	11	13	14
28	4472	4487	4502	4518	4533	4548	4564	4579	4594	4609	2	3	5	6	8	9	11	12	14
29	4624	4639	4654	4669	4683	4698	4713	4728	4742	4757	1	3	4	6	7	9	10	12	13
30	4771	4786	4800	4814	4829	4843	4857	4871	4886	4900	1	3	4	6	7	9	10	11	13
31	4914	4928	4942	4955	4969	4983	4997	5011	5024	5038	1	3	4	6	7	8	10	11	12
32	5051	5065	5079	5092	5105	5119	5132	5145	5159	5172	1	3	4	5	7	8	9	11	12
33	5185	5198	5211	5224	5237	5250	5263	5276	5289	5302	1	3	4	5	6	8	9	10	12
34	5315	5328	5340	5353	5366	5378	5391	5403	5416	5428	1	3	4	5	6	8	9	10	11
35	5441	5453	5465	5478	5490	5502	5514	5527	5539	5551	1	2	4	5	6	7	9	10	11
36	5563	5575	5587	5599	5611	5623	5635	5647	5658	5670	1	2	4	5	6	7	8	10	11
37	5682	5694	5705	5717	5729	5740	5752	5763	5775	5786	1	2	3	5	6	7	8	9	10
38	5798	5809	5821	5832	5843	5855	5866	5877	5888	5899	1	2	3	5	6	7	8	9	10
39	5911	5922	5933	5944	5955	5966	5977	5988	5999	6010	1	2	3	4	5	7	8	9	10
40	6021	6031	6042	6053	6064	6075	6085	6096	6107	6117	1	2	3	4	5	6	8	9	10
41	6128	6138	6149	6160	6170	6180	6191	6201	6212	6222	1	2	3	4	5	6	7	8	9
42	6232	6243	6253	6263	6274	6284	6294	6304	6314	6325	1	2	3	4	5	6	7	8	9
43	6335	6345	6355	6365	6375	6385	6395	6405	6415	6425	1	2	3	4	5	6	7	8	9
44	6435	6444	6454	6464	6474	6484	6493	6503	6513	6522	1	2	3	4	5	6	7	8	9
45	6532	6542	6551	6561	6471	6580	6590	6599	6609	6618	1	2	3	4	5	6	7	8	9
46	6628	6637	6646	6656	6665	6675	6684	6693	6702	6712	1	2	3	4	5	6	7	7	8
47	6721	6730	6739	6749	6758	6767	6776	6785	6794	6803	1	2	3	4	5	5	6	7	8
48	6812	6821	6830	6839	6848	6857	6866	6875	6884	6893	1	2	3	4	4	5	6	7	8
49	6902	6911	6920	6928	6937	6946	6955	6964	6972	6981	1	2	3	4	4	5	6	7	8

LOGARITHMS

Table 1 continued

N	0	1	2	3	4	5	6	7	8	9	1	2	3	4	5	6	7	8	9
50	6990	6998	7007	7016	7024	7033	7042	7050	7059	7067	1	2	3	3	4	5	6	7	8
51	7076	7084	7093	7101	7110	7118	7126	7135	7143	7152	1	2	3	3	4	5	6	7	8
52	7160	7168	7177	7185	7193	7202	7210	7218	7226	7235	1	2	2	3	4	5	6	7	7
53	7243	7251	7259	7267	7275	7284	7292	7300	7308	7316	1	2	2	3	4	5	6	6	7
54	7324	7332	7340	7348	7356	7364	7372	7380	7388	7396	1	2	2	3	4	5	6	6	7
55	7404	7412	7419	7427	7435	7443	7451	7459	7466	7474	1	2	2	3	4	5	5	6	7
56	7482	7490	7497	7505	7513	7520	7528	7536	7543	7551	1	2	2	3	4	5	5	6	7
57	7559	7566	7574	7582	7589	7597	7604	7612	7619	7627	1	2	2	3	4	5	5	6	7
58	7634	7642	7649	7657	7664	7672	7679	7686	7694	7701	1	1	2	3	4	4	5	6	7
59	7709	7716	7723	7731	7738	7745	7752	7760	7767	7774	1	1	2	3	4	4	5	6	7
60	7782	7789	7796	7803	7810	7818	7825	7832	7839	7846	1	1	2	3	4	4	5	6	6
61	7853	7860	7768	7875	7882	7889	7896	7903	7910	7917	1	1	2	3	4	4	5	6	6
62	7924	7931	7938	7945	7952	7959	7966	7973	7980	7987	1	1	2	3	3	4	5	6	6
63	7993	8000	8007	8014	8021	8028	8035	8041	8048	8055	1	1	2	3	3	4	5	5	6
64	8062	8069	8075	8082	8089	8096	8102	8109	8116	8122	1	1	2	3	3	4	5	5	6
65	8129	8136	8142	8149	8156	8162	8169	8176	8182	8189	1	1	2	3	3	4	5	5	6
66	8195	8202	8209	8215	8222	8228	8235	8241	8248	8254	1	1	2	3	3	4	5	5	6
67	8261	8267	8274	8280	8287	8293	8299	8306	8312	8319	1	1	2	3	3	4	5	5	6
68	8325	8331	8338	8344	8351	8357	8363	8370	8376	8382	1	1	2	3	3	4	4	5	6
69	8388	8395	8401	8407	8414	8420	8426	8432	8439	8445	1	1	2	2	3	4	4	5	6
70	8451	8457	8463	8470	8476	8482	8488	8494	8500	8506	1	1	2	2	3	4	4	5	6
71	8513	8519	8525	8531	8537	8543	8549	8555	8561	8567	1	1	2	2	3	4	4	5	5
72	8573	8579	8585	8591	8597	8603	8609	8615	8621	8627	1	1	2	2	3	4	4	5	5
73	8633	8639	8645	8651	8657	8663	8669	8675	8681	8686	1	1	2	2	3	4	4	5	5
74	8692	8698	8704	8710	8716	8722	8727	8733	8739	8745	1	1	2	2	3	4	4	5	5
75	8751	8756	8762	8768	8774	8779	8785	8791	8797	8802	1	1	2	2	3	3	4	5	5
76	8808	8814	8820	8825	8831	8837	8842	8848	8854	8859	1	1	2	2	3	3	4	5	5
77	8865	8871	8876	8882	8887	8893	8899	8904	8910	8915	1	1	2	2	3	3	4	4	5
78	8921	8927	8932	8938	8943	8949	8954	8960	8965	8971	1	1	2	2	3	3	4	4	5
79	8976	8982	8987	8993	8998	9004	9009	9015	9020	9025	1	1	2	2	3	3	4	4	5
80	9031	9036	9042	9047	9053	9058	9063	9069	9074	9079	1	1	2	2	3	3	4	4	5
81	9085	9090	9096	9101	9106	9112	9117	9122	9128	9133	1	1	2	2	3	3	4	4	5
82	9138	9143	9149	9154	9159	9165	9170	9175	9180	9186	1	1	2	2	3	3	4	4	5
83	9191	9196	9201	9206	9212	9217	9222	9227	9232	9238	1	1	2	2	3	3	4	4	5
84	9243	9248	9253	9258	9263	9269	9274	9279	9284	9289	1	1	2	2	3	3	4	4	5
85	9294	9299	9304	9309	9315	9320	9325	9330	9335	9340	1	1	2	2	3	3	4	4	5
86	9345	9350	9355	9360	9365	9370	9375	9380	9385	9390	1	1	2	2	3	3	4	4	5
87	9395	9400	9405	9410	9415	9420	9425	9430	9435	9440	0	1	1	2	2	3	3	4	4
88	9445	9450	9455	9460	9465	9469	9474	9479	9484	9489	0	1	1	2	2	3	3	4	4
89	9494	9499	9504	9509	9513	9518	9523	9528	9533	9538	0	1	1	2	2	3	3	4	4
90	9542	9547	9552	9557	9562	9566	9571	9576	9581	9586	0	1	1	2	2	3	3	4	4
91	9590	9595	9600	9605	9609	9614	9619	9624	9628	9633	0	1	1	2	2	3	3	4	4
92	9638	9643	9647	9652	9657	9661	9666	9671	9675	9680	0	1	1	2	2	3	3	4	4
93	9685	9689	9694	9699	9703	9708	9713	9717	9722	9727	0	1	1	2	2	3	3	4	4
94	9731	9736	9741	9745	9750	9754	9759	9763	9768	9773	0	1	1	2	2	3	3	4	4
95	9777	9782	9786	9791	9795	9800	9805	9809	9814	9818	0	1	1	2	2	3	3	4	4
96	9823	9827	9832	9836	9841	9845	9850	9854	9859	9863	0	1	1	2	2	3	3	4	4
97	9868	9872	9877	9881	9886	9890	9894	9899	9903	9908	0	1	1	2	2	3	3	4	4
98	9912	9917	9921	9926	9930	9934	9939	9943	9948	9952	0	1	1	2	2	3	3	4	4
99	9956	9961	9965	9969	9974	9978	9983	9987	9997	9996	0	1	1	2	2	3	3	3	4

ANTILOGARITHMS

Table 2

N	0	1	2	3	4	5	6	7	8	9	1	2	3	4	5	6	7	8	9
.00	1000	1002	1005	1007	1009	1012	1014	1016	1019	1021	0	0	1	1	1	1	2	2	2
.01	1023	1026	1028	1030	1033	1035	1038	1040	1042	1045	0	0	1	1	1	1	2	2	2
.02	1047	1050	1052	1054	1057	1059	1062	1064	1067	1069	0	0	1	1	1	1	2	2	2
.03	1072	1074	1076	1079	1081	1084	1086	1089	1091	1094	0	0	1	1	1	1	2	2	2
.04	1096	1099	1102	1104	1107	1109	1112	1114	1117	1119	0	1	1	1	1	2	2	2	2
.05	1122	1125	1127	1130	1132	1135	1138	1140	1143	1146	0	1	1	1	1	2	2	2	2
.06	1148	1151	1153	1156	1159	1161	1164	1167	1169	1172	0	1	1	1	1	2	2	2	2
.07	1175	1178	1180	1183	1186	1189	1191	1194	1197	1199	0	1	1	1	1	2	2	2	2
.08	1202	1205	1208	1211	1213	1216	1219	1222	1225	1227	0	1	1	1	1	2	2	2	3
.09	1230	1233	1236	1239	1242	1245	1247	1250	1253	1256	0	1	1	1	1	2	2	2	3
.10	1259	1262	1265	1268	1271	1274	1276	1279	1282	1285	0	1	1	1	1	2	2	2	3
.11	1288	1291	1294	1297	1300	1303	1306	1309	1312	1315	0	1	1	1	2	2	2	2	3
.12	1318	1321	1324	1327	1330	1334	1337	1340	1343	1346	0	1	1	1	2	2	2	2	3
.13	1349	1352	1355	1358	1361	1365	1368	1371	1374	1377	0	1	1	1	2	2	2	3	3
.14	1380	1384	1387	1390	1393	1396	1400	1403	1406	1409	0	1	1	1	2	2	2	3	3
.15	1413	1416	1419	1422	1426	1429	1432	1435	1439	1442	0	1	1	1	2	2	2	3	3
.16	1445	1449	1452	1455	1459	1462	1466	1469	1472	1476	0	1	1	1	2	2	2	3	3
.17	1479	1483	1486	1489	1493	1496	1500	1503	1507	1510	0	1	1	1	2	2	2	3	3
.18	1514	1517	1521	1524	1528	1531	1535	1538	1542	1545	0	1	1	1	2	2	2	3	3
.19	1549	1552	1556	1560	1563	1567	1570	1574	1578	1581	0	1	1	1	2	2	3	3	3
.20	1585	1589	1592	1596	1600	1603	1607	1611	1614	1618	0	1	1	1	2	2	3	3	3
.21	1622	1626	1629	1633	1637	1641	1644	1648	1652	1656	0	1	1	2	2	2	3	3	3
.22	1660	1663	1667	1671	1675	1679	1683	1687	1690	1694	0	1	1	2	2	2	3	3	3
.23	1698	1702	1706	1710	1714	1718	1722	1726	1730	1734	0	1	1	2	2	2	3	3	4
.24	1738	1742	1746	1750	1754	1758	1762	1766	1770	1774	0	1	1	2	2	2	3	3	4
.25	1778	1782	1786	1791	1795	1799	1803	1807	1811	1816	0	1	1	2	2	2	3	3	4
.26	1820	1824	1828	1832	1837	1841	1845	1849	1854	1858	0	1	1	2	2	3	3	3	4
.27	1862	1866	1871	1875	1879	1884	1888	1892	1897	1901	0	1	1	2	2	3	3	3	4
.28	1905	1910	1914	1919	1923	1928	1932	1936	1941	1945	0	1	1	2	2	3	3	4	4
.29	1950	1954	1959	1963	1968	1972	1977	1982	1986	1991	0	1	1	2	2	3	3	4	4
.30	1995	2000	2004	2009	2014	2018	2023	2028	2032	2037	0	1	1	2	2	3	3	4	4
.31	2042	2046	2051	2056	2061	2065	2070	2075	2080	2084	0	1	1	2	2	3	3	4	4
.32	2089	2094	2099	2104	2109	2113	2118	2123	2128	2133	0	1	1	2	2	3	3	4	4
.33	2138	2143	2148	2153	2158	2163	2168	2173	2178	2183	0	1	1	2	2	3	3	4	4
.34	2188	2193	2198	2203	2208	2213	2218	2223	2228	2234	1	1	2	2	3	3	4	4	5
.35	2239	2244	2249	2254	2259	2265	2270	2275	2280	2286	1	1	2	2	3	3	4	4	5
.36	2291	2296	2301	2307	2312	2317	2323	2328	2333	2339	1	1	2	2	3	3	4	4	5
.37	2344	2350	2355	2360	2366	2371	2377	2382	2388	2393	1	1	2	2	3	3	4	4	5
.38	2399	2404	2410	2415	2421	2427	2432	2438	2443	2449	1	1	2	2	3	3	4	4	5
.39	2455	2460	2466	2472	2477	2483	2489	2495	2500	2506	1	1	2	2	3	3	4	5	5
.40	2512	2518	2523	2529	2535	2541	2547	2553	2559	2564	1	1	2	2	3	4	4	5	5
.41	2570	2576	2582	2588	2594	2600	2606	2612	2618	2624	1	1	2	2	3	4	4	5	5
.42	2630	2636	2642	2649	2655	2661	2667	2673	2679	2685	1	1	2	2	3	4	4	5	6
.43	2692	2698	2704	2710	2716	2723	2729	2735	2742	2748	1	1	2	3	3	4	4	5	6
.44	2754	2761	2767	2773	2780	2786	2793	2799	2805	2812	1	1	2	3	3	4	4	5	6
.45	2818	2825	2831	2838	2844	2851	2858	2864	2871	2877	1	1	2	3	3	4	5	5	6
.46	2884	2891	2897	2904	2911	2917	2924	2931	2938	2944	1	1	2	3	3	4	5	5	6
.47	2951	2958	2965	2972	2979	2985	2992	2999	3006	3013	1	1	2	3	3	4	5	5	6
.48	3020	3027	3034	3041	3048	3055	3062	3069	3076	3083	1	1	2	3	3	4	5	6	6
.49	3090	3097	3105	3112	3119	3126	3133	3141	3148	3155	1	1	2	3	3	4	5	6	6

ANTILOGARITHMS

Table 2 continued

N	0	1	2	3	4	5	6	7	8	9	1	2	3	4	5	6	7	8	9
.50	3162	3170	3177	3184	3192	3199	3206	3214	3221	3228	1	1	2	3	4	4	5	6	7
.51	3236	3243	3251	3258	3266	3273	3281	3289	3296	3304	1	2	2	3	4	5	5	6	7
.52	3311	3319	3327	3334	3342	3350	3357	3365	3373	3381	1	2	2	3	4	5	5	6	7
.53	3388	3396	3404	3412	3420	3428	3436	3443	3451	3459	1	2	2	3	4	5	6	6	7
.54	3467	3475	3483	3491	3499	3508	3516	3524	3532	3540	1	2	2	3	4	5	6	6	7
.55	3548	3556	3565	3573	3581	3589	3597	3606	3614	3622	1	2	2	3	4	5	6	7	7
.56	3631	3639	3648	3656	3664	3673	3681	3690	3698	3707	1	2	3	3	4	5	6	7	8
.57	3715	3724	3733	3741	3750	3758	3767	3776	3784	3793	1	2	3	3	4	5	6	7	8
.58	3802	3811	3819	3828	3837	3846	3855	3864	3873	3882	1	2	3	4	4	5	6	7	8
.59	3890	3899	3908	3917	3926	3936	3945	3954	3963	3972	1	2	3	4	5	5	6	7	8
.60	3981	3990	3999	4009	4018	4027	4036	4046	4055	4064	1	2	3	4	5	6	6	7	8
.61	4074	4083	4093	4102	4111	4121	4130	4140	4150	4159	1	2	3	4	5	6	7	8	9
.62	4169	4178	4188	4198	4207	4217	4227	4236	4246	4256	1	2	3	4	5	6	7	8	9
.63	4266	4276	4285	4295	4305	4315	4325	4335	4345	4355	1	2	3	4	5	6	7	8	9
.64	4365	4375	4385	4395	4406	4416	4426	4436	4446	4457	1	2	3	4	5	6	7	8	9
.65	4467	4477	4487	4498	4508	4519	4529	4539	4550	4560	1	2	3	4	5	6	7	8	9
.66	4571	4581	4592	4603	4613	4624	4634	4645	4656	4667	1	2	3	4	5	6	7	9	10
.67	4677	4688	4699	4710	4721	4732	4742	4753	4764	4775	1	2	3	4	5	7	8	9	10
.68	4786	4797	4808	4819	4831	4842	4853	4864	4875	4887	1	2	3	4	6	7	8	9	10
.69	4898	4909	4920	4932	4943	4955	4966	4977	4989	5000	1	2	3	5	6	7	8	9	10
.70	5012	5023	5035	5047	5058	5070	5082	5093	5105	5117	1	2	4	5	6	7	8	9	11
.71	5129	5140	5152	5164	5176	5188	5200	5212	5224	5236	1	2	4	5	6	7	8	10	11
.72	5248	5260	5272	5284	5297	5309	5321	5333	5346	5358	1	2	4	5	6	7	9	10	11
.73	5370	5383	5395	5408	5420	5433	5445	5458	5470	5483	1	3	4	5	6	8	9	10	11
.74	5495	5508	5521	5534	5546	5559	5572	5585	5598	5610	1	3	4	5	6	8	9	10	12
.75	5623	5636	5649	5662	5675	5689	5702	5715	5728	5741	1	3	4	5	7	8	9	10	12
.76	5754	5768	5781	5794	5808	5821	5834	5848	5861	5875	1	3	4	5	7	8	9	11	12
.77	5888	5902	5916	5929	5943	5957	5970	5984	5998	6012	1	3	4	5	7	8	10	11	12
.78	6026	6039	6053	6067	6081	6095	6109	6124	6138	6152	1	3	4	6	7	8	10	11	13
.79	6166	6180	6194	6209	6223	6237	6252	6266	6281	6295	1	3	4	6	7	9	10	11	13
.80	6310	6324	6339	6353	6368	6383	6397	6412	6427	6442	1	3	4	6	7	9	10	12	13
.81	6457	6471	6486	6501	6516	6531	6546	6561	6577	6592	2	3	5	6	8	9	11	12	14
.82	6607	6622	6637	6653	6668	6683	6699	6714	6730	6745	2	3	5	6	8	9	11	12	14
.83	6761	6776	6792	6808	6823	6839	6855	6871	6887	6902	2	3	5	6	8	9	11	13	14
.84	6918	6934	6950	6966	6982	6998	7015	7031	7047	7063	2	3	5	6	8	10	11	13	15
.85	7079	7096	7112	7129	7145	7161	7178	7194	7211	7228	2	3	5	7	8	10	12	13	15
.86	7244	7261	7278	7295	7311	7328	7345	7362	7379	7396	2	3	5	7	8	10	12	13	15
.87	7413	7430	7447	7464	7482	7499	7516	7534	7551	7568	2	3	5	7	9	10	12	14	16
.88	7586	7603	7621	7638	7656	7674	7691	7709	7727	7745	2	4	5	7	9	11	12	14	16
.89	7762	7780	7798	7816	7834	7852	7870	7889	7907	7925	2	4	5	7	9	11	13	14	16
.90	7943	7962	7980	7998	8017	8035	8054	8072	8091	8110	2	4	6	7	9	11	13	15	17
.91	8128	8147	8166	8185	8204	8222	8241	8260	8279	8299	2	4	6	8	9	11	13	15	17
.92	8318	8337	8356	8375	8395	8414	8433	8453	8472	8492	2	4	6	8	10	12	14	15	17
.93	8511	8531	8551	8570	8590	8610	8630	8650	8670	8690	2	4	6	8	10	12	14	16	18
.94	8710	8730	8750	8770	8790	8810	8831	8851	8872	8892	2	4	6	8	10	12	14	16	18
.95	8913	8933	8954	8974	8995	9016	9036	9057	9078	9099	2	4	6	8	10	12	15	17	19
.96	9120	9141	9162	9183	9204	9226	9247	9268	9290	9311	2	4	6	8	11	13	15	17	19
.97	9333	9354	9376	9397	9419	9441	9462	9484	9506	9528	2	4	7	9	11	13	15	17	20
.98	9550	9572	9594	9616	9638	9661	9683	9705	9727	9750	2	4	7	9	11	13	16	18	20
.99	9772	9795	9817	9840	9863	9886	9908	9931	9954	9977	2	5	7	9	11	14	16	18	20

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